GREG ROWE & associates
FOCUSED ON ACHIEVEMENT

LOCAL STRUCTURE PLAN

LOT 661 BERTRAM ROAD, WELLARD

GRA REF 6233 29/10/2015

DOCUMENT CONTROL

This report has been authorised by;

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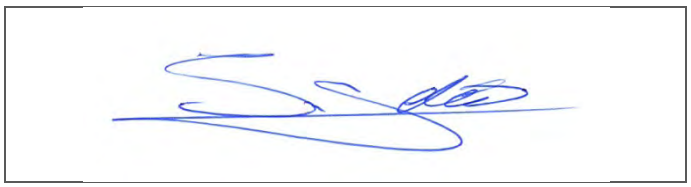
Sam Jeleric Planner



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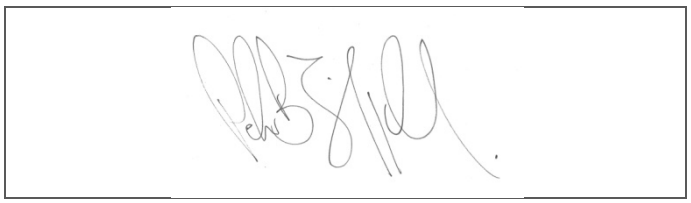
Peter Fitzgerald Senior Designer



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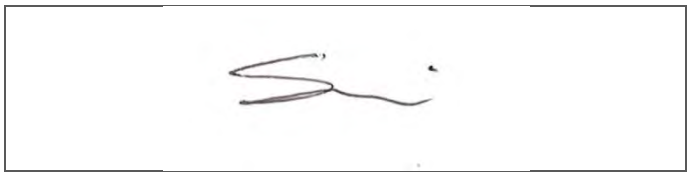

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Document History

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ENDORSEMENT PAGE

This structure plan is prepared under the provisions of the City of Kwinana Town Planning Scheme No 2

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

11 December 2014

Signed for and on behalf of the Western Australian Planning Commission:

an officer of the Commission duly authorised by the Commission pursuant to Section 24 of the Planning and Development Act 2005 for that purpose, in the presence of:

Witness M. Wreclaw

Date: 13 November 2015

Date of Expiry: 13 November 2025

TABLE OF CHANGES OR DEPARTURES FROM STRUCTURE PLAN

Change of Departure No.	Description of Change or Departure	Date Approved by Council	Date Approved by WAPC (if required)	Date Structure Plan Commences Operation

Executive Summary

The subject site is located within the metropolitan south west corridor, within the municipality of the City of Kwinana (the 'City'). The site is situated approximately 32km south of the Perth Central area, 2km south east of the Kwinana Town Centre and midway between the Kwinana Railway Station and the Wellard Railway Station.

The Structure Plan proposes residential development and areas of public open space in the south western corner and at the interface of Structure Plan area with the Bollard Bulrush Swamp. Remnant mature trees will be retained in the south western part of the site for landscape and visual management purposes. Other remnant mature trees will be retained on site where practicable.

Particular provisions have been included in the Structure Plan relating to density and land use to provide for flexibility in the event the Parmelia Railway Station is constructed.

The provisions, standards or requirements specified under Part 1 of this Structure Plan have the same force and effect as if it were a provision, standard or requirement of the City of Kwinana Town Planning Scheme No. 2 ('TPS 2'). Parts 2 and 3 of this Structure Plan are for explanatory purposes and provide a descriptive analysis of the Structure Plan.

Structure Plan Summary Table

Item	Data	Section number referenced within the Structure Plan Report
Gross Structure Plan Area	7.1498 hectares	Part 2. Section 1.2.2
Area of each land use proposed <u>Zone</u> - Residential <u>Reserves</u> - Public Open Space and Reserves	 6.182 hectares 0.6947 hectares	 Figure 1: Structure Plan Map Part 1. Section 5.3
Estimated Lot Yield	198 lots	Part 2. Section 3.3
Estimated Number of Dwellings	198 dwellings	Part 2. Section 3.3
Estimated Residential Density - Dwellings per gross hectare *As per Directions 2031* - Dwellings per site hectare *As per Liveable Neighbourhoods*	 28 dwellings per gross hectare 32 dwellings per site hectare	 Part 2. Section 3.3 Part 2. Section 3.3
Estimated Population	554 people @ 2.8 people/household	N / A
Amount of Public Open Space	0.6947 hectares	Part 1. Section 5.3

CONTENTS

TECHNICAL APPENDICES

1. Certificate of Title
2. Noise Assessment
3. Vegetation and Visual Management Assessment
4. Fire Management Plan
5. Local Water Management Strategy

FIGURES

PART 1

Part One - Statutory Section

1. Structure Plan Area

This Structure Plan shall apply to Lot 661 Bertram Road, Wellard being the land contained within the inner edge of the line denoting the Structure Plan Area on the Structure Plan Map. This Structure Plan is identified as the *Lot 661 Bertram Road, Wellard Local Structure Plan*.

2. Structure Plan Content

The Structure Plan comprises the following sections:

(i) Part One – Statutory Section. This section includes the Structure Plan Map and any textual provisions, standards or requirements that require statutory effect.

(ii) Part Two – Explanatory Section (Non-Statutory). This section provides the planning context and justification for the Structure Plan Map and the textual provisions, standards or requirements contained in Part One of the Structure Plan. Part Two is to be used as a reference to guide interpretation and implementation of Part One.

(iii) Appendices, includes all specialist consultant reports and documentation used in the preparation of and to support the land use outcomes of the Structure Plan.

3. Interpretations and Relationship with the Town Planning Scheme No. 2

3.1	Terms and Interpretations	Unless otherwise specified in this part, the words and expressions used in this Structure Plan shall have the respective meanings given to them in the City of Kwinana town Planning Scheme No. 2 ('Scheme') including any amendments gazetted thereto.
3.2	Relationship of the Structure Plan with Town Planning Scheme No. 2	This Structure Plan has been prepared in Clause 6.17 of the Scheme as the subject land is zoned 'Development'. The Structure Plan Map outlines the Zones and Reserves applicable within the Structure Plan Area. The Zones and Reserves designated under this Structure Plan apply to the land within it as if the Zones and Reserves were incorporated into the Scheme.
3.3	Provisions, Standards or Requirements	Pursuant to Clauses 6.17.7.4 and 6.17.7.5 of the Scheme, the provisions, standards or requirements specified under Part One of this Structure Plan shall ahve the same force and effect as it is where a provision, standard or requirement of the Scheme. In the case of any inconsistency between the Scheme and any provisions, standards or requirements specified under Part One of this Structure Plan, the Scheme prevails to the extent of any inconsistency.
3.4	Land Use Permissibility	Land use permissibility within the Structure Plan Area shall be in accordance with the corresponding zone in the Scheme.

4. Operation

4.1	Operation Date	This Structure Plan commences operation on the date it is adopted by Council pursuant to Clause 6.17.4.15 of the Scheme.
4.2	Change or Departure from Structure Plan	Clause 6.17.5 of the Scheme outlines the manner in which a change to or departure from a Structure Plan is determined.

5. Land Use

5.1	Structure Plan Map	The subdivision and development of land is to generally be in accordance with the Structure Plan.
5.2	Residential Density	Residential densities applicable to the Structure Plan Area shall be those residential densities shown on the Structure Plan Map.

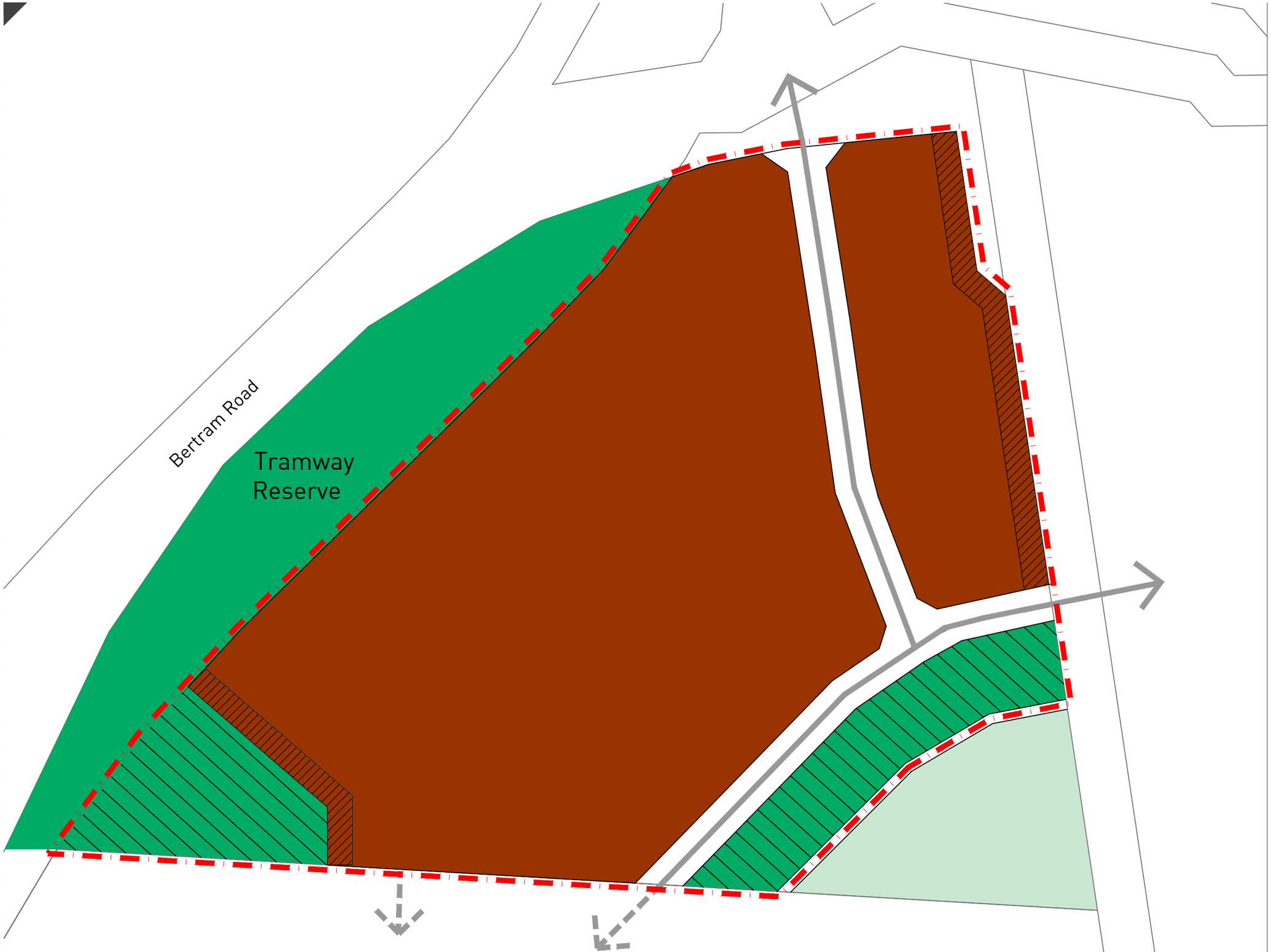
6. Subdivision/Development

6.1	Notifications on Title	In respect of application for the subdivision of land the Council shall recommend to the Western Australian Planning Commission that a condition be imposed on the grant of subdivision approval for a notification to be placed on the Certificates of Titles to advise of the following: - 1. Land or lots deemed to be affected by a Bush Fire Hazard as identified in a updated version of the *Fire Management Plan – Local Structure Plan' Lot 661 Bertram Road, Wellard Western Australia, 6170,* RUIC 2013 (as amended) contained within Appendix 4. 2. Building setbacks and construction standards required to achieve a Bushfire Attack Level of 29 or lower in accordance with Australian Standards (AS3959-2009): Construction of buildings in bushfire prone areas (as amended). 3. Land or Lots deemed to be impacted by noise levels beyond the target prescribed in State Planning Policy 5.4 *Road and Rail Transportation Noise and Freight Consideration in Land Use Planning* (as amended). 4. That the lot is in close proximity to known mosquito breeding areas and that the predominant species is known to carry viruses and other diseases.
6.2	Detailed Area Plans (Local Development Plans)	1. Detailed Area Plans (DAPs) are required to be prepared and implemented pursuant to Clause 6.17.6 of the Scheme for lots comprising one of more of the following site attributes: i. Lots with rear-loaded vehicle access;

		ii. Lots with direct boundary frontage (primary or secondary) to an area of Public Open Space; iii. Lots deemed to be affected by a recognised Bush Fire Hazard with a BAL rating of 12.5 or greater, as identified in an updated version of the *Fire Management Plan – Local Structure Plan; Lot 661 Bertram Road, Wellard Western Australia, 6170* by RUIC 2013 (as amended) contained within Appendix 4; and iv. Lots deemed to be affected by noise from Bertram Road and the Mandurah Railway beyond the target prescribed in *State Planning Policy 5.1 – Road and Rail Transport Noise and Freight Considerations in Land Use Planning* as identified in the *Lot 661 Bertram Road, Wellard Local Structure Plan – Traffic Noise Assessment,* 25 July 2013 by EcoAcoustics (as amended) contained within Appendix 2.
6.3	Other provisions / standards / requirements	<u>Bushfire Construction Standards</u> This Structure Plan is supported by a Bushfire Management Plan (BMP), the *Fire Management Plan – Local Structure Plan; Lot 661 Bertram Road, Wellard Western Australia, 6170* (as amended) contained within Appendix 4. Any land falling within 100 meters of a bushfire hazard identified in the BMP is designated as a Bushfire Prone Area for the purpose of the Building Code of Australia.

7. Other Requirements

7.1	Other land use, development and subdivision requirements	1. The following will be required to support subdivision or development applications" i. Updated version of the *Fire Management Plan – Local Structure Plan; Lot 661 Bertram Road, Wellard Western Australia, 6170* by RUIC 2013 contained within Appendix 4 Fire Management Plan; ii. Mosquito and Midge Management Strategy; iii. Fauna Management Plan; iv. Wetland Management Plan; and an v. Archival record of the Sutton Farm House with its cultural heritage significance to be represented within the Structure Plan Area.



Local Structure Plan - Figure 1

N:\TOWN PLANNING\6000-6999\6233\DRAFTING\A-CAD\6233_FIG06D_20151029 WELLARD (LSP - FIGURE 1).DWG
Matt Sullivan 29 October 2015

Planning Design Delivery

LEGEND

Metropolitan Region Scheme Reserves
- Parks and Recreation

Local Scheme Reserves
- Parks, Recreation and Drainage

Zones
- Residential (R60)
- Rural A

Other
- Structure Plan Boundary
- Access Street
- External Road Connection(s) (General Vicinity)
- Pedestrian and / or Road Interface

0 5 10 20 30 40 80 Metres

REVISIONS

Rev	Date	Drawn
A	2014.11.13	C.Karsakis
B	2015.01.20	M. Sullivan
C	2015.07.29	M. Sullivan
D	2015.10.29	M. Sullivan

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Date Drawn:	2014-08-07
Job Ref:	6233
Scale:	1:1500 @ A3
Client:	Redray Holdings Pty Ltd
Designer:	P. Fitzgerald
Drawn:	C.Karsakis
Projection:	MGA50 GDA94
Plan ID:	6233-FIG-06-D

Lot 661 Bertram Road
Wellard

PART 2

Explanatory Section

1. Planning Background

1.1 Introduction and Purpose

1.1.1 Purpose of the Local Structure Plan

This Local Structure Plan has been prepared by Rowe Group who act on behalf of the owner (Bestall Super Pty Ltd as trustee for the JB Superannuation Fund and The Royale Australian Golf Club Pty Ltd) of Lot 661 Bertram Road, Wellard (the 'subject site'), as a precursor to subdivision.

The purpose of the Structure Plan is to refine provisions under the district framework and ensure a comprehensive approach to planning and development with input from the local community, landowners, government agencies and other key stakeholders.

The Structure Plan is a statutory planning document that will guide future land use and development within the subject area, and provide a framework for more detailed planning at subdivision stage.

1.1.2 Extent of the Structure Plan Area

For the purpose of this report, the Structure Plan Area is defined as the land bound by Bertram Road to the north, a Parks and Recreation Reserve to the west, Peel Main Drain to the east and Lot 69 (No. 50) Bertram Road to the south. The Structure Plan Area is indicated on the Structure Plan Map.

1.1.3 The Study Team

The landowner has established a consultant team comprising of experts across a variety of disciplines. Members of the Study Team are listed in Table 2 below. The work of the consultant team as contained in the Appendices demonstrates the capability, suitability and compliance of the proposal.

Table 2: Members of Study Team.

Discipline	Consultant
Town Planning	Rowe Group
Fire Management	RUIC
Urban Water Management	JDA
Environment and Landscape	Endemic
Acoustics	Eco Acoustics

1.2 Land Description

1.2.1 Location

1.2.1.1 Regional Location

The subject site is located in the Municipality of the City of Kwinana (the 'City'), approximately 32km south of the Perth Central Area and 2km south east of the Kwinana Town Centre. Refer Figure 2 – Regional Location.

FIGURE 2 REGIONAL LOCATION

1.2.1.2 Detailed Location

The subject site is situated in Wellard approximately 1.6km west of the Kwinana Freeway, 550m north-east of the Wellard Road / Bertram Avenue intersection and directly opposite the reservation set aside for the Parmelia Railway Station.

Refer Figure 3 – Locality Plan.

1.2.2 Area and Land Use

The subject site has an area of approximately 7.15 hectares. The site is utilised for rural pursuits and rural living purposes. The land is predominantly cleared with a number of paddocks for grazing and numerous introduced plant species. A dwelling is located towards the north of the site near Bertram Road. A number of sheds are located on the site of varying size.

The subject land (albeit outside the Structure Plan Area) comprises an Environmental Protection Policy ('EPP') Lake, being the Bollard Bulrush Swamp at the south eastern boundary of the site. This Lake and its buffer is excluded from all development areas.

Refer Figure 4 – Site Plan.

1.2.3 Legal Description and Ownership

The subject site comprises a single land parcel as described in Table 3 below.

Table 3: Land Parcel Details.

Lot Address	Land Owner	Volume	Folio	Diagram/Plan
Lot 661 Bertram Road, Wellard	Bestall Super Pty Ltd as trustee for the JB Superannuation Fund and The Royale Australian Golf Club Pty Ltd	2806	474	68787

Refer Appendix 1 – Certificate of Title.

1.3 Planning Framework

1.3.1 Zoning and Reservations

The majority of the Structure Plan Area is zoned 'Urban' under the provisions of the Metropolitan Region Scheme ('MRS'). The balance south eastern portion of the site is zoned 'Rural', being the area the subject of the EPP wetland and associated buffer.

Land directly to the west along Bertram Road is reserved 'Parks and Recreation' under the MRS and is understood to form part of an historical tramway reserve. The Peel Main Drain which runs along the eastern boundary of the site is zoned 'Rural' under the MRS. Lot 607 further to the east is zoned 'Rural', however, is the subject of a MRS rezoning proposal to change the land to 'Urban Deferred'. Lot 69 to the south is a mixture of 'Urban Deferred' and 'Rural' zonings under the MRS.

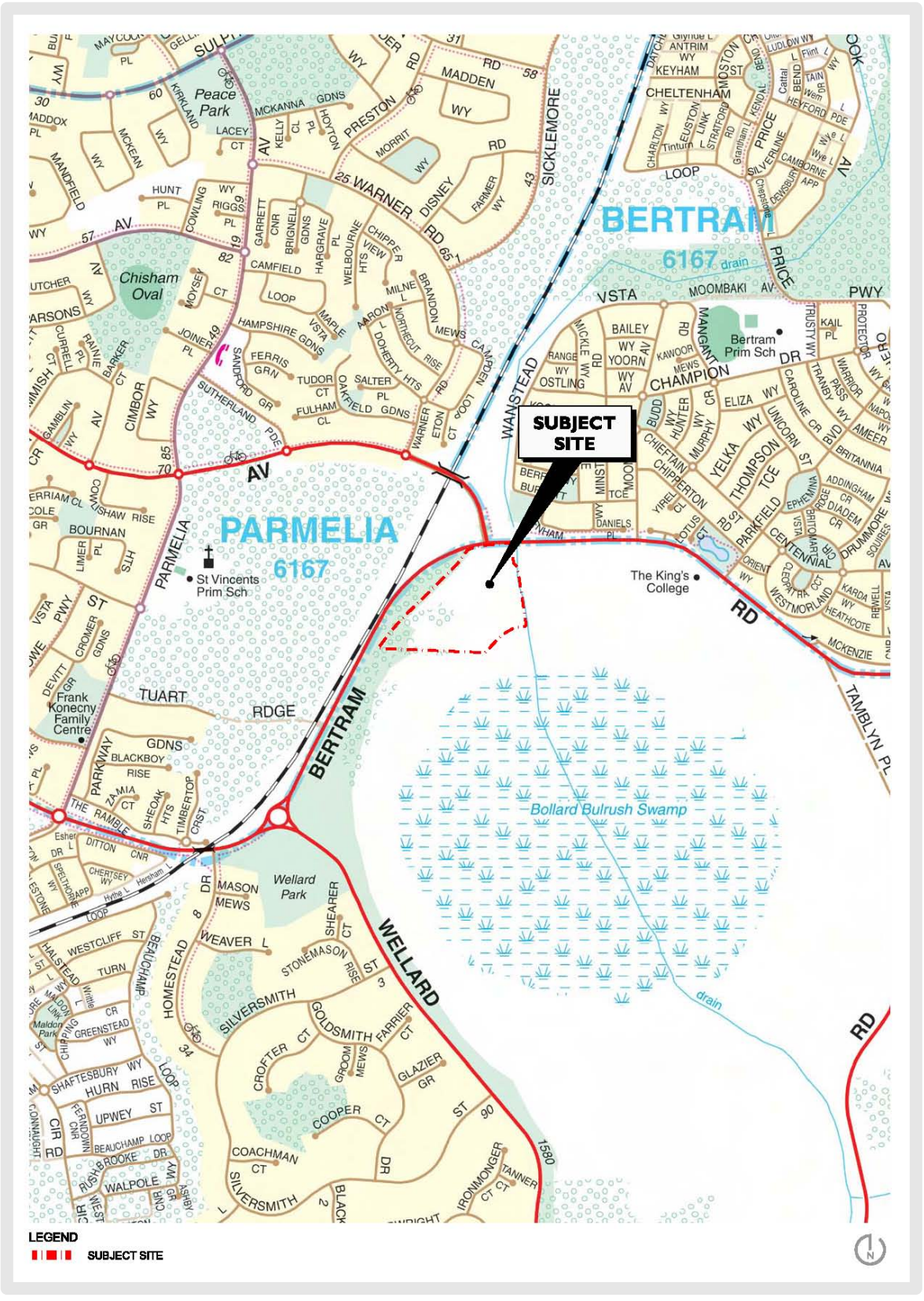


FIGURE 3 LOCALITY PLAN

FIGURE 4 SITE PLAN

Directly opposite the subject site on the northern side of Bertram Road is an expanded area of land reserved 'Railways' and designated for the future possible Parmelia Railway Station. Rowe Group has been advised by the Department of Planning that there are currently no plans for the construction of the Parmelia Railway Station

Refer Figure 5 – MRS Zoning.

The Structure Plan Area is zoned 'Development' under the provisions of the TPS 2. The subject site is contained within an area of Landscape Protection under TPS 2 within which the following is applicable:

> *No person shall, in any Area of Landscape Protection, without Council's Planning Approval in writing;*
>
> *(a) Carry out clearing of trees or other vegetation;*
>
> *(b) Carry out any filling, dredging or changes to the contour of the land;*
>
> *(c) Erect any advertising sign,*
>
> *(d) Erect or construct any building or outbuilding,*
>
> *(e) Degrade any natural wetland system,*
>
> *(f) Detract from the amenity of the locality.*

A Vegetation and Visual Management Assessment, as discussed below, was prepared to address the Landscape Protection designation of the land.

TPS2 also provides further classification of the Scheme Area through the designation of Policy Areas. The subject site is located within 'Policy Area 6 – Wellard', which states:

> *Whereas market gardening has been developed on groundwater supplies and whereas rural homesites have been established primarily on existing lots and whereas the Bollard Bulrush Swamps have landscape amenity as a wetland habitat, the following planning policy shall apply:*
>
> *(a) The predominant use shall be rural provided such uses are not in conflict with principles of groundwater conservation and do not significantly contribute to nutrient discharge to the district drainage network;*
>
> *(b) Council may consider multiple occupancy development in the form of strata titling within this Policy Area provided such development is within the Cluster/Communal Rural Settlement Zone.*
>
> *(c) The landscape amenity of the Bollard Bulrush Swamps shall be conserved;*
>
> *(d) Subdivision shall only be supported where consistent with the predominant use;*
>
> *(e) Tailings ponds are not permitted;*
>
> *(f) A rural community and service centre may be established in the vicinity of the Thomas Road and Johnson Road intersection.*

The ongoing applicability of the rural use applied under Policy Area 6 – Wellard as described above is superceded given the MRS Urban and TPS 2 Development zoning of the land. The protection of the Bollard Bulrush Swamp wetland is nevertheless achieved via the retention of the Swamp in the MRS Rural Zone. Refer Figure 6 – TPS 2 Zoning.

FIGURE 5 MRS ZONING

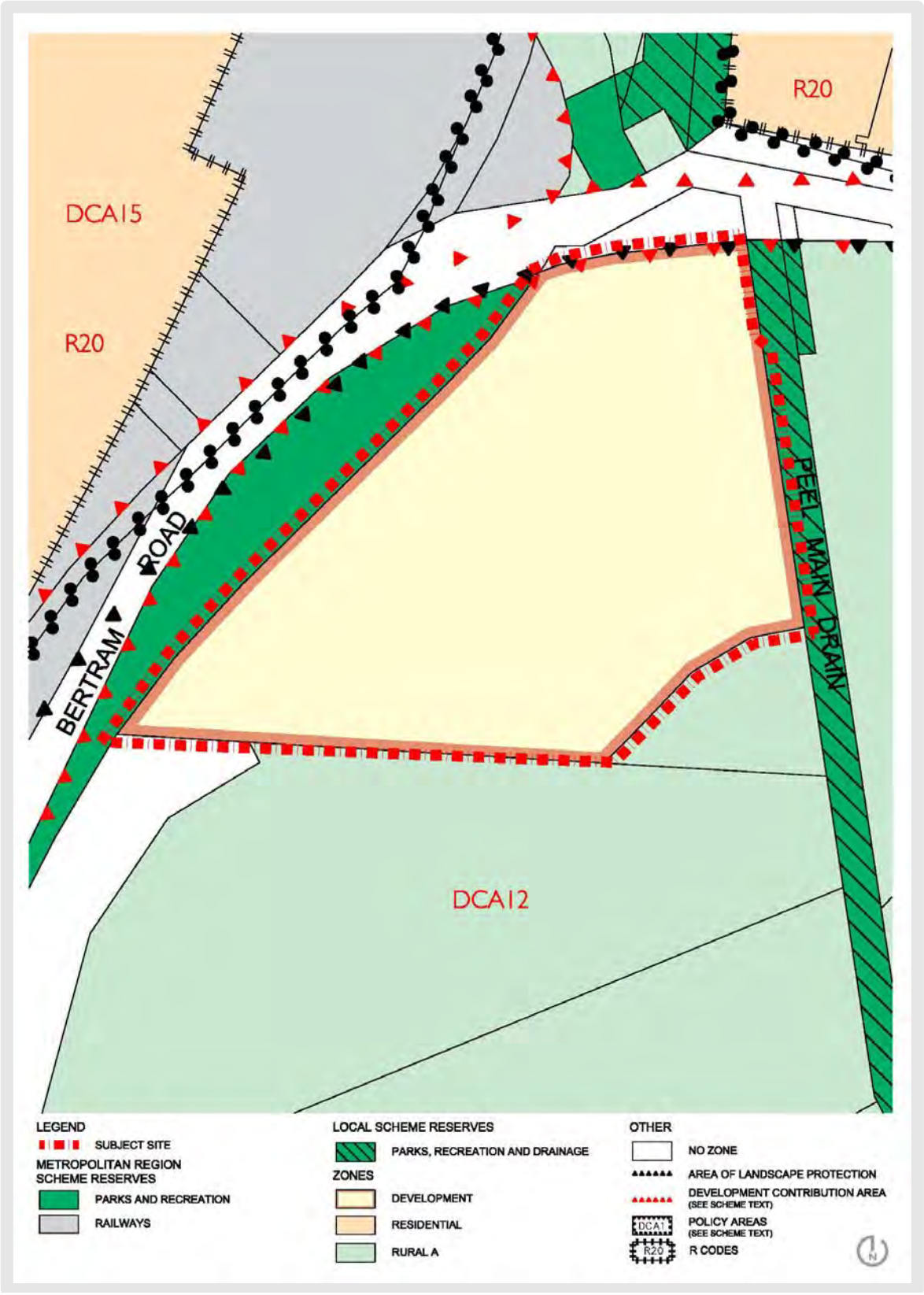


FIGURE 6 TPS 2 ZONING

1.3.2 Planning Strategies and Policies

1.3.2.1 State Planning Policy – Road and Rail Transport Noise and Freight Considerations in Land Use Planning

This Policy is applicable because of the land's vicinity to Bertram Road (a Distributor Road) and a rail line.

The aim of the Policy is essentially to ensure that noise impacts are minimised such that residential amenity is not unduly compromised while also ensuring that key transport routes are protected.

A Noise Impact Assessment for the site has been prepared for the LSP and is attached at Appendix 2. It confirms that noise issues are capable of management through a variety of potential measures at detailed design stage.

1.3.2.2 Jandakot Structure Plan

The Jandakot Structure Plan ('JSP') was finalised in August 2007 and seeks to co-ordinate the development of the district while ensuring environmental, social and economic objectives are met. The subject site is within the JSP area and is designated for 'short term urban' with a timeframe of 0 to 5 years for commencement of development. Under the JSP, the wetland area to the south east of the Structure Plan Area is indicated as open space. The zoning of the land reflects this strategic designation.

1.3.2.3 Eastern Residential Intensification Concept

The Eastern Residential Intensification Concept ('ERIC') was prepared by the City in 2005, to provide strategic direction and refinement of the future urban areas identified within the JSP. ERIC comprises the cells of Mandogalup, Wandi, Anketell, Casuarina, Wellard (east) and Wellard (west) and defines a framework by which urban subdivision and development is able to occur in an orderly and co-ordinated manner. A number of these areas are now established residential estates.

ERIC states that the subject site and surrounding lands are to be considered for urbanisation following full environmental review of impacts of urbanisation on wetland area. The environmental impacts of the urban development of the land has been considered by the Office of the Environmental Protection Authority ('EPA') with the Chairman of the EPA confirming in October 2009 the rezoning of the land could progress without environmental review provided no development occurred within the EPP wetland or its buffer. The zoning of the land reflects this decision. Furthermore a detailed review of the wetland was conducted by the Department of Environment and Conservation ('DEC') in December 2011 and April 2012.

1.3.2.4 Draft City of Kwinana Local Planning Strategy

The Draft City of Kwinana Local Planning Strategy was prepared by the City to plan, control and guide the City's growth pressures in order to achieve State and Metropolitan objectives. The strategy lists the subject site as an area of Landscape/ Environmental Value and within Area No. 12: Conservation. This stipulates that an environmental study must be prepared to determine the extent of the wetland area. As mentioned above, the extent of the EPP wetland was determined through the Office of the EPA and the Chairman of the EPA's decision in October 2009.

The Strategy further identifies the site as an area for Low to Medium density residential in the 'long term'. The Structure Plan is consistent with this designation in providing for medium density housing options for standard subdivision.

1.3.2.5 Local Planning Policies

The City has prepared a suite of Local Planning Policies ('LPP's'), which will be considered and implemented through further detailed design at subdivision and detailed area planning, including:

- Design Guidelines for Medium Density Development;
- Footpaths;
- Residential Development;
- Residential Subdivision and Development Guidelines;
- Residential Subdivision Road Standards;
- Street Lighting;
- Street Naming; and
- Street Trees and Verge Treatments.

The City's Policy on the Conservation of Remnant Vegetation aims to preserve the bushland character of the City and strengthen the system enacting reservation and conservation of remnant vegetation. The policy seeks, amongst other things, the retention of existing trees by developers in residential estates. The Structure Plan proposes retention of trees in the south west of the site and in other areas (if practicable).

1.3.2.6 EPA Guidance Statement for Management of Mosquitoes by Land Developers No 40

Per Part 1 of this report, the proponent will be required to submit a Mosquito & Midge Management Plan for approval by the City and implementation by the developer as a condition of subdivision approval (post approval of this LSP).

The Mosquito & Midge Management Plan will be required to address the provisions of the above-mentioned EPA Guidance Statement.

It is noted that the Plan may include an evaluation of the mosquito breeding and disease risk associated with the development site to be carried out ideally for up to 3 years, but at least 1 year prior to the commencement of ground breaking activities.

2. Site Conditions and Constraints

2.1 Biodiversity and Natural Area Assets

2.1.1 Vegetation/Flora

Endemic Pty Ltd undertook a Vegetation and Visual Landscape Assessment on May 11, 2012. This assessment was conducted to determine the condition of vegetation within the subject site, as well as identify vegetation worthy of retention for screening and environmental purposes.

The Assessment indicated that the site is in a degraded to completely degraded condition, with only confined areas of mature trees remaining and no native understorey present. Despite a total of 12 flora species recorded across the subject site, many of these species are introduced to the area. The Assessment further acknowledged that the site is affected by a heavy weed burden, with blackberry widespread in the treed areas. No Declared Rare Flora, Priority Flora or Threatened Ecological Communities were recorded.

The Vegetation and Visual Landscape Assessment concluded that:

- Mature trees within the western boundary provide valuable aesthetic and visual screening functions. The vegetation in this portion of the site comprises mature *Eucalyptus rudis* (Flooded Gum);
- *Eucaliptus rudis* along the common boundary with Lot 69 should be retained;
- Existing vegetation within the Bertram Road reserve which comprises medium-tall shrubs of *Kunzea ericfolia* which provide effective in-fill screening should be retained, and consideration should be given to any future landscaping treatment along the eastern side of Bertram Road in order to maintain and enhance this screening.

As per Figure 1, a POS area has been provided in the south western portion of the site to retain a portion of the *Eucaliptus rudis* trees identified in Figure 7 below. The balance individual trees will be aimed for retention on a future residential lot(s) in this location. The exact location and number of trees will be determined by a detailed tree survey to be undertaken as a condition of subdivision approval.

In addition to the above recommendations, and as agreed with the City's Senior Planning and Environmental Officers on site on 23 November 2012, other native trees will be retained on site where possible, as determined by a detailed tree survey to be undertaken as a condition of subdivision approval.

To this end, consistent with the City's Conservation of Remnant Vegetation Policy, opportunities to retain native trees have been incorporated into the LSP design. Retaining larger trees and native vegetation where possible will help maintain the landscape values of the area consistent with TPS 2.

Refer Appendix 3 – Vegetation and Visual Landscape Assessment and

Refer Figure 7 – Vegetation Recommended for Retention for Screening Purposes.

FIGURE 7 VEGETATION TO BE POTENTIALLY RETAINED FOR SCREENING

2.1.2 Fauna

As the land the subject of the Structure Plan is predominantly devoid of natural vegetation, the land is not considered to provide significant habitat. Endemic's Vegetation and Visual Landscape Assessment further stipulates that the site does not contain any habitat hollows on site.

The Bollard Bulrush Swamp to the south of the Structure Plan Area (i.e. not within the Structure Plan Area) is considered to support habitat and provide an ecological linkage. The proposed rehabilitation works in the Bollard Bulrush Swamp area (via the relevant Development Contribution Area) will improve biodiversity values in the locality.

It is anticipated that a Fauna Management Plan will be required as a condition of subdivision.

2.2 Landform and Soils

2.2.1 Soil and Topography

The Bollard Bulrush Swamp is part of the Beeliar chain of wetlands that represents the divide between the Bassendean dune system to the east and the Spearwood dune system to the west. The subject lot is of low relief, sitting on peaty lacustrine material associated with a historically drained wetland. The soils are generally Sandy Silt - dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content and of lacustrine origin.

2.2.2 Acid Sulphate Soils

As prescribed by the WAPC Planning Bulletin No. 64: Acid Sulphate Soils ('ASS'), the DEC's ASS mapping indicates the majority of the subject site is classified as having a high to moderate risk of ASS occurring within 3m of natural soil

surface. A small portion of land to the northern boundary is classified as having a moderate to low risk of ASS occurring within 3m of natural soil surface, but a high to moderate risk of ASS occurring beyond 3m of natural soil surface.

Depending on the extent of filling of the land and the final depth of services, an ASS investigation may need to be undertaken at subdivision stage. If it is determined that ASS is likely to be disturbed then an ASS Management Plan will need to be prepared and implemented. Any ASS report will need to address the following considerations:

- Measures to be undertaken to identify and avoid disturbance of ASS;
- Measures to be undertaken to effectively mitigate any impacts during site works; and
- Contingency (or remediation) should site works have negative impacts.

2.3 Groundwater and Surface Water

2.3.1 Groundwater

Groundwater flow on the site is generally towards the Peel Main Drain, with groundwater levels ranging from 5.5m AHD in the north west of the site to 4.75m AHD in the south east of the Structure Plan Area. Based on ground water monitoring undertaken for the approved District Water Management Strategy ('DWMS') for the site, the Maximum Groundwater Levels ('MGL') for the bore on the subject lot and the depth to MGL from ground surface were determined to be 5.48m AHD and 1.42m, respectively. High groundwater levels across much of the Study Area will require management in the post-development environment via a design groundwater level ('DGL'). The design of the proposed development should incorporate a minimum habitable floor level 1.2m above the DGL to meet the required clearance from the DGL as per Better Urban Water Management ('BUWM') (WAPC, 2008).

2.3.2 Surface Water

The Study Area is located within the floodplain of the regionally significant Peel Main Drain and the Bollard Bulrush Swamp within the Peel Main Drain Catchment. The Study Area drains south east toward Bollard Bulrush Swamp then to the Peel Main Drain. Surface water is present seasonally adjacent to the Structure Plan Area in the Bollard Bulrush Swamp and within the Peel Main Drain. The Structure Plan area is partially located within the floodplain of the Peel Main Drain. Under the Bollard Bulrush West District Water Management Strategy (ENV, 2011) the 1 in 100 ARI flood level for the area is given at 5.62m AHD. Finished floor levels ('FFL') will be a minimum of 0.5m above the 100 year peak water level in the Structure Plan area and the DWMS determined that a FFL of 6.12 m AHD should be set for the subject site.

2.3.3 Potential Contamination

A search of the DEC's records and Contaminated Sites Database indicates that the site has not been registered as a contaminated site or as a site suspected of being contaminated.

2.3.4 Wetlands

A search of the DEC Geomorphic Wetlands Database identified a Conservation Category Wetland ('CCW') to the south east of the Structure Plan area and identified the majority of the site as being included within a Multiple Use Wetland ('MUW'). Refer Figure 8 – Wetlands.

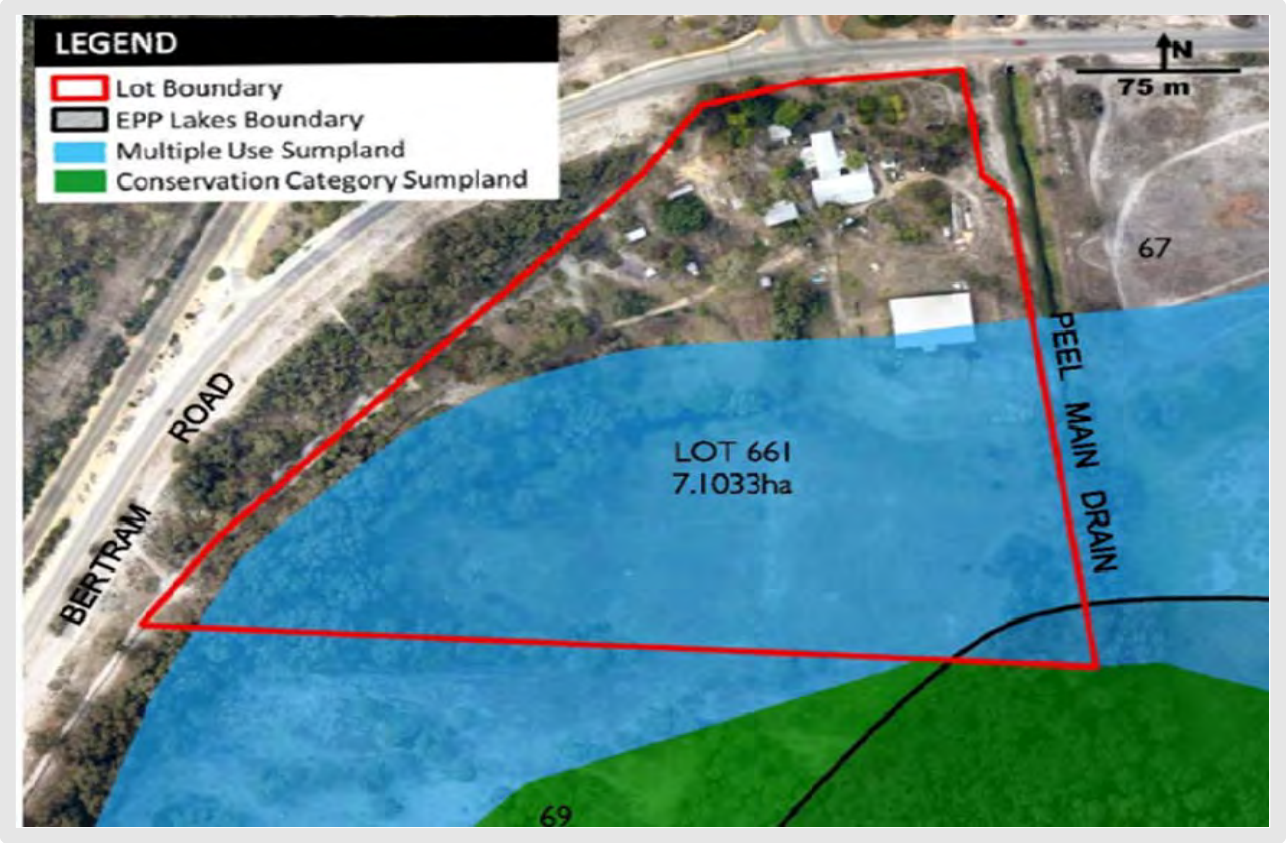


FIGURE 8 WETLANDS

In addition, an EPP Lake is located outside of the Structure Plan area to the south east (Refer Figure 8). The south eastern boundary of the Structure Plan area, as well as the Urban zoning boundary, is represented by a 50m buffer setback from the EPP Lake boundary. The Chairman of the EPA determined in October 2009 that the zoning of the subject lot could proceed provided no development encroached within a 50m buffer of the EPP Lake. The EPA confirmed this via a submission on the MRS rezoning of the land in its letter dated 29 March 2010. A detailed review of the wetland was conducted by the DEC in December 2011 and April 2012, with this review determining the extent of the CCW and MUW shown in Figure 8. As can be seen from Figure 8, the CCW does not extend any further on the land than the EPP Lake. The Structure Plan maintains the 50m buffer setback area to the EPP Lake as per the Chairman of the EPA's decision and is therefore appropriate.

It is understood that the City will be undertaking works to rehabilitate the CCW/EPP wetland (i.e. outside of the Structure Plan Area) via Developer Contributions arrangements.

2.4 Bushfire Hazard

The Structure Plan Area is in a locality that is likely to be the subject of bushfires risk. A Fire Management Plan ('FMP') was undertaken by RUIC. The report sets the level of hazard and suggests various mitigation tactics.

Refer Appendix 4: Fire Management Plan (RUIC).

The entirety of the Structure Plan Area will be developed with grassland and the majority of vegetation removed and included in landscaped areas, which will remove the fire risk on the subject lot and the need for any Building

Protection Zones ('BPZ') and Hazard Separation Zones ('HSZ') associated with these current fire risks. Development on adjacent lots will similarly remove / reduce the fire hazards via development over time.

The FMP requires that building construction standards be increased for all dwellings within 100m of classified vegetation (hazard) as per methodology in the Australian Standard AS3959-2009 "Construction of Buildings in Bushfire Prone Areas". The HSZ as described above and detailed in the FMP can be reduced by increasing the construction standards under AS3959-2009. This will be reviewed at subdivision stage.

A detailed Fire Management Plan will be required to be prepared and implemented as a condition of subdivision approval. Lots affected by the Fire Management Plan will have Notifications on Title highlighting the obligations and responsibilities of the landowner under the Fire Management Plan.

A full list of management approaches can be found within the FMP Report at Appendix 4.

Refer Appendix 4 – Fire Management Plan.

2.5 Heritage

A search of the Department of Indigenous Affairs Aboriginal Heritage Inquiry System indicates no Aboriginal sites of heritage significance have been recorded on the subject site or surrounds.

A search of the State Heritage Register identified no sites of European heritage significance at the subject site.

The City's Municipal Heritage Inventory identifies a number of sites that are of aesthetic and historical importance to the locality, those being the Tramway Reserve, the Wellard Swamp / Bollard Bulrush Swamp and the Sutton Farm House.

The Tramway Reserve abuts the north western boundary of the subject site and is an area of remnant vegetation. The Structure Plan proposes no road crossings or any development within the Tramway Reserve and therefore maintains its integrity. No action is required in relation to this heritage site as part of the implementation of the Structure Plan.

Whilst the Bollard Bulrush Swamp is located on the subject site, it is outside of the Structure Plan Area and the proposal maintains the necessary 50m buffer to this wetland. The City proposes rehabilitation works in the Swamp area via funds collected from Developer Contributions. No action is required in relation to this heritage site as part of the implementation of the Structure Plan.

The Sutton Farmhouse is located on the northern part of the subject lot and is listed within the City's Municipal Heritage Inventory ('MHI') as a 'Management Category B' structure. As stipulated within the MHI, the farmhouse is in very poor condition, concealed from the road by overgrown vegetation and is dilapidated. Given its dilapidated state and location on the alignment of the proposed four way intersection, the Structure Plan proposes the demolition of the existing dwelling. As per the MHI, an archival photographic record will be undertaken of the dwelling and the cultural heritage significance of the dwelling will be represented in writing or physically on site. Options here include a small plaque on the site, a small piece of public art or some form of memorial to provide information on the site's history to the passer by/visitor. The exact nature of the representation can be confirmed at subdivision stage.

We understand from discussion with the City that the proposed demolition of the Sutton Farmhouse would simply require a standard application to the City's Building Services.

2.6 Context and Other Land Use

2.6.1 Movement Network

The subject site is currently serviced by Bertram Road, which is classified as an Integrator B road. Challenger Avenue intersects with Bertram Road directly to the north of the subject site. The location of the Tramway Reserve to the north west of the site means that the subject land has only limited frontage to Bertram Road. Given the status of Bertram Road and the location of the Challenger Avenue intersection, it is not possible to design a 'T' intersection to Bertram Road from the subject site and maintain a suitable separation distance to Challenger Avenue. For this reason, a four way intersection is proposed with Challenger Avenue and being the main connection into the subject land. The City has advised that deceleration lanes are required for all intersections along Bertram Road, which the City is currently constructing for all existing intersections.

Internal subdivisional roads will be constructed in accordance with the City's requirements. Limited internal subdivision roads are proposed under the Structure Plan, with the main entrance road from Challenger Avenue and an east west road connecting across the Peel Main Drain from the east through to the proposed POS in the south western corner of the site proposed.

The reduced number of roads may necessitate the development of a number of Grouped Housing lots on the land. Notwithstanding the reduced number of roads, the proposed road network achieves the required external connections, being a connection north to Bertram Road and east across the Peel Main Drain.

Subdivisional roads have been designed to ensure future connection with abutting landholdings at the time when they are similarly developed.

2.6.2 Public Transport

The subject site is serviced by Transperth bus services 543 along Bertram Road. This route operates north of the subject site along Bertram Road and Challenger Avenue and connects the site to the Kwinana Secondary Centre and Kwinana Railway Station.

3. Land Use and Subdivision Requirements

3.1 Land Use

The Structure Plan area is designated for POS, residential development and the associated public road network. POS is located in the south west and south east of the Structure Plan Area, with the POS in the south west to form a Local Park and includes the retention of trees for screening purposes. The POS in the south east will also be a Local Park and will also have a drainage function and will interface with the wetland buffer.

The POS abutting the wetland buffer will allow for a gradual shift from the natural flora of Bollard Bulrush Swamp and the ultimate built form of the subject site. It is envisaged that the POS proposed for the south east of the subject site will ultimately form a contiguous POS area surrounding the Bullard Bulrush Swamp, at the time when surrounding landholdings are similarly developed.

3.2 Open space

As per Liveable Neighbourhoods, a range of site responsive urban parkland is proposed which appropriately addresses the needs of residents and is comprised of a mixture of restricted and unrestricted open space. The Structure Plan Area will provide POS generally in accordance with Figure 1 and will satisfy in full the requirement for the provision of 10 per cent POS.

A 4,172m^2 Local Park is provided towards the south west boundary of the subject site (POS Site Ref. 1) to conserve and protect a number of the mature *Eucaliptus Rudis* trees for screening and aesthetic purposes, with the balance of the trees in this locality to be potentially retained on private lot(s). The understory in this location is completely degraded, comprising blackberry and pasture species. The POS area will therefore be a landscaped parkland with suitable infrastructure and furniture and will comprise entirely unrestricted POS.

A Local Park of 4,975m^2 will be provided towards the south eastern corner of the Structure Plan Area (POS Site ref. 2) for drainage and POS purposes. Whilst the whole of this park is required to contain the 100 year ARI, only 2,200m^2 of the park is required for the 1 year ARI. Taking into account 1:5 ARI 1,000m^2 is creditable as Restricted POS, with the balance representing unrestricted POS. Although a detailed POS breakdown will be provided at subdivision stage, the Structure Plan is based on the calculation in Table 4. Each Local Park described above is to be reserved under the City's TPS2 as 'Parks, Recreation and Drainage'.

Table 4: POS Breakdown.

Lot 661 Bertram Road, Wellard – Public Open Space Schedule			
Site Area (Local Structure Plan boundary)			71,498.38 m^2
Deductions			
Dedicated Drainage (1:1 yr ARI)	2,200 m^2		
Total		2,200 m^2	
Gross Subdivisible Area			**69,298.38 m^2**
POS @10%			6,929.84 m^2

Public Open Space Contribution		
May comprise:		
- Min 80% unrestricted POS	5,543.87 m^2	
- Min 20% restricted use POS	1,385.97 m^2	
Total Required POS		**6,929.84 m^2**
POS Reference Number	**Unrestricted Urban POS sites (m^2)**	**Restricted Urban POS sites (m^2)**
1	4,171.83	0
2	1,774.95	1,000
Total	**5,946.78 m^2**	**1,000 m^2**
	(8.58%)	**(1.44%)**
		6,946.78 m^2 (10.02%)

3.3 Residential

Both Directions 2031 and Liveable Neighbourhoods specify that new urban land is to achieve a target of 15 dwellings per zoned urban hectare. Based on a total zoned area of just over 7.1ha, the subject site is required to achieve a total of 106 dwellings.

Liveable Neighbourhoods further stipulates an average residential density of 22 dwellings per site hectare to be achieved in new urban areas. Based on the Urban Density definition in Liveable Neighbourhoods, the Structure Plan is therefore required to achieve 101 dwellings at a density of 22 dwellings per site hectare.

The Structure Plan proposes a Residential density of R60 for the site. Subdivision Applications are to be consistent with the density provisions provided under Part 1.

In respect of the Residential density prescribed the development of the subject site will achieve 27.6 dwellings per gross hectare and 32 dwellings per site hectare, achieving the targets prescribed by Directions 2031 and Liveable Neighbourhoods, respectively.

The densities proposed reflect an increasing trend of smaller lots, the desire to provide affordable housing and the high landscape amenity of the subject site. The densities proposed also account for the area of land lost for the Bollard Bulrush Swamp and the protection of vegetation on site. Higher densities similarly take advantage of the site's high accessibility to the Perth public transport network

Through discussions with the City, it is understood that the site may be suitable for an Aged Persons' facility. The R60 density proposed allows for such a development at the subject site, in the event that it is proposed, which will provide sufficient density for a 'whole of village' concept to be developed on the site or could allow smaller portions of the site to be developed for this type of housing.

In the event that the development of the Parmelia Railway Station progresses, it will:

- facilitate a Transit Orientated Development on the land in the event of the train station being constructed consistent with *Liveable Neighbourhoods* and *Development Control Policy 1.6 Planning to Support Transit Use and Transit Oriented Development.*;

- In itself promote/support the construction of the station by guaranteeing a supporting population nearby without requiring developers to commit to higher densities up front with no guarantee of a station.

Providing for the higher densities is consistent with the request of the City dated 22 November 2011 to maintain flexibility in planning of the locality.

It is considered that the Structure Plan provides a variety of lot product and housing choices for a diversified residential population, with flexible options for development to cater for short to longer term planning.

3.4 Water Management

JDA has prepared a Local Water Management Strategy ('LWMS') for the site (Appendix 5). The LWMS proposes a stormwater management system consistent with the Jandakot Drainage and Water Management Plan (DoW 2009) and the more recent Bollard Bulrush West District Water Management Strategy (ENV 2011).

The conceptual design of the flood management system attenuates peak runoff from 5 and 100 year ARI storm events to within estimated pre-development (existing) levels as presented in the DWMS. The 1 year 1 hour rainfall event will be retained on lots within soakwells with an overflow connection to the flood attenuation area. The 1 year 1 hour rainfall event from roads will be retained within a bio-retention area within the stormwater flood attenuation area. Up to the 5 Year ARI storm event discharges to the Peel Main Drain via a low flow outlet with the 100 year ARI discharging via the low flow outlet to the Peel Main Drain and overflow via diffuse overland flow via a spillway to Bollard Bulrush Swamp.

Results from modelling indicate that the flood storage volume, total surface area and flood level (assuming a base invert of 5.65m AHD) for the stormwater attenuation area is:

- 100 year ARI = 2,780m3, 0.39ha (5.6% of Study Area) and 6.61m AHD
- 5 year ARI = 1,575m3, 0.32ha (5% of Study Area) and 6.27m AHD
- 1 year ARI 1 hr = 310m3, 0.22ha (3% of Study Area) and 5.80m AHD

In response to the above, a Local Park / Drainage Area is proposed in the south eastern portion of the subject site to cater for the drainage for the entire Structure Plan Area, as well as forming a Local Park function and interfacing with the buffer area of the Bollard Bulrush Swamp.

Due to high groundwater levels across much of the site a Design Groundwater Level will be implemented at the existing natural surface via subsoil drainage. Subsoils will be within sand fill and will be free draining to the bioretention area. The design of the proposed development should incorporate a minimum habitable floor level 1.2m above the DGL to meet the required clearance from the DGL as per BUWM (WAPC, 2008).

3.5 Education Facilities

There is no requirement for a school site to be included within the Structure Plan Area on either the JSP or ERIC.

The Kings College (K-12) is located 400m east of the subject site. Bertram Primary School is located 900m to the north east of the Structure Plan area. Peter Carnley Anglican Community School is also located 1.8km north west of the subject site.

3.6 Activity Centres and Employment

There is no requirement for an Activity Centre or Employment to be included within the Structure Plan area on either the JSP or ERIC.

The Structure Plan area is 2km south east of the Kwinana Secondary Centre which provides a range of retail, services, community and employment opportunities for the subject land. The Structure Plan area is 1.4km south west of the Bertram Neighbourhood Centre which provides for daily and weekly shopping needs.

Via Transperth bus route 543 the land is afforded high public transport accessibility to the Kwinana Secondary Centre and the Kwinana Railway Station, which enables further connection on to other secondary and strategic metropolitan centres, as well as the Perth Capital City Centre.

4. Infrastructure Coordination, Servicing and Staging

4.1 Services

4.1.1 Water

The Water Corporation has recently completed a high-level strategic review of the Medina Water Scheme, within which this site is located. The site is within the now planned gravity zone of the long-term Medina scheme. The longer term servicing of the full development of the Medina scheme will require the Corporation to construct a large ground tank and an associated elevated tank (to serve a high level area) at a designated reservoir site in Kwinana. Substantial expansion of the distribution mains system will also be required, particularly to serve proposed new urban development areas to the east of the Kwinana Freeway and the areas around the Bollard Bulrush Swamp. In this regard, the Corporation's water planners are currently undertaking more detailed water distribution main planning for the Medina scheme to determine the routes, size and staging of distribution mains to serve this and other land in the locality.

The existing water pipes through Wellard immediately to the north are small reticulation sized pipes (typically 100mm and 150mm diameter) and are not likely to have the capacity to be extended to serve land to the south of Bertram Road. At this stage, it is anticipated that an extension will need to be undertaken from a distribution main on Johnson Road (either from the existing DN300 or a larger future main), heading westwards along Bertram Road to serve the proposed development of this site and surrounding land. These matters will be clarified by the Water Corporation through the finalisation of the distribution main planning for Medina.

4.1.2 Sewer

There is existing reticulated sewerage infrastructure situated along Bertram Road to the north. The Water Corporation does not have any formal wastewater planning over the subject area.

Preliminary advice from the Water Corporation stipulates that Wastewater Infrastructure Planning engineers are currently reviewing the conveyance planning for the Kwinana Sewer District to address the recent changes in urban and urban deferred zonings, particularly around the southern end of the wetland. The review will also identify possible servicing solutions around the subject site.

Advice from the Water Corporation suggests that it will likely be possible to gravitate wastewater from the Structure Plan Area northwards towards the gravity system upstream of the existing Bertram Road Waste Water Pump Station. Details such as the likely sewer pipe routes, grades, sizes, discharge points and any downstream system upgrading required are yet to be determined.

4.1.3 Telecommunications

Telstra services are available within Bertram Road and it is anticipated this infrastructure will have sufficient capacity to provide telecommunication services to the proposed development.

4.1.4 Gas

ATCO Gas services are readily available in Bertram Road.

4.1.5 Power

The proposed development will likely be serviced via connection to existing underground and aerial power infrastructure within Bertram Road. At this stage Western Power are unable to confirm the specific connection location.

4.2 Developer Contribution Arrangements

The subject site is proposed to be included in the modified boundary of Development Contribution Area 1 ('DCA 1') as part of Scheme Amendment No. 132 to TPS 2. The Amendment states that a culvert and road crossing is to be prepared, linking the Structure Plan area to Lot 607 Bertram Road on the eastern side of the Peel Main Drain and this crossing has been indicated on the Structure Plan. The crossing is to be constructed at a standard of an Access Street C under Liveable Neighbourhoods, and contributions are to be later determined by the City. The Amendment to DCA 1 also includes proposed contributions to Wellard Road, Bertram Road, Johnson Road and rehabilitation of the Bollard Bulrush Swamp.

The subject land has been identified as being within the boundaries of Development Contribution Area 12 ('DCA 12). DCA 12 includes contributions for Sub-Regional Facilities (Community Knowledge and Resource Centre, Destination Park Calista and Wells Beach Foreshore Upgrade), District B Facilities (Sporting Pavilion, Community Centre, Youth Centre, Dry Recreation Centre and Branch Library) and Local Facilities (Local Sports Pavilion).

PART 3

Technical Appendices

Technical Appendices Index Table

Appendix No.	Document Title	Nature of Document	Referral / Approval Agency	Summary of Modifications
1.	Certificate of Title	Supporting document only	Not Applicable	
2.	Noise Assessment	Supporting document only	Not Applicable	
3.	Vegetation and Visual Landscape Assessment	Supporting document only	City of Kwinana	
4.	Fire Management Plan	Supporting document only	City of Kwinana	
5.	Local Water Management Strategy	Supporting document only	Department of Water	

APPENDIX 1
CERTIFICATE OF TITLE

297V

REGISTER NUMBER	
661/DP68787	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	29/5/2013

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

VOLUME 2806 FOLIO 474

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 661 ON DEPOSITED PLAN 68787

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

THE ROYALE AUSTRALIAN GOLF CLUB PTY LTD
IN 8/17 SHARE
BESTALL SUPER PTY LTD
IN 9/17 SHARE
BOTH OF 427 RIVERTON DRIVE, SHELLEY
AS TENANTS IN COMMON

(AF M245693) REGISTERED 17 MAY 2013

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

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

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

STATEMENTS:

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

SKETCH OF LAND:	DP68787.
PREVIOUS TITLE:	2802-878.
PROPERTY STREET ADDRESS:	101 BERTRAM RD, WELLARD.
LOCAL GOVERNMENT AREA:	CITY OF KWINANA.

P68787

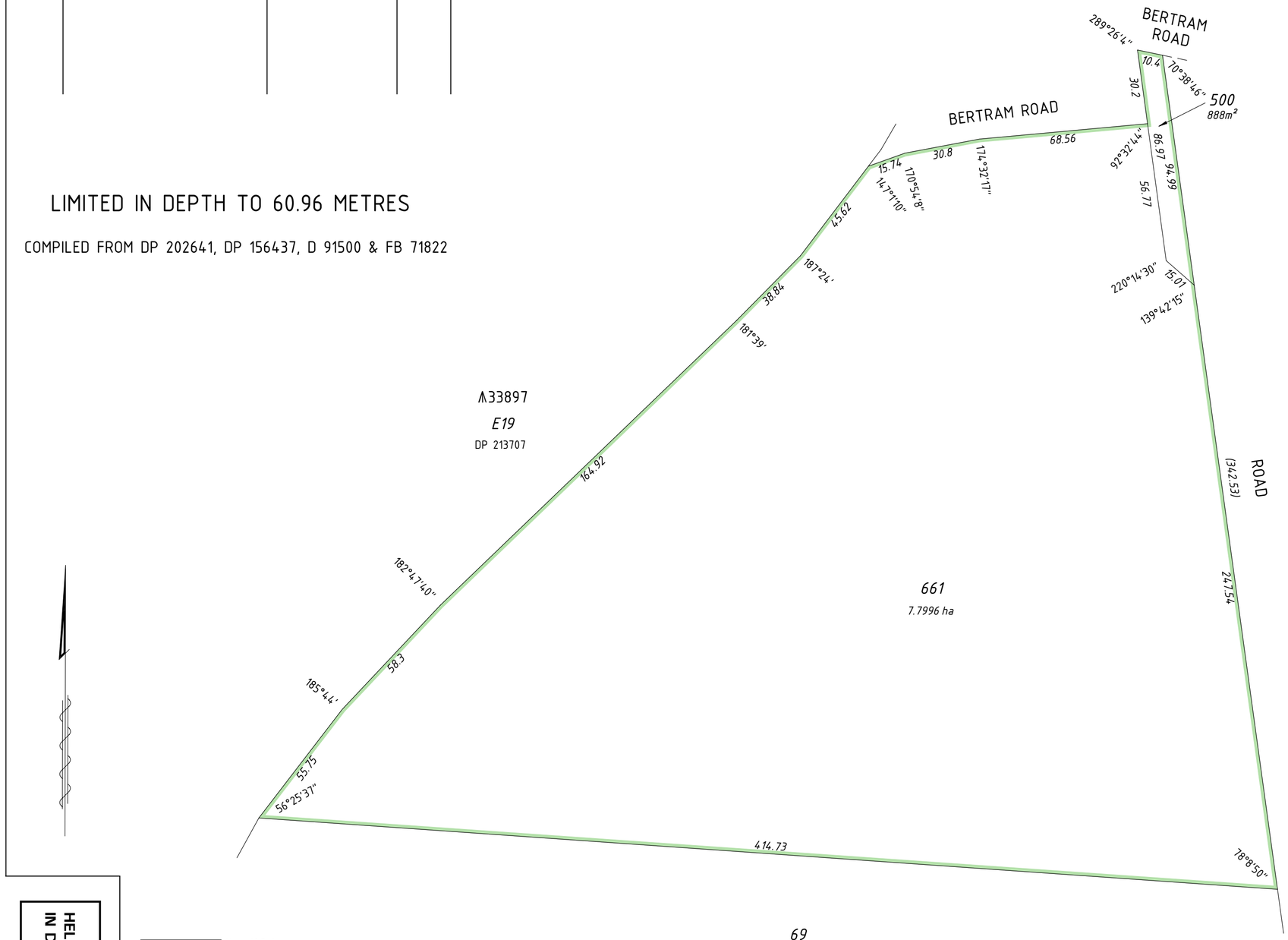
Lot Number	Part Register Number	Section
500	LR 3163/41	

Lot Number	Part Register Number	Section
661	2806/474	

VER	AMENDMENT	AUTHORISED BY	DATE
2	AUDIT REQUIREMENTS	G. GALVIN	6/9/2011

LIMITED IN DEPTH TO 60.96 METRES

COMPILED FROM DP 202641, DP 156437, D 91500 & FB 71822



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25 0 SCALE 1 : 1250 125

ALL DISTANCES ARE IN METRES

INTERESTS AND NOTIFICATIONS

SUBJECT	PURPOSE	STATUTORY REFERENCE	ORIGIN	LAND BURDENED	BENEFIT TO	COMMENTS

FORMER TENURE TABLE

LOT	FORMER TENURE	ON PLAN / DIAGRAM	TITLE
LOT 500	Pt LOT 1416	DP 156437	LR3000 / 656
LOT 661	LOT 660 Pt. LOT 1416	DP 66359 DP 156437	2802-878 LR3000 / 656

TYPE: FREEHOLD

PURPOSE: CROWN LAND AMALGAMATION

PLAN OF

LOTS 500 & 661

DISTRICT: COCKBURN SOUND
TOWNSITE:

SSA NO:

FILE: 02984 - 1978
LOCALITY: WELLARD
LOCAL AUTHORITY: TOWN OF KWINANA

FORMER TENURE: SEE FORMER TENURE TABLE

INDEX ON: BG33 (2) 12.31

FIELD BOOK: COMPILED

SCALE 1 : 1250 @ A2
ALL DISTANCES ARE IN METRES

SURVEYOR'S CERTIFICATE - Compiled

I Glenn P. GALVIN hereby certify that

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

Licensed Surveyor _____ Date 20-Aug-10

SURVEY FIRM: ORACLE SURVEYS

LODGED	TYPE OF VALIDATION	APPROVED BY WESTERN AUSTRALIAN PLANNING COMMISSION
DATE: 23-Aug-11	FULL AUDIT:	FILE:
FEE PAID: $351.00	LEGAL COMPONENT: B. Francis	EXEMPT FROM WAPC APPROVAL
ASSESS No.: 9276074	DOCKET PLAN/DIAGRAM: TRIM	DELEGATED UNDER S.16 P. & D. Act 2005
	CERTIFIED CORRECT: 6-Sept-2011	DATE:
	I.S.C.:	
	F.S.C.:	

IN ORDER FOR DEALINGS

SUBJECT TO

- Prior Dealing on DIA91500 And DP66359
- Section 87 LAA - Amalgamation

A James 7-Sept-2011

For INSPECTOR OF PLANS & SURVEYS / AUTHORIZED LAND OFFICER DATE

APPROVED

17-May-2013

INSPECTOR OF PLANS & SURVEYS / AUTHORIZED LAND OFFICER DATE

THE GOVERNMENT OF WESTERN AUSTRALIA

Landgate
Western Australian Land Information Authority

DEPOSITED PLAN

68787

SHEET 1 OF 1 SHEETS

VERSION 2

A2 ORIGINAL

APPENDIX 2
NOISE ASSESSMENT

Lot 661 Bertram Road, Wellard

Local Structure Plan

Traffic Noise Assessment

25 July 2013

Report Number: 13040020-01

www.ecoacoustics.com.au

ACN 135 697 095
10 Alyxia Place
Ferndale Western Australia 6148
Telephone: **(08) 9258 9009**

Report: 13040020-01

EcoAcoustics Pty Ltd

ACN: 135697095

KEY PERSONNEL

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Document Information			
Author:	Rebecca Ireland	**Verified:**	Francis Prendergast *Approved Noise Officer No. 11043*
Position:	Company Director	**Position:**	Consultant
Signature:		**Signature**	
Date of Issue:	25 July 2013		

Revision History				
Revision	**Description**	**Date**	**Author**	**Checked**

Table of Contents

Executive Summary

EcoAcoustics Pty Ltd was commissioned by Rowe Group on behalf of Royale Australian Gold Club Pty Ltd to conduct a transportation noise assessment for the proposed Local Structure Plan at Lot 661 Bertram Road, Wellard. The proposed subdivision is located within close proximity to the South West Metropolitan Railway corridor and Bertram Road, as such an assessment of future transportation noise levels is required to determine the expected impact of noise intrusion onto the site, and provide a comparison with the relevant noise criteria.

The analysis has shown that to comply with the criteria of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* noise amelioration will be required. The actual treatments will be quantified in the subdivision and development application phase of the project.

1 Introduction

EcoAcoustics Pty Ltd was commissioned by Rowe Group on behalf of Royale Australian Gold Club Pty Ltd to conduct a transportation noise assessment for the proposed Local Structure Plan at Lot 661 Bertram Road, Wellard. The proposed subdivision is located within close proximity to the South West Metropolitan Railway corridor and Bertram Road, as such an assessment of future transportation noise levels is required to determine the expected impact of noise intrusion onto the site, and provide a comparison with the relevant noise criteria.

Appendix B contains a description of some of the terminology used throughout this report.

1.1 Site Locality & Surroundings

The site is located in Wellard, bound by Bertram road to the north and west, and the Peel Diversion drain to the east. The site and surroundings are shown in an aerial photo in *Figure 1.1*.

The South West Metropolitan Railway corridor is located to the west of the site, across Bertram Road.

Figure 1.1: Site and Surroundings

1.2 Site Layout

Figure 1.2 the structure plan area, along with the potential residential locations, internal road structure, and public open space locations.

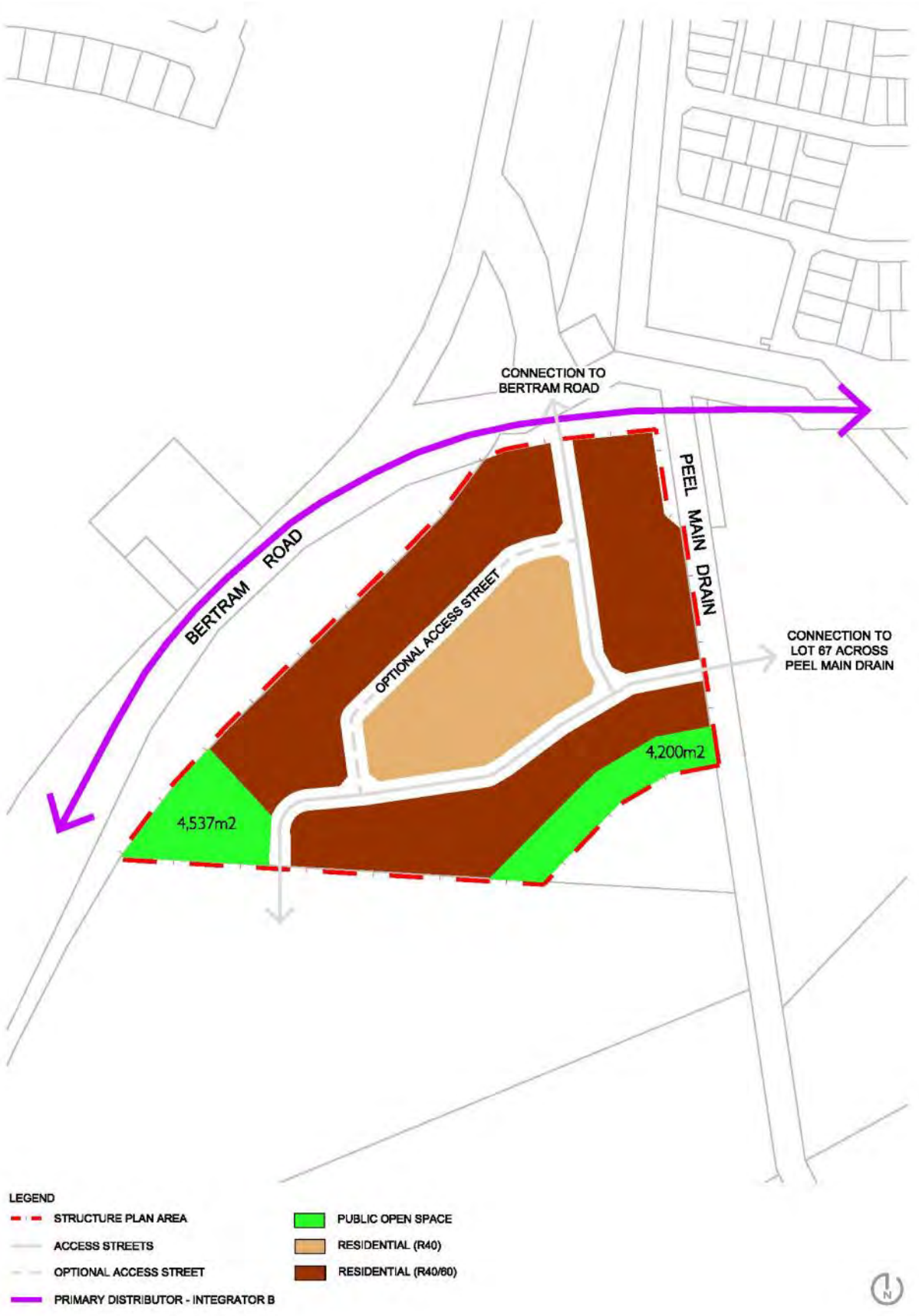


Figure 1.2 Structure Plan Layout

2 Criteria

In Western Australia *State Planning Policy 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (the Policy), produced by the Western Australian Planning Commission, provides the relevant assessment criteria for transportation noise.

The Policy objectives are to:

- *Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;*
- *Protect major transport corridors and freight operations from incompatible urban encroachment;*
- *Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;*
- *Facilitate the development and operation of an efficient freight network; and*
- *Facilitate the strategic co-location of freight handling facilities.*

Section 5.3 of the Policy outlines the noise level criteria applied at 1 metre from the façade of habitable noise sensitive premises, and in one outdoor living area associated with the dwelling. These criteria are shown in *Table 2.1*.

Table 2.1: Outdoor Noise Criteria

Time of Day	Noise Target	Noise Limit
Day (6am to 10pm)	$L_{Aeq\ (Day)}$ = 55 dB(A)	$L_{Aeq\ (Day)}$ = 60 dB(A)
Night (10pm to 6am)	$L_{Aeq\ (Night)}$ = 50 dB(A)	$L_{Aeq\ (Night)}$ = 55 dB(A)

The Policy states that the 5 dB difference between the outdoor noise ***target*** and the outdoor noise ***limit*** represents an acceptable ***margin*** for compliance.

When applying these criteria to new noise sensitive developments, the objectives of the Policy are to achieve:

- *acceptable indoor noise levels in noise-sensitive areas (eg bedrooms and living rooms of houses, classrooms in schools); and*
- *a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.*

The Policy states:

If a noise sensitive development takes place in an area where outdoor noise levels will meet the **target**, *no further measures are required under this policy.*

In areas where the **target** *is exceeded, but noise levels are likely to be within the 5 dB* **margin**, *mitigation measures should be implemented by the developer with a view to achieving the target levels in at least one outdoor living area on each residential lot. Where indoor spaces are planned to be facing any outdoor area in the margin, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.*

In areas where the outdoor noise limit is likely to be exceeded (i.e. above $L_{Aeq(Day)}$ of 60dB(A) or $L_{Aeq(Night)}$ of 55dB(A)), a detailed noise assessment is to be undertaken by the developer. Customised noise mitigation measures should be implemented with a view to achieving the target in at least one outdoor living area on each residential lot, or if this is not practicable, within the margin. Where indoor spaces will face outdoor areas that are above the noise **limit**, *mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.*

The acceptable indoor noise levels for residential buildings as defined in the Policy are shown in Table 2.2.

Table 2.2: Acceptable Indoor Noise Levels

Time of Day	Room	Indoor Noise Limit
Day (6am to 10pm)	Living Room & Work Areas	$L_{Aeq\ (Day)}$ = 40 dB(A)
Night (10pm to 6am)	Bedrooms[1]	$L_{Aeq\ (Night)}$ = 35 dB(A)

All other noise sensitive buildings are required to meet the *Recommended Design Sound Levels under Table 1 of Australian Standard AS 2107:2000 Acoustics – Recommended design sound levels and reverberation times for building interiors.*

The Policy details a number of noise amelioration measures that are available to meet the noise criteria, including:

- *using distance to separate noise-sensitive land uses from noise sources;*
- *construction of noise attenuation barriers such as earth mounds and noise walls;*
- *building design, such as locating outdoor living areas and indoor habitable rooms away from noise sources;*

[1] *For residential buildings, indoor noise levels are not set for utility spaces such as bathrooms. The policy encourages effective "quiet house" design, which positions these non-sensitive spaces to shield the more sensitive spaces from transport noise.*

- *building construction techniques, such as upgraded glazing, ceiling insulation and sealing of air gaps. Note that where upgraded glazing is required, the benefit is only realised when windows are kept closed and, as such, mechanical ventilation should also be considered in these circumstances;*

The guidelines also provide detail on the range of noise mitigation measures and their potential for noise reduction. It is expected that noise management and mitigation strategies would be identified and implemented through a noise management plan, having regard to the guidelines, and will be:

- *effective in reducing noise;*
- *practical and appropriate for the situation; and*
- *compatible with other relevant planning policies.*

Where the **target** *noise levels cannot be achieved, the policy states that: -*

If the measures outlined previously cannot practicably achieve the **target** *noise levels for new noise-sensitive developments, this should be notified on the certificate of title. Notifications on certificates of title and/or advice to prospective purchasers advising of the potential for noise impacts from major road and rail corridors can be effective in warning people who are sensitive to the potential impacts of transport noise. Such advice can also bring to the attention of prospective developers the need to reduce the impact of noise through sensitive design and construction of buildings and the location of outdoor living areas. The notification is to ensure that prospective purchasers are advised of:*

- *the potential for transport noise impacts; and*
- *the potential for quiet house design requirements to minimise noise intrusion through house layout and noise insulation (see the guidelines).*

Notification should be provided to prospective purchasers and be required as a condition of subdivision (including strata subdivision) for the purposes of noise-sensitive development as well as planning approval involving noise-sensitive development, where noise levels are forecast or estimated to exceed the target outdoor noise criteria, regardless of proposed noise attenuation measures. The requirement for notification as a condition of subdivision and the land area over which the notification requirement applies, should be identified in the noise management plan in accordance with the guidelines. An example of a standard form of wording for notifications is presented in the guidelines.

The Policy applies a performance-based approach to the management and mitigation of transport noise.

It is recognised that in a number of instances it may not be reasonable and practicable to meet the noise target criteria. Where transport noise is above the target level, measures are expected to be implemented that best balance reasonable and practicable considerations, such as noise benefit, cost, feasibility, community preferences, amenity impacts, safety, security and conflict with other planning and transport policies. In these cases the community should also be consulted to assist in identifying

best overall solutions. The guidelines assist in outlining ways in which some reasonable and practicable limitations can be addressed in a manner that also minimises transport noise.

It is further acknowledged that there may also be situations in which the noise limit cannot practicably be achieved, especially in the case of major redevelopment of existing transport infrastructure. Similarly, it may not be practicable to achieve acceptable indoor noise levels if the new development is located very close to the transport corridor. In these situations the primary focus should be on achieving the lowest level of noise, with other reasonable and practicable considerations being secondary to this objective.

3 Methodology

Noise level measurements and noise modelling of the site have been completed in accordance with the requirements of the Policy. The methodologies are detailed in *Sections 3.1* and *3.2*.

3.1 Noise Monitoring

Noise measurements were completed at one location within the vicinity of the site to:

- Quantify the existing noise levels;
- Determine the differences between the various acoustic parameters, namely $L_{A10\ (18\ hour)}$, $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$; and
- Calibrate the noise model for the existing conditions.

Noise logging was completed using a Rion NL-42 noise logger (S/N 510236), set to record hourly noise measurements in the following parameters, L_{A1}, L_{A10}, L_{A90} and L_{Aeq}. The noise logger complies with the requirements for instrumentation detailed in *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The logger was field calibrated before and after the measurement session and found to be accurate to within +/- 0.5 dB. This meter has been subject to a laboratory calibration within the last two years (available on request).

The measurement location is shown in. As shown on *Figure 3.1,* the logger was located approximately 30 metres from the road. It was conducted over a 9 day period, from 6th June to 15th June 2013. Measurements were completed in accordance with *Australian Standard 2702-1984: Acoustics - Method for Measurement of Road Traffic Noise*, with the logger positioned in free field conditions with the microphone height at 1.4 metres above ground floor level.

Based on the hourly measurements, the $L_{A10\ (18\ hour)}$, $L_{Aeq\ (24\ hour)}$, $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$ values were determined for each complete measurement day. These results were averaged and the mean level reported.

The noise data collected was verified by inspection and professional judgement. Where hourly data was considered atypical, an estimated value was inserted and highlighted by bold italic lettering.

The weather conditions during the measurement period were obtained from the Bureau of Meteorology's Mount Lawley measurement station. This data was compared against the MRWA specifications for measurement conditions and any unacceptable conditions commented on.

3.2 Noise Modelling

To assess the transportation noise levels to the proposed development, the computer programme SoundPLAN 7.0 was utilised incorporating the Nordic Rail Prediction Method (Kilde Rep. 130) algorithm for rail transport and the Calculation of Road Traffic Noise (CoRTN) algorithms for road transport. Both the rail and road algorithms have been modified to reflect local conditions.

The rail noise modifications include:

- The Nordic Rail Prediction Method (Kilde Rep. 130) algorithm is used to predict noise from generic train types in Europe and requires modification to align with measured noise levels of passenger trains operating in the Perth region. Measured noise levels used are shown in *Table 3.1.*

Table 3.1: Sound Pressure Levels Used in the Noise Model

Description	One-Third Octave Frequencies (Hz), dB(A)									Overall dB(A)
	31.5	63	125	250	500	1K	2K	4K	8K	
Train speed of 130 kph at a distance of 15m	30	51	59	62	73	79	79	77	69	87
	35	54	61	65	73	79	80	74	64	
	42	53	61	69	78	80	78	72	58	

For the road traffic model, an adjustment of –1.7 dB has been applied to the predicted levels based on the findings of An Evaluation of the U.K. DoE Traffic Noise Prediction; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group 1982.

In determining any requirements for noise barriers between the transport corridor and receiver, the predictions are made at a height of 1.4 metres above ground floor level and at 1.0 metre from an assumed building facade (resulting in a + 2.5 dB correction due to reflected noise).

The CoRTN algorithms, used by Soundplan 7.2 to predict road traffic noise levels, were developed to calculate the $L_{A10\ (18\ hour)}$ noise level. The Policy requires that predictions are based on the $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$ parameters. The relationship between these parameters has been determined by noise monitoring on the site, and it is assumed that the same diurnal relationship exists for the future traffic volumes.

Various input data are included in the modelling such as ground topography, road design, traffic volumes and are discussed in the following Sections.

3.2.1 Ground Topography, Road Design & Cadastral Data

Topographical data was from the Department of Land Information (DLI). The contours are in 5 metre intervals and cover the site and surroundings. The ground contours represent the existing ground height, as potential lot heights have not yet been determined.

At this stage of the development, lot locations, heights and sizes have not yet been determined. As such, the modelling has been based on a greenfield site. Once lot designs are known, the inclusion of buildings along the Bertram Road frontage of the site will reduce the noise to those lots further away from the road and rail corridors, as the buildings can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding.

3.2.2 Train Movements

The train configuration and numbers of movements used in the noise prediction modelling are presented below in *Tables 3.2 and 3.3.*

Table 3.2: Variables Used in the Noise Prediction Model

Description of Variable		Value
Type of noise source		Line source
Train length	3 Car Set	75 metres
	4 Car Set	100 metres
	6 Car Set	150 metres
Height of noise source above railhead		0.8 metres
Train Speeds		Up to 130 km/h

Table 3.3 – Rail Movements per Hour Assumed in Noise Model

Train Description	Train Movements per Hour	
	Day	Night
Northbound		
3 Car Sets	6	1
6 Car Sets	1	0
Southbound		
3 Car Sets	5	1
6 Car Sets	1	0

3.2.3 Road Traffic Data

The noise relationship between different road surface types is shown in *Table 3.4*.

Table 3.4: Noise Relationship Between Different Road Surfaces

Road Surfaces						
Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.0 dB	-2.5 dB

Traffic data used in the modelling is shown below in *Table 3.5*. The existing and future volumes were obtained from MRWA.

Table 3.5: Traffic Data Used in the Modelling

Parameter	Scenario (Bertram Road)	
	Existing (based on 2010 data)	Future (Based on 2031)
Road Surface	Worn 14mm chip seal	Worn 14mm chip seal
Speed	70 km/hr	70 km/hr
24 Hour Volume	10,154 vpd	18,000 vpd
Heavy Vehicle Component	3%	3%

4 Noise Monitoring

The results of the noise logging is summarised in Table 4.1 and presented graphically in *Figure 4.1*.

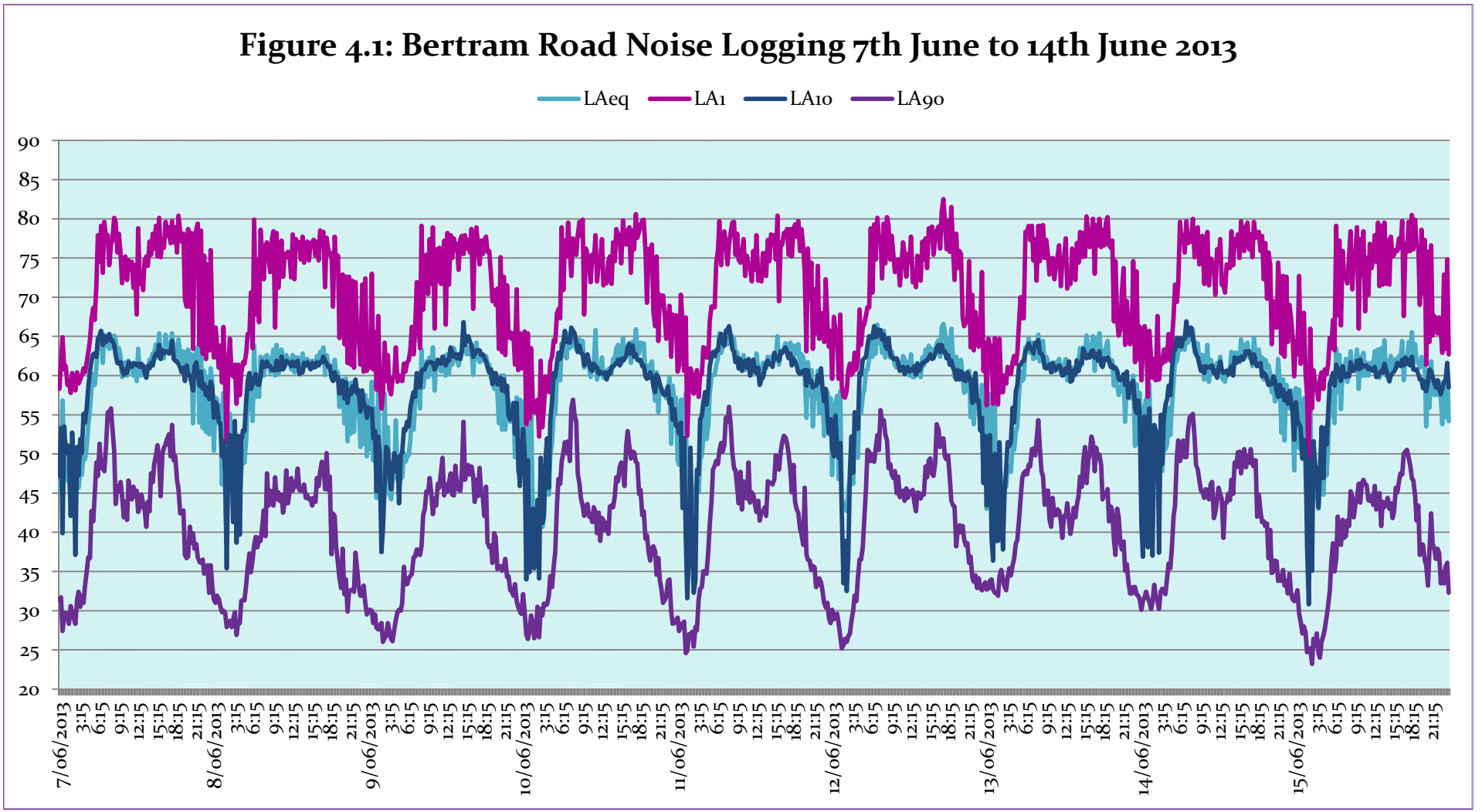
Table 4.1: Measured Average Noise Levels – Bertram Road

Day/Date	Average Weekday Noise Level, dB			
	$L_{A10\ (18\ hour)}$	$L_{Aeq\ (24\ hour)}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Friday 7th June 2013	62	61	63	55
Saturday 8th June 2013	61	60	61	53
Sunday 9th June 2013	61	60	61	55
Monday 10th June 2013	62	61	62	56
Tuesday 11th June 2013	62	61	62	57
Wednesday 12th June 2013	62	61	63	56
Thursday 13th June 2013	62	61	62	57
Friday 14th June 2013	61	61	62	54
Overall Weekday Averages[1]	**62**	**61**	**63**	**56**

1. Weekend results omitted from overall average as only weekday results required

The average differences between the $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$ are 7 dB. This difference has been assumed to exist in future years. As such, it is the daytime noise levels that will dictate compliance since these are at least 5 dB more than night-time levels.

Figure 4.1: Bertram Road Noise Logging 7th June to 14th June 2013



5 Noise Modelling

Figure 5.1 presents the $L_{Aeq\ (Day)}$ noise level predictions associated with both Bertram Road, and the Southern Metropolitan Railway Corridor.

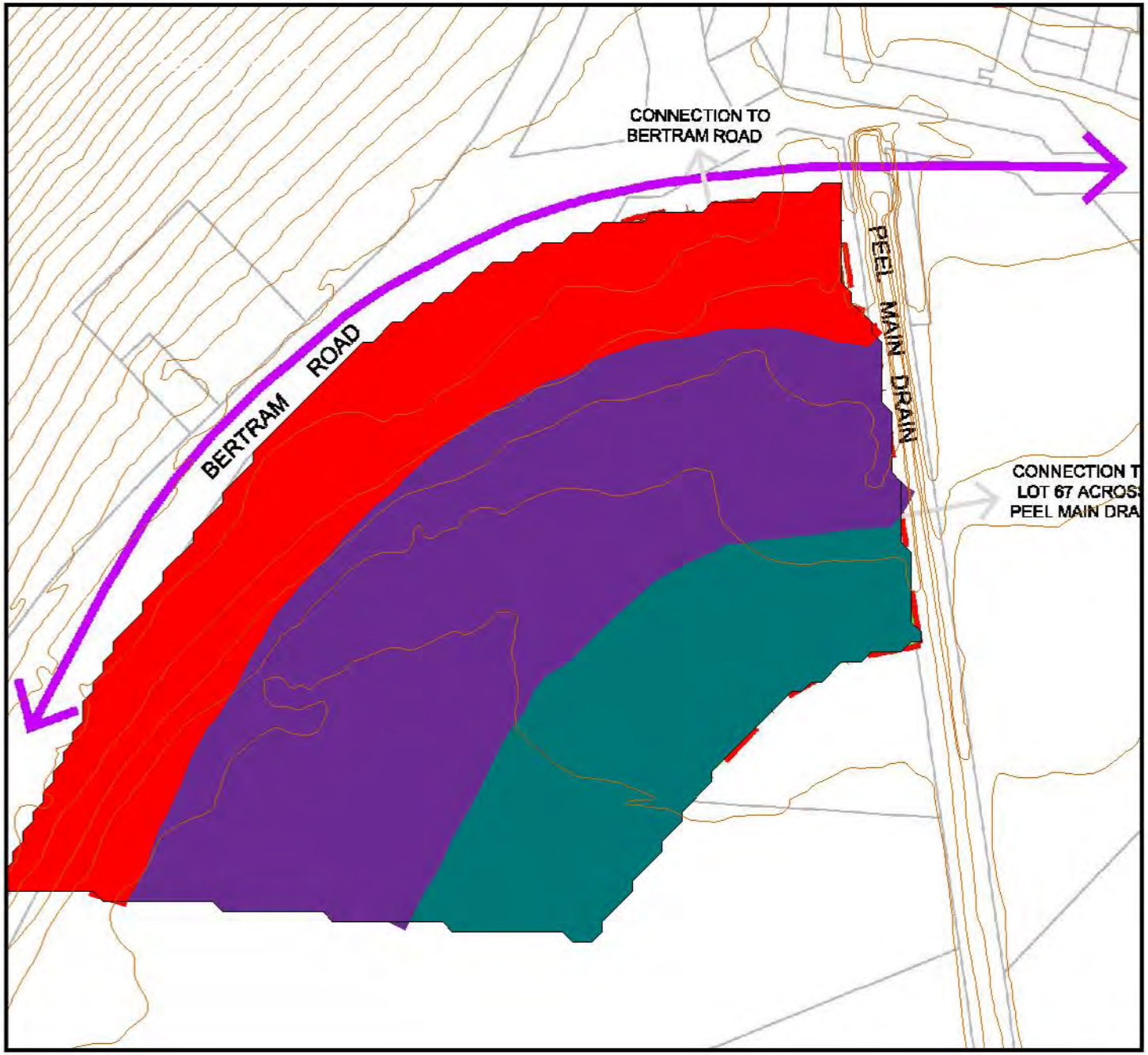


Figure 5.1

Wellard Structure Plan
Rowe Group
13040020

Project engineer: Rebecca Ireland
Created: 18 July 2013
Processed with SoundPLAN 7.2, Update 3/05/2013

Levels LAeq Day
in dB(A)

- <= 55 Below Target
- <= 60 Aove Targe Below Limit
- > 60 Above Limit

N

Length scale 1:3000

0 15 30 60 90 120 m

EcoAcoustics

Figure 5-1

6 Assessment of Noise Levels

As discussed in Section 2, the objectives of the noise Policy are for noise at all houses to be no more than the ***limit,*** but preferably no more than the ***target***.

Based on the existing ground heights, without the inclusion of any noise amelioration, or buildings, noise levels on the site will be above the target, and in those lots closest to Bertram Road and the rail corridor, will be above the limit. Once the lot layout is known, buildings can be updated in the noise model, which will reduce the noise affected area on the site.

As the noise levels exceed the SPP 5.4 Target criteria, noise amelioration needs to be considered. The amelioration options that may be appropriate for this assessment could include a noise barrier along the development boundary adjacent to the road reserve, and/or treatments to the facade of properties exceeding the Target criteria.

7 Noise Control Recommendations

From *Figure 5.1,* it can be seen that the Bertram Road frontage of the site is predicted to exceed the Policy ***limit*** criteria at the closest locations. When determining noise amelioration options, quieter road surface should be investigated, however, the use of a quieter road surface, such as dense or open graded asphalt, does not have the approval of Main Roads Western Australia, due to the high installation and maintenance costs.

Based on the predicted noise levels, noise amelioration may need to be considered. This treatment will be determined and quantified during the subdivision and development application phase of the project.

The proposed treatments will vary depending on the predicted noise levels determined once ground heights are known. For those receivers that are within the ***margin*** between the ***target*** and l***imit*** criteria, the 'deemed to comply package A' as provided in the SPP 5.4 guidelines, can be used. For those receivers that are above the ***limit*** criteria but by no more than 3 dB, the 'deemed to comply package B' as provided in the SPP 5.4 guidelines, can be used. For those receivers that are more than 3 dB above the ***limit*** criteria, a "Detailed Assessment" should be prepared by a competent person. The 'deemed to comply' packages are provided in *Appendix A*.

Dwellings constructed within these areas will require notification on their titles.

8 Conclusion

The analysis has shown that to comply with the criteria of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* noise amelioration will be required. The actual treatments will be quantified in the subdivision and development application phase of the project.

Appendix A

"Deemed to Comply" Construction Packages

The *Implementation Guidelines for State Planning Policy 5.4 Road and Rail Transport Noise & Freight Considerations in Land Use Planning* state:

> *The following "deemed-to-comply" packages outline noise insulation measures designed to ensure that the indoor noise standards in the policy are achieved for residential developments in areas where outdoor noise levels will exceed the "target" noise levels by up to 8dB(A). These packages have been designed for developments adjacent to major roads and passenger railways, where noise levels are likely to be higher during the day than at night. In the case of freight rail, where noise levels are likely to be fairly constant over the 24-hour period, these packages can be adapted. See section 4.8 of the guidelines for guidance on developments adjacent to freight railways.*
>
> *The deemed-to-comply specifications are intended to simplify compliance with the noise criteria, and the relevant package should be required as a condition of development. However, this should not remove the option to pursue alternative measures or designs. Departures from the deemed-to-comply specifications need to be accompanied by acoustic certification from a competent person, to the effect that the development will achieve the requirements of the policy.*
>
> *Superior construction standards, such as those specified in the deemed-to-comply packages, are now becoming more prevalent in residential buildings; and they do not significantly increase the cost of building. A similar standard of construction has been recommended by the Western Australian Planning Commission for new housing in areas forecast to be seriously affected by aircraft noise.*
>
> *That recommendation followed a comprehensive assessment of the efficacy and costs of noise attenuation measures, taking into account the recent changes in industry building standards as well as changes to the Building Code of Australia.*
>
> *Where transport noise levels are more than 8dB above the noise "target", i.e. 3dB above the noise "limit", or where noise-sensitive development other than residential is proposed, a detailed assessment should be prepared by a competent person. The report should specify the level of noise reduction required and the noise insulation measures needed to comply with the policy. The approval may require that the construction drawings be checked for compliance with the detailed assessment, and that follow-up verification be carried out to certify compliance.*
>
> ***Package A: noise levels within the "margin"***
>
> *The following noise insulation package (Table A1) is designed to meet the indoor noise standards for residential developments in areas adjacent to major roads or passenger railways where noise levels exceed the noise "target" but are within the "limit".*

Area type	Orientation	Package A measures
Indoors		
Bedrooms	Facing road/rail corridor	➢ 6 mm laminated glazing ➢ Casement or awning windows ➢ No external doors ➢ Closed eaves ➢ No vents to outside walls/eaves ➢ Mechanical ventilation/airconditioning (see 4.5.3)
	Side-on to corridor	➢ 6 mm laminated glazing ➢ Closed eaves ➢ • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Living and work areas[2]	Facing corridor	➢ • 6 mm laminated glazing ➢ • Casement or awning windows ➢ • 35 mm (minimum) solid core external doors with acoustic seals[3] ➢ • Sliding doors must be fitted with acoustic seals ➢ • Closed eaves ➢ • No vents to outside walls/eaves ➢ • Mechanical ventilation/airconditioning
	Side-on to corridor	➢ • 6 mm glazing ➢ • Closed eaves ➢ • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Other indoor areas	Any	No requirements
Outdoors		
Outdoor living area[4]	Facing corridor	➢ • Minimum 2.0 m high solid fence (e.g. Hardifence, pinelap, or Colorbond) ➢ • Picket fences are not acceptable
	Side-on to corridor	
	Away from corridor	No requirements

[2] These deemed-to-comply guidelines adopt the definitions of indoor spaces used in AS2107-2000. A comparable description for bedrooms, living and work areas is that defined by the Building Guide of Australia as a "habitable room". The Building Guide of Australia may be referenced if greater clarity is needed. A living or work area can be taken to mean any "habitable room" other than a bedroom. Note that there are no noise insulation requirements for utility rooms such as bathrooms. The Building Guide of Australia describes these utility spaces as "non-habitable rooms".

[3] Glazing panels are acceptable in the external doors facing the transport corridor. However these must meet the minimum glazing requirements.

[4] The policy requires that at least one outdoor living area be reasonable protected from transport noise. The protected area should meet the minimum space requirements for outdoor living areas, as defined in the Residential Design Codes of Western Australia

Package B: noise within 3dB above the "limit"

The following noise insulation package is designed to meet the indoor noise standards for residential developments in areas adjacent to major roads or passenger railways where transport noise levels exceed the noise "limit" but by no more than 3dB (See Table 1 in policy).

Area type	Orientation	Package B measures
Indoors		
Bedrooms	Facing road/rail corridor	➢ 10 mm laminated glazing ➢ Casement or awning windows ➢ No external doors ➢ Closed eaves ➢ No vents to outside walls/eaves ➢ Mechanical ventilation/airconditioning (see 4.5.3)
	Side-on to corridor	➢ 6 mm laminated glazing ➢ Casement or awning windows ➢ Closed eaves ➢ • Mechanical ventilation/airconditioning
	Away from	No requirements
Living and work areas	Facing corridor	➢ 10 mm laminated glazing ➢ Casement or awning windows ➢ 40 mm (minimum) solid core external doors with acoustic seals ➢ Sliding doors must be fitted with acoustic seals ➢ Closed eaves ➢ No vents to outside walls/eaves ➢ Mechanical ventilation/airconditioning
	Side-on to corridor	➢ 6 mm laminated glazing ➢ Casement or awning windows ➢ Closed eaves ➢ Mechanical ventilation/airconditioning
	Away from	No requirements
Other indoor areas	Any	No requirements
Outdoors		
Outdoor living area	Facing corridor	➢ Minimum 2.4 m solid fence (e.g. brick, limestone or Hardifence) ➢ Colorbond and picket fences are not acceptable
	Side-on to	
	Away from	No requirements

Mechanical Ventilation/Airconditioning

Where outdoor noise levels are above the "target", both packages A and B require mechanical ventilation or airconditioning to ensure that windows can remain closed in order to achieve the indoor noise standards.

In implementing packages A and B, the following need to be observed:

- *Evaporative airconditioning systems will meet the requirements for packages A and B provided attenuated air vents are provided in the ceiling space. Without such vents, these systems require windows to remain open.*
- *Refrigerative airconditioning systems need to be designed to achieve fresh air ventilation requirements.*
- *Air inlets need to be positioned facing away from the corridor where practicable.*
- *Ductwork needs to be provided with adequate silencing, particularly in higher noise areas, to prevent noise intrusion.*

Appendix B

Terminology

Terminology

Ambient Noise

Ambient noise refers to the level of noise from all sources, including background noise as well as the source of interest.

A-Weighting

An A-weighted noise level is a noise level that has been filtered as to represent the way in which the human ear distinguishes sound. This weighting indicates the human ear is more sensitive to higher frequencies than lower frequencies. The A-weighted sound level is described as L_A dB.

Background Noise

Background noise is the noise level from sources other than the source of interest. Background may originate from such things as traffic noise, wind induced noise, industrial noise etc.

Decibel (dB)

The decibel is the unit that characterises the sound power levels and sound pressure of a noise source. It is a logarithmic scale with regard to the threshold of hearing.

Impulsive Noise

An impulsive noise source is a short-term impact noise which may originate from such things as banging, clunking or explosive sound.

Influencing factor

$=1/10$ (% Type A_{100} + % Type A_{450}) + $1/20$(% Type B_{100} + % Type B_{450})

Where:

% Type A_{100} = The percentage of industrial land within a 100m radius of the premises receiving noise

% Type A_{450} = The percentage of industrial land within a 450m radius of the premises receiving noise

% Type B_{100} = The percentage of commercial land within a 100m radius of the premises receiving noise

% Type B_{450} = The percentage of commercial land within a 450m radius of the premises receiving noise

+ Traffic factor (maximum 6 dB)

= 2 for each secondary road within 100m

= 2 for each major road within 450m

= 6 for each major road within 450m

L_{A1}

An L_{A1} level is the A-weighted noise level which is overreached for one percent of a measurement period. It represents the average of the maximum noise levels measured.

L_{A1} assigned level

An assigned L_{A1} level which is not to be exceeded for more than 1% of a delegated assessment period.

L_{A10} assigned level

An assigned L_{A10} level which is not to be exceeded for more than 10% of a delegated assessment period.

L_{A10}

An L_{A10} level is the A-weighted noise level which is exceeded for 10 percent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{A90}

An L_{A90} level is the A-weighted noise level which is overreached for 90 percent of the measurement period. It is represents the "*background*" noise level.

L_{Aeq}

L_{Aeq} refers to the comparable steady state of an A-weighted sound which, over a specified time period, contains the same acoustic energy as the time-varying level during the specified time period. It represents the "*average*" noise level.

L_{AFast}

The noise level in decibels, obtained using the A frequency weighting and the F time weighting as specified in AS1259.1-1990. L_{AFast} is used when examining the presence of modulation.

L_{Amax}

The L_{AMax} level is the maximum A-weighted noise level throughout a specified measurement.

L_{Amax} assigned level

The L_{Amax} assigned level describes a level which is not to be exceeded at any time.

LAPeak

The L_{APeak} level is the maximum reading (measured in decibels) during a measurement period, using the A frequency weighting and P time weighting AS1259.1-1990.

L_{ASlow}

A L_{ASlow} level is the noise level (measured in decibels) obtained using the A frequency weighting and S time weighting as specified in AS1259.1-1990

Major Road

A Major road has an estimated average daily traffic count of more than 15,000 vehicles.

Maximum Design Sound Level

Maximum Design Sound Level is the level of noise beyond hearing range of most people occupying the space start, become dissatisfied with the level of noise.

Modulating Noise

A modulating source is an audible, cyclic and regular source. It is present for at least 10% of a measurement period. The quantitative definition of tonality is:

a fluctuation in the discharge of noise which;

a) is more than 3 dB $L_{A\ Fast}$ or is more than 3 dB $L_{A\ Fast}$ in any one-third octave band;

b) is present for at least 10% of the representative

One-Third-Octave Band

One-Third-Octave-Band are frequencies that span one-third of an octave which have a centre frequency between 25 Hz and 20 000 Hz inclusive.

Representative Assessment Period

Representative Assessment Period describes a period of time not less than 15 minutes, and not surpassing four hours. It is determined by an inspector or authorised person to be suitable for the assessment of noise emissions.

Reverberation Time

Reverberation time refers to an enclosure for a sound of a specified frequency or frequency band as well as the time that would be necessary for the reverberantly decaying sound pressure level in the enclosure to decrease by 60 decibels.

RMS

The root mean square level is used to represent the average level of a wave form such as vibration.

Satisfactory Design Sound Level

Satisfactory Design Sound Level refers to the level of noise that has been found to be acceptable for the environment in question, which is also to be non-intrusive.

Secondary / Minor Road

A Secondary / Minor road has an estimated average daily traffic count of between 6,000 and 15,000 vehicles.

Sound Pressure Level (L_p)

Sound Pressure Level refers to a noise source which is dependent upon surroundings, and is influenced by meteorological conditions, topography, ground absorption; distance etc. Sound Pressure Level is what the human ear actually hears. Noise modelling predicts the sound pressure level from the sound power levels whilst taking into account the effect of relevant factors (meteorological conditions, topography, ground absorption; distance etc).

Sound Power Level (L_w)

A sound power level of a noise source cannot be directly measured using a sound level meter. It is calculated based on measured sound pressure levels at recognised distances. Noise modelling includes source sound power levels as part of the input data.

Specific Noise

Specific Noise relates to the component of the ambient noise of interest. It can be specified as the noise of interest or the noise of concern.

Tonal Noise

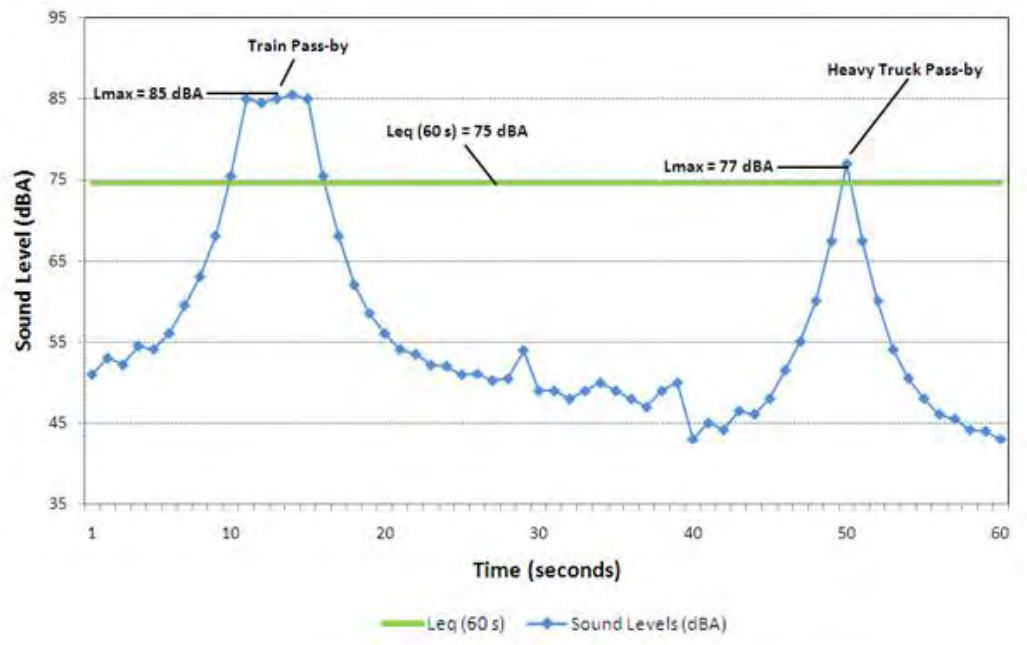
A tonal noise source can be designated as a source that has a specific noise emission over one or several frequencies, such as droning. The quantitative definition of tonality is:

the presence in the noise emission of tonal characteristics where the difference between —

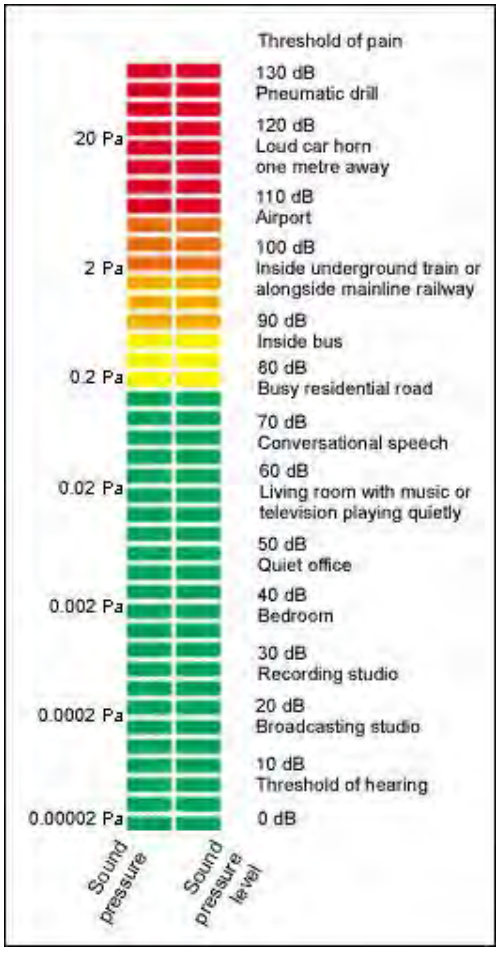
a) the A-weighted sound pressure level in any one-third octave band; and

b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands, is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels.

Chart of Noise Level Descriptors



Typical Noise Levels



APPENDIX 3

VEGETATION AND VISUAL MANAGEMENT ASSESSMENT

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Subiaco WA 6008

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9 January 2013

Ms Abigail Oke

Greg Rowe and Associates

Level 3, 369 Newcastle Street

Northbridge WA 6003

Vegetation and visual landscape assessment: Lot 661 Bertram Road, Wellard

Background

In accordance with your request, Endemic has undertaken an assessment of vegetation at Lot 661 Bertram Road, Wellard, from both a visual landscape and environmental perspective. The lot represents part of a proposed development site, having been rezoned to Urban under the Metropolitan Regional Scheme.

A site visit was undertaken by Endemic staff for the purposes of this assessment on 11 May 2012. A Flora and Vegetation Survey in accordance EPA Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (Level 1 survey) was undertaken, identifying any significant vegetation to be protected during planning and development of future urban landuse.

An assessment of the impact of existing vegetation and future development on the visual landscape has also been included in this report.

The Study Area

This assessment covers Lot 661 Bertram Rd, Wellard, with an area of 7.80 Ha (Figure 1). The lot has been predominantly cleared for rural and livestock purposes.

A significant portion of the area is mapped as Multiple Use Sumpland (UFI 13327) in the DEC's Geomorphic Wetlands Swan Coastal Plain dataset (as at December 2012, see Figure 2). Immediately to the south-east of Lot 661 is Bollard Bulrush Swamp, a Conservation category Sumpland with significant ecological values. Bush Forever site 272 (Sicklemore Rd Bushland, see Figure 1) runs to the northern boundary of the lot (on the opposing side of Bertram Rd).

In addition, a portion of the south east corner of the Lot (approximately 0.12 Ha) is included under the Environmental Protection Swan Coastal Plain Lakes Policy 1992 (Figure 2). Accordingly there is to be no unauthorised filling, draining, excavating, polluting or clearing undertaken within this boundary. The proposed development will therefore not encroach within the EPP Lakes boundary.

The lot is of low relief, sitting on peaty lacustrine material associated with a historically drained wetland. Immediately to the west and north-east lie elevated dunes of the Spearwood and Bassendean systems, respectively.

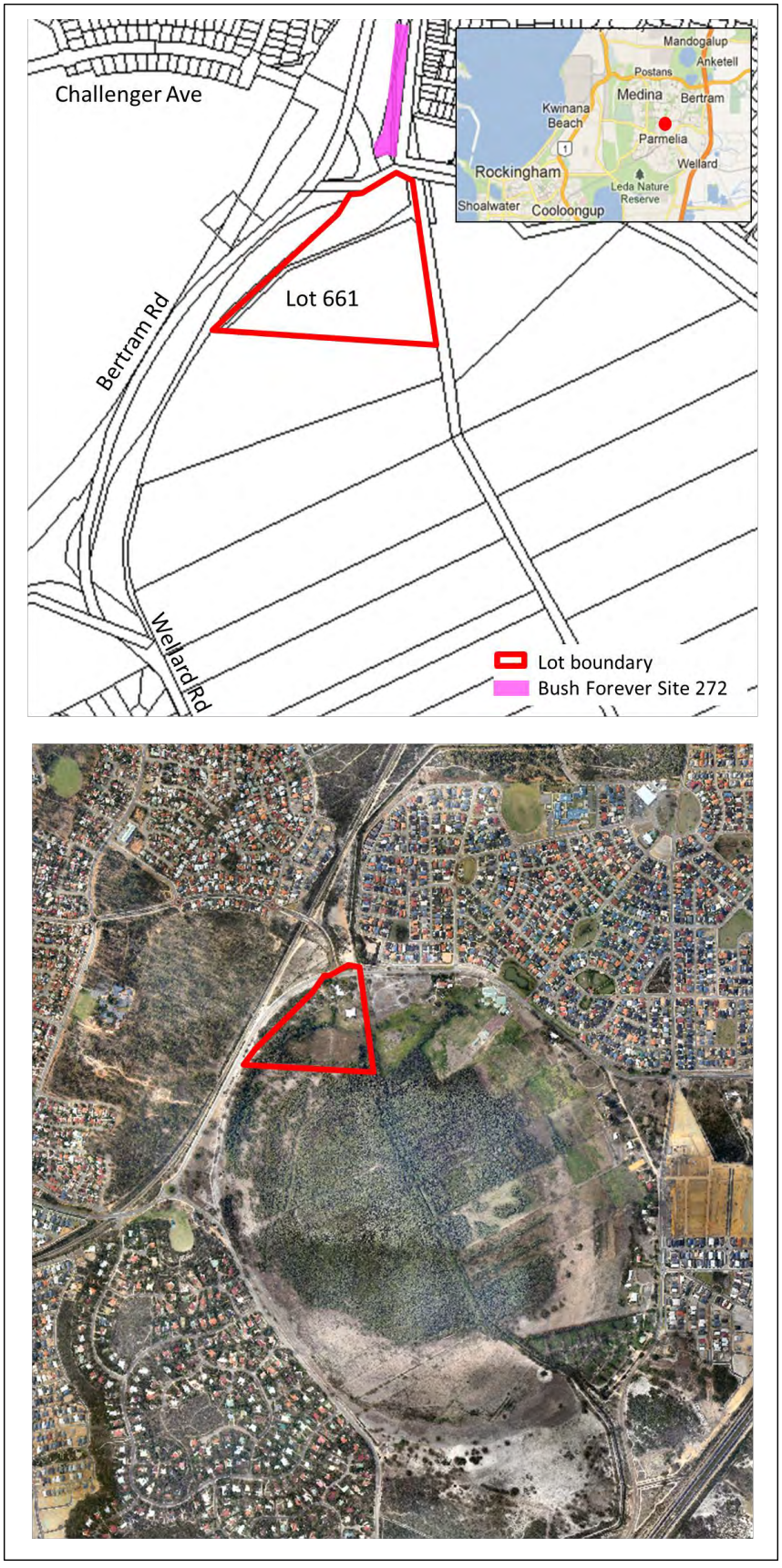

Figure 1: Study Location

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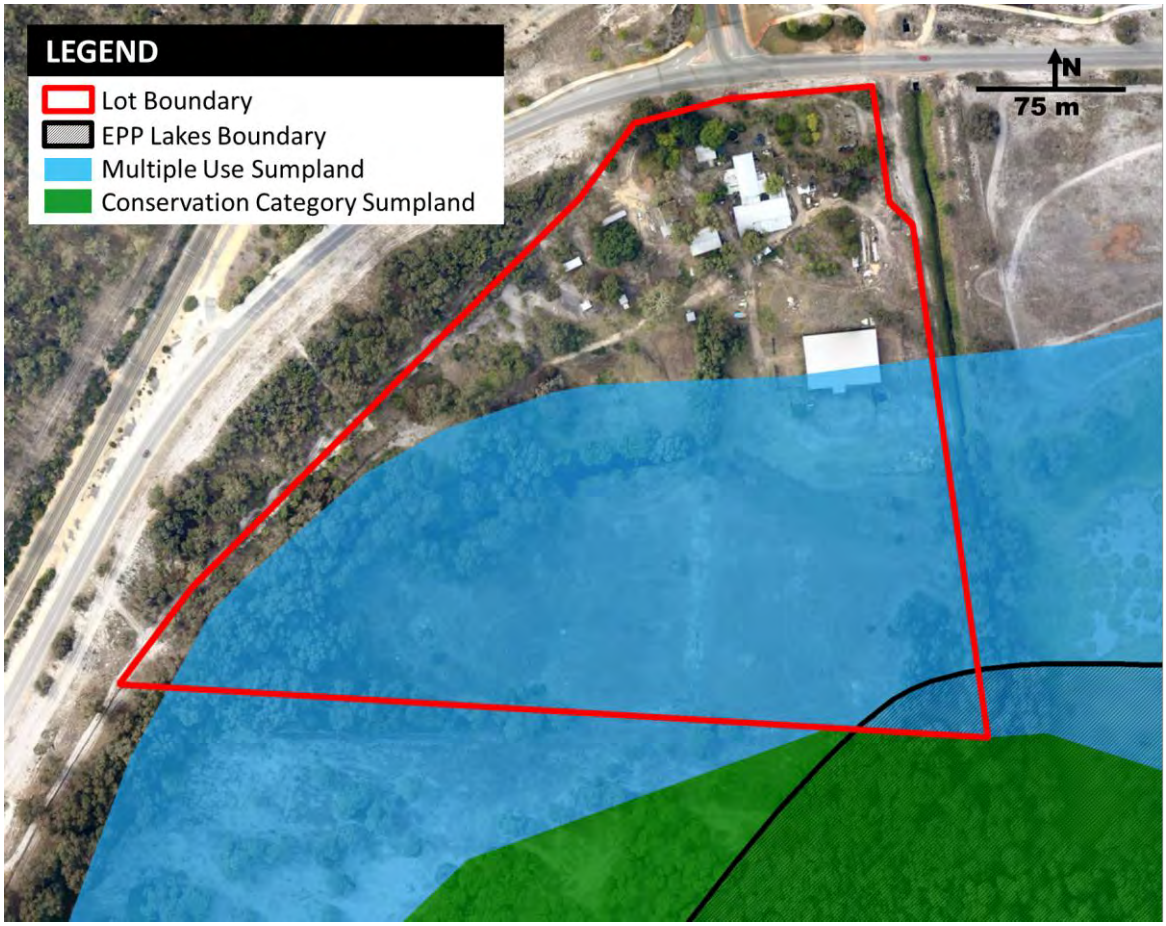

Figure 2: Wetland and EPP Lake Boundaries

Vegetation Condition Assessment

A Vegetation Condition Assessment was undertaken in accordance with methodology outlined in Bush Forever (Government of Western Australia 2000) after Keighery (1994). Descriptions of the vegetation condition categories are included below in Table 1. The entire site was found to be in degraded to completely degraded condition, with only confined areas of mature trees remaining and no native understorey present. There is a heavy weed burden, with blackberry widespread in the treed areas.

Table 1: Vegetation condition categories after Keighery (1994)

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

Tree Survey

A tree survey was completed, identifying significant trees such as mature or habitat trees which may be worthy of retention within POS and/or road reserves.

A large number of mature trees were recorded on the site, many of which are introduced species, surrounding a linear water feature/drain running through the property and surrounding existing buildings. These trees include *Schinus molle* (Peppercorn trees), *Jacaranda mimosifolia* (Jacaranda), *Robinia pseudoacacia* (Robinia), *Paulownia sp*, and *Pinus sp*. amongst others. These were not found to be of any particular ecological significance. Given the requirement for raised fill levels it is unlikely that any of these trees will be retained under future urban land use. No habitat hollows were identified.

In the south-western corner of the lot there is a grove of mature flooded gums (*Eucalyptus rudis*). These are of considerable height between 20 and 30 m and in good health. Mature flooded gums were also identified along the boundary line with Lot 69, and running parallel to the Peel Main Drain in the south-eastern corner of the Lot, possibly inside the drainage easement which was difficult to demarcate during the on-site survey. A grove of juvenile blue gums (*E. globulus*) are also growing adjacent to the drain. A small number of other native species including *Melaleuca raphiophylla*, *Kunzea ericifolia* and *Acacia saligna* (possibly planted) were identified scattered along the southern and western boundary fences. Close to the current access point from Bertram Rd there are a number of tall sheoaks (*Casuarina sp*) and one peppermint (*Agonis flexuosa*) which are local to the area and may be remnant or may have been planted at some point.

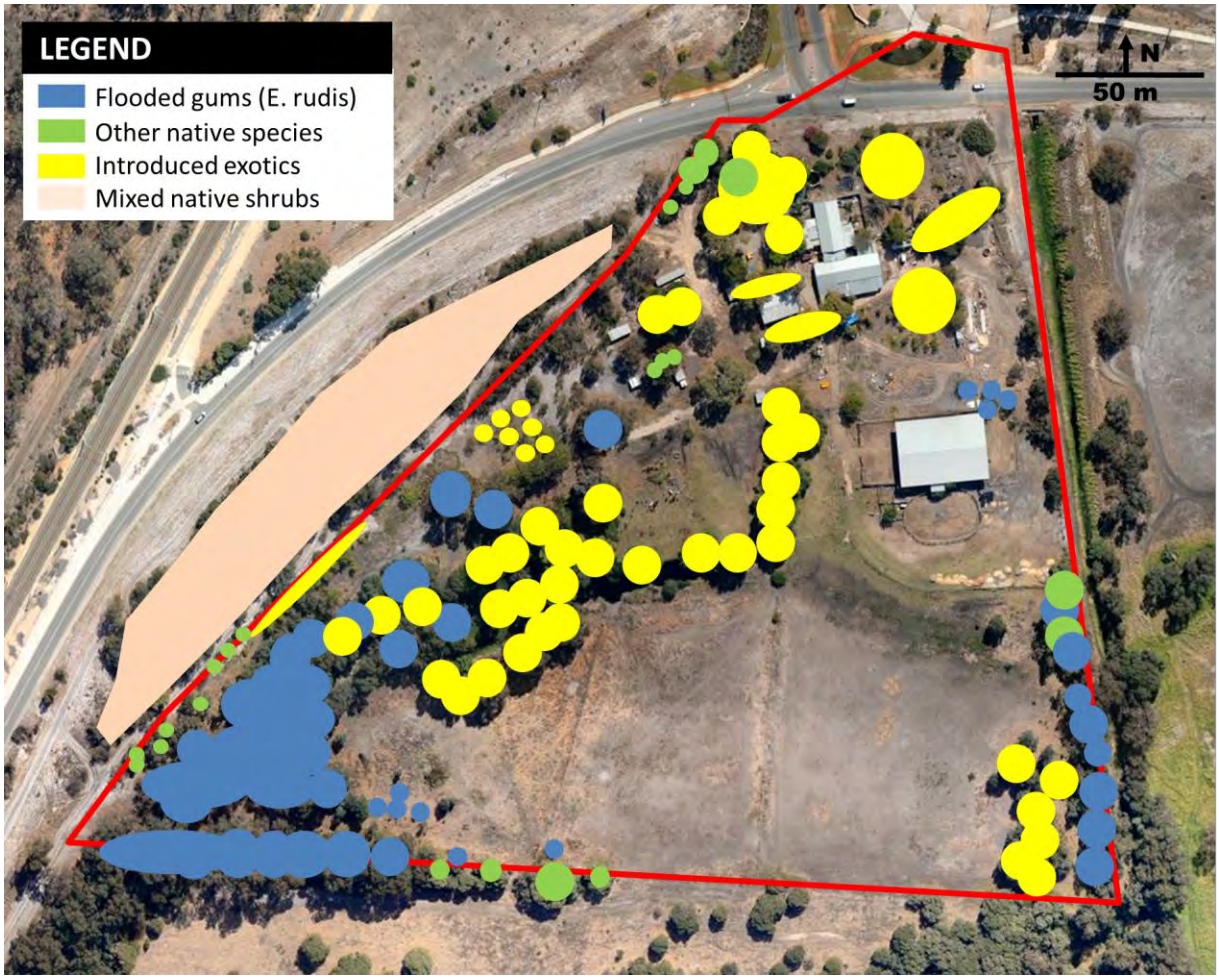

Figure 3: Mature trees

Visual and Landscape Assessment

The single most obvious geomorphological feature of the area is the juxtaposition afforded by the proximity of dunal features associated with Spearwood Sands to the west and Bassendean Sands to the north-east of the site to the Bollard Bulrush Swamp, itself a low-lying swampy area comprising soils of the Vasse system.

The presence of elevated dunes in proximity to the Bollard Bulrush Swamp provides potential vistas of the proposed development site from a number of locations. A number of these dunes have, however, been urbanised in recent years. As such, the gentle nature of these dunal slopes means that the best views are commonly observed looking down and along streets running down gradient towards the swamp.

A landscape analysis by Town of Kwinana identified a number of key vistas and view corridors originating from elevated locations to the west of the Lot 661 (Figure 4). LiDAR elevation data (Figure 5) was used to consider the visual impact of existing vegetation and proposed development of Lot 661 on views from these and other areas.

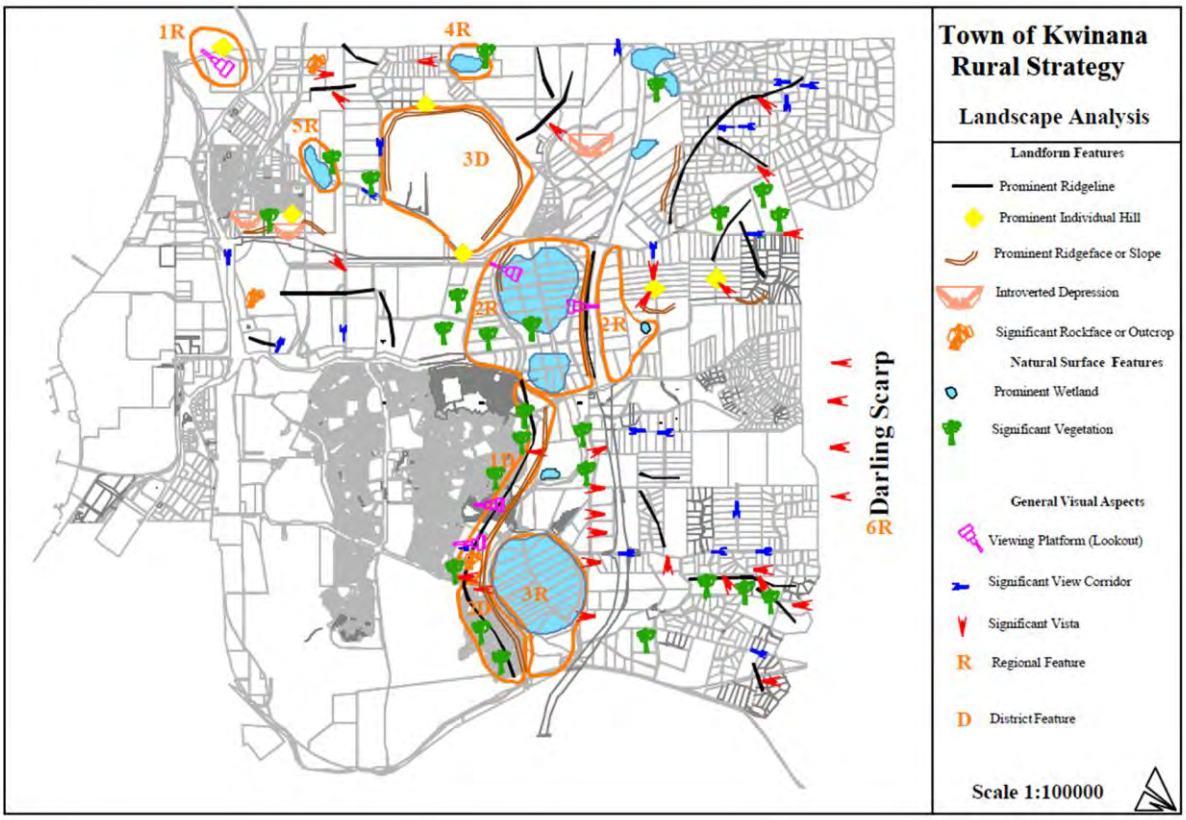

Figure 4: Source- Town of Kwinana Local Planning Strategy Rural Strategy 2003

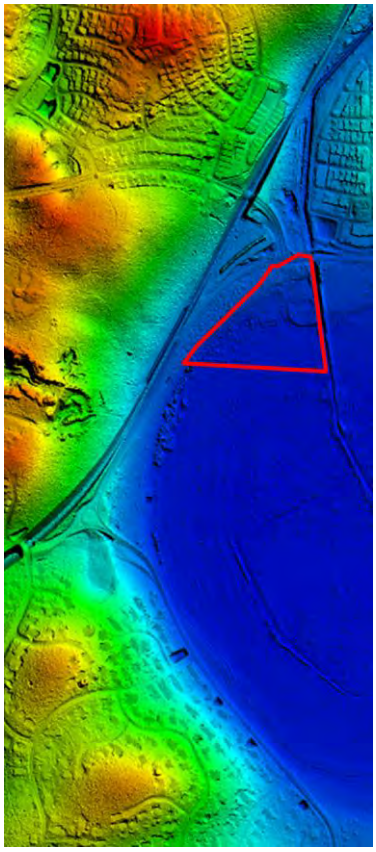

Figure 5: LiDAR data

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Homestead Ridge/Wellard

Areas within Homestead Ridge located on elevated land in the vicinity of Wellard Road have potential views to Lot 661. In this sense the view of urban development in the mid-distance, from a viewpoint located within an existing urban area is not considered to be a significant issue. Further, the presence of mature *Eucalyptus rudis* specimens (25-30m high) along the western boundary and between Lot 661 and Lot 69 Bertram Road as well as existing wetland vegetation on lots to the south (understood to be marked for retention in future conservation reserve) serve to obscure much of the site from viewpoints to the south-west of the site in the vicinity of Wellard Road (Figure 6b).

Figure 6a: Red shading indicates those areas with potential views to Lot 661 in the absence of any blocking vegetation or infrastructure (existing or future).

6b: Potential for views of Lot 661 when wetland vegetation to the south is accounted for and assuming retention of mature flooded gums on Lots 661 and 69 (in green).

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Retention of the abovementioned mature *Eucalyptus rudis* along the boundary of Lot 661 and Lot 69 (adjacent to Bertram Road) is recommended in order to maintain the existing screening. In addition, these trees provide significant visual and landscape amenity.

The presence of 3-4m high *Kunzea ericifolia* and other native shrubs within the existing (Bertram Rd) road reserve (see Figure 3) also serves to screen the site from lower elevation viewpoints, such as from Bertram Road itself, and effectively creates 'in-fill' screening to the much higher canopy of the *Eucalyptus rudis* located in this area.

Challenger Avenue/ Parmelia

Some existing residences north of Challenger Avenue have an outlook to the south and south-east towards Bollard Bulrush Swamp. As is generally the case, these views are most evident along road running down gradient towards the swamp.

Further to the above, the eastern end of Challenger Avenue itself also holds existing views across Lot 661 (Figure 6). There is currently only limited screening of existing infrastructure from this aspect. Modelling shows that unrealistically high vegetation (of similar height to the existing flooded gums further to the south) would need to be established within the Lot boundary in order to fully block views of any development on the site from Challenger Avenue and the adjacent residential area. Medium height trees and shrubs which could be established more quickly along the northern boundary would serve to block views of the development from the lower portion of Challenger Avenue but not those from higher residential areas. Plantings on higher land in or adjacent to the Bertram Rd road reserve could be somewhat effective for this purpose.

Recommendations

As outlined in this report, mature trees within the western portion of Lot 661 boundary provide valuable aesthetic and visual screening functions. The vegetation in this portion of the site comprises mature *Eucalyptus rudis* (Flooded Gum), however, the understorey is completely degraded comprising blackberry and pasture species. Accordingly, the vegetation in this location is of limited ecological/bushland value per se, however, in recognition of the aforementioned aesthetic and visual screening values, Endemic recommends existing individual specimens of Eucalyptus rudis be retained.

Eucalyptus rudis along the southern boundary and between Lot 661 and Lot 69 should be retained as these mature trees (25-30m high) provide significant screening of the site.

Existing vegetation within the Bertram Road reserve which comprises medium-tall shrubs of *Kunzea ericifolia* which provide effective in-fill screening should be retained, and consideration should be given to any future landscape treatment along the eastern side of Bertram Road in order to maintain and enhance this screening. Future roadside plantings should seek to incorporate locally indigenous species that reach a height of 2-3m.

Development of a built form guideline to inform the size, form and colour palate of future buildings within Lot 661 is recommended. The use of highly reflective building materials, including zincalume roofing, is not advocated. An appropriate palate should include hues of green and light brown. The use of light coloured brick for building construction is also not supported.

Figure 7: Vegetation recommended as most suitable for retention for screening purposes

Please do not hesitate to contact me directly on 0418 111 236 if you require additional information or would like to discuss the results of the site visit in greater detail.

Yours faithfully,

Geoff Bott
Director
Endemic Pty Limited

Endemic

Photo 1: Mature flooded gums in south-west corner

Photo 2: Fenceline between Lot 661 and 69

Photo 3: Mix of introduced exotic species surrounding man-made drain

Photo 4: Man-made drain with surrounding mature trees

APPENDIX 4

FIRE MANAGEMENT PLAN

Fire Management Plan

Local Structure Plan: Lot 661 Bertram Road, Wellard, Western Australia, 6170

Prepared for: Rowe Group | (08) 92211991 | rowegroup.com.au

RUIC Fire — PO Box 1931 Margaret River WA 6285

T: 1300797607 **E:** admin@ruic.net.au

Fire Management Plan

RUIC is a trading name of
Rural Fire Risk Consultancy Pty Ltd
PO Box 1931 Margaret River WA 6285
ABN: 77 643 030 227

Disclaimer and Limitation

This report is prepared solely for Royal Australian Golf Club Pty Ltd 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 Fire 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 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 has no control. If the client becomes concerned about changing factors then a new Fire Risk Management Plan should be requested.

To the maximum extent permitted by the law, RUIC, its employees, officers, agents and the writer ("RUIC") 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 client 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 is found liable then RUIC limits its liability to the lesser of the maximum extent permitted by the law and the proceeds paid out by RUIC's professional or public liability insurance following the making of a successful claim against such insurer.

Planning for Bushfire Guidelines 2nd Edition (2010) contains critical errors and omissions that may result in increased risk to life and property if implemented without correction. These errors include:

i. The Bushfire Attack Level (BAL) calculation in Table 2 of Appendix 1, pg 23 is incorrect and AS3959 (as amended) should be directly referred to. Utilising the incorrect table may result in approval being granted to developments where dwellings are subject to BAL-40 and BAL-FZ ratings in accordance with AS3959.
ii. Errors relating to maximum permissible grades in Element 2 of the performance criteria must be acknowledged.
iii. The term "fuel load" is not defined in the guidelines. No distinction between understory and canopy fuel load is identified in either the guidelines or FESA's Visual Fuel Load Guide which does not consider elevated or canopy fuel loads. Understory fuel load is utilised for potential bushfire rate of spread; however total fuel load is required

for fire intensity and Bushfire Attack Level calculation. The use of understory fuel loads alone will result in significant under-calculation of fire intensity and potential resulting in incorrect heat flux calculation.

iv. Ambiguity is also identified in the quantification of fuel load permissible for Hazard Separation Zones Acceptable Solution 4.4 where different fuel loads are permissible between Jarrah and Karri forest. AS3959 does not differentiate fire behaviour between forest species. Guiding fuel load parameters for these forest types are not quantified into understory or canopy fuel loads. Accordingly as the current guidelines require fuel load quantification the lesser value is utilised in this FMP.

v. A3.3 states that a "caveat" must be placed on dams to ensure fire services access. Landgate (Government of Western Australia, 2012) defines a caveat as "(Buyer beware) – A warning to a person searching the original Certificate of Title that there is a claim lodged on the Title to the land, which may prohibit the Registrar of Titles from registering a dealing upon that Title." In accordance with this definition a caveat is the incorrect term and does not ensure fire service access.

vi. Page 2 paragraphs 6-8 of the Guidelines state that it may not be "practical to fully comply with the criteria" and that the guidelines are not intended to be enforced in areas of existing development inclusive of established subdivisions. A significant number of private subdivisions of land parcels in Western Australia occur within previously established larger subdivisions, yet the Guidelines remain the only planning guidance available for decision makers creating ambiguity and confusion.

vii. The Guidelines have not been updated to incorporate specific Plantation Guidelines (FESA, 2012). Whilst AS3959 recognises plantation as Class A Forest for purposes of BAL calculation other specific planning considerations inclusive of increased firebreaks are required.

viii. Acceptable solution (A3.2) of the Guidelines provide certain specifications for firefighting water tanks; the typical connection being a '50mm camlock fitting with full flow valve.' It is critical to acknowledge differences in fire appliance filling systems – in particular the difference between bushfire and structural fire appliance capabilities. Where tanks are to be utilised to supply structural fire fighting appliances a 125mm stortz coupling is more suitable in order to supply water to the hard suction inlet. Further, where connections on water tanks are located below the level of the fire appliance pump impellor this water becomes unattainable unless the appliance is equipped with suction capabilities and hoses that fit the tank outlet. Where structural fire and rescue brigades are likely to respond in the subdivision area it may be more suitable to equip water tanks with BIC fittings or the stortz coupling to ensure access to water supply.

ix. The Guidelines do not acknowledge the difference in capability or requirements between bushfire and fire and rescue (structural firefighting) resources. Reliance solely on bushfire resources and solutions tailored to such brigades will negatively impact on structurally capable firefighting response. It is therefore critical to acknowledge the difference between isolated bushfire and bushfire within the rural urban interface and provide sufficient planning strategies to facilitate such response.

x. The Guidelines do not specify the appropriate knowledge and qualification base for the provision of fire management plans. There is significant difference between planning for isolated bushfire and planning for bushfire within the rural urban interface that will impact on structures requiring structurally capable firefighting response. Extensive planning experience specific to remote and isolated bushfire does not translate to bushfire impacting on urban areas without additional knowledge and experience. The Planning Institute of Australia (NSW Division) (2012) identifies unregulated bushfire planning and consultancy as a potentially critical issue in any

coronial enquiry following a bushfire. The Fire Protection Association of Australia (FPAA) provide a certification scheme for Bushfire Planning and Design (BPAD). Whilst this scheme has been implemented in both NSW and Victoria; bushfire consultancy remains unregulated in Western Australia despite devastating bushfires over the past decade including Roleystone/Kelmscott; Toodyay; Lake Clifton; and Margaret River and numerous national and state bushfire commissions, enquiries and reports (the performance and review of established fire management plans in all Western Australia fires has been outside the scope of relevant enquiries). All RUIC Consultants have completed postgraduate studies through the University of Western Sydney in Bushfire Planning and Protection. RUIC supports regulation of the bushfire consultants through the BPAD scheme.

xi. Western Australian State Planning Policy 3.4 is out dated. Only one paragraph refers to bushfire protection planning – citing the interim 2001 Planning for Bushfire Protection.

RUIC accepts no responsibilities whatsoever for inadequacies of the above standards and guidelines.

RUIC 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 five years only from the date of its issue.

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Document Details

ITEM	DETAIL
Project Name	Wellard LSP
Project Number	201323
Prepared by	Greg Penney
Review by	Client
Approved by	*I confirm all information is trua and accurate to the best of my knowledge.*  Greg Penney Director | RUIC Fire
Version	1.3
Date of Issue	13th November 2013

Executive Summary

Rural Fire Risk Consultancy Pty Ltd trading as RUIC Fire specialises in bushfire engineering and performance based design and construction solutions. RUIC Fire was engaged by the client to prepare this Fire Management Plan to support the Local Structure Plan of Lot 661 Bertram Road, Wellard prepared by the Rowe Group.

Strategic assessment of the site and surrounding area was completed in accordance with Planning for Bushfire Protection Guidelines 2nd Edition (FESA, 2010) and the Rural Urban Threat Analysis Tool (FESA, 2003). Detailed site analysis was completed in accordance with methodologies utilised in AS3959:2009 Construction of buildings in bushfire prone areas; and ISO31000 Risk assessment principles and guidelines. It is concluded the bushfire hazard level of the site is not prohibitive to development.

Design bushfire was quantified and impact of such fire behaviour was modelled in accordance with established bushfire engineering principles. Design of the building protection zones and defendable spaces within the Local Structure Plan using the design bushfire analysis results in the design exceeding the required standards defined in AS3959:2009 and Planning for Bushfire Protection Guidelines 2nd Edition (FESA, 2010).

The Local Structure Plan was assessed against the criteria of Planning for Bushfire Protection Guidelines 2nd Edition (FESA, 2010) and documented Bushfire Policy of the City of Kwinana. In complying with the design specifications of this Fire Management Plan, the Local Structure Plan of Lot 661 Bertram Road, Wellard is found to be compliant with State Planning Policy 3.4 Natural Hazards; the guidance document Planning for Bushfire Protection Guidelines 2nd Edition (FESA, 2010); and documented Bushfire Policy of the City of Kwinana.

Contents Page

1.0 Introduction

1.1 Report Description

1.1.1 Purpose of the Report

The Rowe Group on behalf of Royal Australian Golf Club Pty Ltd (the client) engaged Rural Urban Interface Consultancy Pty Ltd (RUIC Fire) to prepare a Fire Management Plan (FMP) to support the Local Structure Plan as a precursor to subdivision for Lot 661 Bertram Road, Wellard (the site).

The purpose of this Fire Management Plan (FMP) is to analyse the bush fire risk and threat level of the proposed Local Structure Plan and to detail the mitigation strategies and requirements to be implemented to comply with Planning for Bushfire Protection Guidelines 2nd Edition (FESA, 2010) and all other regulatory requirements. The aim of the FMP is to reduce the occurrence and minimise the impact of bush fires thereby reducing the risk to life, property and the environment in the case of bush fire within or near the proposed development.

Increased detail of bushfire risk mitigation measures inclusive of mapped Building Protection Zones will be provided at subdivision stage when a detailed lot layout and building setbacks are known. An updated Fire Management Plan is to be developed and endorsed as part of the subdivision application in accordance with State Planning Policy.

1.1.2 The Project Team

RUIC Fire employs a team of experts specialising in bushfire engineering and performance based designed solutions. Director Greg Penney *GIFireE, MRMIA, Grad Dip Bushfire Protection, BSc* is the principal consultant for the project and is the principle point of contact for all enquiries relating to the Fire Management Plan.

1.1.3 Assessment Methodology

Strategic assessment of bushfire threat at the proposed development site is in accordance with current West Australian Planning Commission requirements utilising Planning for Bushfire Protection Guidelines 2nd Edition and the Rural Urban Interface Bushfire Threat Analysis. A comprehensive and detailed site bushfire threat analysis has also been undertaken during inspection of the site utilising industry best practice in accordance with the Fuel Hazard Assessment Guide 4th Edition (Hines, Tolhurst, Wilson & McCarthy, 2010) ; FESA's Visual Fuel Load Guide (2012); and AS3959:2009.

2.0 Site Details

2.1 Description

2.1.1 Location

The site is located in the Municipality of the City of Kwinana, approximately 32km south of the Perth Central Area in the suburb of Wellard. (See Figure 2A and 2B)

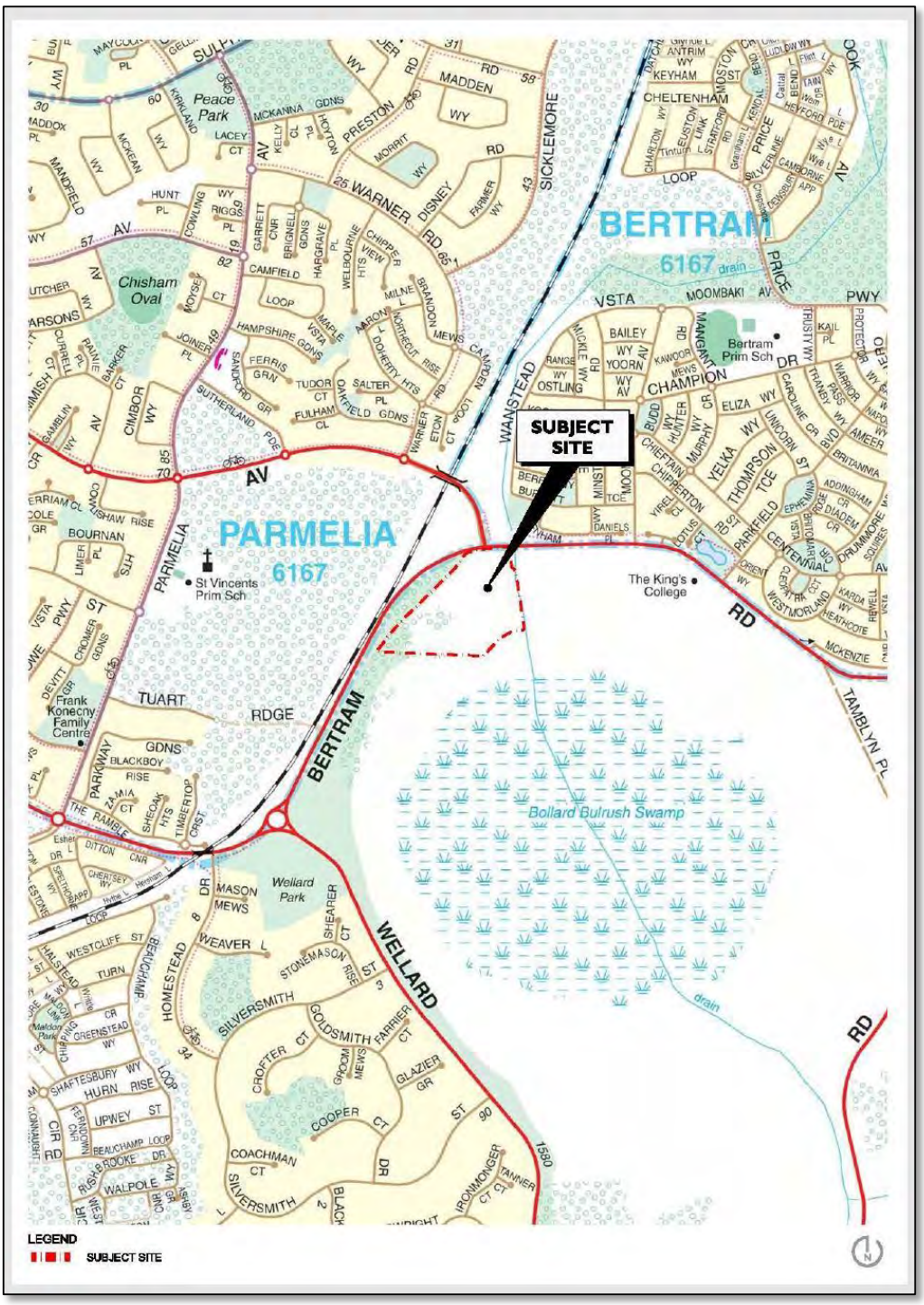


Figure 2A: Local Structure Plan (Greg Rowe & Associates, 2013)

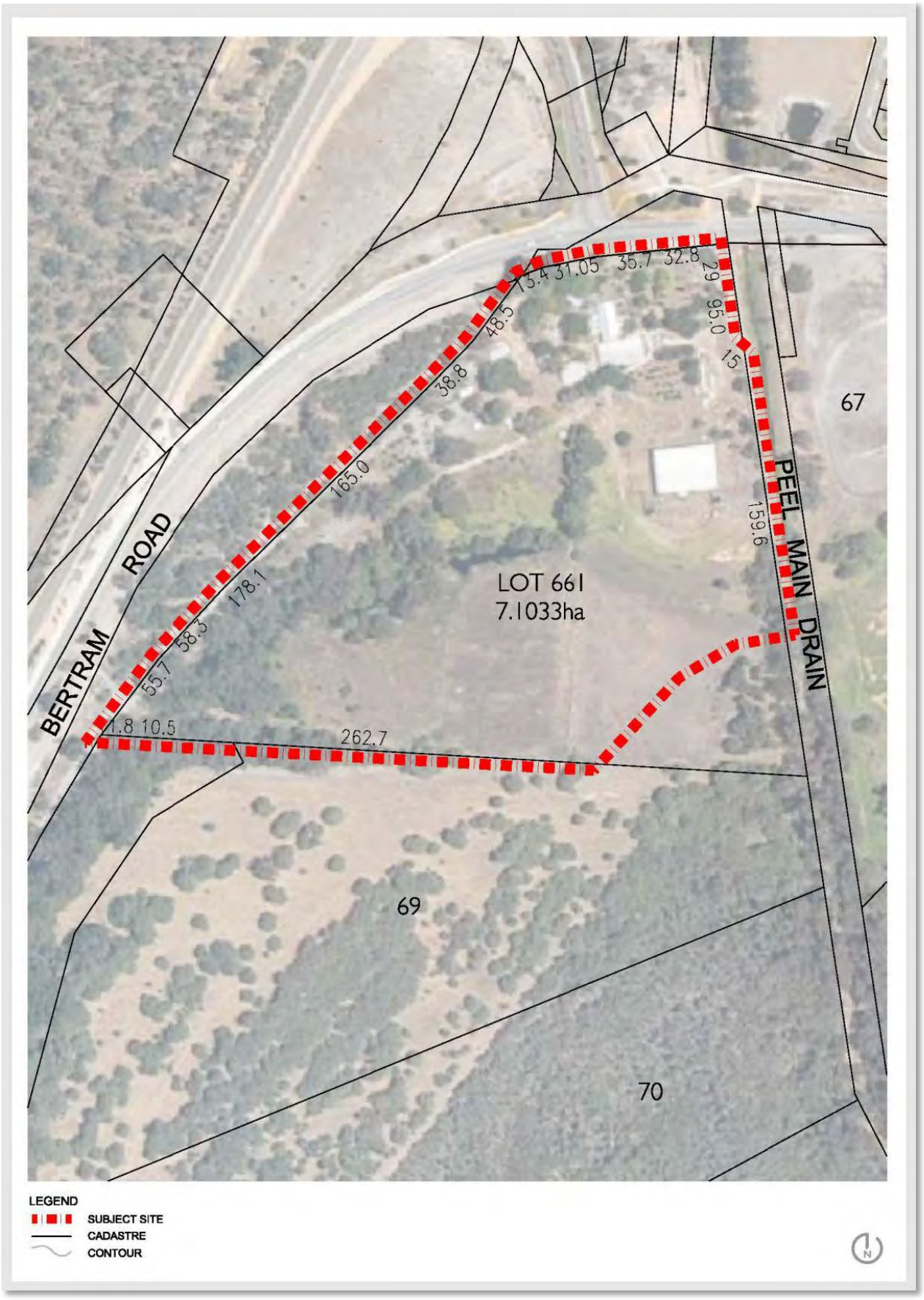


Figure 2B: Structure Plan Area (Greg Rowe & Associates, 2013)

2.1.2 Area & Current Land Use

The site is approximately 7.1 hectares in area. Current land use is rural living with large areas of pasture. An existing dwelling and a number of sheds are located in the northern portion of the site.

2.1.3 Proposed Land Use

The Local Structure Plan Map (Appendix 1) incorporates Residential development consistent with the Eastern Residential Intensification Concept Draft Structure Plan(City of Kwinana, 2005). Development is proposed to include:

- Moderate to high density residential development (inclusive of potential Aged Person's Development consistent with potential construction of the Parmelia Railway Station); and
- Public Open Space.

2.1.4 Bushfire Prone Designation

The Structure Plan Area will be designated a "Bushfire Prone Area" by the City of Kwinana. In accordance with the Bushfire Prone designation, all dwellings within 100m of a bushfire hazard must comply with construction requirements detailed in Australian Standard AS3959 "Construction of Buildings in Bushfire Prone Areas."

Lots affected by the Fire Management Plan will have Notifications on Title highlighting obligations and responsibilities of the landowner under the Fire Management Plan.

Building Protection Zones and Hazard Separation Zones as specified by the City within the Public Open Space and by landowners on private lots.

2.1.5 Bushfire History

2.1.5.1 Gazetted Fire District

Technical and Background Paper No.27 "Western Australia" of the Australian Institute of Criminology (Bryant, 2008) provides the following analysis of historical vegetation fire response in gazetted fire districts within Western Australia:

- Between 2000-2001 to 2006-2007 the Fire and Emergency Services Authority (now the Department of Fire and Emergency Services) attended a total of 61,446 vegetation fires throughout gazetted fire districts in Western Australia.

- 94% of all attended fires were classified as scrub or bush and grass mixture fires; 3.5% classified as small vegetation fires; 1.3% as grassfires; and only 0.2% classified as forest or wood fires greater than one hectare in size.
- Analysis of causal information between 2000-2001 to 2001-2002 revealed 76.7% of vegetation fires were of deliberate origin; 14.8% were accidental; and only 1.6% were started from natural causes (lightning strikes etc).

2.1.5.2 City of Kwinana

Two significant fire events are documented (Carboon, 2013) within the City of Kwinana since 2010:

- On December 29, 2012, the Kwinana Freeway was closed in both directions as 100 firefighters and 3 firefighting helicopters battled a fire near Bertram Primary School. Approximately 35 hectares of bush was burnt. There was no threat to homes or lives.
- On February 24, 2010, 40 fire fighters and three firefighting helicopters battled a fire through the afternoon near Meares and Gilmore Avenues. The cause of the fire was suspicious and 10 hectares of bush were burnt.

2.1.5.3 Post Development Bushfire Events

The proposed development will result in significant modification of site fuel structures. Residential development will replace current unmanaged areas of vegetation. Maintained Public Open Space will include retained mature trees in a parkland cleared state. Whilst the ignition of individual trees from acts of arson cannot be eliminated the potential for bushfire within the developed site will be eliminated. Post development the site may be impacted by bushfire from vegetation structures external to the Structure Plan Area. This impact is not considered to constitute a significant risk to the development; potential impact modelled in accordance with AS3959:2009 is detailed in Tables 3D-3G.

2.1.6 Strategic Bushfire Hazard Assessment

Strategic Bushfire Hazard Assessment completed in accordance with FESA (2010) is conducted solely on the *predominant* vegetation type for the site. Figure 2C illustrates the predominant pre-development site vegetation as unmanaged grassland. This represents a moderate bushfire hazard as defined by FESA (2010). Post development (Appendix 2) all areas of vegetation within the Structure Plan Area will be maintained parkland and gardens constituting a low bushfire hazard as defined by AS3959:2009 and FESA (2010).

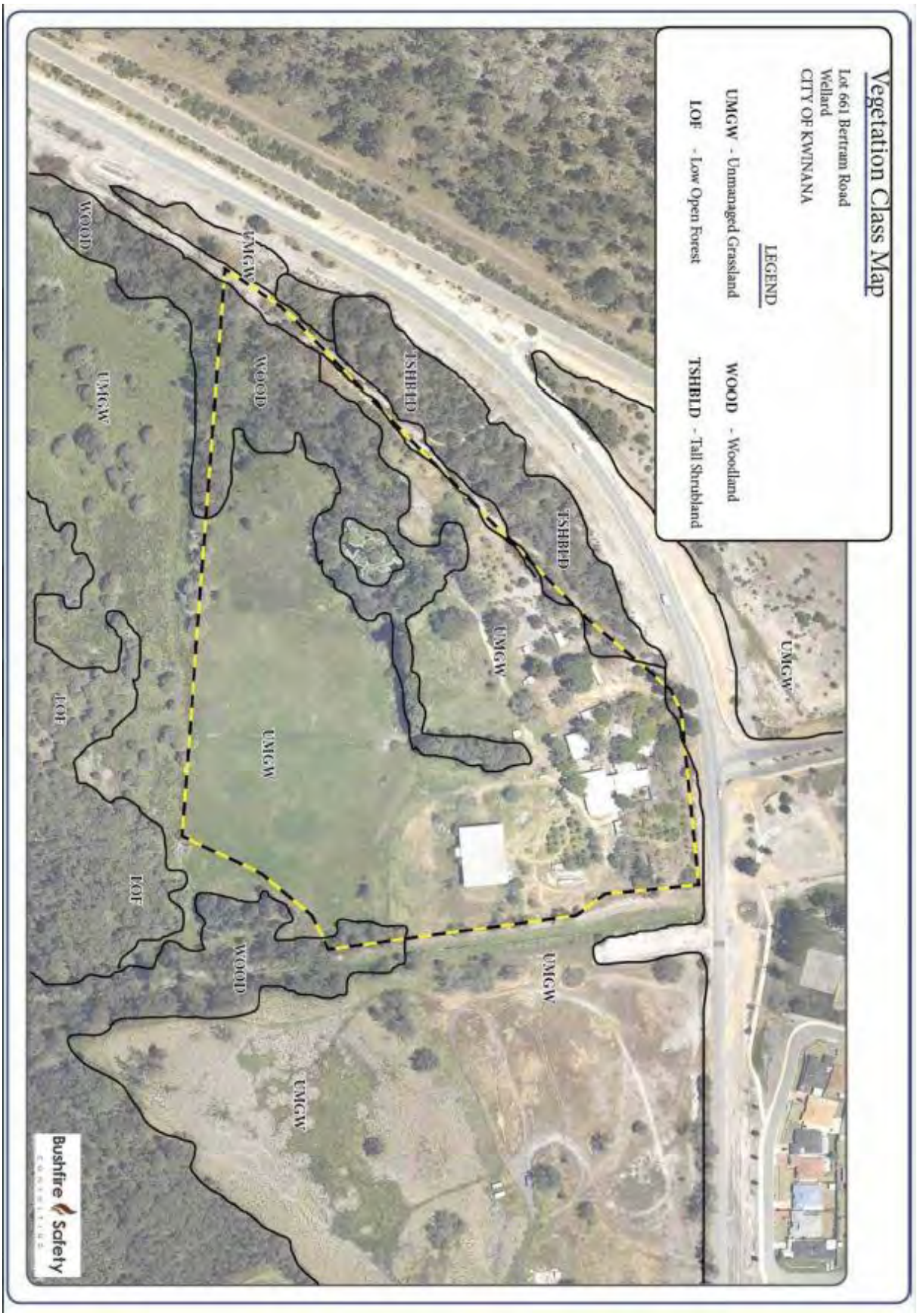


Figure 2C: Predevelopment Vegetation (Carboon, 2013)

2.1.7 Threat Analysis using the Rural Urban Threat Analysis Tool

The RUBTA is designed to identify where a more significant potential problem may exist when compared with other areas after completing a threat analysis of the jurisdiction or assessment zone (FESA, 2003). It is developed specifically for use at the rural urban interface as a risk assessment tool for fire officers and planners; however may be inconsistent with the process detailed in ISO 31000 (2009); COAG (2004) or AS3959 (2009). Comparative analysis of current and post development states is provided in Table 2A.

Hazard levels are shown to significantly decrease post development as a direct result of reduction in site fuel structures and establishment of Building Protection Zones. This contributes to an overall decrease in the bushfire threat to the Structure Plan Area and surrounding lots from within the Structure Plan Area.

Element	Current		Post Development	
	Result	Score	Result	Score
Likelihood of occurrence (risk of ignition)	High	1	Low	0
Fuel load > standard (intensity)	Yes	1	No	0
Vegetation assessment area with fire hazard (manageability)	High	1	Low	0
Hazard reduction < 80% assessment zone	Yes	1	No	0
High visitor usage	No	0	Yes	1
Recent or proposed residential and industrial developments*	No	0	Yes	0*
Total Hazard Assessment	Score – 4 *High*		Score – 1 *Low*	
Easily accessible	No	0	No	0
Response time > 30 minutes	No	0	No	0
Inadequate water supply	No	0	No	0
Inadequate resources	No	0	No	0
Total Management Assessment	Score – 1 *Low*		Score – 1 *Low*	

*Proposed residential development in this instance will result in increased fuel load reduction through enhanced BPZ's and additional compliance required in accordance with the Local Government Fuel Hazard Reduction and Fire Break Notice

Table 2A: Rural Urban Bushfire Threat Analysis (FESA, 2003)

2.1.8 City of Kwinana Fire Hazard Assessment

The Eastern Residential Intensification Concept (District Structure Plan) Draft (2005) identifies the site as being Low Potential Threat bordered by Moderate Potential Threat areas (Figure 2D; Appendix 3). In that document the City of Kwinana states:

"Urbanisation in itself will eliminate the bushfire hazard for the areas and along with the extension of reticulated water will also provide fire hydrants along the rural/urban interface, thereby improving the fire response capacity for the Fire Brigade." (p.67); and

"The principal responses following a hazard assessment is to ensure:

- *Maximum accessibility for emergency vehicles and for emergency escape.*
- *Adequate provision of fire fighting services.*
- *Adequate water supply.*
- *Adequate separation distances from residential development from the bushfire source." (p.67)*

The proposed development is consistent with the urbanisation that the City of Kwinana identifies will ultimately eliminate bushfire threat within the Structure Plan Area. As detailed further in this Fire Management Plan all principle responses identified by the City of Kwinana are achieved in accordance with current state bushfire protection guidance material and AS3959:2009.

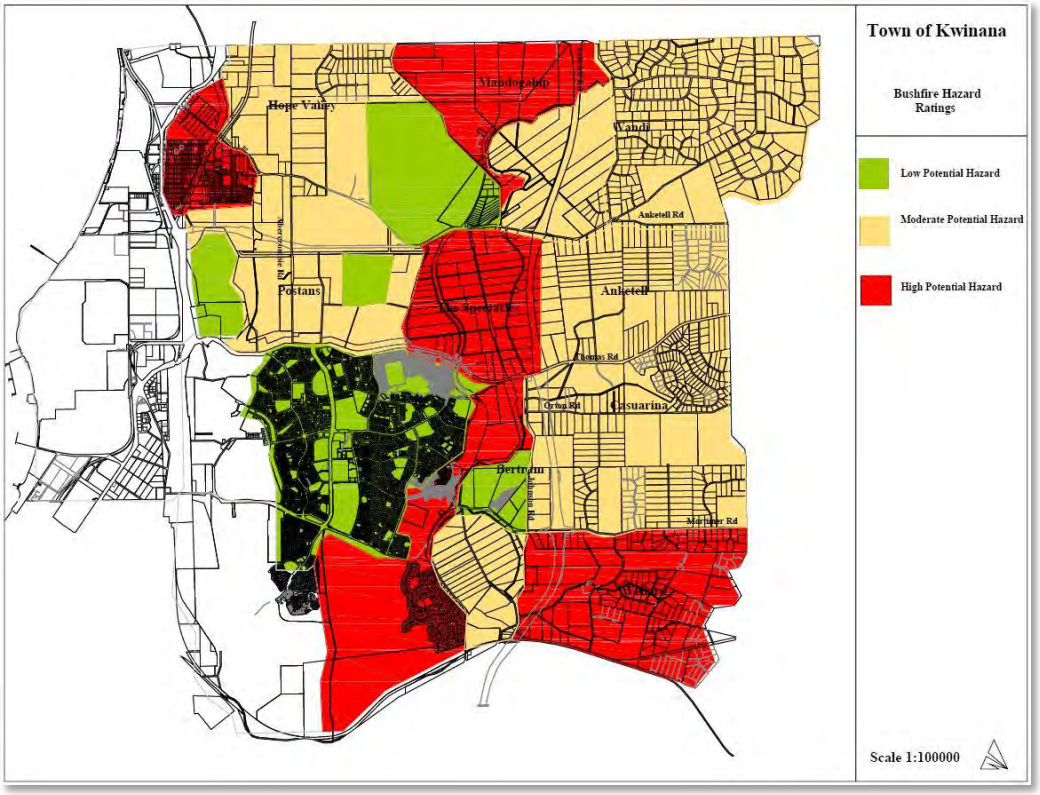


Figure 2D: City of Kwinana Bushfire Hazard Map (ERIC, 2005, p.66)

2.1.9 Conclusion

The proposed development is located in an urban area subject to moderate bushfire hazard. Post development the hazard level of the Structure Plan Area will decrease when assessed in accordance with the Strategic Level Assessment (FESA, 2010) and the Rural Urban Threat Analysis Tool (FESA, 2003).

The site has been declared Bushfire Prone by the City of Kwinana. All Class 1,2 and 3 buildings within 100m of vegetation assessed as a bushfire threat will be subject to compliance with additional construction standards as specified in AS3959:2009 Construction of buildings in bushfire prone areas. This will ultimately increase the bushfire survivability of dwellings within the Structure Plan Area in comparison to dwellings in neighbouring estates as a direct result of increased engineering.

In conclusion the bushfire risk to the Structure Plan Area is not considered unreasonable and should not prohibit development of the site subject to the measures detailed in this Fire Management Plan being complied with.

3.0 Design Bushfire

3.1 Introduction

Quantified modelling of bushfire behaviour utilising predetermined "worst case" parameters, otherwise known as "design bushfire," remains the corner stone of conducting evaluation of performance base design (Kashef, Viegas, Mos & Harvey, 2012). The design fire remains a hypothetical model specifically intended to represent the worst case bushfire event possible within the assessment area. Parameters of design bushfire for the assessment area are identified as being:

- Bushfire Weather (inclusive of FDI);
- Site Topography; and
- Bushfire fuel structure and fuel load

In turn the design bushfire is expressed as components of potential fire behaviour:

- Rate of Spread;
- Flame Length;
- Fire Line Intensity; and
- Heat Flux Impact (Bushfire Attack Level)

3.1.1 Bushfire Weather

3.1.1.1 Climate & Bushfire Danger Period

Data collected from the closest Bureau of Meteorology weather station (Medina Research Centre - 009194) indicates that the site experiences a temperate climate characterised by mild winter periods and hot, dry summers (Appendix 4). The bushfire danger period occurs during the dryer summer months where grass curing has occurred and humidity is low. Temperature of 46°C; relative humidity of 7%; fuel moisture content of 2%; and 100% curing is utilised for design grass fire modelling in unmanaged grassland.

The fire season as deemed by local authorities as between Spring and Autumn. The following fire restrictions apply for the 2013/14 Fire Season:

- Permit required 1st October – 30th November
- Fires Prohibited 1st December – 31st March
- Permit required 1st April – 31st May

3.1.1.2 Fire Danger Index

Section 1.5.12 of AS3959-2009 defines Fire Danger Index (FDI) as

> "The chance of a fire starting, its rate of spread, its intensity and the difficulty of its suppression, according to various combinations of air temperature, relative humidity, wind speed and both the long- and short-term drought effects."

AS3959 defines the FDI in Western Australia as 80. An FDI of 100 representing catastrophic conditions is used for design fire modelling through the Site Assessment Area.

3.1.1.3 Wind

Windrose profiles for summer months indicate predominantly morning E to S 20-30kph winds swinging to SW 30-40+kph winds by 1500hrs. Wind is a significant contributor to bushfire behaviour, in particular when changes in wind direction result in a bushfire flank turning into a running head fire. Predominant winds experienced at 0900hrs may fan fire originating in vegetation in land south and south east of the site. Predominant winds experienced at 1500hrs may fan fire originating in vegetation in land west of Bertram Road towards the site; however fire spread through this vegetation will be mitigated in part by site topography. Wind speed of 40kph is utilised for design bushfire modelling. The effect of prevailing winds on fire behaviour that may impact the site has been considered in the establishment of defendable spaces and buffer zones as detailed in the Fire Management Plan Map (Appendix 2)

3.1.2 Site Topography

The site gently undulates with minimal change in elevation (Appendix 5). Topography will not have significant impact upon fire behaviour through vegetation at the site or through vegetation south or east of the site. Fire spread through vegetation west of Bertram road towards the site will be slowed as any fire progresses through the effective 8° downslope. Topography will not affect fire behaviour through vegetation in the nature strip along Bertram Road immediately to the west of the site due to insufficient distance to support fire run and effective development. Site topography of 1° downslope is utilised for design bushfire modelling; a slope of 0° is utilised for design bushfire modelling through vegetation west of Bertram Road.

3.1.3 Bushfire Fuel Structure & Load

The arrangement of bushfire fuel has significantly greater effect on potential fire behaviour than fuel load. In conjunction with the Visual Fuel Load Guide (FESA, 2007 & 2012); and AS3959:2009, assessment of Class A Forest and Class B Woodland fuel structures in accordance with Hines, Tolhurst, Wilson & McCarthy (2010) allows separate assessment of canopy; bark; elevated; near-surface; and surface fuels to provide more accurate quantification of potential fire intensity. Keith (2004) is referenced for canopy fuel loads. Class B Open Woodland is assessed on the basis of the understory (AS3959:2009 Table 2.3) identified as unmanaged Class G Grassland. Class C Shrub structure is assessed in accordance with AS3959:2009. Class G Grassland structure is assessed in accordance with CSIRO (1997) and AS3959:2009. Maintained Public Open Space and maintained Nature Strips are identified as Low Threat Vegetation in accordance with AS3959:2009 s2.2.3.2.

Figure 3A: Post development bushfire fuel structure

Fuel assessment was conducted in each vegetation structure. Assessments are representative of the average fuel structure across the sampling locations (Figure 3A). Assessment of Class A Forest and

Class B Woodland fuel structures in accordance with Hines, Tolhurst, Wilson & McCarthy (2010) is identified in Table 3A. Calculated fuel loads are identified in Table 3B. Fuel structures are illustrated in Plates 1-6.

Plot	AS3959 Class	Vegetation Type	Bark Fuel Hazard	Elevated Fuel Hazard	Near Surface Fuel Hazard	Surface Fuel Hazard	Combined Surface and Near Surface Fuel Hazard	Overall Fuel Hazard
3	Class A	Low Open Forest	M	VH	VH	H	VH	VH
5	Class B	Woodland	M	M	H	H	VH	H
L	**LOW**	**M**	**MODERATE**	**H**	**HIGH**	**VH**	**VERY HIGH**	**E**	**EXTREME**

Table 3A: Hazard Assessment (Hines, Tolhurst, Wilson & McCarthy, 2010)

Structure	1	2	3	4	5	6
Fuel Load (t/ha)	n/a	15	26	4.5	15	4.5
Total Fuel Load including canopy (t/ha)	n/a	15	31	4.5	20	4.5

Table 3B: Fuel Load Calculation

Highest fuel load is identified through Class A Low Open Forest vegetation to the south and south east of the Structure Plan Area. Fuel loads in areas of Class C Shrub and Class G Grassland can be reduced through minor fuel hazard reduction works. This would result in these areas constituting Low Threat Vegetation in accordance with AS3959:2009 s2.2.3.2 suitable for inclusion as part of Building Protection Zones as defined in FESA (2010).

Plate 1: Structure 1 – Proposed public open space

Plate 2: Structure 1 – Proposed public open space

Plate 3: Structure 2 – Tall shrub and degraded grassland in nature strip along Bertram Road

Plate 4: Structure 2 – Open tall shrub in nature strip along Bertram Road

Plate 5: Structure 3 – Low Open Forest behind unmanaged grassland

Plate 6: Structure 4 – Open Woodland south west of Structure Plan Area

3.1.3.1 Structure Plan Area

The proposed development will result in significant modification of site fuel structures. Residential development will replace current unmanaged areas of vegetation. Maintained Public Open Space will include retained mature trees in a parkland cleared state (Plot 1 in Figure 3A) as identified by Endemic Pty Ltd (2013). Refer to Figure 3B. Class C Tall Shrubland adjacent to the site (Plot 2 in Figure 3A) is identified as a nature strip and aesthetic buffer from Bertram Road. Class B Open Woodland (Plot 4 in Figure 3A) is degraded with unmanaged grassland understory.

3.1.3.2 Greater Area

Class A Open Forest (Plot 3 in Figure 3A) and Class G Grassland (Plot 6 in Figure 3A) is located south and east of the site in land zoned rural (Figure 3B). Class B Woodland (Plot 4 in Figure 3A) is located to the east of the site in urban zoned land identified as DCA 15 Townsite (Figure 3B). As urbanisation consistent with the Eastern Residential Industrial Concept (2005) occurs in these areas significant modification of vegetation will occur and the bushfire threat will ultimately be reduced.

The Local Structure Plan has been developed independently of future development. This ensures all future dwellings with the Structure Plan area are not subject to unreasonable levels of bushfire threat from existing vegetation fuel structures.

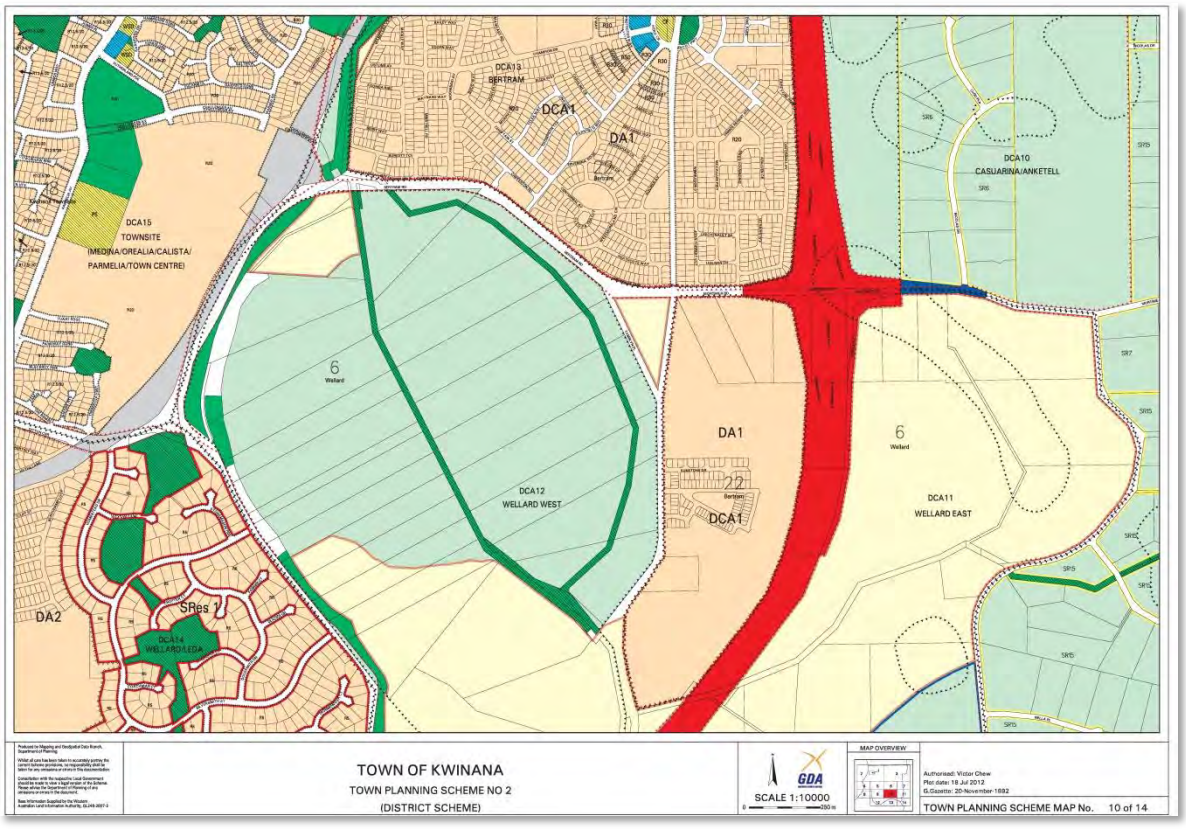


Figure 3B: Bertram Locality District Scheme (Town of Kwinana)

3.2 Design Bushfire Modelling

The design fire represents worst case bushfire behaviour in catastrophic conditions within the Structure Plan Area. Bushfire and grassfire behaviour is expressed as:

- Rate of Spread – the forward rate of spread of the head fire expressed as kilometres per hour;
- Flame Length – the length (not to be confused with vertical height) of flames at the head fire;
- Fire Line Intensity – the intensity of the head fire expressed in kW/m;and
- Heat Flux Impact – determined in accordance with AS3959:2009.

Bushfire behaviour models cited in AS3959:2009; and the CSIRO Grassland Fire Spread Meter (1997) are used to determine the design fire modelling. Design bushfire parameters identified in Section 3.1 are used as inputs in each model. Each vegetation structure is independently modelled. Design bushfire modelling is detailed in Table 3C.

Vegetation Classification	Rate of Spread (kph)	Flame Length (m)	Fire Line Intensity (kW/m)
Class A Low Open Forest	3.3	25.5	53542
Class B Woodland	1.9	14.9	19929
Class C Shrub	3.1	8.3	22495
Class G Grassland (Natural)	15.6	4.0	-
Class G Grassland (Eaten Out)	6.5	0.5	

Table 3C: Design bushfire behaviour

Design bushfire behaviour indicates that bushfire through areas of vegetation in the greater location may be severe enough to prevent firefighting efforts on the head fire. The vegetation fuel structure adjacent to the Structure Plan Area in conjunction with incorporation of maintained public open space serves as low fuel vegetative buffers. These buffers will significantly reduce potential bushfire behaviour so that it can be directly attacked using firefighting tankers (FESA, 2011) allowing it to be stopped prior to fire line impact on dwellings.

3.2.1 Heat Flux (Bushfire Attack Level AS 3959:2009)

The purpose of this indicative Bushfire Attack Level (BAL) Assessment is to demonstrate compliance of the completed project with Performance Criteria P1 as required in FESA's Planning for Bushfire Protection Guidelines 2nd Edition. The Bushfire Attack Level (BAL) is determined in accordance with

AS3959 2nd Methodology in accordance with design bushfire fuel load parameters. Increased design safety is engineered into each Heat Flux calculation through the design fire process; specifically the use of an FDI of 100 (125% of the FDI assigned to Western Australia in AS3959:2009) and utilisation of a minimum 1° downslope across the Structure Plan Area. Heat flux calculations conducted using Flamesol and verified with Tan (2012a, 2012b) are summarised in Table 3D-3G for each vegetation type identified in section 3.1. ***It is essential to note the BAL Table published in Appendix 1 of Planning for Bushfire Protection Guidelines 2nd Edition (FESA, 2010) contains critical errors that result in incorrect determination of BAL for certain vegetation types if used and may result in increased risk to life and property.***

Class A Forest	
Setback from Vegetation	Bushfire Attack Level (BAL)
0 to <21m	FZ
21 to <27m	40
27 to < 38m	29
38 to < 51m	19
51 to 100m	12.5
Greater than 100m	Low

Table 3D: BAL vs Setback Class A Forest

Class B Woodland	
Setback from Vegetation	Bushfire Attack Level (BAL)
0 to <13m	FZ
13 to <17m	40
17 to < 24m	29
24 to < 34m	19
34 to 100m	12.5
Greater than 100m	Low

Table 3E: BAL vs Setback Class B Woodland

Class C Shrub	
Setback from Vegetation	Bushfire Attack Level (BAL)
0 to <7m	FZ
7 to <10m	40
10 to < 14m	29
14 to < 20m	19
20 to 100m	12.5
Greater than 100m	Low

Table 3F: BAL vs Setback Class C Shrubland

Class G Grassland	
Setback from Vegetation	Bushfire Attack Level (BAL)
0 to 6m	FZ
6 to <7.5m	40
7.5 to < 11.5m	29
11.5 to < 17m	19
17 to 100m	12.5
Greater than 100m	Low

Table 3G: BAL vs Setback Class G Grassland

Highest potential heat flux impact is identified as resulting from Class A Low Open Forest. The incorporation of maintained open space will provide a vegetative buffer and protection zone of minimum 27m distance ensuring a maximum BAL-29 rating to all future dwellings situated in the eastern and south eastern aspects of the Structure Plan Area (refer to Table 3D). In the event the nature strip adjacent to the western aspect of the Structure Plan Area is not maintained in a low fuel state a minimum 10m separation to be incorporated into a greater Building Protection Zone to ensure a maximum BAL-29 rating to all future dwellings located along the western boundary of the Structure Plan Area (refer to Table 3F).

3.3 Conclusion

The design of the Structure Plan Area specifically includes measures to reduce the risk from bushfire. The design incorporates bushfire safety engineering analysis to ensure potential bushfire behaviour will be reduced so that it can be safely combated by firefighting agencies should it reach the proposed development. Analysis of heat flux impact in design bushfire conditions incorporating safety measures exceeding Australian Standard 3959:2009 demonstrate the Structure Plan Area is compliant with Performance Criteria P1 as required in FESA's Planning for Bushfire Protection Guidelines 2nd Edition (2010) and the City of Kwinana's Eastern Residential Intensification Concept District Structure Plan (2005).

4.0 Bush Fire Risk Mitigation

The bush fire risk mitigation strategies detailed in this report are designed to comply with the Performance Criteria and Acceptable Solutions detailed in the Planning for Bush Fire Protection Guidelines 2nd Edition.

- The notation (P3) refers to Performance Criteria 3 of the Planning for Bush Fire Protection Guidelines 2nd Edition. Where a Performance Based Solution is offered detailed justification is provided.
- The notation (A3.1) refers to Acceptable Solution 3.1 of the Planning for Bush Fire Protection Guidelines 2nd Edition.
- The notation (E3.1) refers to Explanatory Note 3.1 of the Planning for Bush Fire Protection Guidelines 2nd Edition.
- The notation (CK) refers to City of Kwinana bushfire hazard mitigation priorities defined in the Eastern Residential Intensification Concept Draft Structure Plan .
- Where discrepancy occurs between Planning for Bushfire Protection Guidelines 2nd Edition and the Local Government Fuel Reduction and Firebreak Notice the higher standard of mitigation has been selected.

4.1 Element 1 - Location of Development

Intent

To ensure that development/intensification of land use is located in areas where the bush fire hazard does not present an unreasonable level of risk to life and property

Performance Criteria (P1)(CK)

The subdivision/development is located in an area where the bush fire hazard level is manageable.

Design Solutions

The intent of Element 1 is upheld and Performance Criteria (P1) are met through Performance Based Solutions 1-2.

Performance Based Solution 1 General Site Location

The proposed development is subject to an increased level of bushfire risk typical of development in the rural urban interface within the City of Kwinana. The risk to future dwellings at the site can be reduced subject to the development meeting the requirements of this report. (P1)

Performance Based Solution 2 Managed Bushfire Threat

Bushfire safety engineering supported setbacks from identified vegetation threats; establishment of the Building Protection and Hazard Separation Zones; and increased construction standards in accordance with AS3959 ensure that the development is located in an area when the bushfire hazard does not present an unreasonable level of risk to life and property. (P1)

4.2 Element 2 - Vehicular Access

Intent

To ensure that the vehicular access serving a subdivision/development is safe in the event of a bush fire occurring

Performance Criteria (P2)(CK)

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.

Design Solutions

The intent of Element 2 is upheld and Performance Criteria (P2)(CK) are achieved through Acceptable Solutions 1-4 and Performance Based Solutions 3-7.

Acceptable Solution 1 Access and Egress

Bertram Road currently services the site with additional egress identified on the eastern and southern border of the site. The optional access street will provide alternate access and egress routes for residents and emergency firefighting services throughout the Structure Plan Area.

Performance Based Solution 3 Public Roads

The Local Structure Plan incorporates an internal road network connecting to Bertram Road with additional potential connection to new roads in surrounding lots. All public roads shall meet the requirements as set in Planning for Bush Fire Protection Guidelines 2nd Edition acceptable solutions

A2.2 with the exception of grade requirements which are aligned with Planning for Bush Fire Protection 2006, NSW Rural Fire Service due to error in grade specifications in FESA's Planning for Bush Fire Protection Guidelines 2nd Edition..

(a) Construction Standards:

i. trafficable surface: 6 metres
ii. horizontal clearance: 6 metres
iii. vertical clearance: 4 metres
iv. grade not exceeding: 10°
v. minimum weight capacity: 15 tonnes
vi. maximum crossfall: 1 in 33
vii. curves minimum inner radius: 12 metres

(b) Implementation:

i. Prior to clearance

(c) Development:

i. It is the responsibility of the developer to ensure public meet the required construction standards

(d) Maintenance:

i. It is the responsibility of the Local Government to ensure public roads continue to meet the required construction standards.

Performance Based Solution 4 Cul-de-sac

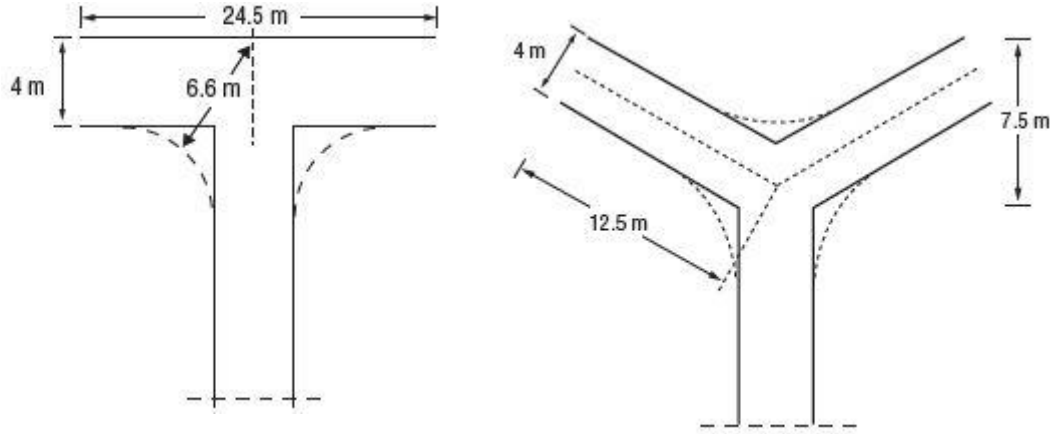
Cul-de-sacs are currently excluded from the design of the Local Structure Plan. Should future versions of the plan be developed involving cul-de-sacs they shall meet the requirements as set in Planning for Bush Fire Protection Guidelines 2nd Edition acceptable solutions A2.5 with the exception of grade requirements which are aligned with Planning for Bush Fire Protection 2006, NSW Rural Fire Service due to error in grade specifications in FESA's Planning for Bush Fire Protection Guidelines 2nd Edition..

(a) Construction Standards:

i. trafficable surface: 6 metres
ii. horizontal clearance: 6 metres
iii. vertical clearance: 4 metres
iv. grade not exceeding: 10°
v. minimum weight capacity: 15 tonnes
vi. maximum crossfall: 1 in 33

vii. curves minimum inner radius: 12 metres

viii. heads: 21m turnaround or as detailed below (Ref: FESA, 2010 p35 "Turning areas":



(b) Implementation:

i. Prior to clearance

(c) Development:

i. It is the responsibility of the developer to ensure the cul-de-sacs meet the required construction standards

(d) Maintenance:

i. It is the responsibility of the Local Government to ensure the cul-de-sacs continue to meet the required construction standards.

Performance Based Solution 5 Battle Axes

The existing Local Structure Plan does not incorporate Battle Axe lots. Should future versions of the plan be developed involving Battle Axe lots they shall meet the requirements as set in Planning for Bush Fire Protection Guidelines 2nd Edition acceptable solutions A2.4 with the exception of grade requirements which are aligned with Planning for Bush Fire Protection 2006, NSW Rural Fire Service due to error in grade specifications in FESA's Planning for Bush Fire Protection Guidelines 2nd Edition..

(a) Construction Standards:

i. Length: not more than 600m

ii. trafficable surface: 6 metres

iii. horizontal clearance: 6 metres

iv. vertical clearance: 4 metres

v. grade not exceeding: 10°

vi. minimum weight capacity: 15 tonnes

vii. maximum crossfall: 1 in 33

viii. curves minimum inner radius: 12 metres

(b) Implementation:

i. Prior to clearance

(c) Development:

i. It is the responsibility of the developer to ensure all Battle Axe lots meet the required construction standards

(d) Maintenance:

i. It is the responsibility of individual land owners to ensure individual Battle Axe lots continue to meet the required construction standards.

Performance Based Solution 6 Private Driveways

The existing Local Structure Plan provides access to all potential dwellings within 50m of a public road; therefore private driveways as defined by FESA (2010) are not required. Should future designs incorporate lots in excess of 50m from an accessible public road a private driveway is will be required. Future private driveways shall meet the requirements as set in Planning for Bush Fire Protection Guidelines 2nd Edition acceptable solutions A2.5 with the exception of grade requirements which are aligned with Planning for Bush Fire Protection 2006, NSW Rural Fire Service due to error in grade specifications in FESA's Planning for Bush Fire Protection Guidelines 2nd Edition..

(a) Construction Standards:

i. trafficable surface: 4 metres

ii. horizontal clearance: 6 metres

iii. vertical clearance: 4 metres

iv. grade not exceeding: 10°

v. minimum weight capacity: 15 tonnes

vi. maximum crossfall: 1 in 33

vii. curves minimum inner radius: 12 metres

viii. passing bays every 200m:

a. length: 20m

b. width: 2m (so that combined private driveway and passing bay is 6m)

(b) Implementation:

i. Prior to habitation of the new dwelling

(c) Development:

i. It is the responsibility of the individual land owner to ensure the private driveway meets the required construction standards

(d) Maintenance:

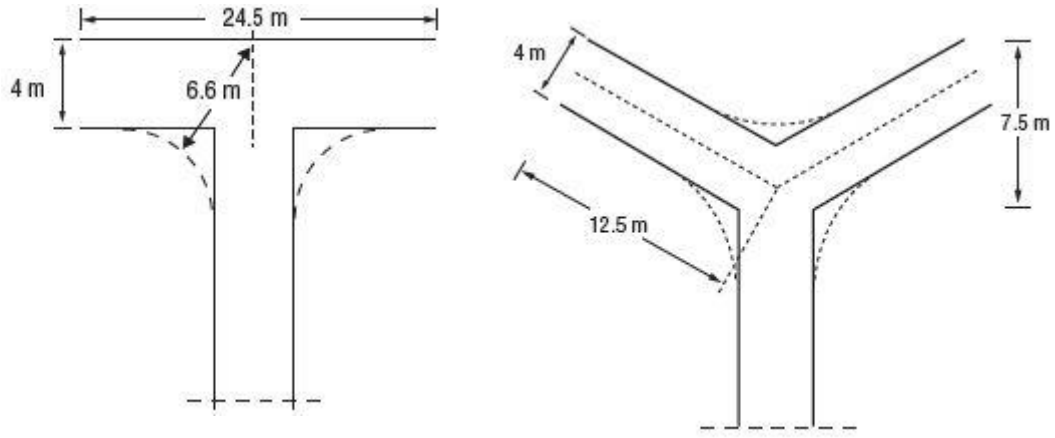
i. It is the responsibility of the individual land owner to ensure the private driveway continues to meet the required construction standards.

Performance Based Solution 7 Fire Service Access Routes

Fire service access routes provide links to public road networks for firefighting purposes. Two potential access routes are incorporated into the design of the Local Structure Plan to provide rapid and multiple access for firefighting services to the south east of the site. The Fire Service Access Routes shall meet the requirements as set in Planning for Bush Fire Protection Guidelines 2nd Edition acceptable solutions A2.6 with the exception of grade requirements which are aligned with Planning for Bush Fire Protection 2006, NSW Rural Fire Service due to error in grade specifications in FESA's Planning for Bush Fire Protection Guidelines 2nd Edition.

(a) Construction Standards:

i. trafficable surface: 6 metres
ii. horizontal clearance: 6 metres
iii. vertical clearance: 4 metres
iv. grade not exceeding: 10°
v. minimum weight capacity: 15 tonnes
vi. maximum crossfall: 1 in 33
vii. curves minimum inner radius: 12 metres
viii. must be signposted
ix. turn around areas to accommodate 3.4 firefighting appliances
x. where fire service access is restricted by fencing a gate meeting the provisions as detailed in Acceptable Solution 3 of this report must be installed;
ix. turning areas identified in the FMP map to reside within areas of Public Open Space and to have a 21m head or as illustrated (Ref: FESA, 2010 p35 "Turning areas":



(b) Implementation:

i. The fire service access route is required prior to clearance.

(c) Development:

i. It is the responsibility of the developer to ensure the fire service access route meets the required construction standards prior to clearance.

(d) Maintenance:

i. It is the responsibility of the Local Government to maintain the fire service access route once it is ceded to the Local Government.

Acceptable Solution 2 Gates

Where fire service route access is restricted by fencing, fire access gates are required to allow unrestricted fire services emergency access. All access gates linking fire service access shall meet the following requirements (A2.8):

(a) Construction Standards:

i. Minimum width 3.6m

ii. Design and construction to be approved by Local Government

iii. Padlocked in accordance with Department of Fire and Emergency Services requirements (common key)

iv. Signposted

(b) Implementation:

i. All access gates must comply with construction standards at the time of installation.

(c) Development:

i. It is the responsibility of the developer to ensure all access gates meet the required construction standards at the time of installation.

(d) Maintenance:

i. It is the responsibility of the Local Government to ensure gates continue to meet the required construction standards post installation and ceding of the Fire Services Access to the Local Government.

Acceptable Solution 3 Signage

All required signage for firebreak shall read "Fire Service Only" and meet the following requirements (A2.10):

(a) Construction Standards:

i. Minimum height above ground 0.9m

ii. Design and construction to be approved by Local Government

iii. Lettering height 100mm

iv. Clearly visible from a distance of 10m

(b) Implementation:

i. All required signage must comply with construction standards prior to clearance.

(c) Development:

i. It is the responsibility of the developer to ensure all required signage meet the required construction standards at the time of installation.

(d) Maintenance:

It is the responsibility of the Local Government to ensure all required signage continue to meet the required construction standards post installation.

Acceptable Solution 4 Firebreaks

Firebreaks are required for lots greater than 0.5ha to facilitate fire service access and prevent the spread of low intensity fire. All lots will be less than 0.5ha and therefore do not require firebreaks in accordance with A2.9. Provisions in accordance with the Local Government Firebreak Notice still apply.

4.3 Element 3 – Water Supply

Intent

To ensure that water is available to the development to ensure life and property to be defended from a bush fire.

Performance Criteria (P3)(CK)

The development is provided with a permanent and secure water supply that is sufficient for fire fighting purposes.

Design Solutions

The intent of Element 3 is upheld; and Performance Criteria (P3) and (CK) achieved through Acceptable Solution 5.

Acceptable Solution 5 Firefighting Water

Reticulated fire hydrants will be installed at intervals not greater than 200m will along all roads within the Structure Plan Area. All hydrants are to the meet specifications as required by the Department of Fire and Emergency Services and the relevant water authority.

4.4 Element 4 – Siting of Development

Intent

To ensure that that the siting of development minimises the level of bush fire impact.

Performance Criteria (P4)

The siting (including paths and landscaping) of the development minimises the bush fire risk to life and property.

Design Solutions

The intent of Element 4 is upheld and Performance Criteria (P4) are achieved through Acceptable Performance Based Solution 8.

Performance Based Solution 8 Building Protection & Hazard Separation Zones

The building protection zone is a low fuel area immediately surrounding a building and is designed to minimise the likelihood of flame contact with buildings. Features such as driveways, roads, vegetable patches, lawn or landscaped garden (including deciduous trees and fire resistant plant species) may form part of building protection zones. Areas of vegetation deemed Low Threat Vegetation and managed in a reduced fuel state inclusive of Public Open Space and nature strips may form part of a dwellings defendable space. Isolated shrubs and trees may be retained within building protection zones.

In areas of dense urban development overlapping Building Protection Zones can be utilised to great effect to enhance the combined safety of dwellings, particularly where lot sizes may be restricted. As detailed in the explanatory notes of (P4) the Building Protection Zone may be reduced in accordance with compliance to AS3959:2009. All Building Protection Zones must remain sufficient to ensure a maximum BAL-29 rating is applicable to all possible dwellings to ensure compliance with (P1).

All separation distances identified in Tables 3E-3G incorporate specific safety measures into bushfire engineering calculations to ensure stated setbacks exceed those required in AS3959:2009 and FESA (2010). Building Protection Zones are to be mapped at subdivision stage.

(a) Construction Standards:

i. width: sufficient to ensure maximum BAL-29 rating (refer to Tables 3E-3G for required setbacks);
ii. trees are low pruned at least to a height of 2 metres
iii. no tall shrub or tree is located within 2 metres of a building (including windows)
iv. there are no tree crowns overhanging the building
v. shrubs in the building protection zone have no dead material within the plant
vi. tall shrubs in the building protection zone are not planted in clumps close to the building ie within3 metres
vii. trees in the building protection zone have no dead material within the plant's crown or on the bole.
viii. Leaf litter shall not be exceed 50% surface coverage or a depth of 10mm
ix. Near surface and elevated bushfire fuels are not permitted in the BPZ

(b) Implementation:

i. Prior to habitation of any new dwelling.

(c) Development:

i. It is the responsibility of the individual land owner to ensure all Building Protection Zones meet the required construction standards.

(d) Maintenance:

i. It is the responsibility of the individual land owner to ensure all Building Protection Zones continue to meet the required construction standards.

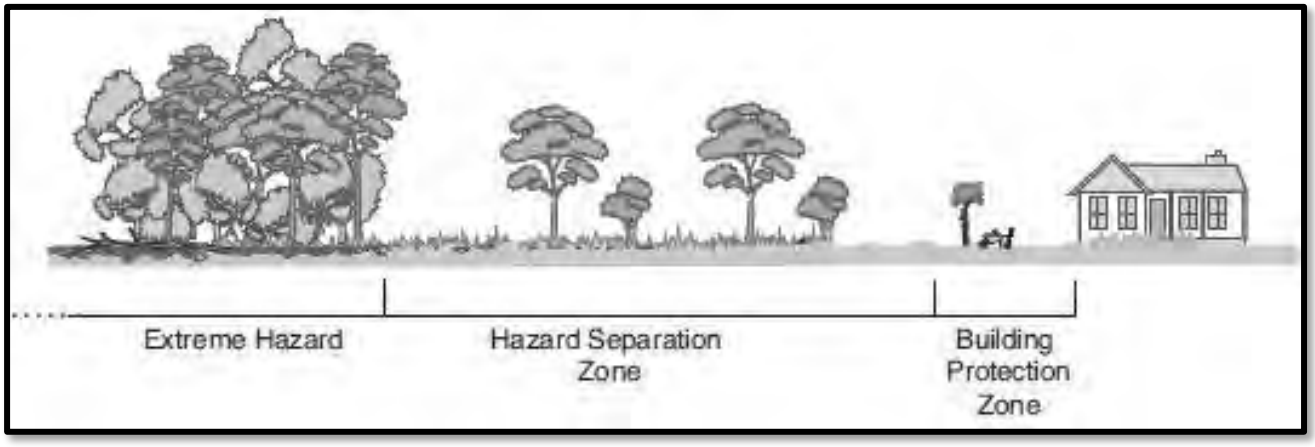


Figure 4A: Building Protection and Hazard Separation Zones (FESA, 2010, p.44)

4.5 Element 5 – Design of Development

Intent

To ensure that the design of the development minimises the level of bush fire impact.

Performance Criteria (P5)

The design of the development is appropriate to the level of bush fire hazard that applies to the development site.

Design Solutions

The intent of Element 5 is upheld and Performance Criteria (P5) are achieved through Performance Solution 9

Performance Based Solution 9 Design of Development

This design utilises Acceptable and Performance Based (Alternative) Solutions to ensure the Intent and Performance Criteria of all Elements are met.

4.6 Element 6 – Additional Provisions

Intent

To address bushfire risk not covered in Planning for Bushfire Protection Guidelines 2nd Edition or detailed previously in the report.

Provisions

The following ongoing Fire Risk Mitigation Strategies are to apply:

i. Any amendments to this FMP shall be approved by the Department of Fire and Emergency Services.

ii. This report shall be registered as an s70A notification on the title of all properties this report is applicable to.

iii. A copy of this report shall be provided to any prospective purchaser prior to the sale of any property covered by this report.

4.7 Works and Responsibilities

This table summarises the responsible party for each mitigation strategy and the time frame in which it must be completed.

Strategy	Implementation		Maintenance	
	Responsible	Time Frame	Responsible	Time Frame
AS3959:2009 Compliance (New Dwellings)	Individual Owner	Prior to Building Licence	n/a	n/a
Battle Axes	Developer	Prior to clearance	Individual Land Owner	Ongoing
Building Protection Zones (New Dwellings)	Individual Land Owner	Prior to habitation	Individual Land Owner	Ongoing
Cul-de-sacs	Developer	Prior to clearance	Local Government	Ongoing
Firebreak Notice Compliance	Individual Land Owners	Ongoing	Individual Land Owners	Ongoing
Fire Service Access	Developer	Prior to clearance	Local Government	Ongoing
Gates	Developer	If access is required to be controlled.	Local Government	Ongoing
Hydrant Network	Developer	During construction	Water Authority	Ongoing
Public Open Space	Developer	During construction	Local Government	Ongoing

Table 4A: Schedule of Works

4.8 FMP Strategies Map

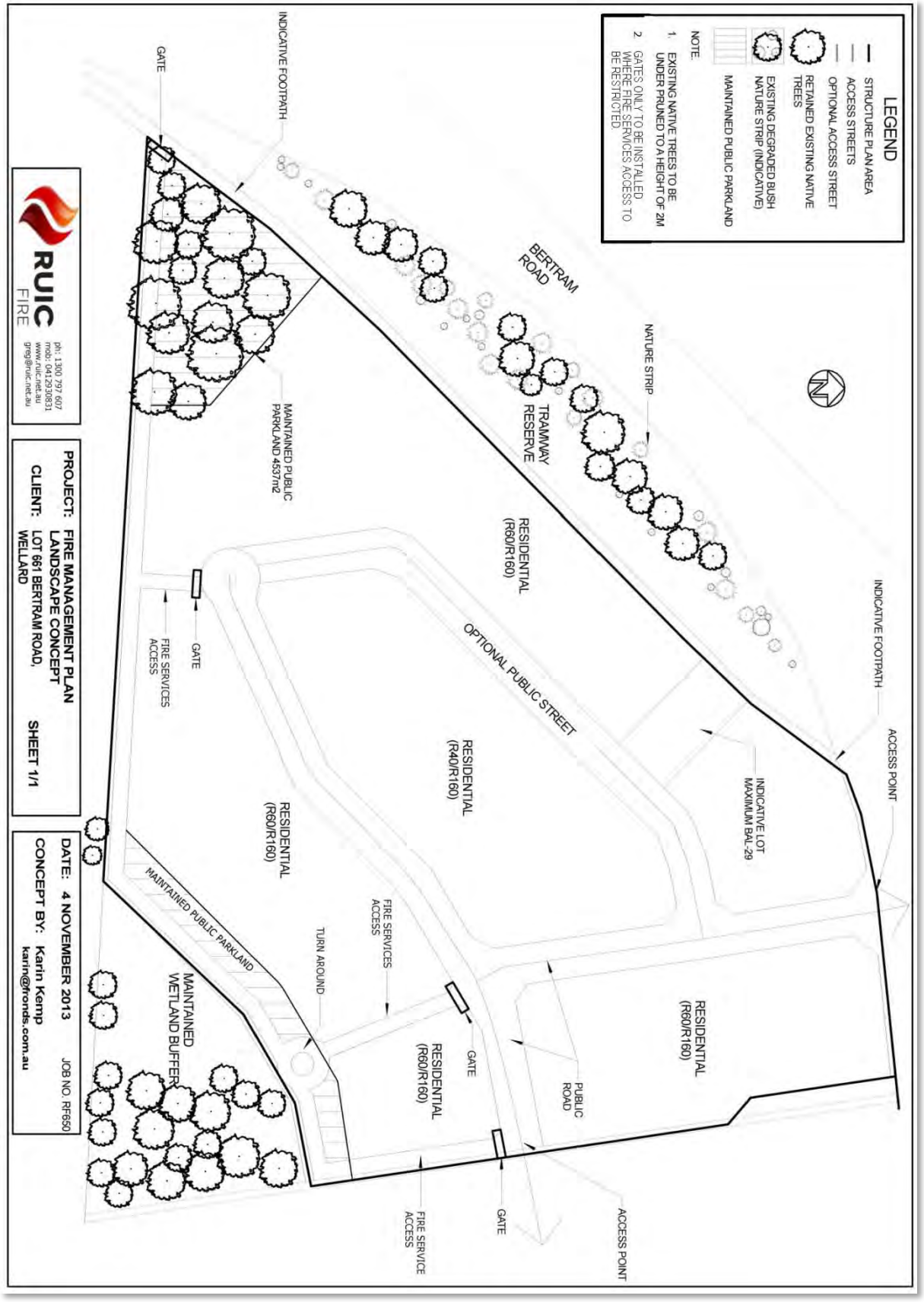


Figure 4B: Fire Management Plan indicative site layout

5.0 Compliance Checklist for Performance Criteria and Acceptable Solutions

5.1 Bushfire hazard levels and performance criteria

Level of bushfire hazard	Bushfire protection performance criteria
Low hazard	Development does not require special bushfire planning controls. Despite this FESA strongly recommends that ember protection features be incorporated in design where practicable.
Moderate hazard	Performance criteria for: • location (P1) • vehicular access (P2) • water (P3) • siting of development (P4) • design of development (P5)
Extreme hazard	Development is to be avoided in areas with these hazards

Table 5A: Bushfire hazard levels and performance criteria (FESA, 2010)

5.2 Performance Criteria and Compliance

The site has been assessed as having a moderate hazard level and is therefore subject to meeting the performance criteria as detailed. It is important to note that the acceptable solutions listed in *Planning for Bushfire Protection Guidelines 2nd Edition* only illustrate "one example of meeting the associated performance criteria" (FESA, 2010, p.28). Where an acceptable solution may not be suitable a performance solution may be implemented. Justification of Performance Solutions is provided in the section 4 of this report.

Element	Acceptable Solution	Compliance	Yes/ No	Acceptable Solution (AS) or Performance Based Solution (PBS)
1. Location	A1.1 Development location	Does the proposal comply with performance criteria P1 by applying acceptable solution A1.1?	NO	PBS 1 PBS 2
2. Vehicular Access	A2.1 Two access routes	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.1?	YES	AS 1
	A2.2 Public roads	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.2?	NO	PBS 3
	A2.3 Cul-de-sacs	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.3?	NO	PBS 4
	A2.4 Battle axes	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.4?	NO	PBS 5
	A2.5 Private driveways	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.5?	NO	PBS 6
	A2.6 Emergency access ways	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.6?	N/A	
	A2.7 Fire service access	Does the proposal comply with performance	NO	PBS 7

	routes	criteria P2 by applying acceptable solution A2.7?		
	A2.8 Gates	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.8?	YES	AS 2
	A2.9 Firebreak widths	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.9?	YES	AS 4
	A2.10 Signs	Does the proposal comply with performance criteria P2 by applying acceptable solution A2.10?	N/A	AS 3
3. Water	A3.1 Reticulated supply	Does the proposal comply with performance criteria P3 by applying acceptable solution A3.1?	YES	AS 5
	A3.2 Non reticulated areas – water tanks	Does the proposal comply with performance criteria P3 by applying acceptable solution A3.2?	N/A	
	A3.3 Non reticulated areas - dam	Does the proposal comply with performance criteria P3 by applying acceptable solution A3.3?	N/A	
4. Siting of development	A4.1 Hazard separation – moderate to extreme bush fire hazard level	Does the proposal comply with performance criteria P4 by applying acceptable solution A4.1?	NO	PBS8
	A4.2 Hazard separation – low bush fire hazard level	Does the proposal comply with performance criteria P4 by applying acceptable solution A4.2?	N/A	
	A4.3 Building protection zone	Does the proposal comply with performance criteria P4 by applying acceptable solution A4.3?	NO	PBS 8
	A4.4 Hazard separation zone	Does the proposal comply with performance criteria P4 by applying acceptable solution A4.4?	NO	PBS 8
	A4.5 Reduction in bushfire attack due to shielding	Does the proposal comply with performance criteria P4 by applying acceptable solution A4.5?	N/A	
5. Design of development	A5.1 Compliant development	Does the proposal comply with performance criteria P5 by applying acceptable solution A5.1?	NO	PERFORMANCE BASED DESSIGN SOLUTIONS
	A5.2 Non-compliant development	Does the proposal comply with performance criteria P5 by applying acceptable solution A5.2?	YES	PBS 9

Table 5B: Performance Criteria Compliance

5.3 Conclusion

This Fire Management Plan demonstrates compliance of the Local Structure Plan with all relevant criteria in Planning for Bushfire Protection Guidelines 2nd Edition (FESA, 2010). Bushfire engineering incorporating design bushfire parameters ensures potential heat flux impact on dwellings exceeds the levels determined in accordance with AS3959:2009. In undertaking the risk mitigation procedures identified in this Fire Management Plan the client is demonstrating due diligence (Robinson et al., 2011) in regards to bushfire risk.

6.0 References

AS3959 Construction of buildings in bushfire prone areas (2009).

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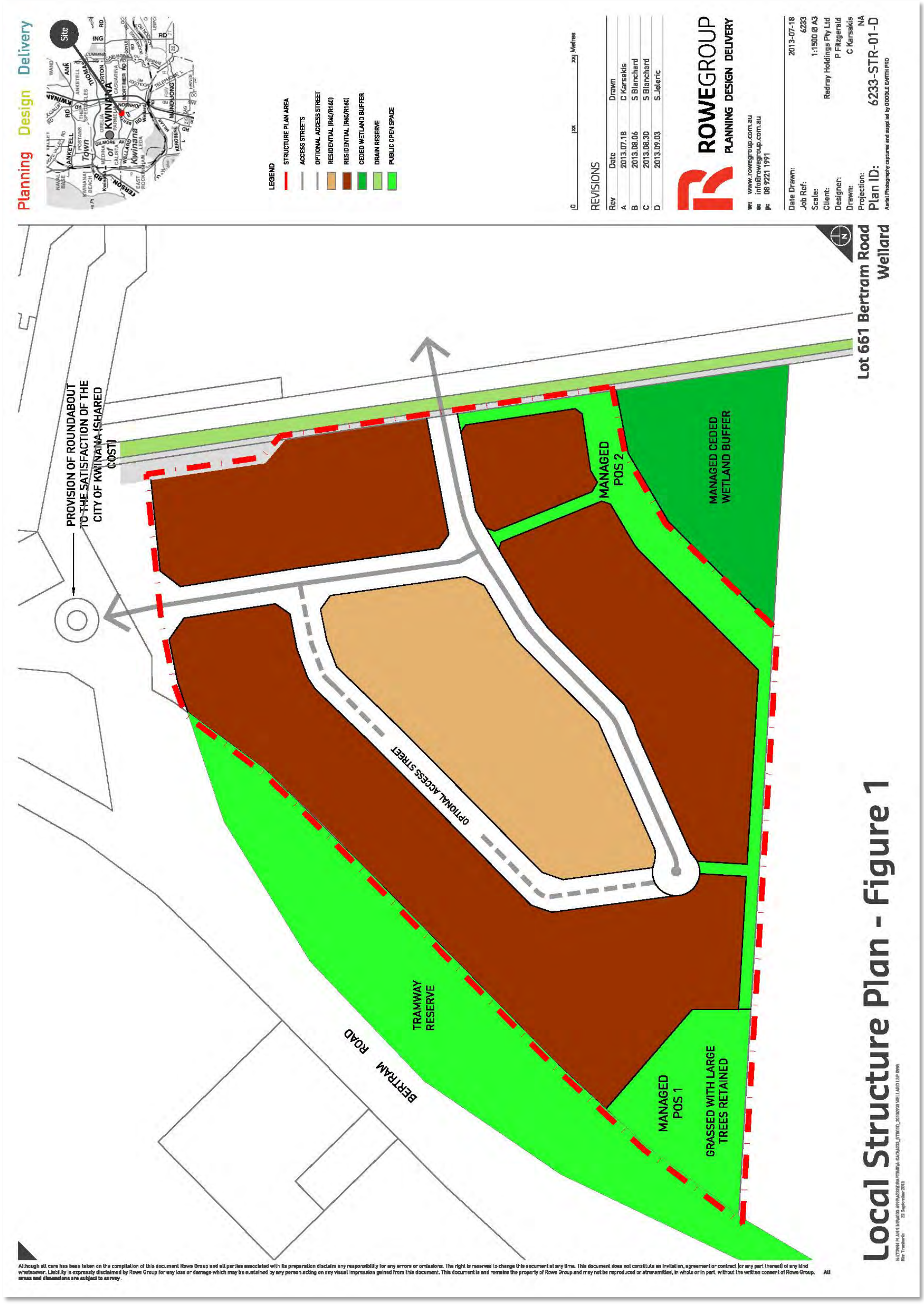
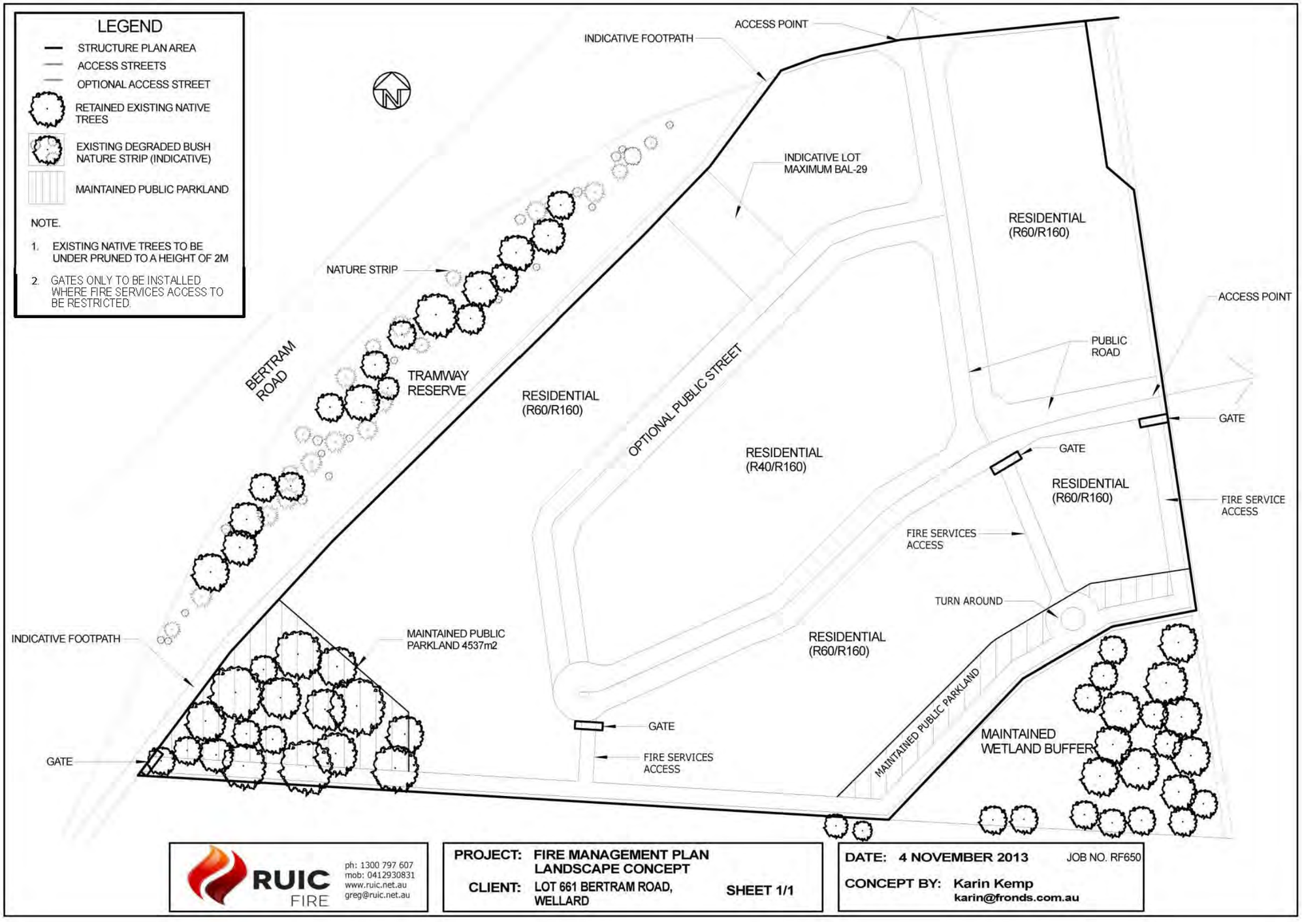
Tan, Z. (2013a). *Transmissivity Calculator*.

Tan, Z. (2013b). *View Factor Calculator*.

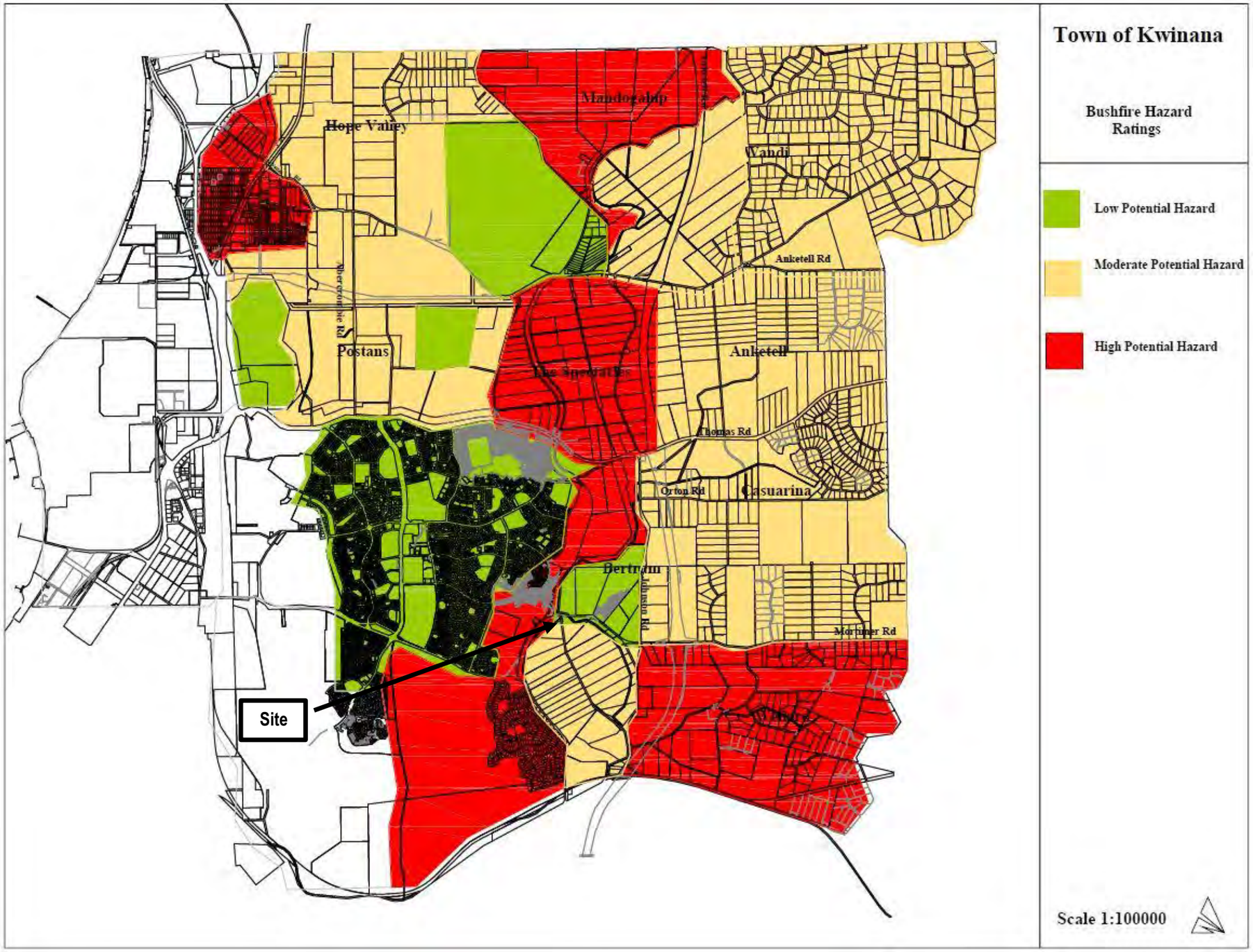
7.0 Appendix 1 – Local Structure Plan Map



8.0 Appendix 2 – Fire Management Plan Map



9.0 Appendix 3 – City of Kwinana Bushfire Hazard

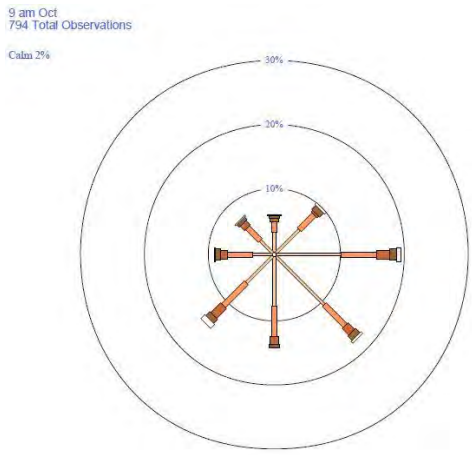
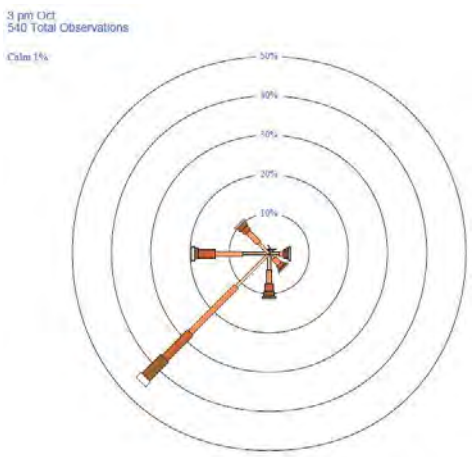
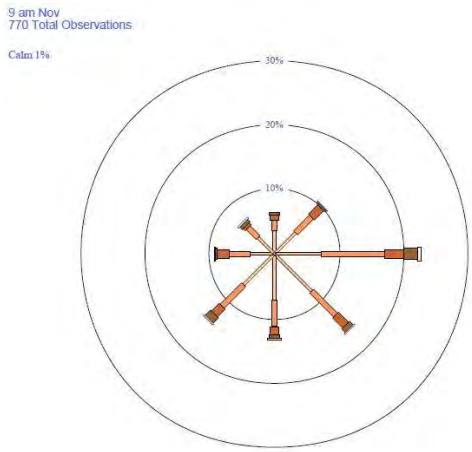
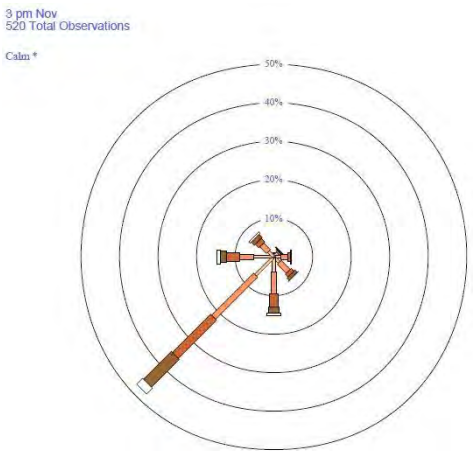
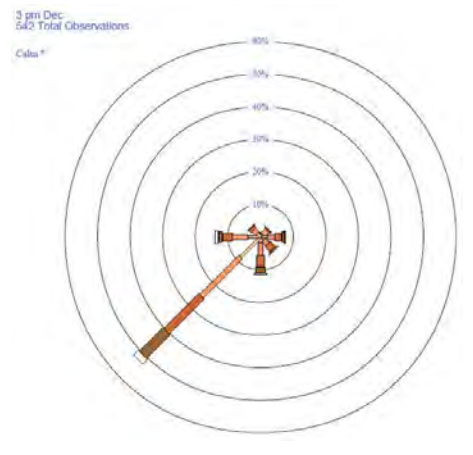


10.0 Appendix 3 – Bushfire Weather

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max Temp (°C)	44.9	45.8	43.3	36.5	32.9	26.2	25.8	26.0	30.9	37.8	41.4	45.0	-
Min Temp (°C)	20.2	19.2	18.0	16.0	12.4	11.4	12.6	12.8	14.6	14.8	13.9	19.7	-
Mean Rainfall (mm)	12.1	19.6	19.5	39.9	98.7	145.2	147.5	114.2	76.4	40.2	32.6	12.2	763.9
Mean 9am Humidity	53	56	61	67	77	82	83	79	73	65	60	55	68
Mean 3pm Humidity	42	42	44	50	57	63	64	60	58	53	49	45	52

Table 7A: Climate Data (Bureau of Meteorology, 2013, Station 9194)

Figure 7A: Maximum temperature (since 1983) vs minimum rainfall (since 1983)

Month	0900hrs	1500hrs
October		
November		
December		

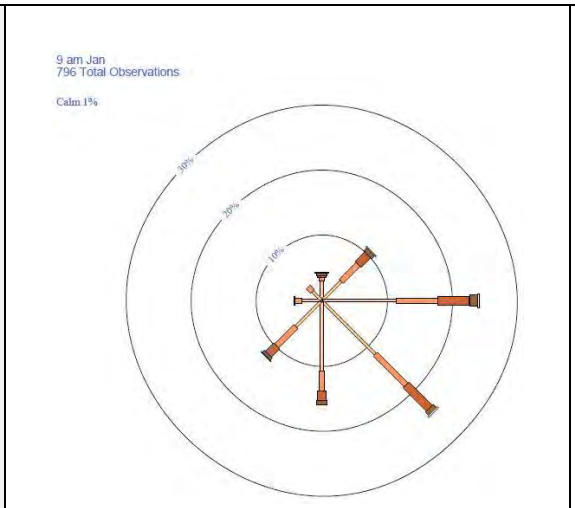
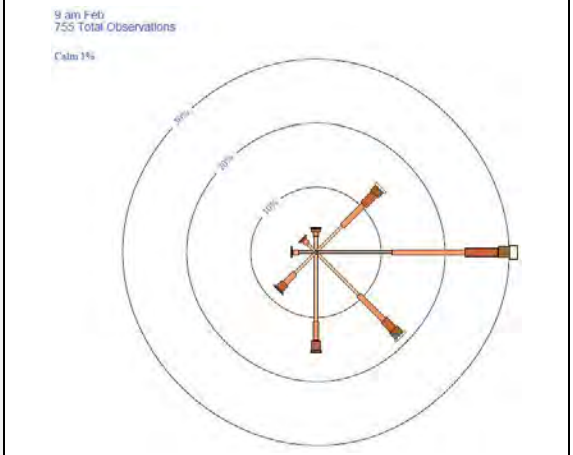
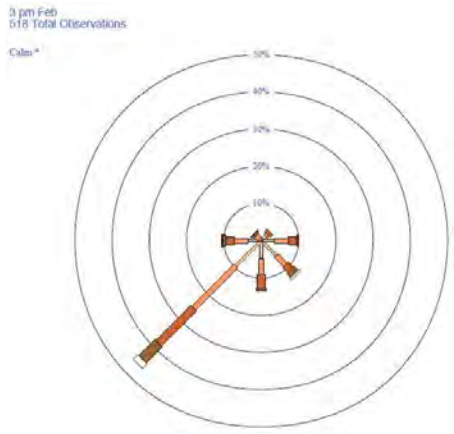
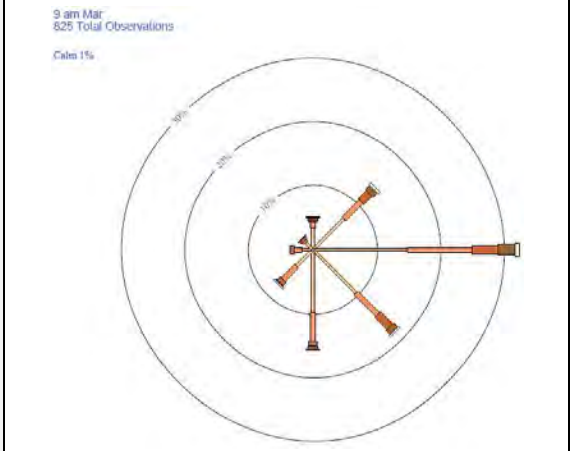
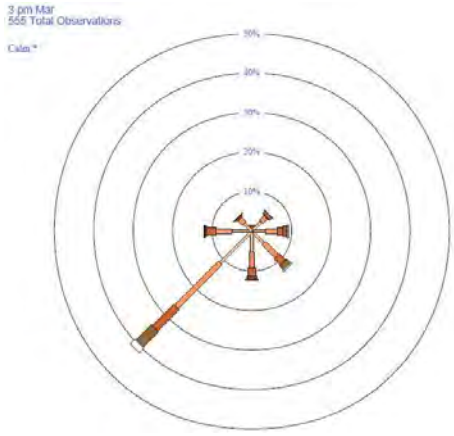
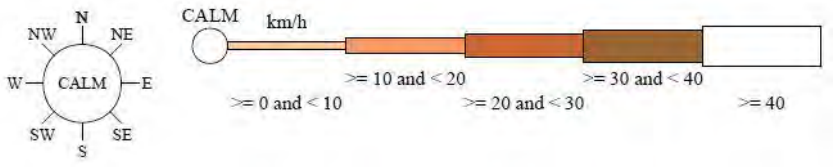
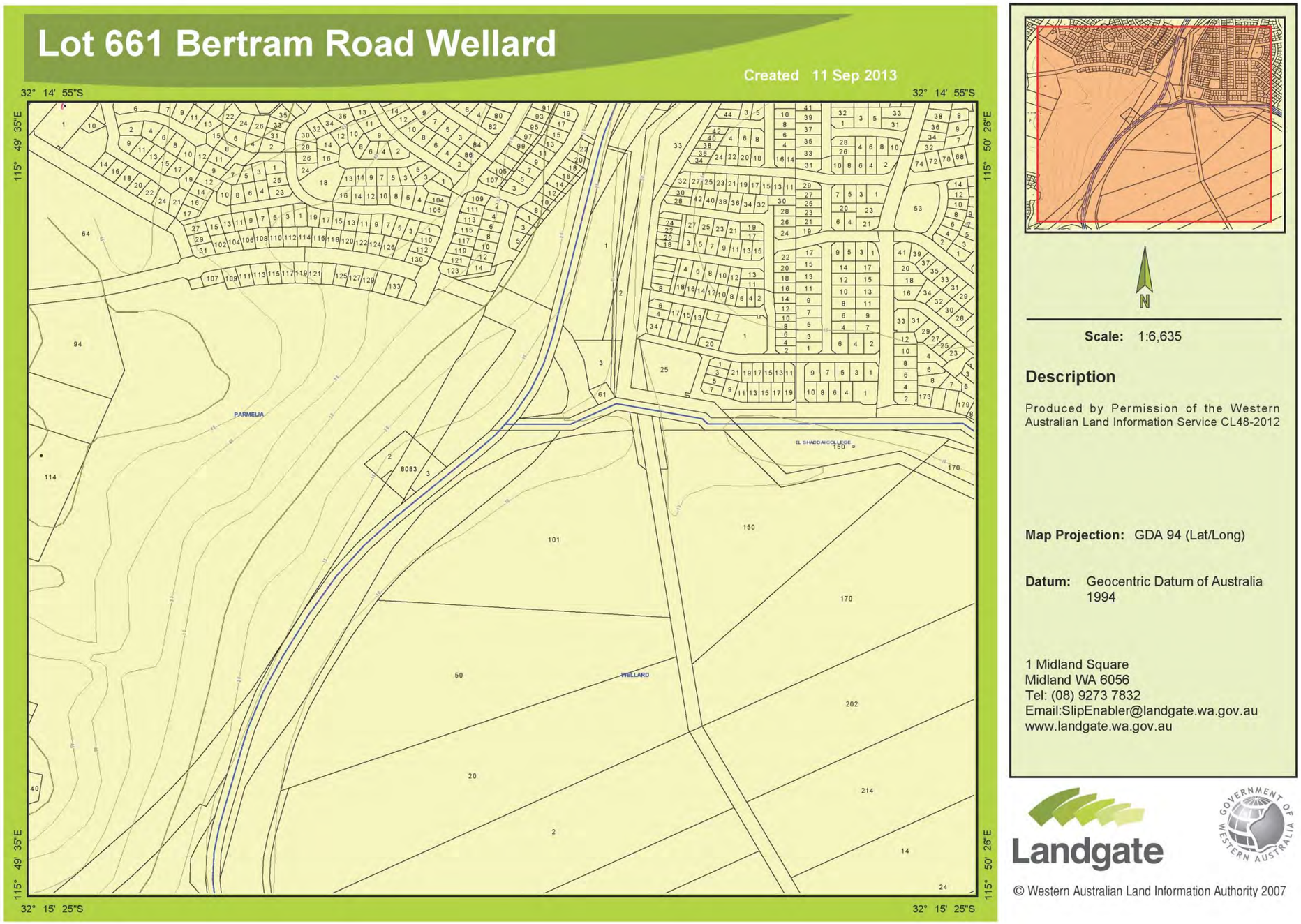
January		
February		
March		
Guide		

Table 7B: Windrose profiles (Bureau of Meteorology, 2013)

11.0 Appendix 5 – Site Topography



12.0 Appendix 6 – Abbreviations & Terms

12.1 Abbreviations Used in the Fire Management Plan

BPZ	Building Protection Zone
DEC	Department of Environment and Conservation
DFES	Department of Fire and Emergency Services (formerly FESA)
DPAW	Department of Parks and Wildlife (Formerly DEC)
FESA	Fire and Emergency Services Authority of Western Australia
FMP	Fire Management Plan
HSZ	Hazard Separation Zone
WAPC	Western Australian Planning Commission

12.2 Terminology Used in the Fire Management Plan

All terminology is sourced from AS3959:2009; Ellis, Kanowski and Whelan (2004); FESA (2011); Ramsay and Rudolph (2003); and *Building Codes of Australia* (2012).

Acceptable risk	That level of risk that is sufficiently low that society is comfortable with it. Society does not generally consider expenditure in further reducing such risks justifiable
Aerial fuel	The standing and supporting combustibles not in direct contact with the ground and consisting mainly of foliage, twigs, branches, stems, bark and creepers
Appliance	A firefighting vehicle, usually equipped with a pump and water supply.
Area of origin	General location where the fire started.
Aspect	The direction towards which a slope faces
Available fuel	The portion of the total fuel that would actually burn under various specified weather conditions.
Available resources	Resources at an incident and available for allocation at short notice
Biodiversity	The variety of nature, including the number of species and the amount of genetic variation present in an area of interest; the range of native plants

	and animals found at a particular site
Buffer	(1) A protective margin of vegetation abutting a stream, spring, wetland, body of standing water, swampy ground or an area of rainforest, which protects it from potentially detrimental disturbances in the surrounding forest. Buffer width is defined as horizontal distance from which various operations are excluded. (2) A protective margin of vegetation around the edge of an area that shields or protects the surrounding vegetation from the effects of a fire or timber harvesting activities, etc. (3) A strip or block of land identified as providing a zone of defined activity or activity limits surrounding a specified area. (4) A fuelbreak.
Burning Debris	Flaming or smouldering branches, twigs, bark or other pieces of ignited material.
Bush	A general term for forest or woodland but normally used to describe indigenous forest
Bushfire	(1) Used synonymously with wildfire to describe an unplanned fire (burning in predominantly native vegetation) (2) A general term used to describe a fire in vegetation (3) An unplanned fire in bush. This is a general term, uniquely used by Australians, and includes grass fires, forest fires and scrub fires—that is, any fire outside the built-up urban environment. Also sometimes known as a wildfire. In the United States it is called a wildfire and sometimes a 'wildland fire'; in Europe and Asia it is usually called a 'forest fire'.
Bushfire danger period	A period of the year, either established by legislation or declared by the relevant agency, when restrictions are placed on the use of fire due to dry vegetation and the existence of conditions conducive to the spread of fire
Bushfire threat	A term used to describe and analyse the danger that a bushfire poses in a particular place, or to specified values. There are four aspects: (1) the risk of a fire starting, and of it becoming uncontrollable; (2) the values which will be lost or damaged if a bushfire starts and gets away;

	(3) the extent of damage which could be caused; and (4) the resources which can be brought to bear on a fire and their efficiency and effectiveness.
Bushfire prone area	Land which has been designated under a power of legislation as being subject, or likely to be subject, to bushfires.
Canopy	The crown of a tree.
Climate	The atmospheric conditions of a place over an extended period of time.
Coarse fuel	Dead fuel of diameter greater than 6mm, such as logs and large branchwood
Consequence	The outcome of an event expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. There may be a range of possible outcomes associated with an event
Crown fire	A fire burning in the crowns of trees.
Crown land	Land that is, or is deemed to be, unalienated land of the Crown. It includes: (1) land of the Crown reserved permanently or temporarily or set aside by or under an Act; (2) land of the Crown occupied by a person under a lease, licence or other right
Dead fuels	Fuels having no living tissue. Their moisture content is governed almost entirely by atmospheric moisture (relative humidity and precipitation), air temperature and solar radiation.
Drought factor	A broad measure of fuel availability as determined by drought index and recent rainfall
Drought index	A numerical value, such as the Keetch–Byram Drought Index, reflecting the dryness of soils, deep forest litter, logs and living vegetation
Ecosystem	An assemblage of plants and animals in a particular physical environment A terrestrial ecosystem encompasses a particular biota, the soil, rock outcrops, wetlands and waterways and the atmosphere. Different ecosystems may respond differently to external pressures, for example, a bushfire, a frost, a flood or prolonged drought. The principal focus of the science of ecology is to understand different responses to imposed or natural events, and the many interactions between species and the

	environment.
Elevated dead fuel	Dead fuel forming part of, or being suspended in, the shrub layer.
Elevated fuel	Combustible material that is erect or suspended above the ground surface, and often comprises shrub, heath and suspended material.
Embers	Glowing particles cast from the fire (as 'showers' or 'storms').
Escape route	A situation in which individuals are exposed to life threatening or potentially life threatening conditions from which they cannot safely remove themselves
Extreme (bushfire) conditions	Extreme bushfire conditions occur when the fuel load is high, the temperature is high, the wind strength is high, the drought index is high, the relative humidity is low, and the fuel moisture is low. These conditions can occur every summer in southern Australia. A bushfire occurring under extreme conditions moves rapidly and generates intense heat and is very difficult or impossible to suppress
Extreme fire behaviour	A level of wildfire behaviour characteristics that ordinarily precludes methods of direct suppression action. One or more of the following is usually involved: (1) high rates of spread (2) prolific crowning and/or spotting (3) presence of fire whirls (4) a strong convection column Predictability is difficult because such fires often exercise some degree of influence on their environment and behave erratically, sometimes dangerously.
Fine fuel	Fuels such as grass, leaves, and fine twigs that ignite readily and are burnt rapidly when dry. They are usually defined as less than 6 millimetres in thickness.
Fingers	Long and narrow slivers of fire which extend beyond the head or flanks.
Fire access road/track	A track constructed and/or maintained for fire management purposes, which is generally of a standard adequate for all-weather use by two-wheeldrive vehicles.
Fire behaviour	The manner in which a fire reacts to the variables of fuel, weather and topography. Common measures of fire behaviour are rate of spread, flame

	height, fire spotting distance and intensity
Fire break	Any natural or constructed discontinuity in a fuel bed that may be used to segregate, stop and control the spread of a fire, or to provide a fire control line from which to suppress a fire
Fire danger	(1) The resultant of all the factors, which determine whether fires start, spread and do damage, and whether and to what extent they can be controlled. (2) An index which combines all the factors that determine the likelihood of a bushfire starting, spreading and causing damage to identified values, and the difficulty of control. Used for daily preparedness planning by land managers and on signs warning the public of the daily fire danger on a scale from low to extreme.
Fire Danger Index (FDI)	A relative number (1 to 100) denoting an evaluation of rate of spread or suppression difficulty for specific combinations of fuel, fuel moisture and wind speed.
Fire danger rating (FDR)	A relative phrase denoting an evaluation of rate of spread or suppression difficulty for specific combinations of fuel, fuel moisture and wind speed
Fire hazard	Any fuel which if ignited may be difficult to extinguish
Fire hazardous area	An area where the combination of vegetation, topography, weather and the threat of fire to life and property, create difficult and dangerous problems
Fire intensity (kW/m)	(1) The rate of energy release for a given unit of fire perimeter. (2) The heat (kilowatts) released per metre of fire perimeter; classified as low (<500 kWm-1), moderate (500–3000 kWm-1), high (3000–7000 kWm-1) or very high (7000–70 000 kWm-1).
Fire risk	The probability of a fire starting
Fire run	A rapid advance of a fire front. It is characterised by a marked transition in intensity and rate of spread
Fire storm	Violent convection caused by a large continuous area of intense fire. Often characterised by destructively violent surface indrafts, a towering convection column, long distance spotting, and sometimes by tornado like whirlwinds
Flame angle	The angle of the flame in relation to the ground, caused by wind direction

	or the effect of a slope.
Flame height	The vertical distance between the tip of the flame and ground level, excluding higher flame flashes
Flammability	The ease with which a substance is set on fire
Forest	(1) An area, incorporating all living and non-living components, that is dominated by trees with an existing or potential stand height exceeding 5 metres, and with existing or potential projective foliage cover of overstorey strata of at least 30 per cent. This definition includes Australia's diverse native forests and plantations, regardless of age. (2) Woody vegetation with a potential top height greater than five metres and with a crown cover projection greater than 10 per cent.
Forest Fire Danger Index (FFDI)	The index related to the chances of a fire starting, its rate of spread, intensity and difficulty of suppression according to various combinations of temperature, relative humidity, wind speed and both long and short term drought effects in a forest. See also *Fire Danger Index*. Readings are normally taken at 3 pm.
Forward rate of spread	The linear rate of advance of the head fire, usually expressed in kilometres per hour or metres per second
Fuel	*Fire fuel.* Any material such as grass, leaf litter, twigs, bark, logs and live vegetation that can be ignited and sustain a fire. Measured in tonnes per hectare. *Fuel type*. An association of fuel characteristics such as species, form, size, and arrangement that will cause a predictable rate of spread, or difficulty of suppression, under specified weather conditions. (1) *Heavy fuel*. Dead woody material in contact with the soil surface, greater than 25 millimetres in diameter. Also called 'coarse fuel'. (2) *Litter fuel.* The top layer of the forest floor composed of loose dead sticks, branches, twigs and recently fallen leaves little altered by decomposition. (3) *Surface fuel*. The loose surface litter on the forest floor. Can consist of fallen leaves, twigs, bark, small branches, grasses,

	shrubs, tree saplings less than a metre high, heavier branches, fallen logs, stumps, seedlings and small plants. (4) *Trash*. The component of surface fuel above the leaf litter layer made up of dead twigs, branches and scrub debris of at least 10 millimetres diameter. (5) *Fine fuel.* Dead leaves, twigs and bark in the litter layer less than 6 millimetres thick as well as the green leaves and twigs of shrubs and grasses less than 2 millimetres in diameter, and all less than 1 metre above the ground. (6) *Elevated fuel*. Fuels that are suspended above the ground, such as shrubs, bark, seedlings. (7) *Available fuel.* The amount or weight of fuel that will be consumed under prevailing weather conditions during a prescribed burn or a bushfire. Available fuel can be less than total fuel, where part of the fuel profile is still damp from previous rain. Measured in tonnes per hectare. (8) *Total fuel*. The sum of the fuel quantity of litter, trash, scrub and fuels that are available to burn under extreme wildfire conditions. Measured in tonnes per hectare. (9) *Fuel age*. The period of time elapsed since fuel was last burnt, usually expressed in years. (10) *Fuel load*. The oven-dry weight of fuel per unit area. Also known as fuel quantity. Expressed as tonnes per hectare.
Fuel array	The totality of fuels displayed in a location: fine and coarse, live and dead
Fuel moisture content	The moisture content of fuel expressed as a percent of the oven dry weight of the fuel.
Fuel reduction burn	A prescribed burn carried out with the intention of reducing the fire fuel so as to minimise the intensity of any subsequent bushfire and to ensure the bushfire is easier and safer to suppress
Grassfire	An unplanned fire burning in predominantly grassy fuels.
Grassland curing	A proportion of dead material in grasslands—usually increases over summer as tillers die off and dry out, increasing the risk of grassland fire
Hazard	A source of potential harm, or a situation with a potential to cause loss

Head fire	The part of a fire where the rate of spread, flame height and intensity are greatest, usually when burning downwind and/or upslope
Ignitability	The ease with which a material ignites
Indirect attack	A fire suppression method where the fire is intended to be brought under control a considerable distance away from its current position, but within a defined area, bounded by existing or planned fire control lines. Backburning is a common method of achieving this
Keetch–Byram Drought Index (KBDI)	A numerical value reflecting the dryness of soils, deep forest litter, logs and living vegetation and expressed as a scale from 0 to 200.
Likelihood	Used as a qualitative description of probability or frequency
Litter	The top layer of the forest floor composed of loose debris of dead sticks, branches, twigs, and recently fallen leaves and needles
Low Threat Vegetation	Vegetation defined in AS3959:2009 section 2.2.3.2 (1) Vegetation of any type that is more than 100 m from the site. (2) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified. (3) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other. (4) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified. (5) Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops. (6) Low threat vegetation, including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks. NOTE: Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).
Mild conditions	Conditions of weather and fuel such that if a fire starts it will behave mildly and can be easily suppressed. For example: (1) wind—less than 15 kilometres per hour (2) temperature—less than 25°C (3) relative humidity—greater than 50 per cent (4) moisture content of fuel 2 to 20 per cent (5) tonnes per hectare of fuel—up to 8 tonnes per hectare.

Mineral earth	A non-flammable soil surface, either natural or prepared.
Objective	A goal statement of what is to be achieved
Plantation	A forest established by the planting of trees of either native or exotic species. Can also comprise dense plantings of commercial shrub species, for example oil mallees or tea tree plantations, or horticultural crops such as sugar cane. Any area of planted trees, other than a wind break, that exceeds three hectares in a gazetted town site or elsewhere a stand of trees 10 hectares or larger, that has been established by sowing or planting native or exotic tree species selected and managed intensively for their commercial and environmental value. A plantation includes roads, tracks, fire breaks and small areas of native vegetation.
Preparedness	All activities undertaken at any time in advance of a wildfire occurrence to decrease wildfire area and severity and to ensure more effective suppression
Prescribed burn	The controlled application of fire to a defined area of land conducted in accordance with an approved burn plan to meet specified management objectives
Rate of spread (ROS)	The rate at which a fire advances. It is measured in metres per hour. Mild fires used for prescribed burning in forests have rates of spread generally below 40 metres per hour. A bushfire spreads in four directions—the headfire (which burns downwind or with the wind behind it), the flank fires (which spread sideways) and the tailfire (where the back of the fire burns slowly into the wind). A fire is usually elliptical in shape, since the headfire rate of spread is always at least double the flankfire rate of spread. Intense bushfires can have a headfire rate of spread that exceeds 3000 metres an hour. The rate of spread depends mainly on wind strength, vegetation type, fuel quantity and slope.
Relative humidity	The amount of water vapour in a given volume of air, expressed as a percentage of the maximum amount of water vapour the air can hold at that temperature

Residual risk	The remaining level of risk after risk treatment measures have been taken
Risk	The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood
Risk reduction	A selective application of appropriate techniques and management principles to reduce either likelihood of an occurrence, its consequences, or both
Scorch height	The maximum height above the ground to which the leaves of trees or shrubs are browned by a fire. Generally about four times the flame height. In Australia, eucalyptus tree crowns that are merely scorched by a fire tend to recover, whereas trees that are defoliated can take several years to recover or may never recover
Scrub	Vegetation, such as heath and shrubs, that grows either as an understorey or by itself in the absence of a tree canopy. The components of scrub are usually called shrubs. In coastal areas, scrub is often referred to as 'heath' or 'heathland'.
Spot fire	A new fire occurring downwind of a headfire (up to 10 kilometres has been observed), usually started by a piece of burning bark. Compare with 'hop over' which is a new fire that has started immediately across a fireline and not necessarily at the headfire
Spotting	Behaviour of a fire producing sparks or embers that are carried by the wind or convective activity and start new fires beyond the zone of direct ignition by the main fire
Structure fire	A fire burning part or all of any building, shelter or other construction
Surface fire	A fire that travels just above ground surface in grass, low shrub, leaves and litter
Topography	The nature of the land surface in terms of slope, steepness, aspect, elevation and landscape pattern. Terms such as mountainous, hilly, undulating, and flat describe the general topography
Total fire ban	Total fire ban (day); declared for days of very high fire risk in regions of the state; prohibits the lighting of any fires in the open air
Urban–rural interface	The line, area or zone where structures and other human development adjoin or overlap with undeveloped bushland
Water point	Any natural or constructed supply of water that is readily available for fire

	control operations
Woodland	Large tract of land covered by trees but more open than a forest and often with a grassy understorey.

APPENDIX 5
LOCAL WATER MANAGEMENT STRATEGY

Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

Lot 661 Bertram Rd, Wellard

Local Water Management Strategy

June 2015

JDA Consultant Hydrologists

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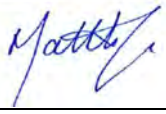
Checked by	Matthew Yan		30 June 2015
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1. INTRODUCTION

1.1 Planning Background

This document details a Local Water Management Strategy (LWMS) for Lot 661 Bertram Rd, Wellard (herein referred to as the Study Area) prepared by JDA Consultant Hydrologists on behalf of the Royale Australian Golf Club Pty Ltd. The location of the Study Area is shown in Figure 1.

On 15 December 2014, the Western Australian Planning Commission (WAPC) approved the Lot 661 Bertram Rd – Wellard, Wellard Local Structure Plan, subject to modifications including preparation of a Local Water Management Strategy (LWMS) to the satisfaction of the Department of Water and City of Kwinana.

This LWMS document has been prepared to support the LSP for the Study Area and to provide conceptual level drainage planning to assist in providing a coordinated approach to future subdivision.

This document presents a recommended approach for total water cycle management within the Study Area consistent with sustainability principles. The document is consistent with State Planning Policy 2.9 Water Resources (GoWA 2006) and guidelines presented in Better Urban Water Management (WAPC 2008).

The compilation of this document has included a range of expertise and guidelines from leading government authorities including the Department of Environment and Conservation (DEC), Department of Water (DoW), and City of Kwinana (CoK), to assist in achieving the implementation of best practice in sustainable urban development and urban water management.

A copy of a completed LWMS Checklist for Developers (WAPC, 2008) has been included as Appendix A to assist the City and DoW in review of this document.

1.2 Key Principles and Objectives

1.2.1 Reference Documents

This LWMS uses the following key documents to define its principles, criteria, and objectives:

- Better Urban Water Management (WAPC, 2008)
- Decision Process for Stormwater Management in WA (Department of Water ,2009a)
- Stormwater Management Manual for WA (Department of Water, 2007)
- Statement of Planning Policy 2.9: Water Resources (WAPC, 2004);
- Peel-Harvey WSUD Local Planning Policy (PDC, 2006);
- Peel-Harvey Water Sensitive Urban Design Technical Guidelines (PDC 2006)
- Peel-Harvey Water Quality Improvement Plan (PDC, 2006);
- Jandakot Drainage and Water Management Plan: Peel main drain catchment (Department of Water, 2009b)
- Bollard Bulrush Swamp West District Water Management Strategy (ENV 2011)

Summaries of key principles and objectives applicable to the LWMS for the Study Area based on these documents are provided in Table 1 and summarised in Sections 1.2.1 to 1.2.5.

Table 1: Summary of LWMS Principles and Objectives

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Encourage environmentally responsible development • Provide integration with planning processes and clarity for agencies involved with implementation • Facilitate adaptive management responses to the monitored outcomes of development • To minimise public risk • To maintain the total water cycle		
Category	Principles	Objectives
Water Use	• Consider all potential water sources in water supply planning • Integration of water and land use planning • Sustainable and equitable use of all water sources having consideration of the needs of all users, including community, industry and environment • No potable water should be used outside of homes and buildings	• Minimise the use of potable water where drinking water quality is not essential, particularly ex-house uses • Consumption target for potable water of 40 – 60 kL/ person/ year
Groundwater Levels and Surface Water Flows	• To retain natural drainage systems and protect ecosystem health • To protect from flooding and waterlogging • To implement economically viable stormwater systems • Post development annual discharge volume and peak flow rates to remain at predevelopment levels or defined environmental water requirements • Minimise change in peak winter levels at groundwater dependent wetlands due to urbanisation	• Manage 1 year 1hour events as close to source as possible to minimise runoff. • Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles • For flood management, manage up to the 1 in 100 year ARI event within the development area to predevelopment flows • Retain and restore existing elements of the natural drainage system.

Groundwater and Surface Water Quality	• To maintain or improve groundwater and surface water quality
	• Where waterways/open drains intersect the water table, minimise the discharge of pollutants from groundwater
	• Where development is associated with an ecosystem dependent upon a particular hydrologic regime, minimise discharge or pollutants to receiving waterways and maintain water quality in specified environment.
	• As compared to a development that does not actively manage stormwater quality:
	  • At least 80% reduction of TSS
	  • At least 60% reduction of TP
	  • At least 45% reduction of TN
	  • At least 70% reduction of gross pollutants
		• Implement current known best management practice as detailed in the DoW's Stormwater Management Manual for Western Australia (2007) and the Decision Process for Stormwater Management in Western Australia. (DoW 2009), with an emphasis on a treatment train approach including nutrient input source control, use of bioretention systems, rehabilitation of waterways as living streams, and maintaining 1 in 1 year ARI post development discharge volumes and peak flow rates at pre development levels.

Disease and Nuisance Insect Management	• To reduce health risks from mosquitoes, retention and detention treatments should be designed that between November and May detained immobile stormwaters are fully infiltrated in a time period not exceeding 96 hours	• Permanent water bodies not proposed for the Study Area. • Detention/ retention areas to be design to ensure retained immobile stormwaters fully infiltrated in a time period not exceeding 96 hours.

1.2.2 Planning Policy 2.9 and Liveable Neighbourhoods

The LWMS has been developed in accordance with regional and local principles and objectives of integrated urban water management (IUWM).

The Western Australian Planning Commission (2004) defines IUWM (also known as total water cycle management) as promoting '*management of the urban water cycle as a single system in which all urban water flows are recognised as a potential resource and where the interconnectedness of water supply, stormwater, wastewater, flooding, water quality, waterways, estuaries and coastal waters is recognised*'.

IUWM should also promote water conservation measures, reuse and recycling of water and best practice in stormwater management (Western Australian Planning Commission 2004).

These objectives are consistent with Liveable Neighbourhoods (Western Australian Planning Commission 2009).

1.2.3 Stormwater Management Manual for WA

DoW's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (Department of Water, 2007), which details the management objectives, principles, and a stormwater delivery approach for WA. Principal objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

The DoW has also released a Decision Process for Stormwater Management in WA (DoW, 2009) to provide a decision framework for the planning and design of stormwater management systems and assist in meeting the objectives specified above.

1.2.4 Better Urban Water Management

This LWMS has been developed to be consistent with the framework and process detailed in WAPC's recently released urban water management planning guideline document Better Urban Water Management (WAPC, 2008).

This LWMS has been prepared to support local structure planning for the Study Area.

Consistent with WAPC (2008) an Urban Water Management Plan (UWMP) will be required to support subdivision applications within the Study Area in due course.

Further details specifying requirements of a UWMP are contained in Chapter 5 Implementation.

Table 2: Integrated Planning and Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Document and Status
Regional	-	Jandakot Drainage and Water Management Plan (DoW, 2009)
District	Amendment 1189/57	Bollard Bulrush West District Water Management Strategy (DWMS) (ENV, 2011)
Local	Lot 661 Bertram Rd, Wellard Local Structure Plan	Lot 661 Bertram Rd, Wellard Local Water Management Strategy (LWMS) **THIS DOCUMENT**
Subdivision	Subdivision Application	Urban Water Management Plan (UWMP) (required for individual stages of development) **FUTURE PREPARATION**

1.2.5 Regional Document Summary

Regional planning guidelines for the Study Area include the following three important documents:

- Peel-Harvey WSUD Local Planning Policy (PDC, 2006a);
- Peel-Harvey Water Sensitive Urban Design Technical Guidelines (PDC, 2006b);
- Peel-Harvey Water Quality Improvement Plan (PDC, 2008)

These documents provided guidance on the design, application, implementation and assessment of water sensitive urban design (WSUD) for the soil-hydrological conditions prominent throughout the Peel-Harvey region (PDC, 2006b).

The Local Planning Policy (PDC, 2006a) encourages the application of the WSUD principles discussed in the Technical Guidelines and provides advice for local government for the assessment of proposals within the EPP Policy Area of the Peel-Harvey region. The Water Quality Improvement Plan provides specific environmental quality objectives for WSUD in the region.

1.2.6 District Document Summary

District drainage and water management guidance is provided by the Jandakot Drainage and Water Management Plan (DWMP) (DoW, 2009) and the Bollard Bulrush West DWMS (ENV, 2011). The DWMP provides conceptual drainage management for the Jandakot Structure Plan area including the Peel Main Drain. The plan provides a catchment scale plan for drainage and water management on which smaller scale developments are based.

The DWMS (ENV, 2011) provides revised drainage management concepts based on the DWMP for the Bollard Bulrush West area draining to Bollard Bulrush Swamp and the Peel Main Drain. Specific discharge rates and conceptual estimated attenuation volumes are provided in the DWMS for sub-catchments of the Bollard Bulrush Swamp West catchment. The DWMS also provides appropriate district scale water design and management principles and objectives which are refined in this document.

2. PRE-DEVELOPMENT ENVIRONMENT

2.1 Location and Topography

The Study Area is approximately 6.97 ha in size, and located approximately 35km south of the Perth CBD within the City of Kwinana. The location of the Study Area is shown in Figure 1.

The topography is generally flat with a gentle grade north west to south east (Figure 2). Elevations range between approximately 4.5 mAHD and 8 mAHD.

A detailed feature survey of the Study Area has not been undertaken. LiDAR contours at 1m (DoW 2012) are shown in Figure 2.

2.2 Climate

The Study Area has a Mediterranean climate with warm dry summers and cool wet winters. The mean summer maximum temperature is 29.5 °C and the mean winter minimum temperature of 17.7 °C.

Annual rainfall recorded at the Bureau of Meteorology's Kwinana BP Refinery station (009064) is shown in Figure 3. The long term average annual rainfall for this site is 745 mm (1955 – 2012). Between 1955 and 1974 the annual rainfall average was 797 mm. The average annual rainfall has dropped since 1974, with the average annual rainfall of 703 mm from 1975 - 2012, reflecting a 6% reduction compared to the long term average and a 12% fall compared to the 1955 – 1974 period.

2.3 Existing Land Use

An aerial photograph (Nearmap, 2015) showing existing land use within the Study Area is shown in Figure 2. Field investigation by JDA indicates the Study Area has been previously used for market gardening; the land is currently used for horse agistment.

The Study Area is predominately cleared with a stand of remnant native trees in the south west. The swamp buffer appears highly degraded and predominately *kikuyu sp.* grass and blackberry bushes.

A search of the Aboriginal Heritage Site database by JDA indicates no known Aboriginal Heritage Sites within the Study Area. A search of the DEC Contaminated Sites database indicates no known contaminated sites within the Study Area.

2.4 Surface Geology

Surface geology and geotechnical mapping is shown in Figure 4. The 1:50,000 Rockingham Environmental Geology Mapping (GSWA 1985) indicates the geology of the Study Area is typically as follows:

- Ms5 SANDY SILT - dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content, of lacustrine origin
- S7 SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin as relatively thin veneer over clay, silt and clayey silt.
- S8 SAND - pale yellowish brown, medium to coarse-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin.

A geotechnical investigation has not been undertaken for the Study Area. A geotechnical investigation will be required prior to subdivision and the results of the investigation included in future water planning documentation including an Urban Water Management Plan (UWMP).

Based on JDA's experience on the Swan Coastal Plain, sands characterising the Study Area (S7, S8) have a low Phosphorus Retention Index (PRI). This is not critical for the LWMS as water quality improvement in

the post-development environment will rely on imported soils with a PRI>10 in bioretention or water quality treatment areas (see Section 4.4).

Due to the high proportion of silty soils over the Study Area opportunities for infiltration of stormwater will be limited in the existing soils.

2.5 Acid Sulfate Soils

Acid Sulfate Soil mapping is shown in Figure 4. Regional ASS mapping indicates majority of the Study Area is classified Moderate to High Risk of ASS within 3m of the natural surface. A small portion of the Study Area in the north east is classified as Moderate to Low Risk of ASS within 3 m of natural surface.

A preliminary site ASS investigation has not been performed as the majority of the site is already classified at the highest level of High Risk. A detailed ASS Investigation will be undertaken prior to subdivision and results and relevant management, as presented in any ASS Management Plan, referenced in the UWMP.

2.6 Wetlands

The Study Area is bounded to the South and East by Bollard Bulrush Swamp. The swamp is classified as a Conservation Category (CCW) wetland (DEC 2008). Wetlands and significant environmental features are shown in Figure 5.

The swamp is also listed under the Environmental protection (Swan Coastal Plain Lakes) Policy 1992 (EPP), made under Section 26 of the Environmental Protection Act. The DWMS (ENV 2011) indicates the Environmental Protection Authority (EPA) chose not to formally assess the DWMS project area on the basis that a separation buffer of 50m between the EPP Lake boundary and the proposed residential development will be maintained. Advice to this effect provided by the EPA is presented in Appendix B.

There are no Bush Forever sites within or adjacent to the Study Area.

2.7 Fresh Water Dependent Ecosystems

The Bollard Bulrush Swamp is listed under the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992. EPP Lakes are managed by the EPA; the EPA has approved a 50m wetland buffer from the EPP Lakes boundary. The buffer is shown in Figure 6 together with the EPP Lake and wetland boundaries.

In 2007 Ecoscape undertook an assessment of wetland ecological water requirements (EWRs) for the Bollard Bulrush Swamp. The EWRs were presented in the DWMP (DoW, 2009b) and are reproduced in Table 3.

Table 3: Bollard Bulrush Swamp Ecological Water Requirements (Ecoscape, 2007 in DoW, 2009)

Most Vulnerable Species			**Least vulnerable species**	**Most vulnerable species**	**Preferred maximum (mAHD)**
Wetland	Upper max. groundwater level (mAHD)	Lower max. groundwater level (mAHD)	Lower max. groundwater level (mAHD)	Upper min. groundwater level (mAHD)	0.50 < Upper min.
Bollard Bulrush Swamp	4.11	1.99	0.67	5.99	5.49

Post-development monitoring will be required to provide monthly groundwater level monitoring where groundwater levels within and directly adjacent to the swamp do not rise above the preferred maximum of 5.49 mAHD or fall below the lower maximum groundwater level of 1.99.

2.8 Surface Water Hydrology

2.8.1 Existing Surface Drainage

The Study Area is located within the floodplain of the regionally significant Peel Main Drain (PMD) and the Bollard Bulrush Swamp within the Peel Main Drain Catchment. The location the drain and swamp are shown in Figure 6. The Study Area drains south east toward Bollard Bulrush Swamp then to the PMD. There are a number of man-made water bodies in the south west of the Study Area. The soaks are groundwater fed; historical aerial photos and anecdotal evidence indicate the water bodies are wet year round and therefore intercept the lower groundwater table elevation during summer minimums.

The Study Area drains to the Bollard Bulrush Swamp in the south east via overland flow. The Peel Main Drain flows south discharging via a culvert under Millar Rd and ultimately discharging to the Serpentine River. Surface water flow is shown in Figure 6.

2.8.2 Surface Water Levels

A pre-development surface water monitoring program was undertaken by ENV (2011) for inclusion in the DWMS (ENV 2011) and to provide baseline conditions for future development. Surface water levels were taken from the upstream culvert and downstream culvert of Bollard Bulrush Swamp in the PMD and in two locations within the DWMS project area. Locations are shown in Figure 6 and levels presented in Table 4.

Table 4: Field Surface Water Level (ENV, 2011)

Location	Measured Surface Water Level (mAHD)
Peel Main Drain Upstream, Bertram Rd Culvert (Same location as PMD56)	5.17
Peel Main Drain Downstream, Millar Rd Culvert (Same location as PMD55)	3.96
SW1	4.26
SW2	4.26

There are a number of man-made surface water bodies in the south west of the Study Area. JDA field investigation undertaken 17th January 2013 indicates these are groundwater fed. The water level was between approximately 0.3 m and 0.7 m below the natural surface (Figure 7). Observation holes augered 10 – 30m from the water bodies indicate groundwater is consistent with water elevation within soaks.

It is not proposed to retain the water bodies in the proposed development.

During the JDA field investigation it was noted the Peel Main Drain was flowing; water was very shallow, approximately 0.2m, and is considered an expression of the groundwater table. Assessment of groundwater level in the field (see Section 2.9) supports this.

The design of the proposed development should incorporate a minimum habitable floor level 6.12 mAHD to meet the required clearance from the 100-year flood of 0.5m above the 100-year level of 5.62 m AHD.

2.8.3 Previous Drainage Planning

The Jandakot DWMP (DoW, 2009b) provides pre-development peak 10 and 100 year ARI flows and levels for the PMD and Bollard Bulrush Swamp as modelled by GHD (DoW 2009b). Peak flows and levels are presented in Table 5 and locations shown in Figure 6.

Table 5: Peel Main Drain Pre-development Flood Estimates

	10 Year ARI Level (mAHD)	10 Year ARI Flow (m^3/s)	100 Year ARI Level (mAHD)	100 Year ARI Flow (m^3/s)
PMD56 (Peel Main Drain Upstream, Bertram Rd Culvert)	7.9	3.25	8.20	3.82
BOLLCB (Bollard Bulrush Swamp)	4.82	3.38	5.62	4.00
PMD55 (Peel Main Drain Downstream, Millar Rd Culvert)	4.70	4.38	5.59	5.06

Criteria presented in Table 3 were readdressed by GHD (2010) as part of the preparation of the DWMS (ENV 2011). Modelling results presented in the DWMS indicate the pre-development flows and levels can be maintained at those parameters presented in the DWMP (DoW 2009b) with adequate onsite stormwater attenuation.

The Study Area is presented as a discrete catchment within the DWMS broad-scale model. The DWMS estimated 100 year ARI pre-development discharge and required flood storage volume for the Study Area is presented in Table 6. Peak flow estimates are consistent with JDA pre-development flow estimates presented in Section 2.8.4. These parameters provide the guideline for the refined stormwater management system presented by JDA in Section 4. The ENV (2011) estimated detention volumes are approximately 50% less than the JDA modelled volumes presented in Section 4.2 and Table 9; this is likely due to a higher runoff rate used by JDA for the post-development environment (See section 4.2.8).

Table 6: DWMS Pre-development Flood Estimates (ENV, 2011)

Detention Volume (m^3)		Peak Flow (m^3/s)
10 year ARI	**100 year ARI**	**100 year ARI**
849	1,100	0.048

2.8.4 JDA Pre-development Flow Estimates

JDA has estimated pre-development surface water flow from the Study Area to Bollard Bulrush Swamp. Modelling was undertaken using XP-Storm for the 100 year and 5 year ARI critical storm events. The 10 minute to 72 hour storm durations were modelled. Whilst predominately cleared and rural, the underlying soils for much of the Study Area are silty sand with variable clay content. As such, a runoff rate of 80% and an initial loss of 15.9mm (equivalent to the 1 year 1 hour storm event) were used for the existing environment. Results for the 100 year and 5 year ARI pre-development flow rates are presented in Table 7. Results are consistent with the DWMS (ENV, 2011).

Table 7: Pre-development Flow Estimates (JDA)

Catchment	100 Year ARI Flow (m^3/s)	5 Year ARI Flow (m^3/s)
Study Area	0.047	0.025

2.8.5 Surface Water Quality

Pre-development surface water quality monitoring was undertaken by ENV for inclusion in the DWMS (ENV 2011) and to provide baseline water quality parameters for future development of the Bollard Bulrush West area. Water quality was sampled at one location on 2 monitoring occasions (2008 and 2009). Results of monitoring are presented in Table 8 (together with groundwater quality monitoring results from MBC). Surface water quality monitoring location (SW2) is shown in Figure 6.

2.9 Groundwater Hydrology

A pre-development groundwater investigation was undertaken by ENV (2011) to inform the DWMS and included 3 winters of monitoring (2008 – 2010). Of the network of groundwater monitoring bores installed by ENV one of the bores, MBC, is located on the Study Area. Groundwater quality results are presented in Table 8 and Maximum Groundwater Level (MGL) contours are shown in Figure 7.

JDA performed a site investigation on the 17th January 2013; three observation holes were augered and groundwater level relative to natural surface was recorded. Results are shown in Figure 7. Generally water levels in January 2013 were 0.5m below the ENV MGL.

2.9.1 Maximum Groundwater Level (MGL)

Maximum Groundwater Contours were estimated for the wider DWMS area by ENV and presented in the DWMS (ENV 2011). The maximum groundwater level is at natural surface across approximately 30% of the Study Area. JDA's field investigation on 12 January 2013 included augering of 3 observation holes. Two of the holes were in the vicinity of the man-made surface water bodies and one adjacent to the PMD. Groundwater levels in the JDA observation holes were consistent with water levels within the surface water bodies and the PMD.

Regional groundwater level seasonal variation on the Swan Coastal Plain, as presented in the DWMS (ENV, 2011), is in the order of 0.8m. ENV estimated MGL in the location of MBC at approximately 5.49 mAHD; based on groundwater levels within field observation holes, groundwater level at the time of JDA recording in January 2013 at this location was approximately 5.2 mAHD. This is significantly higher than the approximate regional seasonal minimum of 4.69 mAHD. JDA site investigation indicates the local seasonal variation is likely to be closer to 0.5m.

The DWMS (ENV, 2011) MGL contours don't appear to include the drawdown influence of the Peel Main Drain. JDA site investigation indicates base flow within the PMD with an approximate water level of 0.2m (4.0 mAHD). JDA site investigation OH3 (Figure 7) water levels adjacent to the PMD show a drawdown impact of approximately 0.5m – 1.0m within the vicinity of the PMD. Regardless of the localised drawdown the adopted MGL for design is considered a conservative approach.

2.9.2 Fill Levels

The design of the proposed development should incorporate a minimum habitable floor level 1.5m above the pre-development AAMGL. This can be achieved by the use of a subsoil drainage system and/or importation of clean sand fill which is described further in Section 4.3.

2.9.3 Water Quality

Groundwater quality was recorded by ENV on 6 occasions over a 2 year period from monitoring bore MBC. Results of monitoring are presented in Table 8. ANZECC assessment levels (ANZECC 2000) are provided for reference only and do not indicate baseline trigger values. The water quality results presented in Table 8 are to be used as baseline water quality parameters for assessment post-development.

Table 8: Water Quality Results

Sample Date	pH	EC	TP	PO_4	TN	NO_3 N	NH_3 N	NH_4 N	TKN	As	Cd	Cr	Cu	Pb	Ni	Zn	Hg
Surface Water Quality (SW2)																	
$ANZECC_1$	7.0 – 8.5[1]	-	60	-	1500	-	-	40	-	-	-	-	-	-	-	-	-
31/10/2008	7.36	4.76	0.97	0.02	2.2	0.1	0.12	-	2.1	0.01	0.0003	0.009	0.009	0.003	0.007	0.049	<0.0001
21/07/2009	6.85	0.7	0.22	0.039	2.4	<0.1	0.10	-	2.4	0.002	<0.0001	<0.001	0.007	<0.001	0.006	0.01	<0.0001
Groundwater Quality (MBC)																	
$ANZECC_2$	6.5 – 8.5	-	-	-	-	3100	-	-	-	24 (ASIII) 13 (ASV)	0.2	10	1.4	3.4	11	15	0.06
30/10/2008	7.02	0.440	0.67	0.010	3.30	0.04	0.33	-	3.30	0.145	0.0007	0.093	0.117	0.221	0.053	0.018	<0.0001
21/01/2009	6.96	0.279	0.18	0.010	1.40	-	0.40	-	1.40	0.050	0.0004	0.022	0.022	0.088	0.019	0.014	<0.0001
16/04/2009	6.34	0.379	0.56	-	1.40	0.02	0.25	-	1.30	0.041	0.0002	0.038	0.056	0.086	0.016	0.009	<0.0001
21/07/2009	6.15	0.420	0.06	0.010	0.72	<0.10	0.09	-	0.72	0.013	<0.0001	<0.001	0.008	0.001	0.008	0.005	<0.0001
28/10/2009	6.30	0.400	0.11	<0.005	0.81	0.80	-	0.24	0.64	0.002	<0.0001	<0.001	0.004	0.001	0.005	0.015	<0.0001
23/09/2010	6.20	0.410	0.05	0.007	1.00	0.03	-	0.19	0.97	0.003	<0.0020	<0.005	<0.005	0.004	<0.005	<0.01	<0.0001
Mean	6.49	0.379	0.27	0.009	1.44	0.22	0.27	0.22	1.39	0.042	0.0004	0.051	0.041	0.067	0.020	0.012	<0.0001

1. Default trigger values for physical and chemical stressors for south-west Australia for slightly disturbed ecosystems; Wetlands (ANZECC 2000);
2. Fresh Waters. Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) *Australian Water Quality Guidelines for Fresh and Marine Water Quality;*
3. In highly coloured wetlands (gilven > 52 $g_{440}m^{-1}$) pH typically ranges 4.5 – 6.5.

2.10 Water Resources

The Study Area is located within the DoW's Serpentine River Catchment Surface Water Management Area and Lower Serpentine Surface Water Management Sub-area (SWMA). Use of surface water for water supply within the Study Area is not considered appropriate as surface water is required to maintain the Bollard Bulrush Swamp hydrological regime.

Contrary to information in the DWMS (ENV 2011) the Study Area is within the DoW's Serpentine Groundwater Management Area (GMA) and Jandakot Mound 2 Groundwater Management Sub-area. A search of the online DoW Water Register indicates the Jandakot Mound 2 Superficial aquifer is currently fully allocated. Limited information is available for the Perth-Leederville aquifer however as this water resource is currently used for potable water use as an alternate non-potable water supply is not considered appropriate.

Potable water supply to homes currently in the Study Area is via the Water Corporation managed Medina Water Scheme which is primarily fed by the Jandakot Mound (Perth-Leederville aquifer). Connection to the existing supply scheme will require the construction additional infrastructure. Confirmation and details of Water Corporation supply will be provided in the UWMP.

There are no existing DoW groundwater licences within the Study Area.

2.11 Hydrological Opportunities and Constraints

The above described characteristics of the pre-development environment in the Study Area provide a number of key constraints and opportunities for the application of water sensitive urban design with land use change:

- Groundwater monitoring and mapping within the Study Area (ENV, 2011) has allowed for a local assessment of groundwater levels in relation to existing natural surface level, which indicate man-made soaks and Bollard Bulrush Swamp intersect the groundwater and approximately 30% of the Study Area has groundwater close to the surface during summer and at surface during winter months. High groundwater levels will require management and control in the post-development environment to prevent rising groundwater table and inappropriate draining of groundwater.
- There is a Conservation Category Wetland and EPP Lake within the Study Area which requires consideration in regard to drainage and water quality.
- WAPC's Bulletin 64 (WAPC, 2003) ASS risk mapping for the Study Area indicates high risk of Actual ASS or Potential ASS within 3 m of the existing surface for the vast majority of the Study Area. An ASS Investigation and Management Plan will be required prior to development.
- Silty clay soils are likely to limit post development infiltration opportunities in the Study Area, and this will impact the ability to meet DoW's preference to infiltrate frequently occurring storm events (typically less than 1 year ARI). Frequently occurring storm events (1 yr 1hr) will be infiltrated at source where possible via soakwells; subsoils will be required to prevent rising of groundwater within fill.
- Historical rural land use within the Study Area has to varying degrees affected groundwater quality within the Study Area, and currently operates without the application of any water quality controls. Change in land use provides an opportunity to improve groundwater quality through application of sustainability principles, water sensitive urban design, and establishment of water quality targets, monitoring and compliance reporting.

These constraints and opportunities are used in Section 4 to assist development of a suitable Local Water Management Strategy (LWMS).

3. PROPOSED DEVELOPMENT

The proposed Local Structure Plan (LSP) for the Study Area is shown in Figure 8.

Key elements of the LSP related to urban water management include:

- Establishment of a buffer for the future protection of the Bollard Bulrush Swamp. This buffer area will include restricted POS but will not contain any active POS or drainage infrastructure;
- POS area proposed to be passive with mulching and use of native water-wise plantings for revegetation. No active turf areas are proposed. City of Kwinana have requested POS area to remain as existing natural condition with only minor revegetation around perimeter. Detailed landscaping to be provided at UWMP stage.
- Use of ephemeral detention areas for management of local stormwater;
- At-source infiltration of frequently occurring storm events, up to 1yr ARI 1hr duration, where possible;
- Maintenance of discharge points from the Study Area to the receiving environment;
- Maintenance of groundwater levels within imported fill via subsoils;
- Minimisation of fill consistent with sustainability principles.

4. LOCAL WATER MANAGEMENT STRATEGY

The following section details the proposed local water management strategy for the Study Area.

It includes discussions regarding water use and conservation, and details key elements of groundwater, surface water and water quality management with respect to demonstrated best management practice in water sensitive urban design.

Issues related to implementation are discussed in Section 5.

4.1 Water Use Sustainability Initiatives

4.1.1 Water Conservation

Development of the Study Area will lead to an increased demand for water for new residents as well as irrigation of public open space areas.

Water conservation measures will be implemented to reduce scheme water consumption within the development and will be consistent with Water Corporation's "Waterwise" land development criteria, and include:

- Use of high density residential zoning and smaller lots to reduce garden (ex-house) use of water.
- Promotion of use of waterwise practices including water efficient fixtures and fitting (taps, showerheads, toilets and appliances, rainwater tanks, waterwise landscaping)
- All houses to be built to 5 star building standards
- Use of native plants in POS areas and waterway rehabilitation and buffer areas
- Maximising on site retention of stormwater (where practicable)

Specific agreed measures and locations to achieve water conservation will be detailed in the UWMP.

4.1.2 Potable & Non-Potable Water Supplies

4.1.2.1 Household Scale

The water source planning strategy for the Study Area is for use of scheme water for domestic household use (both in and ex-house). The Study Area is within the Water Corporation managed Medina Water Scheme area. Advice from the Water Corporation (Email B. Coombes 13/08/2012) states that the Study Area is "within the now planned gravity zone of the long-term Medina scheme… the Corporation's water planners are currently undertaking more detailed water distribution main planning for the scheme to determine the route/s, size and staging of distribution mains' to serve the Study Area".

The Water Corporation also indicates the existing water pipes immediately north of the Study Area are not likely to have sufficient capacity to extend and service the proposed development. Further assessment of the required pipe system upgrades and extensions is being performed by the Water Corporation as part of the distribution main planning for Medina. More detailed information and Water Corporation confirmation of supply will be provided at UWMP stage. Advice from the Water Corporation is provided in Appendix B.

The use of rainwater tanks to supplement potable water use ex-house and in-house will be encouraged by the developer. The use of rainwater tanks will be assessed as part of the UWMP process at subdivision stage when more detailed planning is commenced. The integration of rainwater tanks for non-potable water with the domestic water supply scheme would assist in reducing excess stormwater generation and minimise scheme water importation.

Superficial groundwater abstraction via installation of domestic groundwater bores could also be used for ex-house uses such as irrigation of garden and lawn areas.

4.1.2.2 Public Open Space Areas

POS maintenance and irrigation supply requirements will be managed by the developer for a period of 2 years before hand-over to the City of Kwinana. Detail landscaping design and planting will be presented in the UWMP.

The POS is proposed to be a passive design with water-wise native plantings and mulch. Any active children's play areas will be soft-fall or mulch. No active turf areas are proposed. Short-term irrigation will be required for the establishment of plantings and is proposed to be completed by via water-truck. No long-term irrigation in the POS area is required.

Notwithstanding the above, sources of non-potable water supply for irrigation of POS areas (should it be required) have been investigated and are summarised as follows:

- **Superficial Groundwater Aquifer**
  Department of Water Aquifer Allocation Reports indicate licensed water allocations for superficial groundwater aquifer in this area is currently over-allocated. There is also a list of applicants waiting for any water allocation that could become available from reclamation of unused water entitlements. Consequently, application for a Licence to Take Water for superficial groundwater abstraction is not considered a viable option.
- **Leederville Groundwater Aquifer**
  The Leederville Aquifer contains water of potable quality and thus any abstraction from it is generally reserved for potable uses. Consequently, application for a Licence to Take Water for groundwater abstraction from the Leederville Aquifer for irrigation is not considered a viable option.
- **Stormwater Reuse/ Surface Water**
  The proximity of the Study Area to Bollard Bulrush Swamp and Conservation Category Wetlands means the use of stormwater or surface water as an alternative non-potable resource is not considered feasible. Surface water runoff is required to maintain the swamp and wetland hydrologic regime.
- **3rd Pipe Scheme**
  Implementation of a 3rd pipe scheme is not proposed for the area due to the size of the development, infrastructure requirements and ongoing maintenance.
- **Water from Bollard Bulrush Swamp**
  Bollard Bulrush Swamp contains year round standing water. The City of Kwinana has indicated through their discussions with Water Corporation, pumping from the Swamp could be a viable non-potable water supply option for irrigation. This option could be a viable water supply source and requires further discussions with the Water Corporation and the City of Kwinana during detailed design and outlined in the UWMP if required.

Based on the household and POS water strategies, a water balance for the site has not been provided in the LWMS, as it is typically required to support the identification of excess water generated by the development where use of this excess water as a non-potable water supply scheme is proposed. A water balance would not provide any further information on water use and potable/non-potable supply options. Furthermore, design and building of the proposed development to current industry standard should ensure water use is within current Water Corporation and Department of Water consumption targets.

4.1.3 Wastewater

Wastewater disposal from the development is proposed to be serviced via an extension of the Water Corporations existing infrastructure. Advice from the Water Corporation (Email B. Coombes 13/08/2012) indicates wastewater infrastructure planning for the Study Area is currently being undertaken and preliminary solutions include possible gravity piped wastewater connection North to the Bertram Rd Waste Water Pump Station. Further advice from Water Corporation on the completion of wastewater infrastructure planning for the Study Area will be provided at UWMP stage.

4.2 Surface Water Management

4.2.1 Regional Flood Management

The Study Area is within the Peel Main Drain and Bollard Bulrush Swamp which are significant in post-development regional flood management. As documented in Section 2.8 regional flood management for the Peel Main Drain and Bollard Bulrush Swamp has previously been modelled by GHD and documented in the Jandakot DWMP (DoW, 2009b).

4.2.2 Local Flood Management

As previously documented in Section 2.8 district flood management for Bollard Bulrush Swamp West has been modelled by GHD (2010) and documented in the Bollard Bulrush Swamp West DWMS (ENV, 2011).

Local stormwater management is proposed to be undertaken consistent with water sensitive design practices and meet key objectives and criteria as detailed in Table 1.

The local stormwater management system will consist of a series of pipes and ephemeral water storage areas to attenuate and infiltrate peak surface water flows, and provide water quality treatment for the proposed development prior to discharge from the Study Area.

The stormwater drainage system will be designed using a major/minor approach. The minor drainage system is defined as the system of soakwells, pipes, kerbs, gutters etc. designed to carry runoff generated by low frequency ARI storms, typically less than 5 year ARI. The major drainage system is defined as the arrangement of roads, drainage reserves, attenuation/infiltration areas and open space planned to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system.

Attenuation of flow will then be achieved through:

- Provision of attenuation and water quality treatment areas within ephemeral attenuation/ infiltration areas;
- Use of public open space (POS) areas.

Consistent with principles and objectives discussed in Section 1.2 stormwater will be required to maintain 5 year and 100 year ARI event post-development discharge rates at predevelopment conditions.

As previously discussed in Section 2.4, geotechnical conditions indicate infiltration opportunities on site will be limited. However, opportunities for infiltration and treatment of frequent rainfall events (15mm) higher in the catchment with roadside swales, tree pits, flush kerbing adjacent to POS and soakwells within fill etc. are to be investigated further during detail design and presented in the UWMP. High runoff rates have been adopted in conceptual design on this basis in Section 4.2.3

Minimum building floor levels need to comply with DoW and City of Kwinana requirements. DoW require vertical separation of 0.5m clearance above the estimated 100 year ARI flood levels of adjacent watercourses. Proposed development should therefore incorporate a minimum habitable floor level of 6.12 mAHD to meet the required 0.5m clearance above the Peel Main Drain 100 year flood level of 5.62 mAHD.

City of Kwinana minimum clearance requirements are based on Australian Rainfall & Runoff (Engineers Australia, 2001) recommended separation of 0.5m clearance above estimated 100 year ARI flood level of the stormwater conveyance system.

4.2.3 Conceptual Stormwater System Design

XP-Storm modelling was performed by JDA for the Study Area to determine flood storage requirements for local flood management post development and provide a framework for the stormwater management system in terms of land use planning. Modelling was based on the proposed land use plan shown in Figure 8.

The conceptual design of the flood management areas was based on attenuation of peak runoff from 5 and 100 year ARI storm events to not exceed estimated pre-development (existing) levels. Design flows were previously detailed in Section 2.8.4 and Table 6.

Conceptual detention locations were determined based on topographic contours, and pre-development flow paths. The detention area will need to be separated from the Bollard Bulrush Swamp by a bund or similar. It is assumed that the flood rise was designed to be typically in the order of 1m, side slopes of 1 in 6 (v:h) and the attenuation area base invert assumed to be above the Bollard Bulrush Swamp 100 year ARI flood level to prevent backflow and ensure discharge from the Study Area can occur during all storm events. The Study Area has been modelled as one catchment consistent with pre-development surface water flow.

The design storms modelled by XP-STORM were calculated internally by the model with reference to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2000) and the Bureau of Meteorology Computerised Design IFD Rainfall System (CDIRS). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 10 minutes to 72 hours.

Due to high groundwater levels, Peel Main Drain flood levels and silty clayey soils the proposed development requires fill across the majority of the Study Area. The portion of the Study Area with existing surface levels at or below the required 0.5m above Peel Main Drain 100 year ARI flood levels is shown in Figure 9.

Runoff coefficients for lots were determined considering those used in the Jandakot DWMP (DoW 2009b), DMWS (ENV 2011), JDA experience in drainage planning in the area and proposed landuse. The following runoff coefficients were applied for various land uses:

- Residential Lots 70%
- Road Reserve 80%
- POS/ Drainage 10%

The proposed local flood management system modelling results are presented in Table 9. Modelled detention storage volumes, areas, flood rise and inverts are detailed in Figure 9 and event plans shown in Figure 10. A general bio-retention area cross section is shown in Figure 10.

The total area required for detention storage for the 100 year ARI event is approximately 5% of the total Study Area with a total detention storage volume of approximately 2,820 m^3 within the major flood attenuation area proposed.

Runoff from Roads for the 1 year 1 hour event will be retained and infiltrated within the estate scale flood attenuation area. These storm volumes are presented in Figure 9 to provide a guide for storage requirements for infiltration/treatment of this event. Area for bioretention systems sized as 2% of the connected equivalent impervious area (i.e. roads) for water quality treatment is also shown in Figures 9 and 10.

All Lots will retain the 1 year 1 hour rainfall event within soakwells located in free draining imported sand. Due to high groundwater levels and low hydraulic conductivity of existing soils, the City of Kwinana has requested overflow from soakwells to the local street drainage system is to occur via overfland flow path, rather than pipe connection. This was modelled as an initial loss of the 1 year 1 hour event from lot areas.

Note that storage shapes shown in Figures 9 and 10 are indicative only for determination of area requirements, and representation of storage areas required in relation to POS areas allocated in the structure plan. The final flood attenuation area configuration (side slopes etc.) and locations will be documented in UWMP's and will be dependent on final earthworks, drainage, and road design levels for the development. Minor changes (refinements) in catchment areas shown in this report are therefore considered likely to occur as detailed design proceeds, and stormwater modelling will be updated accordingly during the UWMP process. No drainage infrastructure will be located within the wetland buffer.

The stormwater strategy outlined in this document is consistent with the DWMS (ENV, 2011) and DWMP (DoW, 2009). Notwithstanding, the DoW have advised that overland flow from events greater than the 1yr ARI 1hr event may overflow into the wetland area across the buffer line boundary, preferably evenly spread along the entire buffer boundary edge. The water quality and flood level and volume impact of direct stormwater overflow into the Conservation Category Wetland and Water Corporation's Peel Main Drain can be investigated further during detail design and presented in the UWMP.

4.3 Groundwater Management

This LWMS proposes establishing a design groundwater level (DGL) at the natural surface established in Section 2.9.1.

Minimum separation between building floor levels for development and groundwater will be achieved by combination of subsoil drainage and the importation of clean sand fill. The design of the proposed development should incorporate a minimum habitable floor level 1.5m above the MGL to meet the required clearance from the MGL as per BUWM (WAPC, 2008).

The existing man made open water bodies are not proposed be retained within the development. They should be backfilled with clean sand fill and as per appropriate geotechnical requirements.

Use of subsoil drains will also be required to mitigate the rise of groundwater within fill. It will not be used to lower groundwater levels, but will be installed as a backup to ensure post development groundwater levels are maintained and minimum separation 1.5m is achieved in imported fill. A design groundwater level (DGL) will be implemented by setting subsoil drainage inverts as a minimum at the MGL. Subsoil drains will be located in road reserves and throughout the proposed lot area to achieve the DGL. Subsoil is to discharge into the bioretention area and be free draining.

Conceptual cross section showing subsoil drainage, fill separation to DGL and relevant basin invert separations are included in Figure 10. Detailed cross sections including stormwater pits and pipes and detailed design of subsoil drainage including spacing to achieve the DGL is to be undertaken at subdivision stage and included in the UWMP.

Finished lot levels and fill requirements are a detailed design issue to be addressed during preparation of the UWMP and submitted for council approval at that stage. Note that other factors such as geotechnical, sewerage infrastructure or clearance to 100 year ARI stormwater flood level may be the determining factor for fill level, rather than groundwater clearance.

Groundwater mapping presented in Figure 7 should be considered indicative only for assisting in LWMS strategy development purposes and subject to further investigation/refinement during UWMP stage.

Table 9: XP Storm Modelling Results

Catchment Data	Runoff Coeff.	Lot 661
Lots	70%	5.61
Road	80%	0.60
POS	10%	0.92
Total Area (ha)		7.14
Equivalent Impervious Area (EIA) (ha) – Study Area		4.50
Pre-development Allowable Discharge Rates		
5 Year ARI (JDA calculated)		0.025
100 Year ARI (GHD 2010)		0.048
Flood Attenuation Area		
Base Area (ha) (l x w)		0.19 (148 x 13)
Invert (mAHD)		5.65
Side Slopes (v:h)		1:6
Outlet Pipe Diameter (nominal) (mm)		120
Outlet Pipe Invert (mAHD)		5.80
Spillway Invert (mAHD)		6.55
Spillway Width (m)		2
Spillway Depth (m)		0.10
Groundwater Level (MGL) (mAHD)		4.80
Bollard Bulrush Swamp 100 Year ARI Level (mAHD)		5.62
Bio-retention Area		
2 % of road EIA (ha)		0.01
1 Yr 1Hr from Roads (Retained)		
1Yr 1Hr Volume (m^3) (6000*0.8* 0.0159)		76
Top Water Level Surface Area (ha)		0.20
Flood Rise (m)		0.04
Top Water Level (mAHD)		5.69
Volume Provided (m^3)		79
5 Yr ARI (Attenuated)		
Critical Storm (hr)		48
Runoff Volume (m^3)		4430
Volume (m^3)		1640
Top Water Level Surface Area (ha)		0.32
Flow (m^3/s) (Low Flow Pipe Only)		0.023
Top Water Level (mAHD)		6.29
Flood Rise (m)		0.64
100 Yr ARI (Attenuated)		
Critical Storm (hr)		24
Runoff Volume (m^3)		6010
Volume (m^3)		2820
Top Water Level Surface Area (ha)		0.39
Flow (m^3/s) (Lowflow/ Spillway)		0.024/ 0.037
Top Water Level (mAHD)		6.62
Flood Rise (m)		0.97
Spillway Depth (cm)		7

4.4 Water Quality Management

With respect to water quality management the LWMS proposes the use of a treatment train approach including source control techniques. The proposed water quality management approach for the Study Area will include:

- **Non Structural Controls**
  Planning practices (POS locations and configuration, watercourse buffers)
  Construction practices (construction management, use of plantings with City of Kwinana recommended Endemic Species (see Appendix D))
  Maintenance practices (street sweeping, stormwater system, POS areas)
  Educational and participatory practices (community education)
- **Structural Controls**
  <1yr ARI 1hr Rainfall
  - Infiltration of lot runoff at source via soakwells and gardens
  - Infiltration of road runoff via bioretention swale (designed with soils with a PRI >10 and City of Kwinana recommended Endemic Species (see Appendix D))

  1yr to 5yr ARI Rainfall
  - Creation of ephemeral detention areas within POS areas to infiltrate and detain stormwater to assist with sedimentation and nutrient uptake.

  5yr ARI to 100yr ARI Rainfall
  - Creation of ephemeral detention areas within POS areas to infiltrate and detain stormwater to assist with sedimentation and nutrient uptake.
- **Monitoring**
  Establishment of post development monitoring network
  Annual reporting, including assessment of BMP's performance

The EPA has not formally assessed the Bollard Bulrush Swamp however have prescribed a 50m between proposed development and the lake boundary as per EPP Lake provisions. Details of the EPAs advice are presented in the DWMS (ENV, 2011). No drainage provision or development is to be undertaken in the buffer.

With respect to criteria for water quality, the principle of improving water quality in comparison to existing water quality will be adopted via Water Sensitive Urban Design, and water quality targets developed on this basis as percentage reductions as per Best Management Practise water quality targets (see Section 4.4.1). Assessment of compliance with targets will be through post-development monitoring (refer section 5.5).

To achieve its water quality objectives, the LWMS focuses on implementing current known best management practice as detailed in the DoW's Stormwater Management Manual for Western Australia (2007) and the Decision Process for Stormwater Management in Western Australia (DoE & SRT, 2005), with an emphasis on nutrient input source control, rehabilitation of EPP Lake buffer, and establishing bioretention systems for treatment of frequently occurring storm events and subsoil drainage. Detailed design of these management items will be presented in the UWMP.

Opportunities for infiltration and treatment of frequent rainfall events (15mm) higher in the catchment with roadside swales, tree pits, flush kerbing adjacent to POS and soakwells within fill etc. are to be investigated further during detail design and presented in the UWMP.

4.4.1 Assessment of Proposed Structural BMP's to Design Criteria

Table 10 details a summary from DoW's Stormwater Management Manual for Western Australia (2007) of expected pollutant removal efficiencies for vegetated swales and detention/retention systems in relation to the water quality design criteria specified in Table 1.

While DoW (2007) does not provide expected pollutant removal efficiencies for all BMP's, application of a treatment train approach using a combination of non-structural and structural measures detailed in Section 4.4 will therefore clearly achieve the design objectives for water quality.

Specific details on the location scale of application, and management responsibilities for individual BMP's are to be assessed for individual stages during development of Urban Water Management Plan.

These results together with the results of predevelopment water quality monitoring indicate stormwater runoff quality is likely to be better than existing surface water discharging from the Study Area.

Table 10: BMP Water Quality Performance In Relation to Design Criteria

Parameter	**Design Criteria via DWMP** (required removal as compared to a development with no WSUD)	**Structural Controls** Nutrient Output Reduction [1]	
		Vegetated Swales/ Bioretention Systems	**Detention/ Retention Storages**
Total Suspended Solids	80%	60-80%	65-99%
Total Phosphorus	60%	30-50%	40-80%
Total Nitrogen	45%	25-40%	50-70%
Gross Pollutants	70%	-	>90%

1. Typical Performance Efficiencies via DoW (2007)

4.5 Construction Management

4.5.1 Dewatering

Dewatering of the superficial aquifer may be required for some elements of development construction. As the volume of dewatering will be small compared to aquifer storage and this is to be infiltrated back into the superficial aquifer, the impact upon the aquifer will be minimal.

Drawdown will occur at the dewatering site, and mounding where the water is infiltrated. It should be noted that there will be zero net loss of groundwater, as all water abstracted will be infiltrated (except for minor losses to evaporation).

Prior to the commencement of any dewatering, construction contractors will be required to apply for and obtain from DoW a 'Licence to Take Water'. All dewatering will be carried out in accordance with the conditions of this licence.

Where possible, construction will be timed to minimise impact on groundwater and dewatering requirement.

4.5.2 Acid Sulphate Soils

All assessment and management of ASS will be conducted in accordance with the Acid Sulfate Soil Guideline Series Identification and Investigation of Acid Sulfate Soils (DoE, 2004a), including the Preliminary Site Assessment (PSA) involving a targeted soil and groundwater sampling and analysis program, detailed site assessment (if required), and ultimately and an ASS Management Plan if ASS is to be impacted.

During construction, appropriate handling methods will need to be employed by the construction contractor to manage any potential acid sulphate soils. Handling should be in accordance with the Acid Sulfate Soils Guidelines Series Treatment and Management of Disturbed Acid Sulphate Soils (DoE, 2003). These guidelines specify holding times and specific methods for treatment of such soils. To confirm the status of soils, the site engineer or scientist will regularly inspect the excavations and spoil, and ensure such soils are appropriately tested and managed before reuse or disposal off-site.

4.6 Water Management Strategy Summary

Table 11 provides an overall summary of key elements of the proposed water management strategy for the Study Area, with an assessment of the strategy in relation to DoW (2007) principle objectives for stormwater management in Western Australia (Section 1.2.3).

Table 11: Summary of Proposed Local Water Management Strategy

Principle	Key LWMS Elements
Water Quantity To maintain the total water cycle balance within development areas relative to the pre-development conditions.	• Maintain flow paths for existing catchment • Maintain 1, 5, and 100 year ARI peak flows from the Study Area to at or below current discharge levels. • Stormwater detention area outlets set at above MGL
Water Quality To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.	• Use of treatment train approach to stormwater management • Bioretention areas set at 2% of the equivalent impervious area of development for water quality treatment • Application of source controls – subdivision design street sweeping, education to reduce nutrient application, native plantings, passive POS areas • Application of structural controls – bioretention areas, retention/detention areas. • Infiltration is likely to be limited however where possible infiltration of frequently occurring events to be considered at UWMP stage • Ongoing predevelopment and post development monitoring programs and performance review process
Water Conservation To maximise the reuse of stormwater	• Implement water efficiency and demand management measures • Use of native plantings in POS areas and passive POS areas to minimise irrigation
Ecosystem Health To retain natural drainage systems and protect ecosystem health	• Establishment and rehabilitation of waterway buffers
Economic Viability To implement stormwater systems that are economically viable in the long term	• Use of proven structural WSUD technology • Use of source control techniques to minimise cost of nutrient management
Public Health To minimise the public risk, including risk of injury or loss of life to the community	• Design in accordance with relevant design standards, best management practices, council regulations and government agency requirements.
Protection of Property To protect the built environment from flooding and waterlogging	• Provision of 100 year ARI flood protection for Study Area • Protection of downstream areas by restricting stormwater discharge to existing levels for storm events up to 100 year ARI. • Subsoil drainage to be implemented if required in fill areas to control seasonal groundwater rise
Social Values To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater	• Integration of drainage and POS functions
Development To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.	• Development of the LWMS in accordance with government agency guidelines and best management practice recommendations. • Groundwater management approach to minimise large scale trucking of fill consistent with sustainability principles and maximise tree retention. • Use outcomes of continuing pre development and post development monitoring programs to help guide future water management.

5. IMPLEMENTATION

5.1 Roles and Responsibilities

Table 12 details the roles and responsibilities to undertake the implementation plan. Further detail is provided regarding each deliverable in the LWMS section outlined in Table 8 below.

Table 12: Implementation Responsibilities

IMPLEMENTATION		RESPONSIBILITY	
LWMS Section	**Action**	**The Developer**	**City of Kwinana**
5.3	Preparation of an Urban Water Management Plan for individual development stages	✓	
5.4	Construction of stormwater system and 12 months maintenance post construction (defects period)	✓	
5.4	Long term stormwater system operation and maintenance		✓
5.5	Monitoring program – 2 years post development	✓	

5.2 Local Structure Plan Process

As detailed in Section 1.2.4 and Table 2, this LWMS has been prepared to an appropriate level of detail to support the Outline Development Plan and local structure planning process Lot 661 Bertram Rd, Wellard.

5.3 Subdivision Application Process

Consistent with processes defined in WAPC (2007) an Urban Water Management Plan (UWMP) will be developed and submitted to support subdivision application.The UWMP will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of CoK and DoW.
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Refine stormwater management design presented in the LWMS including the size, location and design of public open space areas, integrating major and minor flood management capability.
- Refine the management of groundwater levels (including proposed fill levels (if any) and subsoil drainage inverts) as presented in the LWMS.
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Management of subdivisional works (including development of a strategy for sediment control during construction).
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken for each UWMP area consistent with the monitoring program defined in the LWMS (Section 5.5).

- Contingency plans (where necessary).
- A geotechnical investigation and Acid Sulfate Soil Investigation to be carried out for Lot 661 with results to be reported in a future UWMP for these lots.

5.4 Stormwater System Operation & Maintenance

Operation and maintenance of the drainage system will initially be the responsibility of the developer, ultimately reverting to the local authority, excluding proposed strata development areas. The surface drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be implemented periodically:

- removal of debris to prevent blockages;
- street sweeping to reduce particulate build up on road surfaces and gutters;
- cleaning of sediment build up and litter layer on the bottom of basins;
- application of slow release/zero phosphorus fertilisers for maintenance of POS areas and any swales;
- undertake education campaigns regarding source control practices to minimise pollutant runoff into stormwater drainage system; and
- checks on any subsoil drainage function.

5.5 Monitoring Program

The monitoring program has been designed consistent with Joint Australian/ New Zealand Standards (2000) to allow quantitative assessment of hydrological impacts of proposed development within the Study Area.

In particular the program addresses the monitoring of surface water discharges and groundwater quality within the development area. The program may need to be modified as data are collected to increase or decrease the monitoring effort in a particular area or to alter the scope of the program itself. Any modification to the program would require the agreement of all parties (DoW, CoK, and developer). The program is designed to operate over a two year post development period including construction to allow for time lag for full impacts of development on the receiving environment to occur.

All water quality testing will be conducted by a NATA approved laboratory. Laboratory analysis results will be typically obtained within 1 month of sample submission.

The timing of commencement of the monitoring program should be negotiated at UWMP stage with DoW and the CoK. Typically the monitoring program is commenced at practical completion of the subdivision.

Surface and groundwater monitoring are described below and summarised in Table 13. Proposed monitoring locations are shown in Figure 10. Ongoing tracking of environmental performance will be undertaken as monitoring data becomes available through a series of consolidated data spreadsheets.

5.5.1 Surface Water

Surface water quality monitoring at the outlet of the detention area prior to discharge into the Peel Main Drain (Figure 11) will be monitored over the first 2 years post development. Timing for the commencement of monitoring will be agreed with DoW and the City of Kwinana and detailed in the UWMP.

Water quality sampling will be undertaken approximately monthly from June to October. Monitoring of the following parameters is:

- In situ - pH, EC and Temperature

- Nitrogen & Phosphorus (full suite)
- Total Suspended Solids

The frequency of surface flow water quality monitoring will be reviewed annually.

5.5.2 Groundwater

Monthly monitoring of groundwater levels in 3 locations is proposed, with quarterly monitoring of groundwater quality for the following parameters:

- In situ - pH, EC and Temperature
- Nitrogen & Phosphorus (full suite)

The depth to water table will be measured by electrical depth probe or an alternative suitable device. Water samples are to be taken after purging the bores to ensure a fresh sample is obtained.

5.5.3 Annual Reporting

Reporting is proposed to be annually, co-ordinated by the developer and submitted to CoK and DoW for review. The report will compare the monitoring results with target design criteria and performance objectives and determine what, if any, further actions may be necessary, and provide ongoing assessment of the suitability of existing monitoring and reporting frequencies.

Assessment of performance compliance against water quality criteria will require careful consideration to account for inter seasonal and inter annual variability, and as both surface and groundwater quality will be a function of historical land use practices not only within the development area, but over the entire upstream catchment.

The proposed process for contingency action in the assessment of performance compliance is

- Assess if an isolated, development area or regional occurrence.
- Determine if due to the development or other external factors.
- Perform appropriate contingency action as required, which may include:
  a) Identify and remove any point sources.
  b) Reinforce Community Education/Awareness program.
  c) Review constructional, operational and maintenance (e.g. fertilising) practices.
  d) Consider alterations to POS areas including landscape regimes and soil amendment.
  e) Consider modifications to the stormwater system.
  f) Consider initiation of community based projects.
- Record in the annual report any action taken, and communicate findings with Department of Water and City of Kwinana.
- If necessary, inform residents of any required works and their purpose.

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

Table 13: Monitoring Schedule and Reporting

Monitoring Type	Parameter	Location	Method	Frequency and Timing	Reporting
Groundwater Level	Water Level (m AHD)	3 locations (Figure 11)	Electrical depth probe or similar	Monthly for 2 years	Annual assessment reports to be submitted to DoW & CoK for a 2 year period. Suitability of existing monitoring and reporting frequencies to be assessed annually with any modifications requiring agreement by all parties (DoW, CoK, & Developer)
Groundwater Quality	pH, EC Nitrogen Phosphorus	3 locations (Figure 11)	Pumped bore samples	Quarterly for 2 years (typically Jan, Apr, Jul & Oct)	
Surface Water Quality	pH, EC, TSS Nitrogen Phosphorus	1 location (Figure 11)	Collected grab samples	Monthly sampling when flowing, typically June to October for 2 years. Frequency to be reviewed following initial 12 month sampling period.	

6. REFERENCES

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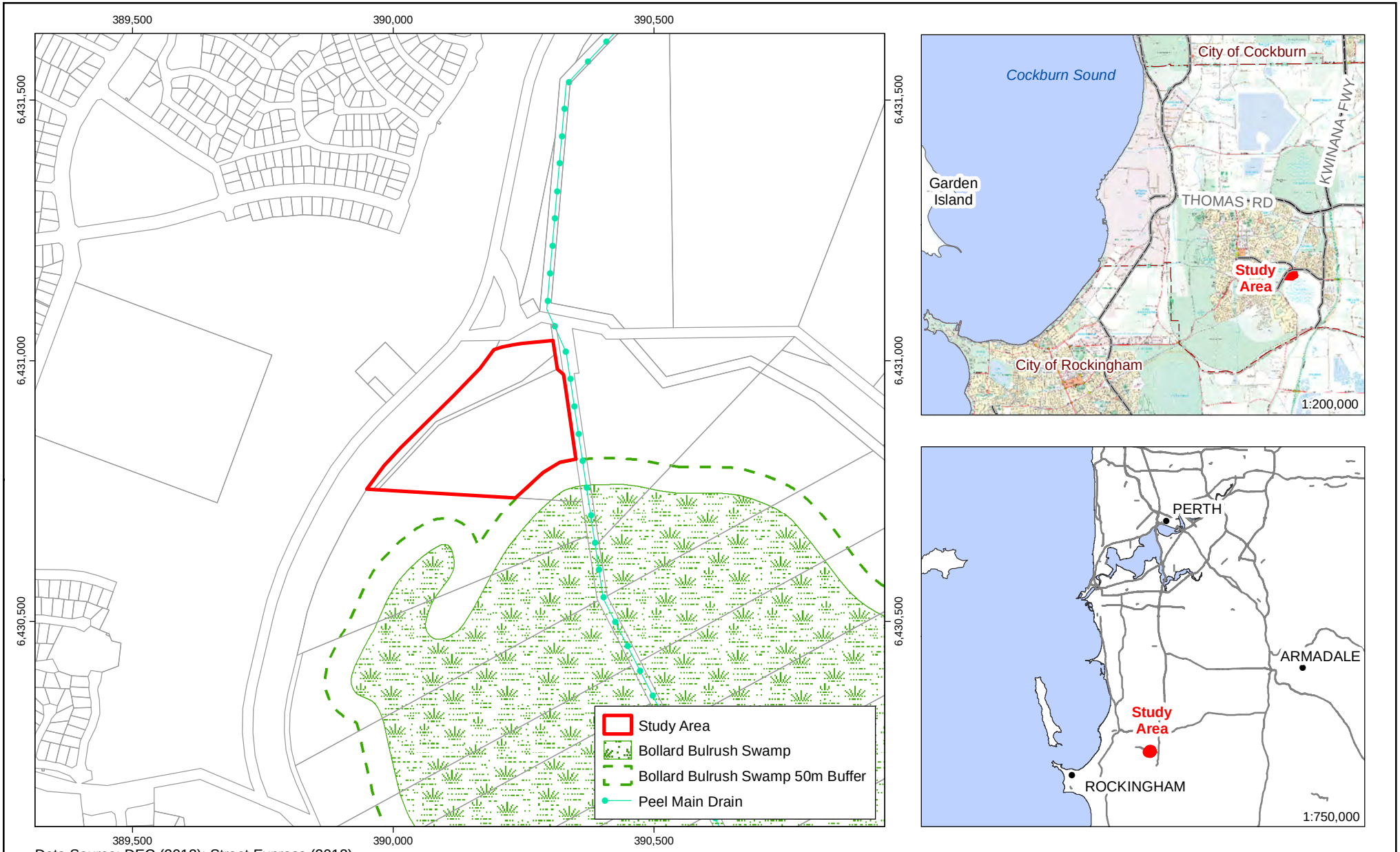
FIGURES



Data Source: DEC (2012); Street Express (2012)

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Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 1: Location Plan

Data Source: DEC (2012); Rowe Group (2015); DoW (2012); Landgate (2012); Nearmap (2015)

JDA

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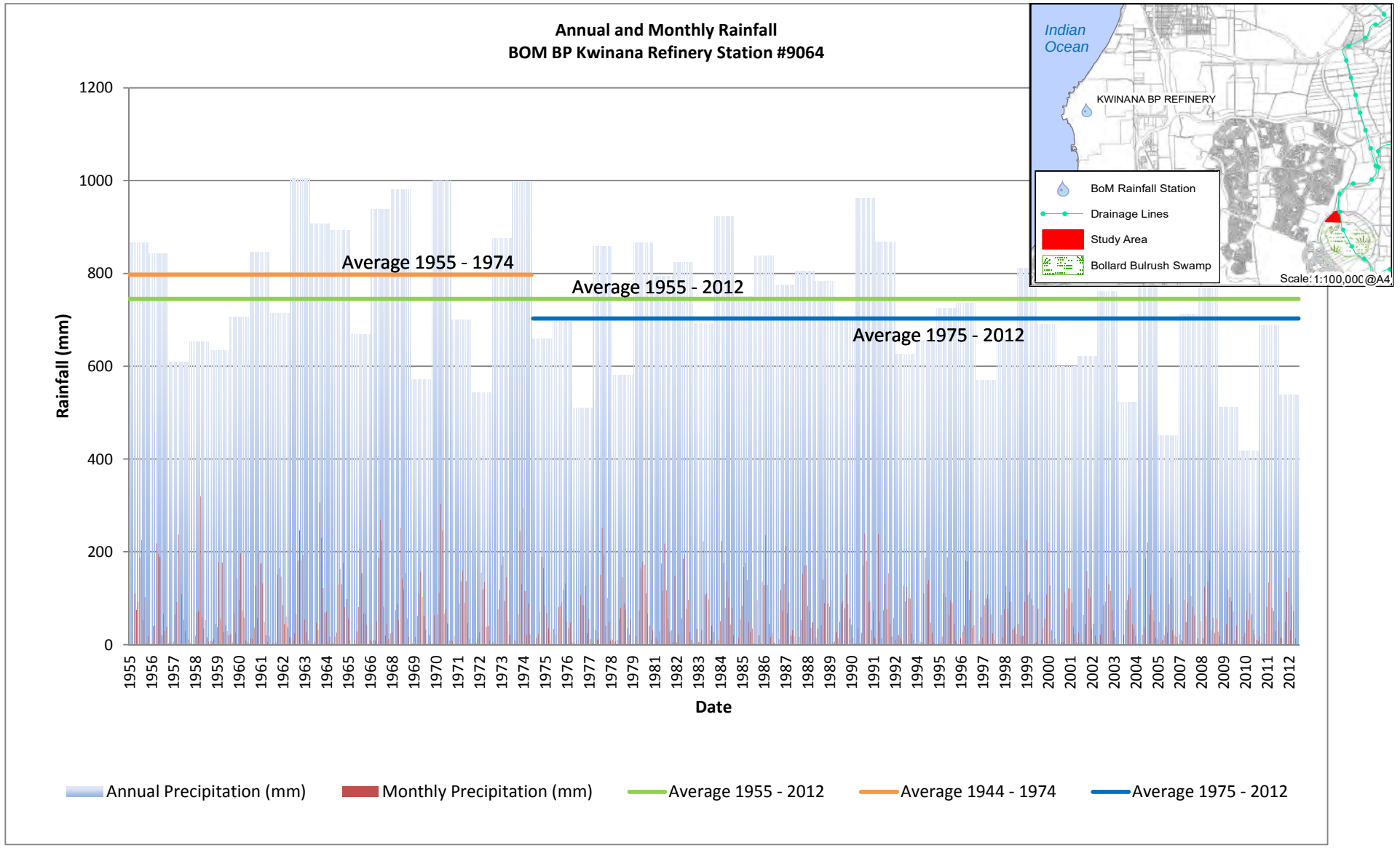
Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 2: Existing Environment and Topography Plan



Data Source: BoM (2012)

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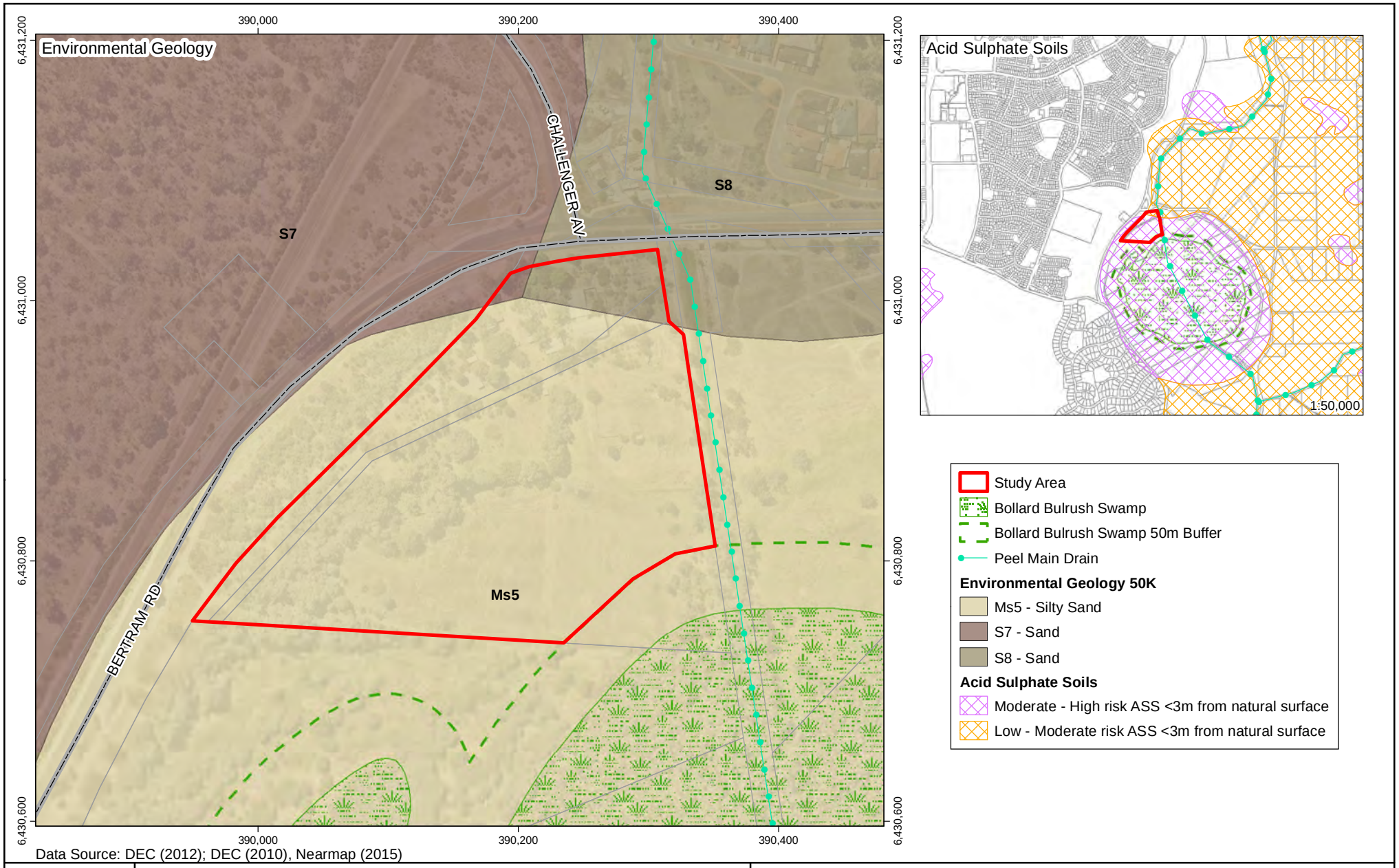
Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 3: Annual Rainfall & BoM Site Location



Data Source: DEC (2012); DEC (2010), Nearmap (2015)

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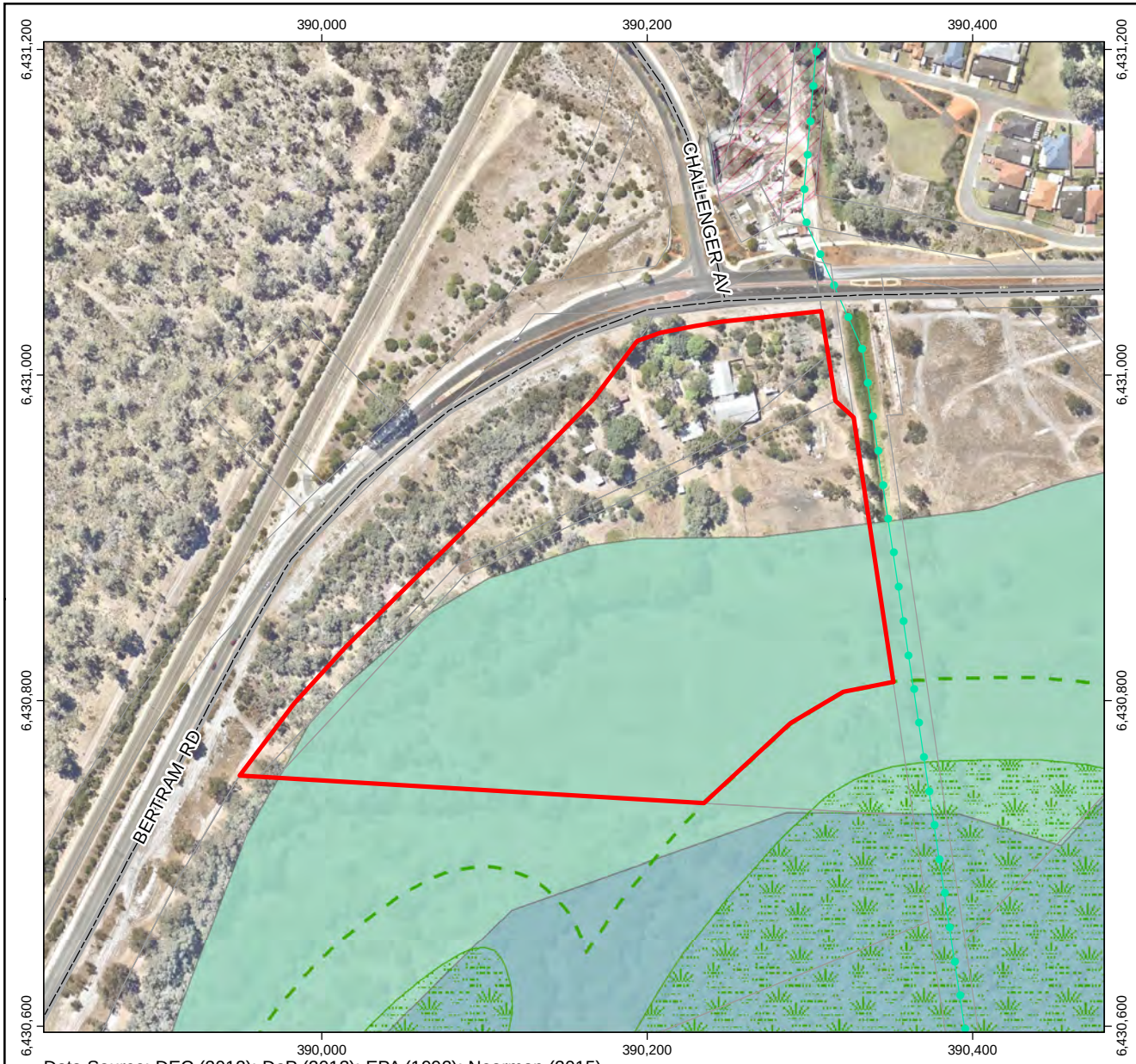
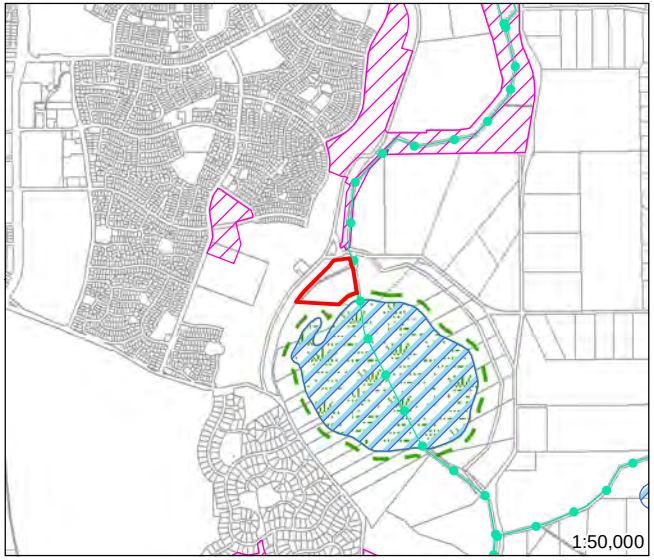
Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 4: Environmental Geology and ASS Plan





- Study Area
- Bollard Bulrush Swamp
- Bollard Bulrush Swamp 50m Buffer
- Peel Main Drain
- EPP Lake (1992)
- Bush Forever Site

Geomorphic Wetland Evaluation

- Conservation
- Multiple Use

Note: EPP Lake and Bollard Bulrush Swamp boundary coincide.

Data Source: DEC (2012); DoP (2013); EPA (1992); Nearmap (2015)

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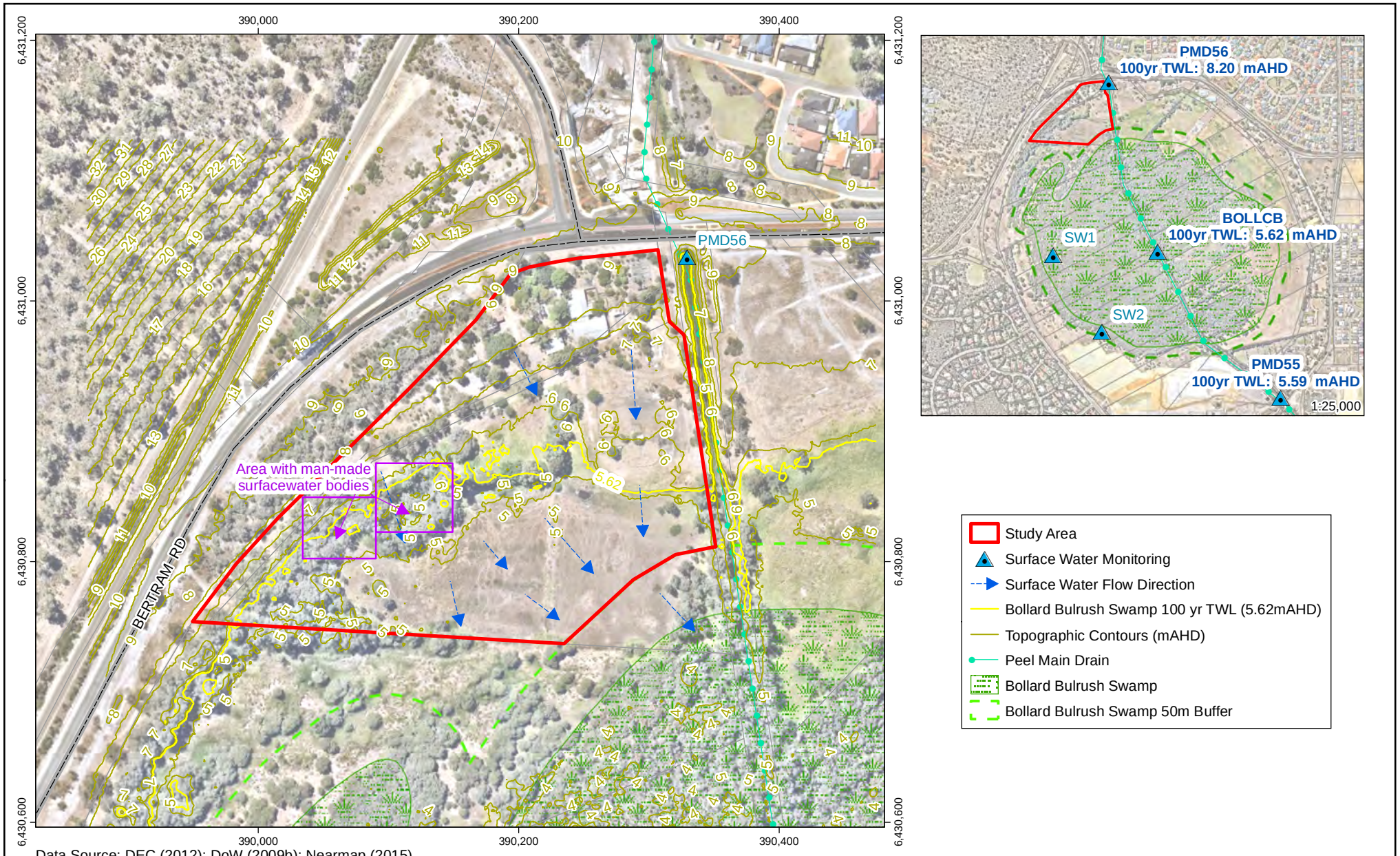
Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 5: Wetland Plan



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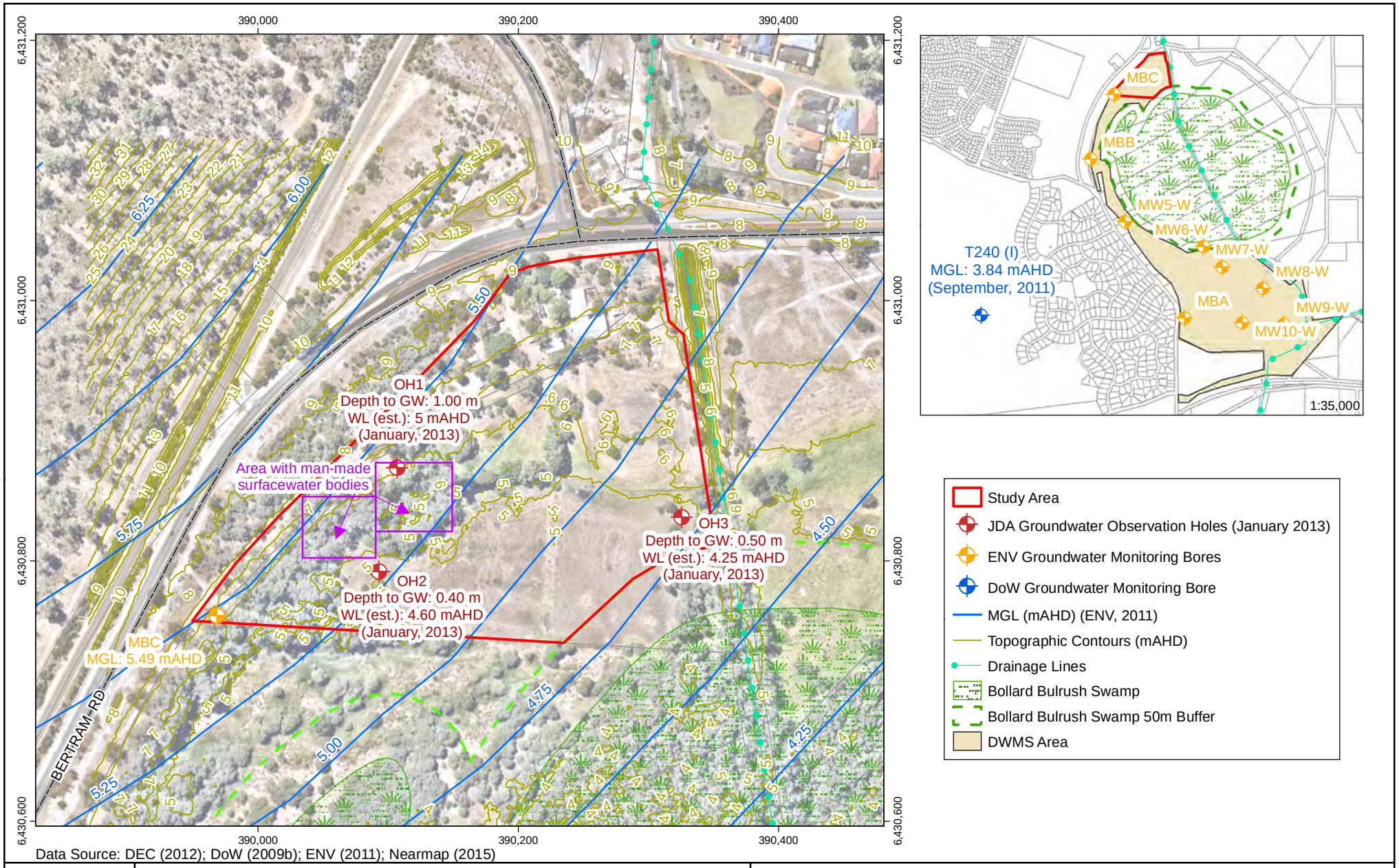
Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 6: Pre-development Surface Water Drainage Plan



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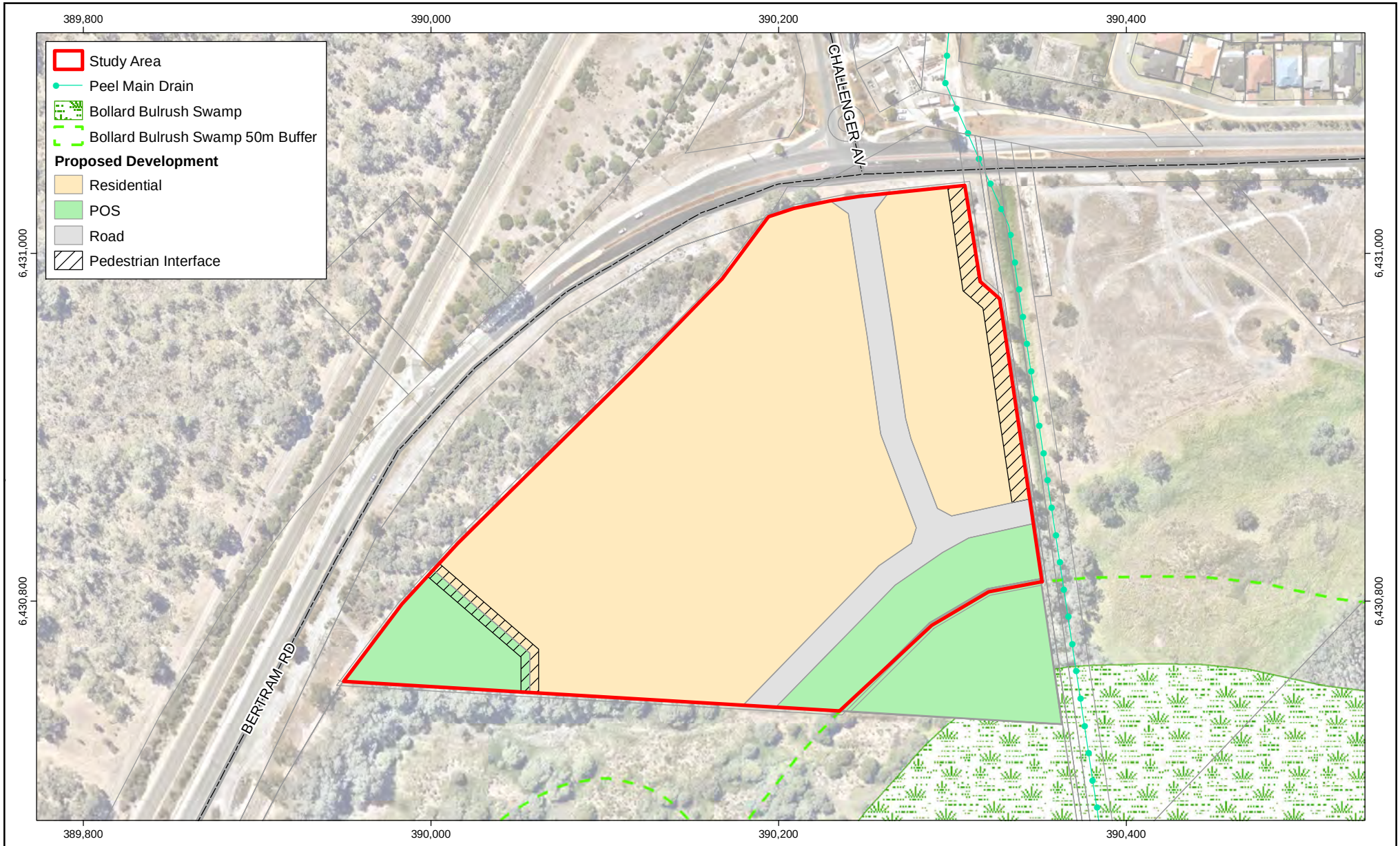
Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 7: Pre-development Groundwater Plan



Data Source: DEC (2012); Rowe Group (2015); Nearmap (2015)

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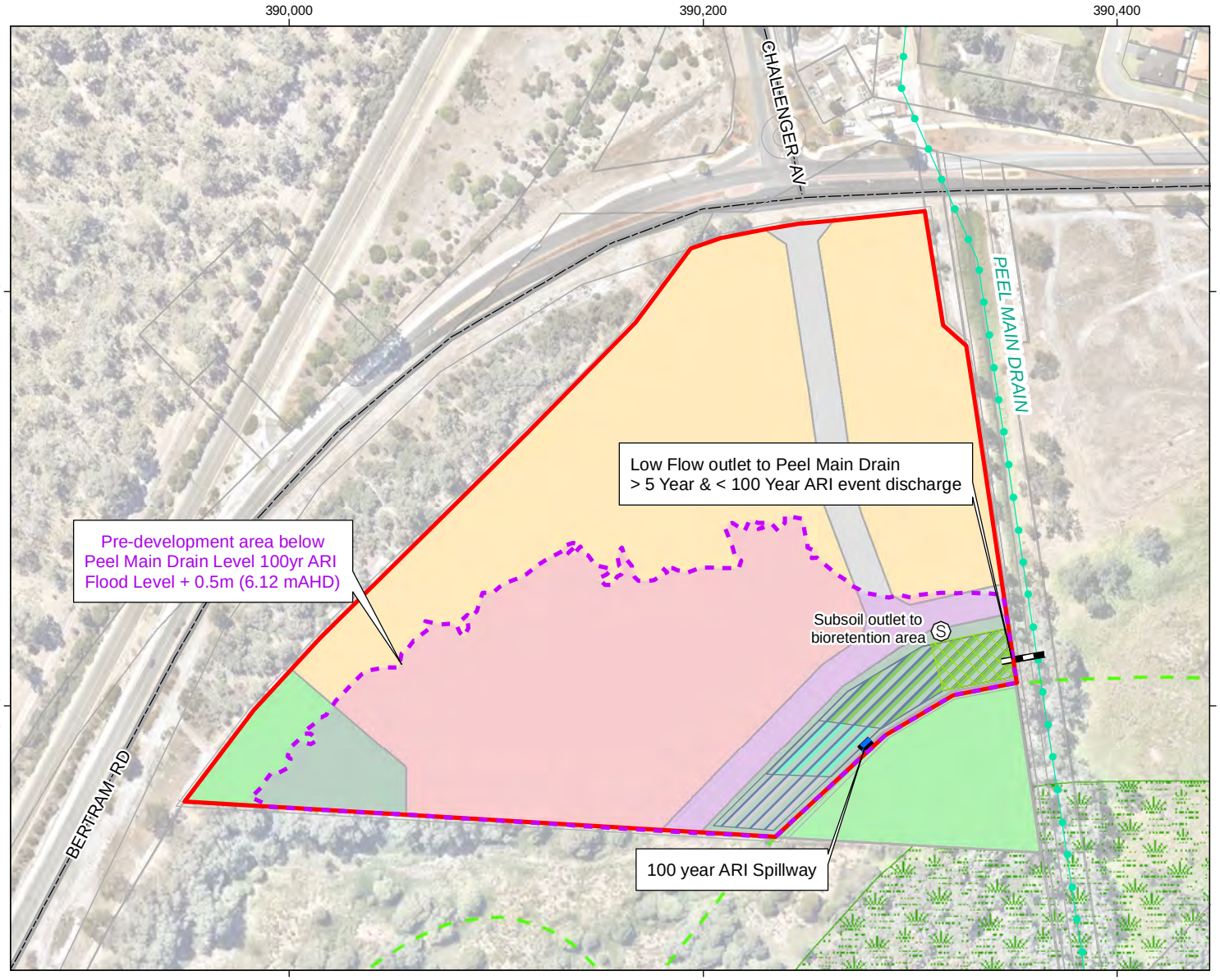
Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 8: Proposed Structure Plan



Stormwater Attenuation Area
Base Area (ha): 0.19
Base Invert (mAHD): 5.65
Outlet Diam (nominal) (mm): 120
Outlet Invert (mAHD): 5.80
Spillway Width / Depth (m): 2.00 / 0.10
Spillway Invert (mAHD): 6.55

100yr TWL Area (ha): 0.39
Volume (m^3): 2820
TWL (mAHD): 6.62
Flow (m^3/s): 0.037
Critical Storm (hrs): 24

5yr TWL Area (ha): 0.32
Volume (m^3): 1640
TWL (mAHD): 6.29
Flow (m^3/s): 0.023
Critical Storm (hrs): 48

1yr TWL Area (ha): 0.20
Volume (m^3): 79
TWL (mAHD): 5.69
Flow (m^3/s): -
Critical Storm (hrs): 1

- Study Area
- 100 year ARI Spillway
- Low Flow Discharge Pipe
- Peel Main Drain
- Bollard Bulrush Swamp
- Bollard Bulrush Swamp 50m Buffer

Proposed Development
- POS
- Residential
- Road

Conceptual Flood Attenuation Area
- Bioretention Area (2% EIA)
- 1 Year 1 Hour
- 5 Year ARI
- 100 Year ARI

Data Source: DEC (2012); Rowe Group (2015); Nearmap (2015)

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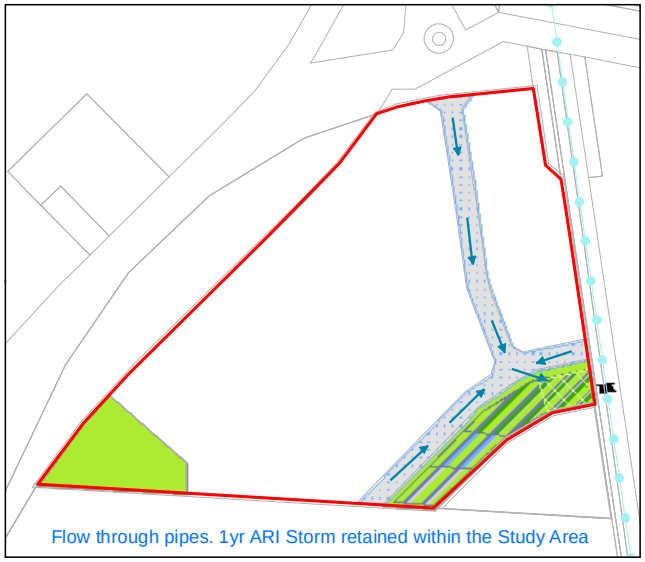
Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

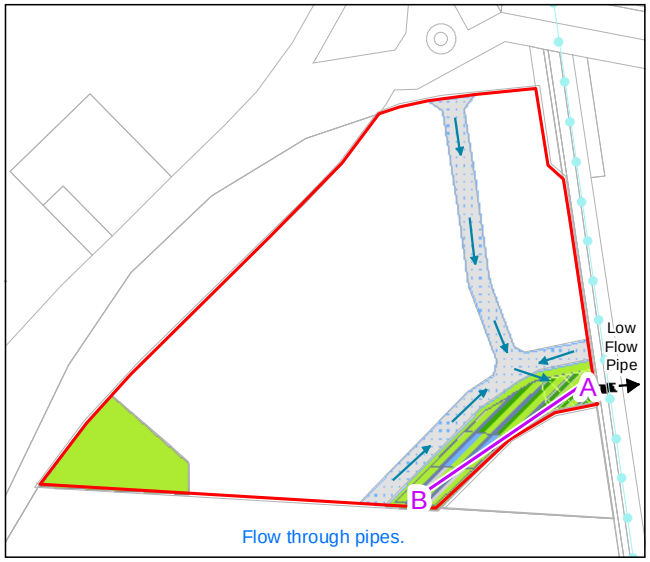
Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 9: Conceptual Stormwater Management Plan

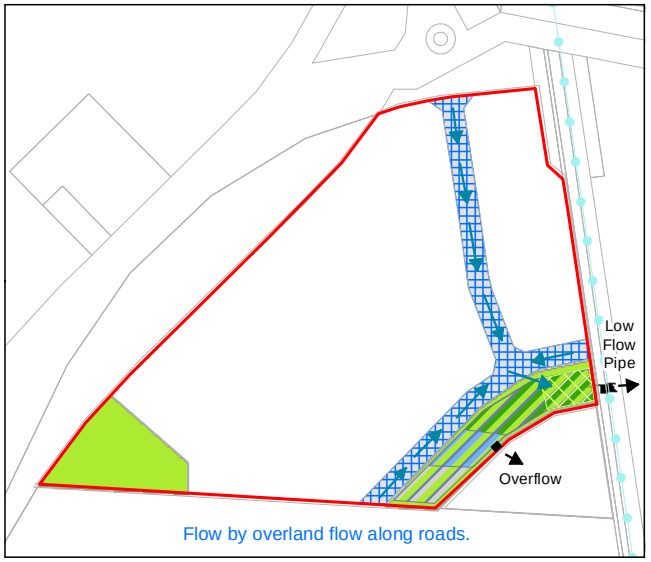
1 year 1 hour ARI Event Plan

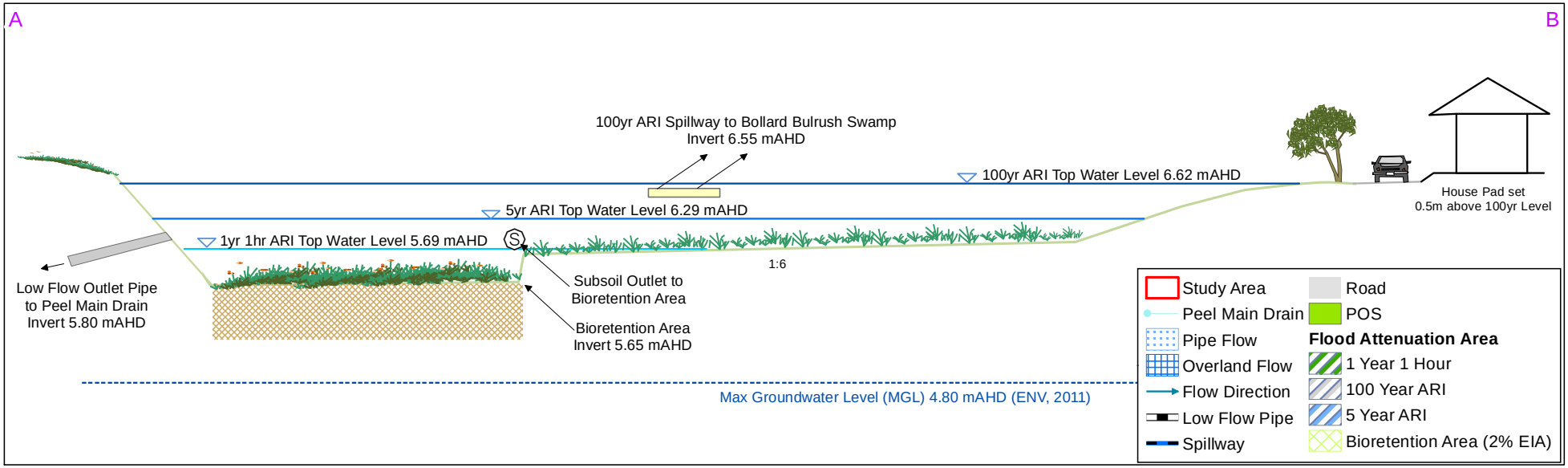


5 year ARI Event Plan



100 year ARI Event Plan





Note: Cross Section is conceptual only, and not drawn to scale

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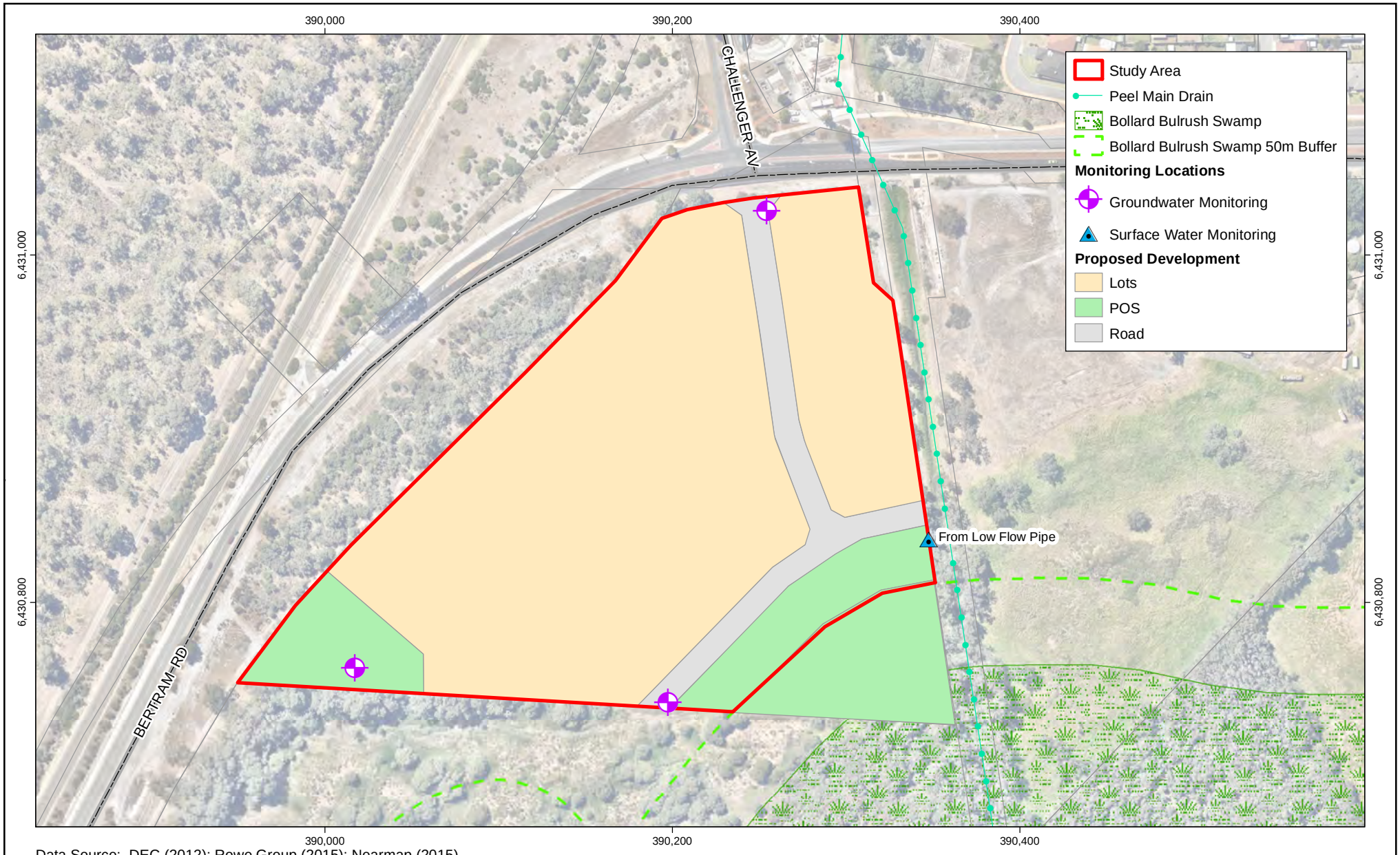
Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 10: 1yr, 5yr and 100yr ARI Event Plans



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Bestall Super Pty Ltd & The Royale Australian Golf Club Pty Ltd

Lot 661 Bertram Rd, Wellard: Local Water Management Strategy

Figure 11: Proposed Post-development Monitoring Locations

APPENDIX A

LWMS Checklist

LOCAL WATER MANAGEMENT STRATEGY: CHECKLIST (WAPC, 2008)

The following checklist provides a guide to items which should be addressed by developers in the preparation of Local Water Management Strategies for assessment by the local authority when an application for a structure plan is lodged.

1. Tick the status column for items for which information is provided
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column
3. Provide brief comments on any relevant issues
4. Provide brief descriptions of any proposed best management practices, e.g. multi-use corridors, community based-social marketing, water re-use proposals

Applicant: Royale Australian Golf Club Pty Ltd **Date:** June 2015

Name of Plan: Lot 661, Bertram Rd, Wellard

Contact: Matthew Yan, JDA Consultant Hydrologists

Address: Suite 1, 27 York St Subiaco WA 6008

Telephone: 9388 2436 **Email:** matt@jdahydro.com.au

Local Water Management Strategy Item	Required Deliverable	Deliverable LWMS Reference	☐	Comment
Executive Summary				
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Design elements and requirements for BMPs and critical control points	Executive Summary		Not Provided
Introduction				
Total water cycle management – principles & objectives Planning background Previous studies		Section 1.2 Section 1.1	✓	
Proposed Development				
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	Sections 2, 3 Fig 1	✓	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	Sections 3.0, 4.1 Figs 8, 9	✓	

Local Water Management Strategy Item	Required Deliverable	Deliverable LWMS Reference	☐	Comment
Design Criteria				
Agreed design objectives and source of objective		Sections 1.2	✓	
Pre-development Environment				
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?	Existing Site Charicteristics	Section 2, Figs 1 - 7	✓	
Site Conditions - existing topography / contours, aerial photo underlay, major physical features	Site Condition Plan	Section 2.1, Figs 1, 2	✓	
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geology Description	Sections 2.4 & 2.5 Fig 4	✓	
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting datasets where appropriate	Sections 2.6, 2.7, Figs 2, 5	✓	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	Section 2.8, Fig 6	✓	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan	Section 2.9, Fig 7	✓	
Water Use Sustainability Initiatives				
Water efficiency measures – private and public open spaces including method of enforcement		Section 4.1, Fig 8	✓	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		Section 4.1	✓	
Wastewater management		Section 4.1	✓	
Stormwater Management Strategy				
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan	Section 4.2, Figs 9 & 10	✓	
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	Section 4.2, Figs 9 & 10	✓	

Local Water Management Strategy Item	Required Deliverable	Deliverable LWMS Reference	☐	Comment
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan	Section 4.2	✓	
Groundwater Management Strategy				
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater Plan	Section 4.3	✓	
Actions to address acid sulfate soils or contamination		Section 4.5.2, Fig 4	✓	
The Next Stage - Subdivision and Urban Water Management Plans				
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		Section 5.2 & 5.3	✓	
Monitoring				
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		Sections 5.4 & 5.5, Fig 11	✓	
Implementation				
Developer commitments		Section 5.1	✓	
Roles, responsibilities, funding for implementation		Section 5.1	✓	
Review		Section 5.1	✓	

Western Australian Planning Commission (2008), Better Urban Water Management, Perth,

APPENDIX B

EPA Advice

Environmental Protection Authority

The Atrium,
Level 8, 168 St Georges Terrace,
Perth, Western Australia 6000.
Telephone: (08) 6364 6500.
Facsimile: (08) 6467 5557.

Postal Address: Locked Bag 33,
Cloisters Square, Perth, Western Australia 6850.
Website: www.epa.wa.gov.au

Secretary
Western Australian Planning Commission
469 Wellington Street
PERTH WA 6000

Your Ref 833-2-26-19 Pt 1
Our Ref CRN222573
Enquiries Gary Williams 6467 5425

Attn: Mr Anthony Muscara

DECISION UNDER SECTION 48A(1)(a)
Environmental Protection Act 1986

SCHEME AMENDMENT TITLE:	**Metropolitan Region Scheme Amendment 1189/57 Wellard Urban Precinct (West)**
LOCALITY:	**Town of Kwinana**
RESPONSIBLE AUTHORITY:	**Western Australian Planning Commission**
DECISION:	**Scheme Amendment Not Assessed - Advice Given (no appeals)**

Thank you for your letter of 26 February 2010 referring the above proposed scheme amendment.

After consideration of the information provided by you, the Environmental Protection Authority (EPA) considers that the proposed scheme amendment should not be assessed under Part IV Division 3 of the *Environmental Protection Act 1986* (EP Act) but nevertheless provides the following advice and recommendations.

ADVICE AND RECOMMENDATIONS

1. Environmental Issues

- Wetland
- Vegetation
- Fauna
- Surface water quality
- Surface water quantity

2. Advice and recommendations regarding Environmental Issues

The Indicative Structure Plan (ISP) provides a buffer (minimum 50 metres) between the Lakes EPP boundary and proposed residential development. The EPA considers that this is an adequate separation between residential development and the EPP boundary and has based its decision to "not assess" the amendment on the provision of this buffer.

Any proposals (eg subdivision applications) to alter the proposed buffer distance could potentially have significant environmental impacts and may require referral to the EPA pursuant to the *Environmental Protection Act 1986*.

3. General Advice

- For the purposes of Part IV of the EP Act, the scheme amendment is defined as an assessed scheme amendment. In relation to the implementation of the scheme amendment, please note the requirements of Part IV Division 4 of the EP Act.
- There is no appeal right in respect of the EPA's decision on the level of assessment of scheme amendments.
- A copy of this advice will be sent to relevant authorities and made available to the public on request.

Colin Murray
Director
Assessment and Compliance Services

29 March 2010

APPENDIX C

Water Corporation Advice

Kate Smith

From: Brett Coombes <Brett.Coombes@watercorporation.com.au>
Sent: Monday, 13 August 2012 12:43 PM
To: Darren Evans
Subject: RE: LOT 661 BERTRAM ROAD, WELLARD (6233)
Attachments: SKON451-10X12081312250.pdf

Darren,

Further to our initial telephone conversation about infrastructure planning for this area.

The Corporation does not have any current wastewater conveyance planning to guide servicing of this site. Previously adopted wastewater planning for this area has not made any allowance for servicing of land abutting the Bollard Bulrush Swamp. For your information, I have attached an excerpt of the current adopted wastewater planning for this area, which is now out-dated.

As previously discussed, our Wastewater Infrastructure Planning engineers are currently reviewing the conveyance planning for the Kwinana Sewer District to address the recent changes in urban and urban deferred zonings, particularly around the southern end of the wetland. The planning review will also look at possible servicing solutions for your site. It may be possible to gravitate wastewater from this site northwards towards the gravity system upstream of the existing Bertram Rd Waste Water Pump Station (see Kwinana PS No.6 shown as a blue dot on the attached). Details such as the likely sewer pipe routes, grades, sizes, discharge point/s and any downstream system upgrading required are yet to be determined. From my experience with similar wastewater planning reviews elsewhere in the metropolitan area, I would anticipate that this wastewater planning review should be completed around October.

With regard to water planning, the Corporation's water planners have recently completed a high-level strategic review of the Medina Water Scheme, within which this site is located. The site is within the now planned gravity zone of the long-term Medina scheme. The longer term servicing of the full development of the Medina scheme will require the Corporation to construct a large ground tank and an associated elevated tank (to serve a high level area) at a designated reservoir site in Kwinana. Substantial expansion of the distribution mains system will also be required, particularly to serve proposed new urban development areas to the east of the Kwinana Freeway and the areas around the Bollard Bulrush Swamp. In this regard, the Corporation's water planners are currently undertaking more detailed water distribution main planning for the Medina scheme to determine the route/s, size and staging of distribution mains to serve this and other land in the locality.

The existing water pipes through Wellard immediately to the north are small reticulation sized pipes (typically 100 and 150mm diameter) and are not likely to have the capacity to be extended to serve land to the south of Bertram Rd. At this early stage, it is anticipated that an extension will need to be undertaken from a distribution main on Johnson Rd (either from the existing DN300 or a larger future main), heading westwards along Bertram Rd to serve the proposed development of this site and surrounding land. These matters will be clarified through the finalisation of the distribution main planning for Medina.

Regards

Brett Coombes
Senior Town Planner
Water Corporation

T: (08) 9420 3165 | F: (08) 9420 3193

From: Darren Evans [mailto:darren.evans@greg-rowe.com]
Sent: Monday, 30 July 2012 8:55 AM
To: Brett Coombes
Subject: RE: LOT 661 BERTRAM ROAD, WELLARD (6233)

Hi Brett
Thanks for your telephone advice on the below. Will you able to get through the written advice and mapping during this week?
Darren

From: Darren Evans
Sent: Thursday, 19 July 2012 2:27 PM
To: 'Ross.Crockett@watercorporation.com.au'; 'Brett Coombes '
Subject: LOT 661 BERTRAM ROAD, WELLARD (6233)

Ross / Brett

Apologies if this is not a query you would normally field.

The below land is zoned Urban and we are currently preparing a Structure Plan for the land. Are you able to advise the latest water and sewer planning for the land, including the provision of any planning mapping you may have?

Darren Evans
Senior Associate (MAIPM)
Mb: 0413 592 724

GREG ROWE & associates
FOCUSED ON ACHIEVEMENT

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CATCHMENT 'V3297 - 042'
R20 - 4.23 @ 75% (D)
R20 - 18.34 @ 100% (D)
R20 - 10.09 @ 100% (W)
SEWER DESIGN FLOW - 4.7 L/s

CATCHMENT 'W6366 - 042'
R20 - 3.77 @ 100% (D)
R20 - 1.10 @ 100% (W)
SEWER DESIGN FLOW - 1.1 L/s

CATCHMENT 'Y9406 - 042'
R20 - 1.16 @ 75% (D)
R20 - 9.73 @ 100% (D)
R20 - 6.37 @ 100% (W)
SEWER DESIGN FLOW - 4.0 L/s

R20 - 5.97 @ 100% (W)
SEWER DESIGN FLOW - 4.2 L/s

CATCHMENT '180 - 042'
R20 - 28.43 @ 75% (D)
SEWER DESIGN FLOW - 4.7 L/s

CATCHMENT 'AC5439 - 042'
SEWER DESIGN FLOW - 0.0 L/s

CATCHMENT 'AA9893 - 042'
R20 - 0.55 @ 75% (D)
R20 - 1.30 @ 75% (W)
R20 - 13.64 @ 100% (D)
R20 - 4.55 @ 100% (W)
SEWER DESIGN FLOW - 4.6 L/s

KWINANA P.S. 6 -
BERTRAM RD
PUMP STN. '106 - 042'
REDUCTION 's84 - 042'
R15 - 4.36 @ 75% (D)
R15 - 0.81 @ 75% (W)
R15 - 0.43 @ 100% (D)
R15 - 5.42 @ 100% (W)
R20 - 50.79 @ 75% (D)
R20 - 10.56 @ 75% (W)
R20 - 132.13 @ 100% (D)
R20 - 46.97 @ 100% (W)
SEWER DESIGN FLOW - 53.8 L/s
EXISTING PUMP RATE - 26.0 L/s
LONG TERM PUMP RATE - 184.7 L/s

V3280
V3289
V3294
V3295
V3297
W6366
W6368
S1385
Y9406
Y9408
Y9410
Y9413
Y9418
A7303
AC5438
AA9893
AA9896

APPENDIX D

City of Kwinana Endemic Species

HEAD

CENTRAL SOILS SPECIES LIST

Start of flowering time: **Spring** **Summer** **Autumn** **Winter** **All Year**

Common Name	Botanical Name	Height (m)	Flower Colour	Flower Time	Other Info
Trees (Up to 15m)					
Fraser's Sheoak	*Allocasuarina fraseriana*	15	brown	May-Oct	
Candle Banksia	*Banksia attenuata*	5-8	yellow	Sep-Oct	
Bull Banksia	*Banksia grandis*	10	yellow	Sep-Dec	✳
Holly-leaf Banksia	*Banksia ilicifolia*	10	pink & cream	Mar-Jan	
Firewood Banksia	°*Banksia menziesii*	10	pink & red	Feb-Aug	✳
Red Flowering Gum	*Eucalyptus ficifolia*	8	red	Dec-May	✳ WA
Coastal Blackbutt	*Eucalyptus todtiana*	9-16	creamy white	Feb	
Coral Gum	*Eucalyptus torquata*	4-11	pink, red	Aug-Dec	WA
Sandplain Woody Pear	*Xylomelum angustifolium*	7	creamy white	Dec-Feb	✳ WA
Shrubs (3 to 5m)					
Coojong	*Acacia saligna*	5	yellow	Aug-Oct	
Common Woollybush	*Adenanthos cygnorum*	2-4	red	Sep-Feb	✳
Tree Smokebush	*Conospermum triplinervium*	4.5	greyish white	Aug-Nov	✳
Red Pokers	*Hakea bucculenta*	4.5	red	Aug-Sep	✳ WA
Royal Hakea	*Hakea victoria*	3	white, colourful foliage	Jun-Jul	✳ WA
Zamia Palm	*Macrozamia riedlei*	3	red cones	Sep-Oct	
River Pea	*Oxylobium lineare*	3	red, yellow	Sep-Jan	
Shrubs (1 to 3m)					
	Acacia dentifera	3	golden	Aug-Nov	
Prickly Moses	*Acacia pulchella*	1.5	yellow	Jun-Oct	
Basket Flower	*Adenanthos obovatus*	2	scarlet, orange	May-Dec	
One-sided Bottlebrush	°*Calothamnus quadrifidus*	1-2	red	Aug-Dec	
Silky-leaved Blood Flower	*Calothamnus sanguineus*	1.5	blood red	Mar-Oct	✳
Plume Smokebush	*Conospermum incurvum*	0.4-1	white-grey	Jul-Nov	
Terete-leaved Dampiera	*Dampiera teres*	0.2-0.6	blue	Aug-Nov	✳
Prickly Dryandra	*Dryandra armata*	1.5	yellow	Jun-Nov	
Orange-flowered Eremaea	*Eremaea pauciflora*	1.5-2	orange	Sep-Dec	✳
Purple-flowered Eremaea	*Eremaea purpurea*	1.5	pink-purple	Oct-Feb	
Pink Pokers	*Grevillea petrophiloides*	3	pink	Jan-Nov	✳ WA
Honey Bush	*Hakea lissocarpha*	3	white-yellow, pink	Jun-Sep	
Candle Hakea	*Hakea ruscifolia*	3	white	Dec-Mar	
Many-flowered Honeysuckle	*Lambertia multiflora*	2.5	yellow	Jun-Dec	
Coast Honey-myrtle	*Melaleuca acerosa*	1	cream	Sep-Dec	
	Melaleuca conothamnoides	0.3-1.5	pink-purple	Apr-Jun/ Sep-Nov	✳
Thread-leaf Snottygobble	*Persoonia saccata*	0.2-1.5	yellow	Jul-Jan	
Spiked Scholtzia	*Scholtzia involucrata*	1.5	white, pale pink	Dec-Mar	✳
Grass Tree	*Xanthorrhoea preissii*	3	white	Nov-Jan	✳
Shrubs (less than 1m)					
Narrow-winged Wattle	*Acacia stenoptera*	0.3-1	cream-yellow	May-Sep	
Grass Wattle	*Acacia willdenowiana*	0.5	yellow	Jun-Oct	
	Andersonia lehmanniana	0.5	white, pink-purple	May-Sep	
Camphor Myrtle	*Baeckea camphorosmae*	1	white-pink	May-Feb	
	Beaufortia elegans	1	purple, pink	Nov-Feb	
Aniseed Boronia	*Boronia crenulata*	1	pale red	Aug-Oct	✳
Common Brown Pea	*Bossiaea eriocarpa*	0.6	brown & yellow	Jul-Oct	
Summer Starflower	*Calytrix flavescens*	0.8	yellow	Nov-Jan	
Pink Summer Calytrix	*Calytrix fraseri*	0.6-1	pink, purple	all year	✳
Common Dampiera	*Dampiera linearis*	0.5	indigo	Jul-Nov	✳
Couch Honeypot	*Dryandra lindleyana*	low	gold	May-Sep	
	Gompholobium confertum	1	blue-purple	Aug-Mar	
Hairy Yellow Pea	*Gompholobium tomentosum*	0.3-1	yellow	Aug-Dec	
Stalked Guinea-flower	*Hibbertia racemosa*	0.3	yellow	Jul-Nov	
Orange Stars	*Hibbertia stellaris*	1	orange-yellow	Aug-Dec	
Devil's Pins	*Hovea pungens*	1	purple	Jun-Nov	✳
Common Hovea	*Hovea trisperma*	0.7	purple	Jun-Sep	
Swan River Myrtle	*Hypocalymma robustum*	1	pale-deep pink	Jul-Oct	✳
Granny's Bonnets	*Isotropis cuneifolia*	0.3	yellow & red	Aug-Oct	
Waldjumi	*Jacksonia sericea*	0.6	orange	Dec-Feb	
Lance-leaved Cassia	*Labichea punctata*	1	yellow	Jul-Oct	
Rough Honey-myrtle	*Melaleuca scabra*	1	pink-purple	Sep-Dec	
	Melaleuca trichophylla	0.7	pink-purple	Nov-Jan	
Pixie-mops	*Petrophile linearis*	0.7	pink, mauve	Sep-Nov	
	Petrophile macrostachya	1	yellow	Aug-Nov	
Pepper-and-salt	*Philotheca spicatus*	0.6	lilac	Jun-Oct	
Rose Banjine	*Pimelea rosea*	1	pale-deep pink	Aug-Nov	✳
Yellow Banjine	*Pimelea sulphurea*	0.5	yellow	Oct-Nov	
Bushy Featherflower	*Verticordia densiflora*	1	pink, white	Nov-Jan	
Perennial Herbs					
Catspaw	*Anigozanthos humilis*	0.5	orange	Aug-Oct	
Kangaroo Paw	*Anigozanthos manglesii*	1	red & green	Sep-Nov	✳
Green Kangaroo Paw	*Anigozanthos viridis*	1	green	Sep-Nov	
Tall Speargrass	*Austrostipa flavescens*	0.5	silver	Sep-Oct	
Bearded Speargrass	*Austrostipa semibarbata*	0.6	white hairy	Aug-Nov	
Blue Squill	*Chamaescilla corymbosa*	0.3	blue	Aug-Oct	
Spiny Cottonheads	*Conostylis aculeata*	0.3	yellow	Sep-Nov	
Grey Cottonheads	*Conostylis candicans*	0.5	yellow	Aug-Sep	✳
Bristly Cottonheads	*Conostylis setigera*	0.3	yellow	Sep-Oct	
Blueberry Lily	*Dianella revoluta*	1	purple	Sep-Jan	
Foxtail Mulga-grass	*Neurachne alopecuroidea*	0.5	grey	Aug-Nov	
Morning Iris	*Orthrosanthus laxus*	0.4-0.6	blue	Aug-Oct	✳
Purple Flag	*Patersonia occidentalis*	0.5-0.8	purple	Sep-Oct	✳
Climbers & Groundcovers					
Native Wisteria	°*Hardenbergia comptoniana*	climber	purple	Jun-Sep	✳
Snakebush	°*Hemiandra pungens*	low	mauve	all year	
Running Postman	*Kennedia prostrata*	low	red	Aug-Nov	✳
Pronaya	*Pronaya fraseri*	climber	pale mauve	Dec-Feb	

° Comes in different forms (ie a shrub might have a groundcover form or different flower colours)

✳- Star Performer (hardy or long flowering) - Butterfly attracting - Bird attracting

WA - Western Australian plant not a local plant

KEY

central

TOWN OF kwinana

Central Coastal Plain
Anketell, Bertram, Casuarina, Wandi and Wellard*
*East of Wellard Road.

save water, money
& bring life back to your garden

Grow Local Plants

Kangaroo Paw
Anigozanthos manglesii
pictured left

COASTCARE

TOWN OF kwinana

Central Coastal Plain
Anketell, Bertram, Casuarina, Wandi and Wellard*
*East of Wellard Road.

This brochure was prepared by Melinda Picton-King, North Metro Catchment Group Inc.

Sponsored by: State Water Strategy Department of the Premier and Cabinet

swan catchment council

Government of Western Australia

WHAT ARE LOCAL PLANTS?

Local plants are species that would naturally occur in your neighbourhood and are therefore adapted to the local climate and soil.

GROW LOCAL PLANTS

There are a huge range of local WA plants that can be used to create many contemporary garden styles such as cottage, formal, Mediterranean and bushland. Be creative with local plants and use them in hanging baskets and containers, as hedges and as topiary.

Garden Design Tips

- Plan your garden design on graph paper.
- Think about areas of usage (eg eating areas, play areas) and incorporate these into your garden design.
- Keep in mind views from the house (eg retain good views and use plants to hide eyesores).
- Plant trees at least 3m from fences and walls so their growth isn't hampered and they don't become a nuisance.
- Make sure you prepare the site and remove all weeds prior to mulching or planting.
- You can use local plants in your whole garden, in a garden bed or mixed in with exotics.
- Group plants with similar water and fertiliser requirements together, especially if mixing local plants with exotics.
- Keep in mind the growing requirements of plants (eg don't plant a sun loving plant in the shade of a larger shrub).
- Be aware that there are different forms of plants you can use in your garden (eg dwarf forms of trees and groundcover forms of many shrubs).
- Select plants that flower in each season to provide colour in your garden all year round.
- Use a diverse range of plants but repeat themes of plants and place them in groups of uneven numbers for greater impact.
- Vary the height layers in your garden to add interest and habitat. (eg tree canopy, shrubs, groundcovers).
- Think of your garden like a room in your house and plant in stages. Lay the carpet (groundcovers) in first, then place the furniture (theme shrubs and trees) and then dress the room with the smaller flowering shrubs and feature plants.
- Continually review your design and keep complementing your garden with new plants. Think of your garden as progressive and ever changing to be built upon over time.

PLANT SELECTION & PLANTING OUT

- Buy plants local to your area or suited to your soil type (see list).
- Buy small plants in bigger pots as they aren't root bound and better establish in the garden. You can buy some larger feature plants for a more instant effect.
- Always read the labels to check the size of the plant when mature to be sure that you are getting the desired plant form.
- Coastal plants will grow inland, but inland plants don't grow well on the coast.
- Don't choose plants that are environmental weeds.
- Plant in late April or May after the first good autumn rains, as plants have more time to establish before summer.

WA PLANT NURSERIES

Different nurseries have varying ranges of WA plants so you might need to shop around. If you really want a particular selection of plants, then it is a good idea to order ahead in about September so the plants can be grown ready for planting in autumn. Some specialist local nurseries are:

APACE Nursery:	1 Johanna St, NORTH FREMANTLE
Boola Wongin:	619 Armadale Rd (near Nicholson Rd), FORRESTDALE
Carramar Coastal Nursery:	Lot 5 885 Mandurah Rd SECRET HARBOUR
Lullfitz Nursery:	1071 Thomas Road, OAKFORD
Men of the Trees:	Rockingham Golf Club, Elanora Dr, COOLOONGUP
Ngulla Community Nursery:	65 Born Road CASUARINA
Australian Native Nurseries Group:	141 King Rd, OAKFORD
Zanthorrea Nursery:	155 Watsonia Rd, MAIDA VALE

WATERING

WA plants are adapted to our dry climate and low rainfall - they are used to a bit of stress and in fact need this to perform their best. Overwatering leads to shorter lived plants with excessive growth and less prolific flowering. An excess of water leads to leaching of nutrients from sandy soils and encourages diseases that can lead to fatal root rot.

Remember the aim is to encourage plants to grow strong root systems, which makes them more water efficient and drought tolerant. To keep your garden looking its best, it may be desirable to give some plants a supplementary watering over summer.

When to water (always follow water restrictions)

For new plants water:
- Once or twice a week in the first few weeks after planting.
- Once or twice a week in the summer period for the first 1-2 years until plants are established (generally from about November to May until the first good rain occurs).

For established plants water:
- When there is a heat wave
- When the soil under the surface is dry
- When signs of stress are apparent (eg wilting, dull foliage colour, leaf shrinkage)

In general the watering regime for mature plants varies with the soil type, origin of the plant, season and natural rainfall.

What irrigation to use

WA plants like the soil surface to remain dry and many are sensitive to overhead watering (eg sprinklers, misters). Thus the best irrigation to use is adjustable dripper/trickle systems or subsurface irrigation.

Watering tips

- Watering in the morning is preferable as moisture sitting on plant leaves and stems overnight can cause plant diseases.
- Avoid watering only the soil surface layer as this encourages shallow roots making plants more susceptible to drying out and blowing over. Longer deeper watering encourages the growth of deeper, more stable roots.
- If water repellence occurs, apply a wetting agent.
- Use a dripper with a high flow rate for water demanding plants eg *Boronia*, *Scaevola*.

Anigozanthos humilis

Hovea pungens

Hemiandra pungens

Conostylis aculeata

Hardenbergia comptoniana

PRUNING

To keep WA plants looking their best, it is necessary to do some pruning to help keep the plant in shape and promote flowering.

When to prune

In general prune after flowering has finished in late spring or early summer. Avoid pruning in winter or mid summer, as this may cause plants to die back extensively. It is better to prune young plants lightly and regularly. Older plants can be rejuvenated by more extensive pruning after flowering.

How to prune

There are two main types of plant flowering habits each requiring different pruning methods:

1. Plants that flower on the end of each season's growth – trim off the flowering stems from behind the seed capsules after the plant has finished flowering. Regular pruning prevents these plants from becoming straggly. Eg *Callistemon* (Bottlebrush), *Pimelea*.
2. Plants that flower on old wood – remove the oldest wood from the centre of the plant, letting the younger wood remain. Eg some species of *Melaleuca*.

Tips for pruning

- Cut off the whole branch cleanly at the join leaving no protruding stump.
- Remove low branches to make weeding easier.
- Use chopped up prunings as mulch.
- Only prune the softer wooded plants (eg large wattles) lightly as they aren't as hardy as the woodier plants and tend to die back extensively.
- *Eucalypts*, *Callistemons* and *Melaleucas* respond well to pruning and can tolerate a hard prune.
- Cut back Kangaroo Paws to the ground after flowering each year. It helps prevent black ink disease and promotes better growth.

MULCH

Good mulch consists of a mixture of different sized materials such as leaves, twigs and bark, lets water easily penetrate through to the soil and prevents evaporation. The mulch materials shouldn't absorb too much water, otherwise they make less available to the plants.

The best mulch

- Groundcovers and natural leaf litter formed by the plants in your garden.
- Street tree loppings – may contain some weeds but they are easily seen and removed.
- Inert materials (eg gravel, crushed brick) are particularly good in windy areas as they don't blow around.

When to mulch

Organic mulches need renewing seasonally as they break down over time, but are best applied at the start of warmer weather in spring and early summer.

How much mulch

Apply mulch about 5cm thick, creating a bowl shape around the plant to aid water retention.

What to avoid:

- Avoid layering mulch too thickly as this can impede water infiltration and reduce plant survival.
- Avoid mulching too close to the stem of the plant as the constant humidity encourages plant diseases and WA plants prefer the surrounding soil surface to be dry.
- Avoid using sawdust and raw wood products (eg wood chips) as they can interfere with iron uptake, draw nitrogen out of the soil and cause the soil to become water repellent. Always compost woody mulches for at least 6 months before use.
- Avoid using mulch from soft leaved plants like many exotic species, as it decays too fast and releases too many nutrients for WA plants.
- Avoid some packaged mulches as they contain high levels of nitrogen and phosphorus which isn't suitable for WA plants.

FERTILISERS

As WA plants are adapted to soils that are low in nutrients they usually don't require fertiliser. In a garden situation you can apply a little fertiliser to keep plants looking perfect, but be cautious as some species are sensitive to fertilisers, particularly phosphorus. Sufficient phosphorus is naturally present in the soil.

When to apply

Apply fertiliser when planting by mixing into the soil at the bottom of the hole. Subsequent fertilising should be done on the surrounding root zone only when nutrient deficiency is apparent and only when plants are actively growing in spring.

What fertiliser to use

(Note: always follow the manufacturer instructions on dosage and application)

- Slow release fertilisers for native plants.
- Low phosphorus and low nitrogen fertilisers.
- Fish emulsion or seaweed fertiliser to boost plants immunity to disease.

What not to fertilise

- Some plants are highly sensitive to fertilisers, particularly fertilisers that contain phosphorus. Eg: *Banksias*, *Grevilleas*, *Dryandras*, *Hakeas* (Proteaceae family).
- Don't overfertilise Everlastings as they get too tall and weak and lie down when flowering.

REFERENCES

For more information refer to

A New Image for WA Plants - George Lullfitz,
Grow With Us - Wildflower Society of WA,
Growing Locals - Robert Powell.

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