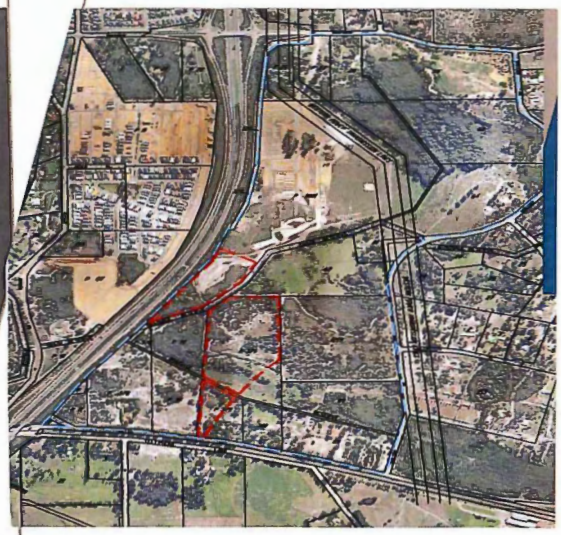
ATTACHMENT 8

Part Lot 9001 Mortimer Road and Part Lot 379 Millar Road, Wellard (East) Local Structure Plan

P02016-001



Prepared for
Armana Holdings

October 2015

DEPARTMENT OF PLANNING
19 NOV 2015
FILE SPN/0711

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 JUNE 2015

Signed for and on behalf of the Western Australian Planning Commission



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

M. Wheelan Witness

8 December 2015 Date

Date of Expiry : 19 October 2030

Document Information

Prepared for	Armana Holdings
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2	3/10/2013	Final (included traffic study)	LVE		LVE	
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CERTIFICATION OF APPROVED STRUCTURE PLAN

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..... Date

Signed for and on behalf of the Western Australian Planning Commission

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

..... Witness

..... Date

This Structure Plan is prepared under the provisions of the City of Kwinana Town Planning Scheme No. 2 and the *Planning and Development (Local Planning Schemes) Regulations 2015*

TABLE OF CHANGES OR DEPARTURES FROM STRUCTURE PLAN

Change or Departure No.	Description of Change or Departure	Date Approved by the WAPC (if required)	Date Structure Plan commences operation

Executive Summary

The Wellard East Local Structure Plan encompasses land described as Part Lot 9001 (previously known as Lot 201) Mortimer Road and Part Lot 379 Millar Road, Wellard (East) and proposes development as summarised in **Table 1**. The Wellard East Concept Plan for the whole Wellard East Cell, which covers land located between Mortimer and Millar Road, proposes development as summarised in **Table 1**. This structure plan does not overlap, supersede or consolidate an approved structure plan. This structure plan is a southern extension to the adopted Local Structure Plan for Lot 27 and part Lot 201 Mortimer Road, Wellard (East).

Table 1. Structure Plan Summary Table

Item	Data Wellard East Cell (Concept Plan)	LSP Area	Section number referenced within the Structure Plan report
Total area covered by the concept plan and the local structure plan	170.3 ha	16.67ha	1
Net land area covered by the concept plan and local structure plan (minus CCW wetland core, WP Easement, drainage reserves, school site, marsupial rehabilitation clinic, 1:1 year drainage basins where relevant)	129.9ha	13.29ha	
Area of each land use proposed: <u>Zones</u>			3
▪ Residential	60.22ha	8.25ha	
▪ Development – Marsupial rehabilitation clinic	1.08ha	Nil	
<u>Reserves</u>			
▪ Public Purposes - Primary school	4ha	3.17 ha	
▪ Parks and Recreation – Public Open Space	42.61ha	1.35ha	
Estimated lot yield	Approximately 1440	Approximately 203	3
Estimated number of dwellings	Approximately 1468	Approximately 208	3
Estimated residential density	R20 to R50 8.6 dwellings per gross hectare	R20 to R50 12.4 dwellings per gross site hectare	3.3
Dwellings per site hectare *As per Liveable Neighbourhoods*		15.3 dwellings per net site hectare	
Estimated population	3,816 (based on 2.6 persons per dwelling as per 2011 census data for Wellard West)	540.8 (based on 2.6 persons per dwelling as per 2011 census data for Wellard West)	3
Number of secondary schools	None	None	
Number of primary schools	One	A portion of one school	3
Public Open Space	11.5%	8.6%	3.2

Table of Contents

Executive Summary iii

PART ONE – STATUTORY SECTION 2

1 Planning Background 6

1.1 Introduction and Purpose 6

1.2 Land Description 6

1.2.1 Location 6

1.2.2 Area and Land Use 6

1.2.3 Legal Description and Ownership 7

1.3 Planning Framework 8

1.3.1 Zoning and Reservations 8

1.3.2 Regional and Sub-Regional Structure Plans 9

1.3.3 Planning Strategies 11

1.3.4 State Planning Policies 13

1.3.5 Local Planning Policies 13

2 Site Conditions and Constraints 15

2.1 Biodiversity and Natural Area Assets 15

2.1.1 Regional Context 15

2.1.2 Flora and Vegetation 15

2.1.3 Bush Forever 19

2.1.4 Wetlands 19

2.1.5 Environmentally Sensitive Areas 20

2.1.6 Biodiversity Linkages 21

2.1.7 Fauna 21

2.2 Landform, Soils and Topography 24

2.2.1 Topography 24

2.2.2 Landforms and Soil 24

2.3 Acid Sulfate Soils 24

2.4 Groundwater and Surface Water 25

2.4.1 Groundwater 25

2.4.2 Surface Water 25

2.5 Bushfire Hazard 26

2.6 Heritage 27

2.6.1 Indigenous Heritage 27

2.6.2 Non-Indigenous Heritage 27

2.7 Context and Other Land Use Constraints 27

2.8 Potential Site Contamination 27

2.9 Adjacent Land Uses 28

2.9.1 Livestock Holding Facility 28

2.9.2 Power Boat Facility 29

2.9.3 Kwinana Freeway 29

2.9.4 Mundijong Freight Line 30

2.9.5 Environmental Protection (Kwinana) (Atmosphere Wastes) Policy 1999 Boundary 30

2.9.6 Basic Raw Materials 30

3 Land Use and Subdivision Requirements 32

3.1 Proposed Land Use 32

3.2 Open Space 33

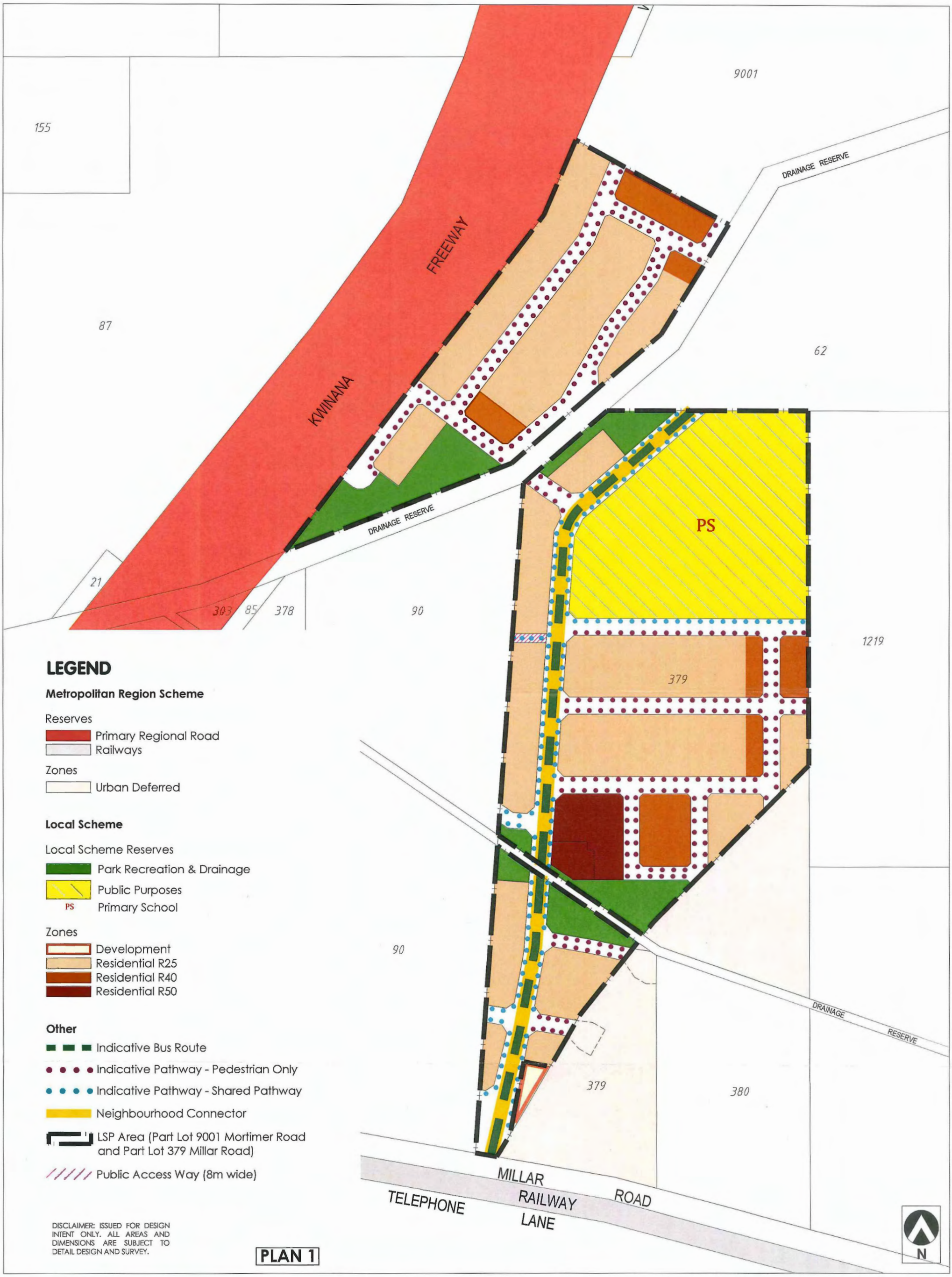
3.3 Residential 35
3.4 Movement Networks 35
3.4.1 Vehicular Access and Transport Assessment 36
3.5 Water Management 37
3.6 Education Facilities 38
3.7 Infrastructure Co-ordination, Servicing and Staging 38
3.7.1 Sewerage 38
3.7.2 Water Supply 39
3.7.3 Natural Gas 39
3.7.4 Power 40
3.7.5 Telecommunications 40
3.7.6 Proposed Staging of Subdivision 40
3.8 Developer Contribution Arrangements 40
4 Conclusion 42
5 References 43

Appendices

Appendix A	Certificate of Titles for LSP Area
Appendix B	Spring Flora and Vegetation Survey and Wetland Assessment
Appendix C	Preliminary Acid Sulfate Soils Assessment
Appendix D	Transport Assessment Report
Appendix E	Local Water Management Strategy Addendum
Appendix F	Local Water Management Strategy (Cardno 2010)
Appendix G	Landscape Masterplan
Appendix H	Noise Assessment
Appendix I	LSP and Wellard East Cell POS Schedules
Appendix J	Fauna Assessment
Appendix K	Fire Management Plan

Figures

Figure 1. Location Plan
Figure 2. Aerial Photograph
Figure 3. Existing Lot Configuration
Figure 4. Metropolitan Region Scheme (Zoning Map)
Figure 5. Final Jandakot Structure Plan
Figure 6. City of Kwinana – Town Planning Scheme No.2 (Zoning Map)
Figure 7. Eastern Residential Intensification Concept
Figure 8. Vegetation Communities
Figure 9. Vegetation Condition
Figure 10. Geomorphic Wetlands and Regional Biodiversity Linkages
Figure 11. Topography
Figure 12. Acid Sulfate Soils
Figure 13. Land Uses within and surrounding the Wellard East Cell
Figure 14. Context and Constraints Plan
Figure 15. Wellard East Concept Plan
Figure 16. Public Open Space
Figure 17. Servicing Plan
Figure 18. Indicative Road Cross Sections
Figure 19. Indicative Road Cross Sections
Figure 20. Indicative Laneways Subdivision Design



LEGEND

Metropolitan Region Scheme

Reserves
- Primary Regional Road
- Railways

Zones
- Urban Deferred

Local Scheme

Local Scheme Reserves
- Park Recreation & Drainage
- Public Purposes
  - PS — Primary School

Zones
- Development
- Residential R25
- Residential R40
- Residential R50

Other
- Indicative Bus Route
- Indicative Pathway - Pedestrian Only
- Indicative Pathway - Shared Pathway
- Neighbourhood Connector
- LSP Area (Part Lot 9001 Mortimer Road and Part Lot 379 Millar Road)
- Public Access Way (8m wide)

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY.

PLAN 1

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LOCAL STRUCTURE PLAN MAP

Part Lot 9001 Mortimer Road and Part Lot 379 Millar Road, Wellard (East)
Local Structure Plan
City of Kwinana

SIZE A3
1:3000
0 metres 30 60 90 120

REF NO.	DRAW NO.	REV.
AMX WEL	RD1 102	G

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

PART ONE

STATUTORY SECTION

PART ONE – STATUTORY SECTION

1.0 Structure Plan Area

This Structure Plan shall apply to Part Lot 9001, Mortimer Road (previously known as Lot 201 Mortimer Road) and Part Lot 379, Millar Road, Wellard (East) being the land contained within the inner edge of the line denoting the structure plan boundary on the Structure Plan Map (**Plan 1**).

This Structure Plan is identified as the Part Lot 9001 Mortimer Road and Part Lot 379 Millar Road, Wellard (East) Local Structure Plan.

2.0 Structure Plan Content

The Structure Plan comprises the following sections:

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

b. 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.

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

3.0 Interpretation and Relationship with 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	The Structure Plan has been prepared under Clause 6.17.2.1 of the Scheme as the subject land is zoned 'Development'.
3.3	Provisions, Standards or Requirements	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.

4.0 Operation

4.1	Operation Date	This Structure Plan commences operation on the date it is adopted by the Western Australian Planning Commission pursuant to Clause 22 of the *Planning and Development (Local Planning Schemes) Regulations 2015*.
4.2	Change or Departure from Structure Plan	Clause 29 *Planning and Development (Local Planning Schemes) Regulations 2015* outlines the manner in which an amendment to a Structure Plan is determined.

5.0 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.

6.0 Subdivision/Development

6.1	Notifications on Title	In respect of applications for the subdivision of land the Council shall recommend to the Western Australian Planning Commission that conditions be imposed on the granting of subdivision approval for the following notifications on title pursuant to Section 70A of the *Transfer of Land Act 1893*: i. Lots affected by noise levels exceeding the noise target as per *State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning.* ii. On lots within 1000 metres of the boundary of the livestock holding facility on Telephone Lane, Baldivis advising of potential adverse impacts associated with odour emissions from the livestock holding facility. iii. Lots with a Bushfire Attack Level (BAL) rating of BAL 12.5 or greater.
6.2	Local Development Plans	Local Development Plans (LDPs) are required to be prepared and implemented pursuant to Part 6 of the *Planning and Development (Local Planning Schemes) Regulations 2015* for lots comprising one or 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 with direct boundary frontage (primary or secondary) to a drainage reserve; iv. Grouped dwelling lots; v. Lots not rear-loaded with a frontage of less than 12 metres;

		vi. Lots deemed to be affected by a recognised Bush Fire Hazard as identified spatially in the accompanying Bushfire Management Plan in Appendix K (as amended); and vii. Lots deemed to be affected by noise from the Kwinana Freeway or the Mundijong Freight Railway as identified spatially in the accompanying acoustic assessment under Appendix H (as amended).
6.3	Other provisions/standards/ requirements	This Structure Plan is supported by a Bushfire Hazard Level Assessment (BFHA), *Fire Management Plan – Local Structure Plan, Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard East* (May 2014) as amended. Any land falling within 100 metres of a bushfire hazard identified in the BFHA is designated as a Bushfire Prone Area for the purposes of the Building Code of Australia.
7.0	Other requirements	The Council shall recommend to the Western Australian Planning Commission that a condition be imposed on a grant of subdivision approval requiring: 1. A Mosquito and Midge Management Plan.

Part Lot 9001
Mortimer Road and
Part Lot 379 Millar
Road, Wellard (East)
Local Structure Plan

PART TWO

NON STATUTORY (EXPLANATORY) SECTION

1 Planning Background

1.1 Introduction and Purpose

This following report provides justification for a Local Structure Plan (LSP) for land described as Part Lot 9001 Mortimer Road and Part Lot 379, Millar Road, Wellard (East) (referred to as the LSP Area or the site in the following report). The following report also refers to the Wellard East Cell, which is land located between Mortimer and Millar Roads (refer to **Figure 1 and Figure 2** for LSP and cell boundaries). The LSP Area is located in the southern part of the Wellard East Cell.

Whilst the LSP Area covers part of the Wellard East Cell, the following report addresses planning (urban design), environmental and engineering issues in a holistic manner, however the detailed technical reports (such as the Local Water Management Strategy Addendum) mainly focus on the LSP Area. Also the Wellard East Concept Plan (**Figure 15)** shows a design over the LSP Area, the approved LSP design over the northern portion of the cell (ie previously part Lot 201 and Lot 27 Mortimer Road) and a conceptual design over the balance of the cell. Also the design shown over part Lot 378 and Lot 90, Millar Road generally reflects the LSP design approved for these lots. The Local Structure Plan for the site is identified as **Plan 1** in Part One of the Structure Plan documentation (ie Statutory Section).

The technical reports demonstrate that recommendations for Armana landholdings will not adversely impact or prejudice future development/subdivision of adjoining land. **On this basis, LSP approval is being requested for the southern portion of Lot 9001 and a portion of Lot 379 (external to the current odour buffer).** This will enable subdivision to proceed in a timely manner, whilst other more detailed issues are addressed and resolved on adjoining land.

The following report recognises the opportunities and constraints of the Wellard East Cell, particularly in terms of the location, lot configuration, topography and environmental features as well as the specific drainage requirements reflected in the Local Water Management Strategy (LWMS) Addendum for Part Lot 9001 and Part Lot 379. The following report also includes a review of the current planning framework, environmental investigations, transport assessment, servicing analysis and design rationale for the LSP Area. It should be noted that many of the reviews in the report, including servicing, environmental and planning cover the whole cell, whilst more specific site works have been undertaken for the LSP Area only.

The LSP (**Plan 1**) will guide the subdivision of part of the Wellard East Cell and ensure that development proceeds in a sustainable manner facilitating the objectives of the Western Australian Planning Commission (WAPC), as advocated through Liveable Neighbourhoods and in accordance with the objectives of the City of Kwinana. The LSP reflects the intended use of the site for urban development as identified in the Jandakot Structure Plan and the Draft District Structure Plan, referred to as the Eastern Residential Intensification Concept (ERIC).

1.2 Land Description

1.2.1 Location

The LSP Area (also referred to as the site) is located approximately 36 kilometres south of Perth's Central Business District (refer to **Figure 1**). The LSP Area is located within the Wellard East Cell, which is situated in the South West Corridor of Perth and is bounded by Kwinana Freeway to the west, Mortimer Road to the north, Millar Road to the south and Woolcoot Road to the east. The Wellard East Cell is situated wholly within the municipality of the City of Kwinana.

1.2.2 Area and Land Use

The LSP Area has a total land area of 16.67 hectares. The site is currently vacant of any built structures and comprises remnant vegetation of varying quality. Lot 379 is dissected by an existing drainage reserve (ie. Peel sub-drain) (refer to **Figure 2 and Figure 3**).

The Wellard East Cell has a land area of approximately 170 hectares. The cell (including the LSP Area) comprises predominantly cleared farmland, although there are some significant wetland areas and other

physical constraints to development including existing drains and power lines. Also Armana Holdings has constructed its subdivision in the approved LSP Area in the northern part of the cell. An existing marsupial rehabilitation clinic is located on part of Lot 379 on land that fronts Millar Road. This use is excluded from the LSP Area. **Figure 2** provides an aerial photograph of the LSP Area and the Wellard East Cell.

1.2.3 Legal Description and Ownership

The LSP Area covers Part Lot 9001 (previously Lot 201) Mortimer Road and Part Lot 379 Millar Road, Wellard (East) (refer to **Table 2**), which are both owned by Armana Holdings Pty Ltd. A copy of the certificates of title for the LSP Area are included in **Appendix A**.

Table 2. Land Ownership and Site Details

Owner	Lot No.	Plan/Diagram	Volume/Folio	Street Address	Area (ha)
Armana Holdings Pty Ltd	379	144536	1778/685	593 Millar Road Wellard	15.3781 (not all of land area included in the LSP)
Armana Holdings Pty Ltd	9001	72800	2815/182	N/A	36.005 (not all of land area included in the LSP)

The Wellard East Cell comprises a number of lots under varying ownership as outlined in **Table 3** below. The lots owned by Armana Holdings Pty Ltd are highlighted. It should be noted that Lots 201 and 27 have been subdivided and now comprise numerous lots and a balance of title lot (known as Lot 9001). Lots 128 and 129 (previously owned by Main Roads) have now been created as Wake Way (gazetted local road).

Table 3. Lot Description, Ownership and Areas

Lot No. and Street	Owner	Land Area (ha)
Pt 27 Mortimer Road (now comprises a road reserve and balance of title Lot 9001)	**Armana Holdings**	**3.51 (including the road reserve)**
Pt 28 Mortimer Road	C. Berry, D. Berry, K. Griffin, B. Munro	3.79
126 Mortimer Road	Main Roads Western Australia	0.23
127 Mortimer Road	Main Roads Western Australia	0.67
201 Mortimer Road (now comprises multiple lots, road reserves and balance of title Lot 9001)	**Armana Holdings Pty Ltd and multiple landowners**	**39.93**
59 Woolcoot Road	Geographe Development Pty Ltd	12.48
61 Woolcoot Road	LM + C Morley	2.69
62 Woolcoot Road*	A. Bombara, M. Bombara, M. Verheggen and Robin Lodge Pty Ltd	12.71
62 Woolcoot Road*	VN Nguyen & Thi Hoa Vo	9.84
64 Woolcoot Road	Sienna Properties Pty Ltd	11.77
89 Woolcoot Road	Bertolini	14.13
1219 Woolcoot Road	Como Residential Pty Ltd	15.18
0 Johnson Road	Main Roads Western Australia	0.10
500 Wake Way	Main Roads Western Australia	2.39
601 Millar Road	Wellard Land Pty Ltd	1.47
90 Millar Road	Mary Donald Nominees (D.J. MacCormick Property Group) and multiple landowners (in the process of being subdivided)	8.94
Pt 378 Millar Road	Mary Donald Nominees Pty Ltd and multiple landowners (in the process of	7.85

Lot No. and Street	Owner	Land Area (ha)
	being subdivided)	
Pt 379 Millar Road	**Armana Holdings Pty Ltd**	**15.37**
Pt 380 Millar Road	S. Liang, J. W Wang, C. Ye	2.70
Closed Road Reserve	Landgate Update	0.15
Drainage Reserves	Water Corporation	3.87
TOTAL		**170.0**

Notes:* There are two lots known as Lot 62 Woolcoot Road

The location and area of each lot are reflected in **Figure 3**.

1.3 Planning Framework

1.3.1 Zoning and Reservations

1.3.1.1 Metropolitan Region Scheme

The majority of the Wellard East Cell is zoned Urban in the Metropolitan Region Scheme (MRS) (refer to **Figure 4**). The Urban Zone includes all of the LSP Area (ie. part Lot 9001 and part Lot 379).

The balance of the cell (ie. south-eastern portion) is still zoned Urban Deferred under the MRS as it is affected by an interim buffer from a livestock holding facility, which is located to the south of Millar Road (outside the Wellard East Cell). This interim buffer is subject to further odour investigations as part of a separate process to the LSP.

This Wellard East Cell is surrounded by the following zones and reservations:

> Urban Deferred and Other Regional Roads to the north;

> Rural to the east and south; and

> Primary Regional Roads and Urban to the west.

1.3.1.2 City of Kwinana Town Planning Scheme No. 2

Under the City of Kwinana Town Planning Scheme No. 2 (TPS2), the majority of the Wellard East Cell is zoned Development (including all of the LSP Area), which occurred concurrently with the lifting of the Urban Deferred Zone in accordance with Section 126(3) of the *Planning and Development Act* (refer to **Figure 6**).

The south-eastern portion of Wellard East Cell, which is still zoned Urban Deferred under the MRS, remains zoned Rural A and Cluster/Communal Rural Settlement under TPS2.

TPS2 Zoning Map also shows a number of landscape protection areas (ie. special control areas) that generally align with the wetlands and vegetation located within the cell. Under Clause 6.16 of the Scheme, the general intent is to protect areas of ecological value or landscape amenity whilst at the same timing allowing development. The LSP Area is not contained within any special control area.

All of the cell is located in a Drainage Catchment Management Area. The implications of this are dealt with through the Local Water Management Strategy Addendum (refer to **Appendix E** and the overall Jandakot Drainage and Management Plan (refer to **Section 3.5**).

According to the Scheme, the purpose of the Development Zone is to:

"provide for orderly planning and development of larger areas of land in an integrated manner within a regional context whilst retaining flexibility to review planning with changing circumstances…Council will have due regard to the desirability of higher densities, transit related development and good pedestrian and vehicular access to stations in order to promote public transport usage.

The objective of this zone is to:

a. *Designate land for future development;*

b. *Provide a planning mechanism for the identification and protection of areas of conservation value whilst facilitating the growth of the Town;*

c. *Provide for the orderly planning of large areas of land for residential, commercial, industrial and associated purposes through a comprehensive structure planning process;*

d. *Enable planning to be flexible and responsive to changing circumstances throughout the development stages of the area; and*

e. *Provide sufficient certainty for demand forecasting by service providers".*

According to Clause 6.15 of TPS 2, the Development Zone triggers the need for a local structure planning process to be completed prior to subdivision of the site. Clause 16 of the *Planning and Development (Local Planning Schemes) Regulations 2015* Scheme sets out the elements to be included in a local structure plan. The LSP has been designed to meet the intent and principles of the Development Zone and is consistent with the Structure Plan requirements in the Regulations. The focus of the technical reports is on part Lot 9001 and part Lot 379. Notwithstanding this, the Wellard East Concept Plan (refer to **Figure 15**) incorporates the balance of the cell, although landowners in these areas will be required to carry out further technical studies to justify the detailed planning and development of their land.

Clause 6.17.3.5 in the Scheme allows Council to consider a proposed structure plan over part of a Development Area or Development Zone, although Council require demonstration of how planning for the site may be integrated with the planning for the balance of the Development Area (ie. Wellard East Cell), including how broad land uses, essential services, main movement systems and major conservation and recreation areas are to be integrated. The integration of land uses, public open space and movement systems across the cell and the site are all demonstrated on the Wellard East Concept Plan and Public Open Space Plan (refer to **Figure 15 and Figure 16**). Section 3.5 deals with general water management issues over the cell and the site, although the LWMS Addendum has been prepared for the site only. Whilst the Transport Assessment (included in **Appendix D**) primarily addresses the site, it also considers the movement network over the whole cell. Also Section 3.7 of the report addresses the servicing of the site and how and where the major services will be brought to the cell. Council and the WAPC have already set a precedent for adopting Structure Plans over part of a Development Area by adopted a LSP for Lots 201 and 27 Mortimer Road. It is proposed that a similar process (adoption by the WAPC) be undertaken for the subject site so that subdivision can continue to progress over the cell.

Under the Scheme, all of the Wellard East Cell is located in Policy Area 6. The provisions in the policy area are mostly outdated as it reflects that area's previous rural land uses.

A Development Contribution Plan for Community Infrastructure, which affects the Wellard East Cell, is included in Schedule 5 of the Scheme. This is further discussed in **Section 3.8** of the report.

1.3.2 Regional and Sub-Regional Structure Plans

1.3.2.1 Southern Metropolitan Sub-Regional Structure Plan

The Draft South Metropolitan Sub-Regional Structure Plan was released for public comment in June 2009. It is only a broad strategic guidance document that aims to guide more detailed planning. The plan outlines a range of key objectives including creation of vibrant and sustainable communities, efficient use of land and infrastructure, protection of natural assets, creation of reliable transport network, and provision of a range of housing densities.

The plan includes Wellard East, which is identified as "Undeveloped Urban and Urban Deferred". The area to the south of Millar Road is identified as "Industrial Investigation".

1.3.2.2 Jandakot Structure Plan

In August, 2007 the Western Australian Planning Commission (WAPC) released the final Jandakot Structure Plan (JSP) following on from the draft JSP released in October, 2001.

The purpose of the Structure Plan is to:

"plan and coordinate the development expectations of the area while balancing environmental issues following a number of reviews and studies of the area".

The JSP recognises potential development areas and proposed indicative road layouts and locations for commercial facilities, whilst retaining environmentally sensitive features such as wetlands. The plan is based on Liveable Neighbourhood principles and aims to accommodate the projected growth of the corridor. The overall intent is to create contained and environmentally responsive urban developments. **Figure 5** illustrates the JSP and shows Wellard East at the southern end of the plan.

The JSP acknowledges that a "Water Resource Management Strategy" will need to be prepared, together with more detailed Local Structure Plans for future development proposals within the JSP area. This requirement has been addressed by the Department of Water (DoW), through the release of the Jandakot Drainage and Water Management Plan. This Drainage Plan is addressed in **Sections 3.5** of this report and the Local Water Management Strategy Addendum for part Lot 9001 Mortimer Road and part Lot 379, Millar Road (refer to **Appendix E**).

According to the JSP, MRS and local scheme amendments are required prior to subdivision proceeding. This has now occurred over the majority of the Wellard East Cell.

The JSP proposes urban development in the Jandakot Region over three timeframes – short (0-5 years), medium (5-10 years) and long term (10+ years). Five urban precincts are identified in the Structure Plan area, with the Wellard East Cell included in Area 4.

Within Area 4, which contains an area of some 300ha, the estimated ultimate population is 8,190 of which 4,990 would be accommodated in the precinct by 2026. Area 4 was estimated to be the most occupied of the 5 precincts by 2026 with 60% of its land area developed by this time.

The JSP earmarks Area 4 for medium term urban development in the draft document when it was released in 2001 (i.e. within 5-10 years) on the basis the land was then zoned Rural. This timeframe was not updated when the JSP was finalised 6 years later. Following the lifting of the Urban Deferred Zone over the majority of the cell, various LSPs and the subdivision approval for Lots 27 and 201, subdivision commenced in the cell in 2012 and the first stages of subdivision were completed in 2013. This is generally consistent with the timeframe in the JSP.

Whilst a significant portion of the Wellard East Cell is shown as medium term urban, the JSP also shows indicative road layouts (key roads only), significant wetlands, commercial centres, primary school, power lines, drainage lines and urban transition areas along the eastern and southern boundaries of the cell. The JSP also shows notional walkable neighbourhoods focussed around commercial centres.

Many of these land uses are reflected in the LSP and the Wellard East Concept Plan and are discussed further in **Section 3** of this report. It should be noted that the JSP states that the land use designations are indicative only and will guide the more detailed planning and other technical investigations at the LSP stage. Guidelines for urban design are required to be based on Liveable Neighbourhoods. In accordance with the JSP there will need to be a clear transition between rural and urban areas (ie. Woolcoot Road for Wellard East), linear road linkages between neighbourhoods located along the freeway and incorporation of green linkages within LSPs.

1.3.2.3 Eastern Residential Intensification Concept

In November 2005, the then Town of Kwinana released for comment the Eastern Residential Intensification Concept, commonly referred to as ERIC (refer to **Figure 7**).

According to the City of Kwinana, ERIC *"has been prepared to provide an overarching framework for the co-ordination of subdivision and development within the areas designated under the Jandakot Structure Plan area as having potential for urban development".*

The plan aims to provide a greater level of detail than the JSP and is in effect a district structure planning framework within which to develop local structure plans.

ERIC has been advertised but has not been finalised by the City of Kwinana. Council officers advised that ERIC is a guidance document only. The LSP for the site generally reflects the design principles in ERIC, as advertised. This is further discussed in **Section 3**.

In terms of land uses within Wellard East, ERIC shows the majority of land being developed for Residential R20 and R30/40 and conservation areas (ie. wetlands). Other land uses proposed in the cell include local primary school, POS and community centre. ERIC also shows how the Wellard East Cell will connect to

land directly to the north of Mortimer Road, which is via a north-south collector road through Wellard East connecting with Nicolas Road in Casuarina. This collector road is reflected on the LSP for the site.

1.3.3 Planning Strategies

1.3.3.1 State Planning Strategy

On 19 December 2012, the Minister for Planning launched the draft revised *State Planning Strategy* for public consultation until 29 March 2013. This Strategy presents a vision for Western Australia to 2050 and beyond based on a framework of planning principles, strategic goals and State strategic directions in response to the opportunities and challenges Western Australia is likely to face in the future.

The purpose and function of the document is to provide a sound basis for the integration and coordination of strategic planning across state, regional and local jurisdictions. It is the lead strategic planning document within Government.

The State Planning Strategy is an overarching strategic document that informs all other State, regional and local planning strategies, policies and approvals. The following is an extract from the *Draft State Planning Strategy 2012*, illustrating the structure of the strategy and how it relates to other policies and strategies, including Structure Plans.



The *State Planning Strategy* states that the primary aim of planning is to provide for the sustainable use and development of land. The Strategy identifies the five key principles (Environment; Community; Economy; Infrastructure and Regional Development), which further define this primary aim and describe the considerations which influence good decision-making in land use planning and development.

1.3.3.2 Directions 2031 and Beyond

The WAPC released *Direction 2031 and Beyond* in August 2010. The purpose of this framework is to establish a vision for future growth of the Perth and Peel Regions and provide a framework to guide detailed planning and the delivery of housing, infrastructure and services to accommodate that growth. It builds on from many of the principles in Network City.

The framework provides three growth scenarios:

1. **Linear City** – continuation of business as usual development patterns with the majority of growth occurring on the urban fringe;
2. **Connected City** – more balanced distribution of infill and greenfield development with a target density of 15 dwelling units per hectare of Urban zoned land; and

3. **Compact City** – more consolidated pattern of growth with an emphasis on infill development.

To achieve the preferred "Connected City" scenario, the framework proposes that new growth occurs in a more balanced way around a diverse activity centres network, which is linked by a robust movement network and supported by a green network of parks, conservation and biodiversity areas.

There are six sub-regional areas identified within the framework and the Wellard East Cell is situated within the South-West Sub-Region. The South-West Sub-Region encompasses the cities of Cockburn, Rockingham and Kwinana. Rockingham is the primary centre, providing a full range of services, facilities and activities necessary to the support the community within its catchment. In general accordance with Directions 2031, the Wellard East Concept Plan and the LSP provides for residential development connected to movement networks and supported by conservation and public open space areas, infrastructure provision and school facilities. The density targets outlined in *Directions 2031 and Beyond* are addressed for the LSP in Section 3.3 of the report.

The South-West Sub-Region is also supported by major industrial locations such as Kwinana and Latitude 32 (Hope Valley-Wattleup), which will generate significant employment self-sufficiency (60% to 70%) for the Region. Whilst there is limited employment opportunities within the Wellard East Cell due to its size and range of proposed land uses, there will be significant employment opportunities for future residents within the sub-region.

Directions 2031 also identifies a possible industrial area to the south of Millar Road. This possible industrial use is identified as an area under investigation. Whilst there are a range of existing and proposed land uses to the south of Millar Road, any industrial development should only accommodate light and service type industrial uses that do not impact on the residential growth in Wellard East. This possible industrial area would form an important employment node for Wellard East in the future.

Directions 2031 also recommends the preparation of growth management strategies and structure plans for the sub-regional areas.

1.3.3.3 Outer Metropolitan Perth and Peel Sub-Regional Strategy

The Outer Metropolitan Perth and Peel Sub-Regional Strategy was released in August 2010 as a "follow-on" planning document to *Directions 2031 and Beyond* and provides broad guidelines for implementation, particularly in terms of achieving housing needs. The Strategy also provides for a balance between greenfield and infill development consistent with *Directions 2031 and Beyond*. The Strategy also includes an urban management programme to retain a sufficient land supply for development on an ongoing basis to meet projected population growth.

The Strategy addresses each of the sub-regions including the South-West in which the Wellard East Cell is located. The cell is identified as "urban deferred zone undeveloped", which does not reflect the MRS zoning over the majority of the cell (ie. Urban). Also the Strategy has estimated a dwelling yield of 1500 for the Wellard East Cell based on the 'Connected City Scenario'. Land to the south of Millar Road is identified as a "priority industrial site – subject to investigation".

1.3.3.4 Economic and Employment Lands Strategy: Non-heavy Industrial Perth Metropolitan and Peel Regions

The Economic Employment Lands Strategy: Non-heavy Industrial Perth Metropolitan and Peel Regions was published by the WAPC in April 2012 in response to a recognised shortfall in general and light industrial land supply. The Strategy focuses on the identification and de-constraining of land suitable for industrial activity for the long term, with the aim of providing an industrial land bank in the Perth metropolitan and Peel regions over the next 20 years and beyond. Heavy industry is reliant on a different set of drivers and conditions to light and general industry and is therefore not included in the Strategy.

The Strategy provides a framework to facilitate the delivery of appropriately zoned industrial land to the market, allowing the market to respond to forecast demand over the next 20 years. The Strategy identifies 37 potential areas for future industrial land use investigation, designated as either short (0-4 years planning timeframe), medium (4-10 years planning timeframe) or long term sites (10 years plus planning timeframe).

The Strategy does not identify the Wellard East Cell area for any future industrial land uses. However, the Strategy identifies a 1026 hectare portion of land to the south of the Wellard East Cell area (generally bound by Millar Road, the Kwinana Freeway and Mundijong Road) referred to as 'North East Baldivis', as a potential medium-term non-heavy industrial area. The site is identified as the preferred site for future industrial development in the South-West Metropolitan Sub-Region.

The site is likely to be suitable for larger lot general industrial uses. Given the low-lying characteristics of the land, the Strategy states that low-polluting and low water use industries would be suited to the location. It is noted that the majority of the site is envisaged to be utilised for general industrial uses that are non-hazardous. It is possible that some consumer services may locate within the site, with light/service industry adjoining the special rural interface (presumably along Millar Road).

The Strategy notes that existing and surrounding uses may present conflicts with the potential industrial development, particularly with the encroachment of Special Rural land uses. The Strategy recommends that future detailed planning should be undertaken to ensure that the amenity of residential areas is not adversely affected. As such, the visual impact of the potential industrial development will require thorough consideration during the appropriate planning processes, with the rural buffer adjacent to the Freeway likely to be a key issue.

1.3.4 State Planning Policies

1.3.4.1 Liveable Neighbourhoods

The LSP and the Wellard East Concept Plan has generally been designed in accordance with the provisions and principles of Liveable Neighbourhoods, in particular the road design. Liveable Neighbourhoods encourages street networks that have a high level of internal connectivity and good external linkages to cycle, pedestrian and bus networks. The road design should also be legible and minimise car travel.

Another key provision in Liveable Neighbourhoods is the promotion of walkable access to activity nodes or destinations with a general requirement for 400 metre walkable catchments. In this case, the location of the primary school, community centre site, public open space and wetland conservation areas within the Wellard East Cell are of relevance. This is further addressed in **Section 3** of the report.

Liveable Neighbourhoods provides guidance on the location, distribution and amount of POS required. A Public Open Space (POS) table has been prepared for the Wellard East Cell and the LSP area in accordance with Liveable Neighbourhoods Table 11 (refer to **Appendix I).**

Liveable Neighbourhoods require Local Structure Plans to specify residential densities and encourages diversity in residential densities and dwelling types thereby providing more choice for changing household types. Residential densities proposed in the LSP Area meet these objectives and are addressed in **Section 3.3** of the report.

Liveable Neighbourhoods also emphasises connections to adjoining development within and external to the Wellard East Cell.

According to Liveable Neighbourhoods it is important for the LSP and the Wellard East Concept Plan design to respond to the site context and characteristics, such as wetlands, Western Power easement and the drainage reserves. This is also important in terms of achieving a Liveable Neighbourhoods objective of an urban structure that achieves a balanced outcome between urban and environmental sustainability.

1.3.5 Local Planning Policies

1.3.5.1 Local Planning Policy 4.3.3 - Public Open Space

The policy was last reviewed in 2006 and as such some parts of the policy are inconsistent with Liveable Neighbourhoods. Notwithstanding this, the POS design shown over the cell and LSP Area is based on key principles in this policy, in particular preservation and enhancement of biodiversity values and preservation of significant trees and remnant vegetation. The policy requires the standard 10% of gross subdividable area as POS, which is consistent with Liveable Neighbourhoods. The policy also requires the provision of district recreational facilities, however the POS function within Wellard East will be largely limited to conservation and local recreational needs. This is consistent with proposed community infrastructure, which proposes the location of district recreational facilities to the north of Wellard East such as the Casuarina District Sporting Ground. The policy also prescribes absolute minimum sizes of POS: 4000m^2 for public use and 1000m^2 for

landscaped area and no POS shall have dimensions of less than 20m for public use and 10m for landscaping areas. However, the policy allows these provisions to be varied to preserve a significant natural feature or recreational asset. The amount and location of POS for the LSP Area and the Wellard East Cell are discussed in **Section 3.2** of the report.

The policy allows for POS to be used for drainage provided Council is satisfied that the recreational and/or landscape function of the reserve are not adversely affected. The policy outlines that no more than 50% of the POS is to be inundated at any time. **Appendix I** includes the POS table and a portion of the drainage areas are included in the 10% POS contribution in accordance with Liveable Neighbourhoods. However, the 1 in 1yr drainage areas are excluded from the 10% POS contribution.

The policy also states that EPP and conservation category wetlands are excluded from POS, which is consistent with Liveable Neighbourhoods. However, buffers to these type of wetlands may be included in POS as per the policy and Liveable Neighbourhoods. This matter is further addressed in **Section 3.2** and **Appendix I**.

1.3.5.2 Local Planning Policy 3.3.7 – Community Facilities Sites

This Policy was also reviewed in 2006 and is based on the key objective of ensuring that social infrastructure (ie. community facilities sites) are incorporated into the design of new residential areas. The Policy discusses the provision of land for private community facilities such as medical centres, however no commercial or neighbourhood centres are proposed within the Wellard East Cell. Such uses may be more appropriately located near the commercial centre on Mortimer Road (just to the north of the Wellard East Cell).

The Policy also addresses the provision of public community centres and allows for such sites to be included in 10% POS contribution as part of the residential subdivision. The sites are required to be at least 2000m^2. The Policy also recommends the community centre be located close to nodes of activity such as primary schools, in order to maximise co-location advantages (ie. shared parking and good access).

The Wellard East Concept Plan shows a community centre located within POS in the centre of the cell. The provision and use of community facilities within Wellard East has already been given detailed consideration by City of Kwinana through preparation of the Community Infrastructure Plan. The need for local and district community infrastructure is currently being reviewed by the City of Kwinana as a result of changing circumstances within the development cells.

1.3.5.3 Local Planning Policy 4.3.1 – Conservation of Remnant Vegetation

This Policy addresses Council's objective of protecting remnant vegetation as part of residential subdivisions by giving a high priority to retaining existing trees and retaining representative samples of different vegetation complexes (ie. biodiversity) and ecological linkages. The Policy requires existing trees to be shown on structure plans and planting of local species occurring naturally in the area will be encouraged by Council. Management measures and recommendations for protecting native flora and fauna for the LSP Area are discussed in **Section 2** and **Appendix B**. Also a landscaping masterplan has been provided in **Appendix G**.

2 Site Conditions and Constraints

Emerge Associates has undertaken a desktop investigation of the Wellard East Cell in order to determine the environmental values of the cell and, in particular, for the site. This included, but was not restricted to, a review of investigations previously conducted for the Wellard East Cell, regional environmental investigations and federal, state and local-level databases and mapping.

The site specific environmental investigations, studies and reports that informed our analysis include the following:

> Wellard East – Local Structure Plan (Cardno, 2011)

> Flora and Vegetation Survey and Wetland Assessment (Cardno 2008)

> Preliminary Acid Sulfate Soils Assessment (Cardno 2009)

> Preliminary Site Contamination Investigation (Cardno 2008)

> District Water Management Strategy (Cardno 2009)

> Local Water Management Strategy Addendum (Emerge Associates 2013)

> Acoustic Assessment (Lloyd George Acoustics 2013)

> Fire Management Plan (Emerge Associates and Bushfire Safety Consulting 2014).

This section broadly addresses the requirements of an Environmental Assessment and Management Strategy, outlining the environmental values and issues applicable to the site and the management of these values or issues.

2.1 Biodiversity and Natural Area Assets

2.1.1 Regional Context

The Wellard East Cell lies within the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region. This region is broadly categorised as *Banksia* low woodland on leached soils with *Melaleuca* swamps on ill-drained soils and woodlands of Tuart (*Eucalyptus gomphocephala*), Jarrah (*E. marginata*) and Marri (*Corymbia calophylla*) on less leached soils (Thackway and Cresswell 1995).

Vegetation complex mapping undertaken by Heddle *et al* (1986) for parts of Western Australia uses a combination of landform, soils and rainfall parameters and indicates that the site is within the 'Bassendean Complex – Central and South'. This complex is described as a range of woodland of *E. marginata* (Jarrah), *Casuarina sp.* (Sheoak) and *Banksia sp.* on the low dunes, to low woodland of *Melaleuca sp.* and sedgelands in the swamps and depressions.

2.1.2 Flora and Vegetation

A *Flora and Vegetation Survey and Wetland Assessment* (Cardno 2008) was undertaken for portions of the Wellard East Cell, including the site and is provided in **Appendix B**. The field survey was conducted by two botanists in August, September, and November 2008 in accordance with *Environmental Protection Authority Guidance Statement No. 51 – Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia* (EPA 2004). Two of the visits were conducted in spring, which is the optimal flowering period for the majority of flowering plants in the south west of Western Australia. It should be noted that some of photos included in the flora and vegetation survey for the approved LSP Area (ie. land north of the site) are no longer current as the land is in the process of being subdivided. Therefore, the report included in **Appendix B** is now only relevant to the site (the subject of this LSP report).

The survey area was traversed on foot and the vegetation values assessed based on vegetation communities present and the condition of the vegetation, to assist in determining the conservation values of the survey area. A total of 94 taxa (including subspecies and varieties) from 78 genera and 31 families were identified as part of the survey. Of these, 45 were identified as weed species (48% of the total species

recorded), and five species were not known to occur endemically in the area but were likely a result of previous revegetation efforts.

The Wellard East Cell retains limited remnant vegetation values due to historic clearing and subsequent grazing of livestock, however areas that retain remnant vegetation values are largely associated with the mapped wetland areas. In terms of the site, the majority of remnant vegetation values are associated with the adjacent drainage reserves or are found adjacent to the Kwinana Freeway in the south-west portion of the site.

Within the Wellard East Cell, the flora and vegetation values have been given spatial consideration through the retention of wetland areas and the provision of public open space in locations where remnant vegetation is found. In the site itself, consideration was given to the area of remnant vegetation adjacent to the Kwinana Freeway, with the majority of vegetation proposed to be retained within public open space while paddock trees associated with public open space through the central portion of the site will be retained, where possible.

2.1.2.1 Vegetation communities

Based on the *Flora and Vegetation Survey and Wetland Assessment* (Cardno 2008), plant communities were identified and described according to the dominant species present. Three plant communities (PC) of differing condition were identified within the site and are described below:

- PC4: Low lying woodland-forest of Eucalyptus rudis – Melaleuca preissiana over Kunzea glabrescens – Pultenaea reticulata over Dielsia stenostachya – Opercularia hispidula - *Zantedeschia aethiopica on grey sandy loam.
- PC5: Low upland woodland of Corymbia calophylla – Eucalyptus marginata over Agonis flexuosa – Casuarina obesa – Banksia menziesii – Banksia grandis over Eremaea pauciflora – Calothamnus quadrifidus over Conostylis aculeate subsp. cygnorum – Kennedia prostrate - *Ehrharta longiflora - *Lolium rigidum - *Carpobrotus edulis on grey sandy loam.
- PC6: Tall Scrub of Kunzea glabrescens – Melaleuca teretifolia over pasture grasses and *Carpobrotus edulis on grey sandy loam.

The vegetation communities within the site are shown in **Figure 8**.

2.1.2.2 Vegetation condition

The condition of vegetation within the site was described based on the Keighery (1994) rating system, refer to **Table 4** below, and shows that the vegetation across the majority of the site is 'Completely Degraded' condition. The northern portion of Lot 379 Millar Road is described as 'Degraded' condition, while the south-western portion of Lot 9001 Mortimer Road is in 'Good' condition, and is described as having a heavily disturbed understorey. **Figure 9** shows the condition of vegetation within the site.

Table 4. Vegetation Condition rating (Keighery 1994)

Condition Rating	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance
Excellent	Vegetation structure intact; disturbance affecting individual species; 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 & grazing
Good	Vegetation structure significantly altered by very obvious signs of multiple of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires; the presence of some very aggressive weeds at high density; partial clearing; dieback & 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 frequent

Condition Rating	Description
	fires; the presence of very aggressive weeds; partial clearing; dieback & 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

Areas of vegetation that are classed as 'Good' and better have been given consideration within the site through placement of public open space, and vegetation will be retained where possible.

2.1.2.3 Conservation Significance

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) promotes the conservation of biodiversity by providing statutory protection for plants at a species level. Sections 178 and 179 of the EPBC Act provides for the lists and categories of threatened species, and is summarised in **Table 5** below.

Table 5. Categories of threatened species (Environmental Protection Biodiversity Conservation Act, Section 178 and 179, 1999)

(Only categories marked with an * are matters of national environmental significance under the EPBC Act)

Conservation Code	Category
E	**Extinct** Taxa which is known only to survive in cultivation, in captivity or as a naturalised population, well outside its past range; or it has not been recorded in its known/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE*	**Critically Endangered** Taxa which is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
E*	**Endangered** Taxa which are not critically endangered and is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
V*	**Vulnerable** Taxa which is not endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** A species that is the focus of a specific conservation program; the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of five years.

Species of flora acquire Declared Rare Flora or Priority Flora conservation status within Western Australia where populations are restricted geographically or threatened by local processes. The Department of Environment Regulation recognises these threats and applies regulations towards population protection and species conservation. The Department of Environment Regulation enforces regulations under the Wildlife Conservation Act 1950 (WC Act) to conserve Declared Rare Flora species and protect significant populations. Priority Flora is described as potentially rare or threatened species and is classified in order of threat. Declared Rare Flora and Priority Flora categories are listed below in **Table 6**.

Table 6. Definition of Rare and Priority Flora species (Atkins 2006)

Conservation Code	Category
R	**Declared Rare Flora – Extant Taxa.** Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
X	**Declared Rare Flora – Presumed Extinct Taxa** Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough

Conservation Code	Category
	searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
P1	**Priority One – Poorly Known Taxa** Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat e.g. road verges, urban areas, farmland, active mineral leases etc., or the plants are under threat, e.g. from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2	**Priority Two – Poorly Known Taxa** Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey.
P3	**Priority Three – Poorly Known Taxa** Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but need further survey.
P4	**Priority Four – Rare Taxa** Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

No species of Declared Rare Flora or Priority Flora were located within the site, and as such require no specific consideration with regard to retention or management in the LSP.

2.1.2.4 Threatened Ecological Communities

Generally, ecological communities can be described as vegetation communities that are assemblages of species that occur together in a particular type of habitat. They are the sum of species within an ecosystem and, as a whole provide many of the processes which support a specific ecosystem.

Specific communities are afforded statutory protection at a federal level pursuant to the EPBC Act. Threatened Ecological Communities (TECs) are listed under Section 181 of the EPBC Act, and are defined as 'Critically Endangered', 'Endangered' and 'Vulnerable' under Section 182.

In Western Australia, TECs are defined by the Department of Environment Regulation, with advice provided by the Western Australian Threatened Ecological Communities Scientific Advisory Committee on community listings. TECs are not afforded direct statutory protection at a state level but their significance is acknowledged through other state environmental approval processes (i.e. environmental impact assessment pursuant to Part IV of the *Environmental Protection Act 1986*). Under the state process the Department of Environment Regulation has been identifying and informally listing TECs since 1994, using a range of definitions to indicate the level of threat. These definitions are outlined below in **Table 7**.

In addition to TECs, the Department of Environment Regulation defines Priority Ecological Communities (PECs), which are communities that do not meet the survey criteria; are adequately known; are rare but not threatened or meet the criteria for near threatened.

Table 7. Categories of Threatened Ecological Communities utilised by the Department of Environment and Conservation (DEC 2007)

Code	Category
PD	**Presumed Totally Destroyed** An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.
CR	**Critically Endangered** An ecological community that has been adequately surveyed and found to have been subject to a

Code	Category
	major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. Generally it has been found to be facing an extremely high risk of total destruction in the immediate future.
EN	**Endangered** An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
VU	**Vulnerable** An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community is considered Vulnerable when it is facing a high risk of total destruction or significant modification in the medium to long-term future

No Threatened Ecological Communities or Priority Ecological Communities were recorded within the site, and as such require no specific consideration with regard to retention or management.

2.1.3 Bush Forever

The Government of Western Australia's Bush Forever Policy is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The overarching objective of Bush Forever is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10% of each vegetation complex for protection (Government of Western Australia, 2000). Bush Forever (BF) sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity (Government of Western Australia, 2000).

No BF sites are located within the Wellard East Cell. BF Site 349 is located approximately 800 metres to the west of the Wellard East Cell and is separated from the site by the Kwinana Freeway. Two other sites, BF Site 70 and BF Site 360, are located a further three kilometres east of the site, separated from the site by extensive areas used for agricultural purposes.

2.1.4 Wetlands

The *Environmental Protection (Swan Coastal Lakes) Policy 1992* (EPP Lakes) protects the environmental values of selected lake wetlands on the Swan Coastal Plain. Two wetlands within the Wellard East Cell and outlined below within **Table 8** are identified under EPP Lakes.

The Department of Environment Regulation also maintains the *Geomorphic Wetlands of the Swan Coastal Plain* database, which identifies wetland areas and categorises individual wetlands into specific management categories, as outlined in **Table 8** (DEC 2012). The significance of each wetland is based on hydrological, biological and human use features, which are the key components for the classification of management categories.

Table 8. Geomorphic Wetlands of the Swan Coastal Plain management categories (DEC 2012)

Management category	General Description	management objectives
Conservation (CCW)	Wetlands which support a high level of attributes and functions.	Highest priority wetlands. Objective is to preserve and protect the existing conservation values of the wetlands through various mechanisms including: ▪ Reservation in national parks, crown reserves and State owned land ▪ Protection under Environmental Protection Policies ▪ Wetland covenanting by landowners. No development or clearing is considered

Management category	General Description	management objectives
		appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is inappropriate.
Resource Enhancement (REW)	Wetlands which may be partially modified but still support substantial ecological attributes and functions.	Priority wetlands. Ultimate objective is to manage, restore and protect towards improving their conservation value. These wetlands have the potential to be restored to Conservation category. This can be achieved by restoring wetland function, structure and biodiversity. Protection is recommended through a number of mechanisms such as crown reserves, state or local government owned land, environmental protection policies and sustainable management on private properties.
Multiple Use (MUW)	Wetlands with few remaining important attributes but still provide important hydrological functions	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through land care.

The *Geomorphic Wetlands of the Swan Coastal Plain* dataset (DEC 2011b) indicates that there are seven wetlands mapped as part of the dataset within the Wellard East Cell. The location of these wetlands is presented in **Figure 10** and detailed within **Table 9** below.

Table 9. Wetland areas within the Wellard East Cell

UFI Number	Wetland Type	management Category	EPP Lakes
6672	Sumpland	Resource Enhancement	Yes
12918	Dampland	Conservation	Yes
12919	Dampland	Resource Enhancement	No
12921	Dampland	Multiple Use	No
15798	Sumpland	Multiple Use	No
15799	Sumpland	Multiple Use	No
15801	Sumpland	Resource Enhancement	No

Within the Wellard East Cell, the Conservation Category Wetland and Resource Enhancement Wetlands outlined in **Table 9** and **Figure 10** have been retained in their entirety, with appropriate buffers provided between the proposed development and these wetland values. A Wetland Management Plan (Cardno 2012) has been approved by the Department of Environment Regulation and City of Kwinana for the Conservation Category Wetland and Resource Enhancement Wetlands located within the northern portion of the Wellard East Cell.

Based on the *Geomorphic Wetlands of the Swan Coastal Plain* mapping, a Multiple Use Wetland occurs over the majority of the site and is shown in **Figure 10**. There are limited ecological values associated with the MUW areas within the site as these areas have been historically cleared.

Multiple Use Wetland areas are afforded no statutory and limited policy protection by the Environmental Protection Authority and the Department of Environment and Regulation. The prevailing policy framework focuses on ensuring that all reasonable measures are made to retain the wetlands hydrological and other wetland functions, primarily through the urban water management framework. The LSP has considered the Multiple Use Wetland within the site and the associated existing drainage lines and they are proposed to be retained and managed within a multiple use corridor and areas of public open space.

2.1.5 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*, and occur over areas of vegetation that are considered to contain high conservation values, or to protect the native vegetation values of areas surrounding significant,

threatened or scheduled ecosystems or communities. For any area that is situated within an ESA, none of the exemptions pursuant to the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* apply.

An ESA is located in the north-eastern portion of the Wellard East Cell and is associated with the Conservation Category Wetland. The values associated with the Conservation Category Wetland are protected through the application of a suitable buffer and implementation of the Wetland Management Plan (Cardno 2012).

No ESAs are identified within the site, and as such do not require specific consideration within the LSP.

2.1.6 Biodiversity Linkages

Biodiversity or ecological linkages can be described as any area of native vegetation that provides a corridor or linkage between larger patches of vegetation to allow movement of flora and fauna and their genetic material through the landscape, and can prevent the isolation of flora and fauna. Biodiversity linkages can either be continuous or near continuous, with the more fractured the linkage, the less efficient the movement of flora and fauna along that corridor (Government of Western Australia 2000).

Regional linkages have been designated by the State Government in Bush Forever, Perth's Greenways and the System 6 study and are supported by the Western Australian Local Government's (WALGA) Perth Biodiversity Project (PBP). The linkages aim to conserve and enhance regional biological linkages and reflect the on-ground linkages throughout the Perth Metropolitan area.

Biodiversity linkage No. 75 encompasses the central portion of the site, as shown in **Figure 10**. This linkage runs east-west across the site and links with Bush Forever (BF) Site 349 in the west and BF Sites 360 and 70 in the east.

The proposed biodiversity linkage has been accommodated within the Local Structure Plan by the provision and placement of public open space which aligns with the drainage corridors adjacent to the site.

2.1.7 Fauna

The conservation status of fauna species in Western Australia is assessed under the WC Act, which utilises a set of schedules described in **Table 10**. In addition to this, the Department of Parks and Wildlife also produces a list of priority species, which while not considered threatened under the WC Act, there is concern over their long-term survival. These categories are outlined below in **Table 11**.

As well as those species protected under the WC Act, the Federal government also maintains a list of protected species under the EPBC Act.

Table 10. Categories of Department of Parks and Wildlife threatened fauna

Category	Code	Description
Schedule 1	S1	Fauna which is rare or likely to become extinct
Schedule 2	S2	Fauna which is presumed extinct
Schedule 3	S3	Birds which are subject to an international agreement between the governments of Australia and other countries relating to the protection of migratory birds and birds in danger of extinction
Schedule 4	S4	Fauna that is otherwise in need of special protection

Table 11. Department of Parks and Wildlife priority fauna categories

Category	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring (Not currently threatened or in need of special protection but could be if present circumstances change) .
Priority 5	P5	Taxa in need of monitoring (Not considered threatened but are subject to specific

Category	Code	Description
		conservation program, the cessation of which would result in the species becoming threatened within five years).

To assess the potential for the site to contain specifically protected fauna species, searches of the Department of Parks and Wildlife *NatureMap Database* and the Department of the Environment (Federal) *Protected Matters Search Tool* were undertaken by Greg Harewood (Zoologist), in addition to a review of various fauna surveys undertaken in nearby areas. The searches of databases and review of various previous surveys indicated that a number of species of conservation significance may potentially occur within or use the site, and have been listed in **Table 12** below. Within **Table 12**, the likelihood of the species occurring within the site and potential impact from the proposed development have also been considered.

Table 12. Significant fauna species occurring or potentially occurring within the site

Species		Conservation Code		Likelihood of occurrence and/or possible impacts
Common name	Scientific name	Federal	State (WA)	
BIRDS				
Painted snipe	*Rostratula benghalensis*	Endangered, Migratory	Schedule 1, Schedule 3	Unlikely, no habitat present.
Carnaby's black cockatoo	*Calyptorhynchus latirostris*	Endangered	Schedule 1	Present. Loss/modification of some areas of natural habitat, no significant impact likely.
Forest red-tailed black cockatoo	*Calyptorhynchus banksii naso*	Vulnerable	Schedule 1	Present. Loss/modification of some areas of natural habitat, no significant impact likely.
Baudin's black cockatoo	*Calyptorhynchus baudinii*	Vulnerable	Schedule 1	Unlikely, no habitat present.
Malleefowl	*Leipoa ocellata*	Vulnerable, Migratory	Schedule 1	Unlikely, species locally extent.
Fairy tern (Australia)	*Sternula nereis nereis*	Vulnerable	-	Unlikely, no habitat present.
Rainbow bee-eater	*Merops ornatus*	Migratory	Schedule 3	Present. Loss/modification of some areas of man-made and natural habitat, no significant impact likely.
Cattle egret	*Ardea ibis*	Migratory	Schedule 3	Possible. Loss/modification of areas of very marginal habitat, no significant impact likely.
Great egret	*Ardea alba*	Migratory	Schedule 3	Possible. Loss/modification of areas of very marginal habitat, no significant impact likely.
Fork-tailed swift	*Apus pacificus*	Migratory	Schedule 3	Unlikely, flyover only.
White-bellied sea-eagle	*Haliaeetus leucogaster*	Migratory	Schedule 3	Unlikely, no habitat present.
Glossy ibis	*Plegadis falcinellus*	Migratory	-	Unlikely, no habitat present.
Osprey	*Pandion haliaetus*	Migratory	-	Unlikely, no habitat present.
Peregrine falcon	*Falco peregrinus*	-	Schedule 4	Possible. Loss/modification of small areas of degraded natural habitat, no significant impact likely.
Little Bittern	*Ixobrychus minutus*	-	Priority 4	Unlikely, no habitat present.
Bush Stone Curlew	*Burhinus grallarius*	-	Priority 4	Unlikely, no habitat present.
Hooded Plover	*Charadrius rubricollis*	-	Priority 4	Unlikely, no habitat present.
INSECTS/INVERTEBRATES				
Graceful Sun-Moth	*Synemon gratiosa*	-	Priority 4	Unlikely, no habitat present.
MAMMALS AND MARSUPIALS				
Chuditch	*Dasyurus geoffroii*	Vulnerable	Schedule 1	Unlikely, no habitat present.
Western Ringtail Possum	*Pseudocheirus occidentalis*	Vulnerable	Schedule 1	Unlikely, no habitat present.
Quokka	*Setonix brachyurus*	Vulnerable	Schedule 1	Unlikely, no habitat present.
Southern brush-tailed Phascogale	*Phascogale tapoatafa*	-	Priority 3	Unlikely, no habitat present.
Southern brown bandicoot (Quenda)	*Isoodon obesulis fusciventer*	-	Priority 5	Present. Loss/modification of small areas of marginal natural habitat, no significant impact likely.
Western Brush Wallaby	*Macropus Irma*	-	Priority 4	Unlikely, no habitat present.
Western False	*Falsistrellus*	-	Priority 4	Unlikely, no habitat present.

Species		Conservation Code		Likelihood of occurrence and/or possible impacts
Common name	Scientific name	Federal	State (WA)	
Pipistrelle	*mackenziei*			
REPTILES AND RODENTS				
Southern carpet python	*Morelia spilota imbricata*	-	Schedule 4	Unlikely, no habitat present.
Perth lined lerista	*Lerista lineata*	-	Priority 3	Possible. Loss/modification of areas of very marginal habitat, no significant impact likely.
Black-striped snake	*Neelaps calonotos*	-	Priority 3	Unlikely, habitat not present.
Water rat	*Hydromys chrysogaster*	-	Priority 4	Unlikely, no habitat present.

A level 1 fauna assessment was undertaken within the site by Greg Harewood in March 2014 and has been provided in **Appendix J**. The fauna assessment identified five fauna habitats, which were based predominantly on the plant communities and soils and landform identified within the site:

> Low lying woodland-forest (medium height) of *Eucalyptus rudis – Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielsia stenostachya - Opercularia hispidula – *Zantedeschia aethiopica* on grey sandy loam. This area is approximately 1.1 ha in extent.

> Low upland woodland (>10m) of *Corymbia calophylla – Eucalyptus marginata* over *Agonis flexuosa – Casuarina obesa – Banksia menziesii – Banksia grandis* over *Eremaea pauciflora – Calothamnus quadrifidus* over *Conostylis aculeata – Kennedia prostrata – *Ehrharta longiflora –*Lolium rigidum – *Carpobrotus edulis* on grey sand. This area is approximately 1.5 ha in extent.

> Tall Scrub (to 10m) of *Kunzea glabrescens – Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis* on grey sand. Some emergent *Eucalyptus gomphocephala* and non-endemic eucalypts. This area is approximately 2.3 ha in extent.

> Open woodland of *Eucalyptus rudis – Melaleuca preissiana* over pasture grasses/weeds on grey sandy loam. Seasonally inundated/waterlogged. This area is approximately 0.5 ha in extent.

> Planted endemic and non-endemic trees and shrubs over pasture grasses/weeds on grey sand. This area is approximately 0.9 ha in extent.

> Cleared (open grassland, bare sand) with scattered trees. This area is approximately 10.3 ha in extent.

Overall, the fauna assessment identified the majority of the site as being cleared of native vegetation, and/or that the areas containing remnant native vegetation were highly degraded and as a result direct impacts on fauna, particularly the species identified in **Table 12**, or fauna habitat are likely to be minimal/negligible. Therefore, no significant impact on any fauna species is considered likely as a result of the proposed development.

As part of the fauna assessment, a black cockatoo habitat assessment was also undertaken within the site. The assessment identified potential breeding and foraging habitat for the two black cockatoo species identified as potentially occurring within the site. No evidence of historic or current use of the site for breeding was observed, and foraging evidence by the black cockatoos was limited to one example. The assessment largely indicates that the potential foraging habitat within the site is low-value (being limited in extent and poor-quality), while breeding is unlikely to occur within the site as there is limited breeding habitat and it is outside documented breeding areas. It is therefore unlikely that any impacts on the foraging and potential breeding habitat from the proposed development would be considered a significant impact.

Broadly within the Wellard East Cell, the areas that support the majority of habitat values, namely the Conservation Category Wetland and Resource Enhancement Wetlands and associated remnant vegetation have been retained as either public open space or conservation areas. Remnant vegetation located within the drainage reserves and southern portion of Lot 9001 will be retained where possible.

2.2 Landform, Soils and Topography

2.2.1 Topography

Topographical contours indicate that the Wellard East Cell is generally flat to gently undulating. The northern portion of the cell has a largely eastern aspect while the southern portion of the cell generally has a south-westerly aspect. The cell ranges in elevation from approximately 8 metres Australian Height Datum (mAHD) at the lowest elevated area in the south-west, up to approximately 16mAHD through the south-central portion. The areas of lowest relief in the cell generally coincide with areas of wetlands and/or drains.

The topography of the site is gently undulating, with a generally south-westerly aspect. The site ranges from 8mAHD through the central portion of the site (and coincides with an agricultural drain) to 16mAHD in the north-east portion of the site, as shown in **Figure 11**.

2.2.2 Landforms and Soil

The site is located on the Swan Coastal Plain and is composed of two wide belts of sediment that differ in origin, with one formed from alluvial deposits (water-laid) and the other formed from aeolian origins (wind-laid). It is approximately 20 to 30 kilometres wide, consisting of a series of geomorphic entities that run parallel to the coastline with the alluvial deposits in the east and the aeolian deposits in the west. The site is located within the Bassendean Dune System, which is described as low relief, leached grey, siliceous Pleistocene sand dunes with well drained grey sands intervening sandy and clayey swamps and gently undulating plains. These sands are mostly leached, infertile and generally contain little slit or clay and very low levels of nutrient elements.

The Perth Metropolitan Region 1: 50,000 Environmental Geology Series, Rockingham (Part Sheets 2033 II and 2033 III) (Gozzard 1983) shows the site is comprised of "Sand", S_8 and S_{10}, and indicates that the site is capable of development for urban purposes. This is in line with the information detailed in previous geotechnical surveys of the Wellard East Cell. The general descriptions of these are provided in **Table 13** below.

Table 13. Soil units found on site

Map Unit	Description	Geological Unit
S8	Sand – very light grey at surface, yellow at depth, fine to medium grained, sub rounded quartz, moderately well sorted and of eolian origin.	Bassendean Sand (Qpb)
S10	Sand – as S8 as relatively thin veneer over C2, M4 and Mc2	Thin Bassendean Sand over Guildford Formation (Qpb/Qpa)

Coffee Geotechnics carried out several site investigations within Sunrise Estate in 2008 and 2009. These geotechnical investigations covered both the subject site area and the previously approved Local Structure Plan area. The results of the investigations were summarised in their report dated 29 April 2009. This report identifies two areas within the subject site with distinct geotechnical characteristics: the area in the direct vicinity of the earth drain running southeast-northwest through Lot 379 (Zone B), and all other areas (Zone A).

All areas within the site are deemed suitable for residential development, subject to the construction of earthworks in accordance with recommendations made within the report. Lots within Zone A can achieve a Site Classification of 'A', subject to the removal of topsoil and subsequent proof compaction. Lots within Zone B can achieve a Site Classification of 'S', subject to approximately 1m of unsuitable material being excavated and removed from the surface, followed by proof compaction.

2.3 Acid Sulfate Soils

Acid Sulfate Soils (ASS) is the name commonly given to naturally occurring soils and sediment containing iron sulphide (iron pyrite) materials. In their natural state ASS are generally present in waterlogged anoxic conditions and do not present any risk to the environment. ASS can present issues when oxidised, producing sulphuric acid, which can impart a range of impacts on the surrounding environment, infrastructure and human health.

A desktop survey indicates that the site has been classified as predominantly having a 'moderate to low' risk of ASS occurring within three metres of the natural soil surface, as shown in **Figure 12**. A preliminary ASS site investigation undertaken by Cardno (2009) (refer to **Appendix C**) determined that the soil conditions were generally slightly acidic, however disturbance of soil above the water table was unlikely to result in ASS related impacts.

Within the Local Structure Plan, no spatial response has been provided or is required for the potential presence of ASS. In line with the Preliminary ASS investigation (Cardno 2008) and Department of Environment Regulation guidelines *Identification and investigation of acid sulfate soils and acidic landscapes (*DEC 2009b), ASS is considered to only be potentially disturbed in those areas where excavation occurs below the natural water table. If required, further detailed ASS investigations will be undertaken as a part of the subdivision process and may be associated with areas where excavation occurs below the natural water table (i.e. for the installation of services such as sewerage). A detailed investigation was undertaken in 2011 for the extension of the main sewer along the southern portion of Lot 9001 to service the approved LSP area. A copy of this report, which was approved by the Department of Environment Regulation in October 3011, can be provided to council if required.

2.4 Groundwater and Surface Water

2.4.1 Groundwater

The groundwater underlying the Wellard East Cell ranges between approximately 13mAHD in the north to approximately 4mAHD in the south, at its lowest level in the seasonal cycle (Cardno 2009). This corresponds to a depth to groundwater ranging from approximately 12 metres below ground surface (mBGS) in the north-west to approximately 6mBGS in the south-east. These contours indicate a groundwater flow direction from south to south-east.

Within the site, groundwater is approximately 9mAHD in the north and 7mAHD in the south, flowing in a south to south-east direction.

Both the groundwater levels and quality within the site will be maintained and managed in accordance with an approved Urban Water Management Plan, to be prepared as a part of future subdivision of the site. An addendum to the Local Water Management Strategy has been prepared in support of the LSP. The requirements of this strategy are further discussed in **Section 3.5** and **Appendix E**.

2.4.2 Surface Water

The Wellard East Cell is situated within the Serpentine River Catchment, which forms part of the Peel-Harvey Drainage Catchment. The cell contains three drains that were historically developed to support agricultural activities within the area, Peel Sub N Drain, Peel Sub N1 Drain and Peel Sub N2 Drain (Cardno 2011a).

As detailed in previous studies of the Wellard East Cell, surface water monitoring was undertaken as part of a three year monitoring program, which determined that there is minimal surface runoff within the cell. This is likely due to the high permeability of the sandy soils and observations made during and following rainfall events (Cardno 2009). The surface water flow observed within the various drains within the cell is generally considered to be an expression of groundwater.

A drain is located adjacent to the central portion of the site. This drain is also located adjacent to the north-eastern boundary of the site. The local structure plan retains the function of the drains through the provision of a multiple use corridor and public open space. An addendum to the Local Water Management Strategy has been prepared in support of the LSP and outlines water quality objectives to be achieved as part of ongoing development of the site. The requirements of this strategy are further discussed in **Section 3.5** and **Appendix E**.

Water issues, including water supply and bore licenses are addressed in the LWMS Addendum in **Appendix E.**

2.5 Bushfire Hazard

A Fire Management Plan (FMP) has been prepared for Armana Holdings Pty Ltd by Bushfire Safety Consulting and Emerge Associates to support the LSP as per WAPCs *Planning for Bushfire Protection Guidelines Edition 2* (WAPC et al 2010) and WAPCs *Structure Plan Preparation Guidelines* (WAPC 2012). The FMP is provided in **Appendix K**. The FMP details the likely bushfire hazards associated with the site, both currently and in the long-term and outlines mitigations strategies to manage the associated risk.

All areas within 100m of the site boundary have been assessed for vegetation classification and bushfire hazard rating levels. Following implementation of the LSP, areas of remnant vegetation within the site will be cleared or where remnant vegetation is retained within the site, it will be landscaped and managed as maintained public reserves and parklands, and are therefore considered as low threat vegetation areas ("Low" bushfire hazard). The majority of the remnant vegetation outside of the site is likely to remain in the short to long term, and as a result will pose differing levels of bushfire hazard to development within the site. The extent of post-development classified vegetation that may pose a bushfire hazard to the site is restricted to the following main areas:

- Closed scrub situated in the freeway road reserve, adjacent to the northwest boundary of the site. This vegetation is likely to pose a permanent hazard consideration.
- Open forest, woodland and open and closed scrub to the west, east and north-east of the site. This vegetation is located in areas intended for future urban development in accordance with the Wellard East Concept Plan and therefore poses only temporary bushfire hazard considerations.
- Woodland and open scrub to the east of the site. A portion of this vegetation is likely to pose a permanent hazard consideration which is associated with a resource enhancement wetland. The remainder of this vegetation is located in areas intended for future urban development in accordance with the Wellard East Concept Plan and therefore poses only temporary bushfire hazard considerations.
- Woodland over a managed understorey to the south of the site, within the Millar Road and the adjacent railway reserve. This vegetation is likely to pose permanent hazard considerations.

The FMP determined that all proposed future dwellings resulting from the LSP will fall within the acceptable level of risk as per *Planning for Bushfire Protection Guidelines* (WAPC et al 2010). The temporary and permanent Building Protection Zones (BPZ) requirements have been assessed and can be accommodated within the LSP. An indicative Bushfire Attack Levels (BALs) assessment was completed as part of the FMP and indicates that the indicative BAL for proposed future lots does not exceed BAL-29. The indicative BAL assessment is considered to be conservative as it does not include consideration of the shielding of dwellings from radiant heat flux by the required acoustic wall (to be located between the site and vegetation within the Kwinana Freeway). Detailed engineering and planning design, to be undertaken as part of the subdivision process, is required before this assessment can be completed, however a preliminary shielding assessment suggests that the BAL for the dwellings adjacent to the Kwinana Freeway will be reduced.

Access and egress from and within the site will adequately service the development. Reticulated water will be available within the site and hydrants will be spaced according to Department of Fire and Emergency Services and Water Corporation standards.

Any new dwellings constructed within 100m of identified classified vegetation will require consideration of the potential need for increased construction requirements to address *AS3959 Construction of Buildings in Bushfire Prone Areas*. In order to pre-empt this requirement, a BAL assessment will be undertaken as part of the subdivision process to determine the BAL ratings for each individual new lot created. A detailed and specific BAL assessment will need to be completed at the subdivision approval stage for all lots currently determined to be within "Bushfire Prone Areas", as outlined within the FMP (refer to **Appendix K**). As part of the subdivision process, any lots deemed to require fire management responses through the BAL assessment will be subject to a notification pursuant to section 70A of the *Transfer of Land Act 1893* placed on the certificate(s) of title indicating that the lot is subject to the requirements of a fire management plan (ie. increased construction standards to meet increased BAL ratings).

It is expected that the final BAL rating assessment at the subdivision stage, in accordance with this FMP, will reduce the threat to future residents, visitors and fire fighters in the areas proposed for urban development associated with this FMP.

2.6 Heritage

2.6.1 Indigenous Heritage

Based on the *Cultural Heritage Due Diligence Guidelines* (DIA 2013), there is a low to moderate risk of Aboriginal heritage sites being disturbed within the Wellard East Cell. The majority of the cell has been subject to ethnographic and archaeological investigations of different extents since 1970, with the most recent being in 1996 to support the extension of the Kwinana Freeway.

A search of the Department of Aboriginal Affairs *Aboriginal Heritage Inquiry System* and associated mapping indicates that no indigenous heritage sites are identified within the site.

While no Aboriginal heritage sites have been identified within the site, it is acknowledged that there is the potential that Aboriginal heritage sites may be found during civil and construction works. It is recognised that if during construction Aboriginal artefacts or sites are uncovered, that these are protected under the *Aboriginal Heritage Act 1972* and that works will need to cease and suitably qualified experts will be brought in to survey the potential site, and if required permission under the *Aboriginal Heritage Act 1972* to manage and disturb sites will be sought.

2.6.2 Non-Indigenous Heritage

A desktop survey undertaken by Emerge indicated that there are no European heritage sites present within the site. There are two listed sites west of the site, on the western side of the Kwinana Freeway. These sites are in reference to the site of the former Wellard Hospital, which was the first medical facility in the area circa 1926, and the site of the house built in 1925 for the first attending physician, Dr Day-Lewis. The hospital was dismantled and relocated to Esperance in 1930.

In addition, a number of heritage sites are listed on the Municipal Heritage Inventory within the City of Kwinana, predominantly to the west of the Kwinana Freeway. The closest is Bollard Bullrush Swamp which is located approximately 500 metres west of the Wellard East Cell, on the western side of the Kwinana Freeway.

No non-indigenous heritage values will be impacted by the Local Structure Plan.

2.7 Context and Other Land Use Constraints

Historical aerial photography indicates that the Wellard East Cell was likely to have been historically used for grazing/agricultural purposes in accordance with the previous Rural Zone and consistent with land use in the wider area. The site has been predominantly cleared since at least 1953, with some regrowth of vegetation in more recent years.

Figure 14 shows the site within the context of the Wellard East Cell and the existing aerial photography and road network. Various constraints and features such as the wetlands, Western Power infrastructure, Mundijong freight line and drainage reserves are shown over the site and Cell. This plan shows there are no major constraints affecting the proposed residential development of the site. Also where there are constraints located nearby, such as the Freeway and the Mundijong freight line, these have been considered as part of the structure plan design and documentation through the preparation of a noise assessment.

2.8 Potential Site Contamination

Broadly, the State Government, through the Department of Environment and Regulation, has the overall responsibility for developing, administering and enforcing the *Contaminated Sites Act 2003* and its associated procedures. Part of this responsibility includes maintenance of the Contaminated Sites Database and Register. The Contaminated Sites Database holds information on known contaminated sites within Western Australia. A search of this database indicated that the site was not listed.

A preliminary site investigation (Cardno 2011) has been undertaken for portions of the Wellard East Cell, with the site specifically considered as part of this investigation. Historically the central portion of Lot 9001 (previously Lot 201), which is located to the north of the site, was identified as containing a former market garden. Based on this, all of Lot 9001 and lots already subdivided (including the portion within the site) was subject to a detailed site investigation, in accordance with Department of Environment and Regulation guidelines. This investigation found that apart from the former market garden, which is located north of the site, the majority of Lot 9001 has only been used for grazing or agricultural-based activities.

The investigations to date indicate that the site has only been used for grazing and agricultural-based activities which are generally not identified by the Department of Environment and Regulation as potentially contaminating land uses. Therefore contamination is not expected to be an issue within the site and the overall risk of contamination being present is therefore considered to be low.

2.9 Adjacent Land Uses

Within the vicinity of the Wellard East Cell, there are a number of different land uses which, based on *Environmental Protection Authority Guidance Statement No. 3 – Separation distances between industrial and sensitive land uses* (EPA 2005), are considered to potentially generate emissions that at times may exceed amenity levels considered acceptable to residential areas and other sensitive land uses. These land uses are shown in **Figure 13** and include:

- Livestock Holding Facility.
- Kwinana Freeway.
- Mundijong freight line.
- Power boat facility.
- *Environmental Protection (Kwinana) (Atmosphere Wastes) Policy 1999* boundary.
- *State Planning Policy (SPP) No. 2.4 Basic Raw Materials*
  - Sand 'Extraction Area' within the central portion of the Wellard East Cell.
  - Clay 'Priority Resource Area' directly south of the Wellard East Cell.

These land uses and associated management are discussed further below.

2.9.1 Livestock Holding Facility

A livestock holding facility is located on part of Lot 732 Telephone Lane, Baldivis, 300 metres south-east of the Wellard East Cell, and approximately one kilometre from the site. The livestock holding facility is licensed under Part V of the *Environmental Protection Act 1986*, to operate as a 'livestock saleyard or holding pen'. Under the associated regulations, a 'livestock saleyard or holding pen' is defined as a premise on which live animals are held pending their sale, shipment or slaughter. This facility is owned, licensed and operated by Wellard Rural Exports Pty Ltd.

Environmental Protection Authority Guidance Statement No. 3 – Separation distances between industrial and sensitive land uses (GS3) (EPA 2005) provides generic separation distances for a range of land uses that could cause noise, dust, odour, gaseous and/or particulate emissions which may affect the amenity of people and the environment, which are referred to as 'sensitive land uses'. Livestock holding facilities are recognised by the Department of Environment Regulation and Environmental Protection Authority as potentially resulting in noise, dust and odour emissions that may exceed the amenity levels considered acceptable in residential areas. According to *Environmental Protection Authority Guidance Statement No. 3 – Separation distances between industrial and sensitive land uses* (EPA 2005), the recommended separation distance for such land uses, depending on the size of the facility, is 1 000 metres from the boundary of the facility.

The WAPC, in its determination of the application for the lifting of urban deferment over the northern portion of the Wellard East Cell in 2009 supported the measurement of the 1000 metre separation distance from the livestock holding sheds based on the applicant's arguments, which included the claim that the sheds were the primary source of odour.

In its consideration of the adjoining LSP to the west *(Lot 90 and Part Lot 378 Millar Road LSP)* in 2013 the City assessed the advice from the then Department of Environment and Conservation (DEC) regarding the methodology to be used in determining an odour buffer for the facility and recommended that the WAPC place a notification on title alerting the landowner to the possibility of odour impacts in the area.

Consistent with its recommendation for the adjoining LSP, the WAPC has adopted the LSP subject to the requirement for a notification on the title of lots pursuant to Section 70A of the *Transfer of Land Act 1893* notifying of potential adverse impacts associated with odour emissions from the livestock holding facility.

2.9.2 Power Boat Facility

A power boat facility, commonly known as Bonney's Water Ski Park, is located approximately one kilometre south-east of the site, within the City of Rockingham and has operated in the local area since 1985. The facility caters for a wide range of water-related activities including water skiing and jet boat racing, operating most days of the week. Jet boat racing events generally occur from October to April, with evening events generally running until 2100 hours on weekends.

It is our understanding that based on previous investigations undertaken by the City of Kwinana and City of Rockingham and the presence of a range of residences within the vicinity of the power boat facility (in closer proximity to the power boat facility than the Wellard East Cell), any potential noise impacts on future residents within the site will be managed by the facility's operator and in accordance with an approved Noise Management Plan and the *Environmental Protection (Noise) Regulations 1997*. On the 29th January, 2011 the City of Rockingham undertook noise readings of the Water Ski Park. According to a City of Rockingham Council report, a number of noise readings were obtained from a variety of locations. The majority of the readings conducted on this day complied with the assigned noise levels under the Environmental Protection (Noise) Regulations 1997. There were some exceedances noted during the noise readings, which appear to be attributed to individual boats. The City of Rockingham Health Services gave an undertaking to continue liaising with the Water Ski Park to further improve the site's operations. This outcome facilitated the lifting of the Urban Deferred Zone over the site.

Notwithstanding the proposed amendments to the *Environmental Protection (Noise) Regulations 1997*, under which motor sports may be able to exceed the limits outlined in the regulations, it is understood that the Water Ski Park will still need to operate under a noise management plan that has been approved by the City of Rockingham and Chief Executive Officer of the Department of Environment Regulation. Whilst it is recognised that the power boat facility has the potential to result in noise impacts, a number of dwellings are already located closer to the power boat facility than the Wellard East Cell, noise impacts should be managed by the facility in accordance with the *Environmental Protection (Noise) Regulations 1997*. The regulations set assigned noise levels for noise emitted on premises or public places, and provide for a level of amenity for a receiver.

2.9.3 Kwinana Freeway

The Kwinana Freeway is located directly adjacent to the western boundary of the Wellard East Cell and the north-western boundary of the site.

The potential noise impacts from the Kwinana Freeway have been considered in the context of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (WAPC 2009). A noise assessment has been completed for the site in accordance with this policy and indicates that there is likely to be noise impacts from the Kwinana Freeway along the north-western boundary of the site (Lloyd George Acoustics 2013) (refer to **Appendix H**). The findings of this assessment indicate that noise impacts from the Kwinana Freeway can be managed through:

- A 3.0m high noise wall along the western boundary of the site, adjacent to the Kwinana Freeway; and
- Architectural treatments (predominantly Package A) for the first row of houses adjacent to the Kwinana Freeway. The indicative architectural treatments are shown within Figure 5.3 of **Appendix H.**

The 3.0m high noise wall will be located adjacent to the noise wall proposed within the LSP to the west (i.e. Lot 90 and part Lot 378 Millar Road). Based on the noise assessments undertaken to date, the gap between

the two separate walls, created as a result of the drainage reserve, is unlikely to result in noise amelioration requirements in addition to those outlined above.

It is important to note that the exact noise amelioration measures will be determined when detailed engineering and planning has been completed for the site (ie. when final lot levels and layout have been determined). A detailed noise assessment will be prepared as a condition of subdivision approval, which will detail the specific height of the noise wall and any architectural treatments that may be required.

2.9.4 Mundijong Freight Line

The Mundijong freight line runs along the southern boundary of the site, with only a small portion of the site located directly adjacent to the freight line. It is described as one of the most heavily used (in terms of tonnage) freight movement corridors in Western Australia.

The potential noise impacts from the freight line have been considered in the context of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (WAPC 2009). A noise assessment completed for the site (Lloyd George Acoustics 2013) (refer to **Appendix H**), indicates that there is the potential for noise impacts along the southern boundary of the site. Due to the configuration of the site and location of the Marsupial Rehabilitation Clinic, there are no future residential lots adjacent to the southern boundary of the site and as a result the Mundijong Freight Line will have less impact on the site than the LSP to the west (i.e. Lot 90 and part Lot 378 Millar Road). Based on the noise assessment, the predicted noise impacts can be managed with either:

> 2.0m high barrier on the residential lot boundary; or

> Architectural treatment (Package A) for the first row of houses.

It is important to note that the exact noise amelioration measures will be determined when detailed engineering and planning has been completed for the site (ie. when final lot levels and layout have been determined). A detailed noise assessment will be prepared as a condition of subdivision approval, which will detail the specific treatment and will be either a boundary fence or architectural treatment.

2.9.5 Environmental Protection (Kwinana) (Atmosphere Wastes) Policy 1999 Boundary

The Wellard East Cell, and specifically the site, is located within the Kwinana Atmosphere Policy Boundary where the provisions of the Environmental Protection Authority's *Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999 (Kwinana Atmospheric Wastes EPP)* apply. The policy aims to set sulphur dioxide and total suspended particle standards and limits for the Kwinana Industrial Area. This policy describes three areas (A, B and C) each with ambient air quality standards and limits, increasing in stringency from Area A (industrial) through to Area C (largely residential).

The site is found within Area C and is provided a level of protection under this policy in line with land uses for residential and rural purposes. Since the *Kwinana Atmospheric Wastes EPP* was enacted in 1992, the 1-hour averages used to measure ambient air quality have not been exceeded (EPA 2009). It is highly unlikely that future residents within the site will be adversely affected by emissions as emission concentrations are required to remain within the levels prescribed in the *Kwinana Atmospheric Wastes EPP*.

Given the site is found within Area C and complies with the allowed land use under this policy, the requirements of this policy requires no specific consideration or management.

2.9.6 Basic Raw Materials

Basic raw materials are described as sand (including silica sand), clay, hard rock, limestone (including metallurgical limestone) and gravel and other construction and road building materials, which are generally important to land development. *State Planning Policy No. 2.4 Basic Raw Materials* provides for the protection of the basic raw materials, with the intention of this policy to ensure these resources can be fully utilised, through appropriate land uses and timeframes for development that may otherwise conflict with this intention.

Under *State Planning Policy 2.4 Basic Raw Materials* a number of basic raw materials are mapped as occurring within the vicinity of the site, and have been considered below:

- Sand 'extraction area' within previous Lot 201 Mortimer Road, to the north of the site. This resource has been extracted as part of the development of this portion of the Wellard East Cell and is therefore not expected to impact future residents.
- Clay 'priority resource area' located approximately 1 200 metres directly south-west of the site, as shown within recent mapping prepared by the Geological Survey of Western Australia (Strickland 2012) and within **Figure 13**. *Environmental Protection Authority Guidance Statement No. 3 – Separation distances between industrial and sensitive land uses* (EPA 2005) recommends a separation distance of 500 metres between clay extraction activities and sensitive land uses. The site is located outside of the recommended separation distance and it is considered that future residential development would not impede extraction of this resource.

The presence of these basic raw materials within the vicinity of the site is not expected to impact on the health or amenity of future residents, while future residents are unlikely to impede the future extraction of these resources.

3 Land Use and Subdivision Requirements

3.1 Proposed Land Use

A Concept Plan has been prepared for the Wellard East Cell to facilitate the co-ordinated development of the whole cell (refer to **Figure 15**). In addition, a statutory LSP plan has been prepared for the site and included in Part One of the Structure Plan (refer to **Plan 1**). This plan is consistent with the Wellard East Concept Plan. Future subdivision of the site will be in accordance with the statutory LSP.

The Concept Plan for the Wellard East Cell and the LSP are generally based on the previous LSP adopted for part Lots 201 and 27, the Jandakot Structure Plan and the Eastern Residential Intensification Concept (ERIC).

Both the JSP and ERIC recognise a linear urban form will result within the Wellard East Cell given the limited width of available land between the freeway and the rural wedge to the east.

The Cell is heavily constrained by the existence of four wetlands (Conservation Category and Resource Enhancement), two (2) drainage reserves traversing the developable area and the 110m wide Western Power 330kv easement. As recognised in ERIC, these constraints largely confine urban development to a linear configuration through the western and central sections of the cell as depicted in the Wellard East Concept Plan.

The design principles underpinning the Concept Plan and LSP are largely based on Liveable Neighbourhoods, and were guided by several influences. The LSP and Concept Plan design endeavours to:

- Where possible maximise the proportion of lots with good solar orientation on the east-west axis to more easily facilitate solar passive housing designs;
- form a modified grid structure to provide strong permeability throughout the development;
- give appropriate consideration to the wetland and buffer areas by demarking the public realm and providing a management barrier;
- clearly identify the north-south neighbourhood connector road that links the whole design together; and
- locating the school centrally within the Cell.

Furthermore, the Wellard East Concept Plan offers a degree of flexibility to enable an innovative and creative response to any future unforseen issues or needs that may arise. As such, the Concept Plan is intended to operate as a guiding framework for subdivision and development that can evolve and adapt over time, rather than function as a rigid and finalised design.

As previously mentioned, the Concept Plan has been prepared in accordance with the principles of Liveable Neighbourhoods including optimising land efficiency, providing lot diversity, and the integration of urban water management strategies.

The Concept Plan shows how the different land uses, POS and local roads integrate across different lots within the Cell. Generally the design for Lot 379 integrates with Lot 378 to the west with a number of road and public access way (PAW) (Pedestrian and Cyclist) linkages. It should be noted that the PAW linkage between the lots has been required by the Department of Planning/WAPC. The only minor exception to this is the area immediately south of the drainage reserve, where no road connection is proposed at this location (ie. between Lots 378 and 379). Armana Holdings has liaised with landowner of part Lot 378 and they have no objection to this proposal.

A 4.0ha primary school site is proposed to be located centrally within the Wellard East Cell, which is discussed in greater detail in **Section 3.6**.

The Concept Plan also makes reference to a 'marsupial rehabilitation clinic' situated at the southern end of the cell on Millar Road. Armana Holdings understands the significant contribution this facility makes to the wider community and the Concept Plan makes provision for the continuation of this land use.

Whilst no neighbourhood centre is shown on the LSP and Concept Plan, a local retail centre is proposed just to the north of the cell on Mortimer Road that will also service the Wellard East Cell. The projected population for the cell is relatively low due to wetlands and other constraints that reduce the developable land area. However, in response to the requirements of the City of Kwinana, a potential home store (maximum floorspace of 100m^2) is shown on the Concept Plan opposite the primary school site. This will allow residents to purchase daily convenience goods within the cell and therefore reduce car reliance for daily retail needs.

The land use areas for the cell and LSP Area are provided in **Table 14**.

Table 14. Structure Plan Summary Table

Item	Data Wellard East Cell (Concept Plan)	LSP Area	Section number referenced within the Structure Plan report
Total area covered by the concept plan and the local structure plan	170.3ha	16.67ha	1
Net land area covered by the concept plan and local structure plan (minus CCW wetland core, WP Easement, drainage reserves, school site, marsupial rehabilitation clinic, 1:1 year drainage basins where relevant)	129.9ha	13.29ha	
Area of each land use proposed:			3
Zones			
▪ Residential	60.22ha	8.25ha	
▪ Development – Marsupial rehabilitation clinic	1.08ha	Nil	
Reserves			
▪ Public Purposes - Primary school	4ha	3.17 ha	
▪ Parks and Recreation – Public Open Space	42.61ha	1.35ha	
Estimated lot yield	Approximately 1440	Approximately 203	3
Estimated number of dwellings	Approximately 1468	Approximately 208	3
Estimated residential density	R20 to R50 8.6 dwellings per gross hectare	R20 to R50 12.4 dwellings per gross site hectare	3.3
Dwellings per site hectare *As per Liveable Neighbourhoods*		15.3 dwellings per net site hectare	
Estimated population	3,816 (based on 2.6 persons per dwelling as per 2011 census data for Wellard West)	540.8 (based on 2.6 persons per dwelling as per 2011 census data for Wellard West)	3
Number of secondary schools	None	None	
Number of primary schools	One	A portion of one school	3
Public Open Space	11.5%	8.6%	3.2

3.2 Open Space

The public open space (POS) is presented on a plan and in schedules for the LSP Area and the cell in accordance with Liveable Neighbourhoods. The POS plan is shown on **Figure 16** and the schedules are

included in **Appendix I**. The POS provision for the LSP Area and the Wellard East Cell are 8.6% and 11.5%, respectively. It is important to note that overall table and Wellard East Concept Plan includes extensive areas of uncredited restricted POS (30 hectares), mainly comprising the wetlands and their buffers.

Whilst the POS area for the site is below the requirement of 10% (as specified in Liveable Neighbourhoods), the average percentage of POS provided over land owned by Armana Holdings is 11%, which satisfies the 10% POS requirement. The previously approved LSP area provided 13.9% credited public open space. It should be noted that two LSPs over Amana's landholdings were required as the land was subject to different Urban Deferred Lifting proposals, otherwise all of the land would have been developed under one LSP. The need for two LSPs should not prevent the addition of POS across all land owned by Armana Holdings.

POS areas shown over some parts of the cell are indicative as they are subject to more detailed urban design, environmental and drainage investigations and POS calculations. The size of the CCW and REW wetlands and buffers in the north-eastern and eastern portions of the cell may change and some drainage calculations included in the POS schedule are estimates only (ie. where no LWMS has been prepared).

The POS areas along the northern and eastern sides of the cell will have a major conservation function as it protects various Conservation Category and Resource Enhancement Wetlands. There is also a POS area in the north-east portion of the cell, which will comprise a senior oval for active POS. Many of the other smaller POS areas will be used for passive and informal active POS and drainage.

The allocation of Public Open Space (POS) has been based on the following principles:

> Provision of useable portions of POS in each proposed urban area;

> Linkage of POS networks;

> Provision of POS within a walkable catchment of all urban development;

> Retention of remnant vegetation in either multiple use corridors or parks where possible; and

> Dual use of multiple use corridors as drainage swales and POS in certain locations.

The LSP and Concept Plan are consistent with the intent of Liveable Neighbourhoods as all lots are within 400 metres of POS.

Armana Holdings has prepared a detailed wetland management plan for the Conservation Category and Resource Enhancement Wetlands over their land in the northern part of the cell. It is anticipated that other landowners will prepare similar wetland management plans for the other REW wetlands and the balance of the CCW wetland.

A Landscape Masterplan is included in **Appendix G** which shows the different functions of each POS area within the site and previously approved LSP Area. There are three main POS areas within the site; POS Areas Q, X and BB (refer to **Figure 16**). Area Q (also identified as Area 14 on the Landscape Masterplan) is located adjacent to the Kwinana Freeway and has a total area of 5480m^2. The primary function of POS Area Q is to provide for passive recreation (inclusion of park furniture as identified on the Landscape Masterplan), retention of trees and provision of drainage. It is not appropriate for Area Q to provide an informal kick-about area as it is not centrally located within the subdivision. Instead POS Area X will perform this function.

It is intended that the design and treatments within POS Area X (also identified as Areas 16, 17, 18 and 19 on the Landscape Masterplan) will be consistent with adjoining POS areas along the drainage reserve (ie. POS Area W), where possible. POS Area X will provide an informal kick-about area where it widens out on the northern side of the drain. It provides sufficient land area (approximately 400m^2) that satisfies Council's requirement for a 20m X 20m space. Also play equipment is proposed to be installed on the southern side of POS Area X. Flood storage areas for storm events up to the 100 year are proposed on both sides of POS Area X, however these areas will be shallow turfed depressions that will still permit passive recreation.

Whilst POS Area BB (also identified as Area 15 on the Landscape Masterplan) only encompasses 2126m^2, it is not an isolated POS parcel as it joins with POS Area DD on a separate lot and ultimately the POS Area will be much larger with a total area of 1.04ha. This situation commonly occurs when there is multiple land ownership, which is the basis for requiring an overall conceptual LSP design to show the integrated provision of POS across the whole Wellard East Cell. Whilst the landowner of Area DD may propose a slightly

different design they would need to have regard to the overall concept plan and the likely requirement for POS along the drainage reserve.

In addition to the various POS areas, active recreation areas will be located within the school site with a series of ovals, which may potentially be available to the public outside school hours. Liveable Neighbourhoods promotes the use of school ovals by the community outside school hours as it leads to the more efficient use of land and it allows schools to form part of the local community.

All POS areas within the cell will be ultimately managed by the City of Kwinana.

3.3 Residential

As outlined in ERIC, the expansion of this broader development corridor would be predominantly for residential purposes and the principal land use within the Wellard East Cell is low density residential (indicated as being R20 and R25 on ERIC). In accordance with ERIC, the majority of the Concept Plan and LSP propose a residential density range of R20-R25 (the higher code is shown on the LSP).

In line with Directions 2031 and Beyond, additional higher densities are shown within the Concept Plan and LSP, including medium density residential areas (nominally indicated as being R40). In addition, an area of R50 (medium density residential) is identified opposite POS to provide alternative housing choices (ie. single level attached housing and grouped dwellings) for smaller households.

The proposed residential densities are also generally consistent with the densities identified on the Wellard East LSP (conceptual component), which was adopted by the WAPC and Council in 2011.

The total dwelling yield estimated by the City of Kwinana for the whole Wellard East Cell is approximately 1468, however this will depend on the final size of wetlands and their buffers and the removal/reduction of the odour buffer.

Under Directions 2031 and Beyond the connected city scenario expects an improvement in the residential densities being achieved for new greenfield development on the urban front. At present, new residential development is being constructed at densities of approximately 10 dwelling units per gross urban zoned hectare. The connected city scenario has set a target of 15 dwellings per gross urban zoned hectare. Based on this target, the Wellard East Cell would need to deliver 2550 dwellings. However, this is not possible to achieve given the presence of the various wetlands and buffers and the odour buffer. In terms of the LSP area, 208 dwellings is projected over 13.58ha (school site has been subtracted from the LSP area), which equates to a density of 15.3 dwellings per hectare. This is just above the density recommended in Directions 2031 and Beyond.

Under Liveable Neighbourhoods the relevant dwelling target for the site is 12 to 20 dwellings per site hectare. The site achieves the target with a density of 15.3 dwellings per hectare.

3.4 Movement Networks

The latest Transport Assessment prepared by Shawmac is an update of the previous transport assessment, which was approved by the then Town of Kwinana as part of the previously adopted Local Structure Plan for Lots 27 and part Lot 201.

The site is located adjacent to Kwinana Freeway, which is the major north south route connecting the CBD to southern suburbs, Mandurah and the South-West, with an estimated traffic volume in the order of 39,000 vpd (vehicles per day). Mortimer Road to the north of the cell is a District Distributer (B) with direct freeway access from both directions, and currently carries approximately 2,300 vpd. To the south and east of the cell are Miller and Woolcoot Roads respectively, with daily volumes estimated at 2,600 vpd and 500 vpd respectively, based on 2006 counts and catchment observations.

No pedestrian or cyclist facilities are provided adjacent to the site, with the nearest facilities being the Principal Shared Path running adjacent to the western side of Kwinana Freeway.

The nearest public transport route is the Transperth 543 bus route through Bertram to the West of Kwinana Freeway, connecting to the Kwinana Station on the Perth – Mandurah Train Line (off Thomas Road).

Further details of the existing road and transport network are presented in Transport Assessment Report by Shawmac (refer to **Appendix D**).

3.4.1 Vehicular Access and Transport Assessment

The Transport Assessment (refer to **Appendix D**) was conducted primarily with respect to the proposed development of the site, and with reference to the remainder of the Wellard East Cell. The Report focused on the following key transport issues:

> Local road capacity for additional traffic generated by the proposal to develop the lots within the site;

> The extent that increased traffic loads can be safely managed on the adjacent current and future road networks;

> The provision of safe access to the proposed development within the site;

> Safe access to the school site; and

> Safety and efficiency of the internal road network including adequate provision for pedestrians and cyclists, and provision for public transport.

The assessment involved modelling of increased traffic flows and the impact of the increased flows on existing and proposed roads and intersections. The assessment also provides recommendations on the intersection and road location and treatments required for upgrading of existing roads and design of proposed roads within the site.

Findings of the assessment are summarised below. For detailed findings refer to the Transport Assessment Report (refer to **Appendix D**).

The proposed internal road layout consists of a main north-south link road running through the Sunrise Estate between Mortimer Road and Millar Road. The remainder of the network is generally permeable with street design and layouts to reinforce the road hierarchy.

Access to the site will be provided from Mortimer Road to the north through the previously approved and partly constructed subdivision area of Sunrise Estate. Once the development front reaches Millar Road, access to the site will be provided from the north and south, via Mortimer Road and Millar Road. As access to the freeway is available only from Mortimer Road, the vast majority of external traffic accessing the site is predicted to remain from Mortimer Road. The intersection of Mortimer Road and the north-south road has previously been approved as part of the adopted LSP and the approved subdivision (now under construction).

Due to the much lower anticipated traffic loads at the entry to the estate via Millar Road, an unsignalised channelised "T" intersection with splitter islands on the east bound and south bound left turn approaches is deemed adequate. It is noted that the potential for a reduction in the speed limit along Millar Road from 80km/h to 60km/h would have an effect on geometric design considerations. This will need to be discussed with Main Roads at the time of detailed design.

The Transport Assessment finds that proposed internal road reservations are able to adequately manage predicted ultimate traffic flows based partly on Liveable Neighbourhood road categories and road reservations previously approved by Council (refer to **Appendix G** and **Figures 18** and **19**). **Figure 20** provides an indicative subdivision design for the laneway lots, demonstrating there is sufficient access and surveillance in this area. Truncations on corner lots have been increased to allow for maximum surveillance and service vehicle turning movements. Sufficient visitor parking for laneway lots is provided in adjacent 15m wide road reserves as shown on **Figure 20**. No visitor parking is proposed within the laneways.

The Report recommends the adoption of 'T' intersections as an alternative to four way intersections as they provide fewer conflict points and are inherently safer, although one internal 4 way intersection is proposed. This intersection will be treated by stop signs on both minor road legs in accordance with MRWA guidelines (refer to Figure 6 in the Transport Assessment Report). These recommendations have been incorporated into design where appropriate. It is also confirms that based on the recommended road profile, direct lot access will be acceptable for all roads within the site, including the primary north-south road.

Pedestrian and cycle networks have been assessed within the Transport Assessment including dual use path (or path and cycle lanes), footpaths, shared road facilities and crossing facilities. Recommendations have been incorporated into the design, including the provision of footpaths on both sides of the road within 400m (walkable distance) of the primary school, the potential homestore and the proposed community centre (Objective and R31 Element 2 of *Liveable Neighbourhoods*). In addition, Council may consider in the future

the provision of potential pedestrian crossings over the central drainage reserve to provide connectivity consistent with *Liveable Neighbourhoods* through the overall Wellard East Cell.

The Public Transport Authority (PTA) has acknowledged the possible future need to service the cell, and indicated a new provisional bus service (548) could potentially operate within the area. The service would operate between Wellard East and the Kwinana Town Centre, and would be assessed in the future depending on demand. The PTA has a stated goal of providing a bus stop within 500m of 95% of Perth's population.

The Transport Assessment finds that modifications to the surrounding external transport network including Mortimer, Millar and Woolcoot Roads are not required from a traffic load perspective, aside from intersection upgrades at entry points to the cell.

3.5 Water Management

The Local Water Management Strategy (LWMS) for the site has been prepared as an addendum to the approved Lot 27 and Lot 201 Wellard East LWMS (Cardno 2010) and is intended to provide additional details specific to the water management strategy within the site. The LWMS addendum (refer to **Appendix E**) has been developed in accordance with Better Urban Water Management (DoW 2008), State Planning Policy 2.9 Water Resources (WAPC 2006) and Planning Bulletin 92 Urban Water Management (WAPC 2008). The LWMS addendum has also considered the objectives and principles detailed in the Jandakot District Water Management Plan (DWMP) (DoW 2009), the Wellard East District Water Management Strategy (DWMS) (Cardno 2010) and the Lot 27 and Lot 201 Wellard East LWMS (Cardno 2010) (refer to **Appendix F**), and should be read in conjunction with the Addendum. Water will be managed using an integrated water cycle management approach, which has been developed using the philosophies and design approaches described in the Stormwater Management Manual for Western Australia (DOW 2007). The key principles of integrated water cycle management that have guided the water management approach within the site include:

- Considering all water sources, including wastewater, stormwater and groundwater;
- Integrating water and land use planning;
- Allocating and using water sustainably and equitably;
- Integrating water use with natural water processes; and
- Adopting a whole of catchment integration of natural resource use and management.

The overall objective for integrated water cycle management for residential developments is to minimise pollution and maintain an appropriate water balance. The LWMS Addendum design objectives seek to deliver best practice outcomes using a Water Sensitive Urban Design (WSUD) approach, including detailed management approaches for:

- Potable water consumption;
- Flood mitigation;
- Stormwater quality management; and
- Groundwater management.

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. The LWMS Addendum provides a summary of the existing environment, based on a number of National and State policies and guidelines and site specific studies undertaken in and around the site. The characteristics and environmental values of the site have guided the design criteria, which will achieve the design objectives for the key management areas discussed above.

The WSUD approach and measures that are proposed for the site include:

- Maintaining existing flow regimes by matching pre-development peak flow rates leaving the site;
- Treatment of minor event runoff prior to infiltration to groundwater;

- Bio-retention areas incorporated in POS areas;
- Major event flood storage requirements addressed within POS areas;
- Co-location of flood storage areas with natural landforms and native remnant vegetation wherever possible;
- Adopting appropriate non-structural best management practices;
- Adopting a fit for purpose water use approach; and
- Minimising use of both scheme and non-potable water.

The LWMS Addendum demonstrates that the design approach for the site is consistent with a best practice WSUD approach, that the water management objectives for the site can be achieved within the spatial allocation of the LSP Area, and the requirements of the relevant State and local government policies and guidelines will be satisfied.

The proposed roads for the site cross the Peel Sub N and Peel Sub N1 drains in a number of locations. Indicative cross-sections for the Peel Sub N and Peel Sub N1 drains are provided in Appendix B of the LWMS addendum. The design of the road and drain crossings will be provide at the detailed engineering design stage and will also be included in the future UWMP.

3.6 Education Facilities

The Wellard East Concept Plan and the LSP include a primary school site (4ha in size) in the same location as identified on ERIC and the Jandakot Structure Plan. It is located slightly further north than the previous Wellard East LSP, in line with ERIC and the Jandakot Structure Plan. This location is viewed as a more appropriate central location within the Wellard East catchment area. The configuration of the site is driven by the REW Wetland and buffer to the east and the proposed alignment of the north-south neighbourhood connector road to the west. The majority of the primary school site is located within Lot 379 (ie. 3.17ha).

3.7 Infrastructure Co-ordination, Servicing and Staging

In accordance with the following sections, all of the services can be brought to the site within the short term (0-5 years) as they are just extending through Sunrise Estate from the north (refer to **Figure 17**). The only partial exception to this is the sewer required to service the lots in the southern portion of the site, as it is planned to be constructed through land to the west and is subject to the adjacent subdivision proceeding. This issue is further discussed in **Section 3.7.1**.

3.7.1 Sewerage

Wood & Grieve Engineers (WGE) on behalf of the Water Corporation has prepared a conceptual sewer catchment plan for an area east of the Kwinana Freeway, which covers both the subject site and the previously approved Local Structure Plan (LSP) area of the Sunrise Estate. Based on this plan, the site will be fully serviceable via the DN375 gravity sewer crossing of Kwinana Freeway, to the adjacent Kwinana D Pump Station (PS) located west of the Freeway on Johnson Road (refer to **Figure 17**). The catchment area for this pump station extends over both the subject site and the previously approved LSP area to the north of the Estate. The bored Freeway crossing has been designed and construction is expected to commence shortly.

The WGE catchment plan currently has no formal status with the Water Corporation. However approvals of previous Sunrise Estate sewer reticulation plans have been provided based on the expected future adoption of the catchment plan.

The northern portion of the cell within the previous Lot 201 will utilise the DN300 main which runs south through the Estate to the freeway crossing. This main has been recently been constructed in order to serve the previously approved LSP area of the Estate. The northern portion of Lot 379 will gravitate sewer internally to the location of the freeway crossing. The southern portion of Lot 379 falls within a separate sub catchment, which will require the construction of a DN225 main through subdivisional roads north of Millar Road. Although flows from this sub catchment will also gravitate to the Freeway crossing, the main is planned to be constructed through subdivisional road reserves not yet created within the adjacent land to the west (refer to **Figure 17**).

The proposed development on adjacent land (Lot 90 and part Lot 378) is currently proceeding, which will include construction of the DN225 from the eastern boundary of Lot 379 to the freeway crossing. The LSP for this area has recently been supported in principle by the City of Kwinana subject to modifications, with structure plan adoption and subdivision approval from the WA Planning Commission expected to follow. In the event that development of the southern portion of Lot 379 proceeds before the adjacent development, the DN225 gravity main will have to be constructed through private land in order to connect the sub catchment to the freeway crossing. If this cannot be negotiated, an alternate arrangement will need to be investigated.

The Water Corporation has advised there is currently sufficient capacity in the wider scheme to cater for development within the cell. No additional offsite modifications or upgrades are required to provide the necessary capacity to serve the subject site.

3.7.2 Water Supply

The Water Corporation has advised that the Medina Scheme, under which the site is proposed to be serviced with water, is currently under review.

In order to provide the previously approved LSP area with water supply services, a DN250 main was constructed along Mortimer Road, connecting the Sunrise Estate to the DN300 main located at the corner of Johnson Road and Mortimer Road (refer to **Figure 17**). Water Corporation advised at the time (June 2010) that this supply would be capable of servicing up to 400 lots to the south of Mortimer Road and west of Woolcoot Road. This would cover all of the previously approved structure plan area, and a portion of the subject site.

Water Corporation has recently advised (August 2013) that this DN250 main may be sufficient to supply all lots within the Sunrise Estate with water services. However, this will require some pressure testing and possibly modelling by the Water Corporation before confirmation can be provided.

Subject to the results of this modelling, the Water Corporation has advised additional offsite upgrades and extensions may be required. The existing DN300 main within Johnson Road may be required to be extended south to the intersection with Millar Road, then east along Millar Road to the site frontage. The Water Corporation also noted the potential requirement to extend a DN700 main along Sulpher Road between Sicklemore and Johnson Roads, as per the current Medina Scheme. Both extensions would be developer prefunded via a Customer Constructed Works Agreement (CCWA).

Pending the outcome of the Medina Scheme review, the Water Corporation will provide further advice as to the future sizing and location of any mains that may be required. However the Water Corporation has confirmed there is no concern that the outcome of the review will indicate the site is unable to be serviced.

3.7.3 Natural Gas

Natural gas has been supplied to the Sunrise Estate via an extension of gas mains along Mortimer Road, as required for the subdivision within the previously approved LSP area (refer to **Figure 17**). This extension was undertaken by ATCO Gas in 2013 at no cost to the developer. Newly constructed gas infrastructure within the Sunrise Estate can be extended into the site, assuming development proceeds in a southerly direction.

Advice from ATCO Gas is that ultimately reinforcement to the gas infrastructure in the area will be required. However at this stage, the existing infrastructure which has been constructed to serve the previously approved LSP area also has the capacity to serve the site.

ATCO notes that if other developments in the area proceed before the subject site, available capacity will be reduced and headworks reinforcement may be required.

Depending on the timing of development, ATCO will determine what upgrades are required and when, and the nature of the cost contribution arrangement between Sunrise Estate, other developers in the area and ATCO Gas.

3.7.4 Power

The existing development within the previously approved LSP area to the north has extended a 22kV feeder (MED501) throughout the development via the extension of Ringmain cable to new Switchgears within that site.

It is proposed to continue to extend this feeder through the subject site, and interconnect with the existing 22kV feeder MED514 along Millar Road (refer to **Figure 17**). This would provide flexibility in the creation of the lots either from the northern section or southern section of the development. The existing overhead distribution lines fronting Millar Road will require undergrounding as part of the subdivision works.

Transformers and Switchgears will be installed to distribute the power throughout the development to distribution pillars provided within the respective lot boundaries (one pillar per two lots).

Two feasibility studies have been previously completed by Western Power within the Wellard East Cell on behalf of Amana Holdings, covering all areas of the Sunrise Estate.

Both studies indicated that the network configuration presently had enough capacity to supply the overall development. However, as the load will span over the next 2-3 years, and with the high possibility of other future load growth in the area, new feeders or the reinforcement of existing feeders may be required to cater for the ultimate load growth in the vicinity. Should this be the case, the developer may be required to fund a proportion of these works.

3.7.5 Telecommunications

The site falls within the NBN service provision footprint. It is assumed that NBN pit and pipe infrastructure installed within the existing subdivision will be extended to provide a fibre connection to the proposed lots within the site (refer to **Figure 17**).

NBN pit and pipe will be installed / extended to suit common trenching provided as part of the subdivision works. This pit and pipe network will be handed over to NBN to facilitate the provision of fibre to the development.

3.7.6 Proposed Staging of Subdivision

Development of the site is proposed to continue from the existing subdivision (north of the site) in a southerly direction towards Millar Road. There are a number of servicing constraints that are currently preventing development from commencing in the opposite direction (ie from Millar Road). Water, gas and communications infrastructure have all been brought to the approved LSP area via Mortimer Road, and reticulated throughout the existing subdivision in a southerly direction. Development must continue in this direction in order to connect new lots to these services.

3.8 Developer Contribution Arrangements

In accordance with the Scheme, the Wellard East Cell is now located in a Developer Contribution Area (DCA 11) for contributions towards community infrastructure through a Development Contribution Plan (DCP). The DCP requires developers in Wellard East to contribute to a range of community type infrastructure at the time of subdivision that will be provided at the local level (eg. local community centre), the district level (eg. Anketell Branch Library and Casuarina Community Centre) and the regional level (eg. Kwinana Youth Facility and the Thomas Oval Recreation/Sporting Ground). This DCP was included in the Scheme via Amendment No. 115, which was gazetted in June, 2012. This DCP and associated Cost Schedules are now subject to review by Council and are the subject of a further Local Scheme Amendment (ie. Amendment No. 154).

Wellard East is affected by a further amendment to the Scheme (ie. Amendment No. 100A), which deals with developer contributions towards various forms of "hard" infrastructure, such as existing roads. The City of Kwinana previously prepared and advertised Amendment No. 100. Wellard East Cell is included in Developer Contribution Area 2. Amendment No. 100A (latest Amendment) requires developers in Wellard East and other cells to contribute to a range of infrastructure at the time of subdivision. Key infrastructure works include upgrading of Mortimer Road and western section of Millar Road and drainage. The original Amendment (Amendment No. 100) was advertised in late 2009 and numerous submissions were lodged by landowners raising a number of issues.

Discussions with Council officers confirm that Amendment No. 100A will be advertised shortly.

The progress of Amendment No. 100A will not hold up LSP and subdivision approvals as approvals will be subject to legal agreements between Council and the subdivider, if the Amendment is still not finalised.

4 Conclusion

As discussed and demonstrated throughout this report, the environmental, bushfire, fauna, acoustic, planning, servicing and transport assessments and the LWMS Addendum all support adoption/approval of the Local Structure Plan for part Lot 9001 Mortimer Road and part Lot 379 Millar Road, Wellard (East) (ie. **Plan 1**). There are no constraints affecting the site, which cannot be addressed through appropriate management strategies such as a noise assessment and a final BAL rating assessment (bushfire) at the subdivision stage. Part of Lot 379 has been excluded from the LSP due to its inclusion in the current odour buffer.

The LSP design is consistent with the overall design shown over the Wellard East Cell (ie. Wellard East Concept Plan). The LSP design for the site is also generally consistent with the various planning documents guiding the development of the site, including Liveable Neighbourhoods, Jandakot Structure Plan, ERIC and TPS2.

The statutory provisions guiding the further subdivision of the site are included in Part One of the structure plan documentation.

It is considered that this LSP provides sufficient detail and technical reports to ensure development throughout the site and cell is co-ordinated and can proceed in an orderly manner without prejudicing the development of adjacent land.

In order for subdivision to progress over part Lot 9001 and part Lot 379, it is requested that the WAPC endorse this LSP. In summary, it is considered that the LSP provides an appropriate framework to guide the future subdivision and development of the site.

5 References

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Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

FIGURES

Figure 1. Location Plan

Figure 2. Aerial Photograph

Figure 3. Existing Lot Configuration

Figure 4. Metropolitan Region Scheme (Zoning Map)

Figure 5. Final Jandakot Structure Plan

Figure 6. City of Kwinana – Town Planning Scheme No.2 (Zoning Map)

Figure 7. Eastern Residential Intensification Concept

Figure 8. Vegetation Communities

Figure 9. Vegetation Condition

Figure 10. Geomorphic Wetlands and Regional Biodiversity Linkages

Figure 11. Topography

Figure 12. Acid Sulfate Soils

Figure 13. Land Uses within and surrounding the Wellard East Cell

Figure 14. Context and Constraints Plan

Figure 15. Wellard East Concept Plan

Figure 16. Public Open Space

Figure 17. Servicing Plan

Figure 18. Indicative Road Cross Sections

Figure 19. Indicative Road Cross Sections

Figure 20. Indicative Laneways Subdivision Design

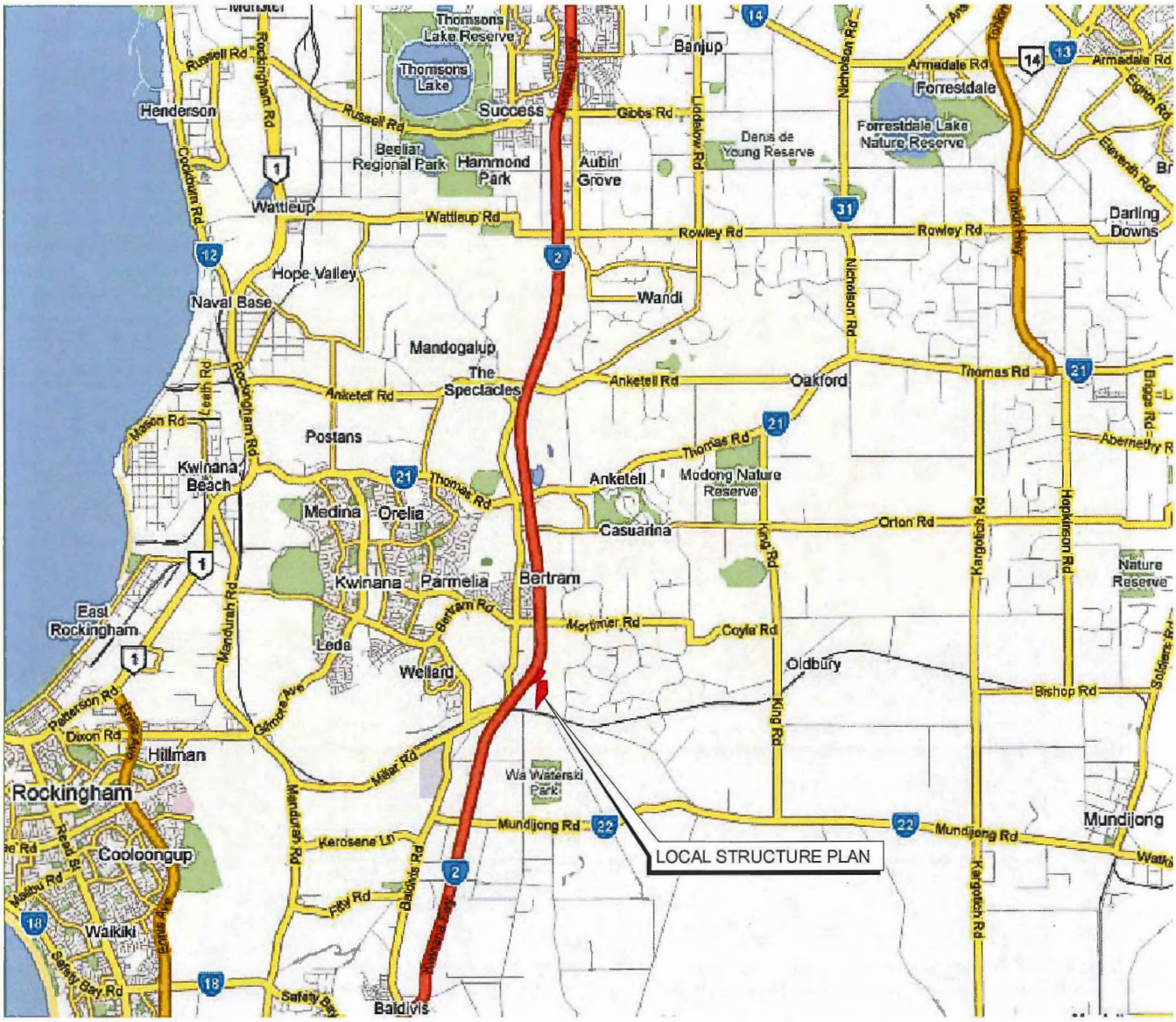

FIGURE 1

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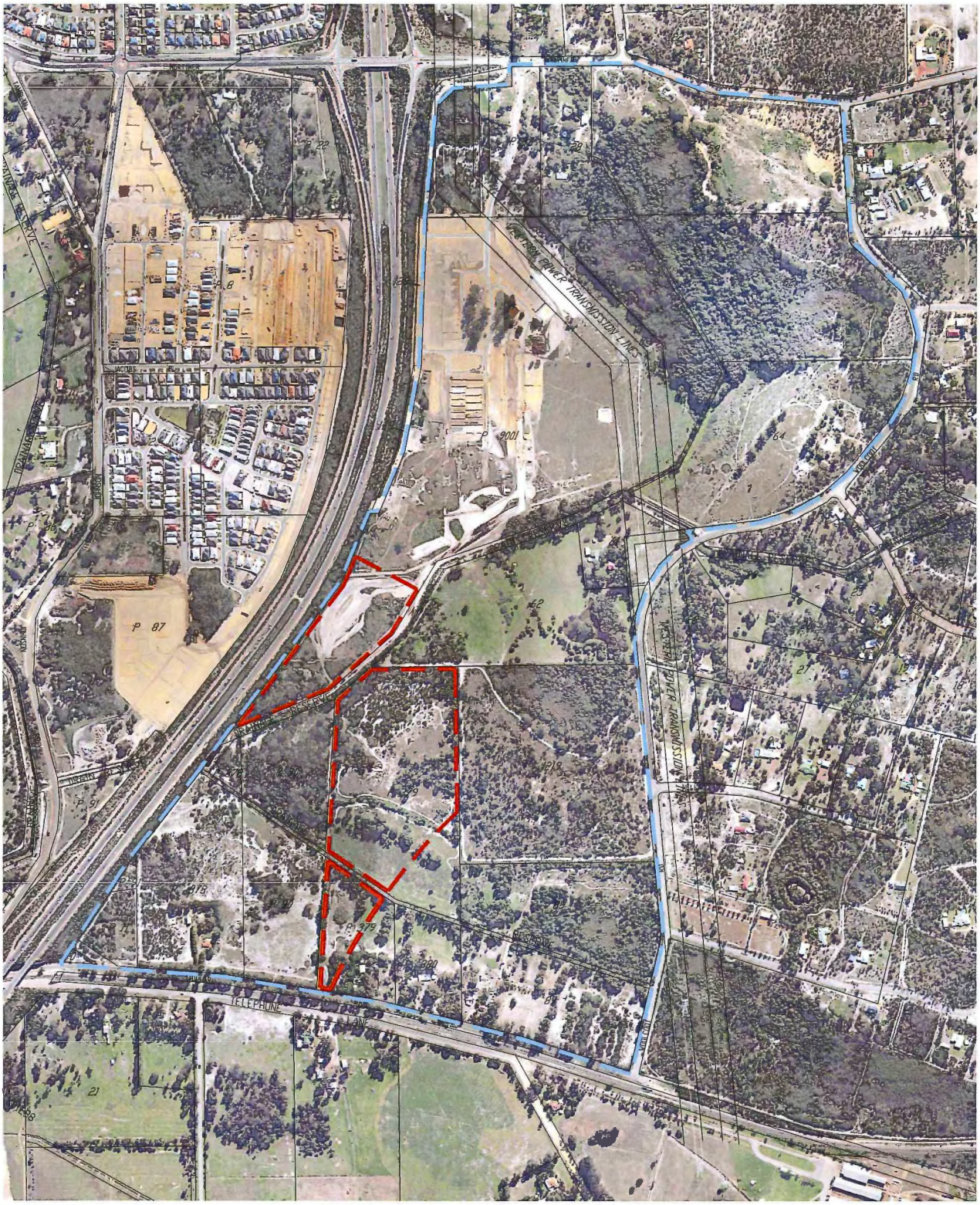
LOCATION PLAN
LOCAL STRUCTURE PLAN
WELLARD EAST

NORTH

Cardno
11 Harvest Terrace
P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
Facsimile (08) 9486 8664

DATE: 31.5.2013 | SCALE AT A4: NTS
DESIGNED: FC | CHECKED: LVE
DRAWN: FC | APPROVED: LVE
LOCAL AUTHORITY
CITY OF KWINANA
PROJECT-PHASE-PLAN NUMBER | REVISION
P02016-001 P702-SPF1



LSP BOUNDARY

WELLARD EAST CELL BOUNDARY

0 200 400 m

FIGURE 2

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AERIAL PHOTOGRAPH

LOCAL STRUCTURE PLAN - PART LOTS 9001 AND 379 MILLAR ROAD

WELLARD EAST

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Telephone (08) 9273 3888
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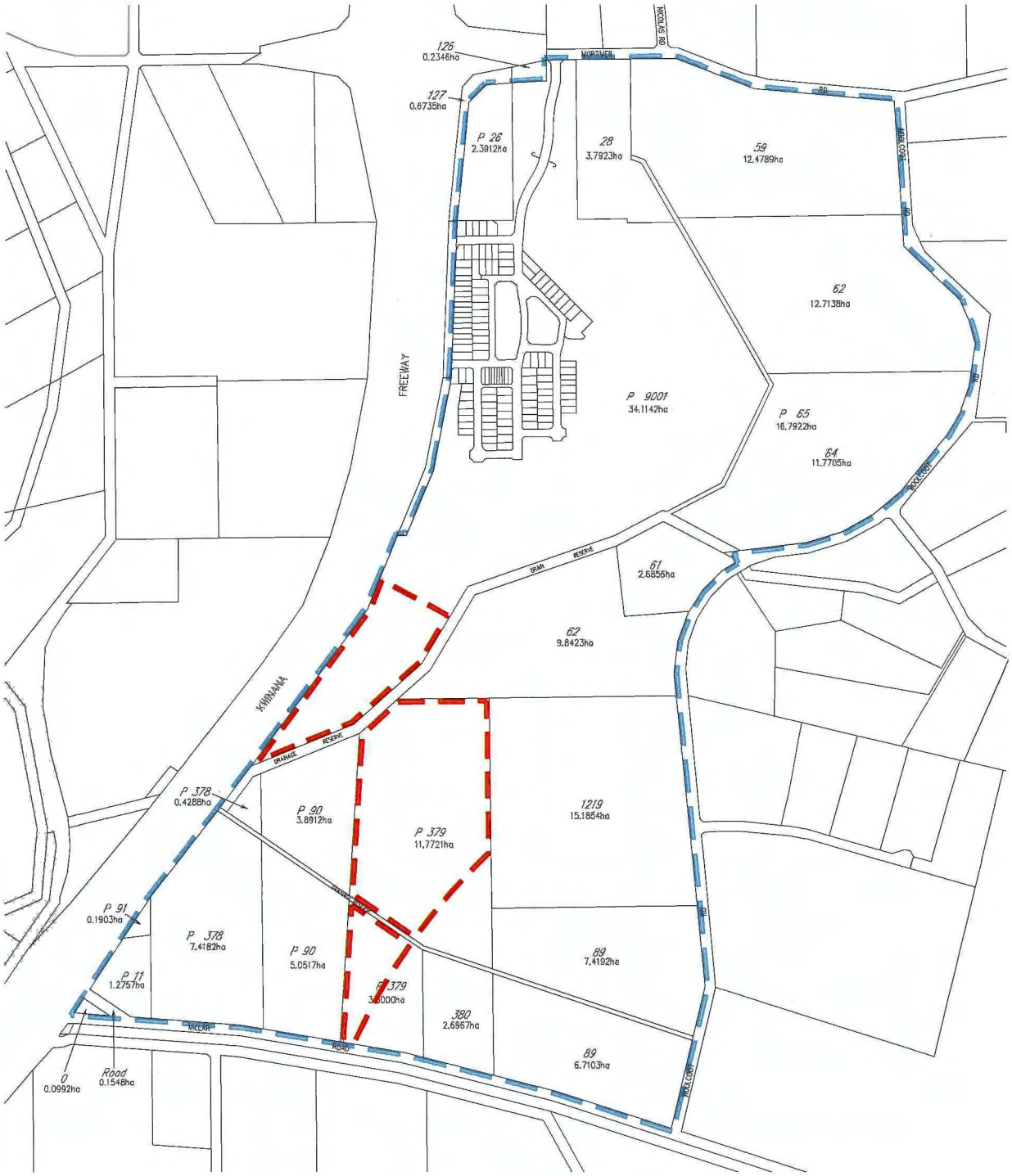

LSP BOUNDARY

WELLARD EAST CELL BOUNDARY

FIGURE 3

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EXISTING LOT CONFIGURATION

LOCAL STRUCTURE PLAN - PART LOTS 9001 AND 379 MILLAR ROAD WELLARD EAST

Cardno
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PROJECT PHASE-PLAN NUMBER: P02016-001 P702-SPF3

REVISION

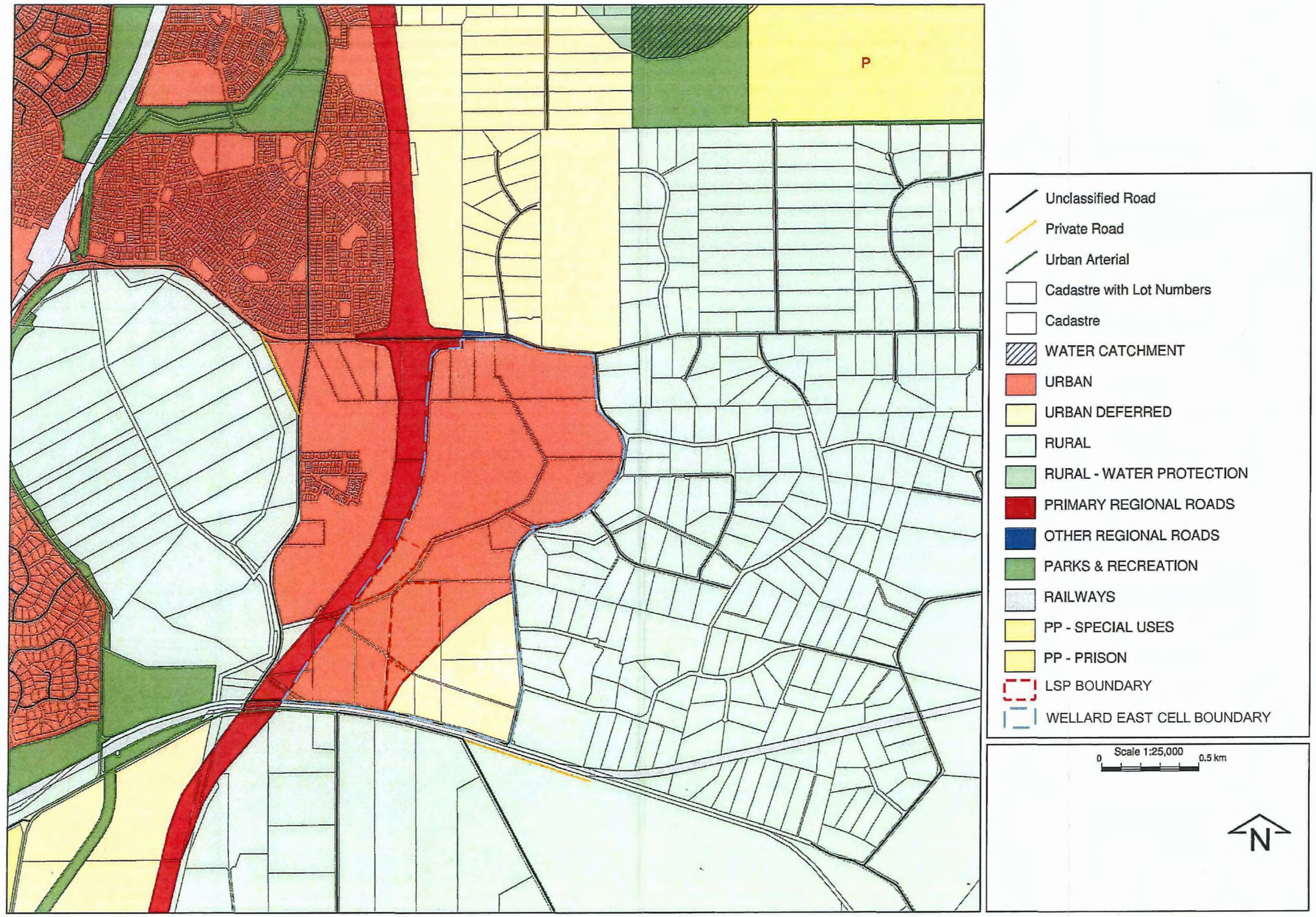

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FIGURE 4

METROPOLITAN REGION SCHEME
LOCAL STRUCTURE PLAN - PART LOT 9001 AND 379 MILLAR ROAD
WELLARD EAST

NORTH

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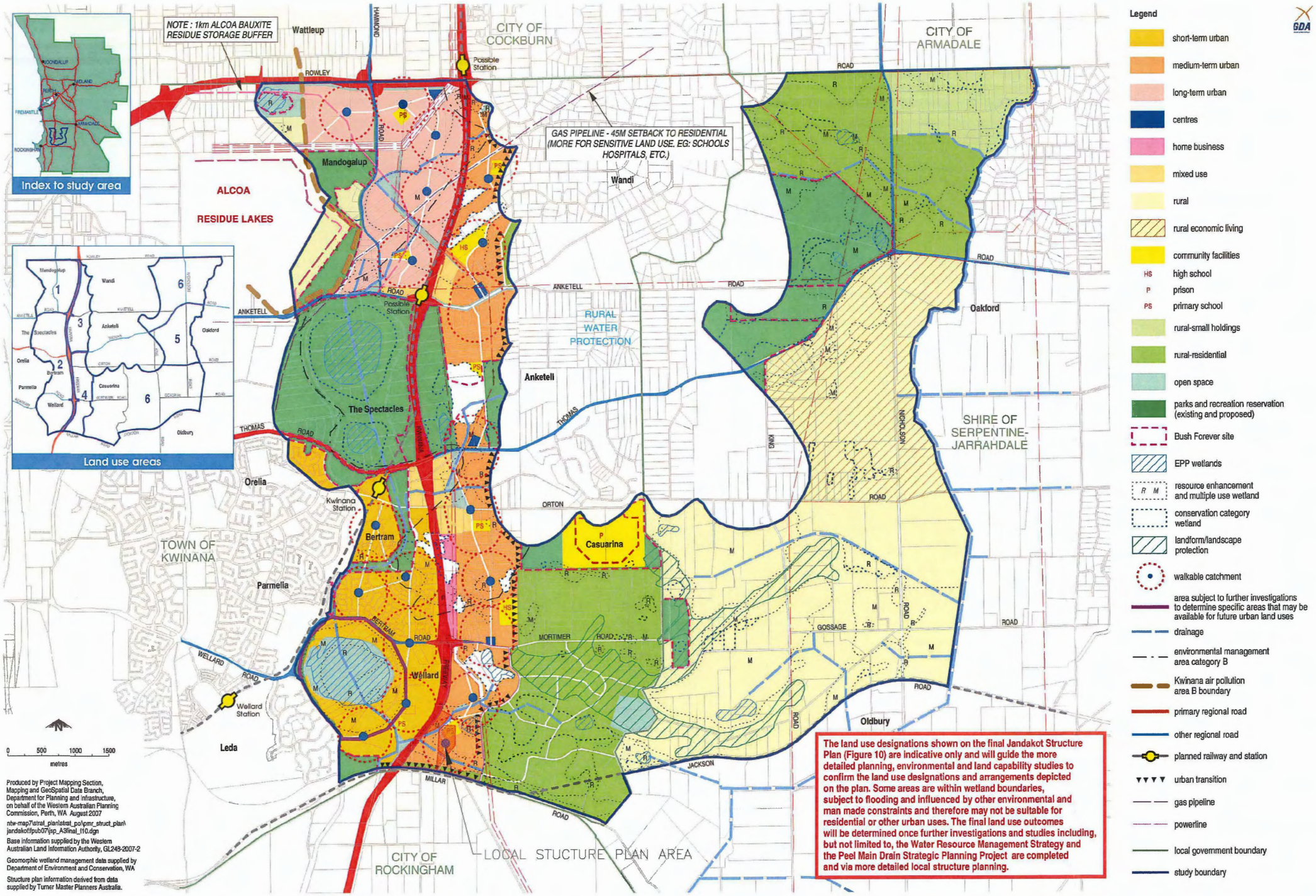

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FINAL JANDAKOT STRUCTURE PLAN

LOCAL STRUCTURE PLAN - PART LOTS 9001 AND 379 MILLAR ROAD WELLARD EAST

NORTH

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P.O. Box 447
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Telephone (08) 9273 3888
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DATE: 31.5.2013 SCALE AT A3: 1:55,000
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DRAWN: FC APPROVED: LVE
LOCAL AUTHORITY
CITY OF KWINANA
PROJECT-PHASE-PLAN NUMBER REVISION
P02016-001 P702-SPF13

Legend

Survey Point

Site Boundary

Remnent Tree Species Locations

- *Allocasuarina fraseriana*
- *Banksia menziessi*
- *Eucalyptus gomphocephala*
- *Eucalyptus marginata*
- *Eucalyptus rudis*
- *Kunzea glabrescens*

Vegetation Communities

Plant Community 1

PC1: Low lying forest of *Eucalyptus rudis* over *Taxandria linearifolia- Astartea scoparia* over *Pteridium esculentum* on sandy loam to sandy clay and areas of permanently inundated peaty clay .

Plant Community 2

PC2: Low lying forest of *Corymbia calophylla* over *Astartea scoparia-Taxandria linearifolia-Melaleuca teretifolia* over **Rubus anglocandicans-*Pennisetum cladestinum*.

Plant Community 3

PC3: Low lying woodland of *Eucalyptus rudis* over *Melaleuca teretifolia* over pasture grasses on grey sandy loam.

Plant Community 4

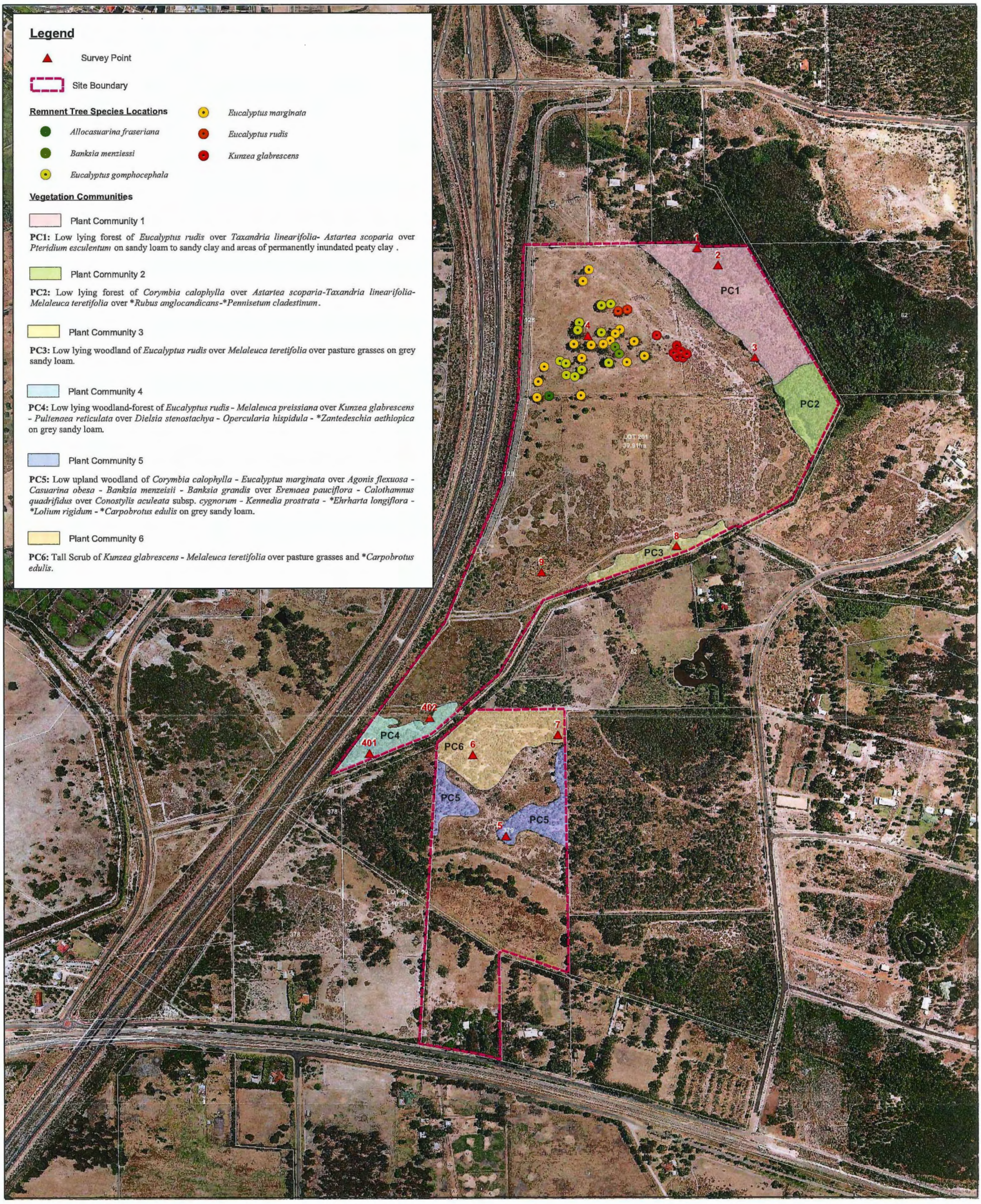
PC4: Low lying woodland-forest of *Eucalyptus rudis - Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielsia stenostachya - Opercularia hispidula - *Zantedeschia aethiopica* on grey sandy loam.

Plant Community 5

PC5: Low upland woodland of *Corymbia calophylla - Eucalyptus marginata* over *Agonis flexuosa - Casuarina obesa - Banksia menzeisii - Banksia grandis* over *Eremaea pauciflora - Calothamnus quadrifidus* over *Conostylis aculeata* subsp. *cygnorum - Kennedia prostrata - *Ehrharta longiflora - *Lolium rigidum - **Carpobrotus edulis* on grey sandy loam.

Plant Community 6

PC6: Tall Scrub of *Kunzea glabrescens - Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis*.



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

Cardno

CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Cardno Centre 2 Bagot Road
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Western Australia 6904

Telephone (08) 9273 3888
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Scale: 1:7,000

0 100 200 400 600 800 1,000 Metres

PROJECT **Flora & Vegetation Survey & Wetland Assessment**

DRAWING TITLE **FIGURE 4: Plant Communities & Individually Mapped Remnant Trees**

PRINCIPAL **Amex Coporation Pty Ltd.**

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Project Number **V8041**

Original **A3**

Drawing Number **SK04**

Revision **00**

Designed GT

Checked

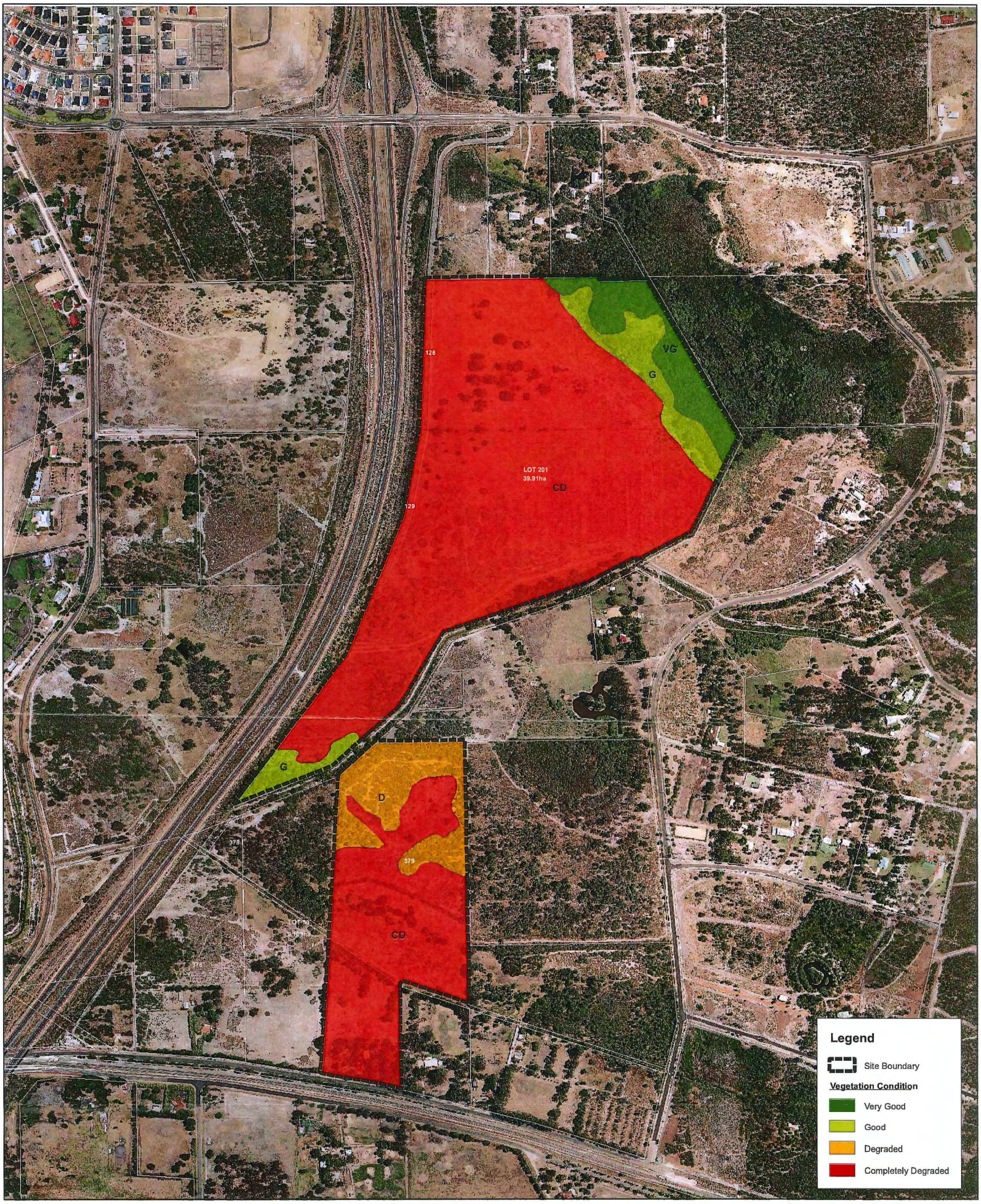
Drawn MGW

Approved

Local Authority Town of Kwinana

Sheet 1 of 1

Date 20/11/08



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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

Cardno

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Telephone (08) 9273 3888
Facsimile (08) 9388 3831

Scale: 1:7,000

0 100 200 400 600 800 1,000 Metres

PROJECT **Flora & Vegetation Survey & Wetland Assessment**

DRAWING TITLE **FIGURE 5: Vegetation Condition**

PRINCIPAL **Amex Coporation Pty Ltd.**

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Project Number **V8041**

Original **A4**

Drawing Number **SK05**

Revision **00**

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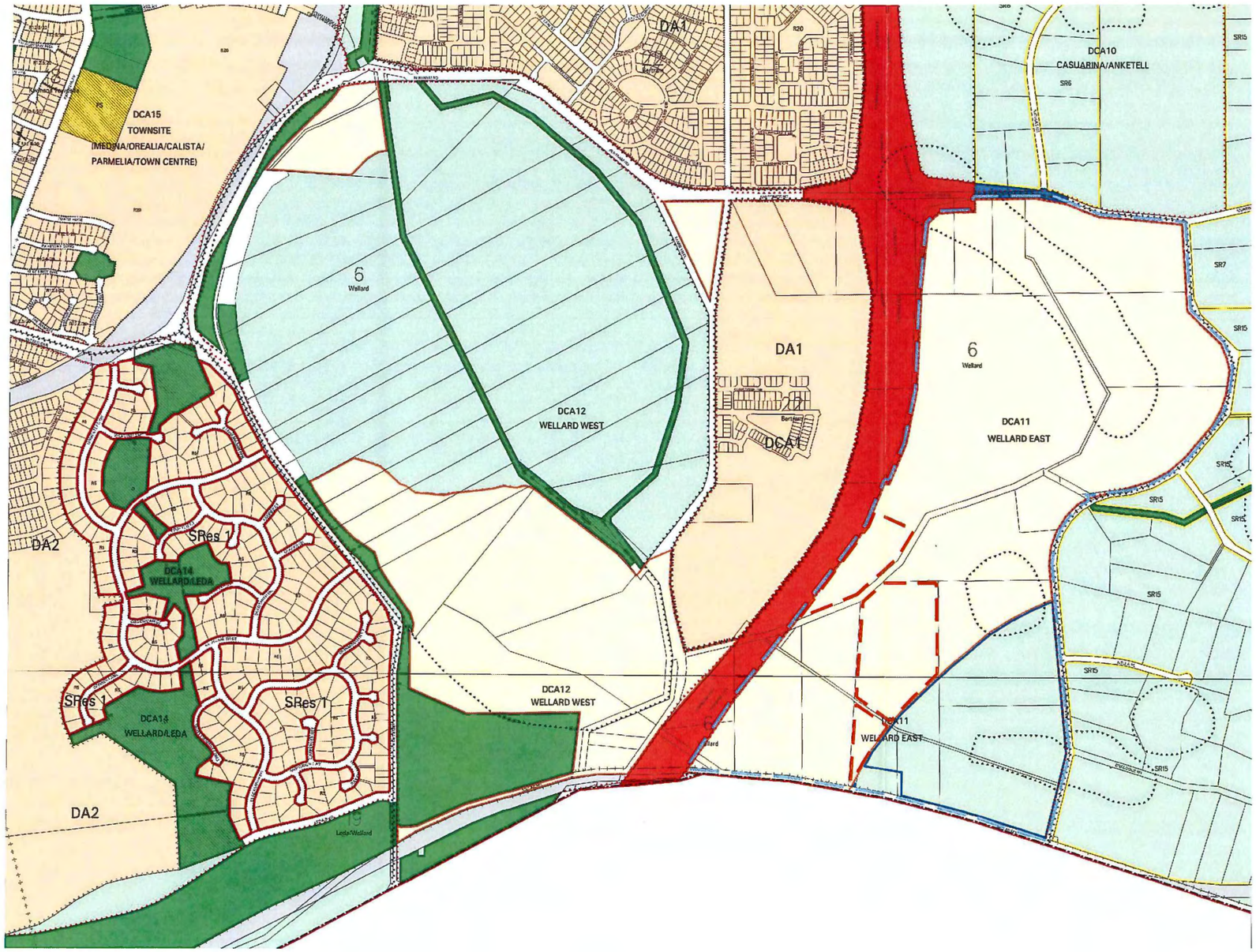
Local Authority Town of Kwinana

Sheet 1 of 1 Date 20/11/08



LEGEND

METROPOLITAN REGION SCHEME RESERVES

- PARKS AND RECREATION
- R — RESTRICTED PUBLIC ACCESS
- RAILWAYS
- PORT INSTALLATIONS
- STATE FORESTS
- WATER CATCHMENTS
- CIVIC AND CULTURAL
- WATERWAYS
- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS
- PUBLIC PURPOSES - DENOTED AS FOLLOWS:
  - H HOSPITAL
  - HS HIGH SCHOOL
  - TS TECHNICAL SCHOOL
  - CP CAR PARK
  - U UNIVERSITY
  - CG COMMONWEALTH GOVERNMENT
  - SEC STATE ENERGY COMMISSION
  - SU SPECIAL USES
  - WSD WATER AUTHORITY OF WA
  - P PRISON

LOCAL SCHEME RESERVES

- PARK RECREATION & DRAINAGE
- PARK RECREATION & DRAINAGE DENOTED AS FOLLOWS:
  - CR CONSERVATION RESERVE
- PUBLIC PURPOSES
- PUBLIC PURPOSES DENOTED AS FOLLOWS:
  - CF COMMUNITY FACILITY
  - CG COMMONWEALTH GOVERNMENT
  - H HALL
  - K KINDERGARTEN
  - LG LOCAL GOVERNMENT
  - PS PRIMARY SCHOOL
  - SG STATE GOVERNMENT
- PUBLIC PURPOSES DENOTED AS FOLLOWS:
  - T TELECOM
  - WSD WATER SUPPLY SEWERAGE & DRAINAGE

ZONES

- DEVELOPMENT
- RESIDENTIAL
- SPECIAL RESIDENTIAL
- COMMERCIAL
- KWINANA TOWN CENTRE
- MIXED BUSINESS 1
- SERVICE COMMERCIAL
- SPECIAL USE
- SPECIAL USE DENOTED AS FOLLOWS:
  - APH AGED PERSONS HOME
  - CC CULTURAL CENTRE
  - F FUNERAL PARLOUR
  - H HOTEL
  - P PRE-PRIMARY
  - S SCHOOL
- SPECIAL USE DENOTED AS FOLLOWS:
  - SS SERVICE STATION
  - T TAVERN
  - TD TRANSPORT DEPOT
  - V VARIOUS
  - W WELFARE
- GENERAL INDUSTRY
- LIGHT INDUSTRY
- CLUSTER/COMMUNAL RURAL SETTLEMENT
- RURAL A
- RURAL B
- RURAL WATER RESOURCE
- SPECIAL RURAL

OTHER

- R20 R CODES
- A1 ADDITIONAL USES
- SCHEME BOUNDARY
- LOCAL GOVERNMENT BOUNDARY
- AREA OF LANDSCAPE PROTECTION
- POLICY AREAS (SEE SCHEME TEXT)
- DRAINAGE CATCHMENT MANAGEMENT
- SR2 SPECIAL RURAL AREA (SEE SCHEME TEXT)
- SRes 1 SPECIAL RESIDENTIAL AREA (SEE SCHEME TEXT)
- DA1 DEVELOPMENT AREA (SEE SCHEME TEXT)
- DCA1 DEVELOPMENT CONTRIBUTION AREA (SEE SCHEME TEXT)
- PRESERVATION OF BUILDINGS, OBJECTS AND PLACE (SEE SCHEME TEXT)
- NO ZONE

VERSION No 1

TOWN OF KWINANA

TOWN PLANNING SCHEME NO. 2
(DISTRICT SCHEME)

LSP BOUNDARY

WELLARD EAST CELL BOUNDARY

0 375 750m

FIGURE 6

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CITY OF KWINANA - TOWN PLANNING SCHEME No.2

LOCAL STRCUTURE PLAN - PART LOT 9001 AND LOT 379 MILLAR ROAD WELLARD EAST

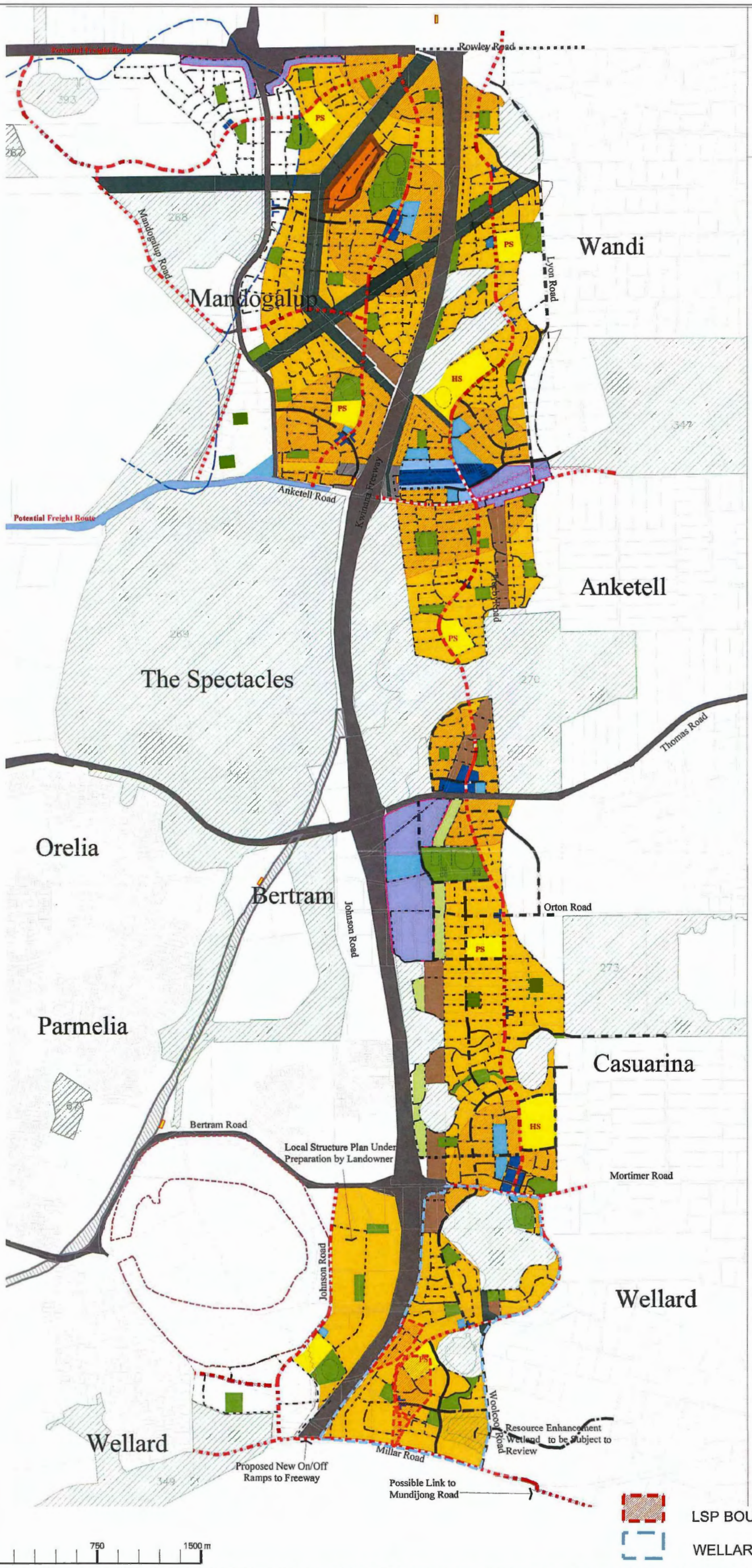
NORTH

Cardno
11 Harvest Terrace
P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
Facsimile (08) 9486 8664

DATE: 31.5.2013 SCALE AT A3: 1:15,000
DESIGNED: FC CHECKED: LVE
DRAWN: FC APPROVED: LVE
LOCAL AUTHORITY
CITY OF KWINANA
PROJECT-PHASE-PLAN NUMBER · REVISION
P02016-001 P702-SPF14

Town of Kwinana Eastern Residential Intensification Concept

(District Structure Plan)



Proposed Land Use

- Residential R20
- Residential R25 (& Higher)
- Residential/Business (Home Based Business)
- Special Residential R5
- Special Residential (Power Lines)
- Possible Mid to Long Term Future Residential
- Commercial Centre
- Mixed Business
- Commercial Centre Mixed Use
- Neighbourhood Node
- HS — High School
- PS — Primary School
- Local/District Recreation
- Community Facilities
- Conservation
- Bush Forever area No.
- Multiple Use Corridor -Infrastructure (Power & Gas Lines) & Ecological Linkages

Transport Infrastructure

- Regional Road
- Structure Plan Local & District Distributor
- Structure Plan Local Collector Roads
- Structure Plan Local Access/Collector Roads (Indicative Only)
- Long Term Road Closure Following Realignment of Current Route
- Railway Purposes
- Railway Station Location
- Noise and Impact Attenuation Bunds

Other Factors

- Modeled Dust Buffer Edge Requires 2 Years of Dust Monitoring by Developers to Validate Model
- Future Urbanisation May be Considered Following Full Technical Environmental Review of Impacts of Urbanisation on Wetland Area. (To be Undertaken by Landowner/Developer in Consultation with DoE)

Scale 1: 30,000

LSP BOUNDARY

WELLARD EAST CELL BOUNDARY

FIGURE 7

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EASTERN RESIDENTIAL INTENSIFICATION CONCEPT
LOCAL STRUCTURE PLAN - PART LOT 9001 AND LOT 379 MILLAR ROAD
WELLARD EAST

Cardno
11 Harvest Terrace
P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
Facsimile (08) 9486 8664

DATE:	10.09.2013	SCALE AT A3:	1:30,000
DESIGNED:	FC	CHECKED:	LVE
DRAWN:	FC	APPROVED:	LVE

LOCAL AUTHORITY
CITY OF KWINANA
PROJECT-PHASE-PLAN NUMBER — REVISION
P02016-001 SPF15

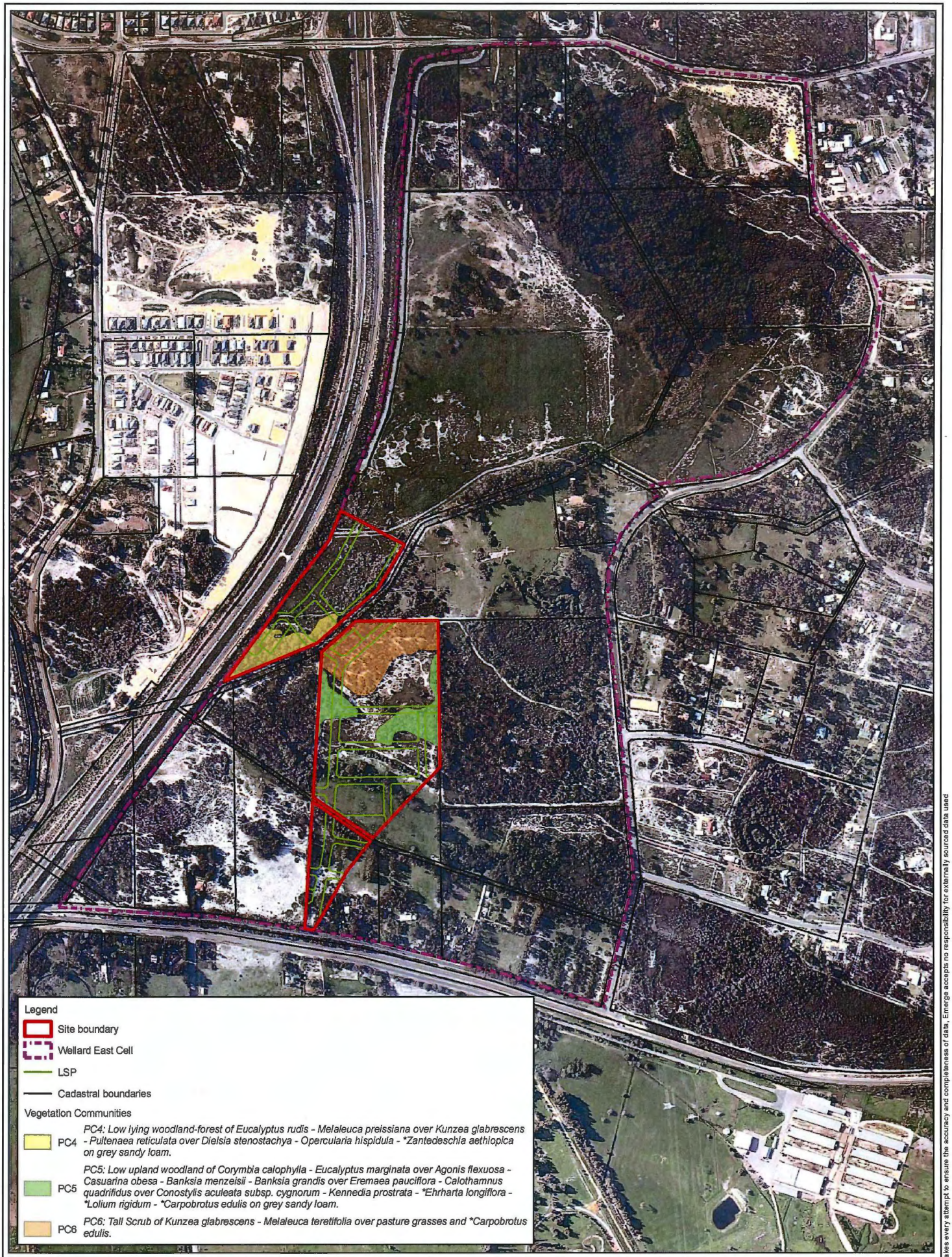

Figure 8:	**Vegetation Communities**	**Plan Number: EP11-011(09)--F57a**	
Project:	Local Structure Plan Part Lot 9001 and 379 Millar Road, Wellard East	Drawn: GRO	Date: 04/07/13
		Approved: KK	Date: 26/08/13
Client:	Armana Holdings Pty Ltd	Checked: KK	Scale: 1:10,000@A4

0 1,000 2,000 4,000 Metres

emerge ASSOCIATES
Integrated Science & Design

Sources: The following datasets were used in the production of this map: Vegetation Communities - Cardno (2009)

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

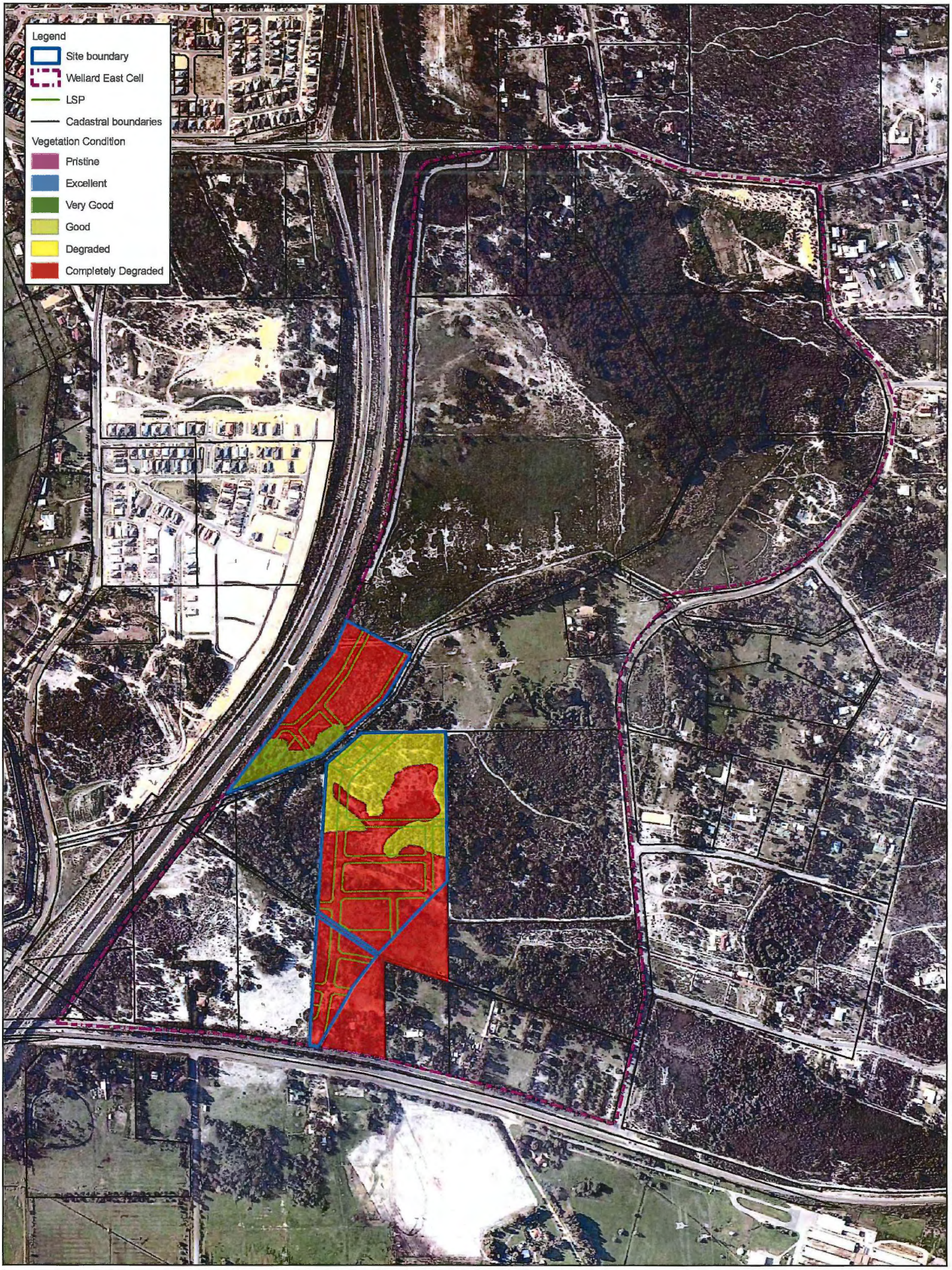

Figure 9:	**Vegetation Condition**
Project:	Local Structure Plan Part Lot 9001 and 379 Millar Road, Wellard East
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F58a			
Drawn:	GRO	Date:	04/07/13
Approved:	KK	Date:	26/08/13
Checked:	KK	Scale:	1:10,000@A4

0 1,000 2,000 4,000 Metres

emerge ASSOCIATES
Integrated Science & Design

Sources: The following datasets were used in the production of this map: Vegetation Condition - Cardno (2009)

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

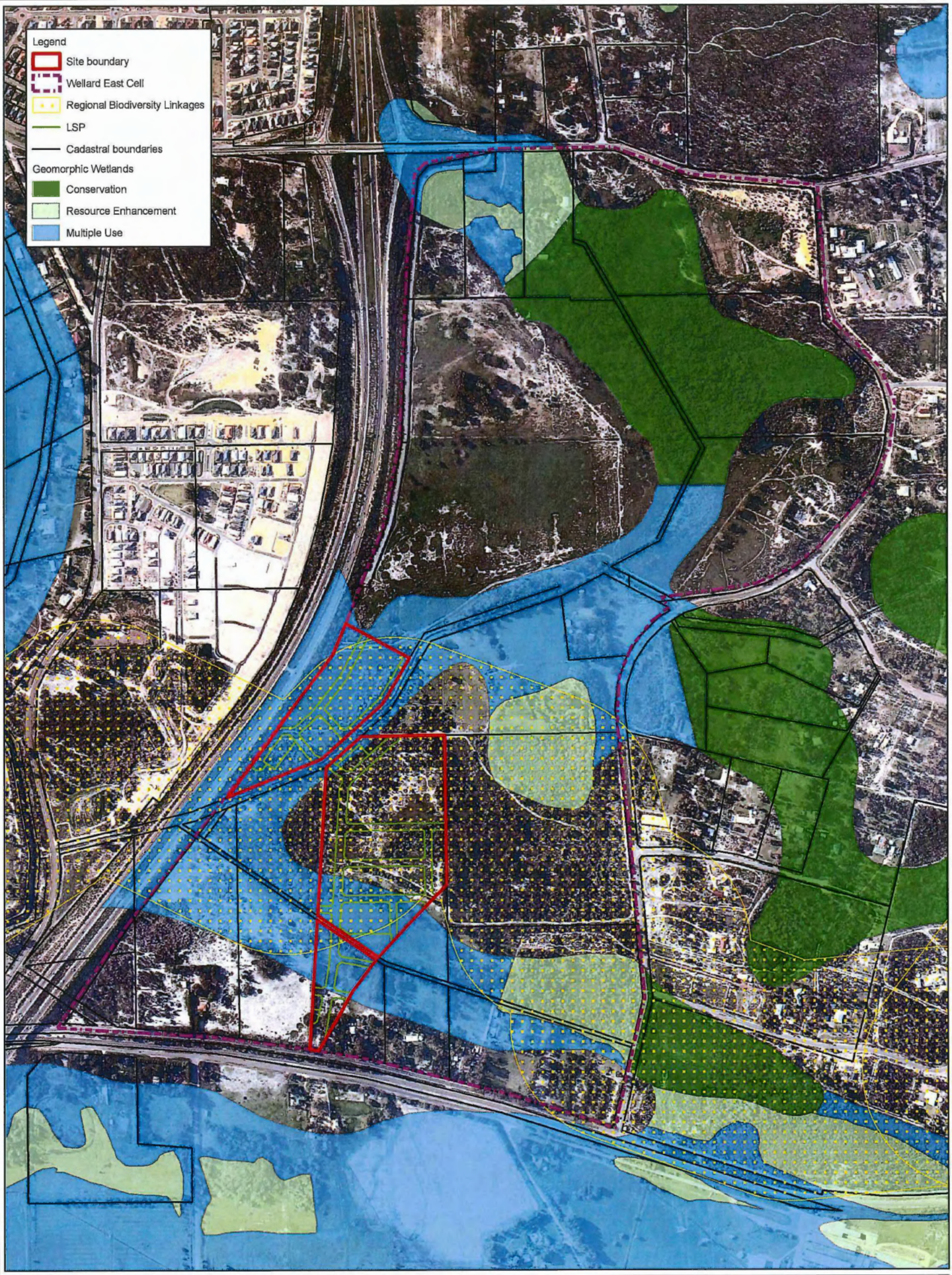

Figure 10:	**Geomorphic Wetlands & Regional Biodiversity Linkages**
Project:	Local Structure Plan Part Lot 9001 and 379 Millar Road, Wellard East
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F59a

Drawn:	GRO	Date:	04/07/13
Approved:	KK	Date:	26/08/13
Checked:	KK	Scale:	1:10,000@A4

0 1,000 2,000 4,000 Metres

emerge ASSOCIATES
Integrated Science & Design

Sources: The following datasets were used in the production of this map: Geomorphic Wetlands - DEC (2012), Regional Biodiversity Linkages - Perth Biodiversity Project (2007)

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

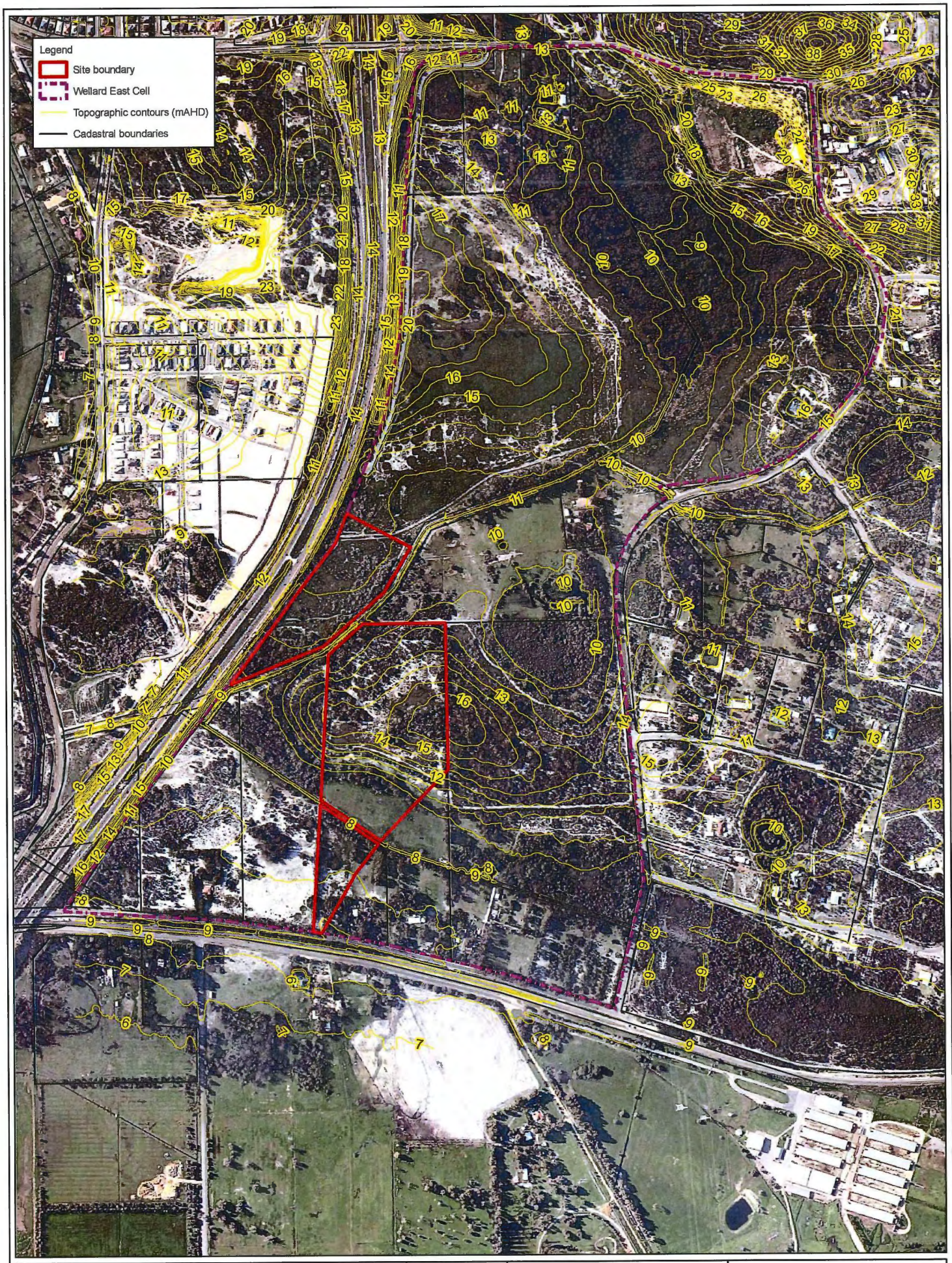

Figure 11: Topography

Project:	Local Structure Plan Part Lot 9001 and 379 Millar Road, Wellard East
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F60a			
Drawn:	GRO	Date:	04/07/13
Approved:	KK	Date:	26/08/13
Checked:	KK	Scale:	1:10,000@A4

0 1,000 2,000 4,000 Metres

emerge ASSOCIATES
Integrated Science & Design

Sources: The following datasets were used in the production of this map: Topographical contours - Whelans (2009)

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

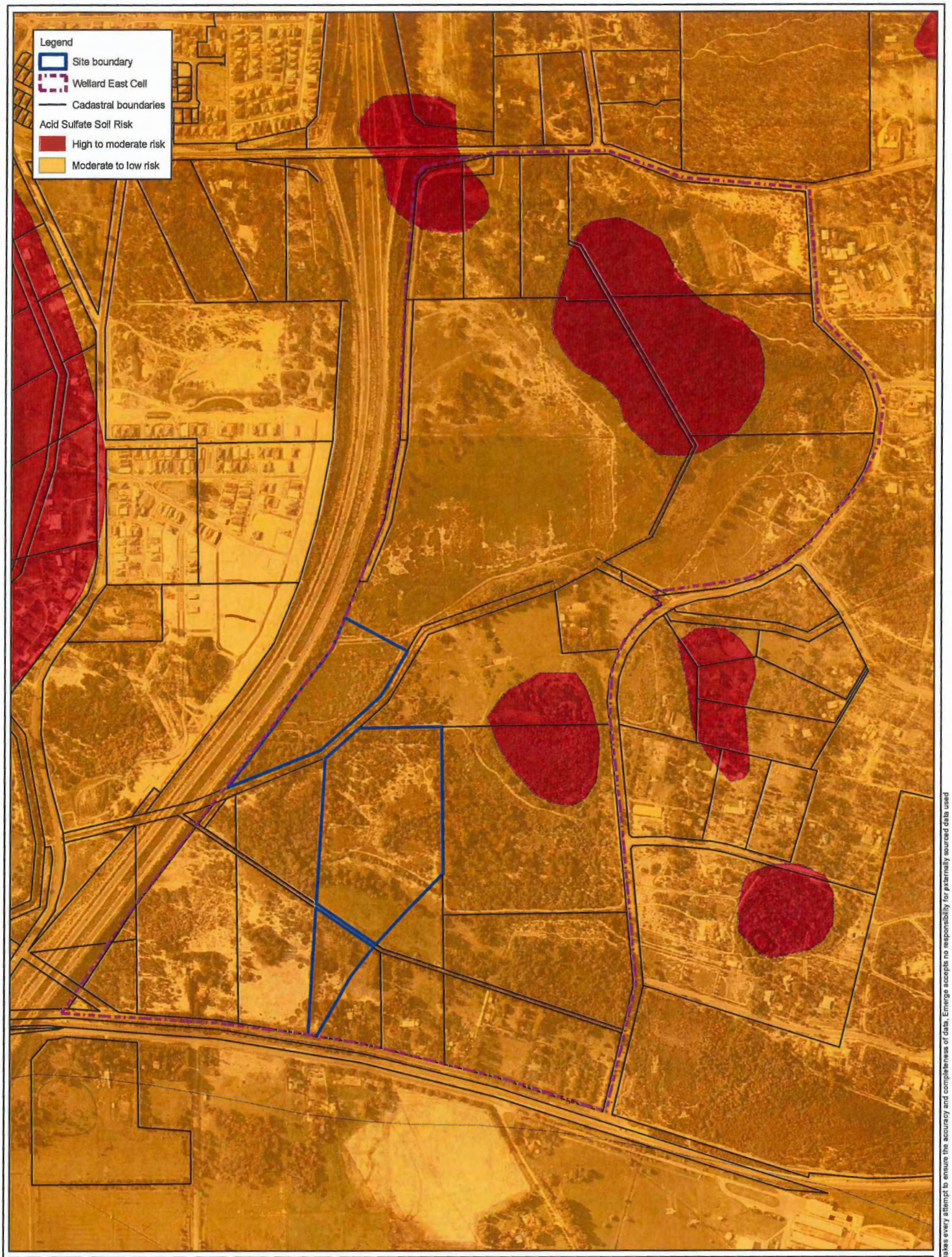

Figure 12: Acid Sulfate Soils

Project: Local Structure Plan
Part Lot 9001 and 379 Millar Road, Wellard East

Client: Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F61a			
Drawn:	GRO	Date:	04/07/13
Approved:	KK	Date:	26/08/13
Checked:	KK	Scale:	1:10,000@A4

0 1,000 2,000 4,000 Metres

emerge ASSOCIATES
Integrated Science & Design

Sources: The following datasets were used in the production of this map: Acid Sulfate Soil Risk - DEC (2010)

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

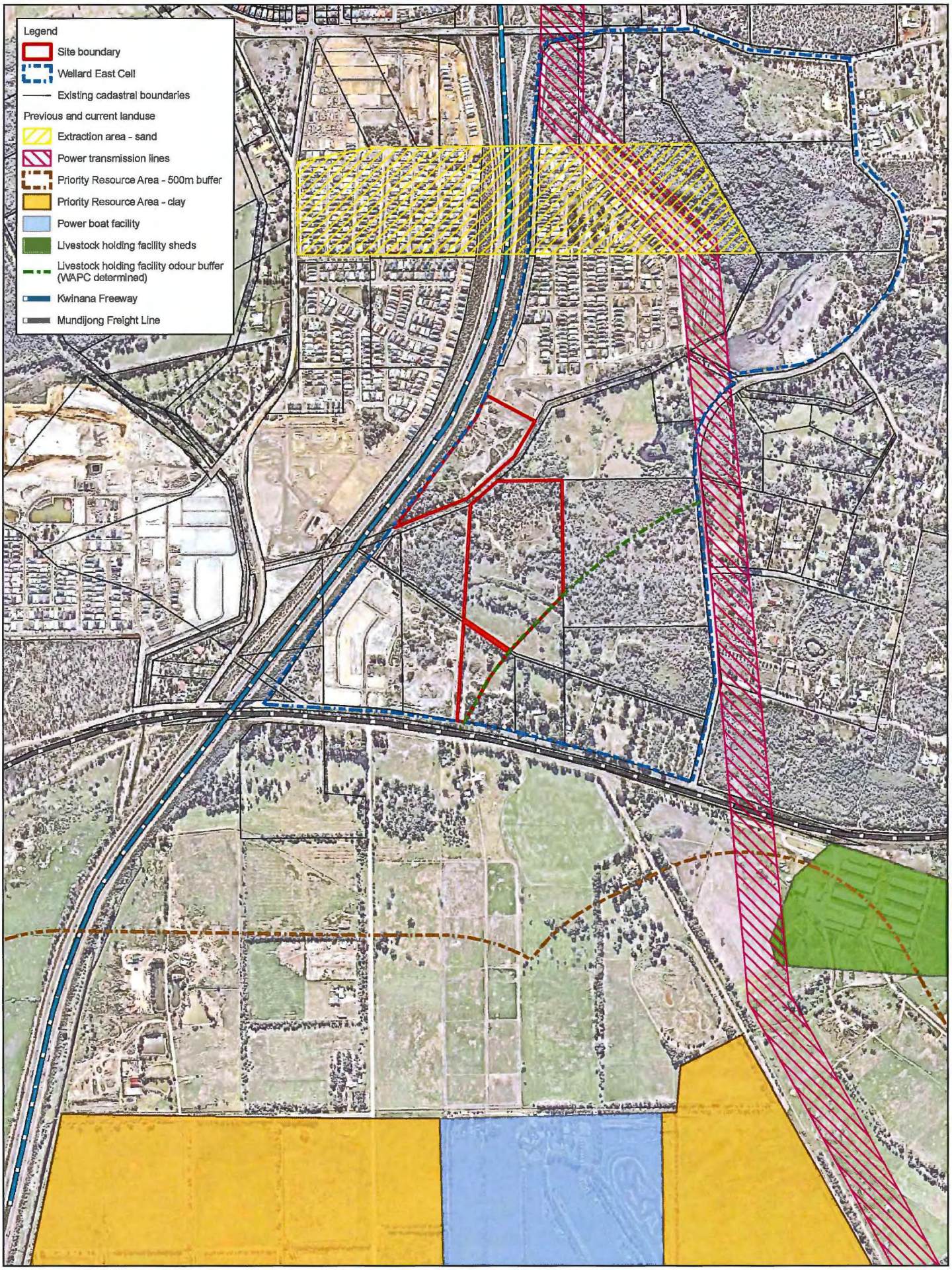

Figure 13: Land Uses Within and Adjacent to Wellard East Cell

Project:	Local Structure Plan Part Lot 9001 and 379 Millar Road, Wellard East
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F62c			
Drawn:	ADB	Date:	31/07/15
Approved:	KK	Date:	18/08/2015
Checked:	KK	Scale:	1:13,000@A4

0 125 250 500 Metres

emerge ASSOCIATES
Integrated Science & Design

While Emerge Associates makes every attempt to ensure the accuracy and completeness of data, Emerge accepts no responsibility for externally sourced data used

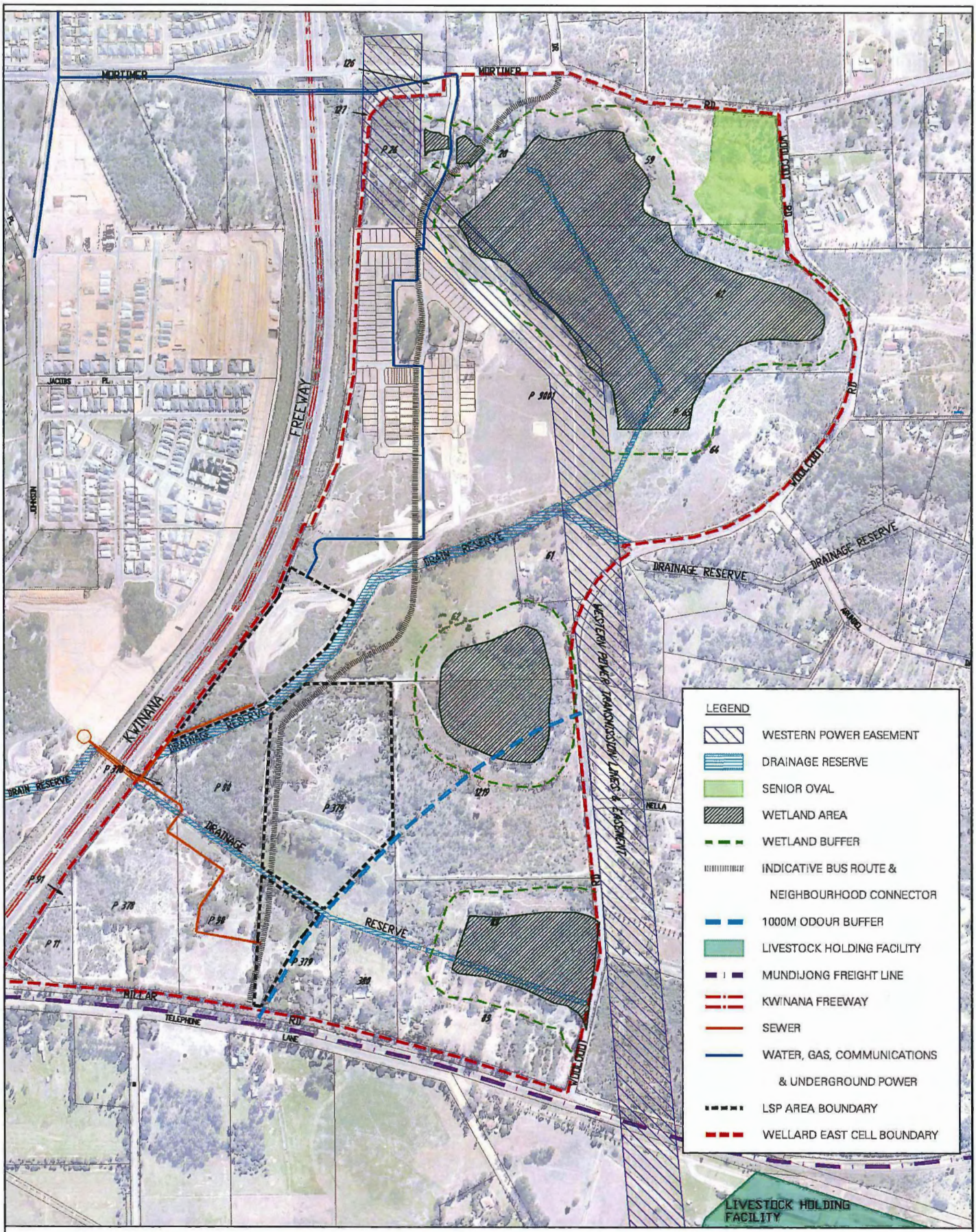

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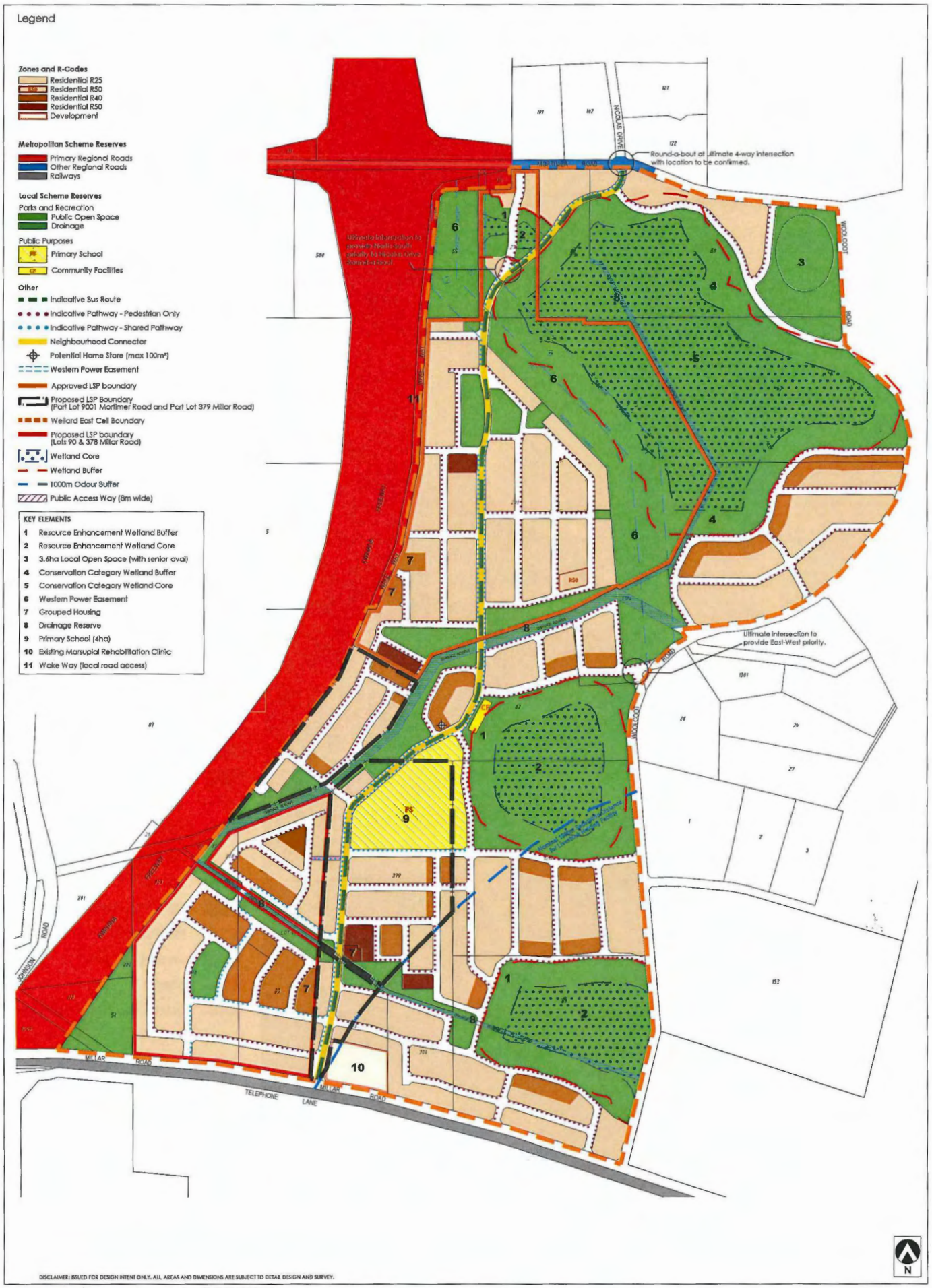
Figure 14

CONTEXT AND CONSTRAINTS PLAN
PART LOTS 9001 AND 379 MILLAR ROAD
WELLARD EAST

NORTH

Cardno
11 Harvest Terrace
P.O. Box 447
West Perth 6872
Telephone (08) 9273 3888
Facsimile (08) 9486 8664

DATE: 23/09/2013 SCALE AT A4: 1:1000
DESIGNED: SB CHECKED:
DRAWN: SB APPROVED:
LOCAL AUTHORITY
CITY OF KWINANA
PROJECT-PHASE-PLAN NUMBER REVISION
P02016-001 SK19



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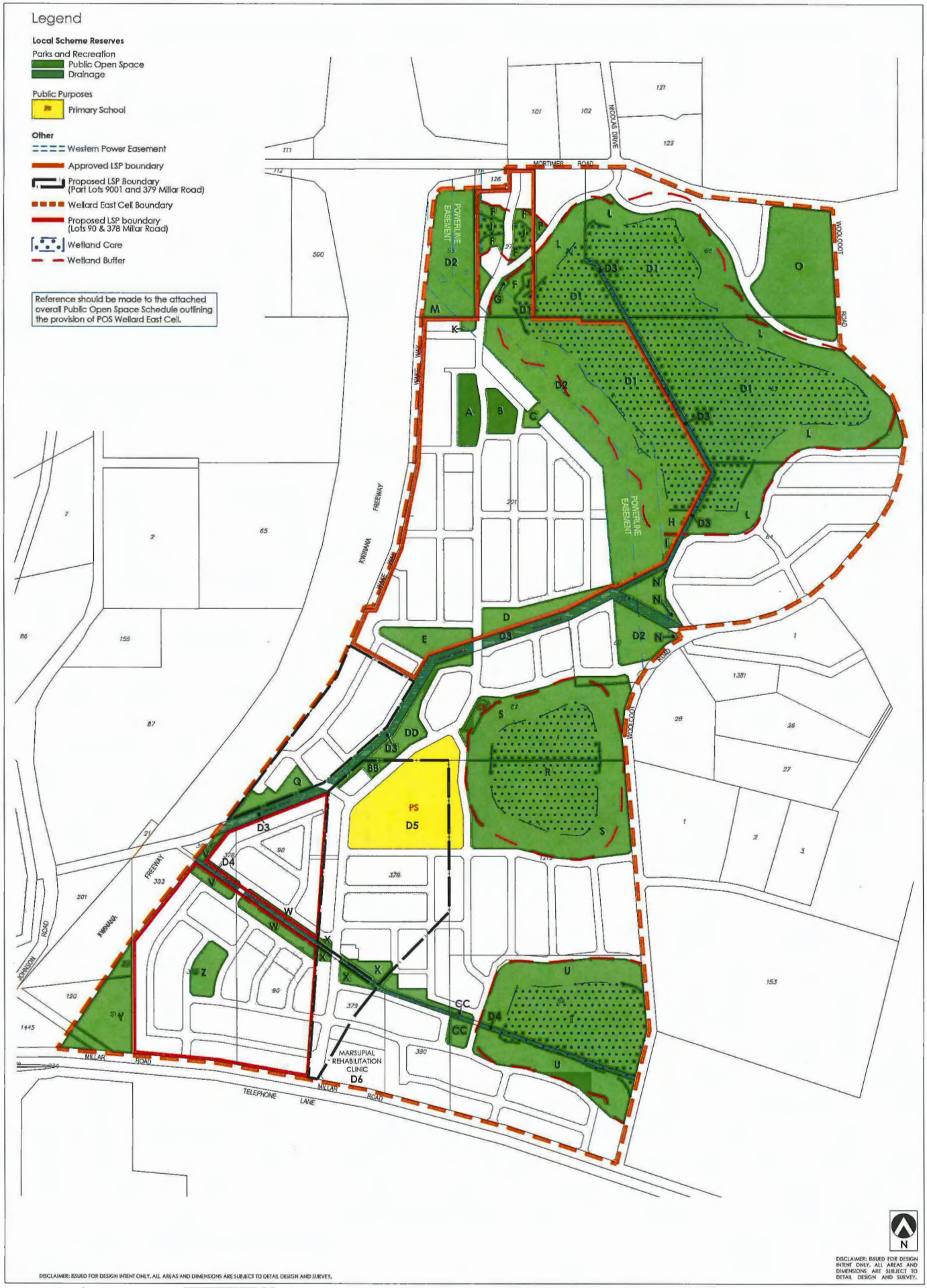
robertsday

AMEX CORPORATION PTY LTD

FIGURE 15
WELLARD EAST CONCEPT PLAN

City of Kwinana

SIZE A2
1:5000
REF NO. AMX WEL
DRAW NO. RD1 100
REV. I



robertsday
perth | sydney | melbourne

AMEX CORPORATION PTY LTD

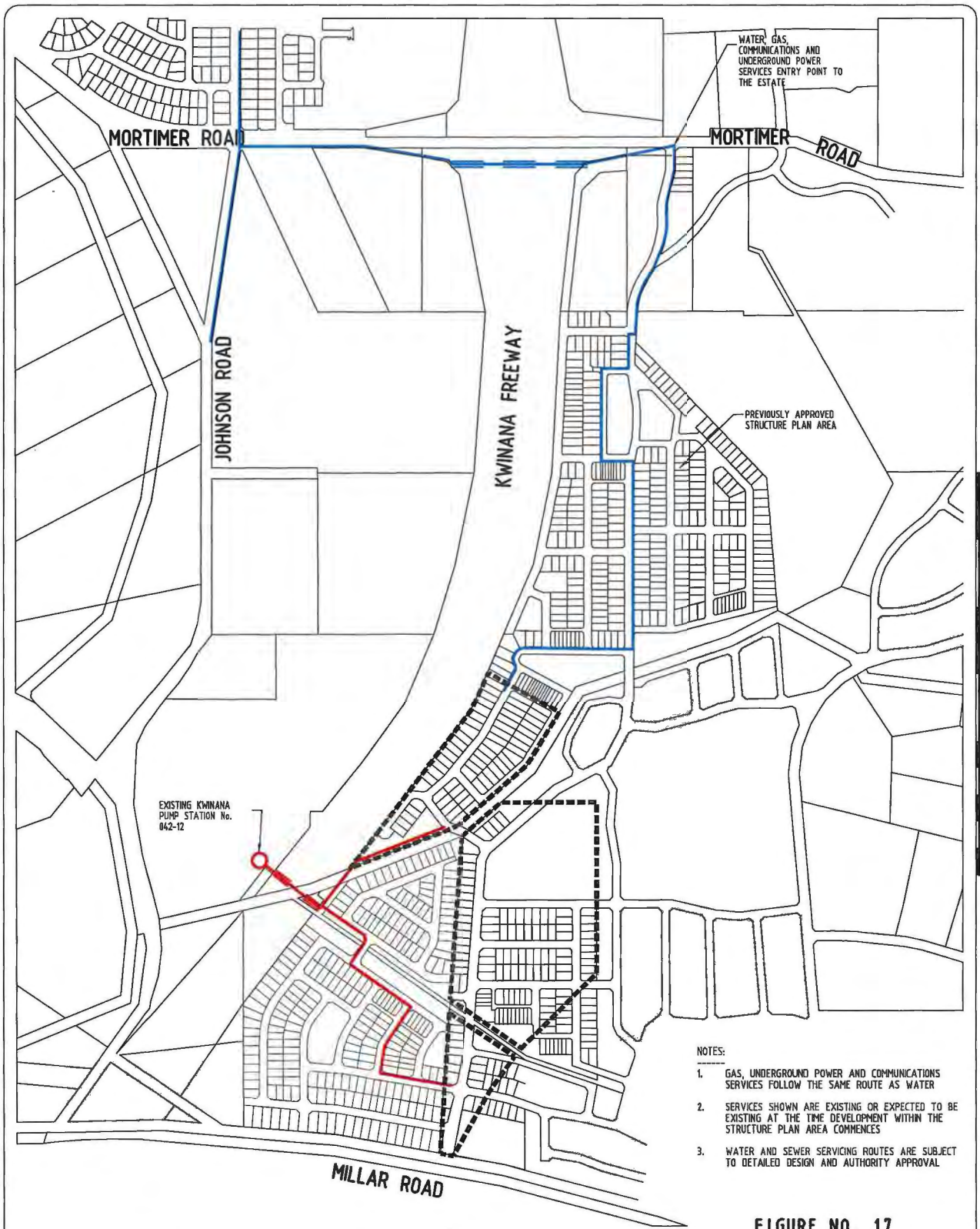
FIGURE 16

WELLARD EAST - PUBLIC OPEN SPACE PLAN

City of Kwinana

SIZE A2
1:5000

REF NO. AMX WEL | DRAW NO. RD1 103 | REV. C



NOTES:

1. GAS, UNDERGROUND POWER AND COMMUNICATIONS SERVICES FOLLOW THE SAME ROUTE AS WATER
2. SERVICES SHOWN ARE EXISTING OR EXPECTED TO BE EXISTING AT THE TIME DEVELOPMENT WITHIN THE STRUCTURE PLAN AREA COMMENCES
3. WATER AND SEWER SERVICING ROUTES ARE SUBJECT TO DETAILED DESIGN AND AUTHORITY APPROVAL

LEGEND

- STRUCTURE PLAN AREA BOUNDARY
- WATER (AND OTHER SERVICES) BORED CROSSING
- SEWER BORED CROSSING

FIGURE NO. 17

WOOD & GRIEVE ENGINEERS
Wood & Grieve Pty Ltd
A.B.N. 75 900 165 652
Level 3, Hyatt Centre
3 Plain Street East Perth
Western Australia 6004
Phone 08 6222 7000
Fax 08 6222 7100
Email wge@wge.com.au
Web www.wge.com.au
PERTH
MELBOURNE
SYDNEY
BRISBANE
ALBANY
BUSSELTON

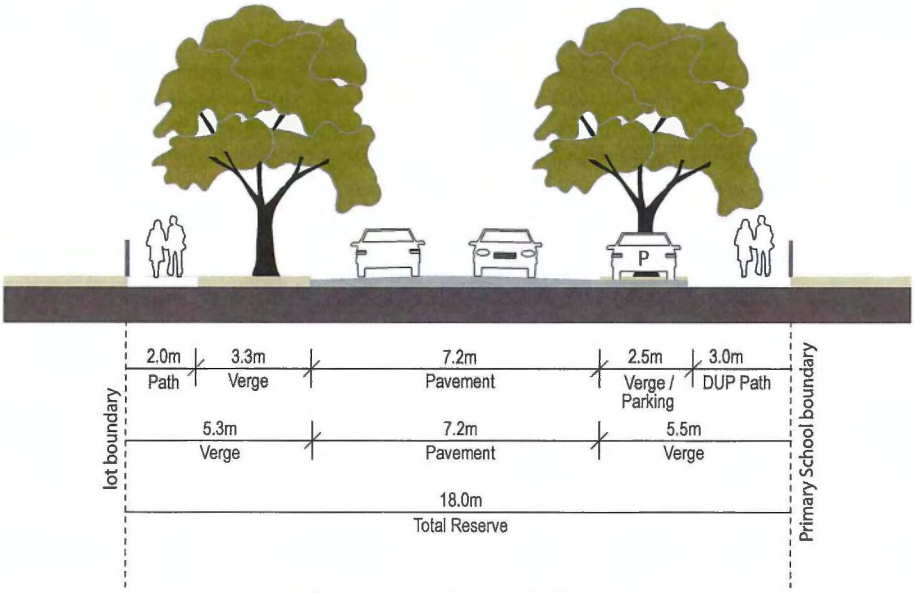
CLIENT:	ARMANA HOLDINGS
PROJECT	WELLARD EAST
TITLE:	OFFSITE SERVICE CORRIDOR PLAN

DESIGNED: A.PACKARD-HAIR	VERIFIED: / /	WAPC No.: -	DATUM: A.H.D.
DRAWN: A.HILL	APPROVED FOR TENDER: / /	DRAWING No.	20169C-PER-C/SK1
APPROVED FOR CONSTRUCTION: / /			

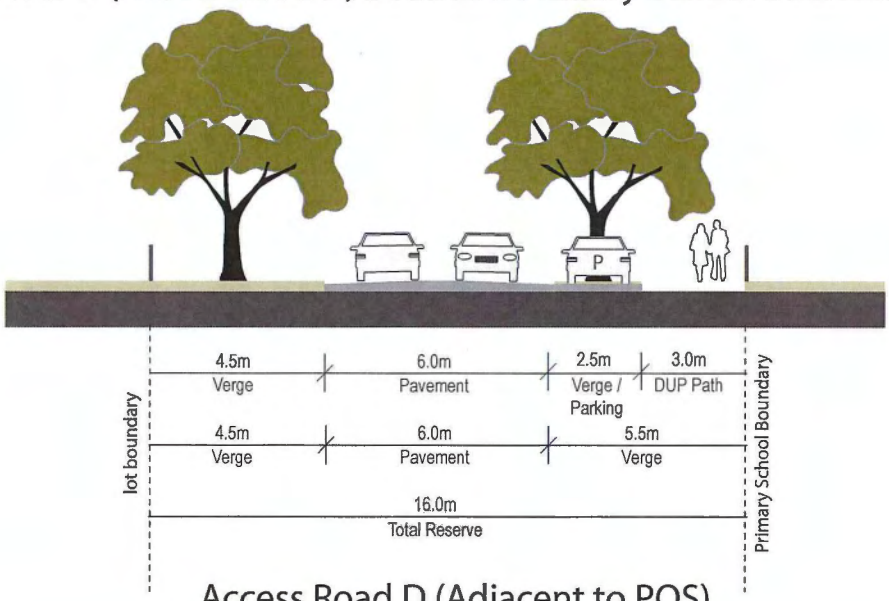
L:\TECH\28100\69\superseded\prelim 12d and plans\Sketch\c_pl_sk1.dgn

N

Road A (Neighbourhood Connector) Western Primary School Boundary



ROAD E (Access Road D) Southern Primary School Boundary



Access Road D (Adjacent to POS)

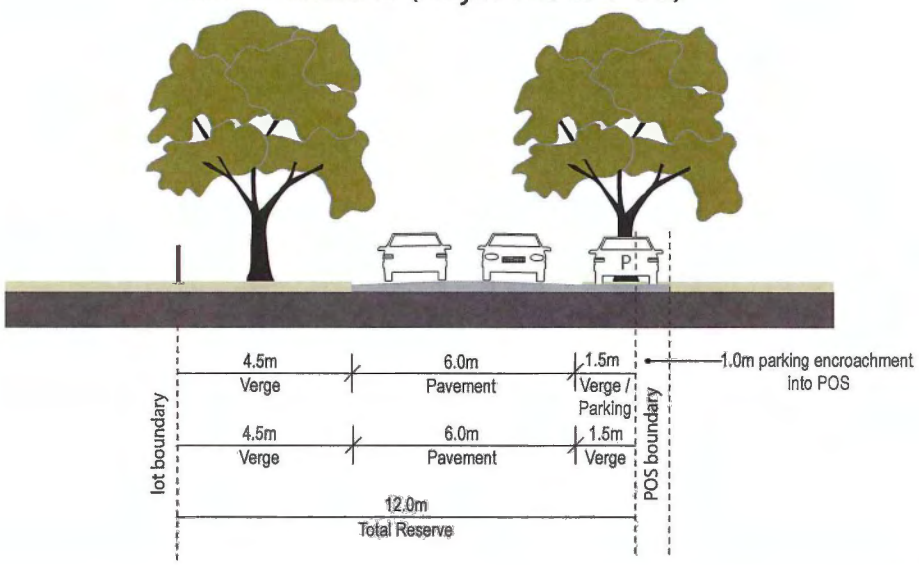


FIGURE 18

robertsday.com.au
planning·design·place

CADASTRAL INFORMATION
SOURCE:
YYMMDD:
DWG REF:
PROJECTION:
SIZE A3
NOT TO SCALE

AERIAL PHOTOGRAPHY
SOURCE:
YYMMDD:

INDICATIVE ONLY

TYPICAL CROSS SECTIONS
Wellard East LSP - Southern Portion of Lot 9001 and Lot 379
Millar Road, Wellard East

REF NO.	DRAW NO.	REV.
AMX WEL	**UD3 002**	**A**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

N

Access Road D

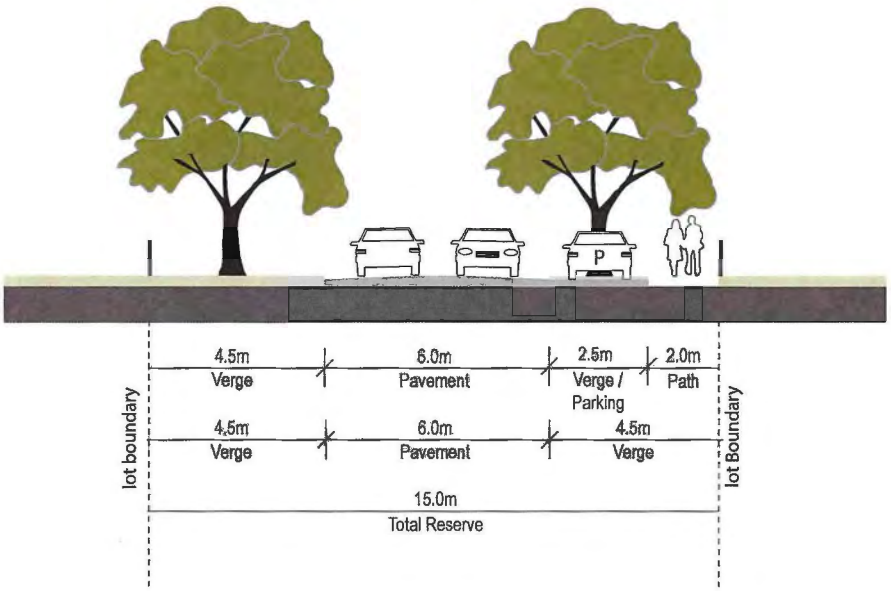


FIGURE 19

great places_
robertsday.com.au
planning·design·place

CADASTRAL INFORMATION
SOURCE:
YYMMDD:
DWG REF:
PROJECTION:

AERIAL PHOTOGRAPHY
SOURCE:
YYMMDD:

SIZE A3
NOT TO SCALE

INDICATIVE ONLY

TYPICAL CROSS SECTIONS
Wellard East LSP - Southern Portion of Lot 9001 and Lot 379
Millar Road, Wellard East

REF NO.	DRAW NO.	REV.
AMX WEL	**UD3 003**	**A**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

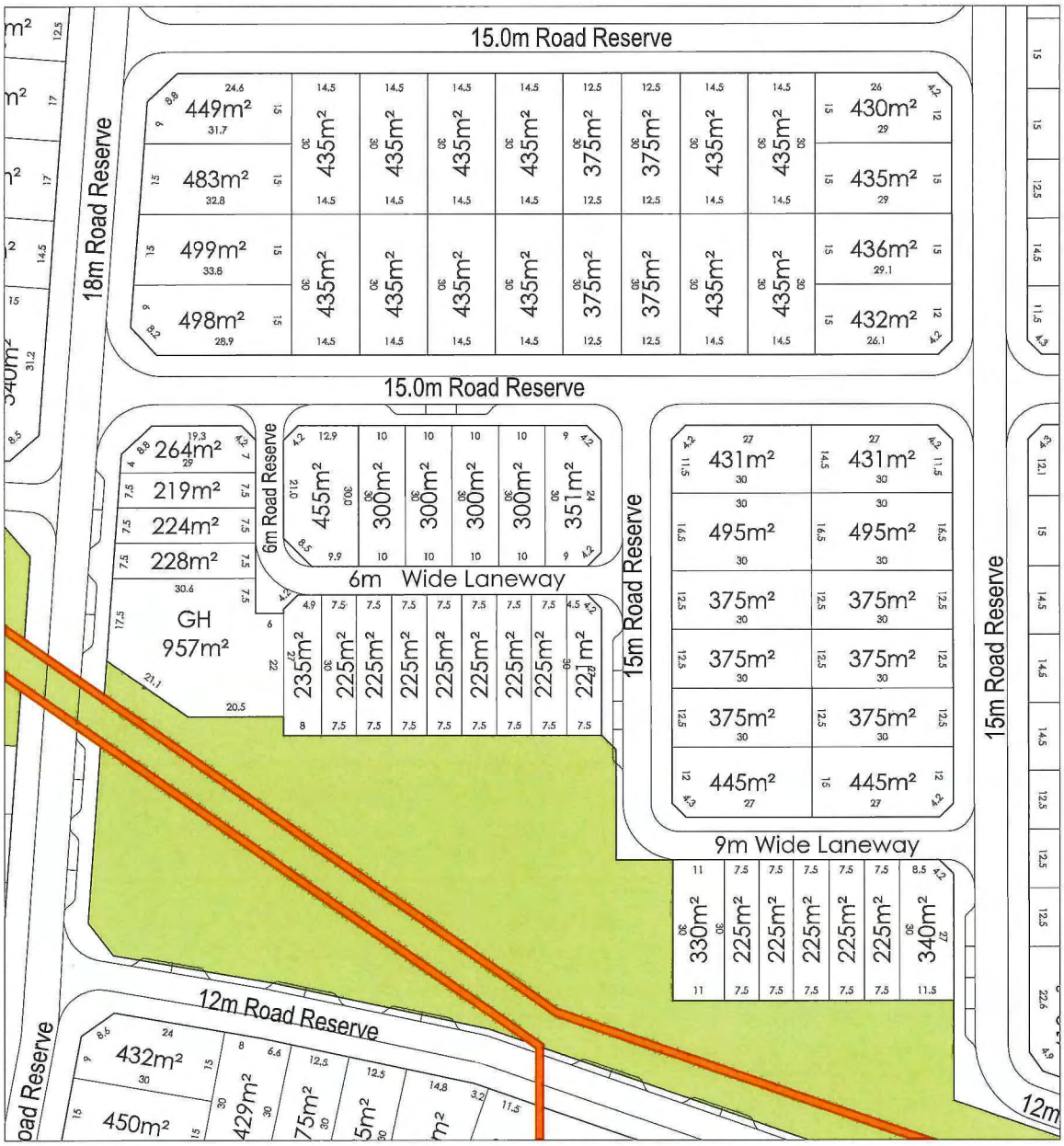


FIGURE 20

great places_
robertsday.com.au
planning·design·place

AMEX CORPORATION PTY LTD

CADASTRAL INFORMATION
SOURCE:
YYMMDD:
DWG REF:
PROJECTION:

AERIAL PHOTOGRAPHY
SOURCE:
YYMMDD:

INDICATIVE ONLY

SIZE A3
1:1000
0 metres 10 20 30 40 50

INDICATIVE LANEWAY SUBDIVISION DESIGN
Lot 379, Millar Road
Wellard

REF NO.	DRAW NO.	REV.
AMX WEL	**RD1 413**	**A**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

Technical Appendices Index

Appendix no.	Document title	Nature of document	Referral/approval agency	Summary of document modifications
A	Certificate of titles for LSP Area	Property information (supporting document only)	N/A	N/A
B	Spring Flora and Vegetation Survey and Wetland Assessment	Environmental assessment (supporting document only)	Referred to DEC as part of the approved LSP (2011)	N/A
C	Preliminary Acid Sulfate Soils Assessment	Preliminary assessment (supporting document only)	Referred to DEC as part of the approved LSP (2011)	N/A
D	Transport Assessment Report	Transport Assessment	Original document approved by City of Kwinana in 2011	Updated to address the subject site and issues discussed with Council officers at meeting on 20/3/14
E	Local Water Management Strategy Addendum	Water management assessment	Original LWMS approved by DOW (2011)	Updated to address the subject site and issues discussed with Council officers at meeting on 20/3/14
F	Local Water Management Strategy (Cardno 2010)	Water management assessment	Approved by DOW in 2011	N/A
G	Landscape Masterplan	Landscape plan (supporting document only)	Original plan considered by City of Kwinana as part of the approved LSP (2011)	Updated to address the subject site
H	Noise Assessment	Preliminary noise assessment (supporting document only)	Original preliminary noise assessment considered by Main Roads and City of Kwinana as part of the previously approved LSP	Updated to address the subject site and issues discussed with Council officers at meeting on 20/3/14
I	LSP and Wellard East Cell POS Schedules	POS calculation tables	Original POS tables considered by City of Kwinana and DOP/WAPC as part of the approved LSP (2011)	Updated to address the subject site
J	Fauna Assessment	Fauna assessment	To be referred to DPaW	N/A
K	Fire Management Plan	Fire hazard and management assessment	Extensive consultation with DFES and COK	Updated to address DFES and COK comments

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX A

CERTIFICATE OF TITLES FOR LSP AREA

WESTERN AUSTRALIA

REGISTER NUMBER	
9001/DP72800	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

RECORD OF CERTIFICATE OF TITLE

VOLUME **2815** FOLIO **182**

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 9001 ON DEPOSITED PLAN 72800

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ARMANA HOLDINGS PTY LTD OF SUITE 5 LEVEL 1, 437 ROBERTS ROAD, SUBIACO
(AF M253768) REGISTERED 23 MAY 2013

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

1. *B912600 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 72800 REGISTERED 6.5.1980.
2. *C178108 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 15.7.1981.
3. *C409801 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 19.8.1982.
4. *F993399 EASEMENT TO ELECTRICITY CORPORATION. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 29.9.1995.
5. *I597507 EASEMENT TO WESTERN POWER CORPORATION. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 20.8.2003.
6. *I653596 EASEMENT TO WESTERN POWER CORPORATION. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 8.10.2003.
7. *M247653 MORTGAGE TO AUSTRALIA & NEW ZEALAND BANKING GROUP LTD REGISTERED 19.4.2013.
8. *EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR DRAINAGE PURPOSES TO LOCAL AUTHORITY - SEE DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
9. *EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR SEWERAGE PURPOSES TO WATER CORPORATION DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
10. *EASEMENT BURDEN CREATED UNDER SECTION 136C T.L.A. FOR WATER SUPPLY PURPOSES - SEE DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
11. *EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR ELECTRICITY PURPOSES TO ELECTRICITY NETWORKS CORPORATION DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
12. *M260775 CAVEAT BY CITY OF KWINANA AS TO PORTION ONLY SEE DEPOSITED PLAN 44349 LODGED 3.5.2013.
13. *M260776 CAVEAT BY CITY OF KWINANA AS TO PORTION ONLY SEE DEPOSITED PLAN 57161 LODGED 3.5.2013.

END OF PAGE 1 - CONTINUED OVER

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Aug 30 13:14:48 2013 JOB 42652672

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:	DP72800.
PREVIOUS TITLE:	2814-388.
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA:	CITY OF KWINANA.

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING M247653

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Aug 30 13:14:48 2013 JOB 42652672

WESTERN AUSTRALIA

REGISTER NUMBER	
9001/DP72800	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	N/A

RECORD OF CERTIFICATE OF TITLE

VOLUME 2815 FOLIO 182

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 9001 ON DEPOSITED PLAN 72800

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ARMANA HOLDINGS PTY LTD OF SUITE 5 LEVEL 1, 437 ROBERTS ROAD, SUBIACO
(AF M253768) REGISTERED 23 MAY 2013

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

1. *B912600 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 72800 REGISTERED 6.5.1980.
2. *C178108 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 15.7.1981.
3. *C409801 EASEMENT TO THE STATE ENERGY COMMISSION OF WESTERN AUSTRALIA. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 19.8.1982.
4. *F993399 EASEMENT TO ELECTRICITY CORPORATION. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 29.9.1995.
5. *I597507 EASEMENT TO WESTERN POWER CORPORATION. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 20.8.2003.
6. *I653596 EASEMENT TO WESTERN POWER CORPORATION. SEE SKETCH ON DEPOSITED PLAN 72800. REGISTERED 8.10.2003.
7. *M247653 MORTGAGE TO AUSTRALIA & NEW ZEALAND BANKING GROUP LTD REGISTERED 19.4.2013.
8. *EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR DRAINAGE PURPOSES TO LOCAL AUTHORITY - SEE DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
9. *EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR SEWERAGE PURPOSES TO WATER CORPORATION DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
10. *EASEMENT BURDEN CREATED UNDER SECTION 136C T.L.A. FOR WATER SUPPLY PURPOSES - SEE DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
11. *EASEMENT BURDEN CREATED UNDER SECTION 167 P. & D. ACT FOR ELECTRICITY PURPOSES TO ELECTRICITY NETWORKS CORPORATION DEPOSITED PLAN 72800 AS CREATED ON DEPOSITED PLAN 72798.
12. *M260775 CAVEAT BY CITY OF KWINANA AS TO PORTION ONLY SEE DEPOSITED PLAN 44349 LODGED 3.5.2013.
13. *M260776 CAVEAT BY CITY OF KWINANA AS TO PORTION ONLY SEE DEPOSITED PLAN 57161 LODGED 3.5.2013.

END OF PAGE 1 - CONTINUED OVER

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Aug 30 13:14:48 2013 JOB 42652672

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:	DP72800.
PREVIOUS TITLE:	2814-388.
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA:	CITY OF KWINANA.

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING M247653

LANDGATE COPY OF ORIGINAL NOT TO SCALE Fri Aug 30 13:14:48 2013 JOB 42652672

WESTERN AUSTRALIA

REGISTER NUMBER	
379/DP144536	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
3	12/11/2004

RECORD OF CERTIFICATE OF TITLE

VOLUME 1778 FOLIO 685

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 379 ON DEPOSITED PLAN 144536

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ARMANA HOLDINGS PTY LTD OF LEVEL 2, 50 SUBIACO SQUARE, SUBIACO
(T I871009) REGISTERED 3 MAY 2004

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

1.	I871010	MORTGAGE TO AUSTRALIA & NEW ZEALAND BANKING GROUP LTD REGISTERED 3.5.2004.
2.	J015246	LEASE TO ROBERT JOHN HANCOCK, MARILYN HANCOCK, BOTH OF 593 MILLAR ROAD, WELLARD, AS JOINT TENANTS EXPIRES: SEE LEASE. AS TO PORTION ONLY REGISTERED 9.9.2004.
3.	*J236643	CAVEAT BY VICTOR ANTHONY FERRERIA, PAMELA JANE FERRERIA LODGED 4.4.2005.
4.	*M261802	CAVEAT BY CITY OF KWINANA LODGED 3.5.2013.

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

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

STATEMENTS:

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

SKETCH OF LAND:	1778-685 (379/DP144536).
PREVIOUS TITLE:	587-154A, 1610-53, 1610-52, 1506-697.
PROPERTY STREET ADDRESS:	593 MILLAR RD, WELLARD.
LOCAL GOVERNMENT AREA:	CITY OF KWINANA.

NOTE 1:	A000001A	LAND PARCEL IDENTIFIER OF PEEL ESTATE LOT 379 (OR THE PART THEREOF) ON SUPERSEDED PAPER CERTIFICATE OF TITLE CHANGED TO LOT 379 ON DEPOSITED PLAN 144536 ON 12-AUG-02 TO ENABLE ISSUE OF A DIGITAL CERTIFICATE OF TITLE.
NOTE 2:		THE ABOVE NOTE MAY NOT BE SHOWN ON THE SUPERSEDED PAPER CERTIFICATE

END OF PAGE 1 - CONTINUED OVER

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OF TITLE OR ON THE CURRENT EDITION OF DUPLICATE CERTIFICATE OF TITLE.

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LT. 37

ORIGINAL – NOT TO BE REMOVED FROM OFFICE OF TIT

CT 1778 0685 F

1778 685

Transfer D566758

Volume	Folio
1506	697
1610	52
1610	53
587	154A

WESTERN AUSTRALIA

CERTIFICATE OF TITLE

UNDER THE "TRANSFER OF LAND ACT, 1893" AS AMENDED

I certify that the person described in the First Schedule hereto is the registered proprietor of the undermentioned estate in the undermentioned land subject to the easements and encumbrances shown in the Second Schedule hereto.

REGISTRAR OF TITLES

Dated 25th September, 1987

ESTATE AND LAND REFERRED TO

Estate in fee simple in Peel Estate Lot 379, delineated on the map in the Third Schedule hereto, limited however to the natural surface and therefrom to a depth of 60.96 metres.

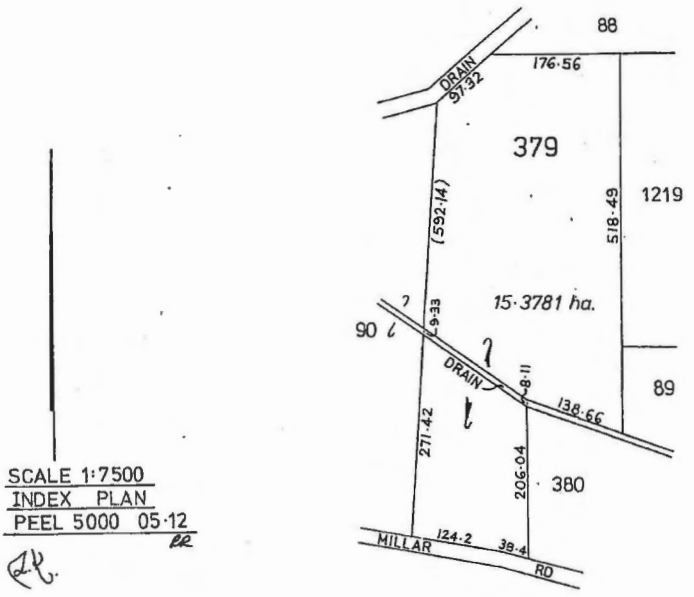
FIRST SCHEDULE (continued overleaf)

Victor Anthony Ferreria and Pamela Jane Ferreria, both of 89 Millar Road, Wellard, Business Proprietors, as joint tenants of one undivided half share and Brian Frederick Breese of 17 Hawter Road, Glen Forrest, Business Proprietor, of one undivided half share, as tenants in common.

SECOND SCHEDULE (continued overleaf)

NIL

THIRD SCHEDULE



SCALE 1:7500
INDEX PLAN
PEEL 5000 05-12

PERSONS ARE CAUTIONED AGAINST ALTERING OR ADDING TO THIS CERTIFICATE OR ANY NOTIFICATION HEREON

NOTE: RULING THROUGH AND SEALING WITH THE OFFICE SEAL INDICATES THAT AN ENTRY NO LONGER HAS EFFECT. ENTRIES NOT RULED THROUGH MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

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FIRST SCHEDULE (continued) NOTE: RULING THROUGH AND SEALING WITH THE OFFICE SEAL INDICATES THAT AN ENTRY NO LONGER HAS EFFECT. ENTRIES NOT RULED THROUGH MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

REGISTERED PROPRIETOR	INSTRUMENT NATURE	INSTRUMENT NUMBER	REGISTERED	TIME	SEAL	INITIALS

SECOND SCHEDULE (continued) NOTE: RULING THROUGH AND SEALING WITH THE OFFICE SEAL INDICATES THAT AN ENTRY NO LONGER HAS EFFECT. ENTRIES NOT RULED THROUGH MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

INSTRUMENT NATURE	INSTRUMENT NUMBER	PARTICULARS	REGISTERED	TIME	SEAL	INITIALS	CANCELLATION	NUMBER	REGISTERED OR LODGED	SEAL	INITIALS
Memorial	G226334	Land Tax Assessment Act 1976. Lodged 11.7.1996 at 8.42	hrs.				Withdrawn	G882498	21.8.98		

CERTIFICATE OF TITLE VOL. 1778 685

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX B

SPRING FLORA AND VEGETATION SURVEY AND WETLAND ASSESSMENT

Cardno
Shaping the Future



CASCADES, WELLARD EAST

Spring Flora and Vegetation Survey and Wetland Assessment

November 2008
Job No. V8041-003

Amex Corporation

Cardno (WA) Pty Ltd

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Document Control

Version	Date	Author		Reviewer	
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1a	November 2008	Gillian Turner	GT	Shane Chalwell	SC

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EXECUTIVE SUMMARY

Amex Corporation Pty Ltd (Amex) commissioned Cardno (WA) Pty Ltd (Cardno) in June 2008 to undertake a Flora and Vegetation Survey and Wetland Assessment of Lot 201 on Plan 52621 (no street address) and Lot 379 Millar Road within Wellard (herein referred to as the site). The aim of this report is to assess and document the botanical and wetland values of the site.

A field survey was conducted by two botanists on the 7th August, 23rd September and 17th November 2008 in accordance with EPA Guidance Statement No. 51 – *Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia* (2004). Two of the visits were undertaken in spring, which is the optimal flowering period for a majority of flowering plants in the south west of Western Australia.

A total of 94 taxa (including subspecies and varieties) from 78 genera and 31 families was recorded within the site. Of the 94 taxa, 45 were introduced (exotic) species and an additional five species were planted species that do not usually occur within the area. No Declared Rare Flora (DRF) or Priority Flora (PF) were recorded.

The site retains very little remnant vegetation due to historic clearing and subsequent grazing of livestock. Areas that still retain remnant vegetation include the mapped Wetland 12918 and a small portion of vegetation within the southern portion of Lot 201 adjacent to the Kwinana Freeway.

Six plant communities of differing condition were identified within the site and are described below:

1. **PC1:** Low lying forest of *Eucalyptus rudis* over *Taxandria linearfolia* - *Astartea scoparia* over *Pteridium esculentum* on sandy loam to sandy clay and areas of permanently inundated peaty clay (**Plate 1**):

2. **PC2:** Low lying forest of *Corymbia calophylla* over *Asteartea scoparia* - *Taxandria linearfolia* - *Melaleuca teretifolia* over **Rubus anglocandicans* - **Pennisetum clandestinum* on sandy loam to sandy clay (**Plate 2**);

3. **PC3:** Low lying woodland of *Eucalyptus rudis* over *Melaleuca teretifolia* over pasture grasses on grey sandy loam (**Plate 3**);

4. **PC4:** Low lying woodland-forest of *Eucalyptus rudis* - *Melaleuca preissiana* over *Kunzea glabrescens* - *Pultenaea reticulata* over *Dielisia stenostachya* - *Opercularia hispidula* - **Zantedeschia aethiopica* on grey sandy loam (**Plate 4**);

5. **PC5:** Low upland woodland of *Corymbia calophylla* - *Eucalyptus marginata* over *Agonis flexuosa* - *Casuarina obesa* - *Banksia menzeisii* - *Banksia grandis* over *Eremaea pauciflora* - *Calothamnus quadrifidus* over *Conostylis aculeata* subsp. *cygnorum* - *Kennedia prostrata* - **Ehrharta longiflora* - **Lolium rigidum* - **Carpobrotus edulis* on grey sandy loam (**Plate 5**);

6. **PC6:** Tall Scrub of *Kunzea glabrescens* - *Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis* on grey sandy loam (**Plate 6**).

The analysis of the combined datasets from the site and the Swan Coastal Plain survey of Gibson *et al.* (1994) grouped most plant communities into Floristic Community Type (FCT) 11 (Wet forests and woodlands) and one site grouped to FCT 5 (Mixed shrub damplands). Neither of these FCTs is listed as a Threatened Ecological Communities (TEC) on the DEC database.

Most of the site is in a 'Completely Degraded' condition due to historic clearing, high disturbance and weed invasion. Vegetation associated with Wetland 12918 has not been historically cleared and is in a 'Good' to 'Very Good' condition. Remaining patches of native vegetation are in a 'Degraded' condition.

The Geomorphic Wetlands Swan Coastal Plain dataset shows two wetlands occurring on the site. Wetland 12918 has been categorised as a Conservation Category Wetland (CCW) whilst Wetland 12921 is categorised as a Multiple Use Wetland (MUW). The Environmentally Sensitive Area (ESA) listed for the subject site is associated with the CCW.

The Geomorphic Wetlands Dataset Mapping for the CCW and MUW within the site is accurate, with relatively minor differences between the mapped boundaries and the observed extent of wetland vegetation. Vegetation condition also confirms the accuracy of the management categories assigned to the two mapped wetlands. Wetland 12918 is in a 'Good' to 'Very Good' condition with reasonably minor disturbances and high ecological values, whereas Wetland 12921 has been historically cleared with little remaining vegetation structure and is in a 'Degraded' to 'Completely Degraded' condition.

A regional biodiversity linkage, designed by the State Government, covers the central to northern portion of Lot 379 with the aim conserving and enhancing regional biological linkages. These linkages reflect the on-ground linkages throughout the Perth Metropolitan area and should be incorporated into land-use planning.

Three 'Declared' plants pursuant to the *Agriculture and Related Resources Protection Act 1976* (ARRP Act) were also identified onsite. These were the Arum Lily (**Zantedeschia aethiopica*), Blackberry (**Rubus anglocandicans*) and Paterson's Curse (**Echium plantagineum*). These weeds should be managed according to their priority ratings and specified by AgWA (2008).

Given the results of this survey, it Cardno's recommendation that:

- Wetland 12918 (CCW) should be retained, including a 50 m buffer;
- Connectivity of vegetation should be retained east-west across Lot 379 and the southern portion of Lot 201 so the regional biodiversity linkage is not negatively impacted;
- The three 'Declared' plants Arum Lily (P1, P4), Blackberry (P1) and Paterson's Curse (P1) should be controlled within the site subject to their priority ratings.

CASCADES - WELLARD EAST

SPRING FLORA AND VEGETATION SURVEY AND WETLAND ASSESSMENT

TABLE OF CONTENTS

EXECUTIVE SUMMARY ii

1. INTRODUCTION 1

1.1 Background 1
1.2 Purpose of the Report 1

2. EXISTING ENVIRONMENT 1

2.1 Regional Environment 1
2.2 Climate 1
2.3 Landforms, Soils and Vegetation 2
2.4 Declared Rare and Priority Flora 2
2.5 DEC Listed and *Environment Protection and Biodiversity Conservation Act* (1999) Threatened Ecological Communities 4
2.6 Priority Ecological Communities 5
2.7 Local and Regional Significance 6
2.8 Wetlands 7
2.9 Environmentally Sensitive Areas 8
2.10 Biodiversity Linkages 8

3. METHODS 9

3.1 Limitations of the study 10

4. RESULTS 11

4.1 Flora 11
4.2 Rare and Priority Flora 11
4.3 Plant Communities 11
4.4 Conservation Status of the Plant Communities 12
4.5 Condition of Plant Communities 12
4.6 Wetland Assessment 12
4.7 Declared Plants pursuant to the *Agriculture and Related Resources Protection Act* (1976) 13

5. DISCUSSION 13

6. CONCLUSIONS AND RECOMMENDATIONS 14

7. REFERENCES 15

LIST OF TABLES

Table 1: Definition of Rare and Priority Flora Species 3
Table 2: Declared Rare and Priority Flora Potentially Occurring within the Site 4
Table 3: Categories of DEC Threatened Ecological Communities 5
Table 4: Categories of Priority Ecological Communities 6
Table 5: Wetland management categories and management objectives 7
Table 6: Vegetation Condition Scale. 9

LIST OF PLATES

Plate 1: PC1 - Low lying forest of *Eucalyptus rudis* over *Taxandria linearlfolia - Astartea scoparia* over *Pteridium esculentum* on sandy loam to sandy clay and areas of permanently inundated peaty clay

Plate 2: PC2 - Low lying forest of *Corymbia calophylla* over *Astartea scoparia - Taxandria linearifolia - Melaleuca teretifolia* over **Rubus anglocandicans-*Pennisetum clandestinum*

Plate 3: PC3 - Low lying woodland of *Eucalyptus rudis* over *Melaleuca teretifolia* over pasture grasses on grey sandy loam

Plate 4: PC4 -. Low lying woodland-forest of *Eucalyptus rudis - Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielsia stenostachya - Opercularia hispidula - *Zantedeschia aethiopica* on grey sandy loam

Plate 5: PC5 - Low upland woodland of *Corymbia calophylla - Eucalyptus marginata* over *Agonis flexuosa - Casuarina obesa - Banksia menzeisii - Banksia grandis* over *Eremaea pauciflora - Calothamnus quadrifidus* over *Conostylis aculeata* subsp. *cygnorum - Kennedia prostrate - *Ehrharta longiflora - *Lolium rigidum - *Carpobrotus edulis* on grey sandy loam

Plate 6: PC6 - Tall Scrub of *Kunzea glabrescens - Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis*

Plate 7: Scattered *Melaleuca preissiana* and *Eucalyptus rudis* trees within low lying areas.

LIST OF FIGURES

Figure 1: Locality Plan

Figure 2: Site Plan

Figure 3: Geomorphic Wetlands, Environmentally Sensitive Areas and Regional Biodiversity Linkages

Figure 4: Survey Locations, Plant Communities and Individually mapped Remnant Trees

Figure 5: Vegetation Condition

APPENDICES

APPENDIX A Species Area Curve, Cluster Analysis and Floristic Community Type Analysis
APPENDIX B Flora Species Recorded at Cascades, Wellard East
APPENDIX C Flora Species Composition with each Plant Community
APPENDIX D Individual Sample Unit Data

1. INTRODUCTION

1.1 Background

Amex Corporation Pty Ltd (Amex) commissioned Cardno (WA) Pty Ltd (Cardno) in June 2008 to undertake a Flora and Vegetation Survey and Wetland Assessment of Lot 201 on Plan 52621 (no street address) and Lot 379 Millar Road within Wellard (herein referred to as the site).

The site is located 35 km south of Perth within the Town of Kwinana and is approximately 62 ha in size. It is situated on the eastern side of the Kwinana Freeway, between Millar Road and Mortimer Road. The location of the site is indicated in **Figure 1** and the site boundary in **Figure 2**.

Historic and current aerial photography shows that the majority of the site has been cleared. It has been heavily used for agriculture, including grazing of stock, market gardening and dairy farming. Cardno understands the site is intended to be developed for the construction of a residential development, however at the time of reporting, no plans detailing the future redevelopment were available.

1.2 Purpose of the Report

The aim of this report is to assess and document the botanical and wetland values of the site. The assessment includes the compilation of a species list and a search for Declared Rare Flora (DRF) and Priority Flora (PF). The assessment also includes the definition and mapping of the plant communities present and an assessment of the presence or absence of TECs and/or plant communities of local or regional significance.

Wetlands and associated wetland vegetation will be defined and mapped. The purpose of this is to groundtruth the accuracy of the both the mapping and management categories of the Geomorphic Wetlands Swan Costal Plain Dataset in respect of the subject site.

2. EXISTING ENVIRONMENT

2.1 Regional Environment

The site lies on the Swan Coastal Plain IBRA region (Thackway and Cresswell 1995), which is approximately equivalent to the Drummond Botanical Subdistrict within the Darling Botanical District, and the Swan Coastal Plain (SCP) subregion as described by Beard (1990). Flora composition of the SCP subregion has been described by Beard (1990) as predominantly consisting of *Banksia* low woodlands on leached sands (with *Melaleuca* swamps where ill drained) and woodlands of *Eucalyptus* spp. on less leached soils.

2.2 Climate

The SCP has a Mediterranean climate with hot dry summers and mild, wet winters. Winter precipitation varies between 600 and 1000mm per year with five to six dry months per year (Beard 1990). The subject site records an average rainfall of 788.9 mm per year (1983 to 2008), with about 91 rain days per year (data from Medina weather station, approximately 5 km northwest of the site and the nearest reporting station). Mean maximum temperatures range from 18.2 °C in July to 31.2 °C in February. Mean minimum temperatures range from 8.0 °C in August to 17.3 °C in February (Bureau of Meteorology 2008).

2.3 Landforms, Soils and Vegetation

The SCP is generally flat, approximately 20 – 30km wide and consists of two sedimentary belts of different origin. On the eastern side of the SCP, the Pinjarra Plain has been formed from the deposition of alluvial material whilst the three dune systems (Quindalup, Spearwood and Bassendean) that form the western part of the SCP are of aeolian origin (Seddon 2004). The dune systems represent differing ages of deposition with soils at different stages of leaching and formation. The coastal plain itself is low lying, often swampy with sandhills and therefore the soils predominantly consist of recent sands or swampy deposits (Beard 1990).

The site occurs within the Bassendean Dune System, which represents an accumulation of beach sands on an ancient coastline. The sands have been leached of much of their calcium carbonate and are quite infertile (Seddon 2004). The landform consists of low hills and swamps in the swales. The vegetation of the Bassendean sands is quite diverse, consisting in the main of *Banksia* low woodlands with a diverse understorey.

Landform and soil mapping by Churchward and McArthur (1980) place a majority of the subject site within the Bassendean Complex – Central and South, which is comprised of sandplains with low dunes and occasional swamps. The vegetation of the Bassendean Complex – Central and South consists of a range of woodlands of *Eucalyptus marginata* (Jarrah), *Casuarina* spp. (Sheoak) and *Banksia* spp. on the low dunes, to low woodlands of *Melaleuca* spp. and sedgelands in the swamps and depressions (Heddle *et al.* 1980).

2.4 Declared Rare and Priority Flora

Species of flora acquire "Declared Rare" (DRF) or "Priority" (PF) conservation status where populations are restricted geographically or threatened by local processes. The Department of Environment and Conservation (DEC) recognises these threats and subsequently applies regulations towards population protection and species conservation. The DEC enforces regulations under the *Wildlife Conservation Act 1950* to conserve Declared Rare species and protect significant populations. PF species are potentially rare or threatened and are classified in order of threat. DRF and PF category definitions are listed in **Table 1**.

Table 1: Definition of Rare and Priority Flora Species (Atkins 2008)

Conservation Code	Category
R	**Declared Rare Flora – Extant Taxa.** Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
X	**Declared Rare Flora – Presumed Extinct Taxa** Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
P1	**Priority One – Poorly Known Taxa** Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat eg road verges, urban areas, farmland, active mineral leases etc, or the plants are under threat, eg from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2	**Priority Two – Poorly Known Taxa** Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey.
P3	**Priority Three – Poorly Known Taxa** Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but need further survey.
P4	**Priority Four – Rare Taxa** Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Rare flora species are gazetted under subsection 2 of section 23F of the *Wildlife Conservation Act 1950* and therefore it is an offence to "take" or damage rare flora without Ministerial approval. Section 23F of the Act defines "to take" as "... to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora to cause or permit the same to be done by any means".

A search was conducted of the DEC DRF and PF databases and the species listed in **Table 2** were returned as potentially occurring in the vicinity of the site. This list is not definitive and only identifies species that have been recorded within the area, additional DRF or PF could potentially occur within the site.

Table 2: Declared Rare and Priority Flora Potentially Occurring within the Site

*Note - Life Strategy: P=Perennial; Pg= Perennial geophyte; A=Annual

Species	Conservation Code	Habitat	Life Strategy	Flowering Period
Aotus cordifolia	P3	Peaty Soils, Swamps	P	Aug-Jan
Aponogeton hexatepalus	P4	Mud, Freshwater	P	Jul-Oct
Boronia juncea subsp. *juncea*	P1	Brown sandy loam/mud	P	Apr
Caladenia huegelii	DRF	Grey or brown deep sand	P	Sept-Oct
Cyathochaeta teretifolia	P3	Grey sand, sandy clay, swamps	P	
Diuris micrantha	DRF	Brown loam clay, swampy flats	Pg	Sept-Oct
Dodonaea hackettiana	P4	Sand, outcropping limestone	P	Jul-Oct
Drakaea elastica	DRF	White or grey sand, low lying	Pg	Oct-Nov
Stylidium longitubum	P3	Sandy clay, seasonal wetlands	A	Oct-Dec
Synaphea sp. Serpentine	P3	Brown loam, low lying	P	

2.5 DEC Listed and *Environment Protection and Biodiversity Conservation Act* (1999) Threatened Ecological Communities

In Western Australia, "Threatened Ecological Communities" (TECs) are defined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee and are assigned to one of the categories outlined below in **Table 3.** While they are not afforded direct statutory protection at a State level (unlike "Declared Rare Flora" under the *Wildlife Conservation Act 1950*) their significance is acknowledged through other State environmental approval processes (i.e. Environmental Impact Assessment pursuant to Part IV of the *Environmental Protection Act 1986*).

Table 3: Categories of DEC Threatened Ecological Communities (English & Blyth 1997)

PD	**Presumably Totally Destroyed** An ecological community that has been adequately searched for but for which no representative occurrences have been located.
CE	**Critically Endangered** An ecological community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
E	**Endangered** An ecological community that has been adequately surveyed and is not critically endangered but is facing a very high risk of total destruction in the near future.
V	**Vulnerable** An ecological community that has been adequately surveyed and is not critically endangered or endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Selected TECs are also afforded statutory protection at a Federal level pursuant to the *Environment Protection and Biodiversity Conservation Act* (1999). The *Environment Protection and Biodiversity Conservation Act* (1999) provides for the strong protection of TECs, which are listed under section 181 of the Act, and are defined as either "Critically Endangered", "Endangered" or "Vulnerable" under Section 182.

A search was conducted of the DEC's TEC database within the boundary of the site and no occurrences of TECs were recorded. A search was then undertaken within a 5 km radius of the site and two TECs were identified, these being the 'Critically Endangered' '*Corymbia calophyllla – Xanthorrhoea preissii* woodlands and shrublands' (SCP 3c) and the 'Vunerable' 'Dense shrublands on clay flats' (SCP 09). The 'Critically Endangered' SCP 3c is also listed as 'Endangered' at a Federal level pursuant to the *Environment Protection and Biodiversity Conservation Act* (1999).

2.6 Priority Ecological Communities

In addition to listing as a TEC, a community may be listed as a Priority Ecological Community (PEC). An ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined, is placed on the list of PECs in either Category 1, 2 or 3 (**Table 4**). Ecological communities that are adequately known and are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5 (DEC 2008).

No PECs have been recorded within the study area, however a Priority 3 community has been recorded within a 5km radius of the site, this being 'Shrublands and Woodlands' (SCP24).

Table 4: Categories of Priority Ecological Communities (DEC 2008)

Priority 1	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
Priority 4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.
Priority 5	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

2.7 Local and Regional Significance

Apart from being listed as either "Declared Rare" or "Priority Flora", plant taxa may be significant for a number of other reasons. In Guidance Statement 51– *Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia* (2004) the Environmental Protection Authority (2004) stated that significant flora may include taxa that have:

"

- a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- relic status;
- anomalous features that indicate a potential new discovery;
- being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- the presence of restricted subspecies, varieties or naturally occurring hybrids;
- local endemism/a restricted distribution; and
- being poorly reserved. "

Similarly, plant communities or vegetation may be significant for reasons other than a listing as a TEC. The EPA (2004) stated that these reasons include:

- "scarcity;
- unusual species;
- novel combinations of species;
- a role as a refuge;
- a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;
- being representative of the range of a unit (particularly, a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range); and
- a restricted distribution. "

2.8 Wetlands

A number of wetlands have been identified as occurring within the site. Wetlands on the SCP are mapped and classified within the Geomorphic Wetland Dataset maintained by the DEC. Wetlands are categorised into management categories based on the hydrological, biological and human use features. These management categories are described below in **Table 5.** This dynamic dataset is continually updated with site-specific wetland surveys providing new and relevant information.

Table 5: Wetland management categories and management objectives (Western Australian Planning Commission 2005)

Management Category	Description of Wetland	Management Objectives
Conservation (C)	Wetlands which support high levels of attributes and functions.	To preserve wetland attributes and functions through reservation in national parks, crown reserves, state owned land and protection under environmental protection policies
Resource Enhancement (R)	Wetlands which have been partly modified but still support substantial functions and attributes.	To restore wetlands through maintenance and enhancement of wetland functions and attributes by protection in crown reserves, state or local government owned land and by environmental protection policies, or in private property by sustainable management
Multiple Use (M)	Wetlands with few attributes, which still provide important wetland functions.	Use, development and management should be considered in the context of water, town and environmental planning through landcare

Each wetland listed within the Geomorphic Wetland Dataset is given a Unique Feature Identifier (UFI) number. There are two mapped wetlands that cover portions of the subject site with UFI numbers 12918 and 12921. They will be herein referred to as 'Wetland' followed by the UFI number e.g. Wetland 12918. Wetland 12918 is categorised as a

Conservation Category Wetland (CCW) and Wetland 12921 is categorised as a Multiple Use Wetland (MUW). The CCW is located within Lot 201 within the north eastern corner and the MUW is located within both Lot 201 and Lot 379 and represents low lying areas that becomes seasonally wet. See **Figure 3** for the location of these wetlands.

2.9 Environmentally Sensitive Areas

One portion of the subject site is also declared as an Environmentally Sensitive Area (ESA) (**Figure 3**). ESAs occur where vegetation has high conservation values and exemptions under the clearing regulations do not apply. ESAs are declared by the Minister for the Environment in a notice pursuant to section 51B of the EP Act and can be declared as ESAs if they are:

- A declared World Heritage property;
- An area included on the Register of the National Estate for natural heritage value;
- A defined wetland and the area within 50 metres of the wetland;
- The area covered by vegetation within 50 metres of rare flora;
- The area covered by a threatened ecological community;
- A Bush Forever site; or
- An area covered by one of the following policies;
    - *Environmental Protection (Gnangara Mound Crown Land) Policy 1992*;
    - *Environmental Protection (Western Swamp Tortoise) Policy 2002*;
    - *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992*;
    - *Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998*; and
    - *Environmental Protection (Swan and Canning Rivers) Policy 1998*.

Therefore, the ESA within the subject site has been declared due to the presence of the CCW that occurs within the north eastern portion of Lot 201. The area covered by the ESA includes the mapped wetland itself and a 50 m buffer.

2.10 Biodiversity Linkages

Biodiversity linkages can be described as any area of remaining native vegetation that provides a corridor or linkage between larger patches of vegetation so as to allow movement of flora and fauna and their genetic material through the landscape, helping to maintain meta-populations. Linkages can prevent isolation of flora and fauna and ultimately extinctions. Biodiversity linkages can either be continuous or near continuous, the more fractured the linkage is, the less efficient the flora and fauna move along that corridor. Within built up areas, these linkages are more fractured.

Regional linkages have been designed by the State Government in Bush Forvever, Perth's Greenways and the System 6 study and supported by the WA Local Government (WALGA and PBP 2004). The designed linkages are aimed to be used to conserve and enhance our regional biological linkages and reflect the on-ground linkages throughout the Perth Metropolitan area.

Biodiversity linkage No. 75 encompasses the middle to upper portion of Lot 379 and the southern corner of Lot 201 (**Figure 3**). This linkage runs east-west across the site and links together Bush Forever (BF) site no. 349 in the west to BF sites 360 and 70 in the east. BF site 349 is Leda and adjacent bushland, BF site 70 is Duckpond Bushland, Peel Estate and BF 360 is Mundijong and Watkins Road Bushland, Peel Estate.

3. METHODS

A field survey was conducted by two botanists from Cardno on the 7th August, 23rd September and 17th November 2008 in accordance with EPA Guidance Statement No. 51 – *Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia* (2004). The subject site was traversed on foot and the vegetation assessed at 12 survey locations. These were selected to sample each plant community observed on the site. The position of each site was recorded with a hand-held GPS unit and all vascular plant species were recorded within a radius of at least 15 metres from that point. In addition, opportunistic plant taxa that were observed, but not located at a particular survey location, were also recorded through the course of the survey.

Environmental data recorded from each site included topographic position, aspect, slope, soil colour and texture class, rock outcropping, litter cover as well as the degree of disturbance and an estimate of the time since the last fire event.

The condition of the vegetation was assessed to assist in determining the conservation values of the site. The vegetation condition was rated according to the vegetation condition scale commonly used in the Perth Metropolitan Region (Keighery 1994) but is also appropriate for other urbanised and agricultural areas. The definitions are shown in **Table 6**.

Table 6: Vegetation Condition Scale (Keighery 1994).

Vegetation Condition	Definition
Pristine (1)	Pristine or nearly so, no obvious signs of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good (3)	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 (4)	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded (5)	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 (6)	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.

Plant communities were identified and described according to the dominant species present and the structural description of the communities follows that of Beard (1990). A cluster analysis was performed by converting Foliage Projective Cover (FPC) at each site to a Domin value (Kent and Coker 1992). Classification was undertaken using hierarchical clustering within the analysis package PC-ORD (McCune and Mefford 2006). Groups were

defined using the Relative Euclidean distance measure with Wards linkage method. The resulting dendrogram was scaled using Wishart's objective function and pruned with 75% of information remaining. Each community was then assigned a floristic community type (as described by Gibson *et al.* 1994 and Government of Western Australia 2000) using presence/absence so that a comparison could be made against the DEC's Threatened Ecological Community database. The species data was combined with that of Gibson *et al.* (1994) and the multivariate analysis package PATN (Belbin 2006) used to perform a Bray & Curtis classification (beta value = -0.1) (**Appendix A**). To best ensure compatibility between the datasets, introduced species that were not recorded in the southern Swan Coastal Plain survey were excluded from the data, taxa that have been revised or had name changes since 1994 were converted to the previous name and any species not identified to species level was excluded.

3.1 Limitations of the study

It is generally not possible to obtain a complete species list of an area from one or two visits, even at optimal times such as during spring. This is due to some species, especially herbaceous ones, being inconspicuous for much of the year and becoming obvious only during flowering. In addition, not all species will flower in the same season and some will not flower every year. Ideally, multiple visits would be made during different seasons on a biennial basis. However, this is rarely possible due to scheduled timeframes and budgetary constraints.

Two of the visits were undertaken in September and November (spring), which is the optimal flowering period for the majority of flowering plants in the south west of Western Australia. Most of the DRF and PF species identified (**Table 2**) are perennial species, which means they persist throughout the year. The exceptions being *Drakea elastica* (DRF), *Caladenia huegelli* (DRF) and *Diuris micrantha* (DRF), which are perennial geophytes, which means they become dormant (aestivate) via underground tubers and regenerate with the autumn rains. The other exception is *Stylidium longitubum*, which is an annual species, which means it only grows during favourable times of the year. These species have flowering periods that co-incides with the survey undertaken and, therefore, would have been observable if present during the time of the survey.

To test the adequacy of the sampling, a species-area curve was generated from the data collected, also known as a "species effort curve" (Angermeier and Smogor 1995). As shown within the curve (**Appendix A**), 6 plots yielded an average of 55 species with the remaining subplots yielding only eleven additional species and increasing in small increments. A first order Jackknife estimate (Palmer 1990) estimated total average species richness to be 100 species, which indicates the average species richness recorded of 66 species, contributes 66% of the total taxa expected to occur within the study area.

The method of combining the data from this survey to the Gibson *et al.* (1994) regional dataset has a number of limitations. The main objective of a flora survey is the compilation of a comprehensive species list, which is best obtained by using larger releves and opportunistic observations compared to the 10 x 10 metre quadrats of the SCP survey. This variation in method introduces a degree of incompatibility with the SCP regional study. Also, the original SCP survey was a regional survey whilst a localised flora survey such as Cascades, Wellard will add a number of spatially correlated sites to the dataset. Such sites are often grouped in any combined analysis and the original classification is often disrupted by the addition of new data (E.A. Griffin & Associates 2005). Since the original work of Gibson *et al.* (1994), additional FCTs have been identified by the System 6 and Part System 1 update program (DEP 1996). The data for the latter program, however, is not available electronically and hence care should be exercised when interpreting the results of any combined analysis.

4. RESULTS

4.1 Flora

A total of 94 taxa (including subspecies and varieties) from 78 genera and 31 families were recorded within the site **(Appendix B)**. The dominant families were Myrtaceae (18 taxa), Poaceae (15 taxa), Papilionaceae (11 taxa) and Proteaceae (7 taxa). From the 94 taxa, 45 of these were introduced (exotic) and five species that are not known to occur endemically in the area but had been planted in previous revegetation efforts. Exotic species included **Briza maxima, *Ehrharta calycina, *Romulea rosea, *Ursinia anthemoides* and **Hypochaeris glabra.*

4.2 Rare and Priority Flora

No species of DRF pursuant to subsection 2 of section 23F of the *Wildlife Conservation Act 1950* were located during the time of the survey and no plant taxa listed as Threatened pursuant to Schedule 1 of the EPBC Act were recorded in the surveyed area. No Priority Flora as listed by the DEC (Atkins 2008) were recorded during the survey.

4.3 Plant Communities

The site retains little remnant vegetation due to historic clearing and subsequent grazing of livestock. Areas that still retain remnant vegetation include the mapped CCW and a small portion of vegetation within the southern part of Lot 201 adjacent to the Kwinana Freeway.

Remnant plant communities and plant associations are described below and illustrated within **Figure 4.** A list of species within each community can be found in **Appendix C.**

1. **PC1:** Low lying forest (medium height 10-30m) of *Eucalyptus rudis* over *Taxandria linearifolia- Astartea scoparia* over *Pteridium esculentum* on sandy loam to sandy clay and areas of permanently inundated peaty clay (**Plate 1**). This community is part of the CCW that occurs within the north-eastern portion of Lot 201;

2. **PC2:** Low lying forest (medium height) of *Corymbia calophylla* over *Astartea scoparia-Taxandria linearifolia-Melaleuca teretifolia* over **Rubus anglocandicans-*Pennisetum cladestinum* (**Plate 2**). This community forms part of the CCW within the north-eastern portion of Lot 201;

3. **PC3:** Low lying woodland (medium height) of *Eucalyptus rudis* over *Melaleuca teretifolia* over pasture grasses on grey sandy loam (**Plate 3**). This is a small remnant patch of *Eucalyptus rudis* along the eastern edge of Lot 201 with regrowth *Melaleuca teretifolia* and a heavily grazed and disturbed understorey of pasture grasses;

4. **PC4:** Low lying woodland-forest (medium height) of *Eucalyptus rudis - Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielsia stenostachya - Opercularia hispidula - *Zantedeschia aethiopica* on grey sandy loam (**Plate 4**). Community 4 is also a remnant piece of bushland within the south-western portion of Lot 201, however has a heavily disturbed understorey through the actions of grazing and weed introduction;

5. **PC5:** Low upland woodland (>10m) of *Corymbia calophylla - Eucalyptus marginata* over *Agonis flexuosa - Casuarina obesa - Banksia menzeisii - Banksia grandis* over *Eremaea pauciflora - Calothamnus quadrifidus* over *Conostylis aculeata* subsp. *cygnorum - Kennedia prostrata - *Ehrharta longiflora - *Lolium rigidum - *Carpobrotus edulis* on grey sandy loam (**Plate 5**). This community occurs within

Lot 379 and represents a drier open woodland community of *Eucalyptus* and *Banksia* spp. This area has been historically cleared; therefore Community 5 has regrown with additional input from revegetation. Australian native species that have been planted within the site, but are not endemic to the area include *Agonis flexuosa, Hakea corymbosa, Melaleuca* sp. and *Eucalyptus* sp.;

6. **PC6:** Tall Scrub (to 10m) of *Kunzea glabrescens - Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis* (**Plate 6**). This community occurs within Lot 379 adjacent to Plant Community 5.

Additional to the above described communities, scattered native trees were present within the open paddocks including Tuart, Jarrah, *Kunzea glabrescens*, *Banksia* spp. and *Corymbia calophylla* (in the drier areas) and *Eucalyptus rudis* and *Melaleuca preissiana* in the seasonally damp and drainage areas (**Plate 7**). These remnant trees have been mapped and illustrated on **Figure 4**.

4.4 Conservation Status of the Plant Communities

The analysis of the combined datasets from the site and the Swan Coastal Plain survey of Gibson *et al.* (1994) grouped all sites except site 6 and 9 into FCT 11 (Wet forests and woodlands). This community type is most commonly defined by the species *Eucalyptus rudis* and/or *Melaleuca rhaphiophylla*. Site 6 grouped with FCT 5 (Mixed shrub damplands), which is dominated by the species *Kunzea ericifolia*. Site 9 consisted of only weed species including **Gomphocarpos fruticosus* and therefore could not be assigned an FCT.

FCT 11 encompasses communities 1, 2, 3, 4, and 5 and is not listed as a TEC due to its 'Low Risk' conservation status. FCT 5 encompasses community 6 and is also not listed as a TEC.

4.5 Condition of Plant Communities

Most of the site is in a 'Completely Degraded' condition due to historic clearing, high disturbance and weed invasion (**Figure 5**). Vegetation associated with Wetland 12918 has not been historically cleared and is in a 'Good' to 'Very Good' condition, although weed species are present and there are other disturbances such as cleared tracks and evidence of grazing. PC4, which is another area of remnant vegetation within the southern portion of Lot 201, is in a 'Good' condition due to a heavily disturbed understorey, which has caused the loss of much of the structure within the community. Areas of regrowth vegetation in the northern portion of Lot 379 (PC5 and PC6) are in a 'Degraded' condition. All other areas are 'Completely Degraded'.

4.6 Wetland Assessment

The Geomorphic Wetlands Dataset Mapping for the CCW and MUW within the site is accurate, with relatively minor differences between the mapped boundaries and the observed extent of wetland vegetation. The extent was determined by mapping the current wetland boundary and comparing it to the Geomorphic Wetlands Dataset. The vegetation condition also confirms accuracy of the management categories assigned to the two mapped wetlands. Wetland 12918 (CCW) is in a 'Good' to 'Very Good' condition with minor disturbances and weed infestations, whereas Wetland 12921 (MUW) has been historically cleared with little remaining vegetation structure and is in a 'Degraded' to 'Completely Degraded' condition.

4.7 Declared Plants pursuant to the *Agriculture and Related Resources Protection Act* (1976)

Three 'Declared' plants pursuant to the *Agriculture and Related Resources Protection Act 1976* (ARRP Act) were also identified onsite. These were the Arum Lily (**Zantedeschia aethiopica*), Blackberry (**Rubus anglocandicans*) and Paterson's Curse (**Echium plantagineum*).

Arum lily has been declared as a Priority 1 (P1) and Priority 4 (P4) plant across the entire state and Blackberry and Paterson's Curse are both declared as P1 plants. For the locations of these priority weeds see **Appendix D**.

5. DISCUSSION

Low species richness was recorded for the 62 ha site with 94 species. Of this number only 44 were naturally occurring species, which may be due to historic clearing and subsequent degrading effects such as grazing and weed invasion. In comparison, an 'Excellent' condition reserve (Banksia Road Nature Reserve - Bush Forever Site 353) of 32 ha in close proximity to the site of the same vegetation complex (Bassendean Complex-Central and South) recorded a species richness of 150 species, with an estimation of >75% of the species recorded (Government of WA 2000). This indicates that vegetation extent within the site does not represent the original vegetation values and therefore support reduced ecological functions.

Only PC1 and PC2 resemble the original plant community in species and structure, with a condition of 'Good' to 'Very Good'. All other areas are highly degraded and hold little of the original ecological values. None of the plant communities within the site are listed as TECs.

The mapped CCW within the site is accurate and is required to be retained due to its conservation values. It is expected that the current CCW boundary reflects the original extent of the wetland before clearing occurred as there is a noticeable drop in land elevation at the wetland boundary. For this reason we believe that the current boundary plus an additional 50 m buffer zone will be adequate for the protection of the original wetland values. It is expected that active management of the wetland will be required as the surrounding land is developed to protect the current values and condition of the wetland. This would include the establishment of a wetland management plan and active measures to ensure continuing protection. In addition to the intrinsic values of the CCW, it also contributes to the adjoining wetland systems and helps maintain regional biodiversity linkages and hydrological functions. The MUW no longer retains vegetation or functions as a wetland system and can support multiple land-uses.

Biodiversity linkage no. 75 that encompasses the middle to upper section of Lot 379 and the southern corner of Lot 201 links BF Site 349 in the west to BF Site 360 and 70 in the east and should be maintained where possible. This proposed linkage provides a way of maintaining the biodiversity of Perth at a regional level and allows the movement of flora and fauna across a fragmented landscape.

Three of the weed species recorded are 'Declared' plants due to their invasiveness and should be controlled within the site. Arum Lily has a P1 and P4 status, and Blackberry and Paterson's Curse have P1 status. P1 status prohibits the movement of plants or their seeds within the State. This means active control of this weed is not required but the movement of contaminated machinery and produce including livestock and fodder is prohibited. P4 status requires infestation areas to be managed in such a way that prevents

the spread of seed or plant parts. P4 weeds should be destroyed and all seed set prevented within:

- 100 metres inside the boundaries of the infested property;
- 50 metres of roads and high-water mark on waterways; and
- within 50 metres of sheds, stock yards and houses.

Treatment of a P4 weed must be undertaken prior to seed set each year and properties with less than 2 hectares of infestation must treat the entire infestation (Department of Agriculture and Food 2008).

6. CONCLUSIONS AND RECOMMENDATIONS

Investigations of site confirm that the remaining vegetation is part of the Bassendean Complex – Central and South and consists of a range of woodland of *Eucalyptus marginata* (Jarrah), *Casuarina* sp. (Sheoak) and *Banksia* sp. on the low dunes, to low woodland of *Melaleuca* spp. and sedgelands in the swamps and depressions. However most of the site has been historically cleared and consists of cleared paddocks with scattered native trees and shrubs.

94 flora species from 78 genera and 31 families were recorded. Of this number 45 were identified as weed species, which is 48% of the total species recorded. A majority of the vegetation is in a 'Completely Degraded' condition, with the vegetation associated with Wetland 12918 in a 'Good' to 'Very Good' condition.

No DRF or PF were recorded within the site. The plant communities described were most closely aligned to FCT 5 and FCT 11, which are both 'Low Risk' community types. They are not listed as TECs within the DEC database.

The Geomorphic Wetland mapping is accurate with relatively minor differences between the mapped boundaries and the observed extent of wetland vegetation. The CCW should be retained due to its conservation significance, while the MUW, due to reduced conservation significance, can support multiple land uses. The current mapped boundary of the CCW plus a 50 m buffer zone will be adequate to protect the wetland values. When the surrounding area is developed, active management and protection of the CCW will be required.

Given the results of this survey, it Cardno's recommendation that:

- Wetland 12918 (CCW) should be retained including a 50 m buffer;
- Connectivity of vegetation should be retained east-west across Lot 379 to incorporate the regional biodiversity linkage;
- The three 'Declared' plants Arum Lily (P1, P4), Blackberry (P1) and Paterson's Curse (P1) should be controlled within the site subject to their priority ratings.

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PLATES



Plate 1: PC1 - Low lying forest (medium height 10-30m) of *Eucalyptus rudis* over *Taxandria linearfolia- Astartea scoparia* over *Pteridium esculentum* on sandy loam to sandy clay and areas of permanently inundated peaty clay



Plate 2: PC2 - Low lying forest (medium height) of *Corymbia calophylla* over *Asteartea scoparia-Taxandria linearfolia-Melaleuca teretifolia* over **Rubus anglocandicans-*Pennisetum cladestinum*



Plate 3: PC3 - Low lying woodland (medium height) of *Eucalyptus rudis* over *Melaleuca teretifolia* over pasture grasses on grey sandy loam.



Plate 4: PC4 -. Low lying woodland-forest (medium height) of *Eucalyptus rudis - Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielisia stenostachya - Opercularia hispidula - *Zantedeschia aethiopica* on grey sandy loam.



Plate 5: PC5 - Low upland woodland (>10m) of *Corymbia calophylla* - *Eucalyptus marginata* over *Agonis flexuosa* - *Casuarina obesa* - *Banksia menzeisii* - *Banksia grandis* over *Eremaea pauciflora* - *Calothamnus quadrifidus* over *Conostylis aculeata* subsp. *cygnorum* - *Kennedia prostrate* - **Ehrharta longiflora* - **Lolium rigidum* - **Carpobrotus edulis* on grey sandy loam.

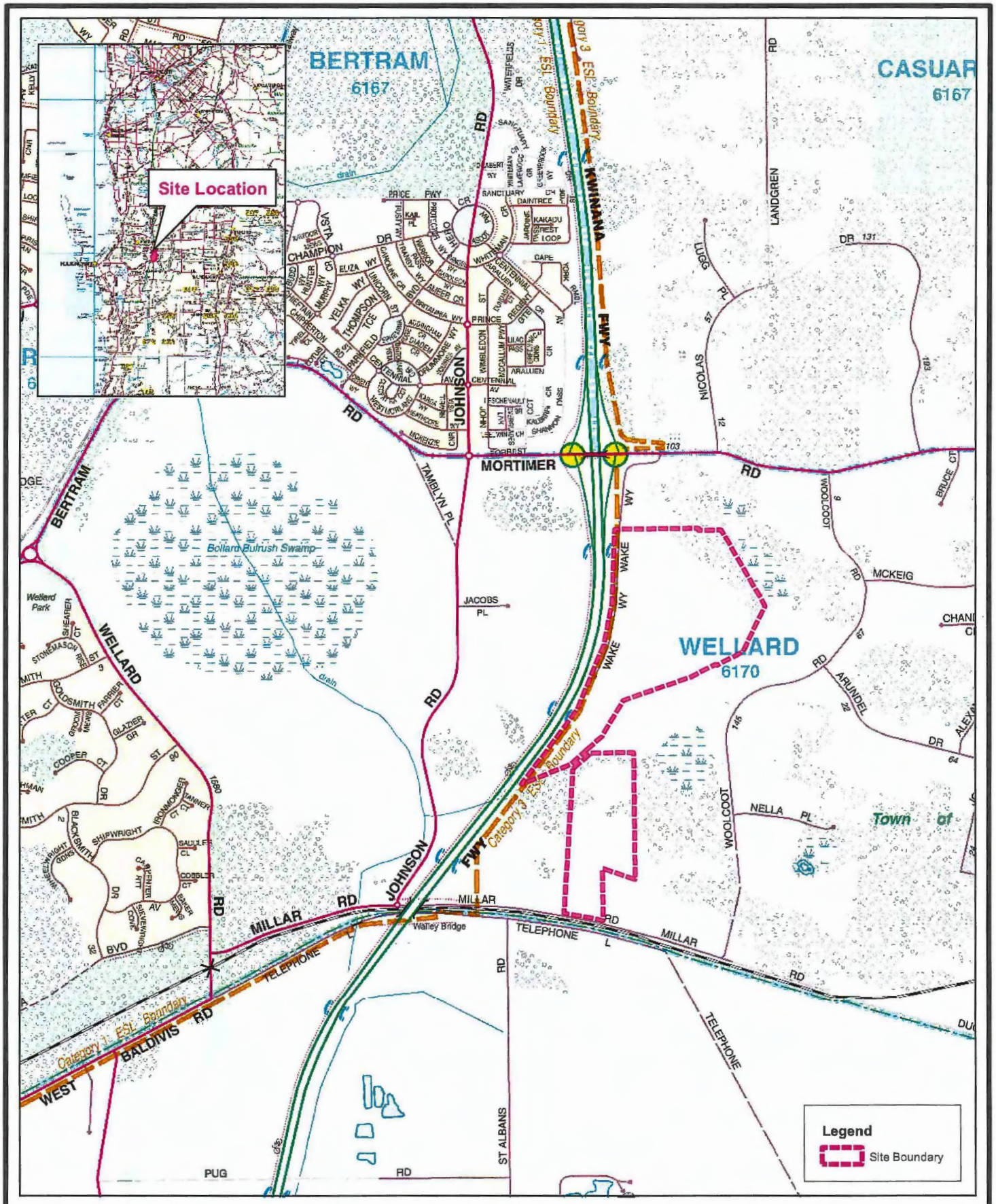


Plate 6: PC6 - Tall Scrub (to 10m) of *Kunzea glabrescens* - *Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis*.



Plate 7: Scattered *Melaleuca preissiana* and *Eucalyptus rudis* trees within low lying areas.

FIGURES



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:20,000

0 250 500 1,000 1,500 2,000 Metres

PROJECT Flora & Vegetation Survey & Wetland Assessment

DRAWING TITLE FIGURE 1 : Locality Plan

PRINCIPAL Amex Coporation Pty Ltd.

Project Number V8041

Original A4

Drawing Number SK01

Revision

Designed GT

Checked

Drawn MGW

Approved

Local Authority Town of Kwinana

Sheet 1 of 1

Date 20/11/08

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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:8,500

0 50 100 200 300 400 500 600 700 800 Metres

PROJECT Flora & Vegetation Survey & Wetland Assessment

DRAWING TITLE FIGURE 2 : Site Plan

PRINCIPAL Amex Coporation Pty Ltd.

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Project Number V8041

Original A4

Drawing Number SK02

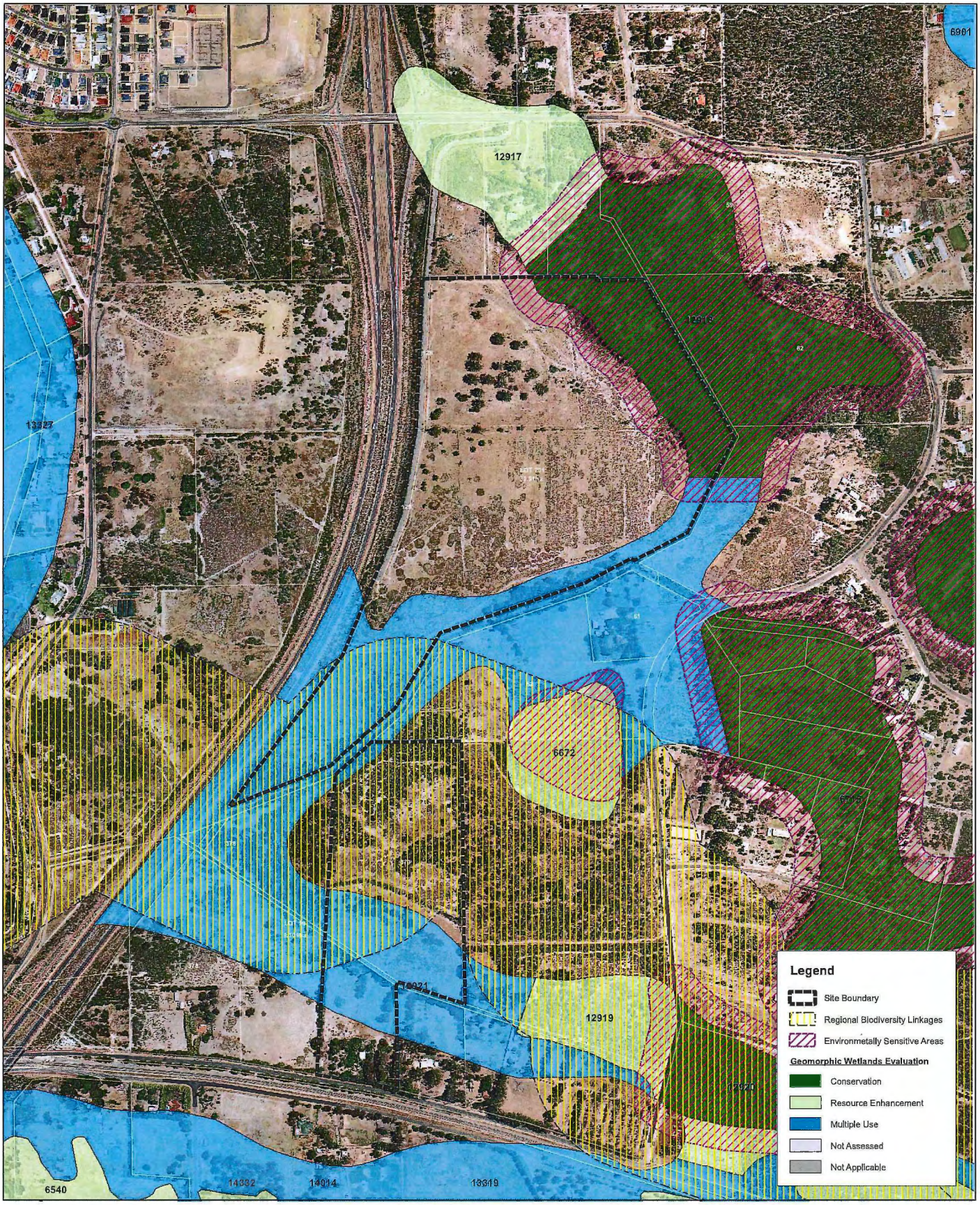
Revision

Designed JWH Checked JWH

Drawn MGW Approved SPG

Local Authority Town of Kwinana

Sheet 1 of 1 Date 14/10/08



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

Cardno

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Scale: 1:7,000 (0, 100, 200, 400, 600, 800, 1,000 Metres)

PROJECT: **Flora & Vegetation Survey & Wetland Assessment**

DRAWING TITLE: **FIGURE 3: Geomorphic Wetlands, Environmentally Sensitive Areas & Regional Biodiversity Linkages**

PRINCIPAL: **Amex Coporation Pty Ltd.**

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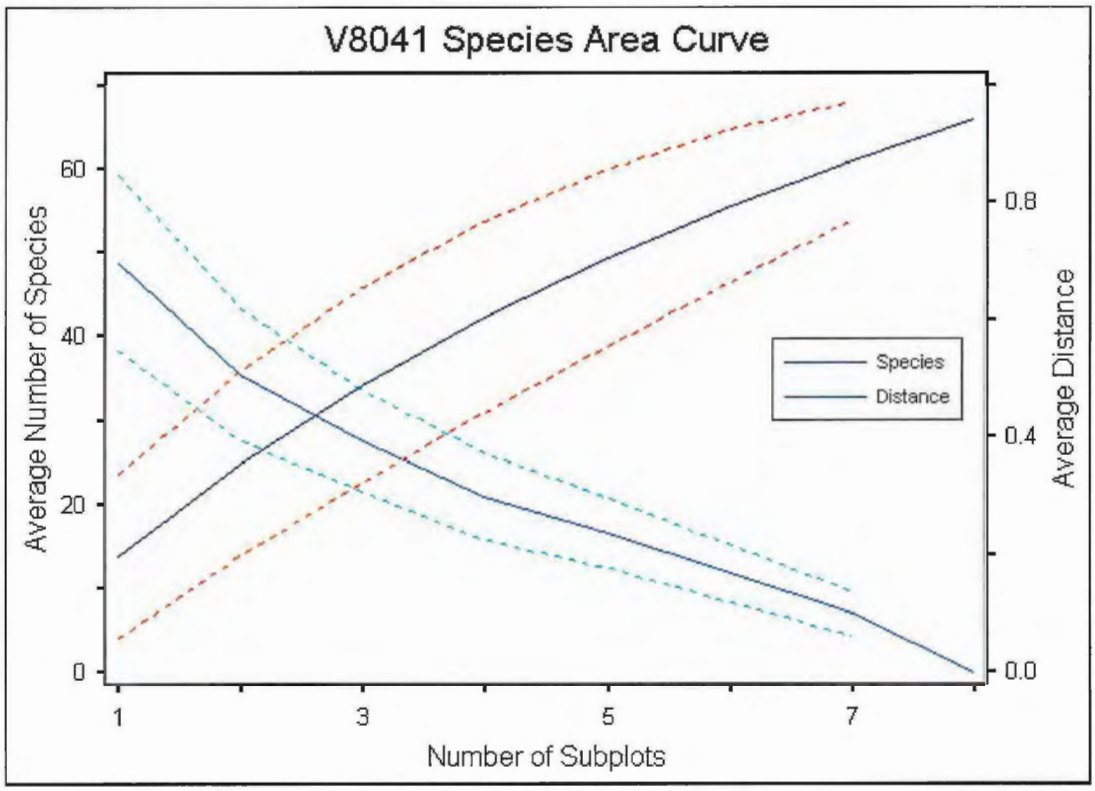
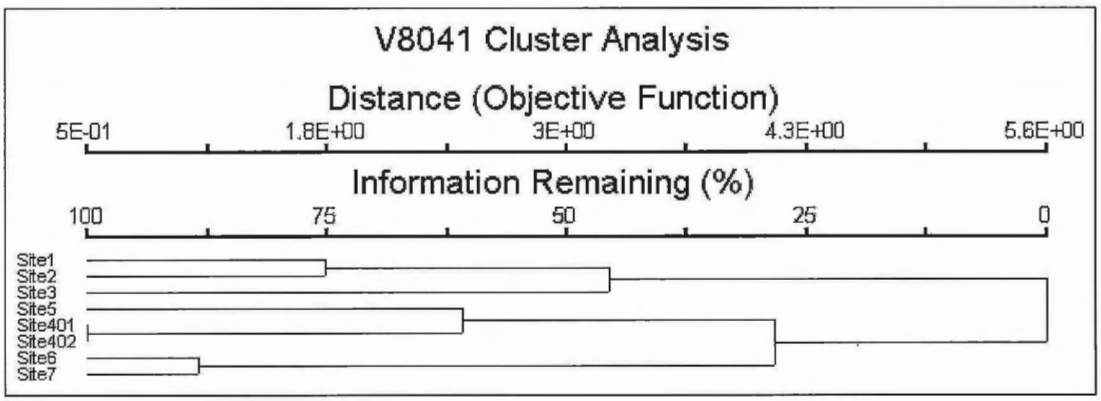
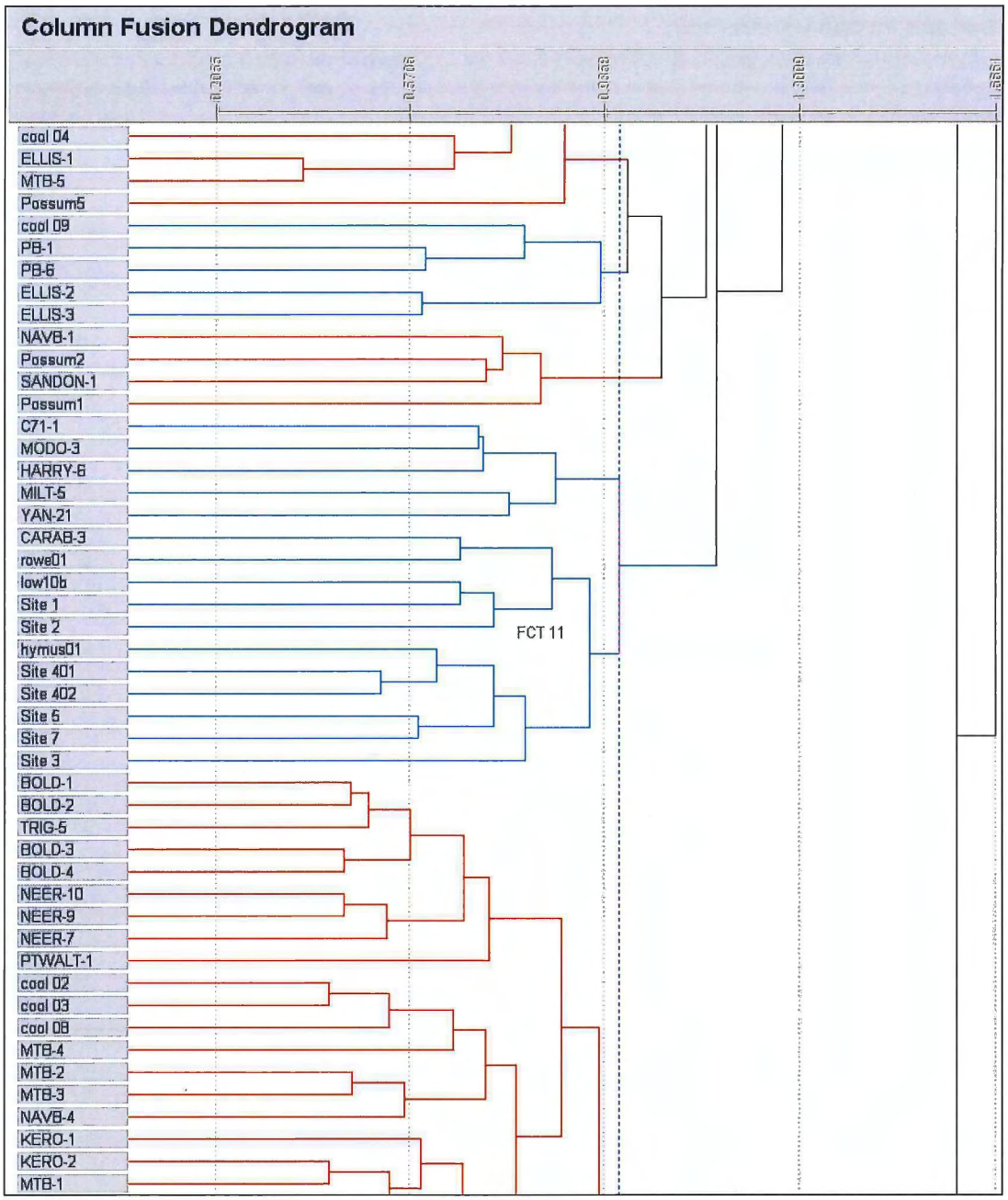
Project Number: **V8041**
Original: **A4**
Drawing Number: **SK03**
Revision: **00**
Designed GT
Checked
Drawn MGW
Approved
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/11/08

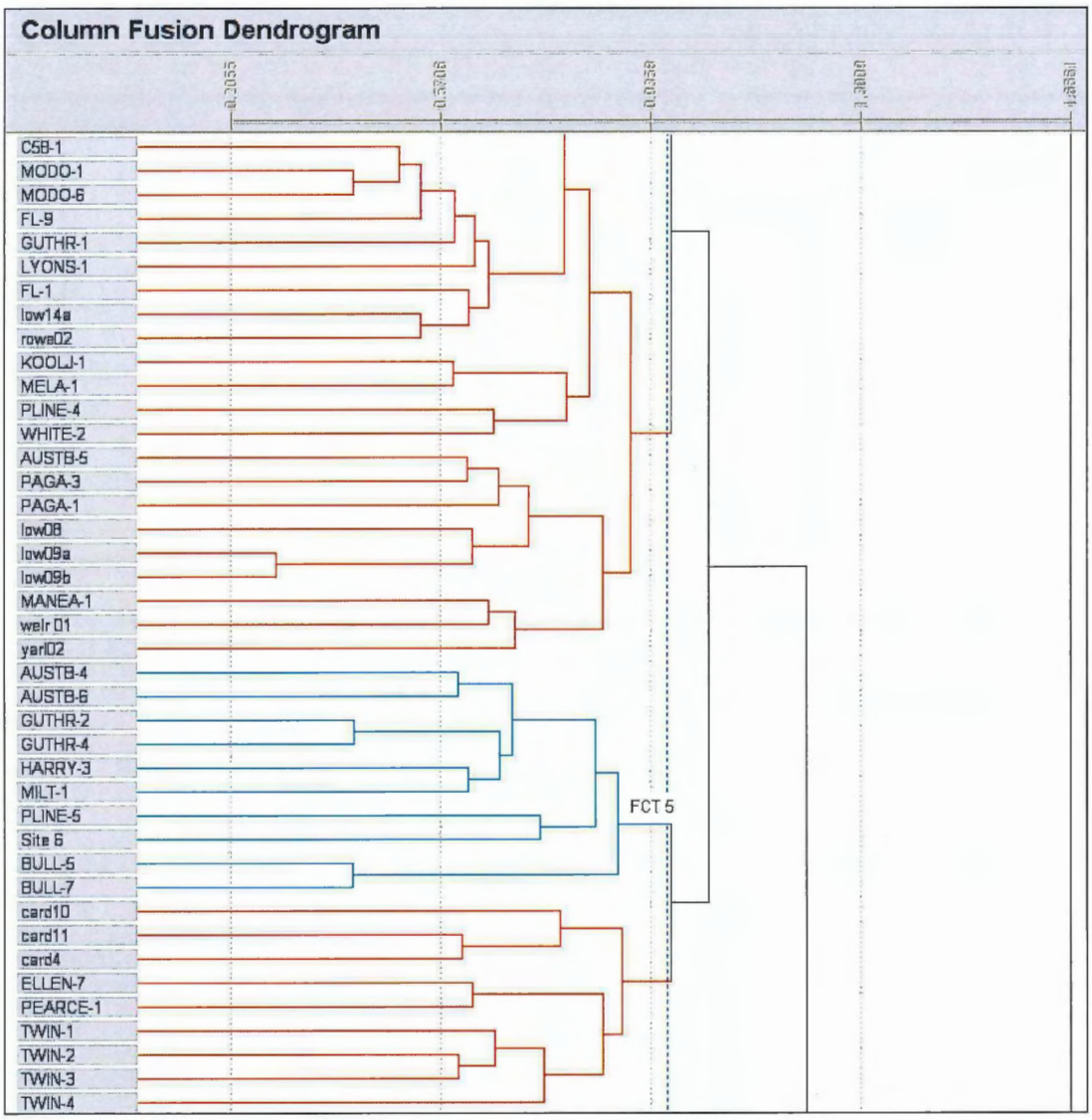
APPENDIX A

Species Area Curve, Cluster Analysis and Floristic Community Type Analysis


V8041 Species Area Curve
Average Number of Species
Average Distance
Number of Subplots
Species
Distance
0
20
40
60
0.0
0.4
0.8
1
3
5
7


V8041 Cluster Analysis
Distance (Objective Function)
5E-01
1.8E+00
3E+00
4.3E+00
5.6E+00
Information Remaining (%)
100
75
50
25
0
Site1
Site2
Site3
Site5
Site401
Site402
Site6
Site7


Column Fusion Dendrogram
cool 04
ELLIS-1
MTB-5
Possum5
cool 09
PB-1
PB-6
ELLIS-2
ELLIS-3
NAVB-1
Possum2
SANDON-1
Possum1
C71-1
MODO-3
HARRY-6
MILT-5
YAN-21
CARAB-3
rowe01
low10b
Site 1
Site 2
hymus01
Site 401
Site 402
Site 5
Site 7
Site 3
BOLD-1
BOLD-2
TRIG-5
BOLD-3
BOLD-4
NEER-10
NEER-9
NEER-7
PTWALT-1
cool 02
cool 03
cool 08
MTB-4
MTB-2
MTB-3
NAVB-4
KERO-1
KERO-2
MTB-1
FCT 11


Column Fusion Dendrogram
C5B-1
MODO-1
MODO-6
FL-9
GUTHR-1
LYONS-1
FL-1
low14a
row02
KOOLJ-1
MELA-1
PLINE-4
WHITE-2
AUSTB-5
PAGA-3
PAGA-1
low08
low09a
low09b
MANEA-1
weir01
yar02
AUSTB-4
AUSTB-6
GUTHR-2
GUTHR-4
HARRY-3
MILT-1
PLINE-5
Site 6
BULL-5
BULL-7
card10
card11
card4
ELLEN-7
PEARCE-1
TWIN-1
TWIN-2
TWIN-3
TWIN-4
FCT 5

APPENDIX B

Flora Species Recorded at Cascades, Wellard East

Appendix B: Flora Species Recorded at Cascades, Wellard East

DP = Declared Plant, P = Planted, * = Weed Species

FAMILY NAME		SPECIES NAME
Dennstaedtiaceae		*Pteridium esculentum*
Juncaginaceae		*Triglochin huegelii*
Poaceae		* *Aira caryophyllea*
		* *Avena barbata*
		* *Briza maxima*
		* *Bromus diandrus*
		* *Cynodon dactylon*
		* *Ehrharta calycina*
		* *Ehrharta longiflora*
		* *Eragrostis curvula*
		* *Holcus lanatus*
		* *Hordeum leporinum*
		* *Lolium rigidum*
		Microlaena stipoides
		* *Pennisetum clandestinum*
		* *Poaceae* sp.
		* *Vulpia muralis*
Cyperaceae		*Baumea articulata*
		* *Isolepis prolifera*
		Lepidosperma longitudinale
Arecaceae	DP	* *Zantedeschia aethiopica*
Restionaceae		*Dielsia stenostachya*
Juncaceae		*Juncus pallidus*
Phormiaceae		* *Dianella revoluta* subsp. *divaricata*
Anthericaceae		*Thysanotus manglesianus*
Haemodoraceae		*Conostylis aculeata* subsp. *cygnorum*
Iridaceae		* *Gladiolus caryophyllaceus*
		* *Romulea rosea*
Orchidaceae		*Caladenia latifolia*
		Cryptostylis ovata
		Microtis media subsp. *media*
		* *Orobanche minor*
Casuarinaceae		*Casuarina obesa*

Appendix B: Flora Species Recorded at Cascades, Wellard East

DP = Declared Plant, P = Planted, * = Weed Species

FAMILY NAME			SPECIES NAME
Proteaceae			*Banksia attenuata*
			Banksia grandis
			Banksia menziesii
		P	*Banksia* sp.
			Grevillea preissii subsp. *preissii*
		P	*Hakea corymbosa*
			Hakea prostrata
Polygonaceae		*	*Rumex acetosella*
Phytolaccaceae		*	*Phytolacca octandra*
Aizoaceae		*	*Carpobrotus edulis*
Caryophyllaceae		*	*Petrorhagia dubia*
		*	*Stellaria media*
Crassulaceae			*Crassula colorata*
Rosaceae	DP	*	*Rubus anglocandicans*
Mimosaceae			*Acacia cyclops*
		*	*Acacia longifolia* subsp. *sophorae*
			Acacia rostellifera
			Acacia saligna
Papilionaceae		*	*Chamaecytisus palmensis*
			Gastrolobium capitatum
			Hardenbergia comptoniana
			Jacksonia furcellata
			Kennedia prostrata
		*	*Lotus subbiflorus*
		*	*Lupinus cosentinii*
		*	*Lupinus luteus*
		*	*Ornithopus compressus*
			Pultenaea reticulata
		*	*Trifolium repens*
Geraniaceae		*	*Erodium cicutarium*
		*	*Pelargonium capitatum*
Oxalidaceae		*	*Oxalis* sp.
Euphorbiaceae		*	*Euphorbia terracina*

Appendix B: Flora Species Recorded at Cascades, Wellard East

DP = Declared Plant, P = Planted, * = Weed Species

FAMILY NAME		SPECIES NAME
Myrtaceae	P	*Agonis flexuosa*
		Astartea scoparia
		Calothamnus quadrifidus
		Corymbia calophylla
		Eremaea pauciflora
		Eucalyptus gomphocephala
		Eucalyptus marginata
		Eucalyptus rudis
	P	*Eucalyptus* sp.
		Hypocalymma angustifolium
		Kunzea glabrescens
		Melaleuca incana subsp. *incana*
		Melaleuca preissiana
		Melaleuca rhaphiophylla
	P	*Melaleuca* sp.
		Melaleuca teretifolia
		Taxandria linearifolia
		Viminaria juncea
Apiaceae	*	*Centella asiatica*
Primulaceae	*	*Anagallis arvensis*
Ascalpiadaceae	DP *	*Gomphocarpus fruticosus*
Boraginaceae	*	*Echium plantagineum*
Rubiaceae		*Opercularia hispidula*
Asteraceae	*	*Arctotheca calendula*
	*	*Hypochaeris glabra*
		Quinetia urvillei
	*	*Sonchus oleraceus*
	*	*Ursinia anthemoides*

APPENDIX C

Flora Species Composition within each Plant Community

Appendix C: Flora Species Composition within each Plant Community

SPECIES NAME	PLANT COMMUNITY					
	1	2	3	4	5	6
Acacia cyclops					X	X
Acacia longifolia subsp. *sophorae*				X		X
Acacia rostellifera					X	
Acacia saligna					X	X
Agonis flexuosa					X	X
Aira caryophyllea						
Anagallis arvensis	X					
Arctotheca calendula						
Astartea scoparia	X	X				
Avena barbata						
Banksia attenuata						X
Banksia grandis					X	X
Banksia menziesii					X	
Banksia sp.					X	
Baumea articulata	X					
Briza maxima	X			X		
Bromus diandrus				X		
Caladenia latifolia	X					
Calothamnus quadrifidus					X	X
Carpobrotus edulis	X			X	X	X
Casuarina obesa					X	
Centella asiatica	X	X				
Chamaecytisus palmensis						
Conostylis aculeata subsp. *cygnorum*					X	
Corymbia calophylla		X		X	X	
Crassula colorata						X
Cryptostylis ovata				X		
Cynodon dactylon	X			X		
Dianella revoluta subsp. *divaricata*				X		X
Dielsia stenostachya	X			X		
Echium plantagineum						
Ehrharta calycina				X		X
Ehrharta longiflora				X	X	
Eragrostis curvula						X
Eremaea pauciflora					X	
Erodium cicutarium						
Eucalyptus gomphocephala			X			
Eucalyptus marginata					X	X
Eucalyptus rudis	X			X		
Eucalyptus sp.					X	
Euphorbia terracina						
Gastrolobium capitatum					X	
Gladiolus caryophyllaceus						
Gomphocarpus fruticosus						
Grevillea preissii subsp. *preissii*						X
Hakea corymbosa						X
Hakea prostrata					X	
Hardenbergia comptoniana				X	X	

Appendix C: Flora Species Composition within each Plant Community

SPECIES NAME	PLANT COMMUNITY					
	1	2	3	4	5	6
Holcus lanatus	X	X				
Hordeum leporinum						
Hypocalymma angustifolium				X		
Hypochaeris glabra	X			X		X
Isolepis prolifera	X					
Jacksonia furcellata				X		
Juncus pallidus	X					
Kennedia prostrata					X	
Kunzea glabrescens				X		X
Lepidosperma longitudinale	X					
Lolium rigidum				X	X	
Lotus subbiflorus				X		
Lupinus cosentinii				X	X	
Lupinus luteus						
Melaleuca incana subsp. *incana*						X
Melaleuca preissiana		X		X		
Melaleuca rhaphiophylla			X			
Melaleuca teretifolia		X	X			X
Microlaena stipoides	X					
Microtis media subsp. *media*				X		
Opercularia hispidula				X		
Ornithopus compressus						
Orobanche minor				X		
Oxalis sp.	X					
Pelargonium capitatum				X		
Pennisetum clandestinum		X				
Petrorhagia dubia						
Phytolacca octandra						
Poaceae sp.	X					
Pteridium esculentum	X			X		
Pultenaea reticulata				X		
Quinetia urvillei						X
Romulea rosea		X		X	X	X
Rubus anglocandicans	X	X				
Rumex acetosella				X		
Sonchus oleraceus	X					
Stellaria media	X					
Taxandria linearifolia	X	X				
Thysanotus manglesianus	X					
Trifolium repens						
Triglochin huegelii	X					
Ursinia anthemoides						X
Viminaria juncea					X	
Vulpia muralis						
Zantedeschia aethiopica	X	X	X	X	X	X

APPENDIX D

Individual Sample Unit Data

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	1	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	392387	6430366

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	LS	Black/Grey	NA	Heavy humus

Geomorphology:	Topography	Aspect	Slope (°)
	F	NA	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2	10	75	1

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	Low	VG-G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	14	5	1
	% Cover	35	70	20

Observations	Thick litter layer

Field description of vegetation	*Eucalyptus rudis* over *Taxandria linearfolia* over *Pteridium esculentum*

Species	Foliage Projective Cover
Eucalyptus rudis	35
Taxandria linearifolia	7
Lepidosperma longitudinale	2
Thysanotus manglesianus	0.03
Rubus anglocandicans	1
Anagallis arvensis	0.03
Sonchus oleraceus	0.03
Juncus pallidus	0.03
Pteridium esculentum	45
Microlaena stipoides	0.1
Stellaria media	0.03
Zantedeschia aethiopica	0.3
Dielsia stenostachya	Opp
Carpobrotus edulis	Opp
Hypochaeris glabra	Opp

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	2	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	392428	6430332

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Black	NA	NA

Geomorphology:	Topography	Aspect	Slope (°)
	SW	NA	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	10	2	60	10

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	Low	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	12	4	0.7
	% Cover	35	10	80

Observations	Surface water to 10 cm

Field description of vegetation	*Eucalyptus rudis* over *Astartea scoparia* over *Centella asiatica* and *Triglochin huegelii*

Species	Foliage Projective Cover
Eucalyptus rudis	35
Astartea scoparia	15
Centella asiatica	40
Triglochin huegelii	5
Juncus pallidus	0.5
Cynodon dactylon	40
Caladenia latifolia	0.02
Zantedeschia aethiopica	1
Briza maxima	1
Baumea articulata	0.1
Oxalis sp.	0.1
Poaceae sp.	2
Isolepis prolifera	0.4
Holcus lanatus	0.1
Microlaena stipoides	0.1

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	3	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	392500	6430150

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Black	NA	Moist

Geomorphology:	Topography	Aspect	Slope (°)
	SW	NA	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	5	70	0

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	High-Medium	G

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	10	5	0.5
	% Cover	20	90	10

Observations	Overgrown with **Rubus anglocandicans*

Field description of vegetation	*Corymbia calophylla* over *Astartea scoparia* and *Taxandria linearfolia* over **Rubus anglocandicans* and **Pennisetum clandestinum.*

Species	Foliage Projective Cover
Corymbia calophylla	20
Astartea scoparia	80
Taxandria linearifolia	10
Rubus anglocandicans	10
Pennisetum clandestinum	5
Holcus lanatus	1
Romulea rosea	1
Centella asiatica	5
Melaleuca teretifolia	2
Zantedeschia aethiopica	1
Melaleuca preissiana	3

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	4	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	392173	6430193

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments

Geomorphology:	Topography	Aspect	Slope (°)

Litter:	Logs	Twigs	Leaves	Bare Ground (%)

Disturbance:	Time Since Fire	Level of Human Impact	Condition

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			
	% Cover			

Observations	

Field description of vegetation	Paddock weeds

Species	Foliage Projective Cover
Lupinus cosentinii	Opp
Ehrharta calycina	Opp
Ursinia anthemoides	Opp
Arctotheca calendula	Opp
Hypochaeris glabra	Opp
Gladiolus caryophyllaceus	Opp
Euphorbia terracina	Opp
Carpobrotus edulis	Opp
Petrorhagia dubia	Opp
Vulpia muralis	Opp
Avena barbata	Opp
Erodium cicutarium	Opp
Trifolium repens	Opp
Lolium rigidum	Opp
Aira caryophyllea	Opp
Eragrostis curvula	Opp
Ehrharta longiflora	Opp
Lupinus luteus	Opp
Echium plantagineum	Opp
Bromus diandrus	Opp
Gomphocarpus fruticosus	Opp
Zantedeschia aethiopica	Opp

Field description of vegetation	Paddock weeds

Species	Foliage Projective Cover
Acacia saligna	Opp
Orobanche minor	Opp
Hordeum leporinum	Opp
Phytolacca octandra	Opp
Ornithopus compressus	Opp

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	5	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	392012	6429209

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Grey	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	F	SW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	10	5	30	0

Disturbance:	Time Since Fire (yrs)	Level of Human Impact	Condition
	>5	High	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	8	4	0.7
	% Cover	40	30	90

Observations	

Field description of vegetation	*Corymbia calophylla* and *Eucalyptus marginata* over *Calothamnus quadrifidus* over **Ehrharta calycina*

Species	Foliage Projective Cover
Corymbia calophylla	5
Eucalyptus marginata	5
Agonis flexuosa	5
Acacia saligna	2
Acacia cyclops	1
Eucalyptus sp.	5
Eremaea pauciflora	3
Banksia sp. - planted	3
Calothamnus quadrifidus	5
Viminaria juncea	2
Casuarina obesa	10
Zantedeschia aethiopica	0.5
Ehrharta longiflora	60
Lupinus cosentinii	2
Carpobrotus edulis	5
Hardenbergia comptoniana	0.3
Romulea rosea	10
Lolium rigidum	20
Acacia saligna	1
Acacia rostellifera	0.5
Gastrolobium capitatum	0.5
Hakea prostrata	Opp

Field description of vegetation	*Corymbia calophylla* and *Eucalyptus marginata* over *Calothamnus quadrifidus* over **Ehrharta calycina*

Species	**Foliage Projective Cover**
Banksia menziesii	Opp
Conostylis aculeata subsp. *cygnorum*	Opp
Kennedia prostrata	Opp
Banksia grandis	Opp

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	6	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	391947	6429369

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	White/Grey	NA	NA

Geomorphology:	Topography	Aspect	Slope (°)
	F	NW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2	2	1	70

Disturbance:	Time Since Fire (yrs)	Level of Human Impact	Condition
	>5	Medium	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	5	1	0.1
	% Cover	30	5	40

Observations	

Field description of vegetation	*Kunzea glabrescens* over **Ursinia anthemoides* and *Quinetia urvillei*

Species	Foliage Projective Cover
Kunzea glabrescens	30
Eragrostis curvula	1
Ursinia anthemoides	5
Hypochaeris glabra	5
Crassula colorata	5
Ehrharta calycina	1
Quinetia urvillei	20

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	7	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	392113	6429408

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	S	Grey	NA	NA

Geomorphology:	Topography	Aspect	Slope (°)
	F	NW	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	2	2	10	20

Disturbance:	Time Since Fire	Level of Human Impact	Condition
	>5	High	CD

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	15	7	1.2
	% Cover	30	40	60

Observations	

Field description of vegetation	*Eucalyptus marginata* over *Kunzea glabrescens* over **Ehrharta calycina*

Species		Foliage Projective Cover
Eucalyptus marginata		30
Kunzea glabrescens		20
Banksia grandis		2
Acacia longifolia subsp. *sophorae*		5
Acacia longifolia subsp. *sophorae*		1
Melaleuca teretifolia		0.1
Agonis flexuosa		1
Acacia saligna		2
Ehrharta calycina		50
Carpobrotus edulis		10
Acacia cyclops		0.5
Hypochaeris glabra		0.5
Ursinia anthemoides		1
Zantedeschia aethiopica		0.5
Dianella revoluta subsp. *divaricata*		0.2
Romulea rosea		10
Grevillea preissii subsp. *preissii*		0.5
Grevillea preissii subsp. *preissii*		0.2
Melaleuca incana subsp. *incana*		0.2
Acacia longifolia subsp. *sophorae*		0.1
Banksia attenuata	Opp	
Calothamnus quadrifidus	Opp	

Field description of vegetation	*Eucalyptus marginata* over *Kunzea glabrescens* over **Ehrharta calycina*

Species	**Foliage Projective Cover**
Hakea corymbosa	Opp

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	8	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	391863	6429075

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments

Geomorphology:	Topography	Aspect	Slope (°)

Litter:	Logs	Twigs	Leaves	Bare Ground (%)

Disturbance:	Time Since Fire	Level of Human Impact	Condition

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			
	% Cover			

Observations	

Field description of vegetation	

Species **Foliage Projective Cover**

Gomphocarpos fruticosus

APPENDIX D: Individual sampling unit data

Date:	23.9.08	Site:	9	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA '94	50	392082	6429728

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments

Geomorphology:	Topography	Aspect	Slope (°)

Litter:	Logs	Twigs	Leaves	Bare Ground (%)

Disturbance:	Time Since Fire	Level of Human Impact	Condition

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			
	% Cover			

Observations	

Field description of vegetation	

Species

Eucalyptus rudis
Melaleuca preissiana
Melaleuca teretifolia
Zantodeschia aethiopica

Foliage Projective Cover

APPENDIX D: Individual sampling unit data

Date:	17.11.08	Site:	401	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing
	GDA	50	391745	6429372

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments
	SL	Grey/Black	NA	

Geomorphology:	Topography	Aspect	Slope (°)
	F	NA	<5

Litter:	Logs	Twigs	Leaves	Bare Ground (%)
	5	5	10	5

Disturbance:	Time Since Fire (yrs)	Level of Human Impact	Condition
	>5	High	D

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)	23	4	1
	% Cover	30	30	50

Observations	High weed invasion

Field description of vegetation	*Eucalyptus rudis* over *Melaleuca preissiana* over *Kunzea glabrescens* and *Pultenaea reticulata*

Species		Foliage Projective Cover
Eucalyptus rudis		25
Kunzea glabrescens		25
Melaleuca preissiana		2
Pultenaea reticulata		7
Dielsia stenostachya		15
Zantedeschia aethiopica		10
Orobanche minor		1
Hypochaeris glabra		3
Ehrharta calycina		1
Opercularia hispidula		7
Pelargonium capitatum		3
Carpobrotus edulis		2.5
Lolium rigidum		0.3
Briza maxima		3.5
Acacia longifolia subsp. *sophorae*		0.5
Rumex acetosella		0.5
Corymbia calophylla		5
Dianella revoluta subsp. *divaricata*		0.2
Microtis media subsp. *media*		0.1
Bromus diandrus	Opp	
Hypocalymma angustifolium	Opp	
Jacksonia furcellata	Opp	

Field description of vegetation	*Eucalyptus rudis* over *Melaleuca preissiana* over *Kunzea glabrescens* and *Pultenaea reticulata*

Species	**Foliage Projective Cover**
Hardenbergia comptoniana	Opp
Cynodon dactylon	Opp
Lupinus cosentinii	Opp
Lotus subbiflorus	Opp

APPENDIX D: Individual sampling unit data

Date:	17.11.08	Site:	402	Sampling Unit Type	relevé

Location:	Datum	Zone	Easting	Northing

Soils:	Soil texture	Soil Colour	Outcrop	Soil Comments

Geomorphology:	Topography	Aspect	Slope (°)

Litter:	Logs	Twigs	Leaves	Bare Ground (%)

Disturbance:	Time Since Fire	Level of Human Impact	Condition

Vegetation Structure:	Strata	Upper	Mid	Lower
	Height (m)			
	% Cover			

Observations	

Field description of vegetation	Patch of *Pteridium esculentum*

Species	Foliage Projective Cover
Pteridium esculentum	80
Rumex acetosella	2
Carpobrotus edulis	3
Romulea rosea	5
Lolium rigidum	3
Bromus diandrus	2
Hypochaeris glabra	5
Ehrharta longiflora	2
Kunzea glabrescens	5
Corymbia calophylla	5
Zantedeschia aethiopica	3
Cryptostylis ovata	Opp

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX C
PRELIMINARY ACID SULFATE SOILS ASSESSMENT

Cardno
Shaping the Future



CASCADES, WELLARD EAST

Preliminary Acid Sulfate Soils Assessment

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CASCADES, WELLARD EAST
PRELIMINARY ACID SULFATE SOILS INVESTIGATION

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

1. INTRODUCTION **3**

1.1 Project Background 3
1.2 Objective 3
1.3 Scope of Work 3
1.4 Relevant DEC Guidelines 4

2. ACID SULFATE SOILS **5**

2.1 Background 5
2.2 Pyrite Accumulation 5
2.3 Pyrite Oxidation 5
2.4 Acid Sulfate Soil Risk Areas 6
2.5 Requirement for Detailed Investigations 7

3. DESKTOP ASSESSMENT **8**

3.1 Topography 8
3.2 Geology 8
3.2.1 Soil Types 8
3.2.2 ASS Risk Map 9
3.3 Hydrogeology 10
3.3.1 Groundwater 10
3.3.2 Wetlands, Surface Water and Drainage 10
3.3.2.1 Wetlands 10
3.3.2.2 Surface Water and Drainage 11
3.4 Vegetation 11
3.5 Previous investigations 12
3.6 Summary 13

4. SITE INSPECTION **14**

4.1 Topography 14
4.2 Geology 14
4.3 Hydrogeology 14
4.3.1 Groundwater 14
4.3.2 Wetlands, Surface Water and Drainage 15
4.4 Vegetation characteristics 15

5. SAMPLING AND ANALYSIS PLAN **16**

5.1 Soil Sampling 16

5.1.1 Field pH 16
5.1.2 SPOCAS Suite of Analysis 16
5.1.3 Chromium Reducible Sulfur Suite of Analysis 17

6. SOIL INVESTIGATION 18
6.1 Field pH Test Results 18
6.2 Analytical Results 19
6.2.1 SPOCAS Results 19
6.2.2 Chromium Reducible Sulfur Results 20
6.1 Summary 20

7. CONCLUSIONS AND RECOMMENDATIONS 21

8. REFERENCES 22

9. PROJECT WARRANTY 23

LIST OF TABLES

Table 1 Wetland management categories 10
Table 2 Geomorphic wetlands in proximity of Lot 201 and 379 11
Table 3 Field pH test results interpretation criteria 16
Table 4 Texture-based acid sulfate soils 'action criteria' 17
Table 5 Soil samples selected for SPOCAS analysis 19
Table 6 Soil samples selected for chromium reducible sulfur analysis 20

LIST OF FIGURES

Figure 1 Locality Plan
Figure 2 Site Cadastral Boundaries
Figure 3 Topographic Contours and Geomorphic Wetlands Areas
Figure 4 Geology
Figure 5 Soil Types
Figure 6 Acid Sulfate Soil Risk Mapping
Figure 7 Groundwater Elevation
Figure 8 Soil Bore Locations

APPENDICES

APPENDIX A Soil Bore Logs
APPENDIX B Laboratory Data

EXECUTIVE SUMMARY

Cardno (WA) Pty Ltd (Cardno) was engaged by Amex Corporation Pty Ltd (Amex Corporation) to undertake a Preliminary Acid Sulfate Soils (ASS) assessment for Lots 379 and 201 which are located east of the Kwinana Freeway in Wellard (hereafter referred to as the site). This investigation was undertaken to determine potential for ASS to occur within the site and be disturbed during subsequent earthworks.

The preliminary ASS assessment was undertaken to highlight areas of the site which may be susceptible for the formation and persistence of ASS. This assessment will be used to provide information for further detailed investigation for the site expected to be required for future subdivision works.

The desktop and field investigations have revealed:

- The natural soil profile underlying the site comprised of fine to medium grained Bassendean Sands, with the presence of clayey sands and clays in the vicinity of the Conservation Category Wetland in the north-east corner of the site;
- Current soil conditions are generally slightly acidic, indicating that minimal natural buffering capacity is present within soils;
- The field pH test results indicated a slight potential for an increase in acidity after oxidation within soil profiles above the watertable, however, the laboratory results confirmed that there was no significant potential acidity related to pyrite within the soil;
- Laboratory analysis confirmed the presence of net acidity in excess of the DEC action criteria in soil profiles encountered below the observed watertable. The analysis indicated that the acidity content found within these profiles were potential acidity. The results also indicated variable acidity content with coffee rock profiles, suggesting the presence of some sulfidic acidity plus acidity from other sources; and
- Disturbance of soils encountered above the observed watertable are unlikely to cause ASS related impact, whilst disturbance of soil below the watertable (including dewatering) may require monitoring and management.

Based upon the results from this investigation Cardno is of the opinion that any potential risk and/or impact resultant from ASS (PASS) disturbance can be appropriately managed during the subdivision works. Whilst avoiding disturbance of soils below the groundwater table are the preferred management measure, this is unlikely to be practical given the servicing requirements of the subdivision. However, it has been shown in numerous developments that the potential impact upon the environment created by disturbing (excavating or dewatering) acid generating soils similar to those encountered at the site can be adequately managed via monitoring, soil treatment and well managed civil works.

Based upon this assessment, Cardno recommends:

- A detailed investigation to be undertaken when detailed design information regarding soil disturbance is available. The investigation should focus on soil from below the groundwater table that may be disturbed during the subdivision works. This would typically involve shallow disturbances in the south of Lot 201 and through most of Lot 379, whilst only deeper disturbances in the north of Lot 201 due to the greater separation distances between existing surface level and the groundwater. This information will enable the development of appropriate mitigation strategies; and
- A groundwater investigation be undertaken to determine groundwater quality specifically relating to ASS attributes of the groundwater to establish baseline conditions, determine the susceptibility of groundwater for acidification and enable any change in groundwater quality to be assessed prior to disturbance.

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1. INTRODUCTION

Cardno WA Pty Ltd (Cardno) was engaged by Amex Corporation Pty Ltd (Amex) to undertake a Preliminary Acid Sulfate Soils Assessment of Lot 201 Wake Way and Lot 379 Millar Road in Wellard (hereafter referred to as the site). These lots form the proposd subdivision known as Cascades, Wellard East.

The aim of this assessment was to review the potential for Acid Sulfate Soil (ASS) to occur within the site based on environmental, soil and landform conditions specific to the site. The assessment involved a desktop appraisal of the site's specific characteristics to identify those areas, if any, with conditions favourable for the formation of ASS within the soil profile. A field assessment of the site including the identification of visual indicators of ASS onsite, and field pH testing of the soils was conducted in order to confirm the findings of the desktop assessment.

The information obtained in this investigation will be assessed against a list of criteria contained in the Department of Environment and Conservation's guideline *'Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes'* (DEC 2009) to determine the requirement, if any, for further investigations.

1.1 Project Background

The site is located to the east of the Kwinana Freeway between Mortimer Road and Millar Road, approximately 35 minutes from the central business district of Perth. The site is situated in the locality of Wellard, within the Local Government Authority of the Town of Kwinana. A locality plan of the site is presented in **Figure 1**.

Under the Metropolitan Regional Scheme (MRS) the site is currently zoned 'Urban Deferred'. The Town of Kwinana Town Planning Scheme (TPS) currently lists the site as being within a 'Rural A' zone. An aerial photograph demonstrating the site's current condition and cadastral boundaries is provided in **Figure 2**.

1.2 Objective

The objective of this assessment is to conduct a systematic review of physical and environmental attributes and existing reports combined with a field investigation component to identify if there are conditions present within the site that are suitable to the formation and persistence of ASS.

1.3 Scope of Work

The scope of work for this ASS investigation includes;

- A desktop review of geomorphological and hydrogeological attributes of the site, previous environmental reports, and ASS risk maps pertinent to the site;
- A soil assessment including;
    - Installation of seven soil bores, noting soil types and visual observation for evidence and/or indicators of ASS;
    - Field pH testing of the soils;
    - Laboratory analysis on selected soil samples for Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) suite of analysis;
    - Confirmatory laboratory analysis on selected soil samples for Chromium Reducible Sulfur (CRS) suite of analysis; and
- A site inspection to identify visual indications of ASS.

1.4 Relevant DEC Guidelines

The DEC has produced a series of guidelines to assist in the identification, assessment and management of ASS in Western Australia. The Acid Sulfate Soils Guidelines Series include:

- *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes published in May 2009*; and
- *Treatment and management of soils and water in acid sulfate soil landscapes* published in draft format by the DEC in January 2009.

Section 4 of the guideline '*Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes'* (DEC 2009) details a number of factors which identify the need for ASS investigations. ASS investigations are required if any of the following works are proposed:

- Soil or sediment disturbance greater than 100 m^3 in ASS high risk areas;
- Lowering of the watertable, whether temporary or permanent in areas depicted as "High risk" of Actual Acid Sulfate Soils (AASS) or Potential Acid Sulfate Soils (PASS) soils occurring or dewatering operations in areas depicted as "Moderate to Low risk" of AASS or PASS occurrence that are located within 500 m from the high risk areas;
- Evidence of a significant risk of disturbing ASS areas classified as "Moderate to Low Risk", where disturbance exceeds 3.0 m below ground surface (mBGS);
- Dredging operations;
- Extractive industry works;
- Flood mitigation works, including construction of levees and flood gates; or
- In any of the areas listed in section 3.2 of the DEC guideline and reproduced in **Section 2.4** of this report.

2. ACID SULFATE SOILS

2.1 Background

ASS is naturally occurring soils that contain iron sulfide (iron pyrite) minerals. In an undisturbed state, ASS is stable and presents no risk to the environment. If disturbed by construction works, such as dewatering, drainage or soil excavation, the pyrite can oxidise thereby releasing acidity and potentially causing environmental impacts, damage to infrastructure and affects on human health.

ASS that have been oxidised and resulted in the creation of acidic conditions are termed Actual Acid Sulfate Soils (AASS); and those that have an acid generating potential but remain in their natural, waterlogged, anaerobic conditions are termed Potential Acid Sulfate Soils (PASS). Soils that are neither acidified nor have the potential to acidify are termed Non Acid Sulfate Soils (NASS).

An overview of the ASS risk potential on the Swan Coastal Plain is provided in the Western Australian Planning Commission Planning Bulletin Number 64 that was initially released in 2003. The risk mapping was updated and the coverage expanded in 2007 (WAPC 2007).

2.2 Pyrite Accumulation

Pyrite forms via bacterial degradation under specific environmental conditions. The chemical equation for the formation of pyrite is:

$$4SO_4^{2-} + Fe_2O_3 + 8CH_2O + \tfrac{1}{2}\,O_2 \rightarrow 2FeS_2 + 8HCO_3^- + 4H_2O$$

The environmental factors required for ASS formation are:

- An anoxic environment (wet and oxygen free);
- A supply of sulphur;
- A source of iron;
- A supply of organic matter; and
- The removal of the reaction products (HCO_3^-).

A supply of organic matter is essential to provide a food source for the microbial degradation process. Sulfur is generally present in the form of the sulphate ion (SO_4^{2-}) and is available from a number of sources within the environment. Typically coastal ASS formations result from the utilisation of sulphur in seawater, whilst inland ASS results from the utilisation of sulphur in groundwater, especially in saline areas. In other areas, sulphur contained within sulfidic minerals (coal seams, shales and pyrytic rocks) is utilised. Iron is generally utilised in the form of Fe (III) oxides within the sediment or soils of the area. Environmental conditions encouraging the removal of reaction products promote the continued formation of the iron sulfide mineral.

2.3 Pyrite Oxidation

Pyrite is stable under reducing conditions. However, disturbance of such conditions may result in oxidation and generation of sulphuric acid and mobilisation of Fe^{2+} ions. The complex series of reactions involved in this process may be simplified to:

$$FeS_2 + {}^{7}/_{2}O_2 + H_2O \rightarrow Fe^{2+} + 2SO_4^{2-} + 2\,H^+ \qquad (1)$$

$$Fe^{2+} + {}^{1}/_{4}O_2 + {}^{3}/_{2}H_2O \rightarrow FeO{\cdot}OH + 2H^+ \qquad (2)$$

2.4 Acid Sulfate Soil Risk Areas

Seasonally inundated soil profiles immediately above the groundwater table are prime locations for the effects of ASS as they will have undergone the periodic formation and oxidation of ASS as groundwater fluctuations within the soil profile create an environment which alternates between aerobic and anaerobic conditions. Soils in the profile significantly above the water table do not generally experience conditions conducive to ASS formation and as such are not considered to present a significant risk of ASS disturbance during development activities. As ASS requires waterlogged conditions to persist, they are therefore present predominantly below the water table.

The DEC guideline '*Identification and investigation of acid sulfate soils and acidic landscapes*' (DEC 2009) lists the following environmental features as locations where ASS is known to have developed or have the appropriate combination of environmental factors to promote the development of ASS:

- Areas depicted on geology and/or geomorphological maps as geologically recent (Holocene) such as –
  - Shallow tidal flats or tidal lakes;
  - Shallow estuarine or shallow marine deposits;
  - Stranded beach ridges and adjacent swales;
  - Interdunal swales or coastal sand dunes;
  - Coastal alluvial valleys;
  - Wetlands;
  - Floodplain;
  - Waterlogged areas;
  - Scalded areas;
  - Marshes;
  - Swamps;
- Areas depicted in vegetation mapping as –
  - Mangroves;
  - Wetland dependant vegetation such as reeds and paperbarks (*Melaleuca spp.*);
  - Areas where the dominant vegetation is tolerant of salt, acid and/or waterlogging conditions e.g. mangroves, salt couch, swamp-tolerant reeds, rushes, paperbarks and swamp oak (*Casuarina spp.*);
- Areas depicted in geological descriptions or in maps as –
  - Bearing sulfide minerals;
  - Former marine or estuarine shales and sediments;
  - Coal deposits;
  - Mineral sand deposits;
- Areas known to contain peat or a build up of organic material;
- Areas where the highest known watertable is within 3.0 m of the surface;
- Land with elevation less than 5.0 mAHD; and
- Any areas in Western Australia (including inland areas) where a combination of all of the following pre-disposing factors exist –
  - Organic matter;
  - Iron minerals;
  - Waterlogged conditions or a high watertable;
  - Sulfidic minerals; and
  - Deep estuarine sediments below ground.

The above features have been attributed to the presence or formation of ASS and are therefore used during a desktop assessment to identify areas where the formation of ASS is most likely. Subsequently, intrusive investigations should target these areas to determine the nature and extent of ASS that could be potentially affected by the proposed works.

2.5 Requirement for Detailed Investigations

In the guideline '*Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* (DEC 2009), the DEC has identified six factors (as detailed in **Section 2.4**) where, if any are present in relation to the site and the proposed disturbance, there is a need for further detailed site investigations or management. These will be assessed as the basis for determining the requirement for further detailed investigations for this site.

3. DESKTOP ASSESSMENT

The desktop appraisal process in this investigation intends to review geomorphological and hydrogeological attributes, existing environmental reports and ASS risk maps to identify where ASS factors and/or characteristics can be found on site. Findings from the desktop review are presented below.

3.1 Topography

Review of site topographic contours indicate that the highest point at the site is in the north west of Lot 201 along a south east, north west facing ridge reaching approximately 19 mAHD. The north east face of the ridge slopes down towards a wetland area in the north east of Lot 201 at approximately 11 mAHD. The west facing slope of the ridge declines to approximately 10 mAHD in the south of Lot 201.

There is also an east west aligned ridge in the north of Lot 379 reaching approximately 16 mAHD. The south facing slope of the ridge declines to approximately 8 mAHD in the south of Lot 379, and is the lowest point of the site.

An area of lower elevation is present between the two ridges, extending to the south of the ridge present in Lot 379. This area of low elevation sets as a drainage pathway from the Conservation Category Wetland to the north-east of Lot 201 and includes defined drainage and paths. The topography of the site is presented in **Figure 3**.

3.2 Geology

Geomorphological classification for the site reported in The *Perth Metropolitan Region 1:50,000 Environmental Geology Series Rockingham (Part of Sheets 2033 II and 2033 III)* (Gozzard 1983) indicates that the majority of the site consists of variations of free draining (highly permeable) Bassendean sands. Bassendean soil types are usually described as very light grey at the surface, yellow at depth, fine to medium-grained, moderately to well sorted. The sands, eolian in origin, were formed during the Pleistocene period.

Another soil unit was identified in areas of low elevation surrounding the ridge in Lot 379. The soil unit generally consists of a thin veneer of Bassendean Sand overlying a clay, silt, clayey silt or variations thereof. The permeability of this soil type is reported to be variable, ranging from low to high, and is dependent on the soil constituents (i.e. increases in the proportion of clay in the soil type would decrease permeability).

Further review of the geological map indicates that the wetland area in the north east of the site consists of dark brownish sandy silt, with fine grain quartz and variable clay content. This sandy silt is reported to have been formed during the Holocene period. Soil units formed during the Holocene period, after the last major sea level rise where waterlogged conditions promoted the production of iron sulfides, are commonly associated with ASS (DEC 2009).

The geology encountered at the site is illustrated in **Figure 4**.

3.2.1 Soil Types

The Department of Agriculture of Western Australia describes the various soil types which are commonly encountered within the regions and sub-regions of Western Australia. The Department of Agriculture map (AGWA 2002) containing the site indicates that there are four different Bassendean Sand phases encountered within the site.

Bassendean wet swamp phase is described as having wet soils, pale deep sands and peaty sands. This phase is present in the north-east part of the site consistent with the boundaries of the Conservation Category Wetland present within that part of the site.

Bassendean B1 phase covers the majority of the site and is described to contain deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 mBGS.

Bassendean B6 phase is described as deep or very deep grey siliceous sand soils. This phase is present within a south-west portion of Lot 201 and within a small part of the south-easterly corner of Lot 379.

Bassendean B3 phase is encountered in the south and south-west part of Lot 201 and within the central part of Lot 379. The soil encountered in this phase are described as moderately deep, bleached sands with an iron-organic pan, or clay subsoil, with dark grey sand or sandy loam surfaces.

Bassendean B2 phase is described to contain deep bleached grey sand soils with a pale yellow B horizon or a weak iron-organic hardpan between 1 and 2 mBGS. This phase is encountered within the southern part of the site.

Bassendean Sand encountered below the watertable often has acid generating potential. Although the potential acidity is low, because of the free draining nature of the soils any acid generated can be mobilised quickly if disturbed. Coffee rock or iron rich soils of varying cementation are also often found at the groundwater table below Bassendean Sand. Coffee rock can have a high acid producing potential upon disturbance and can lead to localised groundwater acidification under prologued dewatering activities.

Site observations of soil types were previously recorded by Cardno (Cardno 2007) in bore logs during the installation of numerous monitor wells in Lots 201 and 379. The logs were consistent with the information predicted in the geological and soil types mapping. Generally pale grey sands were encountered at the surface whilst at depth yellow, white and brown sands were common. Generally brown sands were observed in the lower elevations of Lots 201 and 379.

Soil types encountered at the site are illustrated in **Figure 5**.

3.2.2 ASS Risk Map

Broad scale maps of Acid Soils Risk for the Swan Coastal Plain are published in the Western Australian Mapping Commission (WAPC) *Planning Bulletin No. 64* (WAPC 2007). Since first publishment these maps have been updated and maintained by the DEC (DEC 2009). The ASS risk maps published provide a broad scale indication of areas where ASS is likely to exist based on the review of geological, geomorphological and hydrological information to predict areas susceptible to the formation of ASS.

The ASS risk map indicated the majority of the site as having a 'moderate to low risk of ASS' within three metres of the natural soil surface. The map also shows an area of 'high to moderate risk of ASS' within three metres of the natural soil surface, inside the north east boundary of Lot 201. The 'high risk' area extends outside the fence line of Lot 201 and is consistent with the location of a conservation category wetland, and the sandy silt soil types reported for this area.

In addition, two other 'high risk' areas are located directly east of where Lot 201 and Lot 379 meet. These areas highlighted as 'high risk' are consistent with the location of the wetland areas; although the area to the north has been partially covered by the Kwinana Freeway access ramps for Mortimer Road. The ASS risk map for the site is presented in **Figure 6.**

3.3 Hydrogeology

3.3.1 Groundwater

The *Perth Groundwater Atlas* (DoW 2004) indicates that groundwater underlying the site ranges from approximately 9.0 mAHD in the north to 4.0 mAHD in the south at its lowest point in the seasonal cycle as reported in May 2003. This corresponds to a depth of approximately 9.0 m below ground surface (mBGS) in the north west of Lot 201, and approximately 3.0 mBGS to 4.0 mBGS in the south of Lot 379. The DoW May 2003 groundwater contours are presented in **Figure 7**.

A search of the Department of Water (DoW) Registered Groundwater Bore Database was requested and identified 24 registered bores within a 1 km radius of the site. One registered bore was identified within the site. Bore 20024196 is located within Lot 201 and is used for irrigation purposes.

The registered bore search also indicated that there were some bores in close proximity to the site. Bores 3057 and 3058 located approximately 400 m east of Lot 379 reported groundwater depths between 7.99 mAHD and 10.51 mAHD. These levels are generally consistent with data obtained from the groundwater atlas.

3.3.2 Wetlands, Surface Water and Drainage

3.3.2.1 Wetlands

The *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (1992 EPP) dataset identified surface water bodies that contained over 1,000 m^2 of water on the Swan Coastal Plain during the 1 December 1988. The *Geomorphic Wetlands of the Swan Coastal Plain* dataset was subsequently developed to address many of the shortcomings associated with the 1992 EPP dataset, and is continually updated with site-specific wetland surveys providing new and relevant information. The dataset categorises individual wetlands into management categories outlined below in **Table 1**.

Table 1 Wetland management categories

Management Category	Description of Wetland	Management Objectives
Conservation Category Wetland (CCW)	Wetlands, which support high levels of attributes and functions.	To preserve wetland attributes and functions through reservation in national parks, crown reserves, state owned land and protection under environmental protection policies
Resource Enhancement Wetland (REW)	Wetlands, which have been partly modified but still support substantial functions and attributes.	To restore wetlands through maintenance and enhancement of wetland functions and attributes by protection in crown reserves, state or local government owned land and by environmental protection policies, or in private property by sustainable management
Multiple Use Wetland (MUW)	Wetlands with few attributes, which still provide important wetland functions.	Use, development and management should be considered in the context of water, town and environmental planning through Landcare

Wetland environments provide ideal waterlogged carbon rich conditions that are required for the formation of ASS soils (DEC 2009). Wetlands are therefore strongly tied to the presence of ASS. Review of the *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that part of a 'Conservation Category Wetland' lies within the north east boundary of Lot 201. A 'Multiple Use Wetland' is also located in the southern portions of Lot 201 and 379 along the areas of lowest elevation. Other wetlands classified as 'Multiple Use Wetland', 'Resource Enhancement Wetland' and 'Conservation Category Wetland' are also located in close proximity to the site. The details are outlined in outlined in **Table 2**.

The 'Conservation Category Wetland' to bordering the north east of Lot 201 is considered to be the closest environmental receptor that may potentially experience adverse groundwater impacts as a result of development of the site. The location of wetlands classified in the *Geomorphic Wetlands of the Swan Coastal Plain* is illustrated in **Figure 3**.

Table 2 Geomorphic wetlands in proximity of Lot 201 and 379

UFI Number	Wetland Name	Management Category	Classification	Location from Site
12921	-	MUW	Dampland	South and south east of Lot 201, north east and central Lot 379
12918	-	CCW	Dampland	Eastern part of Lot 201
12917	-	REW	Sumpland	100m north of Lot 201
6672	-	REW	Sumpland	100m east of Lot 379
12919		REW	Dampland	100m east of Lot 380
14014	-	MUW	Palusplain	300m south of Lot 380
6540	-	REW	Palusplain	400m south west of Lot 379
6541	-	REW	Palusplain	500m south west of Lot 379
13327	Bollard Bulrush Swamp	MUW	Sumpland	600m west of Lot 201
6730	Bollard Bulrush Swamp	REW	Sumpland	1000m west of Lot 201

3.3.2.2 Surface Water and Drainage

Review of the *District Water Management Strategy* (Cardno 2009) for the site indicates that surface water on the site consists of two drains, the northern Peel Branch Drain and the southern Peel Branch Drain. The northern Peel Branch Drain extends along the eastern boundary of Lot 201, and the southern Peel Branch Drain crosses the site between Lots 379 and 380 with a branch of the drain crossing the southern part of the Lot 379. The two drains join west of the site, travel beneath the Kwinana Freeway and join the Peel Main Drain running west of the site.

3.4 Vegetation

Review of current aerial photography of the site indicates that the majority of the site has been cleared for agricultural purposes and now consists of predominantly grassed paddocks. Lot 201 retains scattered vegetation within the northern portion and is likely to contain wetland dependant vegetation along the north eastern boundary where the 'Conservation Category Wetland' is located. Lot 379 is parkland cleared, however remnant vegetation is present in the north, and around the homesteads of both Lot 379 and Lot 380.

A *Spring Flora and Vegetation and Wetland Assessment* (Cardno 2008) for the site was undertaken by Cardno in 2008. The investigation confirmed that site retains very little remnant vegetation due to historic clearing and subsequent grazing of livestock. Remnant vegetation was observed in the 'Conservation Category Wetland' 12918 and within the southern portion of Lot 201 adjacent to the Kwinana Freeway.

The investigation identified six plant communities within the site including:

1. **PC1:** Low lying forest of *Eucalyptus rudis* over *Taxandria linearfolia - Astartea scoparia* over *Pteridium esculentum* on sandy loam to sandy clay and areas of permanently inundated peaty clay;
2. **PC2:** Low lying forest of *Corymbia calophylla* over *Asteartea scoparia - Taxandria linearfolia - Melaleuca teretifolia* over **Rubus anglocandicans - *Pennisetum clandestinum* on sandy loam to sandy clay;
3. **PC3:** Low lying woodland of *Eucalyptus rudis* over *Melaleuca teretifolia* over pasture grasses on grey sandy loam;
4. **PC4:** Low lying woodland-forest of *Eucalyptus rudis - Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielisia stenostachya - Opercularia hispidula - *Zantedeschia aethiopica* on grey sandy loam;
5. **PC5:** Low upland woodland of *Corymbia calophylla - Eucalyptus marginata* over *Agonis flexuosa - Casuarina obesa - Banksia menzeisii - Banksia grandis* over *Eremaea pauciflora - Calothamnus quadrifidus* over *Conostylis aculeata* subsp. *cygnorum - Kennedia prostrata - *Ehrharta longiflora - *Lolium rigidum - *Carpobrotus edulis* on grey sandy loam; and
6. **PC6:** Tall Scrub of *Kunzea glabrescens - Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis* on grey sandy loam.

The *Spring Flora and Vegetation and Wetland Assessment* (Cardno 2008) identified wetland vegetation along the north east, and southern boundaries of Lot 201 and in the north and central portions of Lot 379. Wetland dependant vegetation provides an indication of areas which are frequently waterlogged and at risk of containing ASS.

3.5 Previous investigations

Several environmental investigations incorporating the site and surrounding areas have been conducted in previous years.

Cardno was engaged to undertake surface and groundwater investigation to provide baseline water quality data and groundwater levels within an area that incorporated the site. The objective of the project was to characterise the pre-development hydrological environment, and incorporated quarterly groundwater quality monitoring and surface water quality monitoring (undertaken following five rainfall events over the same period. Two annual monitoring reports have been completed incorporating two monitoring periods (October 2005 to September 2006 and October 2006 to September 2007).

The 2005-2006 report concluded:

- Groundwater contours developed for the site based on groundwater levels measured from groundwater bores installed on the site were consistent with those predicted within the Perth Groundwater Atlas;
- Elevated nutrients, in particular Total Phosphorus (TP) were detected in groundwater during the initial groundwater monitoring event, however were localised and not widespread throughout the site;
- Nutrient levels in deep bores were substantially lower than nutrient levels in shallow bores;
- Nutrient levels within groundwater substantially exceeds nutrient levels within surface water; and
- Nutrient concentrations within most groundwater wells exceeded published trigger guideline levels for surface water.

The 2006-2007 report concluded:

- Total Nitrogen (TN) and TP concentrations at the surface water locations within the Peel Main Drain were 'low' to 'moderate';

- Nutrient concentrations at the surface water locations within the Peel Branch Drain were 'moderate' to 'high' (TN) or 'very high' (TP). Both of these trends are consistent with the data collected during the first year of monitoring;
- Significant TN and TP concentration increases were observed between surface water locations in the northern part of Wellard East, suggesting that this area is contributing to the nutrient load of the surface water; and
- Given the lack of surface water data within the Peel Branch Drain, a result of the strong interaction between groundwater and surface water, it is considered the current SAP is yet to accurately characterise the nutrient concentrations of this surface water feature.

Cardno completed a Preliminary Site Investigation (PSI) for Lots 201 and 379 in November 2008. The reported concluded:

- Part of Lot 201 (formerly a market garden) may contain residual soil contamination as a result of previous chemical application;
- A former dairy within Lot 379 may contain residual soil contamination as a result of treatment chemicals for livestock, and the possible storage of hydrocarbons;
- Background information reviewed indicated that there were no environmental or heritage attributes that would preclude the proposed development or be impacted by any identified contamination;
- Human receptors associated with the future subdivision are the most likely receptors for identified on site contamination, and the Bollard Bulrush Swamp is a potential groundwater receptor; and
- Recommendations included a requirement for a detailed soil and groundwater investigation of the two possible sources of contamination.

3.6 Summary

ASS risk mapping for the site indicates that the majority of the site is in a 'moderate to low' ASS disturbance risk within 3.0 mBGS; however an area of 'high to moderate' ASS disturbance risk located along the north east boundary of the site. This area is consistent with the location of a conservation category wetland which extends outside of the site. However, there are also areas where groundwater is present at comparatively shallow depths (< 1.0 mBGS) and drains are also present where wetland dependant vegetation has been identified.

The desktop investigation indicate that based upon the review of geomorphological and hydrogeological attributes of the site, previous environmental reports and ASS risk maps pertinent to the site, there may be conditions present that promote the formation and persistence of ASS and acid generating soils of various depths within the soil profile at the site.

Review of geomorphological and hydrogeological attributes of the site indicate that there are particular areas of the site which present conditions suitable for the formation and persistence of ASS. Isolated areas of the site where wetland, wetland vegetation, silty soil units (associated with wetlands), and a shallow watertable (<3.0 mBGS) exist are at the highest risk of containing ASS and acid generating soil onsite, especially with respect to shallow disturbance or excavation. If present, ASS is likely to be present within soils immediately above or below the groundwater table.

4. SITE INSPECTION

A site inspection, including the installation of seven soil bores, was undertaken on 15 July 2009. The inspection aimed to identify the presence and location of factors commonly associated with the occurrence of ASS and to confirm the findings of the desktop assessment. Relevant site observations are detailed below.

4.1 Topography

A visual inspection of the site indicates that areas of higher elevation exist within the site. The first is located in the north part of Lot 201 and has a south, east and north facing slope all with relatively gentle relief. The second elevation is located in the north part of Lot 379 and has marginally steeper north and south west facing slopes. The remaining area in Lot 379 is relatively flat. These observations are consistent with the data obtained and reviewed during the desktop assessment.

4.2 Geology

Soil profiles at the site were observed by Cardno during the installation of seven soil bores. Placement of the soil bores was based on the expected location of the different Bassendean soil profile types identified during the desktop assessment of the site. The location of soil bores is presented in **Figure 8**.

The soil profies indicated that geology of the site was generally consistent with the expected Bassendean Sand soil types and was comprised of;

- Sand as the predominant soil unit;
- Sand overlying clays and clayey sand soil units in some locations; and
- Limited peaty (organic) sands, and coffee rock horizons.

Generally soil bores placed in areas of higher elevation (i.e. the areas in the north of Lot 201 and Lot 379) contained solely free draining sand (SB1, SB3 and SB5) to depths up to 4.0 mBGS. The soil profile in areas of lower elevation, which appeared to be subject to shallow watertables, varied slightly in soil profile structure. The presence of clay and clayey sands was noted amongst Bassendean Sands in soil bore SB2, installed in the vicinity of the 'Conservation Category Wetland' in the north-east part of the site. Brown sands (coffee rock precursor) were observed below the observed groundwater in soil bores (SB4, SB6 and SB7) placed in the lower elevations in the south of Lot 379 and south of Lot 201. The presence of coffee rock (cemented fragments) was also noted in soil bore SB4, below the observed groundwater, at a depth of approximately 3.8 mBGS.

Sands with elevated levels of organic matter was also observed below the watertable between Bassendean Sands, at a depth between 1.8 mBGS and 3.0 mBGS, in a soil bore (SB6) installed in a low lying area of Lot 379.

4.3 Hydrogeology

4.3.1 Groundwater

Groundwater was intersected in four of the seven soil bores which were installed to a maximum depth of 4.0mBGS. The approximate observed depth to groundwater includes;

- 3.0 mBGS in SB2;
- 2.5 mBGS in SB4;
- 0.6 mBGS in SB6; and
- 2.1 mBGS in SB7.

Soil bores SB2, SB4, SB6 and SB7 were installed in areas of lower elevation, and presented groundwater levels that were approximately consistent with the DoW groundwater contours indicated in the Groundwater Atlas.

4.3.2 Wetlands, Surface Water and Drainage

Visual inspection of the site confirmed that the only surface water visible onsite was located in the northern Peel Branch Drain running along the boundary between Lot 201 and Lot 379 and within a branch of the drain located in the southern part of Lot 379. At the time of inspection the southern Peel Branch Drain contained no visible surface water. This confirms the information reviewed during the desktop assessment. No other visible surface water was encountered within the site at the time of inspection.

4.4 Vegetation characteristics

Visual inspection of the site confirms that the majority of the site has been parkland cleared for agricultural (grazing) purposes. Limited scattered remnant vegetation was observed within the site including:

- Mature trees in the upper elevations of Lot 201;
- Dense *Melaleuca teretifolia (mallee and peppermint tree)* dominated woodland in the south of Lot 201 and the north of Lot 379;
- Melaleuca (paperbark species) observed in the lower elevations of Lot 379.

No vegetation stress or salt scars were identified during the site inspection.

5. SAMPLING AND ANALYSIS PLAN

Soil bore locations were distributed across the site in order to support the findings of the desktop assessment (soil profile and groundwater depth) and to indicate the likelihood of ASS occurrence within the site.

Collection of soil samples occurred at 0.25 m intervals through the soil profile for field pH testing and samples potentially for laboratory analysis were collected at 0.50 m intervals throughout each soil profile.

5.1 Soil Sampling

A total of seven soil bores were installed to a maximum depth of 4.0 m using a sonic push probe. The location of the soil bores is provided in **Figure 8**.

The field pH measurements and the analytical results were compared with observation data (soil types, depths and field test results) to assess the correlation between this data and the laboratory results obtained from selected samples, which would enable an extrapolation from the observation data to ascertain the presence and distribution of ASS across the site.

5.1.1 Field pH

Soil field pH testing was undertaken on all soil samples at 0.25 m intervals through the profile of each soil bore. Samples were collected into snap-lock plastic bags and rolled to expel air. The samples were then stored in a chilled esky and transported to ALS where field pH testing was undertaken using the QASSIT fast field assessment method.

The criteria applied when interpreting the relevance of field pH results in relation to the presence of AASS and PASS are presented in **Table 3**.

Table 3 Field pH test results interpretation criteria

	AASS	PASS	NASS
pH_F	≤ 4	> 4	> 4
pH_{FOX}	< 4	< 4	> 4

In addition to the criteria detailed in **Table 3**, the observed reaction strength and relative changes between soil pH (pH_F) and oxidised soil pH (pH_{FOX}) provide further evidence of the likely presence of PASS.

5.1.2 SPOCAS Suite of Analysis

Suspension Peroxide Oxidation Combined Acidity and Sulfate (SPOCAS) analysis was the method selected for laboratory analysis of the samples to confirm the findings indicated by the field pH results.

SPOCAS is a self-contained acid base counting test that provides a measurement of the maximum oxidisable sulphur, Titratable Actual Acidity (TAA) and Titratable Peroxide Acidity (TPA) and the potential Acid Neutralising Capacity (ANC) present in the soil sample. The TPA result from the SPOCAS analysis represents a measure of net acidity, effectively equivalent to the sum of the soil's potential sulfidic acidity and actual acidity. The calculated Titratable Sulfidic Acidity (TSA) is the difference between TPA and TAA. The peroxide oxidisable sulphur content (S_{POS}) provides a measure of the amount of potentially oxidisable sulphur in the soil sample and represents the sulfur trail.

The net acidity obtained from the samples submitted for SPOCAS analysis was compared against the DEC texture-based acid sulfate soils 'action criteria'. The DEC criteria applied when assessing the results are presented in **Table 4**.

Table 4 Texture-based acid sulfate soils 'action criteria'

Type of material	Net Acidity Action Criteria <1000 tonnes of materials disturbed	>1000 tonnes of materials disturbed
Sands to Loamy Sands	0.03 %S	0.03 %S
Sandy Loams to Light Clays	0.06 %S	0.03 %S
Medium to Heavy Clays and Silty Clays	0.10 %S	0.03 %S

5.1.3 Chromium Reducible Sulfur Suite of Analysis

The chromium reducible sulfur suite of analysis was used to confirm the results obtained from the SPOCAS suite of analysis.

The chromium reducible sulfur suite (S_{CR}) is a set of independent analytical methods each of which determines a component of the acid base account. Only the required components of the acid base account are measured using this approach, initially measuring the reduced inorganic sulfur content, by the chromium reducible sulfur to estimate the potential sulfidic acidity and then measuring the existing acidity and the Acid Neutralising Capacity (ANC).

6. SOIL INVESTIGATION

Soils encountered during the drilling process were visually examined by a Cardno representative and soil bore logs detailing the profile and field observations are presented in **Appendix A**.

During investigation works the presence of sands with elevated levels of organic matter and coffee rock horizons were observed in soil bores installed in areas of lower elevation in the south of Lot 201 and Lot 379. The presence of these soil units is generally associated with the presence of potential acidity. In relation to AASS, there was no presence of corroded shell, substantial iron oxide mottling in surface material, or in soils retrieved during the investigation.

6.1 Field pH Test Results

Field pH test results for soil bores SB1 and SB3 demonstrated essentially similar characteristics. The field pH (pH_F) test results obtained for these locations indicated the soil pH was slightly acidic with pH values ranging between pH 6.1 and pH 5.5. The oxidised soil field pH (pH_{FOX}) results indicated the pH_{FOX} remained above 4.0, with the exception of one sample collected within the topsoil profile that indicated pH_{FOX} 3.8 (SB3). These results indicate AASS and/or PASS are unlikely to be present at these locations to the depths investigated.

The pH_F for samples collected from soil bore SB2 indicated the soil pH was slightly acidic to neutral with pH values ranging between pH 7.6 and pH 4.8. The pH_{FOX} remained above 4.0, with the exception of one sample collected within the topsoil profile (pH_{FOX} 3.6), one sample collected within a clayey sand profile between 1.25 and 1.5 mBGS (pH_{FOX} 3.5) and the samples collected below the observed watertable (3.0 mBGS). The minimal change in the pH between the pH_F and the pH_{FOX} (ΔpH) in the samples collected above the observed watertable suggested that the pH_{FOX} values do not strongly indicate the presence of PASS within these soil profiles. However, the samples collected below the observed watertable indicated a significant ΔpH indicating the likely presence of PASS.

The pH_F results for soil bores SB4, SB6 and SB7 demonstrated essentially similar characteristics, indicating soil pH slightly acidic with pH values ranging between pH 6.4 and pH 4.2. The pH_{FOX} remained generally above 4.0 for the soils encountered above the observed watertable. However, samples collected from within the watertable fluctuation zone and below indicated a probable acid generating potential with pH values dropping to between pH 1.6 and pH 3.8.

The pH_F for samples collected from soil bore SB5 were similar to those reported for soil bores SB1 and SB3 in that the soil was slightly acidic with pH values ranging between pH 5.0 and pH 5.8. The results indicated the pH_{FOX} remained above 4.0, with the exception of one sample collected within the topsoil profile that indicated pH_{FOX} 2.8 and one sample collected between 1.25 and 1.5 mBGS that indicated pH_{FOX} 2.6. Both of these samples indicated minimal ΔpH and a free draining environment, suggesting that these results do not strongly indicate the presence of PASS.

The field pH test results indicate the soils within the site are generally slightly acidic, although the acidity is unlikely to be related to AASS. The field pH test results indicate soils above the groundwater present no significant likelihood of PASS, which is consistent with the conditions necessary for the development and persistence of ASS. Soils below the groundwater table, including coffee rock and organic rich soils have exhibited an acid producing potential.

Field pH test results have been used for sample selection and although the majority of the samples failed to demonstrate a strong ASS likelihood, laboratory testing is required to confirm the absence of ASS.
Field pH testing results are presented within the bore logs in **Appendix A.**

6.2 Analytical Results

Selected soil samples were submitted to ALS for laboratory testing. ALS is a NATA accredited laboratory for the analysis undertaken. The laboratory results are detailed in the soil bore logs provided in **Appendix A.** The laboratory certificates are provided in **Appendix B.**

6.2.1 SPOCAS Results

Soil samples submitted for SPOCAS analysis were selected to be representative of the soil types encountered within the site, focusing upon soil samples with stronger indications of an acid generating potential based on field pH results. **Table 5** indicates the samples that were selected for analysis and includes the sample collection depth (mBGS), soil type and field pH readings.

Table 5 Soil samples selected for SPOCAS analysis

Sample ID	Soil Texture	pH_F	pH_{FOX}
SB2 - 1.5m	SC, Clayey Sand – fine medium grained, pale brown, fines of low plasticity	5.3	3.5
SB2 - 3.5m	SP, Sand – fine medium grained, grey/brown	7.2	2.1
SB3 - 1.0m	SP, Sand – fine medium grained, yellow	5.8	4.3
SB4 - 4.0m	SP, Sand – fine to medium grained, brown, with partially cemented coffee rock	6.0	1.9
SB5 - 1.5m	SP, Sand – fine medium grained, white/cream	5.4	2.6
SB6 - 2.25m	SP, Sand – fine to medium grained, brown/dark brown, with high levels of humus and organic matter (coffee rock precursor)	6.2	2.3
SB7 - 2.0m	SP, Sand – fine to medium grained, white	4.8	3.3
SB7 - 3.0m	SP, Sand – fine to medium grained, brown (coffee rock precursor)	5.4	1.7

Laboratory results from soil samples SB2 1.5m, SB3 1.0m, SB5 1.5m and SB7 2.0m all reported concentrations of existing and potential acidity below the action criteria. These results confirm the soil encountered above the groundwater contains no significant existing or potential acidity, even those soil profiles where field pH results indicate $pH_{FOX} < 4.0$.

The laboratory results for soil samples SB2 3.5m, SB4 4.0m, SB6 2.25m and SB7 3.0m collected from below the observed watertable, reported potential acidity above the action criteria. The net acidity reported for these samples was between 0.18 %S and 0.24 %S.

The SPOCAS results have indicated that mostly of the soil samples has negligible buffering capacity.

The net acidity calculated for the SPOCAS analysis takes into account both sulfidic (sulfur trail) and sulfidic and non sulfidic (acid trail) acidity that is created during oxidation. As such, the net acidity of some soil samples, in particular from coffee rock profiles, does not always represent only the potential ASS generated acidity within this soil profile but the total acidity potentially present within the sample from all sources.

Samples SB6 2.25m indicated a TSA acidity of 0.23 %S, whilst S_{POS} acidity of 0.12 %S. The difference between these results can be attributed to other forms of acidity, which although are not ASS, need to be included in the risk assessment.

6.2.2 Chromium Reducible Sulfur Results

Selected soil samples chosen to undergo SPOCAS suite of analysis were also submitted for confirmatory testing using the S_{CR} suite of analysis. Samples were selected based on the soil material content and field pH results. Sample selections are shown in **Table 6**.

Table 6 Soil samples selected for chromium reducible sulfur analysis

Sample ID	Soil Texture	pH_F	pH_{FOX}
SB2 - 3.5m	SP, Sand – fine medium grained, grey/brown	7.2	2.1
SB4 - 4.0m	SP, Sand – fine to medium grained, brown, with partially cemented coffee rock	6.0	1.9
SB6 - 2.25m	SP, Sand – fine to medium grained, brown/dark brown, with high levels of humus and organic matter (coffee rock precursor)	6.2	2.3
SB7 - 2.0m	SP, Sand – fine to medium grained, white	4.8	3.3
SB7 - 3.0m	SP, Sand – fine to medium grained, brown (coffee rock precursor)	5.4	1.7

S_{CR} results confirmed the results obtained from the SPOCAS analysis, indicating total acidity below the action criteria in the soil sample collected above the watertable (SB7 2.0m), and soil acidity above the action criteria in soil samples collected below the observed watertable. The S_{CR} results indicated soil sulfide content varying between 0.07 %S and 0.12 %S.

The S_{CR} results confirm the information obtained from the SPOCAS analysis which indicated different TSA and S_{POS} acidity for coffee rock samples. This supports the SPOCAS analysis findings, suggesting that other sources of acidity form a significant portion of the overall potential acidity of the sample.

6.1 Summary

Based on the laboratory results and the findings of this assessment, PASS and acid generating soils has been identified at the site in soil profiles encountered below the observed watertable and, if disturbed, may require treatment to mitigate potential environmental impacts.

Soil profiles encountered above the watertable at the site do not contain significant acid generating potential and will not require treatment.

7. CONCLUSIONS AND RECOMMENDATIONS

The preliminary ASS assessment was undertaken to highlight areas of the site which may be susceptible for the formation and persistence of ASS. This assessment will be used to provide information for further detailed investigation for the site expected to be required for future subdivision works.

The desktop and field investigations have revealed:

- The natural soil profile underlying the site comprised of fine to medium grained Bassendean Sands, with the presence of clayey sands and clays in the vicinity of the Conservation Category Wetland in the north-east corner of the site;
- Current soil conditions are generally slightly acidic, indicating that minimal natural buffering capacity is present within soils;
- The field pH test results indicated a slight potential for an increase in acidity after oxidation within soil profiles above the watertable, however, the laboratory results confirmed that there was no significant potential acidity related to pyrite within the soil;
- Laboratory analysis confirmed the presence of net acidity in excess of the DEC action criteria in soil profiles encountered below the observed watertable. The analysis indicated that the acidity content found within these profiles were potential acidity. The results also indicated variable acidity content with coffee rock profiles, suggesting the presence of some sulfidic acidity plus acidity from other sources; and
- Disturbance of soils encountered above the observed watertable are unlikely to cause ASS related impact, whilst disturbance of soil below the watertable (including dewatering) may require monitoring and management.

Based upon the results from this investigation Cardno is of the opinion that any potential risk and/or impact resultant from ASS (PASS) disturbance can be appropriately managed during the subdivision works. Whilst avoiding disturbance of soils below the groundwater table are the preferred management measure, this is unlikely to be practical given the servicing requirements of the subdivision. However, it has been shown in numerous developments that the potential impact upon the environment created by disturbing (excavating or dewatering) acid generating soils similar to those encountered at the site can be adequately managed via monitoring, soil treatment and well managed civil works.

Based upon this assessment, Cardno recommends:

- A detailed investigation to be undertaken when detailed design information regarding soil disturbance is available. The investigation should focus on soil from below the groundwater table that may be disturbed during the subdivision works. This would typically involve shallow disturbances in the south of Lot 201 and through most of Lot 379, whilst only deeper disturbances in the north of Lot 201 due to the greater separation distances between existing surface level and the groundwater. This information will enable the development of appropriate mitigation strategies; and
- A groundwater investigation be undertaken to determine groundwater quality specifically relating to ASS attributes of the groundwater to establish baseline conditions, determine the susceptibility of groundwater for acidification and enable any change in groundwater quality to be assessed prior to disturbance.

8. REFERENCES

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9. PROJECT WARRANTY

This report has been prepared on the basis of a unique project specific requirements as understood by Cardno and applies only to the site that is the subject of this report.

The findings and conclusions given in this report are based on site conditions unique to the project and applicable Government regulations that existed at the time the environmental investigation was conducted and the report prepared. This report was prepared in accordance with accepted environmental practices used by environmental professionals undertaking projects of a similar nature.

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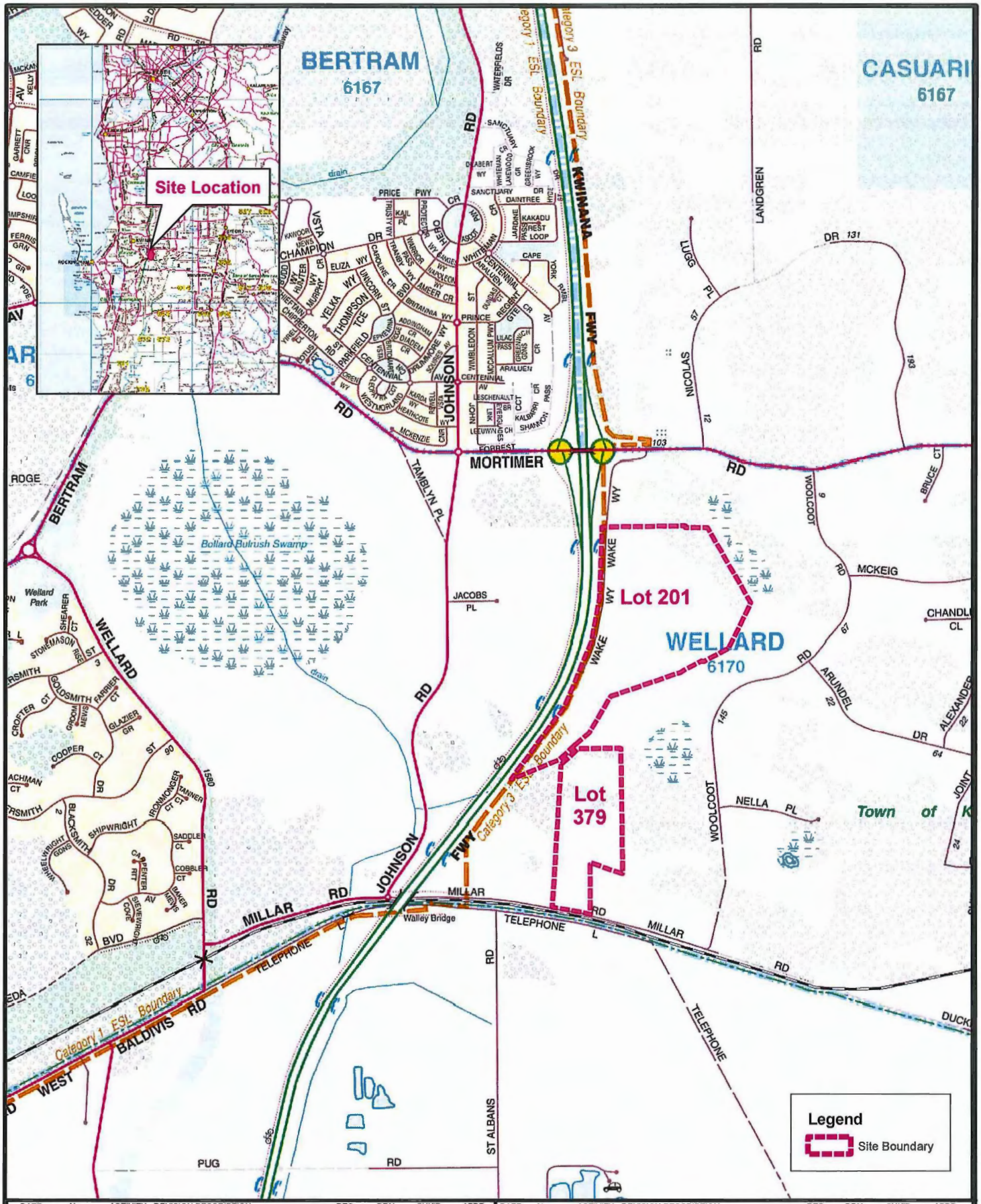
FIGURES

Figure 1 **Locality Plan**
Figure 2 **Site Cadastral Boundaries**
Figure 3 **Topographic Contours and Geomorphic Wetlands Areas**
Figure 4 **Geology**
Figure 5 **Soil Types**
Figure 6 **Acid Sulfate Soil Risk Mapping**
Figure 7 **Groundwater Elevation**
Figure 8 **Soil Bore Locations**



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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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0 125 250 500 750 1,000 1,250 1,500 1,750 2,000 Metres

PROJECT: Cascades, Wellard East
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE: FIGURE 1 : Locality Plan

PRINCIPAL: Amex Corporation Pty Ltd.

Project Number: V8041
Original: A4
Drawing Number: SK01
Revision: 00
Designed JLP
Checked JLP
Drawn DTF
Approved SPG
Local Authority Town of Kwinana
Sheet 1 of 1
Date 10/09/09

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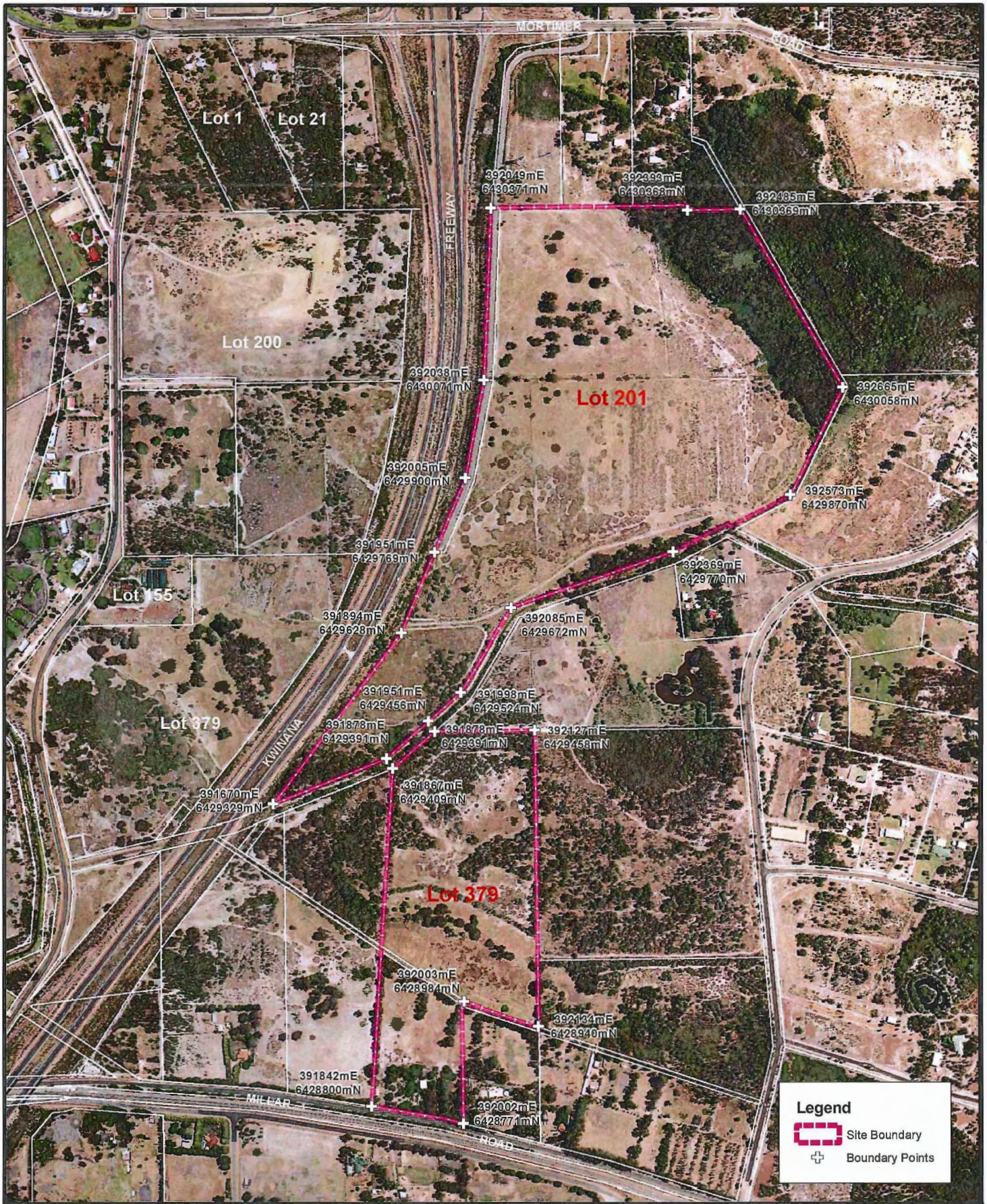

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Scale: 1:8,500

0 50 100 200 300 400 500 600 700 800 Metres

PROJECT **Cascades, Wellard East**
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE **FIGURE 2 : Site Cadastral Boundaries**

PRINCIPAL **Amex Corporation Pty Ltd.**

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Original **A4**
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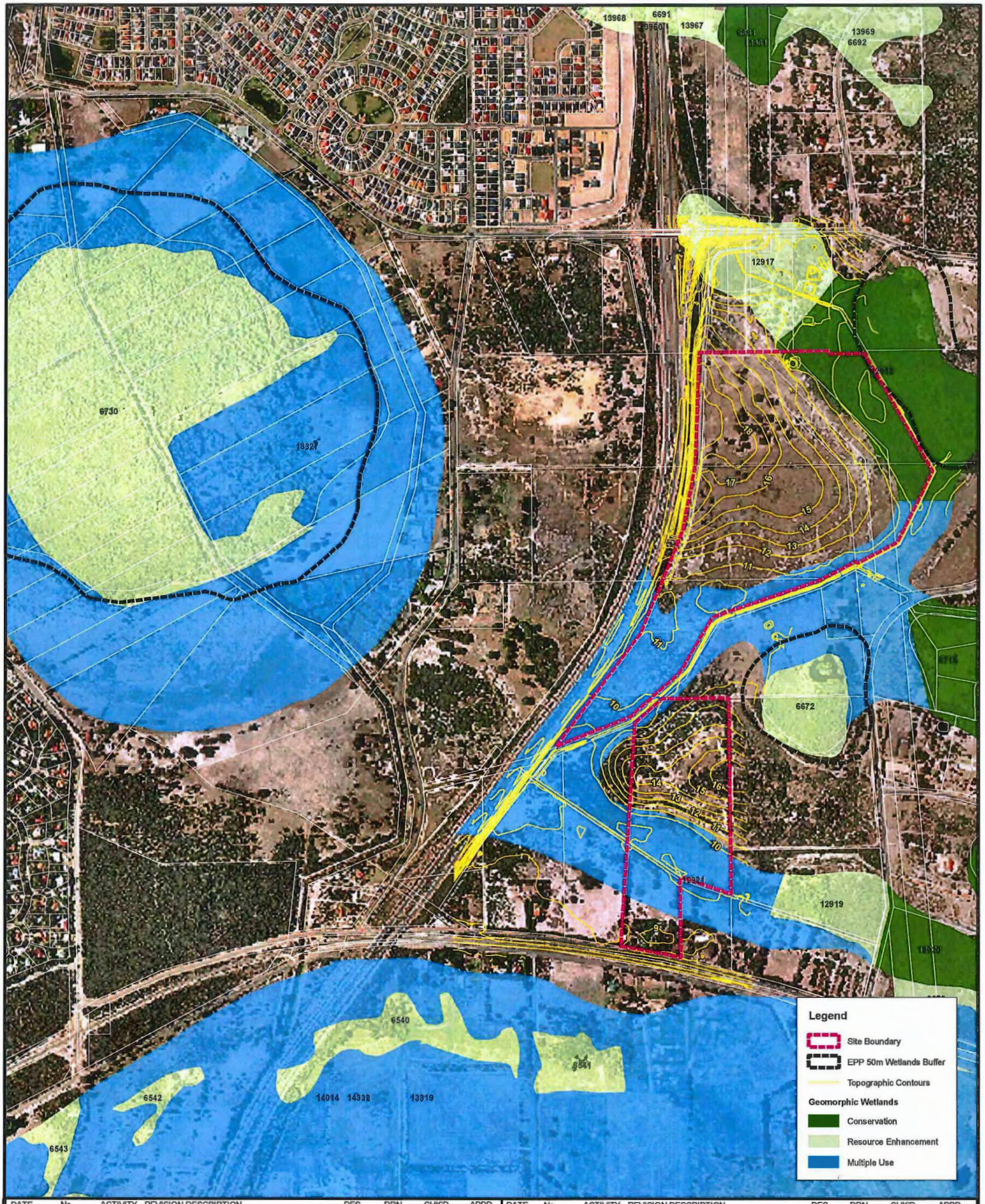
Sheet 1 of 1
Date 10/09/09



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:9,000

0 75 150 300 450 600 750 900 1,050 1,200 Metres

PROJECT Cascades, Wellard East
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE FIGURE 3: Topographic Contours and Geomorphic Wetland Areas

PRINCIPAL Amex Corporation Pty Ltd

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Project Number V8041
Original A3
Drawing Number SK03
Revision 00
Designed JLP
Checked JLP
Drawn DTF
Approved SPG
Local Authority Town of Kwinana
Sheet 1 of 1
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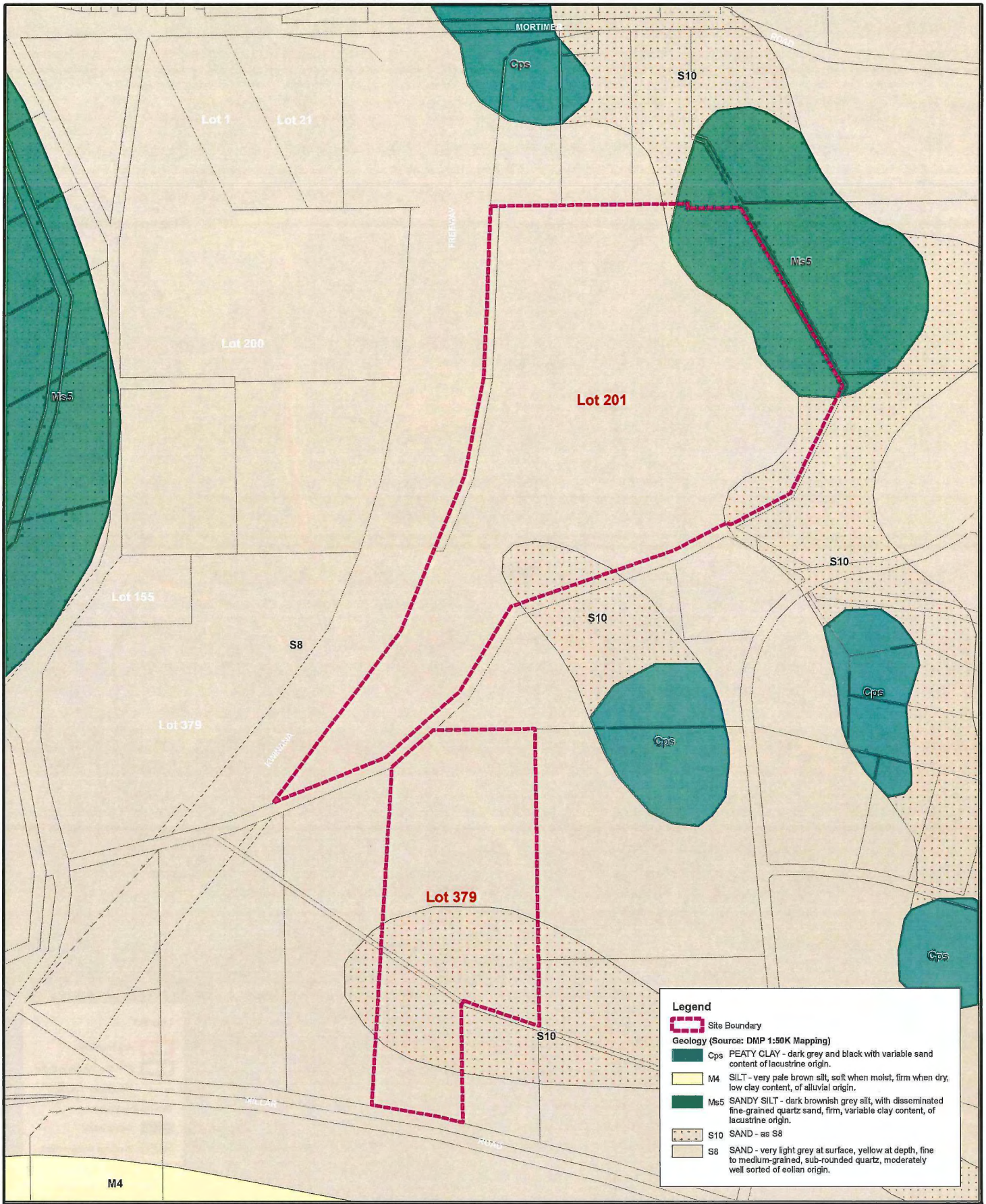

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:6,000

0 50 100 200 300 400 500 600 700 800 Metres

PROJECT: Cascades, Wellard East
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE: FIGURE 4 : Geology

PRINCIPAL: Amex Coporation Pty Ltd.

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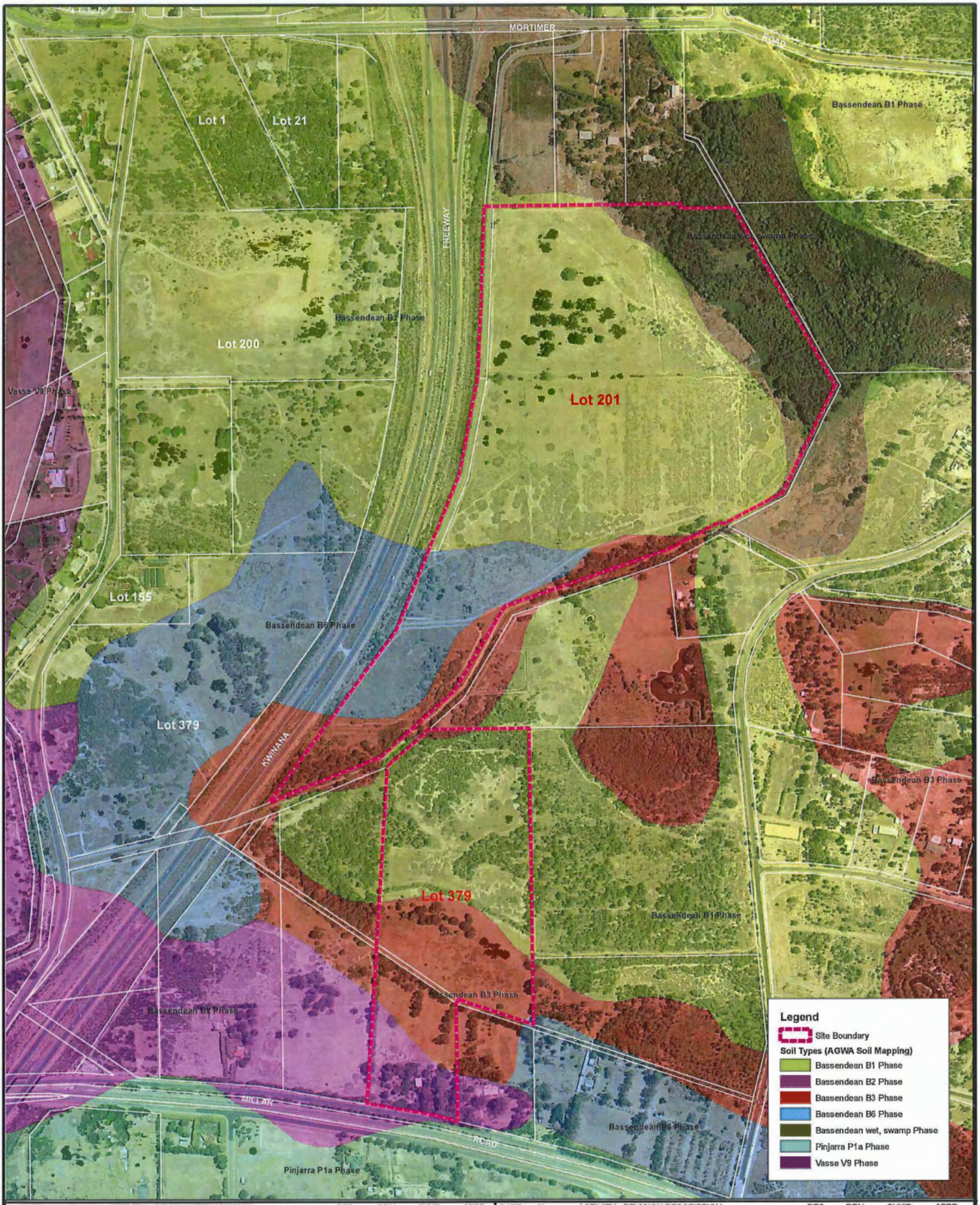
Project Number: V8041
Original: A3
Drawing Number: SK04
Revision: 00
Designed JLP
Checked JLP
Drawn DTF
Approved SPG
Local Authority Town of Kwinana
Sheet 1 of 1
Date 10/09/09



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHKD	APPD

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Scale: 1:6,000

0 50 100 200 300 400 500 600 700 800 Metres

PROJECT: Cascades, Wellard East
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE: FIGURE 5 : Soil Types

PRINCIPAL: Amex Coporation Pty Ltd.

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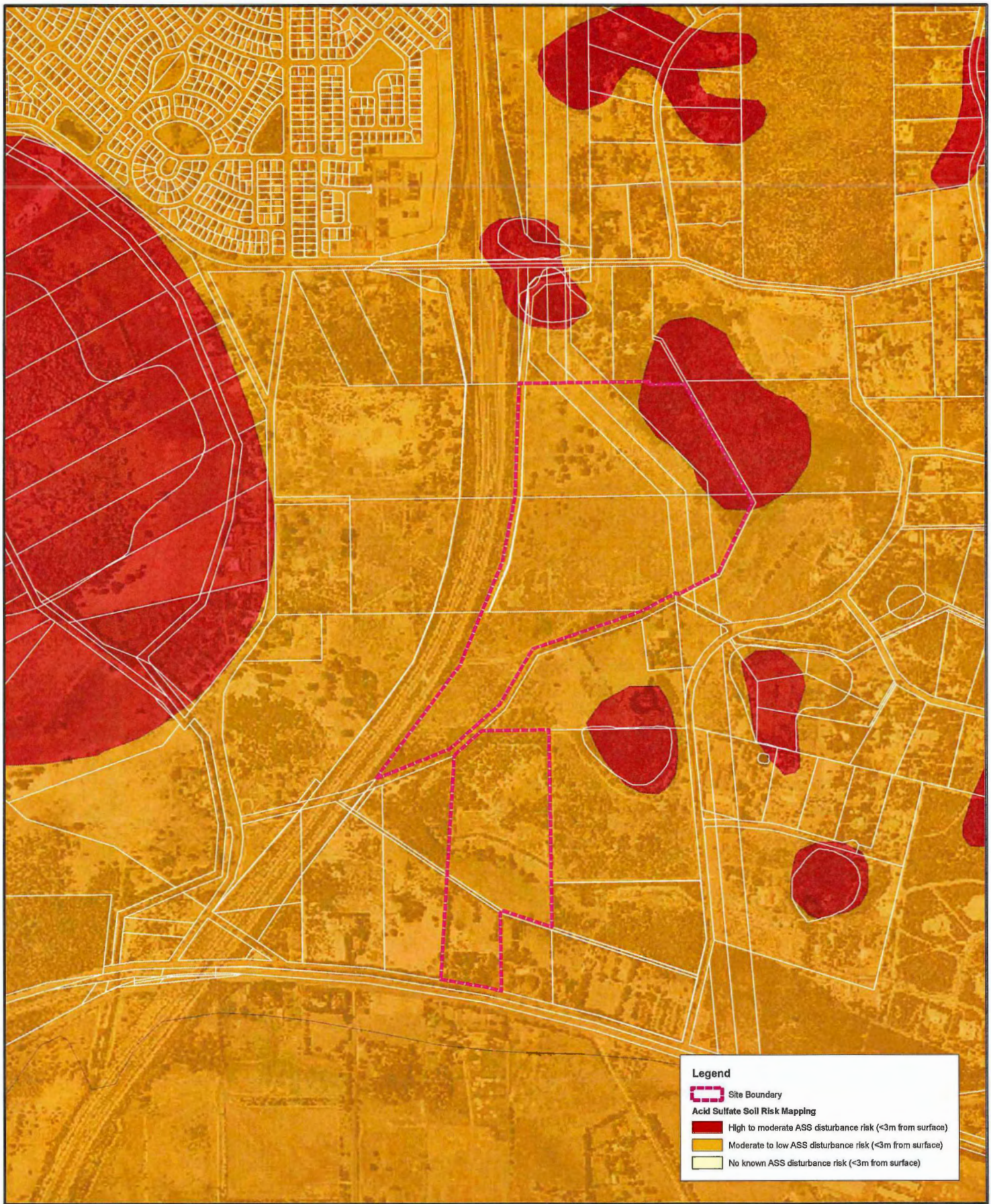
Project Number: V8041
Original: A3
Drawing Number: SK05
Revision: 00
Designed JLP
Checked JLP
Drawn DTF
Approved SPG
Local Authority Town of Kwinana
Sheet 1 of 1
Date 10/09/09



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:9,000

0 75 150 300 450 600 750 900 1,050 1,200 Metres

PROJECT: Cascades, Wellard East
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE: FIGURE 6: Acid Sulfate Soil Risk Mapping

PRINCIPAL: Amex Corporation Pty Ltd.

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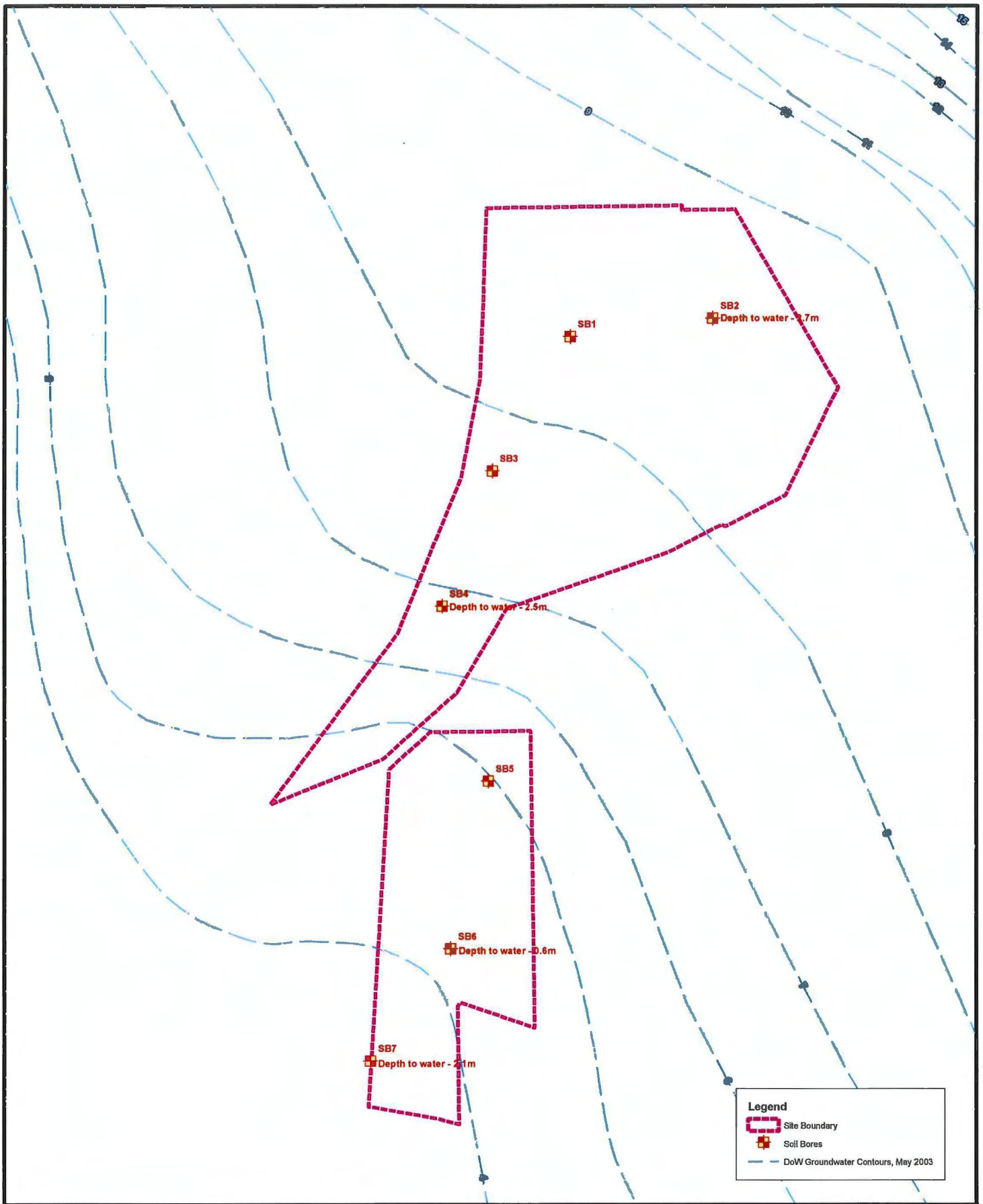
Project Number: V8041
Original: A3
Drawing Number: SK06
Revision: 00
Designed JLP
Checked JLP
Drawn DTF
Approved SPG
Local Authority Town of Kwinana
Sheet 1 of 1
Date 10/09/09



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:6,000

0 50 100 200 300 400 500 600 700 800 Metres

PROJECT: Cascades, Wellard East
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE: FIGURE 7 : Groundwater Levels

PRINCIPAL: Amex Coporation Pty Ltd.

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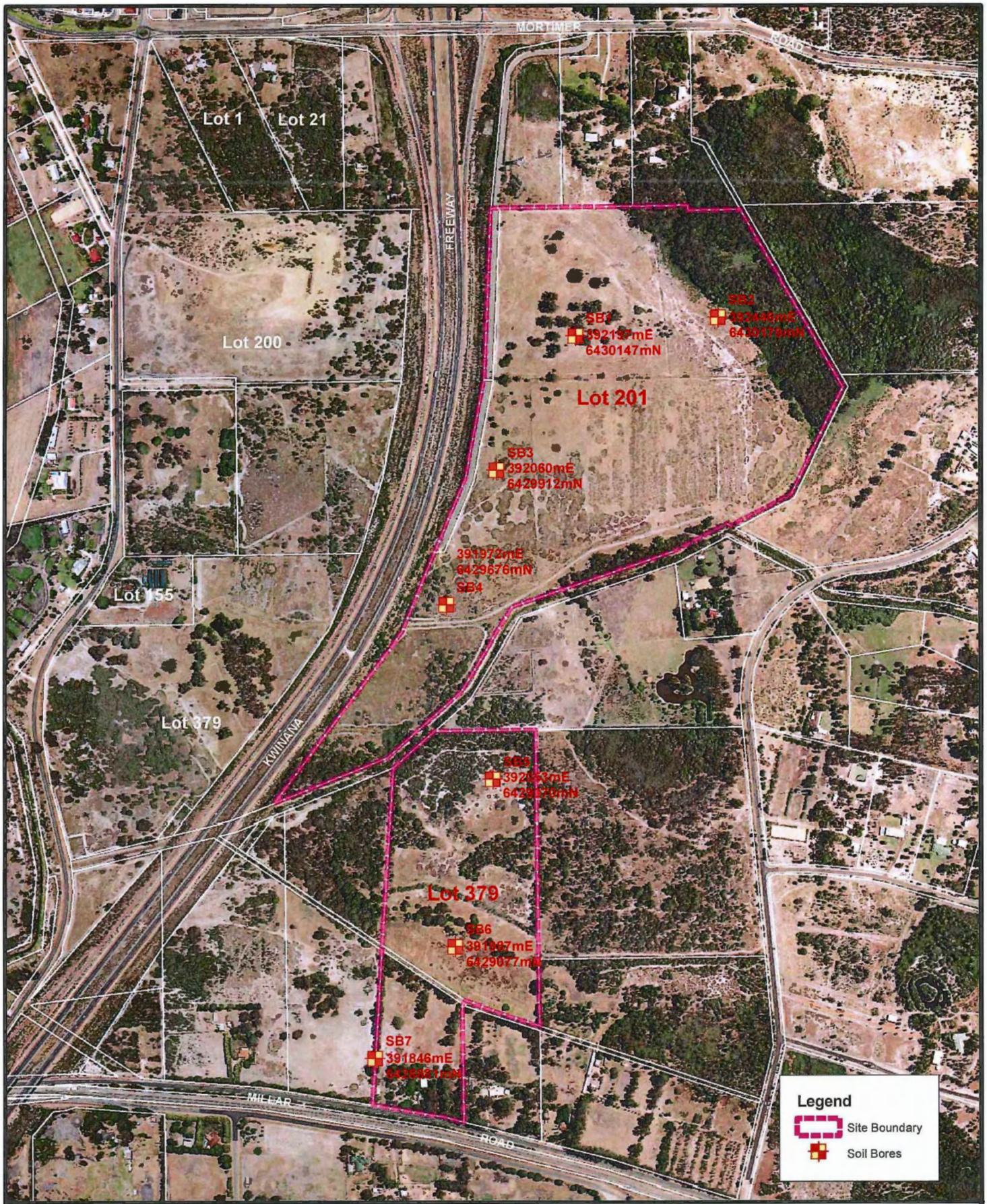
Project Number: V8041
Original: A3
Drawing Number: SK07
Revision: 00
Designed: JLP
Checked: JLP
Drawn: DTF
Approved: SPG
Local Authority: Town of Kwinana
Sheet 1 of 1
Date: 10/09/09



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:8,500

0 55 110 220 330 440 550 660 770 880 Metres

PROJECT Cascades, Wellard East
Preliminary Acid Sulfate Soils Assessment

DRAWING TITLE FIGURE 8 : Soil Bore Locations

PRINCIPAL Amex Corporation Pty Ltd.

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Project Number V8041
Original A4
Drawing Number SK08
Revision 00
Designed JLP
Checked JLP
Drawn DTF
Approved SPG
Local Authority Town of Kwinana
Sheet 1 of 1
Date 10/09/09

APPENDIX A

Soil Bore Logs

SOIL BORE LOG
ACID SULFATE SOILS

Cardno

JOB NUMBER:	V8041	**DATE:**	15/7/09	**BORE LOCATION:**	392197E/6430147N	**TOTAL DEPTH:**	4.0m
PROJECT:	Cascades	**LOGGED BY:**	JLP	**DATUM:**	GDA 94	**RL TOP OF CASING:**	n/a
BORE NAME:	SB1	**DRILLING METHOD:**	Sonic	**CASING DIAMETER:**	75mm	**RL NATURAL SURFACE:**	n/a

Field Observations						Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Criteria	
Depth	Depth to Water	Soil Profile	Soil Description	Moisture Content	Sample Depth	pHF	pHFOX	ΔpH	Reaction Strength	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Total Acidity	pH KCl	TAA	S_{Cr}	Total Acidity (SPOCAS)	Total Acidity (S_{Cr})
mBGL												%S	%S	%S	%S	%S	%S		%S	%S	%S	%S
0.00			SP, SAND - fine to medium grained, brown/grey, moderate levels of organic matter, TOPSOIL	Moist	0.25	6.0	4.5	1.5	M													
				Moist	0.5	5.6	5.0	0.6	M													
					0.75	5.7	5.4	0.3	M													
1.00			SP, SAND - fine to medium grained, yellow, moisture from rain infiltration		1.0	5.5	5.2	0.3	SL													
					1.25	5.6	5.2	0.4	SL													
					1.5	5.7	5.0	0.7	M													
					1.75	5.5	5.1	0.4	M													
2.00					2.0	5.7	5.3	0.4	SL													
					2.25	5.7	5.2	0.5	SL													
					2.5	5.9	5.2	0.7	SL													
					2.75	5.8	5.3	0.5	SL													
3.00					3.0	5.8	5.4	0.4	SL													
					3.25	5.9	5.2	0.7	SL													
			SP, SAND - fine to medium grained, yellow, slightly cemented	Dry	3.5	5.7	5.1	0.6	SL													
					3.75	5.6	5.0	0.6	SL													
4.00					4.0	5.7	4.9	0.8	SL													

NOTES:

SOIL BORE LOG
ACID SULFATE SOILS

Cardno

JOB NUMBER:	V8041	**DATE:**	15/7/09	**BORE LOCATION:**	392446E/6430179N	**TOTAL DEPTH:**	4.0m
PROJECT:	Cascades	**LOGGED BY:**	JLP	**DATUM:**	GDA 94	**RL TOP OF CASING:**	n/a
BORE NAME:	SB2	**DRILLING METHOD:**	Sonic	**CASING DIAMETER:**	75mm	**RL NATURAL SURFACE:**	n/a

Field Observations						Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Criteria	
Depth	Depth to Water	Soil Profile	Soil Description	Moisture Content	Sample Depth	pHF	pHFOX	pH Δ	Reaction Strength	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Total Acidity	pH KCl	TAA	S_{Cr}	Total Acidity (SPOCAS)	Total Acidity (S_{Cr})
mBGL												%S	%S	%S	%S	%S	%S		%S	%S	%S	%S
0.00			CL, CLAY - low plasticity, black/brown, moderate levels of organic matter, TOPSOIL	Moist	0.25	4.8	3.6	1.2	M													
				Moist	0.5	4.8	4.2	0.6	M													
			SP, SAND - fine to medium grained, grey/light brown		0.75	4.9	4.5	0.4	SL													
1.00					1.0	4.9	4.9	0	SL													
					1.25	5.5	4.3	1.2	SL													
			SC, CLAYEY SAND - fine to medium grained, pale brown, fines of low plasticity, light brown	Moist	1.5	5.3	3.5	1.8	M	9.4	7.0	<0.02	<0.02	<0.02	<0.02	0.09	<0.02				<0.02	
					1.75	5.5	4.4	1.1	SL													
2.00			CL, CLAY - medium plasticity, grey/brown/green mottling, with some sand of fine to medium grain, poorly sorted	Moist	2.0	5.9	5.8	0.1	SL													
					2.25	5.9	4.7	1.2	M													
					2.5	6.5	5.1	1.4	M													
			SC, CLAYEY SAND - fine to medium grained, grey/white/yellow mottle, fines of medium plasticity		2.75	6.4	5.0	1.4	M													
	▼			Moist	3.0	7.5	5.1	2.4	SL													
3.00			SP, SAND - fine to medium grained, grey/brown	Moist	3.25	7.6	4.7	2.9	SL													
					3.5	7.2	2.1	5.1	ST	6.8	2.7	<0.02	0.22	0.22	0.21	0.04	0.21	6.8	<0.02	0.11	0.21	0.08
			SP, SAND - fine to medium grained, white	Moist	3.75	6.9	1.9	5	ST													
			colour change to grey.	Moist	4.0	5.5	1.8	3.7	ST													
4.00																						

NOTES:

SOIL BORE LOG
ACID SULFATE SOILS

Cardno

JOB NUMBER:	V8041	**DATE:**	15/7/09	**BORE LOCATION:**	392060E/6429912N	**TOTAL DEPTH:**	4.0m
PROJECT:	Cascades	**LOGGED BY:**	JLP	**DATUM:**	GDA 94	**RL TOP OF CASING:**	n/a
BORE NAME:	SB3	**DRILLING METHOD:**	Sonic	**CASING DIAMETER:**	75mm	**RL NATURAL SURFACE:**	n/a

Field Observations						Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Criteria	
Depth	Depth to Water	Soil Profile	Soil Description	Moisture Content	Sample Depth	pHF	pHFOX	ΔpH	Reaction Strength	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Total Acidity	pH KCl	TAA	S_{Cr}	Total Acidity (SPOCAS)	Total Acidity (S_{Cr})
mBGL												%S	%S	%S	%S	%S	%S		%S	%S	%S	%S
0.00			SP, SAND - fine to medium grained, brown/grey, moderate levels of organic matter, TOPSOIL	Dry	0.25	5.8	3.8	2	M													
				Moist	0.5	5.8	4.7	1.1	M													
			SP, SAND - fine to medium grained, brown/grey	Moist	0.75	5.8	4.5	1.3	M													
1.00					1.0	5.8	4.3	1.5	M	8.9	6.9	<0.02	<0.02	<0.02	<0.02	0.07	<0.02				<0.02	
			SP, SAND - fine to medium grained, yellow		1.25	5.8	4.5	1.3	M													
					1.5	5.8	4.7	1.1	M													
					1.75	5.9	5.2	0.7	SL													
2.00					2.0	5.9	5.1	0.8	M													
					2.25	6.1	5.0	1.1	SL													
					2.5	6.0	5.3	0.7	SL													
					2.75	6.2	4.9	1.3	M													
3.00					3.0	5.7	4.9	0.8	M													
					3.25	5.6	5.5	0.1	SL													
					3.5	5.9	5.4	0.5	SL													
					3.75	5.8	5.0	0.8	M													
4.00					4.0	6.0	4.7	1.3	M													

NOTES:

SOIL BORE LOG
ACID SULFATE SOILS

Cardno

JOB NUMBER:	V8041	**DATE:**	15/7/09	**BORE LOCATION:**	391972E/6429676N	**TOTAL DEPTH:**	4.0m
PROJECT:	Cascades	**LOGGED BY:**	JLP	**DATUM:**	GDA 94	**RL TOP OF CASING:**	n/a
BORE NAME:	SB4	**DRILLING METHOD:**	Sonic	**CASING DIAMETER:**	75mm	**RL NATURAL SURFACE:**	n/a

Field Observations						Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Criteria	
Depth	Depth to Water	Soil Profile	Soil Description	Moisture Content	Sample Depth	pHF	pHFOX	pH Δ	Reaction Strength	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Total Acidity	pH KCl	TAA	S_{Cr}	Total Acidity (SPOCAS)	Total Acidity (S_{Cr})
mBGL												%S	%S	%S	%S	%S	%S		%S	%S	%S	%S
0.00			SP, SAND - fine to medium grained, brown/grey, high levels of organic matter, TOPSOIL	Moist	0.25	5.3	4.2	1.1	M													
				Moist	0.5	4.9	4.2	0.7	M													
			SP, SAND - fine to medium grained, brown/grey, moderate levels of organic matter		0.75	4.4	4.2	0.2	SL													
1.00					1.0	4.3	4.1	0.2	SL													
			SP, SAND - fine to medium grained, grey	Moist	1.25	4.4	4.1	0.3	SL													
					1.5	4.6	4.4	0.2	SL													
					1.75	4.3	4.0	0.3	SL													
2.00					2.0	4.2	4.1	0.1	SL													
					2.25	4.9	3.0	1.9	M													
	▼				2.5	4.9	2.7	2.2	M													
			SP, SAND - fine to medium grained, grey/cream	Wet	2.75	4.6	2.3	2.3	M													
3.00					3.0	4.8	3.4	1.4	M													
					3.25	5.3	2.2	3.1	ST													
			SP, SAND - fine to medium grained, grey	Wet	3.5	5.6	2.3	3.3	ST													
					3.75	5.8	1.8	4	ST													
			SP, SAND - fine to medium grained, brown, with partially cemented coffee rock	Wet	4.0	6.0	1.9	4.1	ST	6.6	2.5	<0.02	0.21	0.21	0.19	<0.01	0.20	6.6	<0.02	0.12	0.20	0.12
4.00																						

NOTES:

SOIL BORE LOG
ACID SULFATE SOILS

Cardno

JOB NUMBER:	V8041	**DATE:**	15/7/09	**BORE LOCATION:**	92053E/6429370N	**TOTAL DEPTH:**	4.0m
PROJECT:	Cascades	**LOGGED BY:**	JLP	**DATUM:**	GDA 94	**RL TOP OF CASING:**	n/a
BORE NAME:	SB5	**DRILLING METHOD:**	Sonic	**CASING DIAMETER:**	75mm	**RL NATURAL SURFACE:**	n/a

Field Observations						Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Criteria	
Depth	Depth to Water	Soil Profile	Soil Description	Moisture Content	Sample Depth	pHF	pHFOX	pH Δ	Reaction Strength	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Total Acidity	pH KCl	TAA	S_{Cr}	Total Acidity (SPOCAS)	Total Acidity (S_{Cr})
mBGL												%S	%S	%S	%S	%S	%S		%S	%S	%S	%S
0.00			SP, SAND - fine to medium grained, black/grey	Moist	0.25	5.0	2.8	2.2	M													
				Moist	0.5	5.2	4.4	0.8	SL													
			SP, SAND - fine to medium grained, grey	Moist	0.75	5.1	4.5	0.6	SL													
1.00			SP, SAND - fine to medium grained, white/cream		1.0	5.1	5.0	0.1	SL													
					1.25	5.2	4.8	0.4	M													
					1.5	5.4	2.6	2.8	M	7.0	5.6	<0.02	<0.02	<0.02	<0.02		<0.02				<0.02	
					1.75	5.2	4.6	0.6	SL													
					2.0	5.4	4.1	1.3	SL													
2.00			SP, SAND - fine to medium grained, orange, slightly cemented	Moist	2.25	5.3	4.8	0.5	SL													
					2.5	5.4	5.2	0.2	SL													
					2.75	5.2	5.1	0.1	SL													
3.00					3.0	5.4	5.2	0.2	SL													
					3.25	5.4	5.2	0.2	SL													
					3.5	5.8	4.8	1	M													
			SP, SAND - fine to medium grained, yellow/orange, slightly cemented		3.75	5.7	4.9	0.8	SL													
4.00				Moist	4.0	5.6	4.4	1.2	SL													

NOTES:

SOIL BORE LOG
ACID SULFATE SOILS

Cardno

JOB NUMBER:	V8041	**DATE:**	15/7/09	**BORE LOCATION:**	391987E/6429077N	**TOTAL DEPTH:**	4.0m
PROJECT:	Cascades	**LOGGED BY:**	JLP	**DATUM:**	GDA 94	**RL TOP OF CASING:**	n/a
BORE NAME:	SB6	**DRILLING METHOD:**	Sonic	**CASING DIAMETER:**	75mm	**RL NATURAL SURFACE:**	n/a

Field Observations						Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Criteria	
Depth	Depth to Water	Soil Profile	Soil Description	Moisture Content	Sample Depth	pHF	pHFOX	pH Δ	Reaction Strength	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Total Acidity	pH KCl	TAA	S_{Cr}	Total Acidity (SPOCAS)	Total Acidity (S_{Cr})
mBGL												%S	%S	%S	%S	%S	%S		%S	%S	%S	%S
0.00			SP, SAND - fine to medium grained, brown, TOPSOIL	Moist	0.25	5.0	5.0	0	SL													
			SP, SAND - fine to medium grained, pale brown	Moist	0.5	5.1	5.0	0.1	SL													
					0.75	5.4	4.9	0.5	SL													
1.00					1.0	5.6	4.9	0.7	SL													
					1.25	5.8	4.6	1.2	SL													
					1.5	6.0	4.7	1.3	M													
					1.75	6.3	2.1	4.2	M													
2.00			SP, SAND - fine to medium grained, brown/dark brown, high levels of humus and organic matter	Wet	2.0	6.0	3.4	2.6	M													
					2.25	6.2	2.3	3.9	M	6.0	3.4	<0.02	0.24	0.23	0.12		0.24	6.0	<0.02	0.06	0.24	0.07
					2.5	6.2	2.8	3.4	M													
					2.75	6.3	3.7	2.6	M													
3.00					3.0	6.4	2.5	3.9	M													
			SP, SAND - fine to medium grained, brown/pale brown	Wet	3.25	6.1	2.0	4.1	ST													
					3.5	6.0	2.0	4	ST													
					3.75	5.7	2.0	3.7	ST													
4.00					4.0	6.0	2.0	4	ST													

NOTES:

SOIL BORE LOG
ACID SULFATE SOILS

Cardno

JOB NUMBER:	V8041	**DATE:**	15/7/09	**BORE LOCATION:**	391846E/642881N	**TOTAL DEPTH:**	4.0m
PROJECT:	Cascades	**LOGGED BY:**	JLP	**DATUM:**	GDA 94	**RL TOP OF CASING:**	n/a
BORE NAME:	SB7	**DRILLING METHOD:**	Sonic	**CASING DIAMETER:**	75mm	**RL NATURAL SURFACE:**	n/a

Field Observations						Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Criteria	
Depth	Depth to Water	Soil Profile	Soil Description	Moisture Content	Sample Depth	pHF	pHFOX	pH Δ	Reaction Strength	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Total Acidity	pH KCl	TAA	S_{Cr}	Total Acidity (SPOCAS)	Total Acidity (S_{Cr})
mBGL												%S	%S	%S	%S	%S	%S		%S	%S	%S	%S
0.00			SP, SAND - fine to medium grained, grey, moderate levels of organic matter, TOPSOIL	Dry	0.25	5.6	4.4	1.2	M													
				Dry	0.5	5.1	4.9	0.2	M													
			SP, SAND - fine to medium grained, grey	Moist	0.75	4.7	3.6	1.1	M													
					1.0	4.6	4.4	0.2	SL													
1.00			SP, SAND - fine to medium grained, white		1.25	4.7	4.4	0.3	SL													
					1.5	4.6	3.6	1	SL													
					1.75	4.7	3.8	0.9	SL													
					2.0	4.8	3.3	1.5	M	7.1	4.2	<0.02	<0.02	<0.02	<0.02	0.01	<0.02	7.1	<0.02	<0.02	<0.02	<0.02
2.00	▼				2.25	4.5	2.6	1.9	M													
			SP, SAND - fine to medium grained, brown	Wet	2.5	4.9	2.8	2.1	M													
					2.75	5.2	1.6	3.6	M													
					3.0	5.4	1.7	3.7	ST	6.7	2.8	<0.02	0.18	0.18	0.18	0.02	0.18	6.7	<0.02	0.12	0.18	0.11
3.00					3.25	5.5	1.9	3.6	ST													
					3.5	5.7	1.8	3.9	ST													
					3.75	5.6	1.7	3.9	ST													
4.00					4.0	6.1	1.8	4.3	ST													

NOTES:

APPENDIX B

Laboratory Data

CHAIN OF CUSTODY DOCUMENTATION

ALS

CLIENT: Cardno (WA) Pty Ltd	POSTAL ADDRESS: 2 Bagot Road, Subiaco WA, 6008	LABORATORY BATCH NO.
SEND REPORT TO: Jeremy Payet	SEND INVOICE TO: Sandra Gillon	SAMPLERS: Jeremy Payet
DATA NEEDED BY: Standard 5 day TAT	REPORT NEEDED BY: Standard 5 day TAT	PHONE: 9273 3888 FAX: 9388 3831 E-MAIL: jeremy.payet@cardno.com.au
QUOTE NO.: EN/024/09 PROJECT ID: V8041	PROJECT NAME: Cascades Preliminary ASS	REPORT FORMAT: HARD: FAX: DISK: E-MAIL: ✓
P.O. NO.:	COMMENTS/SPECIAL HANDLING/STORAGE OR DIPOSAL	QC LEVEL: QCS1: QCS2: QCS3: ✓ QCS4:

FOR LAB USE ONLY
COOLER SEAL
Yes No
Broken Intact
COOLER TEMP deg C

Some substitute non ALS plastic zip lock bags were used

ANALYSIS REQUIRED

	SAMPLE DATA				CONTAINER DATA		QASSIT (2004) pH field + phox	NOTES
	SAMPLE ID	MATRIX	DATE	Time	TYPE & PRESERVATIVE	No.		
1	SB1-0.25	Soil	15/07/09		B	1	X	
2	SB1-0.50	Soil	15/07/09		B	1	X	
3	SB1-0.75	Soil	15/07/09		B	1	X	
4	SB1-1.0	Soil	15/07/09		B	1	X	
5	SB1-1.25	Soil	15/07/09		B	1	X	
6	SB1-1.50	Soil	15/07/09		B	1	X	
7	SB1-1.75	Soil	15/07/09		B	1	X	
8	SB1-2.0	Soil	15/07/09		B	1	X	
9	SB1-2.25	Soil	15/07/09		B	1	X	
10	SB1-2.50	Soil	15/07/09		B	1	X	
11	SB1-2.75	Soil	15/07/09		B	1	X	
12	SB1-3.0	Soil	15/07/09		B	1	X	
13	SB1-3.25	Soil	15/07/09		B	1	X	
14	SB1-3.50	Soil	15/07/09		B	1	X	
15	SB1-3.75	Soil	15/07/09		B	1	X	
16	SB1-4.0	Soil	15/07/09		B	1	X	

Environmental Division
Perth
Work Order
EP0903915
Telephone : +61-8-9209 7655



RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
NAME : Jeremy Payet	DATE: 16 /07 / 09	NAME : MW	DATE: 16/7	CONSIGNMENT NOTE NO.
OF: Cardno	TIME:	OF:	TIME: 15:00	
NAME :	DATE:	NAME :	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

Container Type: **P** = Neutral Plastic; **J** = Solvent Washed Acid Rinsed Jar; **S** = Solvent Washed Acid Rinsed Glass Bottle; **V** = Vial; **GB** = Glass Bottle; **PB** = Plastic Bottle; **B** = Plastic Bag; **O** = Other.

Preservative Codes :**N** = No Preservative; **Ni** = Nitric Acid Preserved; **Na** = Sodium Hydroxide Preserved; **H** = Hydrochloric Acid Preserved; **Su** = Sulfuric Acid Preserved; **Z** = Zinc Acetate Preserved; **E** = EDTA Preserved Bottles; **F** = Formaldehyde Preserved; **St** = Sterile Bottle

ALS Environmental

CHAIN OF CUSTODY DOCUMENTATION

ALS

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QUOTE NO.: EN/024/09 PROJECT ID: V8041	PROJECT NAME: Cascades Preliminary ASS	REPORT FORMAT: HARD: FAX: DISK: E-MAIL: ✓
P.O. NO.:	COMMENTS/SPECIAL HANDLING/STORAGE OR DIPOSAL	QC LEVEL: QCS1: QCS2: QCS3: ✓ QCS4:

FOR LAB USE ONLY
COOLER SEAL
Yes No
Broken Intact
COOLER TEMP deg C

Some substitute non ALS plastic zip lock bags were used

ANALYSIS REQUIRED

	SAMPLE DATA			CONTAINER DATA		QASSIT (2004)	NOTES
	SAMPLE ID	MATRIX	DATE		No.		
17	SB2-0.25	Soil	15/07/09	B	1	X	
18	SB2-0.50	Soil	15/07/09	B	1	X	
19	SB2-0.75	Soil	15/07/09	B	1	X	
20	SB2-1.0	Soil	15/07/09	B	1	X	
21	SB2-1.25	Soil	15/07/09	B	1	X	
22	SB2-1.50	Soil	15/07/09	B	1	X	
23	SB2-1.75	Soil	15/07/09	B	1	X	
24	SB2-2.0	Soil	15/07/09	B	1	X	
25	SB2-2.25	Soil	15/07/09	B	1	X	
26	SB2-2.50	Soil	15/07/09	B	1	X	
27	SB2-2.75	Soil	15/07/09	B	1	X	
28	SB2-3.0	Soil	15/07/09	B	1	X	
29	SB2-3.25	Soil	15/07/09	B	1	X	
30	SB2-3.50	Soil	15/07/09	B	1	X	
31	SB2-3.75	Soil	15/07/09	B	1	X	
32	SB2-4.0	Soil	15/07/09	B	1	X	

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
NAME : Jeremy Payet	DATE: 16 /07 / 09	NAME : MW	DATE: 16/7	CONSIGNMENT NOTE NO.
OF: Cardno	TIME:	OF:	TIME: 15:00	
NAME :	DATE:	NAME :	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

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ALS Environmental

CHAIN OF CUSTODY DOCUMENTATION

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DATA NEEDED BY: Standard 5 day TAT	REPORT NEEDED BY: Standard 5 day TAT	PHONE: 9273 3888 FAX: 9388 3831 E-MAIL: jeremy.payet@cardno.com.au
QUOTE NO.: EN/024/09 PROJECT ID: V8041	PROJECT NAME: Cascades Preliminary ASS	REPORT FORMAT: HARD: FAX: DISK: E-MAIL: ✓
P.O. NO.:	COMMENTS/SPECIAL HANDLING/STORAGE OR DIPOSAL	QC LEVEL: QCS1: QCS2: QCS3: ✓ QCS4:
FOR LAB USE ONLY COOLER SEAL Yes No Broken Intact COOLER TEMP deg C	Some substitute non ALS plastic zip lock bags were used	ANALYSIS REQUIRED

	SAMPLE DATA			CONTAINER DATA		QASSIT (2004)										NOTES
	SAMPLE ID	MATRIX	DATE		No.											
33	SB3-0.25	Soil	15/07/09	B	1	X										
34	SB3-0.50	Soil	15/07/09	B	1	X										
35	SB3-0.75	Soil	15/07/09	B	1	X										
36	SB3-1.0	Soil	15/07/09	B	1	X										
37	SB3-1.25	Soil	15/07/09	B	1	X										
38	SB3-1.50	Soil	15/07/09	B	1	X										
39	SB3-1.75	Soil	15/07/09	B	1	X										
40	SB3-2.0	Soil	15/07/09	B	1	X										
41	SB3-2.25	Soil	15/07/09	B	1	X										
42	SB3-2.50	Soil	15/07/09	B	1	X										
43	SB3-2.75	Soil	15/07/09	B	1	X										
44	SB3-3.0	Soil	15/07/09	B	1	X										
45	SB3-3.25	Soil	15/07/09	B	1	X										
46	SB3-3.50	Soil	15/07/09	B	1	X										
47	SB3-3.75	Soil	15/07/09	B	1	X										
48	SB3-4.0	Soil	15/07/09	B	1	X										

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
NAME : Jeremy Payet	DATE: 16 /07 / 09	NAME : MW	DATE: 16/7	CONSIGNMENT NOTE NO.
OF: Cardno	TIME:	OF:	TIME: 15:00	
NAME :	DATE:	NAME :	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

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QUOTE NO.: EN/024/09 PROJECT ID: V8041 PROJECT NAME: Cascades Preliminary ASS		REPORT FORMAT: HARD: FAX: DISK: E-MAIL: ✓
P.O. NO.:	COMMENTS/SPECIAL HANDLING/STORAGE OR DIPOSAL	QC LEVEL: QCS1: QCS2: QCS3: ✓ QCS4:
FOR LAB USE ONLY COOLER SEAL Yes: No: Broken: Intact: COOLER TEMP: deg C	Some substitute non ALS plastic zip lock bags were used	ANALYSIS REQUIRED

	SAMPLE DATA			CONTAINER DATA		QASSIT (2004)											NOTES
	SAMPLE ID	MATRIX	DATE		No.												
49	SB4-0.25	Soil	15/07/09	B	1	X											
50	SB4-0.50	Soil	15/07/09	B	1	X											
51	SB4-0.75	Soil	15/07/09	B	1	X											
52	SB4-1.0	Soil	15/07/09	B	1	X											
53	SB4-1.25	Soil	15/07/09	B	1	X											
54	SB4-1.50	Soil	15/07/09	B	1	X											
55	SB4-1.75	Soil	15/07/09	B	1	X											
56	SB4-2.0	Soil	15/07/09	B	1	X											
57	SB4-2.25	Soil	15/07/09	B	1	X											
58	SB4-2.50	Soil	15/07/09	B	1	X											
59	SB4-2.75	Soil	15/07/09	B	1	X											
60	SB4-3.0	Soil	15/07/09	B	1	X											
61	SB4-3.25	Soil	15/07/09	B	1	X											
62	SB4-3.50	Soil	15/07/09	B	1	X											
63	SB4-3.75	Soil	15/07/09	B	1	X											
64	SB4-4.0	Soil	15/07/09	B	1	X											

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
NAME : Jeremy Payet	DATE: 16 /07 / 09	NAME : MW	DATE: 16/7/09	CONSIGNMENT NOTE NO.
OF: Cardno	TIME:	OF:	TIME: 15:05	
NAME :	DATE:	NAME :	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

Container Type: **P** = Neutral Plastic; **J** = Solvent Washed Acid Rinsed Jar;
S = Solvent Washed Acid Rinsed Glass Bottle; **V** = Vial; **GB** = Glass Bottle;
PB = Plastic Bottle; **B** = Plastic Bag; **O** = Other.

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E = EDTA Preserved Bottles; **F** = Formaldehyde Preserved; **St** = Sterile Bottle

ALS Environmental

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QUOTE NO.: EN/024/09 PROJECT ID: V8041	PROJECT NAME: Cascades Preliminary ASS	REPORT FORMAT: HARD: FAX: DISK: E-MAIL: ✓
P.O. NO.:	COMMENTS/SPECIAL HANDLING/STORAGE OR DIPOSAL	QC LEVEL: QCS1: QCS2: QCS3: ✓ QCS4:
FOR LAB USE ONLY COOLER SEAL Yes No Broken Intact COOLER TEMP: deg C	Some substitute non ALS plastic zip lock bags were used	ANALYSIS REQUIRED

	SAMPLE DATA				CONTAINER DATA		QASSIT (2004)											NOTES
	SAMPLE ID	MATRIX	DATE			No.												
65	SB5-0.25	Soil	15/07/09		B	1	X											
66	SB5-0.50	Soil	15/07/09		B	1	X											
67	SB5-0.75	Soil	15/07/09		B	1	X											
68	SB5-1.0	Soil	15/07/09		B	1	X											
69	SB5-1.25	Soil	15/07/09		B	1	X											
70	SB5-1.50	Soil	15/07/09		B	1	X											
71	SB5-1.75	Soil	15/07/09		B	1	X											
72	SB5-2.0	Soil	15/07/09		B	1	X											
73	SB5-2.25	Soil	15/07/09		B	1	X											
74	SB5-2.50	Soil	15/07/09		B	1	X											
75	SB5-2.75	Soil	15/07/09		B	1	X											
76	SB5-3.0	Soil	15/07/09		B	1	X											
77	SB5-3.25	Soil	15/07/09		B	1	X											
78	SB5-3.50	Soil	15/07/09		B	1	X											
79	SB5-3.75	Soil	15/07/09		B	1	X											
80	SB5-4.0	Soil	15/07/09		B	1	X											

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
NAME : Jeremy Payet	DATE: 16 /07 / 09	NAME : MW	DATE: 16/7	CONSIGNMENT NOTE NO.
OF: Cardno	TIME:	OF:	TIME: 15:00	
NAME :	DATE:	NAME :	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

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ALS Environmental

CHAIN OF CUSTODY DOCUMENTATION

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QUOTE NO.: EN/024/09 PROJECT ID: V8041	PROJECT NAME: Cascades Preliminary ASS	REPORT FORMAT: HARD: FAX: DISK: E-MAIL: ✓
P.O. NO.:	COMMENTS/SPECIAL HANDLING/STORAGE OR DIPOSAL	QC LEVEL: QCS1: QCS2: QCS3: ✓ QCS4:
FOR LAB USE ONLY COOLER SEAL Yes No Broken Intact COOLER TEMP: deg C	Some substitute non ALS plastic zip lock bags were used	ANALYSIS REQUIRED

	SAMPLE DATA			CONTAINER DATA		QASSIT (2004)											NOTES
	SAMPLE ID	MATRIX	DATE		No.												
81	SB6-0.25	Soil	15/07/09	B	1	X											
82	SB6-0.50	Soil	15/07/09	B	1	X											
83	SB6-0.75	Soil	15/07/09	B	1	X											
84	SB6-1.0	Soil	15/07/09	B	1	X											
85	SB6-1.25	Soil	15/07/09	B	1	X											
86	SB6-1.50	Soil	15/07/09	B	1	X											
87	SB6-1.75	Soil	15/07/09	B	1	X											
88	SB6-2.0	Soil	15/07/09	B	1	X											
89	SB6-2.25	Soil	15/07/09	B	1	X											
90	SB6-2.50	Soil	15/07/09	B	1	X											
91	SB6-2.75	Soil	15/07/09	B	1	X											
92	SB6-3.0	Soil	15/07/09	B	1	X											
93	SB6-3.25	Soil	15/07/09	B	1	X											
94	SB6-3.50	Soil	15/07/09	B	1	X											
95	SB6-3.75	Soil	15/07/09	B	1	X											
96	SB6-4.0	Soil	15/07/09	B	1	X											

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
NAME : Jeremy Payet	DATE: 16 /07 / 09	NAME : [illegible]	DATE: 16/7	CONSIGNMENT NOTE NO.
OF: Cardno	TIME:	OF:	TIME: 15:00	
NAME :	DATE:	NAME :	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

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ALS Environmental

CHAIN OF CUSTODY DOCUMENTATION

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QUOTE NO.: EN/024/09 PROJECT ID: V8041	PROJECT NAME: Cascades Preliminary ASS	REPORT FORMAT: HARD: FAX: DISK: E-MAIL: ✓
P.O. NO.:	COMMENTS/SPECIAL HANDLING/STORAGE OR DIPOSAL	QC LEVEL: QCS1: QCS2: QCS3: ✓ QCS4:
FOR LAB USE ONLY COOLER SEAL Yes No Broken Intact COOLER TEMP: deg C	Some substitute non ALS plastic zip lock bags were used	ANALYSIS REQUIRED

	SAMPLE DATA				CONTAINER DATA		QASSIT (2004)											NOTES
	SAMPLE ID	MATRIX	DATE			No.												
97	SB7-0.25	Soil	15/07/09		B	1	X											
98	SB7-0.50	Soil	15/07/09		B	1	X											
99	SB7-0.75	Soil	15/07/09		B	1	X											
100	SB7-1.0	Soil	15/07/09		B	1	X											
101	SB7-1.25	Soil	15/07/09		B	1	X											
102	SB7-1.50	Soil	15/07/09		B	1	X											
103	SB7-1.75	Soil	15/07/09		B	1	X											
104	SB7-2.0	Soil	15/07/09		B	1	X											
105	SB7-2.25	Soil	15/07/09		B	1	X											
106	SB7-2.50	Soil	15/07/09		B	1	X											
107	SB7-2.75	Soil	15/07/09		B	1	X											
108	SB7-3.0	Soil	15/07/09		B	1	X											
109	SB7-3.25	Soil	15/07/09		B	1	X											
110	SB7-3.50	Soil	15/07/09		B	1	X											
111	SB7-3.75	Soil	15/07/09		B	1	X											
112	SB7-4.0	Soil	15/07/09		B	1	X											

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
NAME : Jeremy Payet	DATE: 16 /07 / 09	NAME : MW	DATE: 16/7	CONSIGNMENT NOTE NO.
OF: Cardno	TIME:	OF:	TIME: 15:00	
NAME :	DATE:	NAME :	DATE:	TRANSPORT CO. NAME.
OF:	TIME:	OF:	TIME:	

Container Type: **P** = Neutral Plastic; **J** = Solvent Washed Acid Rinsed Jar; **S** = Solvent Washed Acid Rinsed Glass Bottle; **V** = Vial; **GB** = Glass Bottle; **PB** = Plastic Bottle; **B** = Plastic Bag; **O** = Other.

Preservative Codes :**N** = No Preservative; **Ni** = Nitric Acid Preserved; **Na** = Sodium Hydroxide Preserved; **H** = Hydrochloric Acid Preserved; **Su** = Sulfuric Acid Preserved; **Z** = Zinc Acetate Preserved; **E** = EDTA Preserved Bottles; **F** = Formaldehyde Preserved; **St** = Sterile Bottle

ALS Environmental

Environmental Division

SAMPLE RECEIPT NOTIFICATION (SRN)

Comprehensive Report

Work Order	: **EP0903915**		
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JEREMY PAYET	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Jeremy.payet@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V8041	Page	: 1 of 5
Order number	: ----		
C-O-C number	: ----	Quote number	: EP2009CARBSD0294 (EN-024-09 BQ)
Site	: Cascades Preliminary ASS		
Sampler	: Jeremy Payet	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Dates

Date Samples Received	: 16-JUL-2009	Issue Date	: 17-JUL-2009 11:29
Client Requested Due Date	: 17-JUL-2009	Scheduled Reporting Date	: **17-JUL-2009**

Delivery Details

Mode of Delivery	: Carrier	Temperature	: Ambient
No. of coolers/boxes	: 1 Large	No. of samples received	: 112
Sercurity Seal	: Intact.	No. of samples analysed	: 112

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Requested Deliverables
- Samples received in appropriately pretreated and preserved containers.
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- **Samples received in appropriately pretreated and preserved containers.**
- **Sample(s) have been received within recommended holding times.**
- **pH analysis should be conducted within 6 hours of sampling.**
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Sample Disposal - Aqueous (14 days), Solid (90 days) from date of completion of Work Order.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exist.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process neccessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Matrix: **SOIL**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	SOIL - EA037 ASS Field Screening Analysis
EP0903915-001	15-JUL-2009 15:00	SB1 0.25	✓
EP0903915-002	15-JUL-2009 15:00	SB1 0.5	✓
EP0903915-003	15-JUL-2009 15:00	SB1 0.75	✓
EP0903915-004	15-JUL-2009 15:00	SB1 1	✓
EP0903915-005	15-JUL-2009 15:00	SB1 1.25	✓
EP0903915-006	15-JUL-2009 15:00	SB1 1.5	✓
EP0903915-007	15-JUL-2009 15:00	SB1 1.75	✓
EP0903915-008	15-JUL-2009 15:00	SB1 2	✓
EP0903915-009	15-JUL-2009 15:00	SB1 2.25	✓
EP0903915-010	15-JUL-2009 15:00	SB1 2.5	✓
EP0903915-011	15-JUL-2009 15:00	SB1 2.75	✓
EP0903915-012	15-JUL-2009 15:00	SB1 3	✓
EP0903915-013	15-JUL-2009 15:00	SB1 3.25	✓
EP0903915-014	15-JUL-2009 15:00	SB1 3.5	✓
EP0903915-015	15-JUL-2009 15:00	SB1 3.75	✓
EP0903915-016	15-JUL-2009 15:00	SB1 4	✓
EP0903915-017	15-JUL-2009 15:00	SB2 0.25	✓
EP0903915-018	15-JUL-2009 15:00	SB2 0.5	✓
EP0903915-019	15-JUL-2009 15:00	SB2 0.75	✓
EP0903915-020	15-JUL-2009 15:00	SB2 1	✓
EP0903915-021	15-JUL-2009 15:00	SB2 1.25	✓
EP0903915-022	15-JUL-2009 15:00	SB2 1.5	✓
EP0903915-023	15-JUL-2009 15:00	SB2 1.75	✓
EP0903915-024	15-JUL-2009 15:00	SB2 2	✓
EP0903915-025	15-JUL-2009 15:00	SB2 2.25	✓
EP0903915-026	15-JUL-2009 15:00	SB2 2.5	✓
EP0903915-027	15-JUL-2009 15:00	SB2 2.75	✓
EP0903915-028	15-JUL-2009 15:00	SB2 3	✓
EP0903915-029	15-JUL-2009 15:00	SB2 3.25	✓
EP0903915-030	15-JUL-2009 15:00	SB2 3.5	✓
EP0903915-031	15-JUL-2009 15:00	SB2 3.75	✓
EP0903915-032	15-JUL-2009 15:00	SB2 4	✓
EP0903915-033	15-JUL-2009 15:00	SB3 0.25	✓
EP0903915-034	15-JUL-2009 15:00	SB3 0.5	✓
EP0903915-035	15-JUL-2009 15:00	SB3 0.75	✓

			SOIL - EA037 ASS Field Screening Analysis
EP0903915-036	15-JUL-2009 15:00	SB3 1	✓
EP0903915-037	15-JUL-2009 15:00	SB3 1.25	✓
EP0903915-038	15-JUL-2009 15:00	SB3 1.5	✓
EP0903915-039	15-JUL-2009 15:00	SB3 1.75	✓
EP0903915-040	15-JUL-2009 15:00	SB3 2	✓
EP0903915-041	15-JUL-2009 15:00	SB3 2.25	✓
EP0903915-042	15-JUL-2009 15:00	SB3 2.5	✓
EP0903915-043	15-JUL-2009 15:00	SB3 2.75	✓
EP0903915-044	15-JUL-2009 15:00	SB3 3	✓
EP0903915-045	15-JUL-2009 15:00	SB3 3.25	✓
EP0903915-046	15-JUL-2009 15:00	SB3 3.5	✓
EP0903915-047	15-JUL-2009 15:00	SB3 3.75	✓
EP0903915-048	15-JUL-2009 15:00	SB3 4	✓
EP0903915-049	15-JUL-2009 15:00	SB4 0.25	✓
EP0903915-050	15-JUL-2009 15:00	SB4 0.5	✓
EP0903915-051	15-JUL-2009 15:00	SB4 0.75	✓
EP0903915-052	15-JUL-2009 15:00	SB4 1	✓
EP0903915-053	15-JUL-2009 15:00	SB4 1.25	✓
EP0903915-054	15-JUL-2009 15:00	SB4 1.5	✓
EP0903915-055	15-JUL-2009 15:00	SB4 1.75	✓
EP0903915-056	15-JUL-2009 15:00	SB4 2	✓
EP0903915-057	15-JUL-2009 15:00	SB4 2.25	✓
EP0903915-058	15-JUL-2009 15:00	SB4 2.5	✓
EP0903915-059	15-JUL-2009 15:00	SB4 2.75	✓
EP0903915-060	15-JUL-2009 15:00	SB4 3	✓
EP0903915-061	15-JUL-2009 15:00	SB4 3.25	✓
EP0903915-062	15-JUL-2009 15:00	SB4 3.5	✓
EP0903915-063	15-JUL-2009 15:00	SB4 3.75	✓
EP0903915-064	15-JUL-2009 15:00	SB4 4	✓
EP0903915-065	15-JUL-2009 15:00	SB5 0.25	✓
EP0903915-066	15-JUL-2009 15:00	SB5 0.5	✓
EP0903915-067	15-JUL-2009 15:00	SB5 0.75	✓
EP0903915-068	15-JUL-2009 15:00	SB5 1	✓
EP0903915-069	15-JUL-2009 15:00	SB5 1.25	✓
EP0903915-070	15-JUL-2009 15:00	SB5 1.5	✓
EP0903915-071	15-JUL-2009 15:00	SB5 1.75	✓
EP0903915-072	15-JUL-2009 15:00	SB5 2	✓
EP0903915-073	15-JUL-2009 15:00	SB5 2.25	✓
EP0903915-074	15-JUL-2009 15:00	SB5 2.5	✓
EP0903915-075	15-JUL-2009 15:00	SB5 2.75	✓
EP0903915-076	15-JUL-2009 15:00	SB5 3	✓

			SOIL - EA037 ASS Field Screening Analysis
EP0903915-077	15-JUL-2009 15:00	SB5 3.25	✓
EP0903915-078	15-JUL-2009 15:00	SB5 3.5	✓
EP0903915-079	15-JUL-2009 15:00	SB5 3.75	✓
EP0903915-080	15-JUL-2009 15:00	SB5 4	✓
EP0903915-081	15-JUL-2009 15:00	SB6 0.25	✓
EP0903915-082	15-JUL-2009 15:00	SB6 0.5	✓
EP0903915-083	15-JUL-2009 15:00	SB6 0.75	✓
EP0903915-084	15-JUL-2009 15:00	SB6 1	✓
EP0903915-085	15-JUL-2009 15:00	SB6 1.25	✓
EP0903915-086	15-JUL-2009 15:00	SB6 1.5	✓
EP0903915-087	15-JUL-2009 15:00	SB6 1.75	✓
EP0903915-088	15-JUL-2009 15:00	SB6 2	✓
EP0903915-089	15-JUL-2009 15:00	SB6 2.25	✓
EP0903915-090	15-JUL-2009 15:00	SB6 2.5	✓
EP0903915-091	15-JUL-2009 15:00	SB6 2.75	✓
EP0903915-092	15-JUL-2009 15:00	SB6 3	✓
EP0903915-093	15-JUL-2009 15:00	SB6 3.25	✓
EP0903915-094	15-JUL-2009 15:00	SB6 3.5	✓
EP0903915-095	15-JUL-2009 15:00	SB6 3.75	✓
EP0903915-096	15-JUL-2009 15:00	SB6 4	✓
EP0903915-097	15-JUL-2009 15:00	SB7 0.25	✓
EP0903915-098	15-JUL-2009 15:00	SB7 0.5	✓
EP0903915-099	15-JUL-2009 15:00	SB7 0.75	✓
EP0903915-100	15-JUL-2009 15:00	SB7 1	✓
EP0903915-101	15-JUL-2009 15:00	SB7 1.25	✓
EP0903915-102	15-JUL-2009 15:00	SB7 1.5	✓
EP0903915-103	15-JUL-2009 15:00	SB7 1.75	✓
EP0903915-104	15-JUL-2009 15:00	SB7 2	✓
EP0903915-105	15-JUL-2009 15:00	SB7 2.25	✓
EP0903915-106	15-JUL-2009 15:00	SB7 2.5	✓
EP0903915-107	15-JUL-2009 15:00	SB7 2.75	✓
EP0903915-108	15-JUL-2009 15:00	SB7 3	✓
EP0903915-109	15-JUL-2009 15:00	SB7 3.25	✓
EP0903915-110	15-JUL-2009 15:00	SB7 3.5	✓
EP0903915-111	15-JUL-2009 15:00	SB7 3.75	✓
EP0903915-112	15-JUL-2009 15:00	SB7 4	✓

Requested Deliverables

MR JEREMY PAYET

- *AU Certificate of Analysis - NATA (COA)	Email	Jeremy.payet@cardno.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Jeremy.payet@cardno.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Jeremy.payet@cardno.com.au
- A4 - AU Sample Receipt Notification - Environmental (SRN)	Email	Jeremy.payet@cardno.com.au
- Default - Chain of Custody (COC)	Email	Jeremy.payet@cardno.com.au
- EDI Format - ENMRG (ENMRG)	Email	Jeremy.payet@cardno.com.au
- EDI Format - ESDAT (ESDAT)	Email	Jeremy.payet@cardno.com.au
- EDI Format - XTab (XTAB)	Email	Jeremy.payet@cardno.com.au

THE ACCOUNTS PAYABLE (WA)

- A4 - AU Tax Invoice (INV)	Email	sandra.gillon@cardno.com.au

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0903915**	Page	: 1 of 25
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JEREMY PAYET	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Jeremy.payet@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V8041	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 16-JUL-2009
Sampler	: Jeremy Payet	Issue Date	: 20-JUL-2009
Site	: Cascades Preliminary ASS		
		No. of samples received	: 112
Quote number	: EN-024-09 BQ	No. of samples analysed	: 112

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

WORLD RECOGNISED ACCREDITATION

Signatories

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

Signatories	*Position*	*Accreditation Category*
Stacey Hawkins	Senior Chemist - Acid Sulphate Soils	Perth ASS

General Comments

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

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

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

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

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

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

- **ASS Field Screening: NATA accreditation does not cover performance of this service.**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB1 0.25	SB1 0.5	SB1 0.75	SB1 1	SB1 1.25
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-001	EP0903915-002	EP0903915-003	EP0903915-004	EP0903915-005
EA037: Ass Field Screening Analysis									
pH (F)	-----	0.1	pH Unit		6.0	5.6	5.7	5.5	5.6
pH (Fox)	-----	0.1	pH Unit		4.5	5.0	5.4	5.2	5.2
Reaction Rate	----	1	-		Moderate	Moderate	Moderate	Slight	Slight

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB1 1.5	SB1 1.75	SB1 2	SB1 2.25	SB1 2.5
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-006	EP0903915-007	EP0903915-008	EP0903915-009	EP0903915-010
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		**5.7**	**5.5**	**5.7**	**5.7**	**5.9**
pH (Fox)	----	0.1	pH Unit		**5.0**	**5.1**	**5.3**	**5.2**	**5.2**
Reaction Rate	----	1	-		**Moderate**	**Moderate**	**Slight**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: SOIL				Client sample ID	SB1 2.75	SB1 3	SB1 3.25	SB1 3.5	SB1 3.75
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound	CAS Number	LOR	Unit		EP0903915-011	EP0903915-012	EP0903915-013	EP0903915-014	EP0903915-015
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		5.8	5.8	5.9	5.7	5.6
pH (Fox)	----	0.1	pH Unit		5.3	5.4	5.2	5.1	5.0
Reaction Rate	----	1	-		Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB1 4	SB2 0.25	SB2 0.5	SB2 0.75	SB2 1
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound / CAS Number	LOR / Unit	EP0903915-016	EP0903915-017	EP0903915-018	EP0903915-019	EP0903915-020
EA037: Ass Field Screening Analysis						
pH (F) ----	0.1 pH Unit	5.7	4.8	4.8	4.9	4.9
pH (Fox) ----	0.1 pH Unit	4.9	3.6	4.2	4.5	4.9
Reaction Rate ----	1 -	Slight	Moderate	Moderate	Slight	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB2 1.25	SB2 1.5	SB2 1.75	SB2 2	SB2 2.25
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound	CAS Number / LOR / Unit	EP0903915-021	EP0903915-022	EP0903915-023	EP0903915-024	EP0903915-025
EA037: Ass Field Screening Analysis						
pH (F)	---- / 0.1 / pH Unit	5.5	5.3	5.5	5.9	5.9
pH (Fox)	---- / 0.1 / pH Unit	4.3	3.5	4.4	5.8	4.7
Reaction Rate	---- / 1 / -	Slight	Moderate	Slight	Slight	Moderate

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB2 2.5	SB2 2.75	SB2 3	SB2 3.25	SB2 3.5
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound / CAS Number / LOR / Unit		EP0903915-026	EP0903915-027	EP0903915-028	EP0903915-029	EP0903915-030
EA037: Ass Field Screening Analysis						
pH (F) ---- 0.1 pH Unit		6.5	6.4	7.5	7.6	7.2
pH (Fox) ---- 0.1 pH Unit		5.1	5.0	5.1	4.7	2.1
Reaction Rate ---- 1 -		Moderate	Moderate	Slight	Slight	Strong

Analytical Results

Sub-Matrix: SOIL				Client sample ID	SB2 3.75	SB2 4	SB3 0.25	SB3 0.5	SB3 0.75
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound	CAS Number	LOR	Unit		EP0903915-031	EP0903915-032	EP0903915-033	EP0903915-034	EP0903915-035
EA037: Ass Field Screening Analysis									
pH (F)	---	0.1	pH Unit		6.9	5.5	5.8	5.8	5.8
pH (Fox)	---	0.1	pH Unit		1.9	1.8	3.8	4.7	4.5
Reaction Rate	---	1	-		Strong	Strong	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID: SB3 1	SB3 1.25	SB3 1.5	SB3 1.75	SB3 2
				Client sampling date / time: 15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
				EP0903915-036	EP0903915-037	EP0903915-038	EP0903915-039	EP0903915-040
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	5.8	5.8	5.8	5.9	5.9
pH (Fox)	----	0.1	pH Unit	4.3	4.5	4.7	5.2	5.1
Reaction Rate	----	1	-	Moderate	Moderate	Moderate	Slight	Moderate

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB3 2.25	SB3 2.5	SB3 2.75	SB3 3	SB3 3.25
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-041	EP0903915-042	EP0903915-043	EP0903915-044	EP0903915-045
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		6.1	6.0	6.2	5.7	5.6
pH (Fox)	----	0.1	pH Unit		5.0	5.3	4.9	4.9	5.5
Reaction Rate	----	1	-		Slight	Slight	Moderate	Moderate	Slight

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB3 3.5	SB3 3.75	SB3 4	SB4 0.25	SB4 0.5
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound / CAS Number	LOR / Unit	EP0903915-046	EP0903915-047	EP0903915-048	EP0903915-049	EP0903915-050
EA037: Ass Field Screening Analysis						
pH (F) ----	0.1 pH Unit	5.9	5.8	6.0	5.3	4.9
pH (Fox) ----	0.1 pH Unit	5.4	5.0	4.7	4.2	4.2
Reaction Rate ----	1 -	Slight	Moderate	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB4 0.75	SB4 1	SB4 1.25	SB4 1.5	SB4 1.75
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound / CAS Number	LOR / Unit	EP0903915-051	EP0903915-052	EP0903915-053	EP0903915-054	EP0903915-055
EA037: Ass Field Screening Analysis						
pH (F) ----	0.1 pH Unit	4.4	4.3	4.4	4.6	4.3
pH (Fox) ----	0.1 pH Unit	4.2	4.1	4.1	4.4	4.0
Reaction Rate ----	1 -	Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB4 2	SB4 2.25	SB4 2.5	SB4 2.75	SB4 3
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-056	EP0903915-057	EP0903915-058	EP0903915-059	EP0903915-060
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		4.2	4.9	4.9	4.6	4.8
pH (Fox)	----	0.1	pH Unit		4.1	3.0	2.7	2.3	3.4
Reaction Rate	----	1	-		Slight	Moderate	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB4 3.25	SB4 3.5	SB4 3.75	SB4 4	SB5 0.25
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-061	EP0903915-062	EP0903915-063	EP0903915-064	EP0903915-065
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		5.3	5.6	5.8	6.0	5.0
pH (Fox)	----	0.1	pH Unit		2.2	2.3	1.8	1.9	2.8
Reaction Rate	----	1	-		Strong	Strong	Strong	Strong	Moderate

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB5 0.5	SB5 0.75	SB5 1	SB5 1.25	SB5 1.5
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound / CAS Number	LOR / Unit	EP0903915-066	EP0903915-067	EP0903915-068	EP0903915-069	EP0903915-070
EA037: Ass Field Screening Analysis						
pH (F) ----	0.1 pH Unit	5.2	5.1	5.1	5.2	5.4
pH (Fox) ----	0.1 pH Unit	4.4	4.5	5.0	4.8	2.6
Reaction Rate ----	1 -	Slight	Slight	Slight	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL			Client sample ID	SB5 1.75	SB5 2	SB5 2.25	SB5 2.5	SB5 2.75
			Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound	CAS Number	LOR	Unit	EP0903915-071	EP0903915-072	EP0903915-073	EP0903915-074	EP0903915-075
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	5.2	5.4	5.3	5.4	5.2
pH (Fox)	----	0.1	pH Unit	4.6	4.1	4.8	5.2	5.1
Reaction Rate	----	1	-	Slight	Slight	Slight	Slight	Slight

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB5 3	SB5 3.25	SB5 3.5	SB5 3.75	SB5 4
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-076	EP0903915-077	EP0903915-078	EP0903915-079	EP0903915-080
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		**5.4**	**5.4**	**5.8**	**5.7**	**5.6**
pH (Fox)	----	0.1	pH Unit		**5.2**	**5.2**	**4.8**	**4.9**	**4.4**
Reaction Rate	----	1	-		**Slight**	**Slight**	**Moderate**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB6 0.25	SB6 0.5	SB6 0.75	SB6 1	SB6 1.25
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-081	EP0903915-082	EP0903915-083	EP0903915-084	EP0903915-085
EA037: Ass Field Screening Analysis									
pH (F)	---	0.1	pH Unit		**5.0**	**5.1**	**5.4**	**5.6**	**5.8**
pH (Fox)	---	0.1	pH Unit		**5.0**	**5.0**	**4.9**	**4.9**	**4.6**
Reaction Rate	---	1	-		**Slight**	**Slight**	**Slight**	**Slight**	**Slight**

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB6 1.5	SB6 1.75	SB6 2	SB6 2.25	SB6 2.5
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-086	EP0903915-087	EP0903915-088	EP0903915-089	EP0903915-090
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		6.0	6.3	6.0	6.2	6.2
pH (Fox)	----	0.1	pH Unit		4.7	2.1	3.4	2.3	2.8
Reaction Rate	----	1	-		Moderate	Moderate	Moderate	Moderate	Moderate

Analytical Results

Sub-Matrix: **SOIL**

Compound	CAS Number	LOR	Unit	Client sample ID	SB6 2.75	SB6 3	SB6 3.25	SB6 3.5	SB6 3.75
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0903915-091	EP0903915-092	EP0903915-093	EP0903915-094	EP0903915-095
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		**6.3**	**6.4**	**6.1**	**6.0**	**5.7**
pH (Fox)	----	0.1	pH Unit		**3.7**	**2.5**	**2.0**	**2.0**	**2.0**
Reaction Rate	----	1	-		**Moderate**	**Moderate**	**Strong**	**Strong**	**Strong**

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB6 4	SB7 0.25	SB7 0.5	SB7 0.75	SB7 1
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound / CAS Number	LOR / Unit	EP0903915-096	EP0903915-097	EP0903915-098	EP0903915-099	EP0903915-100
EA037: Ass Field Screening Analysis						
pH (F) ----	0.1 pH Unit	6.0	5.6	5.1	4.7	4.6
pH (Fox) ----	0.1 pH Unit	2.0	4.4	4.9	3.6	4.4
Reaction Rate ----	1 -	Strong	Moderate	Moderate	Moderate	Slight

Analytical Results

Sub-Matrix: SOIL				Client sample ID	SB7 1.25	SB7 1.5	SB7 1.75	SB7 2	SB7 2.25
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound	CAS Number	LOR	Unit		EP0903915-101	EP0903915-102	EP0903915-103	EP0903915-104	EP0903915-105
EA037: Ass Field Screening Analysis									
pH (F)	----	0.1	pH Unit		4.7	4.6	4.7	4.8	4.5
pH (Fox)	----	0.1	pH Unit		4.4	3.6	3.8	3.3	2.6
Reaction Rate	----	1	-		Slight	Slight	Slight	Moderate	Moderate

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB7 2.5	SB7 2.75	SB7 3	SB7 3.25	SB7 3.5
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound / CAS Number	LOR / Unit	EP0903915-106	EP0903915-107	EP0903915-108	EP0903915-109	EP0903915-110
EA037: Ass Field Screening Analysis						
pH (F) ---	0.1 pH Unit	4.9	5.2	5.4	5.5	5.7
pH (Fox) ---	0.1 pH Unit	2.8	1.6	1.7	1.9	1.8
Reaction Rate ---	1 -	Moderate	Moderate	Strong	Strong	Strong

Analytical Results

Sub-Matrix: SOIL			Client sample ID	SB7 3.75	SB7 4	----	----	----
			Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	----	----	----
Compound	CAS Number	LOR	Unit	EP0903915-111	EP0903915-112	----	----	----
EA037: Ass Field Screening Analysis								
pH (F)	----	0.1	pH Unit	5.6	6.1	----	----	----
pH (Fox)	----	0.1	pH Unit	1.7	1.8	----	----	----
Reaction Rate	----	1	-	Strong	Strong	----	----	----

Alan Davies

From: Jeremy Payet (Perth) [Jeremy.Payet@cardno.com.au]
Sent: Thursday, 6 August 2009 3:35 PM
To: Perth
Cc: Samples Perth
Subject: Further analysis

Hi,

Could you please arrange for the following samples to be submitted to the following suites of analysis?

Work order number: EP0903915 (Cascades Preliminary ASS).

Samples for SPOCAS analysis (EA-029):

- EP0903915-022 (SB2-1.5)
- EP0903915-036 (SB3-1.0)
- EP0903915-070 (SB5-1.5)

Samples for SPOCAS analysis (EA-029) **AND** CRS analysis (EA033):

- EP0903915-030 (SB2-3.5)
- EP0903915-064 (SB4-4.0)
- EP0903915-089 (SB6-2.25)
- EP0903915-104 (SB7-2.0)
- EP0903915-108 (SB7-3.0)

Environmental Division
Perth
Work Order
EP0904382

Could you please advise when this email has been received.

Thank you

Regards,

Telephone : +61-8-9209 7655

Jeremy Payet
Environmental Consultant

Cardno (WA) Pty Ltd [ABN 77 009 119 000]
2 Bagot Road Subiaco WA 6008 PO Box 155 Subiaco WA 6008

Phone: +61 8 9273 3703 Fax: +61 8 9388 3831
Email: jeremy.payet@cardno.com.au Web: http://www.cardno.com.au

Cardno

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This email has been scanned through the CBL Domain

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

SAMPLE RECEIPT NOTIFICATION (SRN)

Comprehensive Report

Work Order	: **EP0904382**		
Amendment	: ?		
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JEREMY PAYET	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Jeremy.payet@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: Ex EP0903915 V8041	Page	: 1 of 2
Order number	: ----		
C-O-C number	: ----	Quote number	: EP2009CARBSD0294 (EN-024-09 BQ)
Site	: CASCADES PRELIMINARY ASS		
Sampler	: JEREMY PAYET	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement

Dates

Date Samples Received	: 06-AUG-2009	Issue Date	: 18-AUG-2009
Client Requested Due Date	: 13-AUG-2009	Scheduled Reporting Date	: **13-AUG-2009**

Delivery Details

Mode of Delivery	: Samples on hand	Temperature	: ----
No. of coolers/boxes	: ----	No. of samples received	: 8
Sercurity Seal	: Intact.	No. of samples analysed	: 8

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Requested Deliverables
- Samples received in appropriately pretreated and preserved containers.
- Please see scanned COC for sample discrepencies: extra samples , samples not received etc.
- **Samples received in appropriately pretreated and preserved containers.**
- **Sample(s) have been received within recommended holding times.**
- **pH analysis should be conducted within 6 hours of sampling.**
- Analytical work for this work order will be conducted at ALS Environmental Perth.
- Please direct any turnaround / technical queries to the laboratory contact designated above.
- Please direct any queries related to sample condition / numbering / breakages to Sample Receipt (SamplesPerth@alsenviro.com)
- Sample Disposal - Aqueous (14 days), Solid (90 days) from date of completion of Work Order.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exist.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process neccessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Matrix: **SOIL**

Laboratory sample ID	Client sampling date / time	Client sample ID	SOIL - EA029-WA WA - SPOCAS	SOIL - EA033-WA WA - Chromium Suite for Acid Sulphate Soils
EP0904382-001	15-JUL-2009 15:00	SB2 1.5	✓	
EP0904382-002	15-JUL-2009 15:00	SB3 1.0	✓	
EP0904382-003	15-JUL-2009 15:00	SB5 1.5	✓	
EP0904382-004	15-JUL-2009 15:00	SB2 3.5	✓	✓
EP0904382-005	15-JUL-2009 15:00	SB4 4.0	✓	✓
EP0904382-006	15-JUL-2009 15:00	SB6 2.25	✓	✓
EP0904382-007	15-JUL-2009 15:00	SB7 2.0	✓	✓
EP0904382-008	15-JUL-2009 15:00	SB7 3.0	✓	✓

Requested Deliverables

MR JEREMY PAYET

- *AU Certificate of Analysis - NATA (COA)	Email	Jeremy.payet@cardno.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	Jeremy.payet@cardno.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	Jeremy.payet@cardno.com.au
- A4 - AU Sample Receipt Notification - Environmental (SRN)	Email	Jeremy.payet@cardno.com.au
- Default - Chain of Custody (COC)	Email	Jeremy.payet@cardno.com.au
- EDI Format - ENMRG (ENMRG)	Email	Jeremy.payet@cardno.com.au
- EDI Format - ESDAT (ESDAT)	Email	Jeremy.payet@cardno.com.au
- EDI Format - XTab (XTAB)	Email	Jeremy.payet@cardno.com.au

THE ACCOUNTS PAYABLE (WA)

- A4 - AU Tax Invoice (INV)	Email	sandra.gillon@cardno.com.au

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0904382**	Page	: 1 of 7
Amendment	: **2**		
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JEREMY PAYET	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: Jeremy.payet@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: Ex EP0903915 V8041	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ---		
C-O-C number	: ---	Date Samples Received	: 06-AUG-2009
Sampler	: JEREMY PAYET	Issue Date	: 18-AUG-2009
Site	: CASCADES PRELIMINARY ASS		
		No. of samples received	: 8
Quote number	: EN-024-09 BQ	No. of samples analysed	: 8

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

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

Signatories	*Position*	*Accreditation Category*
Stacey Hawkins	Senior Chemist - Acid Sulphate Soils	Perth ASS

General Comments

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

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

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

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

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

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

- **Liming rate is calculated and reported on a dry weight basis assuming use of fine agricultural lime (CaCO3) and using a safety factor of 1.5 to allow for non-homogeneous mixing and poor reactivity of lime. For conversion of Liming Rate from 'kg/t dry weight' to 'kg/m3 in-situ soil', multiply 'reported results' x 'wet bulk density of soil in t/m3'.**
- **Retained Acidity not required because pH KCl greater than or equal to 4.5**
- **This report has been amended as a result of misinterpretation of sample identification numbers (IDs). All analysis results are as per the previous report**

Analytical Results

Sub-Matrix: SOIL				Client sample ID	SB2 1.5	SB3 1.0	SB5 1.5	SB2 3.5	SB4 4.0
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
Compound	CAS Number	LOR	Unit		EP0904382-001	EP0904382-002	EP0904382-003	EP0904382-004	EP0904382-005
EA029-A: pH Measurements									
pH KCl (23A)	----	0.1	pH Unit		9.4	8.9	7.0	6.8	6.6
pH OX (23B)	----	0.1	pH Unit		7.0	6.9	5.6	2.7	2.5
EA029-B: Acidity Trail									
Titratable Actual Acidity (23F)	----	2	mole H+ / t		<2	<2	<2	<2	<2
Titratable Peroxide Acidity (23G)	----	2	mole H+ / t		<2	<2	<2	135	132
Titratable Sulfidic Acidity (23H)	----	2	mole H+ / t		<2	<2	<2	135	132
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S		<0.02	<0.02	<0.02	<0.02	<0.02
sulfidic - Titratable Peroxide Acidity (s-23G)	----	0.02	% pyrite S		<0.02	<0.02	<0.02	0.22	0.21
sulfidic - Titratable Sulfidic Acidity (s-23H)	----	0.02	% pyrite S		<0.02	<0.02	<0.02	0.22	0.21
EA029-C: Sulfur Trail									
KCl Extractable Sulfur (23Ce)	----	0.02	% S		<0.02	<0.02	<0.02	<0.02	<0.02
Peroxide Sulfur (23De)	----	0.02	% S		<0.02	<0.02	<0.02	0.22	0.20
Peroxide Oxidisable Sulfur (23E)	----	0.02	% S		<0.02	<0.02	<0.02	0.21	0.19
acidity - Peroxide Oxidisable Sulfur (a-23E)	----	10	mole H+ / t		<10	<10	<10	129	117
EA029-D: Calcium Values									
KCl Extractable Calcium (23Vh)	----	0.02	% Ca		0.10	0.12	0.05	<0.02	<0.02
Peroxide Calcium (23Wh)	----	0.02	% Ca		0.11	0.12	0.05	<0.02	<0.02
Acid Reacted Calcium (23X)	----	0.02	% Ca		<0.02	<0.02	<0.02	<0.02	<0.02
acidity - Acid Reacted Calcium (a-23X)	----	10	mole H+ / t		<10	<10	<10	<10	<10
sulfidic - Acid Reacted Calcium (s-23X)	----	0.02	% S		<0.02	<0.02	<0.02	<0.02	<0.02
EA029-E: Magnesium Values									
KCl Extractable Magnesium (23Sm)	----	0.02	% Mg		<0.02	<0.02	<0.02	0.03	<0.02
Peroxide Magnesium (23Tm)	----	0.02	% Mg		<0.02	<0.02	<0.02	0.03	<0.02
Acid Reacted Magnesium (23U)	----	0.02	% Mg		<0.02	<0.02	<0.02	<0.02	<0.02
Acidity - Acid Reacted Magnesium (a-23U)	----	10	mole H+ / t		<10	<10	<10	<10	<10
sulfidic - Acid Reacted Magnesium (s-23U)	----	0.02	% S		<0.02	<0.02	<0.02	<0.02	<0.02
EA029-F: Excess Acid Neutralising Capacity									
Excess Acid Neutralising Capacity (23Q)	----	0.02	% CaCO3		0.29	0.22	----	----	----
acidity - Excess Acid Neutralising Capacity (a-23Q)	----	10	mole H+ / t		58	43	----	----	----
sulfidic - Excess Acid Neutralising Capacity (s-23Q)	----	0.02	% S		0.09	0.07	----	----	----
EA029-H: Acid Base Accounting									

Analytical Results

Sub-Matrix: SOIL

Compound	CAS Number	LOR	Unit	Client sample ID	SB2 1.5	SB3 1.0	SB5 1.5	SB2 3.5	SB4 4.0
				Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00
					EP0904382-001	EP0904382-002	EP0904382-003	EP0904382-004	EP0904382-005
EA029-H: Acid Base Accounting - Continued									
ANC Fineness Factor	----	0.5	-		1.5	1.5	1.5	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S		<0.02	<0.02	<0.02	0.21	0.20
Net Acidity (acidity units)	----	10	mole H+ / t		<10	<10	<10	133	127
Liming Rate	----	1	kg CaCO3/t		<1	<1	<1	10	10
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		<0.02	<0.02	<0.02	0.21	0.19
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		<10	<10	<10	129	117
Liming Rate excluding ANC	----	1	kg CaCO3/t		<1	<1	<1	10	9
EA033-A: Actual Acidity									
pH KCl (23A)	----	0.1	pH Unit		----	----	----	6.8	6.6
Titratable Actual Acidity (23F)	----	2	mole H+ / t		----	----	----	<2	<2
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S		----	----	----	<0.02	<0.02
EA033-B: Potential Acidity									
Chromium Reducible Sulfur (22B)	----	0.02	% S		----	----	----	0.11	0.12
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t		----	----	----	69	74
EA033-C: Acid Neutralising Capacity									
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3		----	----	----	0.14	<0.01
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t		----	----	----	27	<10
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S		----	----	----	0.04	<0.01
EA033-E: Acid Base Accounting									
ANC Fineness Factor	----	0.5	-		----	----	----	1.5	1.5
Net Acidity (sulfur units)	----	0.02	% S		----	----	----	0.08	0.12
Net Acidity (acidity units)	----	10	mole H+ / t		----	----	----	50	74
Liming Rate	----	1	kg CaCO3/t		----	----	----	4	6
Net Acidity excluding ANC (sulfur units)	----	0.02	% S		----	----	----	0.11	0.12
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t		----	----	----	69	74
Liming Rate excluding ANC	----	1	kg CaCO3/t		----	----	----	5	6

Analytical Results

Sub-Matrix: SOIL	Client sample ID	SB6 2.25	SB7 2.0	SB7 3.0	----	----
	Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	----	----
Compound	CAS Number / LOR / Unit	EP0904382-006	EP0904382-007	EP0904382-008	----	----
EA029-A: pH Measurements						
pH KCl (23A)	---- 0.1 pH Unit	6.0	7.1	6.7	----	----
pH OX (23B)	---- 0.1 pH Unit	3.4	4.2	2.8	----	----
EA029-B: Acidity Trail						
Titratable Actual Acidity (23F)	---- 2 mole H+ / t	5	<2	<2	----	----
Titratable Peroxide Acidity (23G)	---- 2 mole H+ / t	150	4	110	----	----
Titratable Sulfidic Acidity (23H)	---- 2 mole H+ / t	145	4	110	----	----
sulfidic - Titratable Actual Acidity (s-23F)	---- 0.02 % pyrite S	<0.02	<0.02	<0.02	----	----
sulfidic - Titratable Peroxide Acidity (s-23G)	---- 0.02 % pyrite S	0.24	<0.02	0.18	----	----
sulfidic - Titratable Sulfidic Acidity (s-23H)	---- 0.02 % pyrite S	0.23	<0.02	0.18	----	----
EA029-C: Sulfur Trail						
KCl Extractable Sulfur (23Ce)	---- 0.02 % S	<0.02	<0.02	0.03	----	----
Peroxide Sulfur (23De)	---- 0.02 % S	0.13	<0.02	0.21	----	----
Peroxide Oxidisable Sulfur (23E)	---- 0.02 % S	0.12	<0.02	0.18	----	----
acidity - Peroxide Oxidisable Sulfur (a-23E)	---- 10 mole H+ / t	74	<10	113	----	----
EA029-D: Calcium Values						
KCl Extractable Calcium (23Vh)	---- 0.02 % Ca	<0.02	<0.02	0.04	----	----
Peroxide Calcium (23Wh)	---- 0.02 % Ca	<0.02	<0.02	0.04	----	----
Acid Reacted Calcium (23X)	---- 0.02 % Ca	<0.02	<0.02	<0.02	----	----
acidity - Acid Reacted Calcium (a-23X)	---- 10 mole H+ / t	<10	<10	<10	----	----
sulfidic - Acid Reacted Calcium (s-23X)	---- 0.02 % S	<0.02	<0.02	<0.02	----	----
EA029-E: Magnesium Values						
KCl Extractable Magnesium (23Sm)	---- 0.02 % Mg	0.03	<0.02	<0.02	----	----
Peroxide Magnesium (23Tm)	---- 0.02 % Mg	0.03	<0.02	<0.02	----	----
Acid Reacted Magnesium (23U)	---- 0.02 % Mg	<0.02	<0.02	<0.02	----	----
Acidity - Acid Reacted Magnesium (a-23U)	---- 10 mole H+ / t	<10	<10	<10	----	----
sulfidic - Acid Reacted Magnesium (s-23U)	---- 0.02 % S	<0.02	<0.02	<0.02	----	----
EA029-H: Acid Base Accounting						
ANC Fineness Factor	---- 0.5 -	1.5	1.5	1.5	----	----
Net Acidity (sulfur units)	---- 0.02 % S	0.13	<0.02	0.18	----	----
Net Acidity (acidity units)	---- 10 mole H+ / t	79	<10	111	----	----
Liming Rate	---- 1 kg CaCO3/t	6	<1	8	----	----
Net Acidity excluding ANC (sulfur units)	---- 0.02 % S	0.13	<0.02	0.18	----	----
Net Acidity excluding ANC (acidity units)	---- 10 mole H+ / t	79	<10	113	----	----

Analytical Results

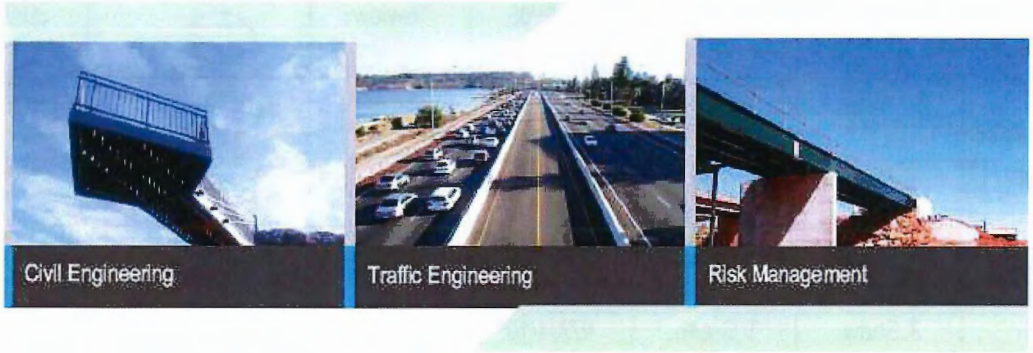
Sub-Matrix: SOIL			Client sample ID	SB6 2.25	SB7 2.0	SB7 3.0	----	----
			Client sampling date / time	15-JUL-2009 15:00	15-JUL-2009 15:00	15-JUL-2009 15:00	----	----
Compound	CAS Number	LOR	Unit	EP0904382-006	EP0904382-007	EP0904382-008	----	----
EA029-H: Acid Base Accounting - Continued								
Liming Rate excluding ANC	----	1	kg CaCO3/t	6	<1	8	----	----
EA033-A: Actual Acidity								
pH KCl (23A)	----	0.1	pH Unit	6.0	7.1	6.7	----	----
Titratable Actual Acidity (23F)	----	2	mole H+ / t	5	<2	<2	----	----
sulfidic - Titratable Actual Acidity (s-23F)	----	0.02	% pyrite S	<0.02	<0.02	<0.02	----	----
EA033-B: Potential Acidity								
Chromium Reducible Sulfur (22B)	----	0.02	% S	0.06	<0.02	0.12	----	----
acidity - Chromium Reducible Sulfur (a-22B)	----	10	mole H+ / t	38	<10	76	----	----
EA033-C: Acid Neutralising Capacity								
Acid Neutralising Capacity (19A2)	----	0.01	% CaCO3	----	0.04	0.06	----	----
acidity - Acid Neutralising Capacity (a-19A2)	----	10	mole H+ / t	----	<10	13	----	----
sulfidic - Acid Neutralising Capacity (s-19A2)	----	0.01	% pyrite S	----	0.01	0.02	----	----
EA033-E: Acid Base Accounting								
ANC Fineness Factor	----	0.5	-	1.5	1.5	1.5	----	----
Net Acidity (sulfur units)	----	0.02	% S	0.07	<0.02	0.11	----	----
Net Acidity (acidity units)	----	10	mole H+ / t	43	<10	67	----	----
Liming Rate	----	1	kg CaCO3/t	3	<1	5	----	----
Net Acidity excluding ANC (sulfur units)	----	0.02	% S	0.07	<0.02	0.12	----	----
Net Acidity excluding ANC (acidity units)	----	10	mole H+ / t	43	<10	76	----	----
Liming Rate excluding ANC	----	1	kg CaCO3/t	3	<1	6	----	----

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX D
TRANSPORT ASSESSMENT REPORT

SHAWMAC

CONSULTING CIVIL & TRAFFIC ENGINEERS, RISK MANAGERS.



Project:	Transport Assessment. Lot 9001 Mortimer Road and 379 Millar Road, Wellard. Version 16
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5	T Shaw.	T Green.	01/04/10	Client use		01/04/10
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8	T Shaw.	T Green.	20/07/10	Client use		20/07/10
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11	T Shaw.		02/10/13	Client use		02/10/13
12	T Shaw.		09/10/13	Client use		09/10/13
13	T Shaw.		12/11/13	Client use		12/11/13
14	T Shaw.		12/11/13	Client use		12/11/13
15	T Shaw.		27/03/14	Client use		27/03/14

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CONTENTS.

1. Summary. 5
2. Introduction and Background. 6
2.1. Proponent. 6
2.2. Site Location and Land Use. 6
3. Development Proposal 7
3.1. Regional Context. 7
3.2. Proposed Land Uses. 7
3.3. Major Attractors and Generators of traffic. 10
4. Existing Situation. 11
4.1. Current Landuse. 11
4.2. Existing Network Configuration. 12
4.3. Existing Pedestrian/Cyclist Networks. 13
4.4. Public Transport. 13
5. Proposed Transport Networks. 15
5.1. Proposed Infrastructure. 15
6. Changes to External Transport Networks 20
7. Integration with Surrounding Area 21
8. Analysis of Transport Networks – General 22
8.1. Assessment Year 22
8.2. Time Periods for Assessment 22
9. Analysis of Internal Transport Networks. 23
9.1. Subdivision Generated Traffic. 23
9.2. Non Subdivision Traffic. 29
9.3. Roads and Intersections. 29
9.3.1. Intersections. 32

9.3.2. Mortimer Road – Road A intersection 33
9.3.3. Analysis Warrants. 33
9.4. Pedestrian / Cycle networks 34
9.5. Access to Public Transport. 35
10. Analysis of External Transport Networks. 37
10.1. Extent of Analysis. 37
10.2. Impact on external intersections. 37
11. Safety Issues 38

1. Summary.

Shawmac Pty Ltd was commissioned by Wood and Grieve on behalf of Armana Holdings to undertake an assessment of the transportation impacts associated with the development of a residential subdivision situated on various parcels of land in Wellard.

This assessment is an update of the previous Transport Assessment which was approved by the then Town of Kwinana as part of the previous Local Structure Plan (LSP) for Lots 27 and part Lot 201.

Key transport issues focus on the following matters:

- The capacity of the local road network to accommodate the additional traffic generated by the proposal;
- The extent to which the additional traffic generated can be safety managed on the adjacent current and future road network;
- The provision of safe access to the proposed subdivision from the adjacent road network;
- The provision of safe access to the proposed school especially student pick up location and road crossings; and
- The safety and efficiency of the site's internal road network and in particular the extent that the site is able to safety and efficiently accommodate alternative and sustainable transport modes including pedestrians and cyclists.

Analysis shows that the District Distributor Mortimer Road is likely to be the major traffic carrying route adjacent to the development in part due to traffic generated by the subdivision and in part by traffic generated from yet to be developed land to the east of the site (i.e. the balance of the Wellard East Cell) and to the west of Woolcoot Road. With the exception of the main north-south link, all of the other streets are predicted to carry relatively low traffic volumes generally less than 3,000 vehicles per day, with most predicted to carry less than 1,000 vehicles per day.

The proposed road network is generally permeable and the design of the streets will reinforce distribution of traffic onto the higher hierarchy roads.

It is concluded that the proposed street network will provide an acceptable range of choices for travel and ensure that traffic volumes on individual streets can be kept below threshold levels to ensure the amenity of the area is preserved and safe movement options exist for pedestrians, cyclists and local traffic.

2. Introduction and Background.

2.1. Proponent.

Shawmac Pty Ltd has been commissioned by Wood and Grieve on behalf of Armana Holdings to undertake an assessment of the transportation impacts associated with the development of a residential subdivision on land south of Mortimer Road, Wellard East and as detailed below.

2.2. Site Location and Land Use.

The site is located as shown on Figure 1 and is within the City of Kwinana.

The site is located approximately 36 kilometres south of the Perth City CBD and to the east of the Kwinana Freeway. The transport assessment has been undertaken in order to assess the potential effect that development of the site from its current part rural part developed land use to predominantly residential land use would have in terms of the interaction with the existing and proposed road network. The assessment is based on the structure plan prepared by Roberts Day.

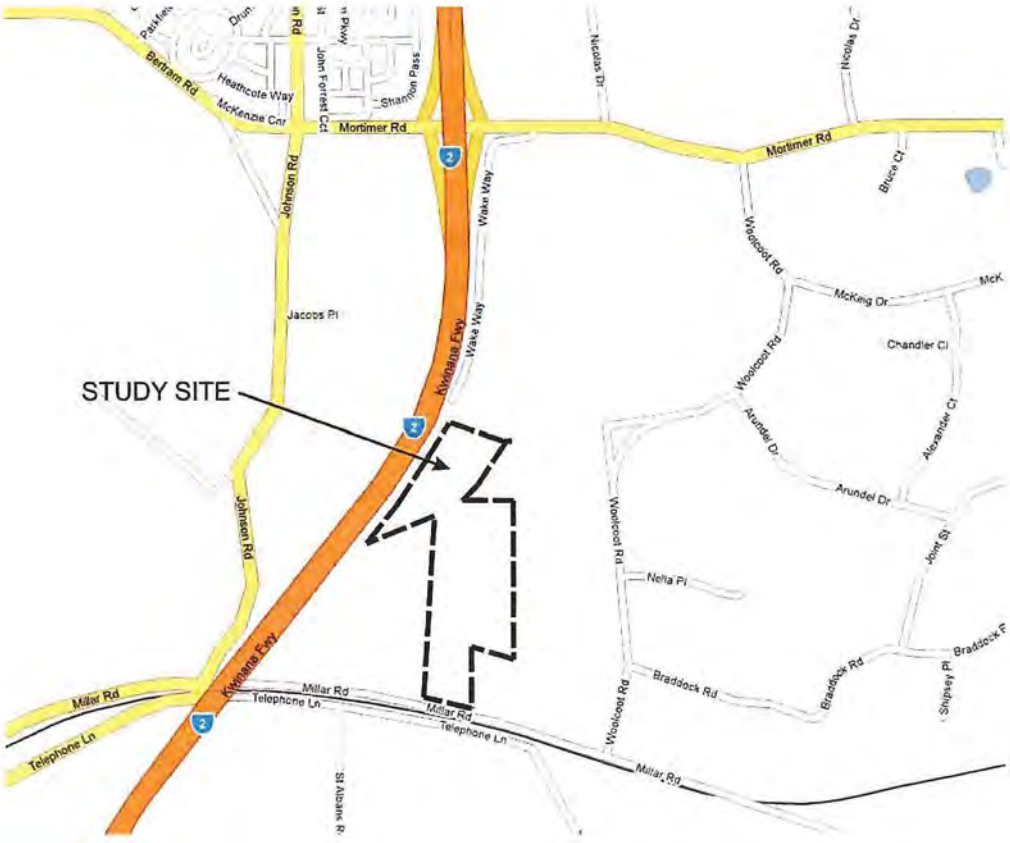


Figure 1. Site Location.

3. Development Proposal

3.1. Regional Context.

The study site is currently undeveloped and is bounded by the Kwinana Freeway to the west, Millar Road to the south and partially developed land to the north.

To date subdivision has occurred over part of lot 201 located to the north of the study site.

3.2. Proposed Land Uses.

Proposed land use allocation within the structure plan area is shown on Figure 2 with Figure 3 providing an overall view of the cell.

The proposed plan comprises the development of a residential subdivision together with a primary school site.

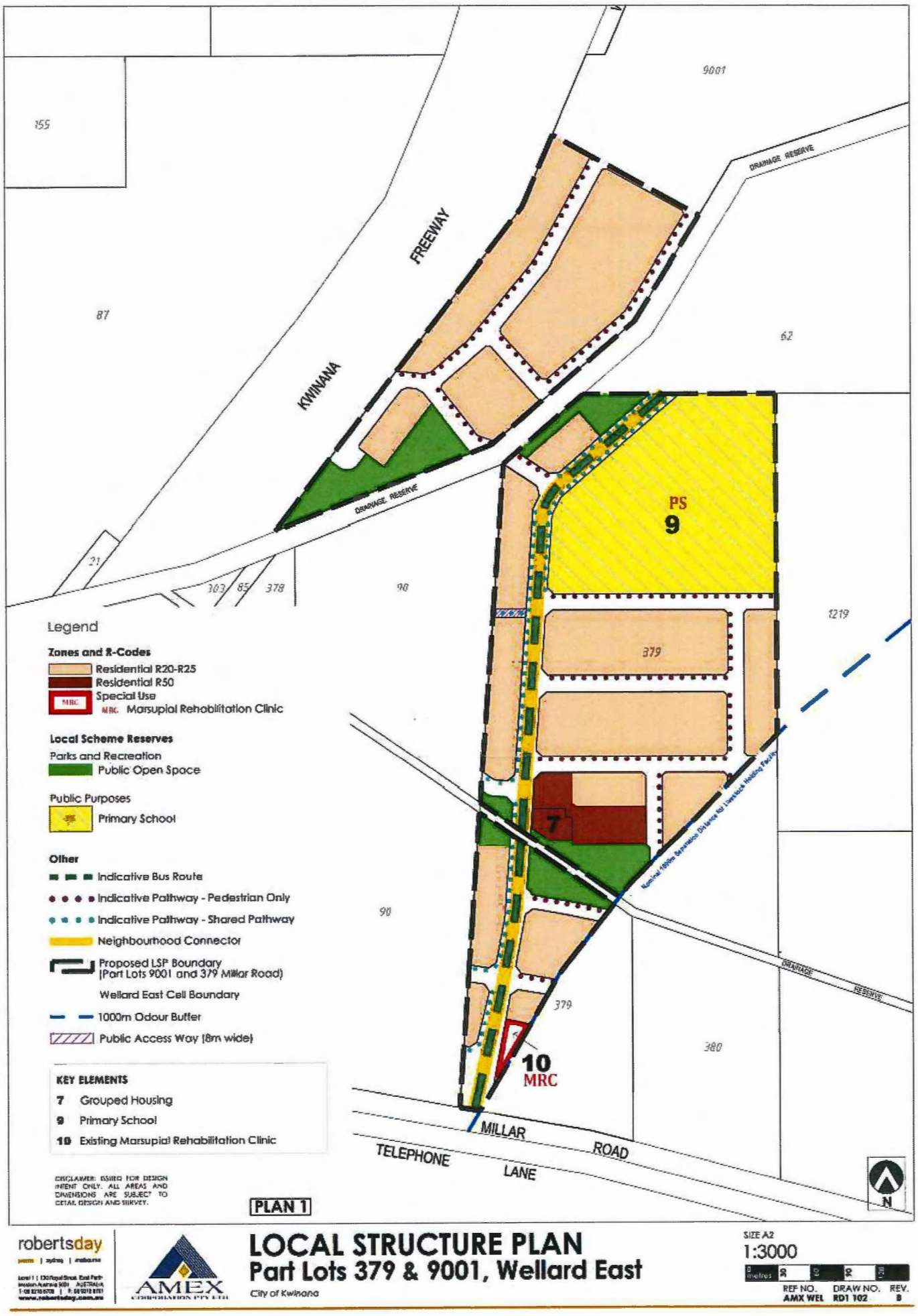


Figure 2. Proposed Layout[1]

[1] Source – Roberts Day



Figure 3. Proposed Layout[2]

[2] Source – Roberts Day

3.3. Major Attractors and Generators of traffic.

The site's location to the south of the Perth CBD and east of the Kwinana regional centre and industrial area limits the number of attractors and generators external to the site. The major generator / attractor is likely to be the Perth CBD which is expected to provide the origin / destination for the majority of the Internal – External trips from the subdivision. Other external attractor – generators are the commercial and work related centres in Kwinana townsite and industrial area.

It is understood that ongoing future development of the land to the east and west of the study site and to the west of Woolcoot Road has the potential to introduce an additional 750 to 800 residential lots to the Wellard East Cell.

4. Existing Situation.

4.1. Current Landuse.

Figure 4 indicates the existing land uses adjacent to, and within the proposed subdivisional boundaries, together with existing road network details.

Enquiries as to the availability of existing traffic counts have been made to Main Roads WA and the Local Authority and reference has been made to previous reports. Where information has been available it is shown in later sections of the report.

Current adjacent land use typically comprises small rural holdings, existing lots already developed within the cell, residential development to the north west and to the west of the Kwinana Freeway. Future staged planning will result in full development of the land area bounded by Mortimer Road, Woolcoot Road, Millar Road and the Kwinana Freeway (with the exception of wetland areas).

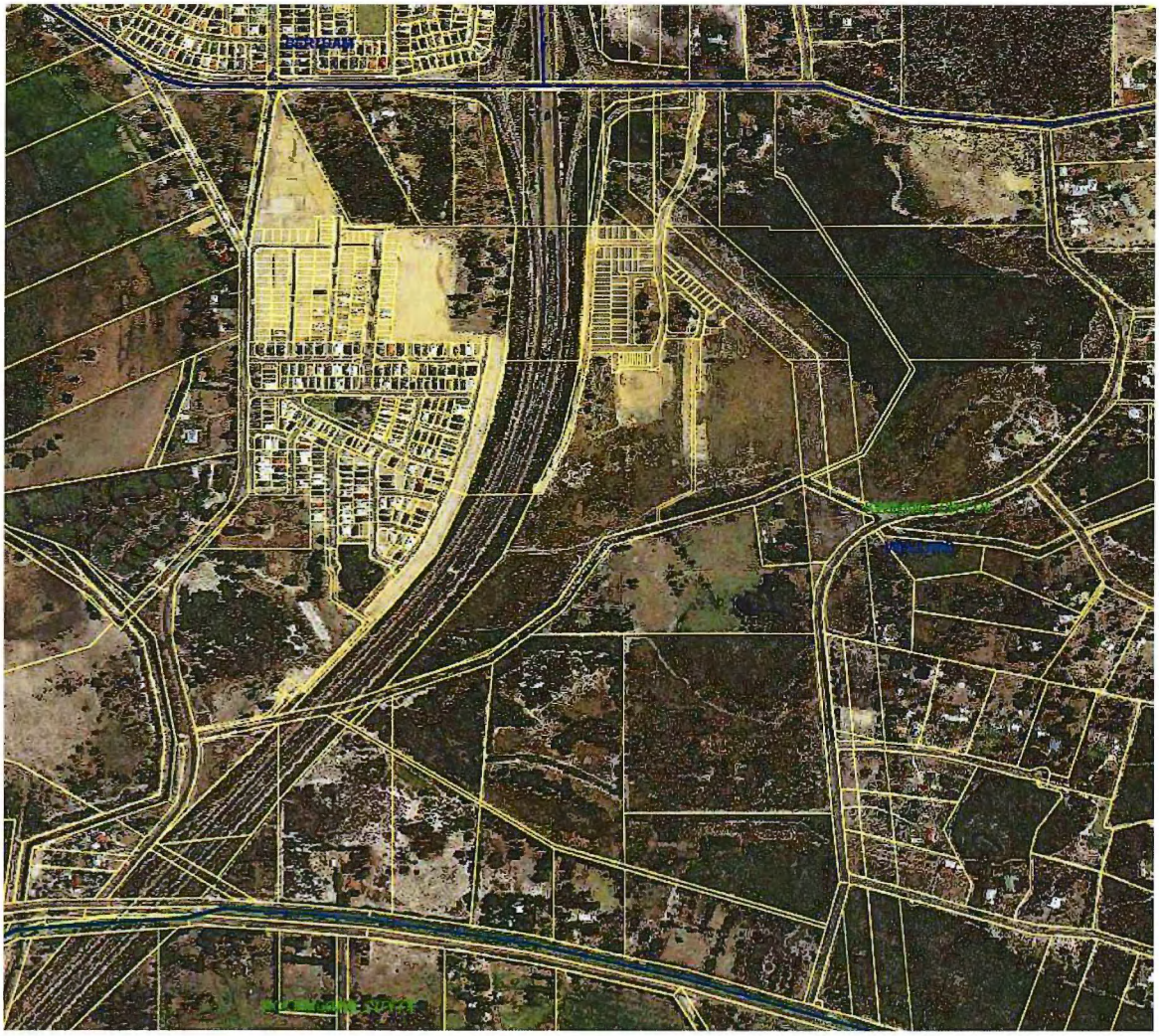


Figure 4. Existing Land Use.

4.2. Existing Network Configuration.

The Kwinana Freeway is a major north-south route connecting Mandurah and the southern suburbs to the CBD and forms the western boundary of the site. The freeway is constructed as a four lane dual carriageway with speed zoning set at 100 km/h and carries in the order of 39,000 vehicles daily. The Freeway is a controlled access road with connections to Mortimer Road via a grade separated signal controlled dual point interchange. There is currently no connection between the freeway and Millar Road.

Mortimer Road is a District Distributor (B) road that primarily consists of a two lane unkerbed road operating at a speed zoning of 80 km/h. Immediately east of the Kwinana Freeway, Mortimer Road widens to form a grade separated signalised dual point interchange accommodating Kwinana Freeway southbound on and off ramp and northbound on and off ramp. Mortimer Road currently carries in the order of 2,300 vehicles per day (vpd).

Similarly, Millar Road and Woolcoot Road are classified as access roads but tend to operate as local district distributor roads and primarily consist of two lane unkerbed roads. Millar Road operates at a zoned speed of 80 km/h. Woolcoot Road currently has a derestricted speed zone. While current counts are not available, 2006 counts indicate that Millar Road is expected to currently carry in the order of 2,600 vpd. Based on the traffic catchment serviced by Woolcoot Road, and assuming a generation rate of 9 vehicles trips per dwelling, it is expected that background traffic flow in Woolcoot Road would be in the order of 500 vpd. This does not include future predicted traffic flows.

Wake Way currently provides connection from the subject site to Mortimer Road via a "T" junction located approximately 200 metres east of the Kwinana Freeway – Mortimer Road southbound off ramp. Wake Way is a part unkerbed sealed rural standard road and part sealed and kerbed urban road with a carriageway width of approximately 8 metres. The alignment of Wake Way incorporates two small radii ninety degree bends south of Mortimer Road.

4.3. Existing Pedestrian/Cyclist Networks.

No pedestrian or cyclist facilities are provided immediately adjacent to the site. A Principal Shared Path is located adjacent to the Kwinana Freeway and this provides good commuter and recreational cycle facilities to the north and south. Other cycle and path facilities are provided in the newly constructed areas and areas under construction to the north in the previously approved LSP area.

4.4. Public Transport.

There are no public transport services immediately adjacent to the proposed structure plan.

Transperth operate a service through Bertram as shown on Figure 5 below.

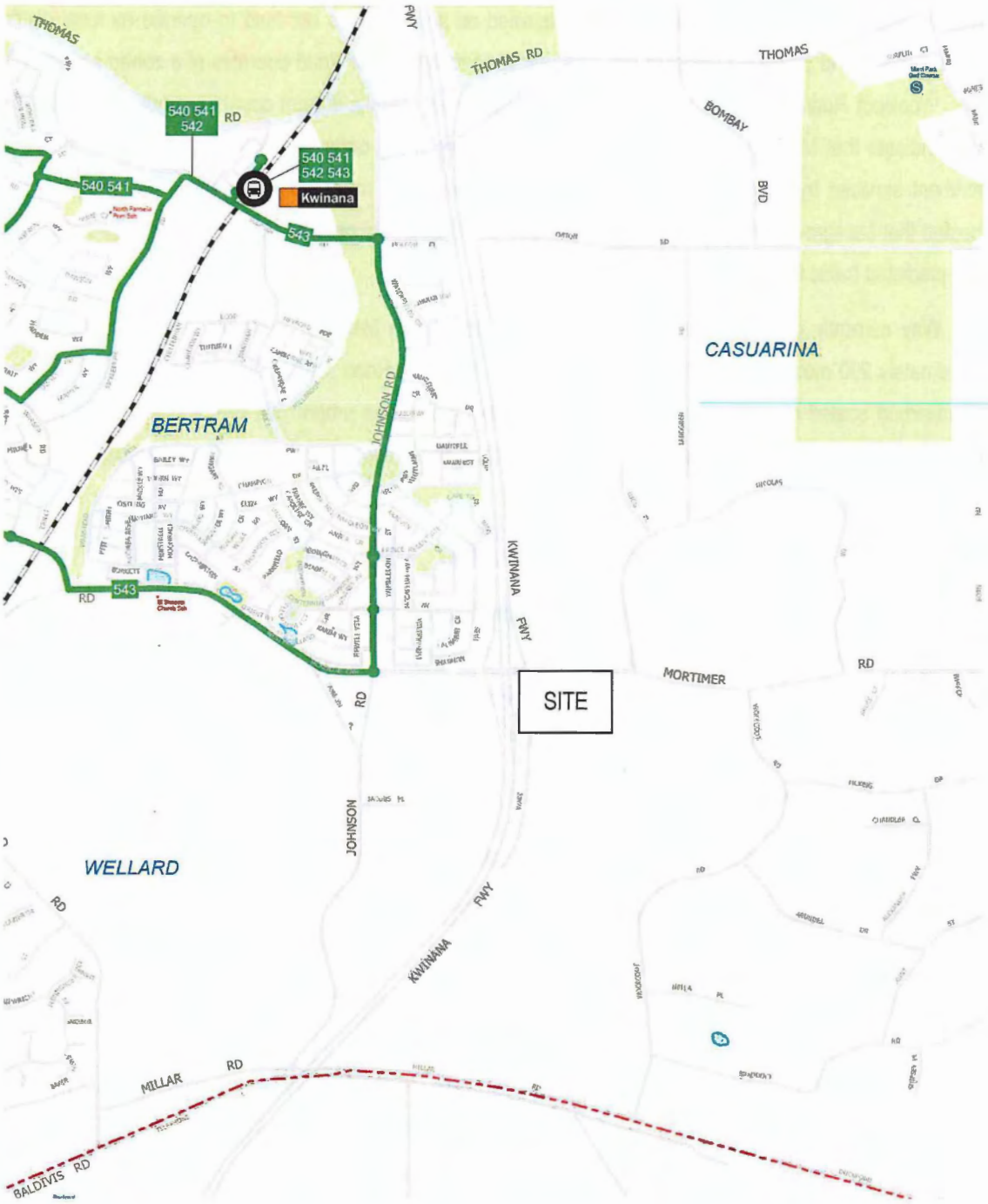


Figure 5. Adjacent Bus Routes.

5. Proposed Transport Networks.

5.1. Proposed Infrastructure.

Figure 6 indicates the proposed layout of the internal transport network by classification of road type.

For each road type, the road reservation widths and cross section details are as indicated in Table 8 and in Figures 7, 8, 9 and 10 over. These are based on recommendations from Livable Neighbourhoods and are indicative only and are subject to detailed design. It should be noted that some roads in the previously approved subdivision to the north differ from the widths shown over; however these widths have been previously reviewed and agreed to and were approved by the City of Kwinana.

It is noted that the land on which the north – south road (Road A) is located is not in one ownership and as such, the construction may be staged. This may result in an interim period during which traffic cannot directly access the northern section of Road A and is required to use some of the minor roads to bypass the unmade section of Road A. The proposed road cross sections on these minor roads provide sufficient capacity and no unacceptable adverse impacts are predicted.

Also indicated on Figure 6 are recommended intersection controls.

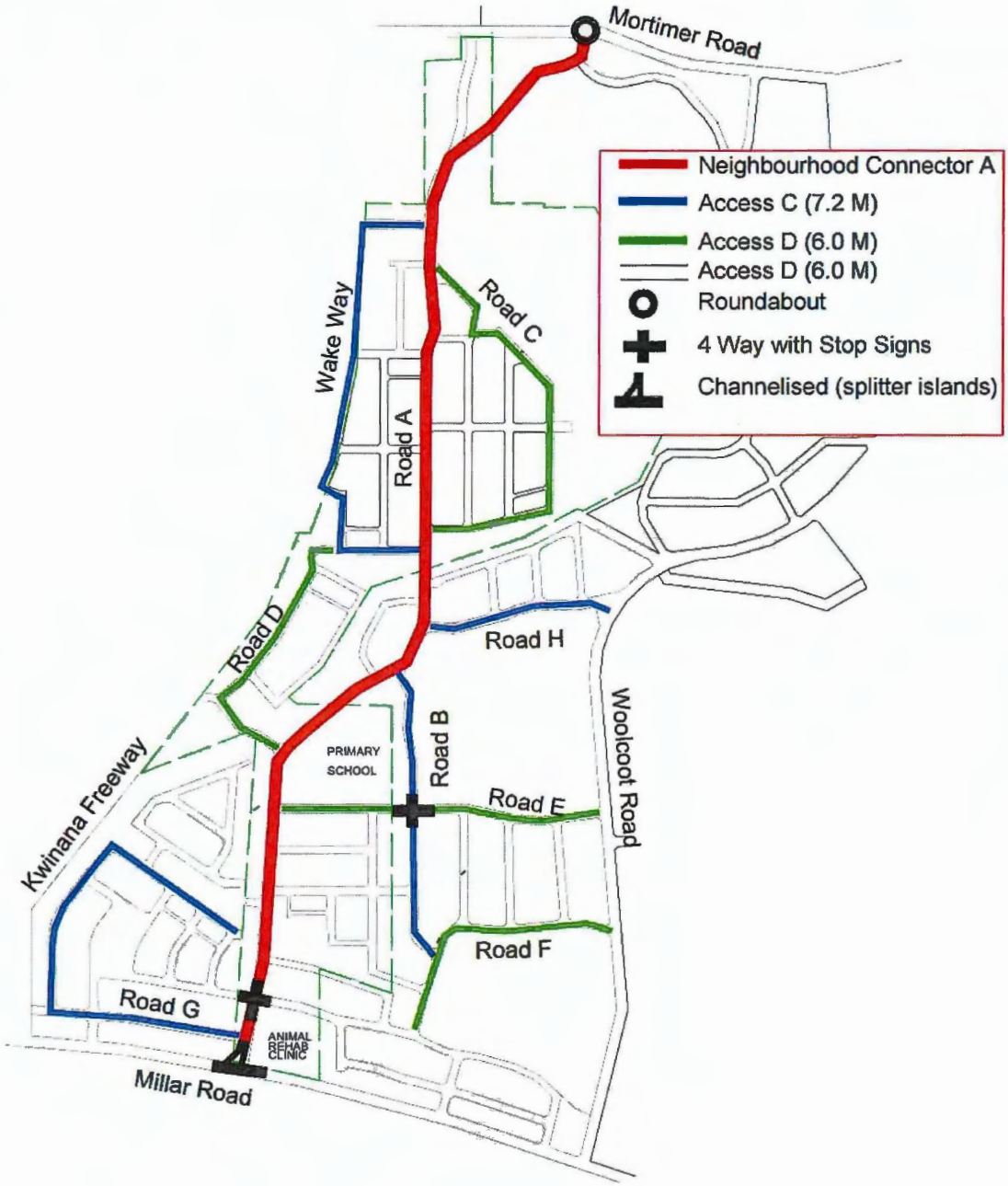
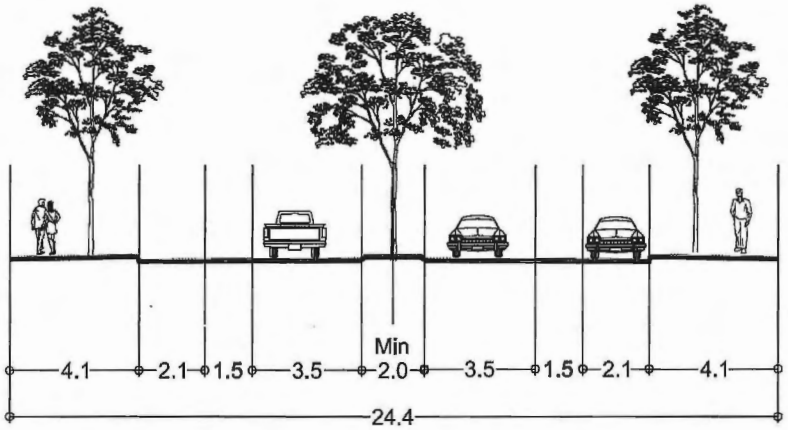


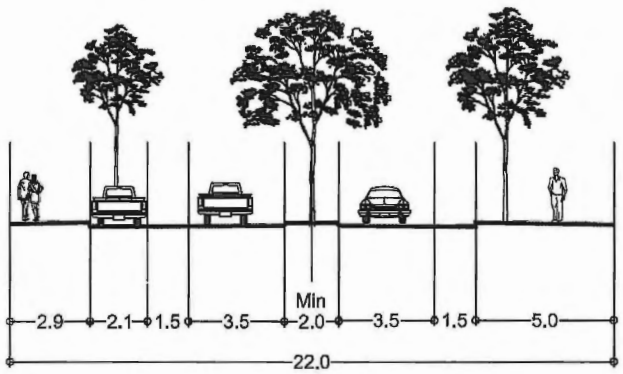
Figure 6. Proposed Network Infrastructure.



Neighbourhood Connector A - 50 km/h (up to 7,000 vpd with >3,000 preferred)

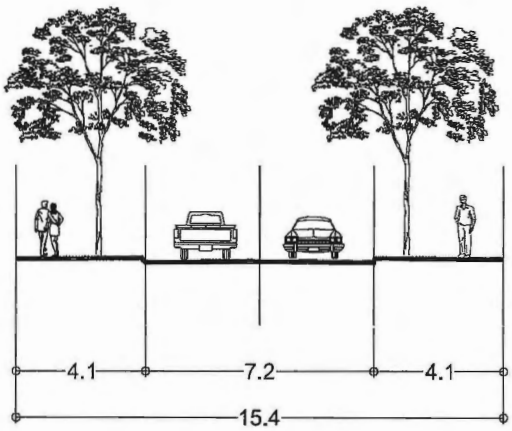
Figure 7. Neighbourhood Connector A.

For a Neighbourhood Connector A road, 1.5 metre cycle lanes are provided together with 2.0 metre footpaths down either side of the street. Notwithstanding this, Liveable Neighbourhoods indicates that subject to further considerations at the detailed design stage, a modified cross section similar to that shown below on Figure 8 may be adopted. It should be noted that the previously approved and partly constructed road layout in the northern portion of the precinct has the Road A reserve width set at 18.0 metres. In order to maintain consistency over the balance of Road A, reserve and pavement width consistent with the already approved and constructed section will be maintained.



Neighbourhood Connector A (Modified) - 50 km/h (up to 7,000 vpd with >3,000 preferred)

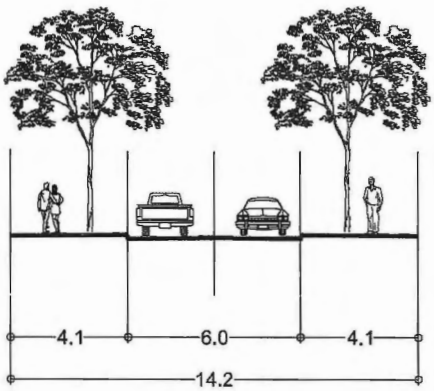
Figure 8. Neighbourhood Connector A (Modified).



Access Street C - yield (or give way) street target speed 40 km/h (<3,000 vpd)

Figure 9. Access Road C.

For Access Road C, the reserve width recommended by Liveable Neighbourhoods is 15.4 metres; notwithstanding this, the proposed width for roads designated Access Road C are typically set at 16.0 metres except where they abut either POS or Drainage Reserve on one side where the width is reduced to 12 metres. This is consistent with the road widths adopted in the previously approved northern section of the cell and provides sufficient width for infrastructure and services to be provided for.



Access Street D - narrow yield (or give way) street target speed 30 km/h (<1,000 vpd)

Figure 10. Access Road D.

For Access Road D, the reserve width recommended by Liveable Neighbourhoods is 14.2 metres; notwithstanding this, the proposed width for roads designated Access Road C are typically set at 15.0 metres except where they abut either POS or Drainage Reserve on one side where the width is reduced to 12 metres. However, Access Road D to the south of the School site will be widened to 16m to accommodate a shared

pathway. This is consistent with the road widths adopted in the previously approved northern section of the cell and provides sufficient width for infrastructure and services to be provided for.

6. Changes to External Transport Networks

The City of Kwinana advises that upgrades to adjacent roads are proposed as part of developer contribution plans, and that certain works may be required to be funded by the developer.

7. Integration with Surrounding Area

The interaction with the surrounding area can be impacted by the presence of major traffic attractors and generators nearby or possible changes to existing land uses. Tables 1 and 2 below summarise major traffic attractors and generators located external to the subdivision's boundaries and any identified changes to land use that can impact on the transport network.

Attractor / Generator.	Location.	Impact of Attractor / Generator.	Deficiencies.	Proposed Modifications.
Perth CBD.	North of subject site.	Study Site residents will contribute to flows along Mortimer Road west of the site and the Kwinana Freeway north of Mortimer Road, daily and during the AM and PM peak periods. Flows are expected to reflect a strong northerly demand between the site and the CBD in the morning and equivalent southerly flows in the evening.	Current pavement widths along Mortimer Road and the Kwinana Freeway are adequate.	None proposed - upgrade of the Mortimer Road – Study Site's north – south road intersection completed.
Kwinana Townsite / Industrial strip.	West of subject site.	Study Site residents will contribute to flows along Mortimer Road west of the site, daily and during the AM and PM peak periods.	Current pavement width along Mortimer Road is adequate.	None proposed - upgrade of the Mortimer Road – Study Site's north – south road intersection completed.
Kwinana Townsite / Industrial strip.	West of subject site.	Study Site residents will contribute to flows along Millar Road west of the site, daily and during the AM and PM peak periods.	Current pavement width along Millar Road is adequate.	Upgrade of the Millar Road – Study Site's north – south road intersection.

Table 1. Adjacent Attractors and Generators.

Land Use Changes.	Location.	Land use change impacts.	Deficiencies.	Proposed Modifications.
Land adjacent to the Study Site	North of subject site within the Wellard East Cell.	Development of the land predominantly to the north of the Study Site's will increase traffic flow on the internal road system and on external roads (Mortimer Road, Millar Road and Woolcoot Road).	Intersection geometry at Millar Road – Woolcoot Road and Mortimer Road – Woolcoot Road are likely to be inadequate.	Intersections will be subject to review and possible upgrading.

Table 2. Changes to Adjacent Land Use.

8. Analysis of Transport Networks - General

8.1. Assessment Year

The assessment has been taken to the year at which the subdivision is programmed for completion. In respect to considerations of the impact on external networks, traffic from adjacent catchments has been determined based on the assumption of full development of adjoining land.

8.2. Time Periods for Assessment

As it is expected that morning and evening peaks shall be similar in terms of the total volume entering intersections, the PM peak has been selected for intersection assessment purposes. Where significant differences in AM or PM peak have been identified, either in total volumes entering intersections or where turning movements are significantly different enough to impact on operational characteristics, both AM and PM peaks are used for assessment.

For midblock assessments, the daily traffic volume has been used for assessment purposes.

9. Analysis of Internal Transport Networks.

9.1. Subdivision Generated Traffic.

The Structure Plan for the site as prepared by Roberts Day was used to determine the following land use data:

- Approximately 182 residential lots;
- Animal Rehabilitation Clinic (90 daily trips assumed);
- 1 Primary School.

An assessment of the likely order of lot yield on the adjacent land was made based on the lot layout shown on Figure 3 with an assumed total residential yield of about 1468 dwelling units.

The site boundary was amended to include all of Armana Holding's land and was divided into traffic generating and attracting zones as shown on Figure 6. Generation was calculated based on trip production and generation rates recommended by the Road Traffic Authority of New South Wales.

The values adopted are summarised below.

Work trip productions	=	3.3 trips per household.
Non work trip productions	=	4.5 trips per household.
Other trip productions	=	1.2 trips per household.
Total		9 trips per dwelling
Education Attractions	=	0.65 trips per lot
Other Attractions (Animal clinic)	=	90 daily trips.

Table 3. Generation Rates.

Traffic assignment and distribution was based on the adopted Traffic Assessment Zones shown on Figure 11 over.

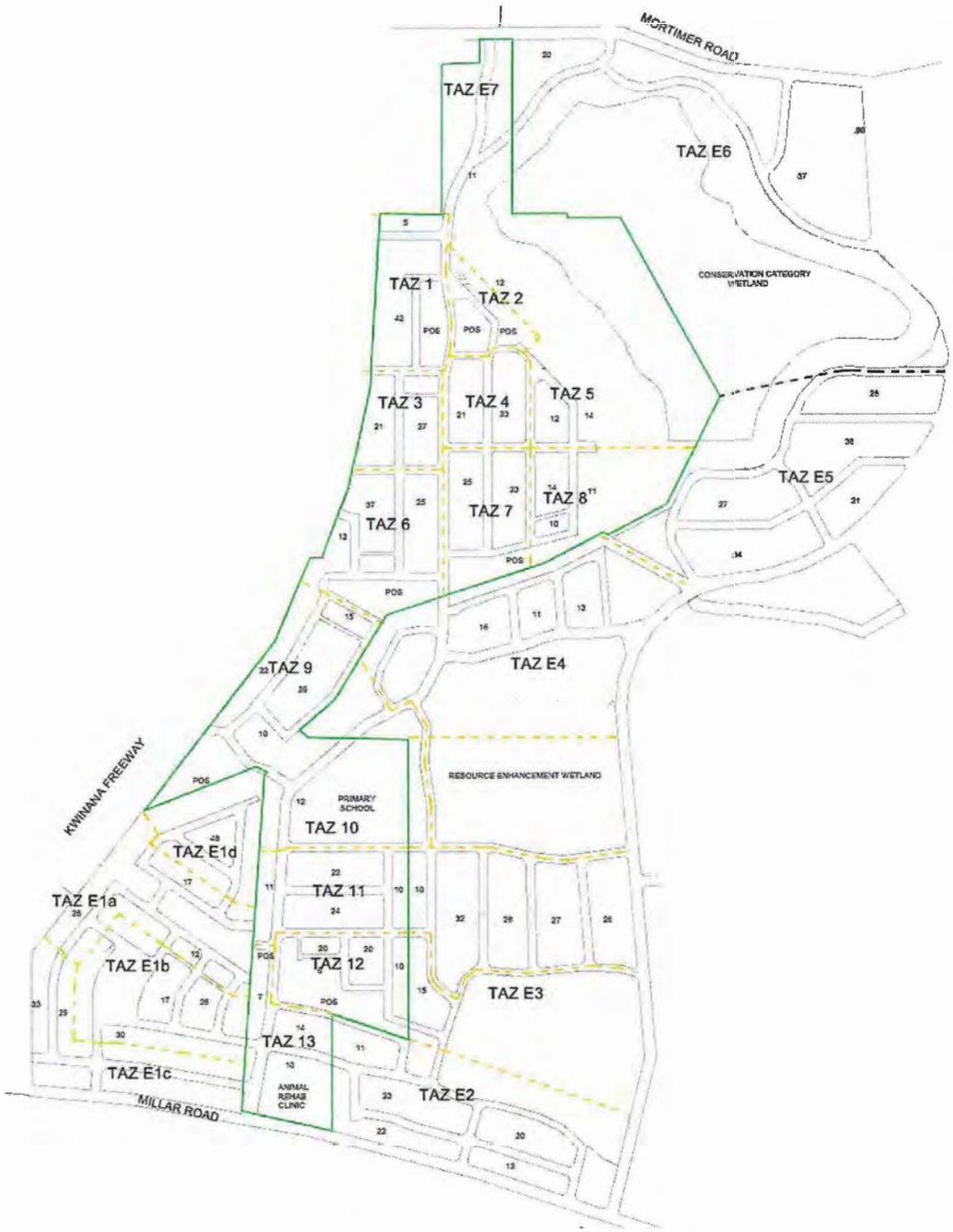


Figure 11. Traffic Analysis Zones.

Applying the values for trip production and attraction gave the trip generation from the site shown over on Tables 4 and 5.

Given the nature of the site which is largely residential, it is estimated that the total number of trips with origin or destination external to the site would be high and on that basis internal-external trips were assumed to represent 75 % of all trips generated by the site.

			ZONAL SPLIT		TRIP DISTRIBUTION							
					PRODUCTIONS				Internal - Internal			
			Int - Ext	Int - Int								
ZONE	LOTS	TRIPS			HBW	HBNW	NHB	TOTAL	HBW	HBNW	NHB	TOTAL
			75%	25%	37%	50%	13%	100%	37%	50%	13%	100%
TAZ1	6	54	34	11	12	17	4	34	4	6	1	11
	42	378	284	95	105	142	37	284	35	47	12	95
TAZ 2	12	108	81	27	30	41	11	81	10	14	4	27
TAZ3	21	189	142	47	52	71	18	142	17	24	6	47
	27	243	182	61	67	91	24	182	22	30	8	61
TAZ4	21	189	142	47	52	71	18	142	17	24	6	47
	23	207	155	52	57	78	20	155	19	26	7	52
TAZ5	12	108	81	27	30	41	11	81	10	14	4	27
	14	126	95	32	35	47	12	95	12	16	4	32
TAZ6	13	117	88	29	32	44	11	88	11	15	4	29
	37	333	250	83	92	125	32	250	31	42	11	83
	25	225	169	56	62	84	22	169	21	28	7	56
TAZ7	25	225	169	56	62	84	22	169	21	28	7	56
	23	207	155	52	57	78	20	155	19	26	7	52
TAZ8	14	126	95	32	35	47	12	95	12	16	4	32
	10	90	68	23	25	34	9	68	8	11	3	23
	11	99	74	25	27	37	10	74	9	12	3	25
TAZ9	68	612	459	153	170	230	60	459	57	77	20	153
TAZ10	12	108	81	27	30	41	11	81	10	14	4	27
TAZ11	22	198	149	50	55	74	19	149	18	25	6	50
	24	216	162	54	60	81	21	162	20	27	7	54
TAZ12	20	180	135	45	50	68	18	135	17	23	6	45
	20	180	135	45	50	68	18	135	17	23	6	45
TAZ13	24	216	162	54	60	81	21	162	20	27	7	54
Rehab	0	0	0	0	0	0	0	0	0	0	0	0
TAZ E1a	17	153	115	38	42	57	15	115	14	19	5	38
	12	108	81	27	30	41	11	81	10	14	4	27
	26	234	176	59	65	88	23	176	22	29	8	59
TAZ E1b	30	270	203	68	75	101	26	203	25	34	9	68
	17	153	115	38	42	57	15	115	14	19	5	38
	26	234	176	59	65	88	23	176	22	29	8	59
TAZE1c	33	297	223	74	82	111	29	223	27	37	10	74
	29	261	196	65	72	98	25	196	24	33	8	65
TAZE1d	48	432	324	108	120	162	42	324	40	54	14	108
	17	153	115	38	42	57	15	115	14	19	5	38
TAZ E2	11	99	74	25	27	37	10	74	9	12	3	25
	23	207	155	52	57	78	20	155	19	26	7	52
	22	198	149	50	55	74	19	149	18	25	6	50
	12	108	81	27	30	41	11	81	10	14	4	27
	20	180	135	45	50	68	18	135	17	23	6	45
TAZ E3	25	225	169	56	62	84	22	169	21	28	7	56
	32	288	216	72	80	108	28	216	27	36	9	72
	26	234	176	59	65	88	23	176	22	29	8	59
	27	243	182	61	67	91	24	182	22	30	8	61
	26	234	176	59	65	88	23	176	22	29	8	59
TAZ E4	16	144	108	36	40	54	14	108	13	18	5	36
	11	99	74	25	27	37	10	74	9	12	3	25
	13	117	88	29	32	44	11	88	11	15	4	29
TAZ E5	28	252	189	63	70	95	25	189	23	32	8	63

			ZONAL SPLIT		TRIP DISTRIBUTION							
					PRODUCTIONS				Internal - Internal			
			Int - Ext	Int - Int								
ZONE	LOTS	TRIPS			HBW	HBNW	NHB	TOTAL	HBW	HBNW	NHB	TOTAL
			75%	25%	37%	50%	13%	100%	37%	50%	13%	100%
	29	261	196	65	72	98	25	196	24	33	8	65
	35	270	203	68	75	101	26	203	25	34	9	68
	31	279	209	70	77	105	27	209	26	35	9	70
	32	288	216	72	80	108	28	216	27	36	9	72
TAZ E6	87	783	587	196	217	294	76	587	72	98	25	196
TAZ E7	11	99	74	25	27	37	10	74	9	12	3	25
		11628	***8721***	***2907***	3227	4361	1134	8721	1076	1454	378	2907

Table 4. Trip Productions.

ZONE		TRIPS	E-i	i-i	External – Internal (E-i)				Internal – Internal (i-i)			
					HBW	HBNW	NHB	TOTAL	HBW	HBNW	NHB	TOTAL
School		818	655	818	242	327	85	655	303	409	106	818
Animal Care		90	72	18	27	36	9	72	7	9	2	18
		908	*727*	*836*	*269*	*363*	*94*	*727*	*309*	*418*	*109*	*836*

Table 5. Trip Attractions.

With regard to external trips, most movements from the site are predicted to be along Mortimer Road to access the Kwinana Freeway or the Kwinana townsite and / or industrial strip. With the development of land within the balance of the Wellard East Cell, increased traffic is expected on the Study Site's north – south road and along Woolcoot Road, ultimately increasing traffic on Mortimer Road. A smaller percentage of the total external traffic will move along north south roads to access Millar Road.

Based on assumed desire lines traffic was split generally as shown on Table 6.

External Station	Split (%)
Mortimer Road West	85.00%
Mortimer Road East	5.00%
Millar Road West	5.00%
Millar Road East	5.00%

Table 6. Traffic External Stations.

Within the subdivision trips were assigned to the road network using the QRS II software.

Traffic assignments for the Study Site and adjacent land within the balance of the Wellard East Cell are shown on Figures 12 and 13 over.

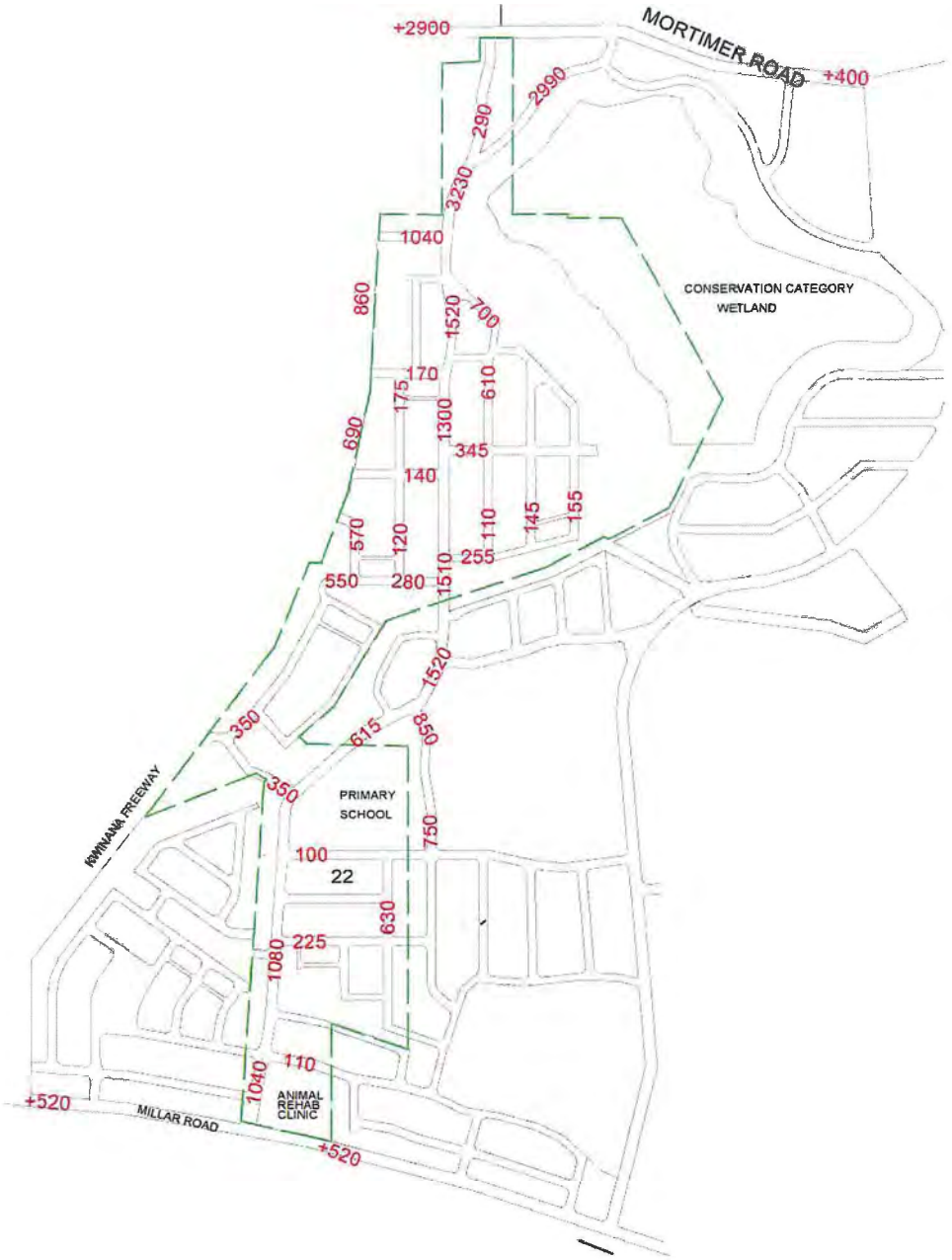


Figure 12. Predicted Subdivision Traffic – Armana Land Holdings.

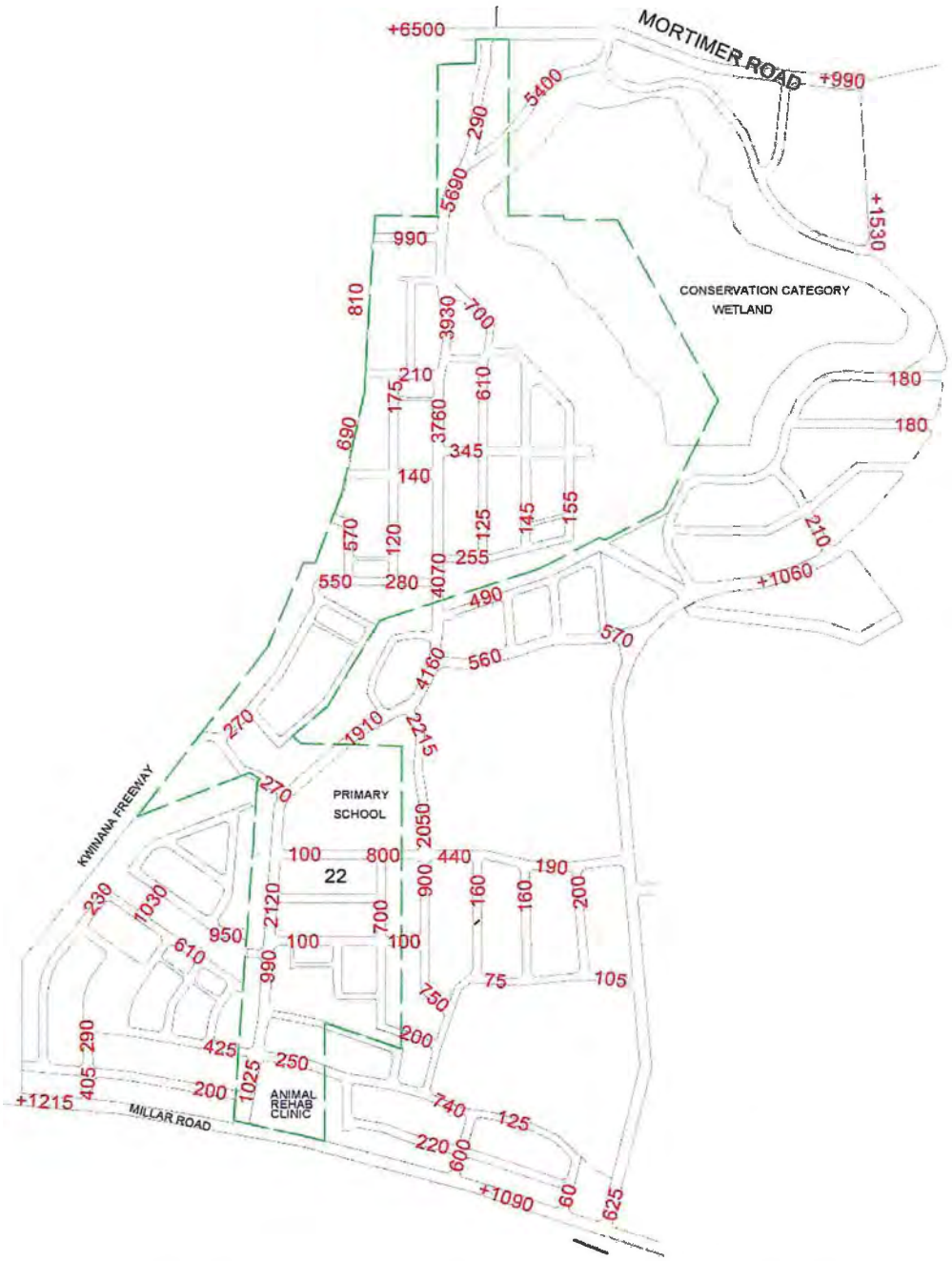


Figure 13. Predicted Subdivision Traffic - Study Site plus Adjacent Development.

9.2. Non Subdivision Traffic.

The impact of existing or future traffic generated from areas east of the subdivision within the balance of the Wellard East Cell will likely be confined to Mortimer Road, Millar Road and Woolcoot Road. Traffic from the east using these roads is expected to have a primary origin or destination to the north.

Road	Section	Existing flow.	With Study Site flows	With Study Site and adjacent dev flows
Mortimer Road.	West of Wake Way.	2,200	5,100 (+2,900)	8,700 (+6,500)
Mortimer Road.	West of Woolcoot Road.	2,200	2,600 (+400)	3,190 (+990)
Millar Road.	West of N-S Road.	2,120[3]	2,670 (+520)	3,335 (+1,215)
Millar Road.	West of Woolcoot Road.	2,120	2,670 (+520)	3,210 (+1,090)
Woolcoot Road	South of Mortimer Road	500[4]	500 (0)	2,030 (+1,530)
Woolcoot Road	North of Mortimer Road	500	500 (0)	1,125(+625)

Table 7. External Traffic Impact.

9.3. Roads and Intersections.

Where volumes are not shown on roads in Figures 12 and 13, they are predicted to be less than 1,000 vehicles per day. Requirements for road cross sections have been based on recommendations contained within Liveable Neighborhoods and the Austroads Guide to Traffic Engineering Practice which requires the following:

Indicative volume.	Route type / name.	Indicative Reserve Width.	Indicative Carriageway Width.
50,000.	Primary Distributor.		6 X 3.5 metre lanes.
35,000.	Primary Distributor.		4 X 3.5 metre lanes.
15,000 to 35,000.	Integrator Arterial A (District Distributor A).	50.6 – 52.6 metres.	2 X 8.2 metre carriageways including bike lane and 2 X 5.5 metre service roads containing parking.
<25,000	Integrator Arterial A (District Distributor A).	35.6 metres.	2 X 10.7 metre carriageways including combined on street parking and bike lane.
7,000 to 15,000.	Integrator Arterial B (District Distributor B).	29.2 metres.	2 X 7.5 metre carriageways with on street parking and bike lane.
15,000.	Integrator Arterial B (District Distributor B).	25.2 metres.	2 X 7.5 metre carriageways with on street parking.

[3] From MRWA data for 2004/2005 at 5% annual growth.

[4] Estimated daily flow based on number of properties served.

Indicative volume.	Route type / name.	Indicative Reserve Width.	Indicative Carriageway Width.
7,000.	Neighborhood Connector A.	24.4 metres (Not applicable as a lesser approved width adopted for the north – south road in the existing subdivided portion).	2 X 7.1 metres including parking, on street bike lane, median plus shared path on one verge. (Not applicable as a lesser approved width adopted for the north – south road in the existing subdivided portion).
3,000.	Neighborhood Connector B.	19.4 metres (Not applicable as a lesser approved width adopted for the north – south road in the existing subdivided portion).	11.2 metres including parking plus shared path on one verge. (Not applicable as a lesser approved width adopted for the north – south road in the existing subdivided portion).
3,000.	Access Street A (Avenue).	20 - 24 metres.	2 x 3.5 metre lanes plus indented parking.
3,000.	Access Street B (Wider street).	16.5 - 18 metres.	9.7 metre lane.
3,000.	Access Street C (Yield or give way street).	15.4 - 16 metres.	7.2 (7.8 – 7.5) metre lane.
1,000.	Access Street D (Narrow yield or give way street).	14.2 metres.	5.5 – 6.0 metre lane.
150	Access Street D (Narrow yield or give way street).	14.2 metres.	3.5 metre lane plus parking indents.
3,000.	Access Street D (Wider street).	16.5 - 18 metres.	9.7 metre lane.

Table 8. Road Hierarchy Criteria.

Based on these criteria an in recognition of previously approved widths, road requirements are as shown on Table 9.

Road[5]	Predicted Volume (vpd).	Indicative Reserve Width.	Carriageway Requirement.
Road A	Up to 5,600	Neighbourhood Connector A (Median). 18.0 metres.	As approved in northern section.
Road B	Up to 2,200	Access Street C. Liveable Neighbourhoods recommendation is for 15.4 metres. Road B width set at 15 metres to provide consistency with previously approved network widths in the portion of the cell north of the site. 15 metres provides for all infrastructure and services without loss of network integrity.	7.2 metre lane.
Road H	Up to 600	Access Street C. Liveable Neighbourhoods recommendation is for 15.4 metres. Road H width set at 18 metres.	7.2 metre lane.
Road G	Up to 600	Access Street C. Liveable Neighbourhoods recommendation is for 15.4 metres. Road G width set at 15 metres to provide consistency with previously approved network widths in the portion of the cell north of the site. 15 metres provides for all infrastructure and services without loss of network integrity. Adjacent to the drainage reserve, the width has been reduced to 14 metres.	7.2 metre lane.
Road D	Up to 550	Access Street D. Liveable Neighbourhoods recommendation is for 14.2 metres. Road D width set at 15 metres to provide consistency with previously approved network widths in the portion of the cell north of the site. Access Road D to the south of the School site will be widened to 16m to accommodate a shared pathway.	6.0 metre lane.
Road E	Up to 800	Access Street D. Liveable Neighbourhoods recommendation is for 14.2 metres. Road E width set at 15 metres to provide consistency with previously approved network widths in the portion of the cell north of the site.	6.0 metre lane.

[5] Road designations as shown on Figure 6.

Road[5]	Predicted Volume (vpd).	Indicative Reserve Width.	Carriageway Requirement.
Road F	Up to 105	Access Street C. Liveable Neighbourhoods recommendation is for 14.2 metres. Road D width set at 12 metres as it is bounded on one side by a reserve area. 12 metres provides for all infrastructure and services without loss of network integrity.	7.2 metre lane.
All other roads		Access Street D. 12 to 15 metres.	6.0 metre lane.

Table 9. Road Cross Sections.

Liveable Neighbourhoods encourages development to front connector streets such as Road A, provided appropriate consideration is given to vehicles reversing onto the adjacent roadway. Where volumes are between 5,000 and 7,000 vehicles per day, it is considered acceptable for vehicles to reverse onto connector roads where protection is provided by a parking bay.

9.3.1. Intersections.

The subdivision design generally provides for adequate sight distance to be provided at each intersection; however the detailed consideration of sight distance should be undertaken at the detailed engineering design stage and is dependent on factors such as vertical design, ultimate alignments and adjacent development envelopes. Detailed design will ensure minimum sight distances as per Austroads guidelines are provided. For intersections where a curved alignment has the potential to affect sight distances, this may include the introduction of traffic management devices to control speeds to equate to available sight distance.

For intersections with Mortimer Road and Millar Road, design considerations should include discussions with Main Roads WA with respect to the continuing applicability of the existing 80 km/h speed zones and the possible reduction to 60 km/h.

The intersection of Millar Road and Road A is to be configured as an unsignalised channelised "T" intersection with splitter islands on the east bound and southbound left turn approaches. Detailed design of the intersection will be undertaken to define geometry as part of the subdivision process and consideration will be given to designing the intersection such that priority is assigned to the western and northern legs with the eastern leg being the minor road.

Analysis of the 4 way intersection with Road A (Neighbourhood Connector) immediately North of Millar Road confirms that the provision of a roundabout is not warranted based on operational performance of the intersection. While a roundabout will typically reduce the frequency and severity of right angle crashes it will often result in an increase in rear end crashes. Roundabouts are not pedestrian nor cycle friendly and unless there is a

need to address right angle crashes or reduce speeds along the road a roundabout is not recommended. It is considered that all 4 way intersections can be safely and efficiently controlled by "Stop" signs on both minor road legs in accordance with MRWA guidelines.

The layout proposed on the Roberts Day plan indicates a number of internal staggered "T" junctions primarily on Road A. Liveable Neighbourhoods recommends that the stagger distance should be 20 metres for both "left-right" and "right-left" staggers for local roads and this distance should be provided where possible. The 2 intersection stagger immediately north of the Peel Sub N1A drain measures 23 metres and is considered compliant. Notwithstanding this, detailed design will include provision of appropriate traffic management devices to regulate movements and ensure that road safety is achieved and any adverse risks are designed out. Design of the traffic management devices will be undertaken in conjunction with the City of Kwinana.

9.3.2. Mortimer Road – Road A intersection

The intersection of Mortimer Road and Road A has been constructed in accordance with previous approvals.

9.3.3. Analysis Warrants.

Warrants as shown in Table 8.1 of Austroads Guide to Engineering Practice Part 2, Roadway Capacity were applied to determine which intersections required capacity analysis. Assuming peak hour volumes are approximately 10% of predicted daily traffic it was identified that the following intersections required analysis.

Intersection	Hourly volume major road VPH (two way)	Hourly volume minor road VPH (two way)	Comment.
Warrants as per Table 8.1 of Austroads Guide to Engineering Practice Part 2, Roadway Capacity - Two Lane Major Road Cross Road	*400 vph* *500 vph* *650 vph*	*250 vph* *200 vph* *100 vph*	Table details flows that initiate intersection analysis. As major flows increase, there is reduced capacity to accept minor flows.
Road A - Road C.	390	70	Tee intersection – Analysis not required.
Road A - Road B	300	220	3 way intersection – Analysis not required.
Road A - Road E	200	80	Tee intersection – Analysis not required.
Road A - Road G	100	55	Tee intersection – Analysis not required.
Road A - Road H	400	60	Tee intersection – Analysis not required.
Road A – Millar Road	250	100	Tee intersection – Analysis not required.

Table 10. Analysis Warrants

Internal peak hour traffic volumes within the subdivision are generally small and as such negligible impacts are predicted.

9.4. Pedestrian / Cycle networks.

A review of pedestrian and cyclist access was undertaken and consideration given to:

- Identifying which roads could potentially be difficult for pedestrians and cyclists to cross;
- Identifying where safe crossing facilities should be provided;
- Indicating where safe crossing facilities are proposed;
- The ability of public transport users to cross the road to access bus stops;
- Identifying which roads within the subdivision are likely to have traffic volumes that would adversely impact on the efficiency and safety of pedestrians trying to cross.

The analysis included consideration of road cross-sections and volume ceilings at which traffic volume is expected to affect the ability of pedestrians to cross roads. This assessment was based on recommended values prescribed by the WAPC document, Transport Assessment Guidelines for Developments, Volume 3 – Subdivisions which is reproduced in Table 11 below.

Road Cross Section	Traffic volume
2 lane undivided	1100 vph
2 lane divided (or with pedestrian refuge islands)	2800 vph
4 lane undivided (without pedestrian refuge islands)	700 vph
4 lane divided (or with pedestrian refuge islands)	1600 vph

Table 11. Pedestrian Crossing Assessment Criteria.

Desirable crossing spacing was also assessed against the recommend values prescribed by the WAPC document, Transport Assessment Guidelines for Developments, Volume 3 – Subdivisions which is reproduced in Table 12 below.

Road Type	Maximum spacing
Arterial – Minimum frontage activity.	400 metres.
Arterial – Significant frontage activity.	200 metres.
Local Distributor – Neighborhood Connector.	100 metres.

Table 12. Pedestrian Spacing Criteria.

Based on the assessment, the pedestrian and cyclist facilities as shown on Figure 14 were identified as being required. The detailed design requirements will incorporate pedestrian crossing points in line with the tables above. Pedestrian crossing facilities may range from a minimum requirement for pram ramps to be provided at each intersection, through to median islands installed at key intersections so as to provide safe refuge.

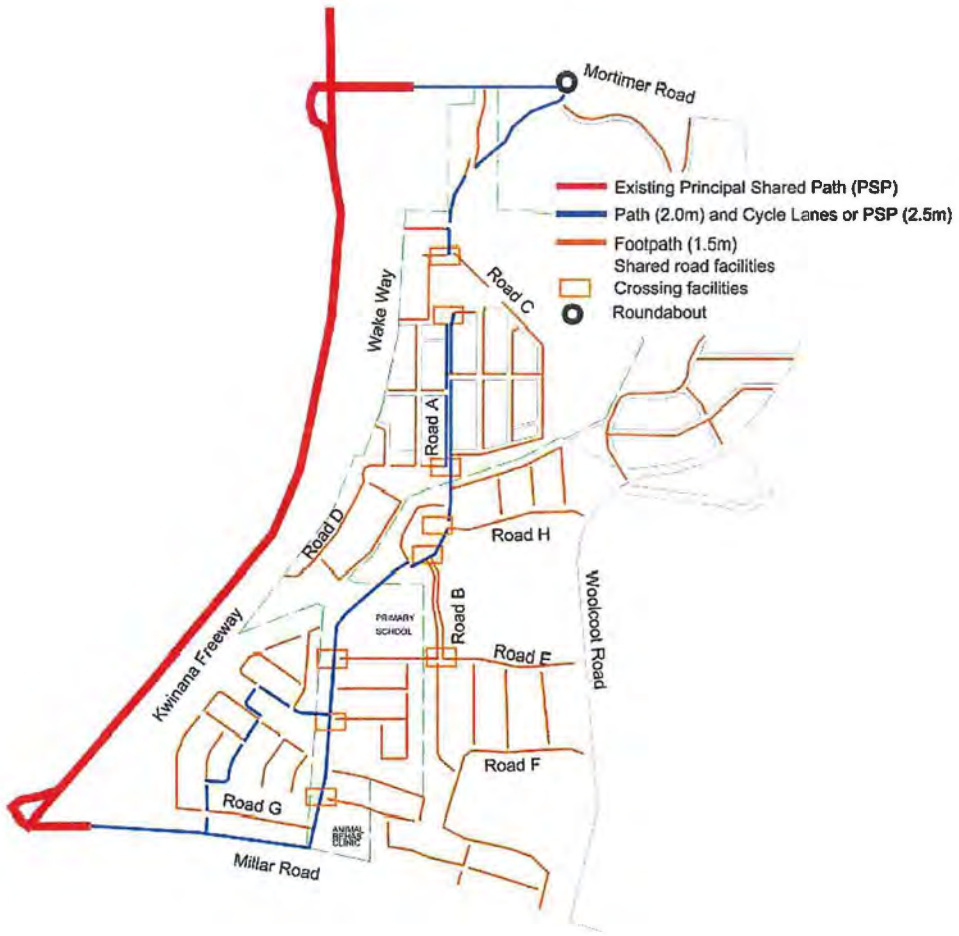


Figure 14. Pedestrian and Cycle Facilities.

9.5. Access to Public Transport.

The PTA in its Design and Planning Guidelines for Public Transport Infrastructure – Bus Route Planning and Transit Streets gives an indication of the desired level of access. The Guidelines state that:

- The Transperth Ten-Year Plan service coverage goal is that there will be a bus stop within 500 metres of where 95 percent of Perth's population lives.
- At the subdivision stage, bus routes, existing and proposed are likely to be known but new bus stop locations may not. The assessment should therefore be based on a 400 metre walk distance to bus routes if bus stop locations are unknown, or 500 metres walk to bus stops, if their locations are known.

These guidelines are considered to provide appropriate guidelines for the planning of new services in Wellard East.

Transperth currently provides a bus service to Bertram along the route shown on Figure 5; however it is unlikely that PTA would extend this service along Mortimer Road to service the subdivision. Previous discussions with PTA (Simon Cox) indicate that PTA is aware of the possible future need to service the area and that a provisional service (548) has been considered. The service which would be considered in future and would be dependent on need, would operate between Wellard and the Kwinana Town Centre and most likely follow the route shown on Figure 15. Liveable Neighbourhoods indicates that roads designated as bus routes should have the indicative road widths shown for the classification (Neighbourhood Connector) unless alternative cross sections are agreed to by the PTA. Current discussions (Andrew Foreman) confirm that where opposing lanes exist without a central median, minimum lane widths of 3.5 metres should be provided and this requirement has been met.

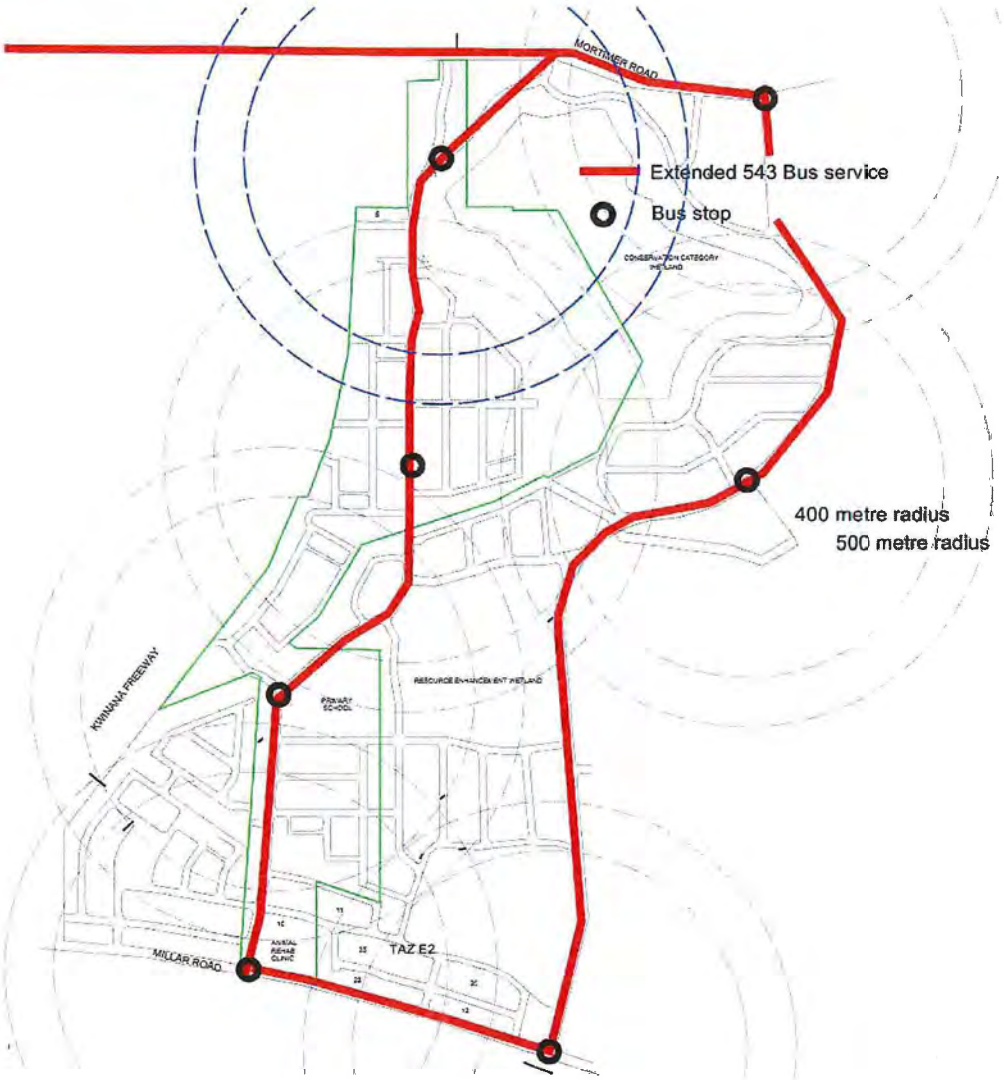


Figure 15. Possible Bus Facilities

10. Analysis of External Transport Networks.

10.1. Extent of Analysis.

Design traffic flows on the external road network were determined as previously detailed. External design volumes have been incorporated into the design traffic shown previously and road cross sections requirements have been analysed and are reported in section 9

10.2. Impact on external intersections.

The impact on external intersections has been assessed and the analysis is included in Section 9.

11. Safety Issues.

A review of the overall transport proposals for the subdivision did not identify any specific issues that present unacceptable risks to the road user or that cannot be managed through appropriate design protocols.

Road hazards are typically present at intersections and may be manifest through inadequate sight distance, inappropriate geometry or substandard capacity that promotes undesirable and potentially hazardous movements.

For new roads, the allocation of adequate road reservation widths and truncations of corners will allow sight distance requirements to be accommodated in the detailed design phase of the project. Geometric standards prescribed by Austroads and Main Roads WA guidelines will ensure that no unacceptable risk is introduced into the road environment. Assessment of the operational performance of intersections undertaken in this study prescribes appropriate geometry and lane allocations to minimise delays and optimise performance.

Pedestrian and cyclist movements are provided for by on road and off road facilities, thereby addressing potential safety issues.

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX E
LOCAL WATER MANAGEMENT STRATEGY ADDENDUM

DEPARTMENT OF PLANNING
19 NOV 2015
FILE SPN/0711

emerge ASSOCIATES
Integrated Science & Design

LOCAL WATER MANAGEMENT STRATEGY ADDENDUM

WELLARD EAST PART LOTS 379 AND 9001

Project Number EP11-011

Prepared for Armana Holdings
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Table of Contents

1 Introduction 4
1.1 Background 4
1.2 Purpose of the document 4
1.3 Town planning context 4
1.4 Policy framework 4
1.5 Previous studies 5
1.5.1 Jandakot Drainage and Water Management Plan 5
1.5.2 Cascades Wellard East District Water Management Strategy 5

2 Proposed Development 7

3 Pre-development Environment 8
3.1 Summary of LWMS pre-development environment 8
3.2 Surface water quantity 8
3.2.1.1 Existing drainage network 8
3.2.2 Modelling approach 9
3.2.2.1 Pre-development sub-catchments 9
3.2.2.2 Pre-development modelling parameters 9
3.2.2.3 Pre-development modelling results 10

4 Design Criteria and Objectives 11
4.1 Water conservation 11
4.2 Groundwater management 11
4.3 Stormwater management 11

5 Water Source Allocation, Infrastructure, Fit-for-Purpose and Water Use 13
5.1 Fit-for-Purpose water use 13
5.1.1 Scheme water 13
5.1.2 Groundwater 13
5.2 Water conservation measures 13
5.3 Lot water balance 13
5.4 Estate scale water use 14
5.5 Wastewater management 15
5.6 Water conservation criteria compliance summary 15

6 Groundwater Management Strategy 16
6.1 Groundwater level management 16
6.2 Groundwater quality management 16
6.3 Groundwater criteria compliance summary 16

7 Stormwater management strategy 17
7.1 Development drainage system 17
7.2 Lot drainage system 17
7.3 Post-development surface runoff modelling 18
7.3.1 Minor rainfall event modelling results 18
7.3.2 Major Rainfall event modelling results 19
7.4 Surface water criteria compliance summary 21

8 Subdivision and Urban Water Management Plans 22

9 Monitoring 23

10 Implementation 24

11 References 25

List of Tables

Table 1 Top water levels within Peel Branch Drain 9
Table 2 Pre-development sub-catchment characteristics 9
Table 3 Pre-development peak flow rates 10
Table 4 Part Lost 379 and 9001 lot water consumption 14
Table 5 Irrigation requirements 14
Table 6 Water conservation compliance summary 15
Table 7 Groundwater management compliance summary 16
Table 8 1 year 1 hour retention storage 18
Table 9 Extreme event storage 20
Table 10 Pre- to post-development peak flow rate comparison 20
Table 11 Stormwater management compliance summary 21

Figures

Figure 1: Locality diagram
Figure 2: Site boundary
Figure 3: Topographical and groundwater contours
Figure 4: Soil types
Figure 5: ASS risk mapping
Figure 6: Existing wetland and hydrological features
Figure 7: Pre-development catchments
Figure 8: Stormwater management features
Figure 9: 1 year 1 hour ARI inundation areas
Figure 10: 5 year ARI stormwater inundation areas
Figure 11: 10 year ARI stormwater inundation areas
Figure 12: 100 year ARI stormwater inundation areas

Appendices

Appendix A
Wellard East Concept Plan

Appendix B
Landscape Masterplan

Appendix C
Hydrological Modelling Catchment Details

1 Introduction

1.1 Background

The Sunrise development is located in Wellard East, in the south west corridor of Perth, immediately east of the Kwinana Freeway and within the City of Kwinana (**Figure 1**). The proponent for the development is Armana Holdings. The proponent's landholdings within Wellard East include Lots 379, 27, 9001 and various subdivided lots, as shown in **Figure 1**. This LWMS addendum covers part Lots 379 and 9001, as shown in **Figure 2**, referred to herein as 'the site'.

The site is located immediately north of Millar Road and currently consists of open paddocks, some remnant bushland and a small number of private buildings, including a wildlife refuge/hospital. An aerial photograph illustrating the current condition of the site is shown in **Figure 2**.

1.2 Purpose of the document

The Wellard East LWMS (Cardno 2010) details the water management strategy for Lots 27 and 201 (now part Lot 9001). The LWMS was approved by the Town of Kwinana (now City of Kwinana) and Department of Water. This document is an addendum to '*Lot 27 and Lot 201 Wellard East Local Water Management Strategy*' (LWMS) (Cardno 2010) and is intended to provide additional details specific to the water management strategy within the site. This addendum has been prepared in accordance with the principles and objectives detailed within the Wellard East LWMS and is intended to support the part Lots 379 and 9001 Local Structure Plan (LSP). This addendum should only be read in conjunction with the Wellard East LWMS.

A holistic approach to water management is needed to ensure that the most appropriate strategy is used and carried out across all stages of development, thus the requirement for this addendum to the Wellard East LWMS to ensure that all lots are included under one water management strategy at LSP stage and all future subdivision stages. Detailed objectives for water management within the site are further discussed in **Section 4**.

1.3 Town planning context

The site is currently zoned as 'Urban' under the Metropolitan Region Scheme (MRS) (WAPC 2010), and 'Development' under the *Town of Kwinana Town Planning Scheme* (TPS) #2 (ToK 1992).

1.4 Policy framework

There are a number of State Government policies, published guidelines and standards that are of relevance to the site and this document. These policies include:

- *State Water Strategy* (Government of WA 2003)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Liveable Neighbourhoods Edition 4* (WAPC 2007)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009)
- *Better Urban Water Management* (WAPC 2008)
- *Australian Runoff Quality* (Engineers Australia 2006)

- *Decision Process for Stormwater Management in Western Australia* (DoW 2009a)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *National Water Quality Management Strategy* (ANZECC 2000).

1.5 Previous studies

1.5.1 Jandakot Drainage and Water Management Plan

The Jandakot District Water Management Plan (DWMP) (DoW 2009b) presented the Department of Water (DoW) guide for developers and stakeholders within the area. The Jandakot DWMP provided guidance on protection of environmental assets, stormwater management, groundwater management and implementation within the Peel Main Drain catchment. The key objectives proposed in the Jandakot DWMP include:

- New developments should achieve a residential water consumption target of 100 kL/person/year.
- Of the lot scale (residential) use less than 40-60 kL/person/year should be from scheme water.
- Protect wetlands and waterways from the impacts of urban runoff.
- Protect infrastructure and assets from flooding and inundation by:
  - Retain and or detain the 1 year 1 hour ARI event at source.
  - Maximise infiltration at source via soakwells, swales, basins and other structures.
  - Use detention storages disbursed throughout urban areas to attenuate peak runoff rates.
  - Avoid modification of existing channels unless it is to ensure continuation of flows.
  - Use revegetation and strategic channel stabilisation.
  - Provide protection from 100 year ARI event levels by achieving 500 mm clearance for lot levels.
  - Major arterial roads should remain passable in a 100 year ARI event.
- Minimise changes to hydrology to prevent impacts on receiving environments by:
  - Maintain post development peak discharges to pre-development levels for the 1 year critical duration ARI event.
  - Manage catchment runoff such that the critical 10 year and 100 year ARI event peak flows are consistent with the pre-development peak flows.
  - Promote Water Sensitive Urban Design (WSUD) and Best Management Practices (BMPs) which promote onsite retention of events up to the 1 year 1 hour ARI event.

1.5.2 Cascades Wellard East District Water Management Strategy

Prior to the preparation of the Wellard East LWMS, the *Cascades Wellard East District Water Management Stategy* (DWMS) (Cardno 2010) was prepared and approved by the Department of Water (DoW) and Town of Kwinana which includes Lots 27, 201 and 379. The key objectives proposed in the DWMS include:

- Water Conservation
  - Ensure the efficient use of all water resources in newly developing urban form.
  - Aim to achieve the highest value use of fit for purpose water.
  - Use water more efficiently.
  - Consumption target for potable water of 100 kL/person/year for residential areas.
- Stormwater Quantity
  - Mitigate flooding to manage risks to human life and property.
  - Minimise changes in hydrology to prevent impacts on receiving environments.

- Managed surface water flows from major events to protect infrastructure and assets.

- Stormwater Quality
  - Maintain surface water quality at pre-development levels (winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub-catchment in which the development is located.
  - Ensure that there is no deterioration in water quality in the Peel Main Drain.
- Groundwater Quantity
  - Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture.
  - Protection of groundwater dependent ecosystems from the impacts of urban runoff.
  - Manage and minimise changes to the shallow aquifer to protect the value of groundwater resources.
- Groundwater Quality
  - Maintain groundwater at pre-development levels (winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub-catchment in which the development is located.
- Ecological Protection
  - Minimise changes to the hydrology to prevent impacts on watercourses and wetlands.
  - Manage and restore watercourses and wetlands.
  - Assess and manage impacts on native flora and fauna.
- Wastewater Management
  - Ensure that the site is capable of being connected to deep sewer.

2 Proposed Development

Within the Sunrise development, the site has a mixture of residential housing densities, POS areas and a primary school. A total of approximately 181 single lots and one group housing lot with 5 units are provided across 16.7 ha with 1.35 ha of POS and a mixture of road and laneways to be used within the development. The wildlife refuge/hospital, located on Millar Road, will be retained. The Wellard East concept plan, containing part Lots 379 and 9001, is included in **Appendix A**.

3 Pre-development Environment

3.1 Summary of LWMS pre-development environment

The pre-development environment and investigations carried out to date are described in detail within the Wellard East LWMS (Cardno 2010). A summary of key points relevant to the site are provided below with details of the existing drainage and hydrological modeling provided in **Section 3.2**:

- The site receives 745 mm of average annual rainfall, predominantly received between June and August.
- The site ranges in height from 16 m Australian Height Datum (AHD) to 8 m AHD in elevation, with a central ridge providing northerly and southerly aspects (see **Figure 3**).
- The soil types encountered during site investigations were consistent with Bassendean Sand soil types (see **Figure 4**).
- Acid Sulfate Soils (ASS) risk maps indicate that the site is classified as having a 'moderate to low risk of encountering ASS to depths of 3 m Below Ground Level (BGL)' (see **Figure 5**).
- Surface water quality data indicates that existing conditions exceed relevant default trigger values.
- Surface water flow within the Peel Sub N1 and Sub N drains are considered to be an expression of groundwater.
- Groundwater underlying the site flows in a south to south easterly direction.
- Underlying measured maximum groundwater levels (MGL) range between 9.00 m AHD to 7.20 m AHD. Referenced MGL ranges between 9.21 and 7.41 m AHD (see **Section 3.3**)
- Groundwater quality underlying the majority of the Wellard East site has 'moderate' to 'high' nutrient concentrations.
- The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there is a Multiple Use Wetland (Dampland UFI#12921) within the site (see **Figure 6**).
- The site has been historically used for rural agricultural purposes.

3.2 Surface water quantity

Hydrological and hydraulic modelling has been carried out to determine the pre-development environment with regards to stormwater runoff. The modelling has been carried out in accordance with the approach detailed in the LWMS and the results are discussed below.

3.2.1.1 Existing drainage network

The Peel Sub N Drain borders the north west of Lot 379 where it connects to Lot 9001 (see **Figure 6**). Surface water from the north and east of the Wellard East LSP area will discharge to the Peel Sub N Drain which discharges to the Peel Main Drain to the west of the Kwinana Freeway. Long sections provided within the JDWMP (DoW 2009b) provide peak flows for both the 10 year and 100 year ARI events at the discharge point of the Peel Sub N Drain of 0.84 m^3/s and 1.23 m^3/s respectively.

The Peel Sub N1 Drain runs through the centre of Lot 379 (see **Figure 6**) and joins the Peel Sub N Drain before discharging to the Peel Main Drain. Flows within the Peel Sub N1 Drain are 0.05 m^3/s and 0.14 m^3/s for the 10 year and 100 year ARI events respectively (DoW 2009b). Top water levels within the two drains during a 10 year and 100 year ARI event are given in the JDWMP and are provided in **Table 1**.

Table 1 Top water levels within Peel Branch Drain

Drain Section	Top Water level (m AHD)	
	10 year ARI event	100 year ARI event
Peel Sub N1 - u/s	7.14	8.02
Peel Sub N1 – d/s	7.63	7.95
Peel Sub N – u/s	9.00	9.08
Peel Sub N – d/s	7.66	7.98

3.2.2 Modelling approach

The stormwater management strategy aims to match pre- and post-development flows and volumes leaving the site. To help achieve this, a hydrological and hydraulic model has been constructed that represents the pre-development environment.

3.2.2.1 Pre-development sub-catchments

The pre-development model is based on assumptions informed by the existing environment and parameters detailed in the LWMS (Cardno 2010). Sub-catchments and related slopes were developed according to the topography of the site and analysis of aerial photography. The site contains four major sub-catchments, three of which are separated into two sections consistent with the vegetation coverage; medium and sparse. All catchments are assumed to consist of the same sandy soils, as detailed in **Section 3.1**.

The pre-development catchments are shown in **Figure 7**, with the sub-catchment attributes summarised in **Table 2**.

Table 2 Pre-development sub-catchment characteristics

Catchment	Sub-catchment	Area (ha)	Slope	Mannings Number 'n'
Ct1	Ct1a	4.604	0.20	0.3
	Ct1b	0.601	0.01	0.3
Ct2	Ct2a	3.463	0.20	0.3
	Ct2b	3.087	0.01	0.2
Ct3	Ct3a	1.852	0.20	0.3
	Ct3b	1.731	0.01	0.2
Ct4	Ct4	4.665	0.04	0.3

3.2.2.2 Pre-development modelling parameters

An 'initial loss – proportional loss' infiltration model was adopted to generate stormwater runoff hydrographs in the hydraulic and hydrological model XPStorm, consistent with the approach used within the Wellard East LWMS. The infiltration rates for the different soil and land types are given in Appendix B of the Wellard East LWMS (Cardno 2010).

3.2.2.3 *Pre-development modelling results*

The 24 hour duration event was used as the critical duration event, consistent with that used in the LWMS. The pre-development peak flow rates for the 5 year, 10 year and 100 year ARI events leaving each catchment within the site as calculated in XPStorm are summarised in **Table 3**.

Table 3 Pre-development peak flow rates

Catchment	Peak flow rates (m^3/s)			Discharge location
	5 year ARI	10 year ARI	100 year ARI	
Ct1	0.005	0.007	0.012	Sub N Drain
Ct2	0.009	0.011	0.018	Sub N1 Drain
Ct3	0.005	0.007	0.011	Sub N1 Drain
Ct4	0.003	0.004	0.008	Sub N Drain
Total	*0.022*	*0.029*	*0.049*	

3.3 Groundwater levels

Groundwater levels on site were monitored between October 2005 and September 2007. The maximum recorded level on site was recorded in October 2005 with levels ranging between 9.00 m AHD to 7.20 m AHD

DoW bore 305 has been used to reference the recorded levels on site (DoW 2014). A review of the historical record at bore 305 shows a general decline in peak winter groundwater levels over the last 30 years (record provided in **Appendix D**). Referencing to the maximum ever recorded level at bore 305 (seen in October 1984) would provide an overly high representation of MGL across the site. The last 20 years historical record only has therefore been used to reference the site MGL.

The MGL at bore 305, recorded in 1996 is 10.01 m AHD (DoW 2014). The level recorded at bore 305 in October 2005 is 9.8 m AHD, a difference of 210 mm below the MGL. The site MGL has been calculated on the assumption that the site MGL is 210 mm above the recorded 2005 level.

The referenced MGL for the site ranges from 7.41 m to 9.21 m AHD. Referenced MGL contours are shown in **Figure 3**.

4 Design Criteria and Objectives

Design criteria and objectives detailed here are consistent with guidance documents and design criteria discussed within the Wellard East LWMS.

4.1 Water conservation

Water conservation design criteria have been determined in line with the guidelines presented in *Better Urban Water Management* (WAPC 2008) and Wellard East LWMS (Cardno 2010). The following water conservation criteria are proposed for the site:

Criteria WC1: Ensure the efficient use of all water resources in newly developing urban form.

Criteria WC2: Achieve domestic scheme water consumption of 100 kL/person/year.

The manner in which these objectives will be achieved is further detailed in **Section 5**.

4.2 Groundwater management

The principle behind the groundwater management strategy is to maintain the existing groundwater hydrology. The groundwater management criteria for the site include:

Criteria GW1: Finished lot levels should have a clearance to the MGL of at least 1.2 m.

Criteria GW2: The clean fill imported for bio-retention areas is to incorporate a band of material that will reduce phosphorus export via soil leaching. The soil should be >150 mm thick with a Phosphorous Retention Index (PRI) >20.

Criteria GW3: Surface runoff shall be treated prior to discharge to groundwater.

The manner in which these objectives will be achieved is further detailed in **Section 6**.

4.3 Stormwater management

The principle behind stormwater management at the site is to mimic the pre-development hydrological conditions, as described in **Section 3.2**. This principle and the Wellard East LWMS have guided the stormwater management criteria for the site, which include:

Criteria SW1: Retain the 1 year 1 hour ARI event at source or as close as practicable.

Criteria SW2: The post-development 5 year and 100 year ARI event peak flows shall be generally consistent with the pre-development environment at the discharge points into waterways.

Criteria SW3: The concrete pipe network shall be designed to convey the 5 year ARI event.

Criteria SW4: All road reserves will be adequately sized to convey the 100 year ARI event within the road reserve.

Criteria SW5: Finished floor levels shall have at least 500 mm clearance to the 100 year ARI event flood level within Flood Storage Areas (FSA) and within the Peel Sub Drains as indicated in the Jandakot DWMP.

Criteria SW6: Bio-retention systems, FSAs and drainage inverts should have a minimum clearance of 500 mm from the MGL.

Criteria SW7: Bio-retention areas will have a maximum water depth of 500 mm.

Criteria SW8: Bio-retention areas will be sized to (at least) 2% of the connected impervious area.

Criteria SW9: Appropriate structural and non-structural measures shall be applied to reduce nutrient loads infiltrating to groundwater.

Criteria SW10: Finished lot levels shall have at least 300 mm clearance above the 100 year ARI event flows within road reserves.

The manner in which these objectives will be achieved is further detailed in **Section 7**.

5 Water Source Allocation, Infrastructure, Fit-for-Purpose and Water Use

5.1 Fit-for-Purpose water use

Conservation of water through fit-for-purpose use and best management practices is encouraged so that scheme water is not wasted. Fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water, as discussed within Section 5 of the Wellard East LWMS. Fit-for-purpose principles have been utilised in the water conservation strategy for the site.

5.1.1 Scheme water

Potable water will be provided through the Water Corporation Integrated Water Supply Scheme.

5.1.2 Groundwater

The DoW 'Online Water Register' indicates that the site is located in the Serpentine groundwater area, within the Jandakot Mound 2 sub-area (DoW 2012).

The proponent currently holds a groundwater abstraction licence for the Sunrise Estate (licence #171714) for a total volume of 100,402 kL.

Groundwater will be used for irrigation of POS areas and some road verges instead of utilising scheme water. Turfed areas typically require 7,500 kL/ha/year, therefore at full rates, the 1.29 ha of unrestricted POS within the site would require a maximum of 9.7 ML a year.

Groundwater use for POS irrigation is further discussed in **Section 5.4**.

5.2 Water conservation measures

The development will utilise groundwater for POS irrigation, active POS irrigation management, contemporary lot sizes (CLS) (which provide less room for gardens), Rainwater Tanks (RWT), WaterWise gardening (WWG) principles (Water Corporation 2003) for lot scale gardens and within estate landscaping and Water Efficient Fixtures and Appliances (WEFA) to ensure that the development minimises the use of water. These measures are discussed in detail in the Wellard East LWMS.

5.3 Lot water balance

A water balance analysis has been undertaken for the site to demonstrate the effectiveness of the Water Conservation Strategy (WCS) proposed for lot-scale measures when compared to a development without a water conservation strategy.

Three scenarios are presented to provide a comparison of the potential water savings through implementation of the Sunrise WCS. The second scenario assumes that only those measures that can and will be mandated are taken up, plus typical uptake rates of the other measures proposed. The uptake rate assumptions are calculated using data taken from the Australian Bureau of Statistics (ABS 2004; ABS 2009; ABS 2010) and development specific criteria. The third scenario assumes 100% uptake of the water conservation measures discussed in **Section 5.2**.

While this may not actually be achieved, it shows the potential water savings if all measures are implemented in full. Note that the water balance does not include assessment of estate scale irrigation of POS areas; this is discussed in **Section 5.4**.

This water balance compares:

1. Scenario 1 – No water conservation measures
2. Scenario 2 – Wellard WCS (15% RWT, 100/35% WEFA, 50% WWG)
3. Scenario 3 – Wellard WCS (100% uptake).

Table 4 Part Lots 379 and 9001 lot water consumption

	Scenario 1 - NWC	Scenario 2 - % uptake	Scenario 3 – 100% uptake
Total water use per capita (kL/per/yr)	105.4	28.9	20.4
Total Water use (ML/yr)	101.8	46.3	32.7

The results of the water balance indicate that on average, a dwelling not using any water conservation strategies will not be able to achieve the 100 kL/person/year water consumption target. The comparison of the consumption rates between Scenario 1 and Scenario 2 provided in **Table 4** indicates that the proposed water conservation strategy has the potential to significantly reduce the total water used in the household. As demonstrated in **Table 4**, Scenario 2 has the potential to reduce the water usage to 46.3 kL/person/year.

The water balance analysis demonstrates that the water conservation strategy satisfies **Criteria WC1** and **WC2**.

5.4 Estate scale water use

The water use at an estate scale is determined by the amount of POS provided that requires irrigation, the amount of road verge that will require irrigation and the rates at which these are irrigated. Not all of the POS areas will be irrigated at the same rates as some areas consist of native vegetation (new and retained), while others will utilise turf to provide active recreation areas. It should be noted that irrigation within the school site is not included within the water balance as this is assumed to be covered by separate allocations provided to the school directly.

Table 5 Irrigation requirements

	Area (ha)	Irrigation rate (kL/ha/year)	Water required (ML/yr)
POS	1.65	7500	12.4
Road verge	0.25	7500	1.85
Total	*1.90*		*14.2*

The irrigation water requirements detailed in **Table 5** will be supplied by groundwater. The existing groundwater abstraction licence (#171714) for a total volume of 100 ML/year for POS irrigation and dust suppression includes use within the site and is adequate to cover all irrigation requirements within the site.

5.5 Wastewater management

The site will be connected to the Water Corporation deep sewer network.

5.6 Water conservation criteria compliance summary

A summary of the proposed water conservation design criteria, and how these are addressed within the site, is provided in **Table 6**.

Table 6 Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
WC1	Ensure the efficient use of all water resources in newly developing urban form	Contemporary lot sizes with less room for garden
		Promotion/use of rainwater tanks within lots
		Promotion/use of waterwise gardening principles
		Promotion/use of water efficient appliances
		Mandated use of water efficient fittings
		Use of groundwater for irrigation requirements
WC2	Achieve domestic scheme water consumption of 100 kL/person/year	Contemporary lot sizes with less room for garden
		Promotion/use of rainwater tanks within lots
		Promotion/use of waterwise gardening principles
		Promotion/use of water efficient appliances
		Mandated use of water efficient fittings

6 Groundwater Management Strategy

The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4.2.**

6.1 Groundwater level management

The primary objective for groundwater level management is to ensure the final lot levels are at least 1.2 m above the MGL (see **Section 4.3**). As shown in **Figure 3**, the pre-development separation to the measured MGL is greater than 1.2 m across the site, except for within the Sub N1 drain channel which intersects groundwater.

Stormwater will be encouraged to infiltrate at source wherever practicably possible to be consistent with the existing hydrological regime. Measures used to infiltrate stormwater locally include soakwells, bio-retention areas and FSAs.

The above measures will ensure that **Criteria GW1**, **GW2** and **SW5** are achieved.

6.2 Groundwater quality management

The main objective for the management of groundwater quality is to maintain or improve the existing groundwater quality. This can be achieved by reducing the total nutrient load into the groundwater that originates from the development using the methods discussed in Section 6.2 of the LWMS.

These measures will be used within the site and will improve the quality of the water prior to it infiltrating into the underlying groundwater, and will assist in achieving **Criteria GW3** and **GW2**.

6.3 Groundwater criteria compliance summary

A summary of the proposed groundwater quantity design criteria and how these are addressed within the site are given in **Table 7**.

Table 7 Groundwater management compliance summary

Criteria number	Criteria Description	Manner in which compliance will be achieved
GW1	Finished lot levels should have a clearance to the MGL of at least 1.2 m	The earthworks strategy will see imported fill used where necessary to ensure finished lot levels are at least 1.2 m clear of the MGL
GW2	The clean fill imported for bio-retention areas is to incorporate a band of material that will reduce phosphorus export via soil leaching. The soil should be >150 mm thick with a Phosphorous Retention Index (PRI) >20	Bio-retention areas will be underlain by 150 mm of soil with PRI > 20
GW3	Surface runoff shall be treated prior to discharge to groundwater	Surface water runoff will be treated prior to infiltration to groundwater through the use of bio-retention areas (1 year 1 hour ARI event) and FSAs (up to the 100 year ARI event)

7 Stormwater management strategy

The principles behind the stormwater management strategy for the site aim to maintain the existing hydrology by retaining or detaining surface flows and to infiltrate the stormwater runoff as close to source as possible. The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4.3**.

7.1 Development drainage system

The storm water runoff from the 1 year 1 hour ARI rainfall event will be retained as close to source as practicably possible. There will be no runoff from the development during a 1 year 1 hour ARI rainfall event. This is consistent with the pre-development environment and the design criteria (see **Section 4.3**). The retention storage will be provided by soakwells in lot and vegetated bio-retention areas. The vegetation and the infiltration process within the soil column will remove a large portion of the contaminants (nutrients, gross pollutants, suspended sediments, etc.) within the stormwater runoff.

Rainfall events greater than the 1 year 1 hour ARI event will be conveyed by overland flow or pipe network to a flood storage area (FSA). The FSAs will detain the large event runoff so that the overall peak discharge from the development does not exceed the pre-development peak discharge rate. The size of the detention storages will be minimised due to the retention storage provided higher up in the catchment and within lots. The stormwater drainage system for the development (including nominal locations for bio-retention areas and FSAs) is provided within **Figure 8**.

7.1.1 Lot drainage

Rainfall on the front and backyards of lots (garden areas) will either infiltrate directly at-source or, in large rainfall events (i.e. > 5 year ARI event), a portion of the runoff may discharge to the road network. The runoff from roof areas will be directed to soakwells which will infiltrate into the sandy soil and ultimately the groundwater.

The use of soakwells will assist in achieving **Criteria SW1**.

7.1.2 Bio-retention areas

Runoff from the 1 year 1 hour ARI event that is not captured on lot will be captured and retained within a vegetated bio-retention area. These will be located within dedicated bio-retention basins within POS. The bio-retention areas have been assumed to have a depth of 500 mm, have 1:3 side slopes and contain amended soil with a high Phosphorous Retention Index (PRI). Bio-retention areas will be vegetated with native species known for nutrient uptake to provide treatment of runoff prior to infiltration to groundwater.

Where bio-retention areas are located in road reserve (Catchment 4 detailed in **Section 7.2**) a maximum depth of 300 mm and 1:6 side slopes will be required (P. Ridley, DoW, 2014, pers. comm., 14 February).

The use of bio-retention areas will assist in achieving **Criteria SW1**, while the design of the basins will ensure that **SW6**, **SW7**, **SW8** and **SW9** are achieved.

7.1.3 Flood storage areas

FSAs will be utilised to retain/detain major event flows in order to maintain post-development peak flows to pre-development conditions. The FSAs are not designed to be permanently wet. To achieve this, the inverts of the FSAs will have a minimum clearance above groundwater (500 mm). The sizes and spatial requirements for FSAs are further discussed in **Section 7.2.2**.

The design of FSAs will be such that maximum top water levels within basins will remain at least 500 mm below finished floor levels of adjacent lots to ensure protection from flooding during extreme rainfall events. The future design of the FSAs will be provided in future UWMPs and will need to comply with CoW guidelines and expectations.

The use of FSAs will achieve **Criteria SW2**, while the design of the basins will ensure that **Criteria SW5** and **SW6** are achieved.

7.2 Post-development surface runoff modelling

As described in **Section 7.1**, this LWMS proposes to utilise soakwells, bio-retention areas and FSAs to ensure post-development peak discharges are comparable to the pre-development peak discharges. The post-development modelling uses the same methodology and parameters as pre-development modelling (described in Appendix B of the Wellard East LWMS). Post-development catchments are shown in **Figure 8** with catchment details provided in **Appendix C**. The location of proposed storage bio-retention areas and FSAs are shown in **Figure 8**, with design details for each detailed in **Appendix C**.

7.2.1 Minor rainfall event modelling results

The 1 year 1 hour ARI rainfall event will be retained onsite to satisfy Criteria SW1 (**Section 4.3**). The location and size of the proposed retention storage required to achieve the design criteria is presented in **Figure 8** with the required storage volume and Top Water Level (TWL) inundated areas within bio-retention areas shown in **Table 8**. The bio-retention areas have been assumed to have a maximum depth of 500 mm and side slopes of 1:3.

Table 8 1 year 1 hour retention storage

Catchment	Total volume (m^3)	TWL area (m^2)
Ct1	44	118
Ct2	310	696
Ct3	71	179
Ct4	14	73
Ct5	158	371
Total	597	1409

The total size of the bio-retention system, achieved through at-source retention storage provided by bio-retention areas, is equal to 7.8% of the connected impervious area, which achieves **Criteria SW8**. Native vegetation known for nutrient uptake potential will be used for areas equal to at least 2% connected impervious area to ensure nutrient uptake is undertaken.

The inundated area within the development for the 1 year 1 hour ARI event is shown in **Figure 9**. The Landscape Masterplan, provided in **Appendix B**, shows how the development and stormwater management components within the development are intended to be landscaped.

7.2.2 Major Rainfall event modelling results

The post-development peak discharge from the entire site aims to be comparable to the pre-development peak discharge for rainfall events greater than the 5 year ARI up to the 100 year ARI event. This is achieved by the use of at-source retention and infiltration storage. The retention storage within the development (soakwells and bio-retention areas) contributes to reducing the peak discharge from the post-development environment. However, additional detention storage is typically required to achieve the peak discharge design requirement. The FSAs proposed ensure that the post-development peak flows do not exceed the pre-development conditions. The proposed locations of the FSA's are shown in **Figure 8**. The modelled storage volumes, and associated inundated depths and areas, required to meet pre-development discharge rates are provided in **Table 9**. A comparison of the pre- and post-development peak discharge flow rates is given in **Table 10**.

The 5, 10 and 100 year ARI event stormwater inundation areas are shown in **Figure 10**, **Figure 11** and **Figure 12** respectively.

7.2.3 Jandakot DWMP

The site is located within the Millar Road South Catchment detailed in the Jandakot DWMP (DoW 2009b). Based on a relative percentage of the storage volume across the Millar Road South catchment, the Jandakot DWMP recommends approximately 6,230 m^3 of major event storage be provided across the site.

The proposed surface water management approach is to mimic pre-development peak flow rates within the existing drains (**Section 4.3**). Surface water storage has been designed to meet this requirement through retention/detention of surface flows prior to discharge into the drains. The design has been informed by a hydrological and hydraulic model (as detailed in **Section 7.2.2**) using assumptions that are specific to the site, as opposed to generic assumptions for the greater catchment area (as used in the Jandakot DWMP). A pre-development model was used to identify the pre-development peak flow rates leaving the site. Storage volumes were then calculated using a post-development model such that pre-development peak flow rates in the drains were maintained. Multiple storage areas have also been proposed which results in increased infiltration compared to a single large storage area, thus reducing the overall storage volume required onsite.

The total storage provided across the site is 3,880 m^3, which while lower than the total storage area identified in the Jandakot DWMP is shown to be appropriate to maintain peak flow rates within the drains.

Table 9 Extreme event storage

Catchment	5 year ARI			10 year ARI			100 year ARI		
	Max depth (m)	TWL area (m^2)	Volume (m^3)	Max depth (m)	TWL area (m^2)	Volume (m^3)	Max depth (m)	TWL area (m^2)	Volume (m^3)
Ct1	0.459	216	67	0.536	244	85	0.697	309	129
Ct2	0.209	2221	453	0.284	2264	621	0.499	2379	1123
Ct3	0.225	545	117	0.297	566	158	0.500	632	280
Ct4	0.247	85	18	0.322	94	24	0.496	114	43
Ct5.5	0.609	803	374	0.676	850	429	0.700	867	450
Ct5.100	0	0	0	0.01	779	8	0.293	979	256
Total		3870	1028		4797	1352		5280	2281

Table 10 Pre- to post-development peak flow rate comparison

Catchment	Equivalent pre-development catchment	5 year ARI peak flow rates (m^3/s)		10 year ARI peak flow rates (m^3/s)		100 year ARI peak flow rates (m^3/s)		Discharge location
		Pre-development	Post-development	Pre-development	Post-development	Pre-development	Post-development	
Ct1	Ct1	0.005	0.006	0.007	0.008	0.012	0.012	Sub N Drain
Ct2	Ct2	0.009	0.009	0.011	0.011	0.018	0.016	Sub N1 Drain
Ct3	Ct3	0.005	0.006	0.007	0.007	0.011	0.009	Sub N1 Drain
Ct5.5	Ct4	0.003	0.002	0.004	0.003	0.008	0.003	Sub N Drain
Ct5.100	Ct4		0.000		0.000		0.005	Sub N Drain
Total		0.022	0.023	0.029	0.029	0.049	0.045	

7.3 Surface water criteria compliance summary

A summary of the proposed surface water design criteria and how these are addressed within the site is given in **Table 11**.

Table 11 Stormwater management compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	Retain the 1 year 1 hour ARI event at source or as close as practicable	Lots will retain the 1 year 1 hour ARI event flows within soakwells and garden areas. Road reserve runoff will be retained within bio-retention areas within POS
SW2	The post-development 5 year and 100 year ARI event peak flows shall be generally consistent with the pre-development environment at the discharge points into waterways	Pre-development peak flows have been characterised, and post-development detention areas are designed to limit runoff peak flows to be generally consistent with pre-development peak flows
SW3	Roads shall be designed to convey the 5 year ARI event within the concrete pipe network	This will be achieved at detailed design stage and will ensure that roads remain passable in a 5 year ARI event
SW4	All road reserves will be adequately sized to convey the 100 year ARI event within the road reserve	This will be achieved at detailed design stage and will ensure that roads are sized to convey the 100 year ARI event
SW5	Finished floor levels shall have at least 500 mm clearance to the 100 year ARI event flood level within FSAs and within the Peel Sub Drains as indicated in the Jandakot DWMP	Fill be used where necessary to ensure that finished floor levels are at least 500 mm clear of 100 year ARI event flood levels within drainage basins and the Peel Sub Drains
SW6	Bio-retention systems, FSAs and drainage inverts should have a minimum clearance of 500 mm from the MGL	This will be achieved at detailed design stage and will ensure that a minimum clearance of 500 mm from MGL is maintained within all bio-retention systems, FSAs and new drains
SW7	Bio-retention areas will have a maximum water depth of 500 mm	The modelling has assumed that bio-retention areas will have a maximum depth of 500 mm. This criteria will be adopted for detailed civil design
SW8	Bio-retention areas will be sized to (at least) 2% of the connected impervious area	Bio-retention provided within POS will currently provide >5% of the connected impervious area.
SW9	Appropriate structural and non-structural measures shall be applied to reduce nutrient loads infiltrating to groundwater	Structural measures include soakwells, bio-retention areas, WWG practices, education of residents, street sweeping, active POS management and ongoing maintenance of POS and drainage areas. These will be confirmed in the UWMP and detailed designs

8 Subdivision and Urban Water Management Plans

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of any future UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008).

While strategies have been provided within this LWMS that address planning for water management within the site, it is a logical progression that future subdivision designs and the supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further clarification within future UWMPs include:

- Modelling of local road drainage network
- Infiltration basin area configurations and outlet structures
- ASS investigations
- Imported fill specifications and requirements
- Implementation of water conservation strategies
- Non-structural water quality improvement measures
- Management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program
- Status of groundwater abstraction license.

These are further detailed in Section 8 of the Wellard East LWMS. The part Lots 379 and 9001 LSP will be consistent with all management plans and strategies detailed therein. As stated above, ongoing monitoring of groundwater will be detailed in the UWMP, however is outlined broadly in **Section 9.**

9 Monitoring

Section 9 of the LWMS provides a monitoring program designed to assess the effectiveness of the pre-development monitoring that has been undertaken and make recommendations regarding future post-development monitoring.

Pre-development monitoring was carried out at ten locations across the entire Wellard East site, with four bores located within the site (Cardno 2010).

The post-development monitoring program for the site will be consistent with that detailed within the LWMS including:

- Quarterly groundwater quality monitoring
- Identification of site specific trigger values
- Implementation of the Contingency Action Plan (CAP) should trigger values be exceeded

An indicative location for the proposed groundwater monitoring bore is shown in **Figure 8**. Monitoring programs will also be further detailed at UWMP stage.

Post-development trigger values for the Wellard East site are provided in Table 9.2.1 within the LWMS (Cardno 2010). The trigger values for the east region (as presented in the LWMS) are indicative of the site and will be used within the CAP for the site. Specific details of the CAP are provided in Section 9.2 of the LWMS (Cardno 2010).

10 Implementation

The LWMS is a key supportive document for the LSP that provides guidance on water management strategies across the entire LSP development. This addendum has been provided to allow inclusion of part Lots 379 and 9001 within the LWMS, ensuring a fully integrated approach to water management at LSP stage and continuing through to subdivision stages.

Implementation of the water cycle management strategy detailed in this addendum is consistent with that detailed in Section 10 of the Wellard East LWMS (Cardno 2010).

It is not anticipated that this LWMS addendum will be reviewed, unless additional land parcels/lots are added to the LSP prior to subdivision, or the LSP undergoes significant change post-lodgement of the LWMS addendum. If the LSP is substantially modified surface runoff modelling undertaken for this LWMS will need to be reviewed and the criteria proposed revised to ensure that all are still appropriate.

The next stages of water management are anticipated to be lot planning through subdivision. Subdivision approvals will be supported by a UWMP, as discussed in Section 10 of the Wellard East LWMS (Cardno 2010).

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FIGURES

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Figure 1: Locality diagram

Figure 2: Site boundary

Figure 3: Topographical and groundwater contours

Figure 4: Soil types

Figure 5: ASS risk mapping

Figure 6: Existing wetland and hydrological features

Figure 7: Pre-development catchments

Figure 8: Stormwater management features

Figure 9: 1 year 1 hour ARI inundation areas

Figure 10: 5 year ARI stormwater inundation areas

Figure 11: 10 year ARI stormwater inundation areas

Figure 12: 100 year ARI stormwater inundation areas

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Figure 1:	**Locality Diagram**
Project:	Wellard East - Part Lots 379 and 9001 Addendum
Client:	Armana Holdings

Plan Number: EP11-011(05)--F39a			
Drawn:	GRO	Date:	23/08/12
Approved:	DPC	Date:	17/09/13
Checked:	RLE	Scale:	1:12,000@A4

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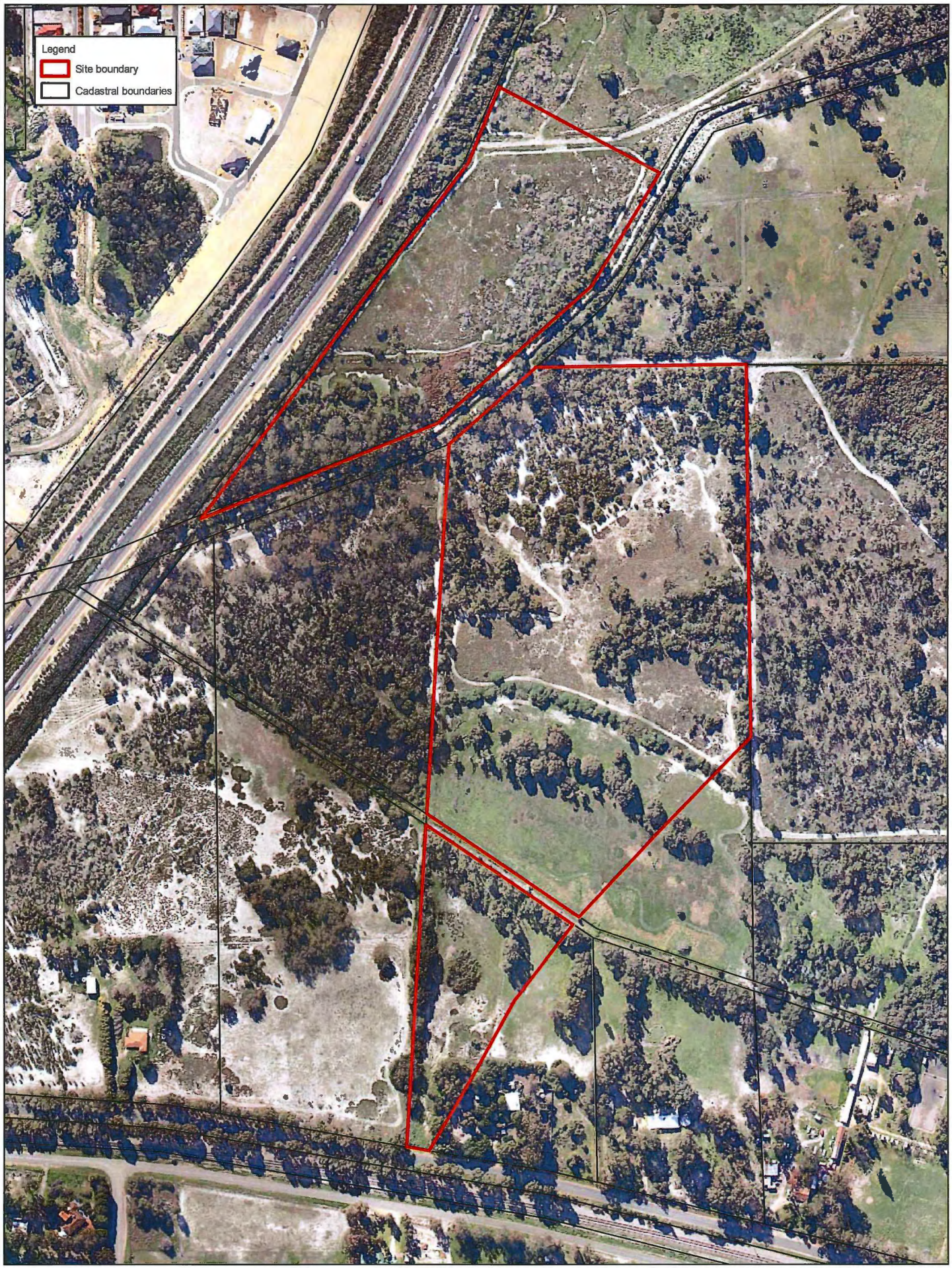

Figure 2:	Site Boundary
Project:	Wellard East - Part Lots 379 and 9001 Addendum
Client:	Armana Holdings

Plan Number: EP11-011(05)--F40a			
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Approved:	DPC	Date:	17/09/13
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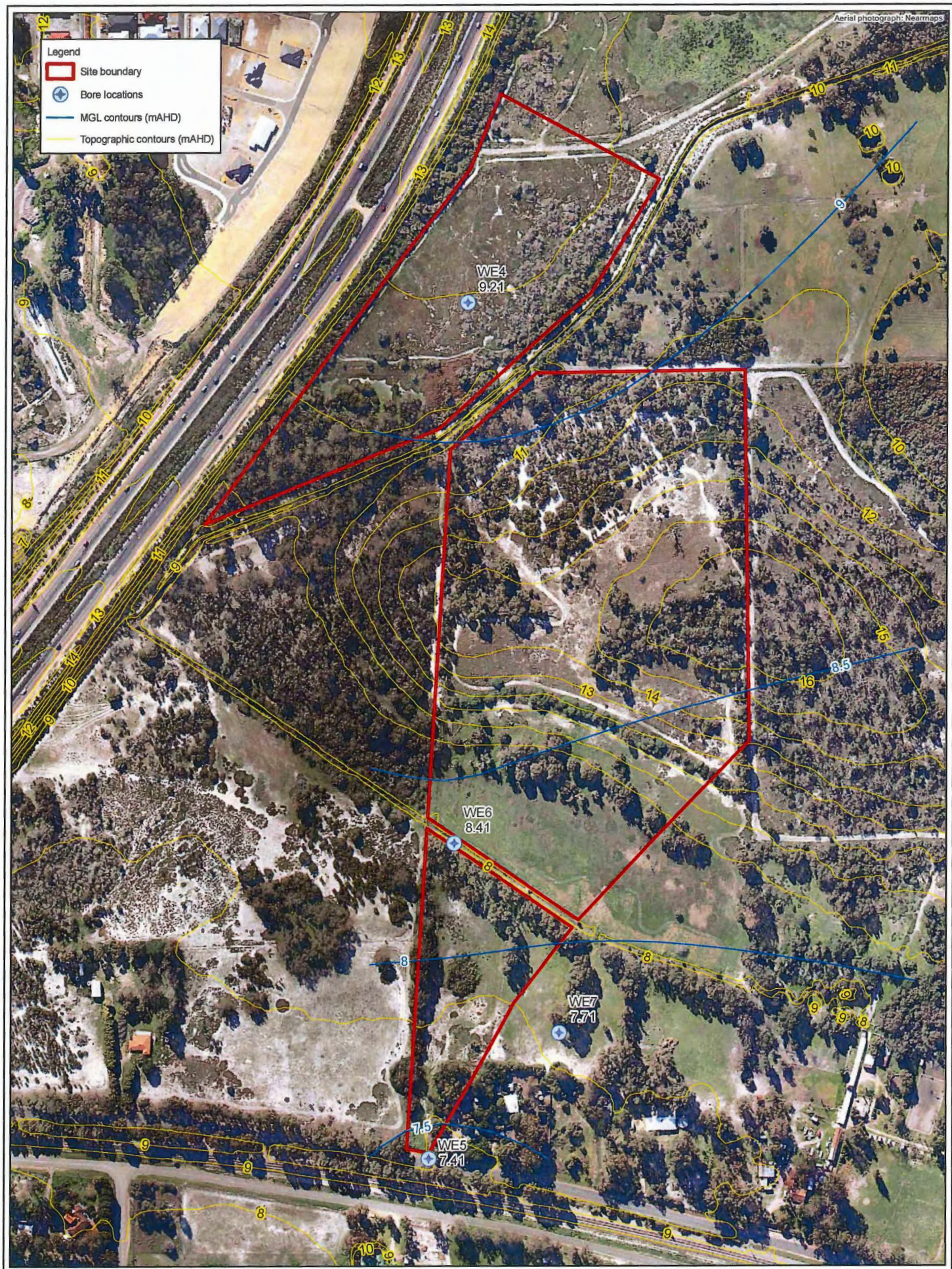

Figure 3:	Topographic and MGL Contours	Plan Number: EP11-011(05)--F41b	
Project:	Wellard East - Part Lots 379 and 9001 Addendum	Drawn: GRO	Date: 23/08/12
Client:	Armana Holdings	Approved: DPC	Date: 10/03/14
		Checked: RLE	Scale: 1:4,000@A4

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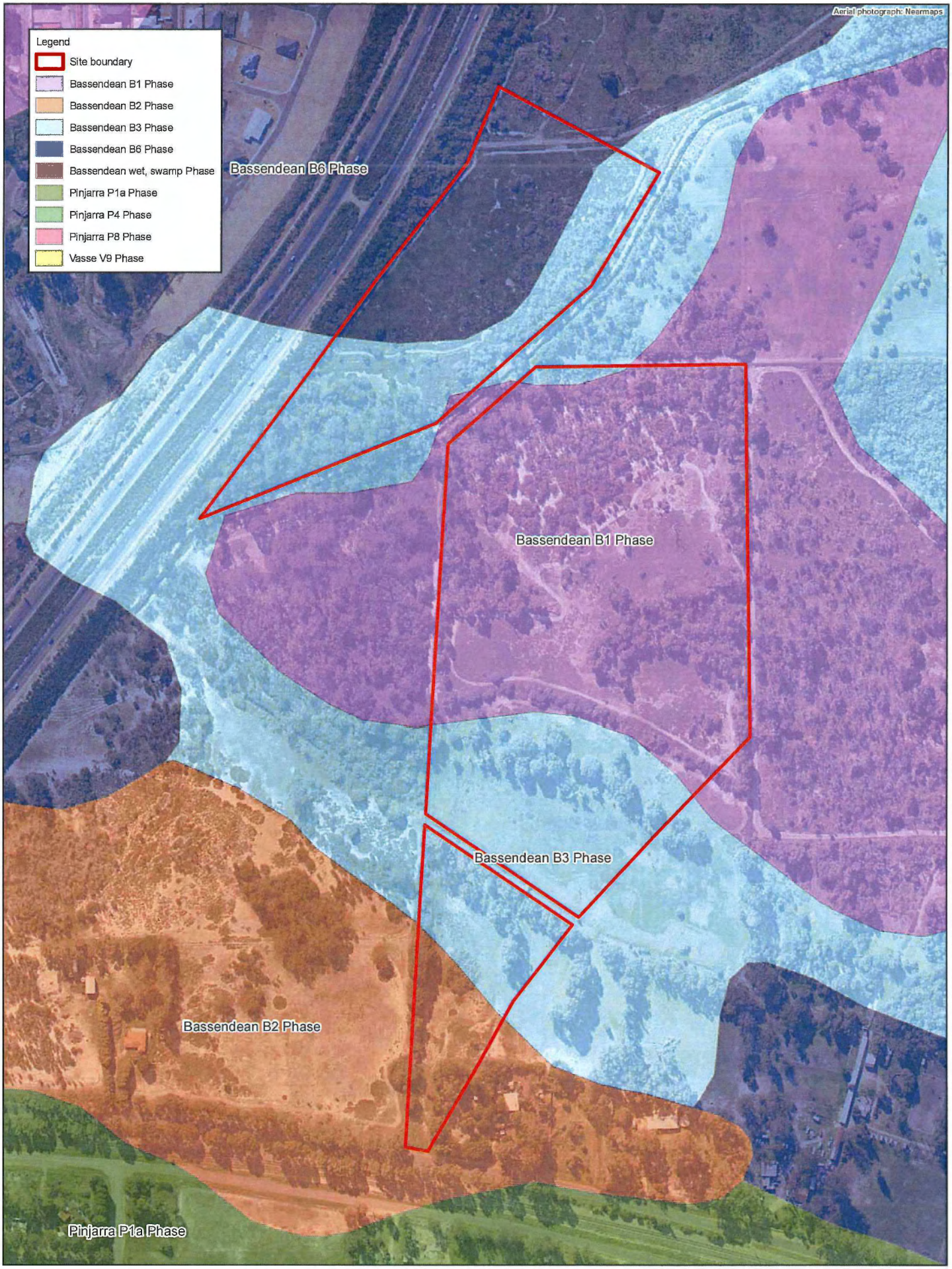

Figure 4:	Soil Types	Plan Number: EP11-011(05)--F42a	
Project:	Wellard East - Part Lots 379 and 9001 Addendum	Drawn: GRO	Date: 23/08/12
Client:	Armana Holdings	Approved: DPC	Date: 17/09/13
		Checked: RLE	Scale: 1:4,000@A4

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Sources: The following datasets were used in the production of this map: Soil Types - DoA (2007)

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Figure 5:	ASS Risk Mapping	Plan Number: EP11-011(05)--F43a	
Project:	Wellard East - Part Lots 379 and 9001 Addendum	Drawn: GRO	Date: 23/08/12
Client:	Armana Holdings	Approved: DPC	Date: 17/09/13
		Checked: RLE	Scale: 1:4,000@A4

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Sources: The following datasets were used in the production of this map: Acid Sulfate Soil Risk - DEC (2010)

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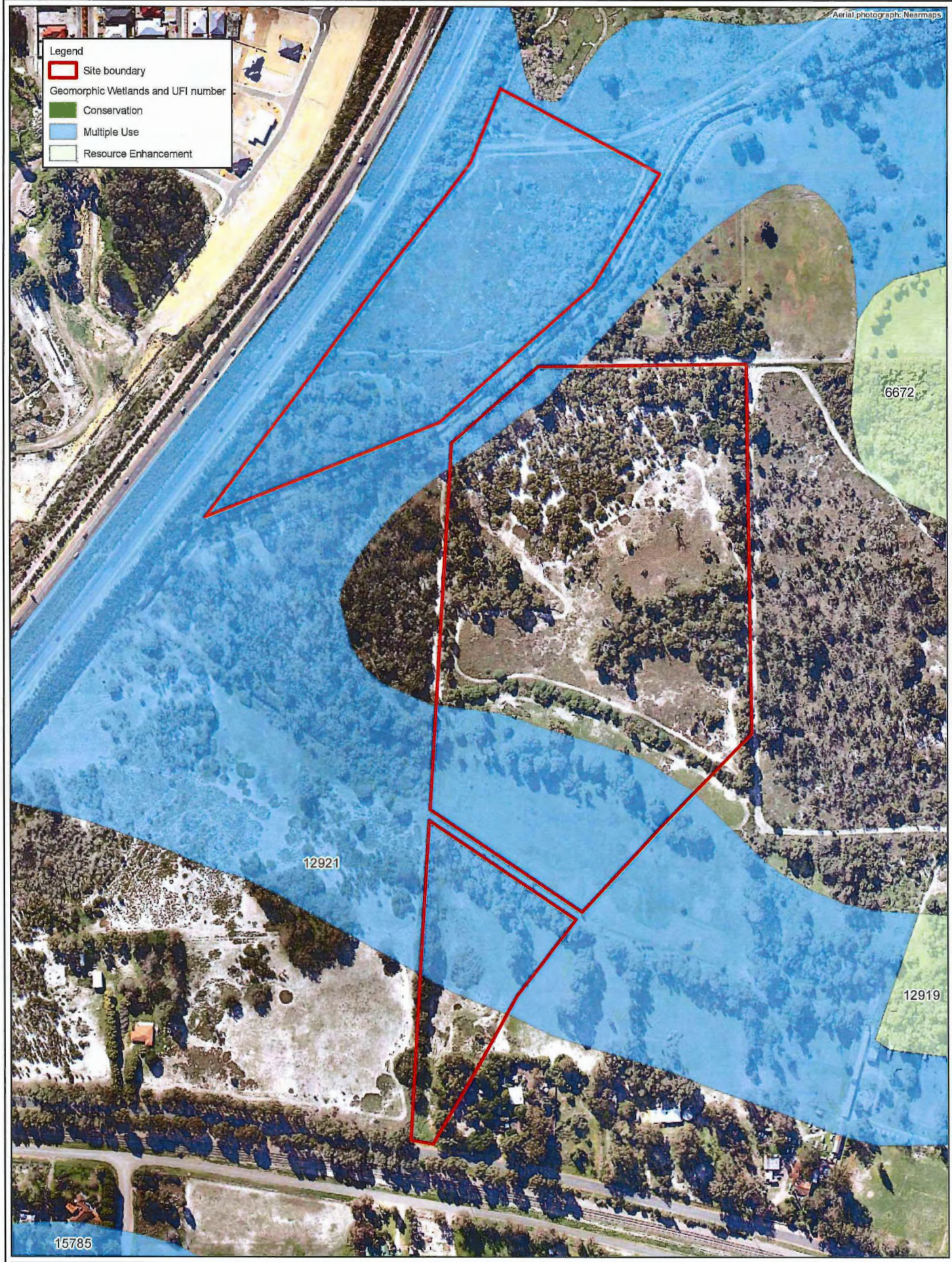

Figure 6:	Existing Hydrological Features	Plan Number: EP11-011(05)--F45a	
Project:	Wellard East - Part Lots 379 and 9001 Addendum	Drawn: GRO	Date: 23/08/12
Client:	Armana Holdings	Approved: DPC	Date: 17/09/13
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Sources: The following datasets were used in the production of this map: Geomorphic Wetlands - DEC (2012)

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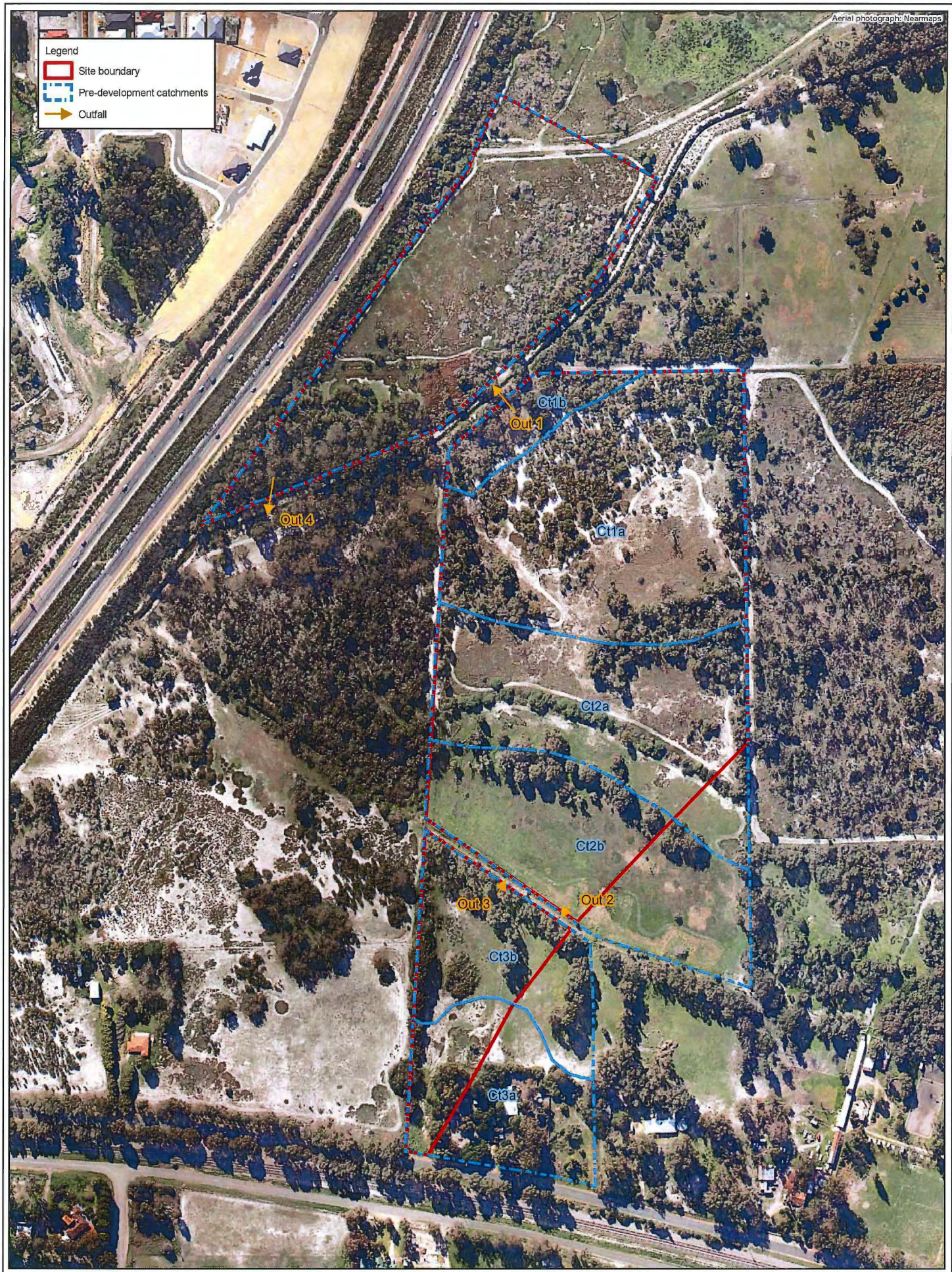

Figure 7:	Pre-development Catchments	Plan Number: EP11-011(05)--F46a	
Project:	Wellard East - Part Lots 379 and 9001 Addendum	Drawn: GRO	Date: 23/08/12
Client:	Armana Holdings	Approved: DPC	Date: 17/09/13
		Checked: RLE	Scale: 1:4,000@A4

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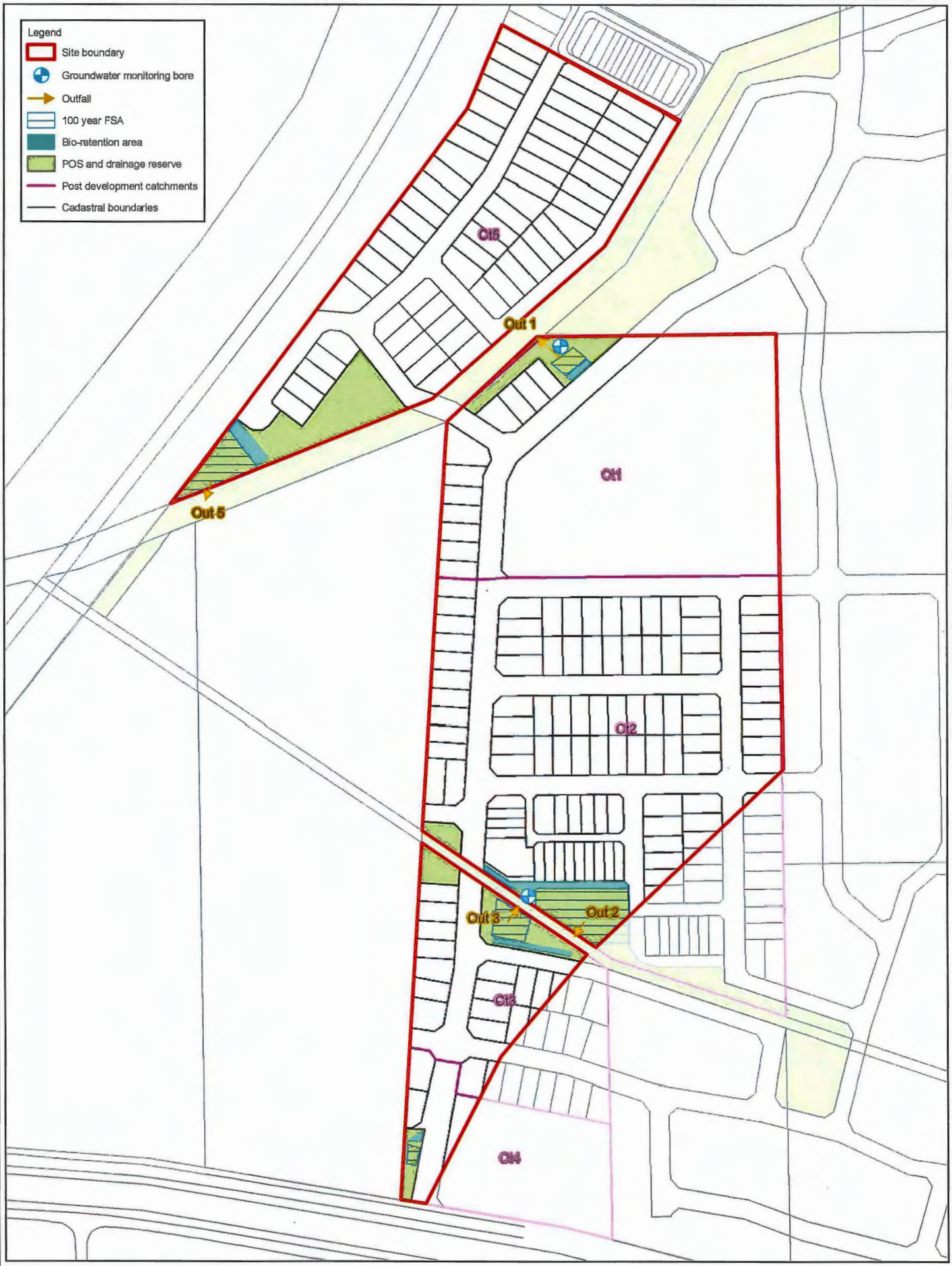

Figure 8:	Stormwater Management Features	Plan Number: EP11-011(05)--F47b	
Project:	Wellard East - Part Lots 379 and 9001 Addendum	Drawn: GRO	Date: 10/09/13
Client:	Armana Holdings	Approved: DPC	Date: 10/03/14
		Checked: RLE	Scale: 1:3,600@A4

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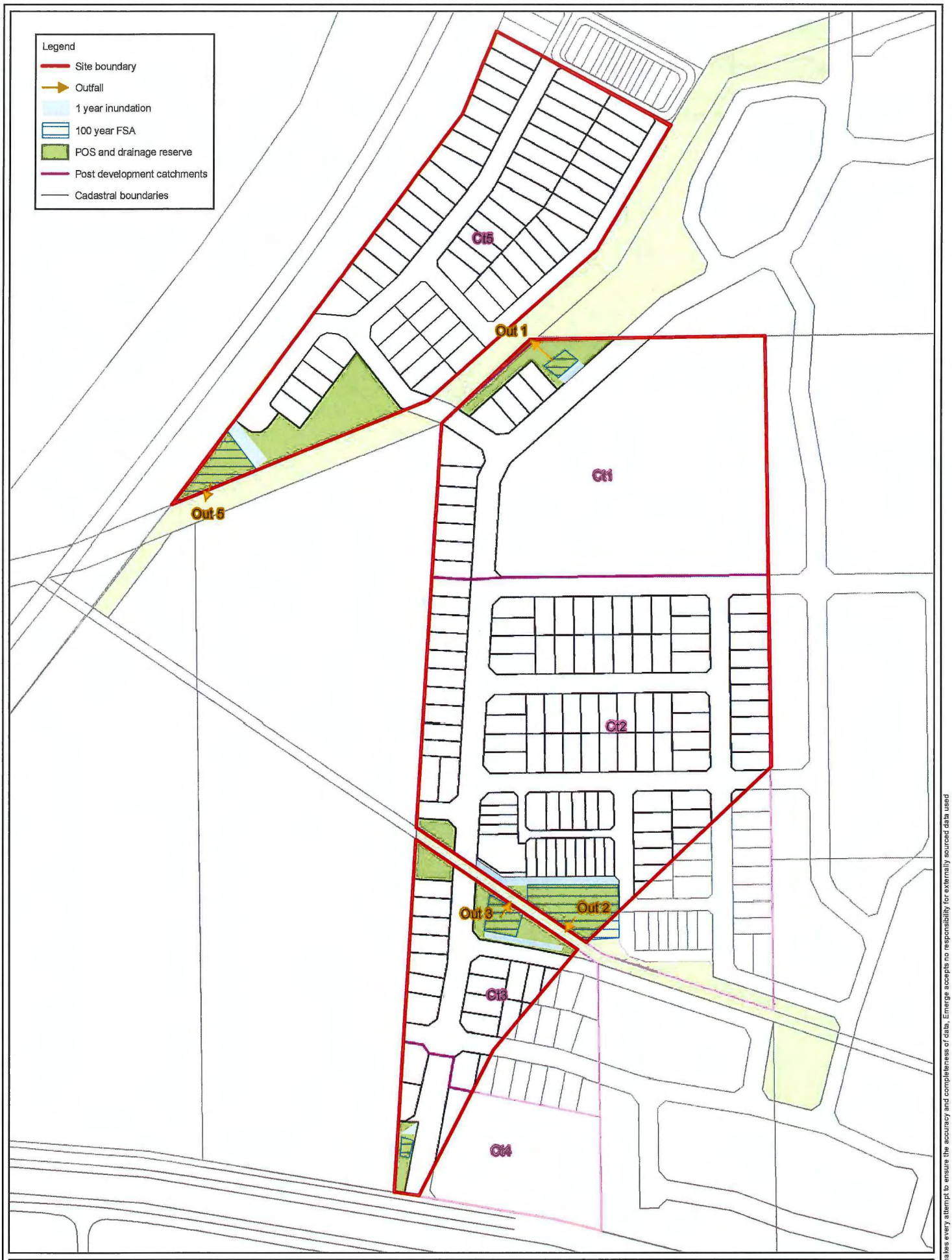

Figure 9:	1 Year 1 Hour ARI Inunation Areas	Plan Number: EP11-011(05)--F48a	
Project:	Wellard East - Part Lots 379 and 9001 Addendum	Drawn: GRO	Date: 10/09/13
Client:	Armana Holdings	Approved: DPC	Date: 17/09/13
		Checked: RLE	Scale: 1:3,600@A4

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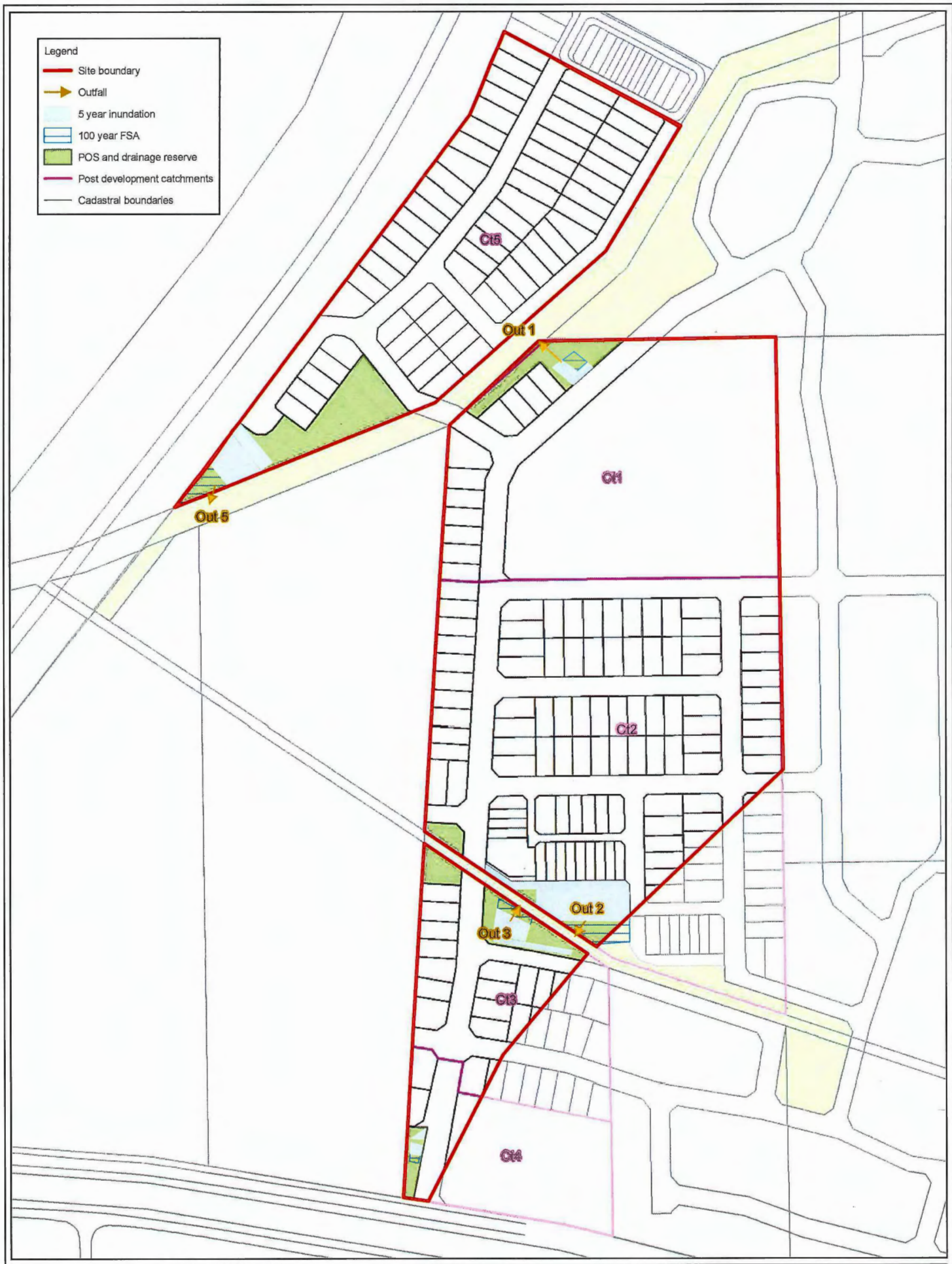

Figure 10: 5 Year ARI Inunation Areas

Project: Wellard East - Part Lots 379 and 9001 Addendum

Client: Armana Holdings

Plan Number: EP11-011(05)--F49a			
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Approved:	DPC	Date:	17/09/13
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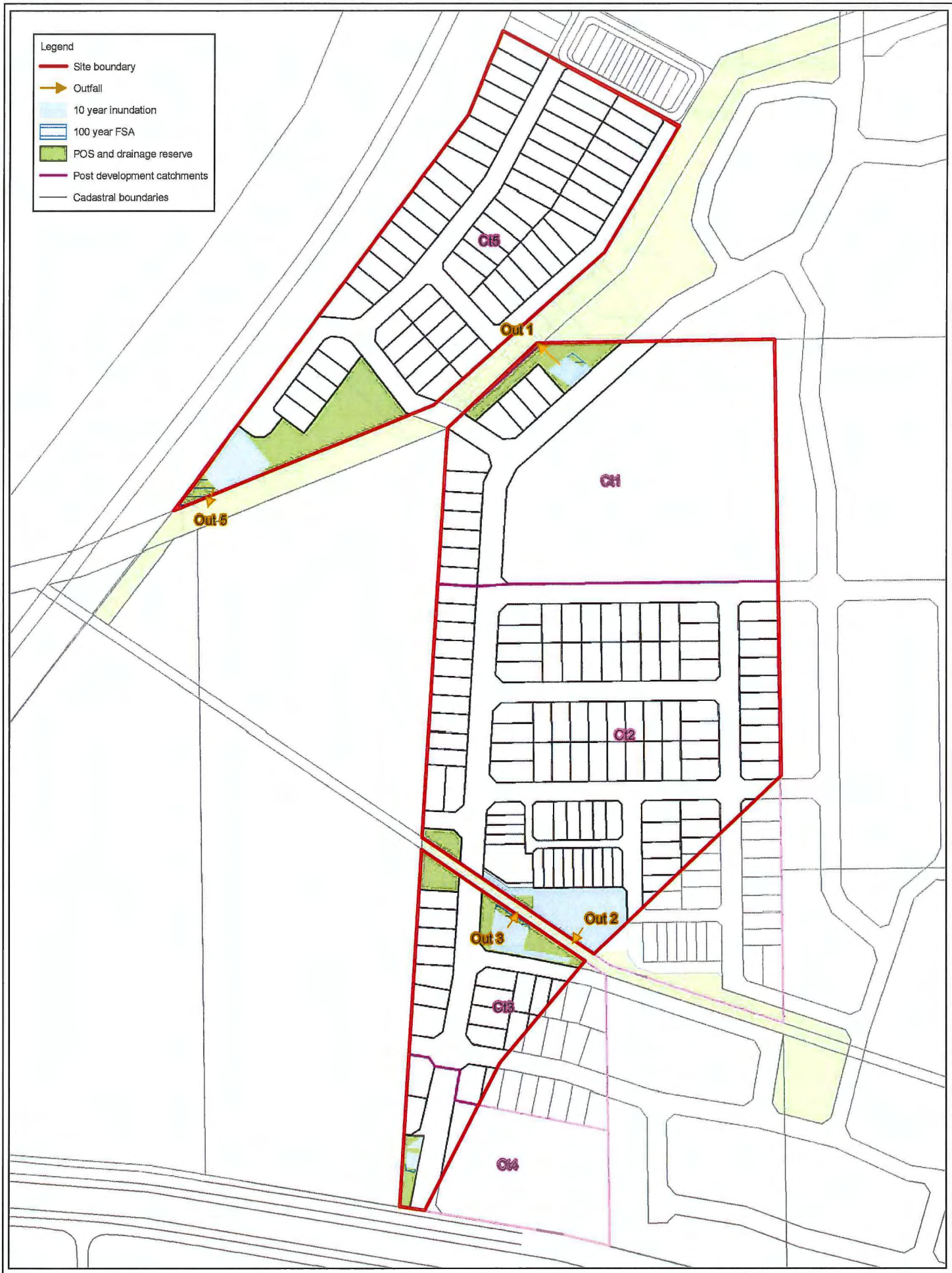

Figure 11: 10 Year ARI Inunation Areas		Plan Number: EP11-011(05)--F51a	
Project: Wellard East - Part Lots 379 and 9001 Addendum		Drawn: GRO	Date: 10/09/13
		Approved: DPC	Date: 17/09/13
Client: Armana Holdings		Checked: RLE	Scale: 1:3,600@A4

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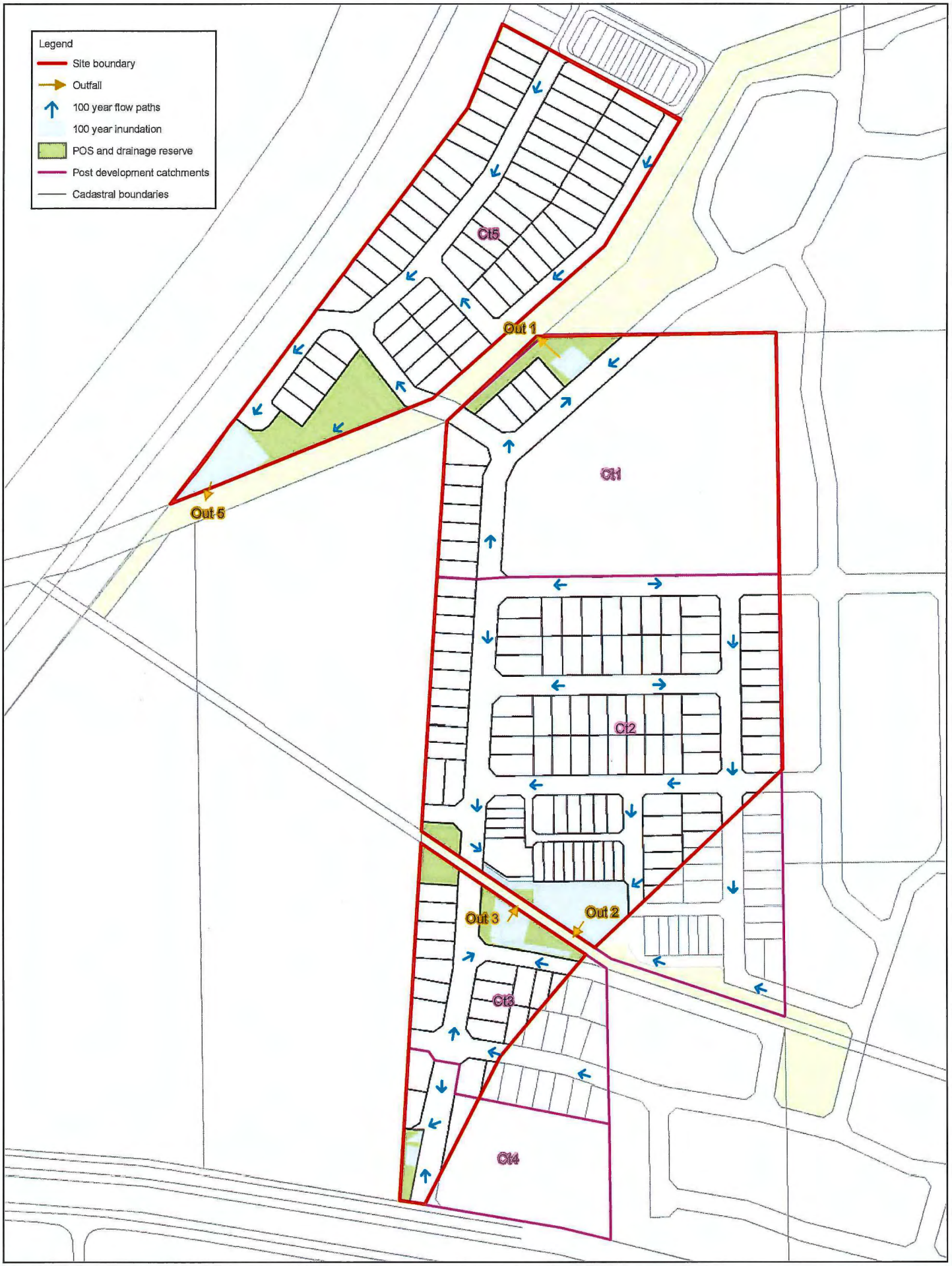

Figure 12: 100 Year ARI Inunation Areas

Project: Wellard East - Part Lots 379 and 9001 Addendum

Client: Armana Holdings

Plan Number: EP11-011(05)--F50a

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Approved:	DPC	Date:	17/09/13
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APPENDIX A

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WELLARD EAST CONCEPT PLAN

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robertsday
perth | sydney | melbourne

AMEX

FIGURE 15
WELLARD EAST CONCEPT PLAN

City of Kwinana

SIZE A2
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APPENDIX B

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LANDSCAPE MASTERPLAN

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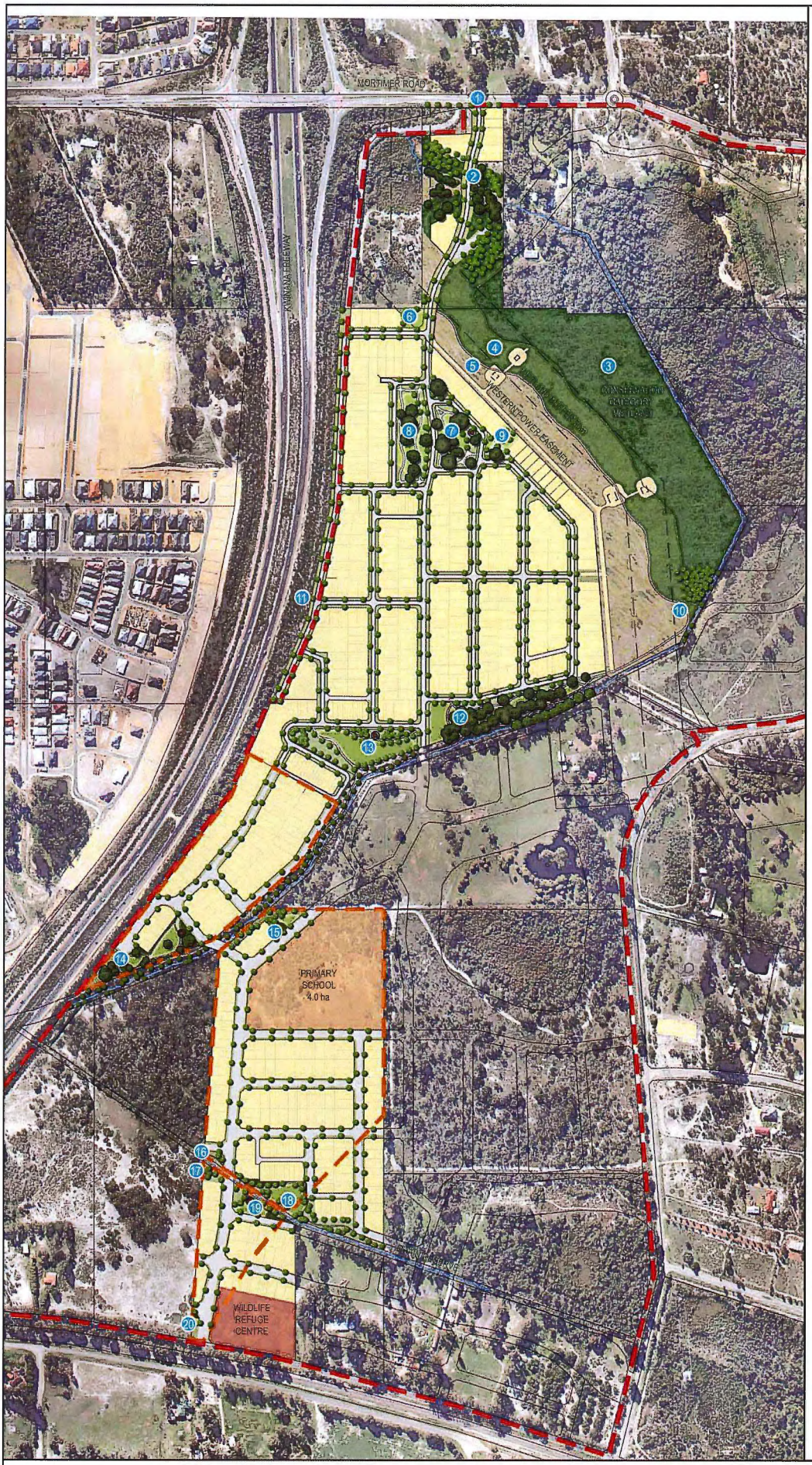

1. ENTRY STATEMENT
   - SIGNAGE INTO ESTATE AND HIGH PROFILE PLANTING
2. RESOURCE ENHANCEMENT AREA
   - LIVING STREAM / MULTIPLE USE CORRIDOR
   - EXISTING TREES TO BE RETAINED
3. CONSERVATION CATEGORY WETLAND (CCW)
   - MINIMAL LANDSCAPE WORKS TO OCCUR
   - WEED ERADICATION AND REVEGETATION
4. WETLAND BUFFER
   - NATIVE NON-IRRIGATED PLANTING & REVEGETATION
   - LIMESTONE FIREBREAKS
   - VEGETATION BUFFERS
5. WESTERN POWER EASEMENT
   - WESTERN POWER LIMESTONE MAINTENANCE ACCESS AND FIREBREAKS
   - TYPICALLY NO TREE PLANTING
   - NON-IRRIGATED NATIVE PLANTING & REVEGETATION
6. PUBLIC OPEN SPACE 6
   - KEY SHELTER OR ART ON AXIS TO DISTRACT FROM PYLONS ON ENTRY ROAD
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - BORE IRRIGATION
7. PUBLIC OPEN SPACE 7
   - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
   - RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, FURNITURE, AND PLAY EQUIPMENT
   - EXISTING TREES TO BE RETAINED
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - BORE IRRIGATION
8. PUBLIC OPEN SPACE 8
   - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
   - RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, PUBLIC ART, AND FURNITURE
   - EXISTING TREES TO BE RETAINED
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - PASSIVE POS WITH DRAINAGE CAPABILITIES
   - BORE IRRIGATION
9. PUBLIC OPEN SPACE 9
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - PASSIVE POS WITH DRAINAGE CAPABILITIES
   - BORE IRRIGATION
10. PUBLIC OPEN SPACE 10
    - LIMESTONE FIREBREAKS
    - NATIVE NON-IRRIGATED PLANTING
11. ROAD RESERVE
    - NATIVE PLANTING AND BORE IRRIGATION
    - INCLUDES DRAINAGE FUNCTIONS
12. PUBLIC OPEN SPACE 12
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - EXISTING TREES TO BE RETAINED
    - PASSIVE POS WITH PREDOMINANTLY SOFT LANDSCAPE TREATMENTS
    - INCLUDES DRAINAGE FUNCTIONS
    - BORE IRRIGATION
13. PUBLIC OPEN SPACE 13
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - RECREATION FACILITIES SUCH AS PLAY ELEMENTS AND FURNITURE
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - INFORMAL KICKABOUT AREA
    - INCLUDES DRAINAGE FUNCTIONS
    - BORE IRRIGATION
14. PUBLIC OPEN SPACE 14
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - RECREATION FACILITIES SUCH AS FURNITURE
    - SOME EXISTING TREES TO BE RETAINED
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - INCLUDES DRAINAGE FUNCTIONS
    - BORE IRRIGATION
15. PUBLIC OPEN SPACE 15
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - PASSIVE POS WITH PREDOMINANTLY SOFT LANDSCAPE TREATMENTS
    - INCLUDES DRAINAGE FUNCTIONS
    - BORE IRRIGATION
16. PUBLIC OPEN SPACE 16 and 17
17. - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - PASSIVE POS WITH PREDOMINANTLY SOFT LANDSCAPE TREATMENTS
    - INCLUDES DRAINAGE FUNCTIONS
    - BORE IRRIGATION
18. PUBLIC OPEN SPACE 18 and 19
19. - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - RECREATION FACILITIES SUCH AS PLAY EQUIPMENT AND FURNITURE
    - INFORMAL KICKABOUT AREA
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - INCLUDES DRAINAGE FUNCTIONS
    - BORE IRRIGATION
20. ROAD RESERVE
    - SIGNAGE INTO ESTATE AND HIGH PROFILE PLANTING
    - INCLUDES DRAINAGE FUNCTIONS
    - BORE IRRIGATION

SUNRISE AT WELLARD

Landscape Masterplan

Armana Holdings Pty Ltd.

LEGEND

- WELLARD EAST BOUNDARY
- LSP BOUNDARY
- RECREATION FACILITY
- PUBLIC OPEN SPACE & VERGE AREAS
- LIVING STREAM
- WETLAND BUFFER
- WESTERN POWER EASEMENT
- EXISTING TREES TO BE RETAINED

NOTE: PROPOSED LOT BOUNDARIES ARE INDICATIVE ONLY

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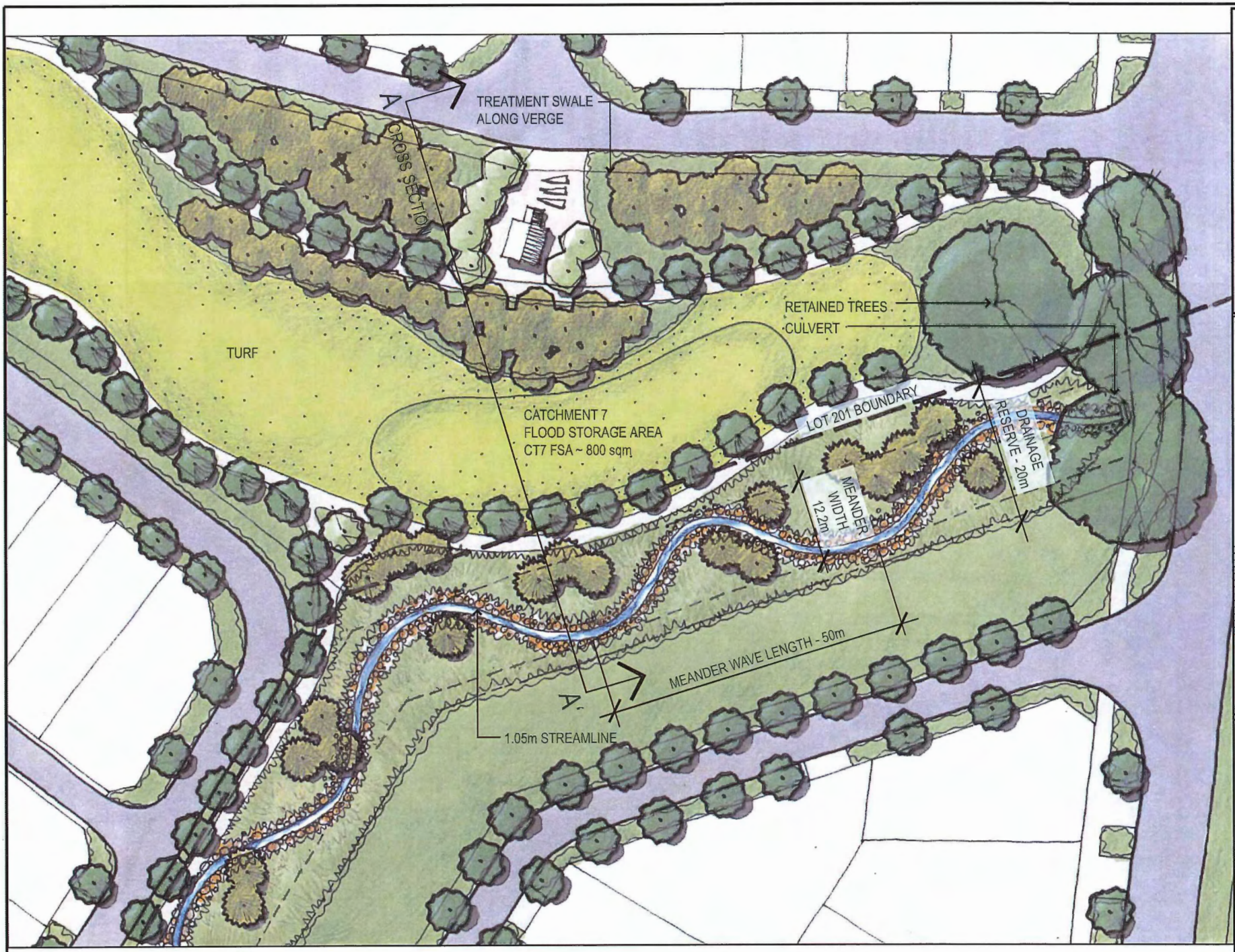
Scale 1:6000 at A3
Rev L November 2013



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B	11.08.10	MD	ISSUE FOR COMMENT

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INTERNAL DESIGN REVIEW

INTERNAL PRETENDER REVIEW

AUTHORISED FOR CONSTRUCTION

PROJECT
Wellard

STAGE OR PHASE
LWMP

DRAWING TITLE
Landscape Concept Drainage Plan

CLIENT
AMEX

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mcnally newtown landscape architects
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urban systems sustainability environment landscape

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DRAWN BY	MD	PRELIM DWG REVIEWED BY	PB
DATE INITIALLY DRAWN	11 Aug 2010		
SCALE	1:500 AT A 3		
DRAWING NUMBER	WE-LWMP-01	REV	A

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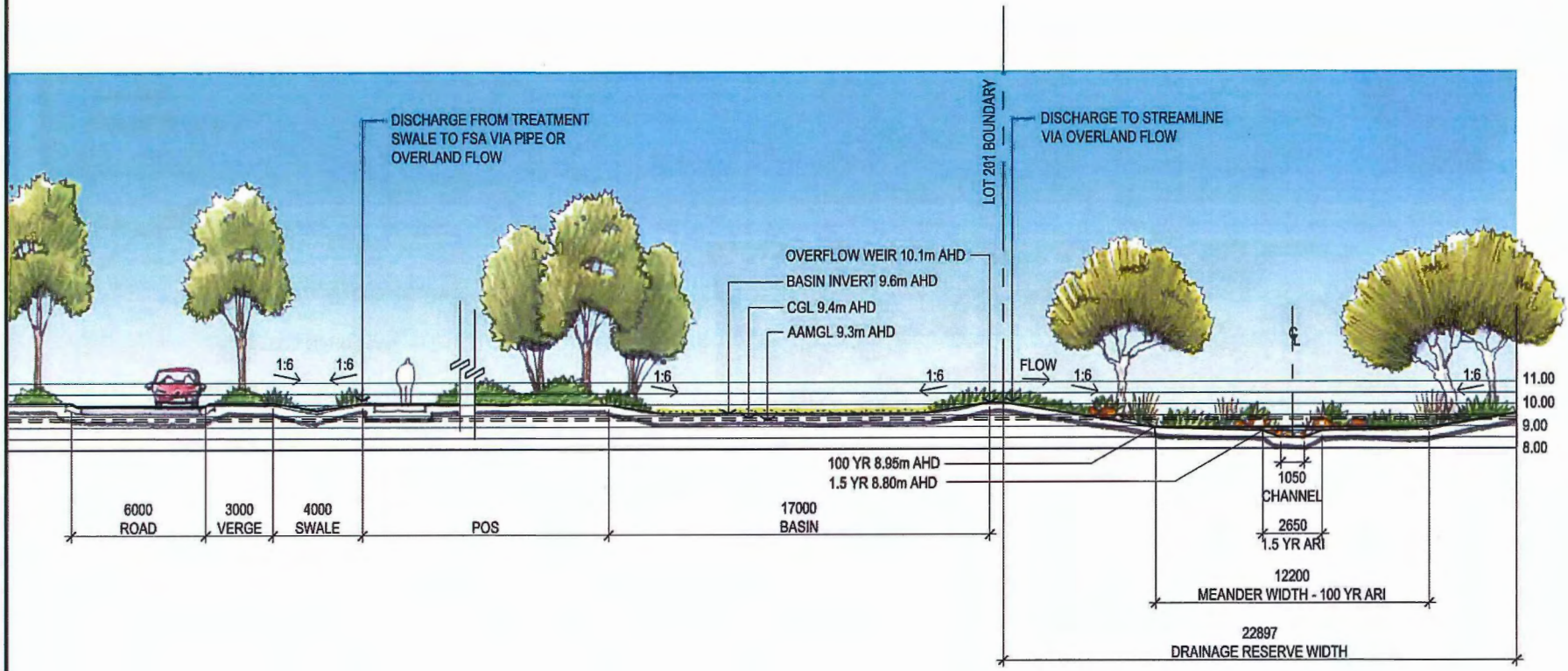

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PROJECT: Wellard

STAGE OR PHASE: LWMP

DRAWING TITLE: Landscape Concept Drainage Section A - A'

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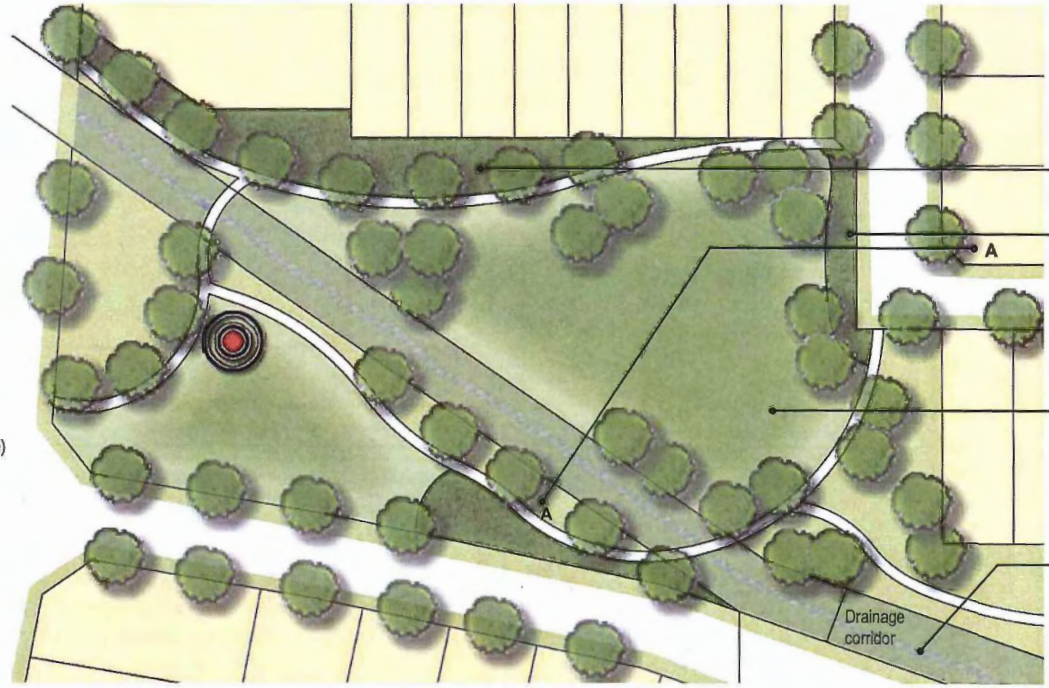
INDICATIVE POS DRAINAGE SECTION

NOTE:
The below diagrams (plan and sections) are provided as guidance only. Final design levels, concept design, open space amentiy is subject to the future detailed design process and local government approvals process.

INDICATIVE PLAN
1:1500 @ A3



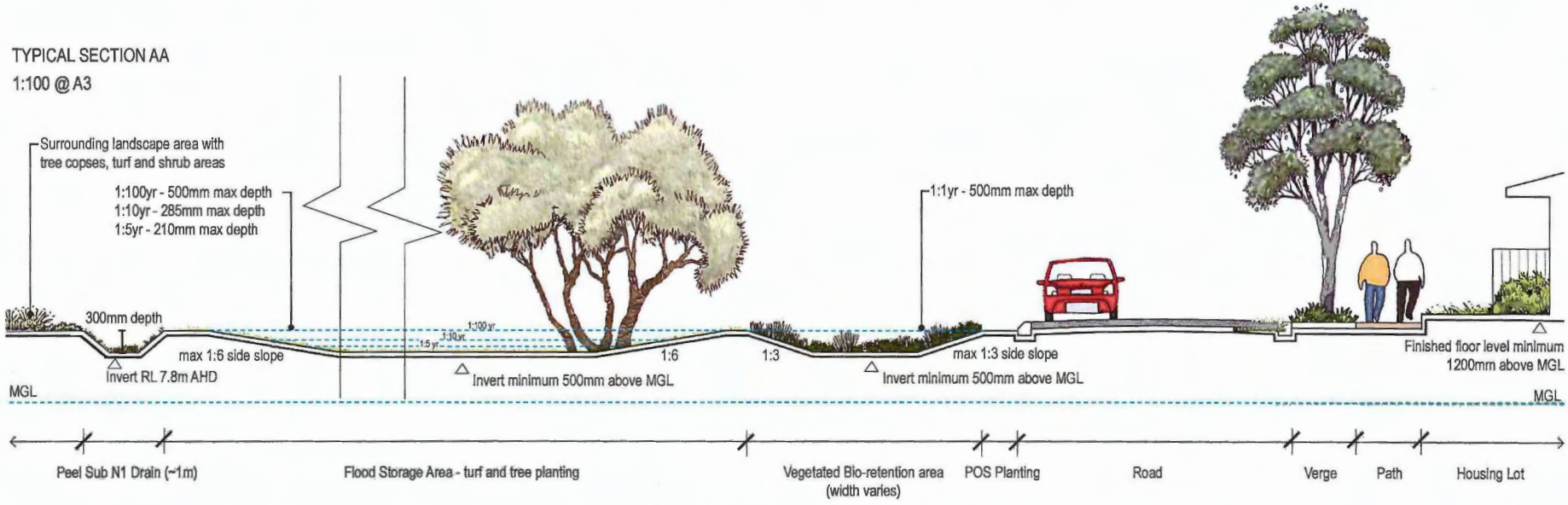
PROPOSED REEDS AND SEDGE PLANTING (with 1yr ARI event storage)

OPEN TURF AREA (1yr to 100yr ARI event storage)

PEEL SUB N1 DRAIN

SURROUNDING LANDSCAPING

TYPICAL SECTION AA
1:100 @ A3



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APPENDIX C

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HYDROLOGICAL MODELLING CATCHMENT DETAILS

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Table 1 Pre-development catchment areas

Catchment	Area (ha)	Slope	Sand-Sparse (ha)	Sand-Medium (ha)
1a	4.604	0.02	4.604	
1b	0.601	0.01	0.601	
2a	3.463	0.02	3.463	
2b	3.087	0.01		3.087
3a	1.852	0.02	1.852	
3b	1.731	0.01		1.731
4	4.665	0.04	4.665	
Total	*20.003*		*15.185*	*4.818*

Table 2 Post-development catchment areas

Sub-catchment	Corresponding Pre-dev Sub-catchment	Slope	Area (ha)													
			Total Area	Total Road	Road Pavement	Road Verge	Total Lots	Roof	Lot Paved	Lot Garden	Total High Density Lots	Roof	Lot Paved	Lot Garden	POS	100 Yr Retained On-Lot
Ct1	1a, 1b	0.02	4.402	0.500	0.200	0.300	0.515	0.258	0.129	0.129	0.000	0.000	0.000	0.000	0.213	3.174
Ct2	2a, 2b	0.03	7.378	2.139	0.856	1.283	4.187	2.093	1.047	1.047	0.476	0.238	0.214	0.024	0.576	0.000
Ct3	3b	0.04	2.142	0.592	0.237	0.355	1.281	0.640	0.320	0.320	0.000	0.000	0.000	0.000	0.270	0.000
Ct4	3a	0.04	1.461	0.211	0.085	0.127	0.093	0.047	0.023	0.023	0.000	0.000	0.000	0.000	0.072	1.085
Ct5	4	0.04	4.665	1.073	0.429	0.644	3.044	1.522	0.761	0.761	0.000	0.000	0.000	0.000	0.549	0.000
Total			20.048	4.515	1.806	2.709	9.120	4.560	2.280	2.280	0.476	0.238	0.214	0.024	1.678	4.259

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APPENDIX D

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GROUNDWATER MONITORING DATA

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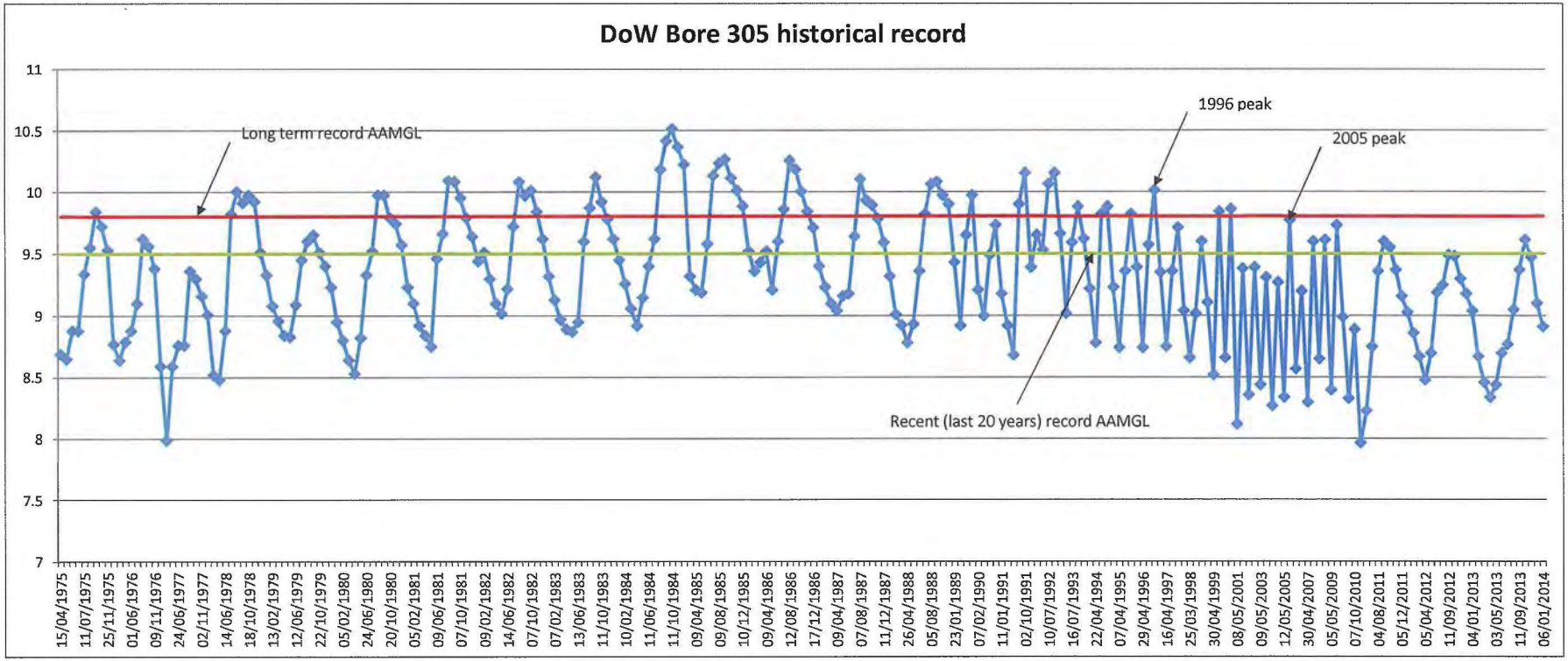
DoW Bore 305 historical record
Long term record AAMGL
1996 peak
2005 peak
Recent (last 20 years) record AAMGL
11
10.5
10
9.5
9
8.5
8
7.5
7
15/04/1975
11/07/1975
25/11/1975
01/06/1976
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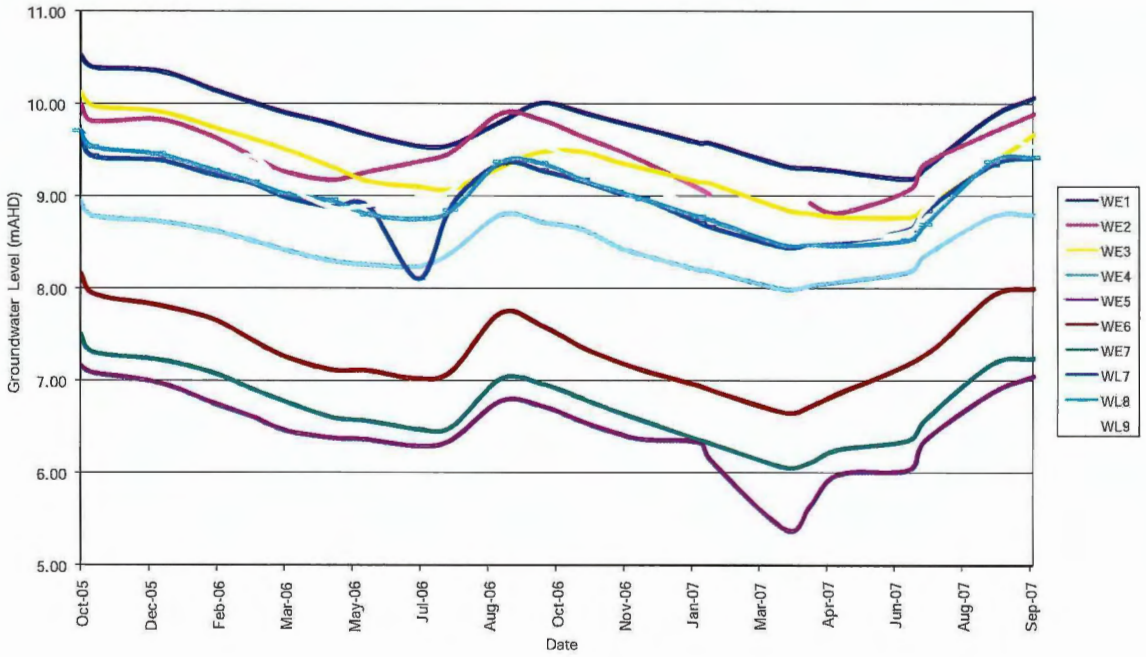

Figure C1 Groundwater Hydrographs

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX F

LOCAL WATER MANAGEMENT STRATEGY (CARDNO 2010)

Cardno
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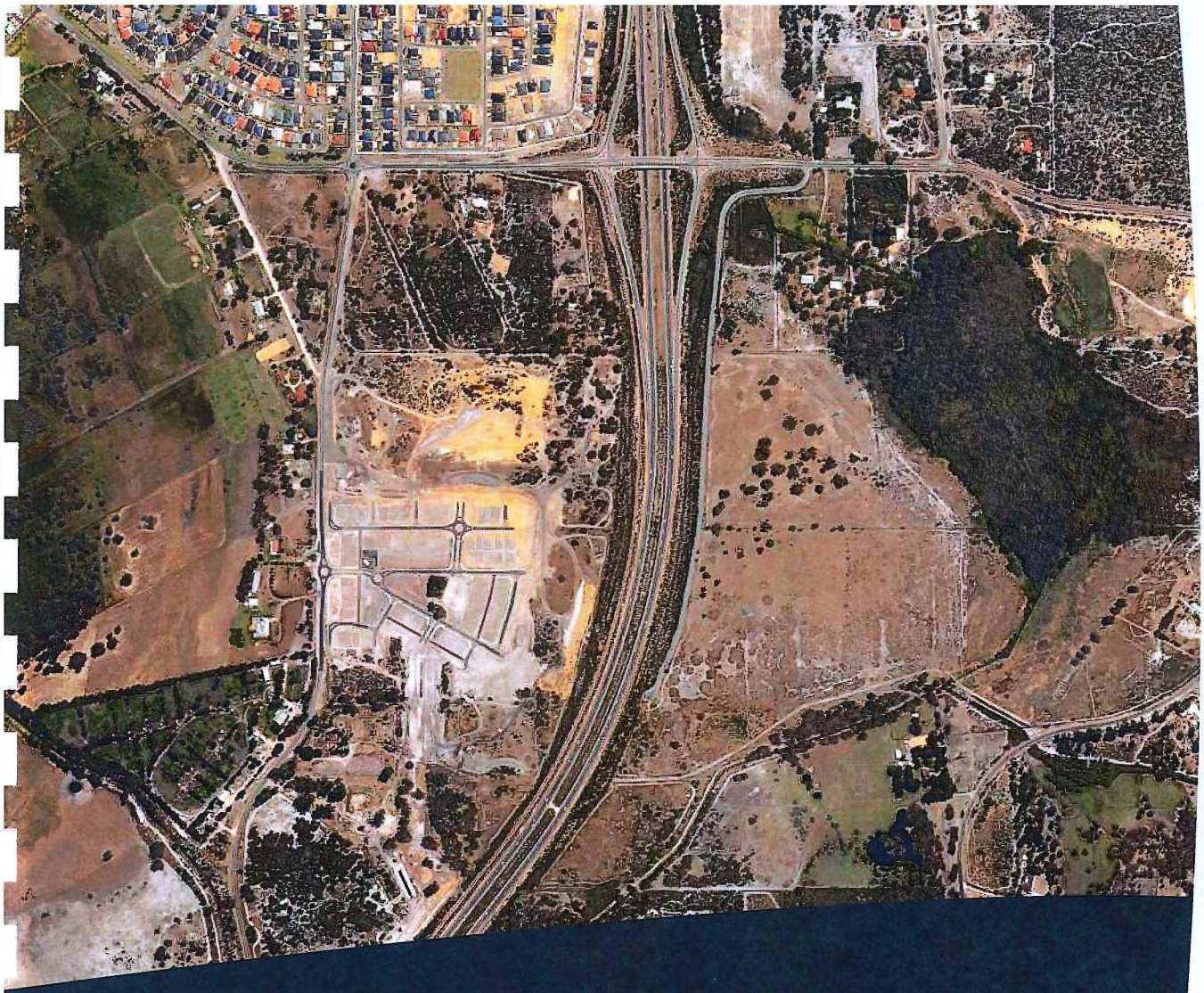

Lot 27 and Lot 201 Wellard East

Local Water Management Strategy

Prepared for Armana Holdings Pty Ltd

August 2010

Project Number V8041

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Document Control

Version	Date	Author		Reviewer	
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2	August 2010	Samuel Cleary		David Coremans	
Filename	V8041--DLM100008.20--DPC.docx				

Author: Samuel Cleary
Position Title: Environmental Engineer

Reviewer: David Coremans
Position Title: Section Leader Hydrology and Hydraulics

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Executive Summary

Armana Holdings Pty Ltd has commenced structure planning for the development on Lot 27 Mortimer Road and Lot 201, Wellard, within the Town of Kwinana. The development of a Local Water Management Strategy (LWMS) is the appropriate mechanism to establish broad-level designs and management measures for flood mitigation and effective stormwater management at the structure planning stage.

The LWMS is a key supportive document for the Local Structure Plan (LSP) of Lot 27 and Lot 201. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with a 'total water cycle management' approach described in the document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide future Urban Water Management Plans (UWMPs) that will support subdivision approval.

This LWMS for the LSP has been developed to:

- Provide a broad level stormwater management framework to support future urban development;
- Incorporate appropriate BMPs into the drainage systems that address the environmental and stormwater management issues identified;
- Minimise development construction costs, which will result in reduced land costs for future home owners;
- Minimise ongoing operation and maintenance costs for the land owners and ToK;
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area; and
- Gain support from the DoW and ToK for the proposed method to manage stormwater within Lot 27 and Lot 201 and potential impacts on downstream areas.

A number of broad level studies that include the LSP area provide a regional environmental context for the LWMS. These have been reviewed in order to provide suitable background information for Lot 27 and Lot 201 and also to provide an indication of the issues requiring further investigation. Further, a number of site-specific investigations into various aspects of Lot 27 and Lot 201 have recently been conducted as a part of the LSP preparation process. In summary, the investigations conducted to date indicate that:

- Lot 27 and Lot 201 receives an average of 745mm of annual rainfall with the majority of rainfall received between June and August;
- Lot 27 and Lot 201 ranges from 21mAHD to 9mAHD in elevation, with a generally southerly aspect;
- The soil types encountered during investigations were consistent with Bassendean Sand soil types;
- ASS risk maps suggest that the proposed development area of Lot 27 and Lot 201 has been classified as having a moderate to low risk of encountering ASS to depths of 3m below ground surface (BGS);
- The Peel Sub N Drain borders the south east boundary of Lot 27 and Lot 201;
- The long sections provided in the Jandakot Structure Plan Area Drainage and Water Management Plan (JDWMP) provide peak flows for both the 10 year and 100 year ARI events at the discharge point of the Peel Sub N Drain of 0.75m^3/s and 1.07m^3/s respectively;
- Modelling conducted using XPSWMM resulted in peak discharges from the Peel Sub N Drain of 0.60m^3/s and 0.93m^3/s for the 10 and 100 year ARI events respectively;
- Surface water quality indicates that existing conditions exceed relevant default trigger values;
- Surface water flow is considered to be an expression of the groundwater and only flows at times of high groundwater;
- Groundwater underlying Lot 27 and Lot 201 flows in a south to south easterly direction;
- Groundwater levels underlying Lot 27 and Lot 201 range between 7.5mBGS to less than 1.2mBGS. The depth to groundwater is less than 1.2m for the majority of the Lot 27 and the south west portion of the Lot 201;

- Groundwater quality underlying the majority of Lot 27 and Lot 201 has 'moderate' to 'high' nutrient concentrations;
- The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there is a Conservation Category Wetland (CCW) within the site boundary to the north east of Lot 201, a Resource Enhancement Wetland (REW) across Lot 27 and a Multiple Use Wetland (MUW) within Lot 201 to the south east;
- No portion of the proposed development area of Lot 27 and Lot 201 is classified as an Environmentally Sensitive Area (ESA);
- Lot 27 and Lot 201 has historically been used for rural agricultural purposes; and
- There are no known sites of Aboriginal Heritage significance recorded within Lot 27 and Lot 201.

The LWMS has determined appropriate Storm Water Management, Groundwater Management and Water Conservation design criteria based on overarching documents, requirements of the Town of Kwinana, Department of Water (DoW) and similar developments. The most relevant quality document is the Wellard East DWMS (Cardno, 2009a) which was approved by DoW in 2009.

The stormwater management objectives for Lot 27 and Lot 201 is to mitigate post-development peak discharge rates to pre-developments rates and to retain (and treat) the 1 year – 1 hour ARI rainfall event. The LWMS document provides the location and size of all retention and detention storage areas.

Stormwater flows will be distributed to retention and detention storage areas via a conventional piped drainage network, designed based on the 5 year ARI storm event. For major stormwater flows greater than the 5 year ARI storm event, stormwater will be directed to Flood Storage Areas (FSAs) via public open space (POS) areas and the Western Power easement. The FSAs would then provide detention storage of major flows, such that the ultimate post-development peak discharge is comparable to the pre-development peak discharge.

It is widely thought that the Perth's climate is undergoing a drying trend, and that as the City's population grows and demands for potable water sources increase, significant attention should be focused on the manner in which the resources currently available are utilised. Therefore, it is recommended that demands for water within the subdivision be managed by application of the following broad criteria:

- Ensure the efficient use of all water resources in newly developing urban form;
- Use water more efficiently; and
- Consumption target for potable water of 100kL/person/year for residential areas.

In addition, the development will aim to mimic the natural environment and will minimise the net use of water, by maximising surface aquifer recharge.

The preferred strategy to maintain groundwater levels throughout Lot 27 and Lot 201 will be through localised recharge from drainage infrastructure that encourages lot scale infiltration.

While strategies have been provided within this LWMS that address planning for water management within the LSP area, several issues have been identified that will require additional investigation to ensure that the proposed subdivision designs are realistically achievable. The main areas that will require further clarification within future UWMPs include:

- Modelling of local road drainage network;
- Flood storage area configurations and outlet structures;
- Detailed geotechnical investigation;
- The need for ASS investigations;
- Implementation of water conservation strategies;
- Non-structural water quality improvement measures;
- Management and maintenance requirements;
- Construction period management strategy; and
- Monitoring and evaluation program.

Pre-development monitoring of hydrological conditions of Lot 27 and Lot 201 has been undertaken and completed consistent with accepted industry standards. It is anticipated that the post-development monitoring of surface and groundwater conditions would be consistent with the pre-development monitoring in terms of sample density and parameters monitored. In addition to the existing monitoring program, it is expected that Best Management Practices will be maintained and monitored to ensure that they continue to serve their intended functions. These would be further detailed at UWMP stage.

The Lot 27 and Lot 201 LWMS provides a framework that future landowners can follow to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the Town of Kwinana. The responsibility for working within the framework established within the LWMS rests with the individual landowners, although it is anticipated that future UWMPs will be developed in consultation with the Town of Kwinana, DoW and in consideration of other relevant policies and documents as well as this LWMS.

Table 1 Design Elements and Compliance

Key Element	Design Objectives and Criteria	Compliance
Surface Water Quantity	Retain the 1 year - 1 hour duration ARI rainfall event on site.	Runoff from lots for this event will be retained within lot boundaries. Rainwater tanks and soakwells will be used to retain the 1 year - 1 hour ARI storm event on lots. For the remainder of the development the runoff from this event will be retained within tree-pits, bio-pockets, subsurface storage devices and/or retention swales. Larger runoff events will also flow into these bio-retention systems and overtop into the Flood Storage Areas (FSAs) (**Section 7.1**).
	Bio-retention systems should be sized to accommodate at least 2% of the connected impervious area.	This will be provided by tree-pits, bio-pockets and retention swales.
	Piped road network designed based on the 5 year ARI rainfall event.	The development will have a mixture of pathways for conveying rainfall runoff events to the downstream FSAs; these include swales, road pavement and concrete piped network. The concrete piped network will be sized for the 5 year ARI rainfall event.
	Ensure that the 100 year ARI rainfall event conveyance can be contained within the road reserve.	With the combination of at-source storage within lot soakwells, infiltration within bio-retention systems and the use of a piped network to convey the 5 year ARI rainfall event, the 100 year ARI event conveyance will be contained within the road reserve with overland flow incorporated.
	Ensure that properties have a finished floor level of 500mm above the 100 year flood level within the adjacent basins.	The major event detention storage will be within FSAs. The 100 year ARI water levels in the FSAs are provided in **Figure 16**, which can be used to determine earth works levels at subdivision stage.
	Detain the 5 year ARI through to the 100 year ARI rainfall events so that the post-development peak discharge is comparable to the pre-development peak discharge.	The post-development peak discharge has been mitigated so that it is comparable to the pre-development peak discharges for the 5 year ARI through to the 100 year ARI rainfall events. The modelling results for this comparison are provided in **Section 7.3**.
Surface Water Quality	Maintain or improve the surface and groundwater quality within the development relative to pre-development conditions.	The Lot 27 and lot 201 development will achieve this objective by implementing treatment trains that include tree-pits, bio-pockets, vegetated retention swales and/or FSAs. The retention of the 1 year - 1 hour ARI storm event and the provision of a minimum bio-retention area of 2% connected impervious area will ensure the surface and groundwater quality is maintained (**Section 7.3.1**).
	Maintaining the total water cycle balance within the development relative to the pre-development conditions.	The WSUD techniques have been located and sized so that the post-development peak discharge is comparable to the pre-development peak discharge. In doing so, the surface runoff and infiltration has been made comparable pre to post; thus maintaining the total water cycle balance.
	Maximising the reuse of stormwater.	Infiltration of stormwater as close to source as practicably possible is a key design objective for the Lot 27 and Lot 201 development. This infiltrated water will enter the groundwater and will be reused by the natural environment.

Groundwater Quantity	Lots should have a separation distance to the annual average maximum groundwater level (AAMGL) of at least 1.2m.	The depth to groundwater is greater than 2m across the majority of the Lot 27 and Lot 201 development. The southern region of the LSP may require clean fill and/or subsoil drainage to ensure the FSA remain as dry basins and sufficient clearance to groundwater is provided. The requirements for fill and/or subsoils will be determined at the UWMP stage following outcomes from the geotechnical investigation and pending final FSA designs.
Groundwater Quality	Minimise the risk of nutrient enrichment of downstream receiving surface water bodies from groundwater sources.	The Lot 27 and Lot 201 development reduces the risk of nutrient enrichment and transportation by using a treatment train approach and ensuring nutrient uptake in the bio-retention systems.
	The groundwater leaving Lot 27 and Lot 201 should at least be the same, or better, than the water entering Lot 27 and Lot 201.	The groundwater currently has low to moderate nutrient concentrations. The development will minimise additional nutrient loading of the groundwater through management strategies. The retention of the 1 year - 1 hour ARI storm event and the provision of a minimum bio-retention areas sized to be 2% of the connected impervious area will ensure the infiltration of nutrient rich surface water to groundwater is minimised; thus improving the groundwater quality exiting the LSP area (**Section 6.2** and **Section 7.3.1**).
Water Conservation	Ensure the efficient use of all water resources in newly developing urban form.	Remnant trees will be maintained within proposed POS areas, reducing the water requirements to establish vegetation. Low water requiring plant species (such as native species) will be utilised. Minimising the use of turfed areas. Where turf is to be used, a low nutrient and water requiring species should be utilised.
	Use water more efficiently.	Water conservation devices and practises are proposed to be implemented within the Lot 27 and Lot 201 development including water efficient appliances and gardens (**Section 5**). Groundwater is proposed to be used as the water source for irrigation of POS, reducing the demand for scheme water within the development. Recharging the groundwater through infiltration of stormwater could minimise potential drawdown of the aquifers where these are used during dry periods.
	A target for domestic scheme water use of 100kL/year per person.	The 100kL/person/year target can be achieved in the development with the implementation of water conservation devices and practises such as rainwater tanks, water efficient gardens and water efficient appliances (**Section 5.3**).

Table of Contents

Executive Summary ii

1 Introduction 1

1.1 Background 1

1.2 Town Planning Context 1

1.3 Policy Framework 2

1.4 LWMS Objectives 3

2 Proposed Development 4

3 Pre-development Environment 5

3.1 Sources of Information 5

3.2 Climate 5

3.3 Geotechnical Conditions 6

3.3.1 Topography 6

3.3.2 Soils 6

3.3.3 Acid Sulfate Soils 6

3.4 Wetlands 6

3.5 Flora 7

3.6 Fauna 7

3.7 Hydrology 7

3.7.1 Surface Water Quantity 8

3.7.1.1 Existing Drainage Network 8

3.7.1.2 Pre-development Sub-catchments 8

3.7.1.3 Pre-development Modelling Parameters 8

3.7.1.4 Pre-development Modelling Results 9

3.7.2 Surface Water Quality 9

3.7.3 Groundwater Levels 10

3.7.4 Groundwater Quality 10

3.8 Current and Historical Land Uses 11

3.9 Ethnographic Considerations 11

3.10 Summary of Existing Environment 11

4 Design Criteria and Objectives 13
4.1 Total Water Cycle Management 13
4.2 Water Conservation 13
4.3 Groundwater Management 14
4.4 Surface Water Management 14
4.4.1 Stormwater Quantity 15
4.4.2 Stormwater Quality 15
5 Water Source Allocation, Infrastructure and Fit for Purpose 17
5.1 Water Conservation Strategy 17
5.2 Water Conservation Measures 17
5.2.1 Rainwater Tanks 17
5.2.2 Water Efficient Appliances 18
5.2.3 Water Efficient Gardens 18
5.2.4 Groundwater 19
5.2.5 Waste Water Reuse 19
5.2.6 Grey Water Reuse 19
5.3 Water Balance 19
5.4 Wastewater Management 20
6 Groundwater Management Strategy 21
6.1 Groundwater Level Management 21
6.2 Groundwater Quality Management 21
7 Stormwater Management Strategy 23
7.1 Development Drainage System 23
7.1.1 Tree-Pits 23
7.1.2 Swales 23
7.1.3 Bio-pockets 24
7.1.4 Flood Storage Areas 24
7.2 Lot Drainage System 24
7.3 Post-development Surface Runoff Modelling 24
7.3.1 Minor Rainfall Event Modelling Results 24

7.3.2 Major Rainfall Event Modelling Results 25
7.4 Peel Sub N Design 27
8 Subdivision and Urban Water Management Plans 28
8.1 Modelling of Local Road Drainage Network 28
8.2 Flood Storage Area Configurations and Outlet Structures 28
8.3 Detailed Geotechnical Investigation 29
8.4 ASS Investigation 29
8.5 Clean Fill and Subsoil Drainage Requirements 29
8.6 Approval of Wetland Boundary Modification 29
8.7 Implementation of Water Conservation Strategies 30
8.8 Non-Structural Water Quality Improvement Measures 30
8.9 Management and Maintenance Requirements 30
8.10 Construction Period Management Strategy 30
8.11 Monitoring and Evaluation Program 31
8.12 Groundwater Licence Status 31
8.13 Peel Sub N Drain Land Transfer 31
9 Monitoring 32
9.1 Recommended Program for UWMP 32
9.2 Contingency Action Plan 33
9.2.1 Trigger Criteria 33
9.2.2 Contingency Actions 33
9.3 Reporting 34
10 Implementation 35
10.1 Roles and Responsibility 35
10.2 Funding 35
10.3 Review 35
11 References 37

List of Figures

Figure 1 **Site Locality**

Figure 2 **Site Plan**

Figure 3 **Topographic Contours**

Figure 4 **Soil Classification**

Figure 5 **Acid Sulfate Soil Risk Mapping**

Figure 6 **Wetlands**

Figure 7 **Proposed Wetland Alignment**

Figure 8 **Hydrological Features and Pre-Development Sub-Catchments**

Figure 9 **Maximum Groundwater Levels**

Figure 10 **Depth to Groundwater**

Figure 11 **Total Nitrogen Distribution Mapping**

Figure 12 **Total Phosphorous Distribution Mapping**

Figure 13 **Stormwater Drainage System**

Figure 14 **1yr Inundation Area**

Figure 15 **5yr Inundation Area**

Figure 16 **100yr Inundation Area**

Figure 17 **Indicative Post-Development Monitoring Locations**

Appendices

Appendix A Local Structure Plan

Appendix B Modelling Assumption, Parameters and Results

Appendix C Groundwater and Surface Water Quality Results and Hydrographs

Appendix D Subsoil Concept Designs

Appendix E Landscape Master Plan

Appendix F Living Stream Concept Design

1 Introduction

1.1 Background

The locality of Wellard is situated in the south west corridor of Perth, immediately west and east of the Kwinana Freeway, within the Town of Kwinana (ToK). The Wellard area has been identified in the Jandakot Structure Plan as being suitable for urban development. As Wellard is dissected by the Kwinana Freeway, the area to the east of the freeway is referred to as Wellard East. An amendment to the Metropolitan Region Scheme (MRS) (WAPC, 2007c) listed the majority of the Wellard East LSP area as "Urban" with the south-west portion zoned as "Urban Deferred". Armana Holdings Pty Ltd landholdings in Wellard East includes Lot 27 Mortimer Road, Lot 201 on Plan 52621 (no street address) and Lot 379 Millar Road. This LWMS has been prepared for Lot 27 and 201.

Lot 27 and Lot 201 currently consists of open paddocks and some remnant bushland. The location of Lot 27 and Lot 201 is indicated in **Figure 1**. An aerial photograph illustrating the current condition and cadastral boundaries of Lot 27 and Lot 201 is provided in **Figure 2**.

It is important that the manner in which stormwater runoff from urban zoned areas is to be managed to avoid flooding and protect the environment are clearly documented early in the planning process. This approach provides the framework for actions and measures to achieve the desired outcomes at subdivision stage. The *Cascades - Wellard East District Water Management Strategy* (DWMS) (Cardno, 2009a) further developed the guidance presented in the *Draft Jandakot Structure Plan Area Drainage and Water Management Plan* (JDWMP) (DoW, 2008a). This LWMS follows on from this previous work to further determine in more detail the water management strategy for Lot 27 and Lot 201, with final water management plans to be determined and presented in future UWMP documents.

1.2 Town Planning Context

In August, 2007, the Western Australian Planning Commission (WAPC) released the final *Jandakot Structure Plan* (JSP) following on from the draft JSP released in October, 2001. The Plan recognises potential development areas and proposes indicative road layouts and locations for community facilities whilst retaining environmentally sensitive features such as wetlands.

In November 2005, the Town of Kwinana released for comment the *Eastern Residential Intensification Concept*, commonly referred to as ERIC. ERIC was "prepared to provide an overarching framework for the coordination of subdivision and development within the areas designated under the *Jandakot Structure Plan* area as having potential for urban development" (ToK, 2005). The plan aims to provide a greater level of detail than the JSP and is in effect a District Structure Planning framework within which to develop Local Structure Plans.

The Town of Kwinana has released a draft *Local Biodiversity Strategy* (LBS) (2007) with the aim of striking a new balance between development and environmental protection by planning for the protection of important natural areas identified across the local government area. The LBS provides a framework that helps to identify and protect important natural areas and to ensure that the development and management of land is compatible with the maintenance and conservation of these areas. The LBS aims to provide long-term protection for a proportion of these natural areas, with a preference being given to those that have the highest environmental value wherever possible. It is also understood that not all natural areas will be able to be protected due to a range of constraints posed by development.

There are a number of potentially incompatible land uses situated in varying proximities to Lot 27 and Lot 201. These include an inert landfill site, a poultry farm, a livestock holding facility and the

Kwinana Atmosphere Policy Boundary. Approval was attained in December 2009 for the amendment and rezoning of the "Urban Deferred" to "Urban" classification in the MRS.

1.3 Policy Framework

There are a number of State Government policies of relevance to Lot 27 and Lot 201. These policies include:

- *State Water Strategy* (Government of WA, 2003);
- *State Planning Policy 2.9 Water Resources* (Government of WA, 2006);
- *State Planning Policy 2.3 Jandakot Groundwater Protection Policy* (WAPC, 1998);
- *Jandakot Structure Plan Area Drainage and Water Management Plan* (JDWMP) (DoW, 2010);
- *Australian Runoff Quality* (Engineers Australia, 2006);
- *Environmental Protection (Swan Coastal Lakes) Policy* (Government of WA, 1992);
- *Draft Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA, 2005);
- *Jandakot Structure Plan* (WAPC, 2007a);
- *Liveable Neighbourhoods Edition 4* (WAPC, 2007b);
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC, 2007d);
- *Framework for Developing the Jandakot Water Resources Management Strategy* (PB, 2004); and
- *Eastern Residential Intensification Concept* (ERIC) (Town of Kwinana, 2005).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that urban developments should aim to achieve. These are key inputs that relate either directly or indirectly to Lot 27 and Lot 201 and include:

- *Better Urban Water Management* (WAPC, 2008);
- *Decision Process for Stormwater Management in Western Australia* (DoW, 2009);
- *Stormwater Management Manual for Western Australia* (DoW, 2007);
- *National Water Quality Management Strategy* (ANZECC, 2000); and
- *Development of Sampling and Analysis Programs* (DoE, 2001).

The *Decision Process for Stormwater Management in WA* (DoW, 2009) provides a decision framework for the planning and design of stormwater management systems. Effectively, the document provides guidance as to how urban developments can achieve compliance with the objectives, principles and delivery approach outlined in the Stormwater *Management Manual for WA* (DoW, 2007).

The essence of the recommended approach is to address water quality concerns for minor events (up to a 1 year – 1 hour ARI event) at source, or as close as possible to source. Following this and where appropriate, water quality should also be addressed through a 'treatment train' approach, such that the combined effect meets the water quality management objectives specified in relevant regional water management targets. Conveyance of flows up to the 5 year ARI event should be accommodated within the minor system (i.e. pipes and swales), while flows up to the 100 year ARI event should be catered for by overland flow paths. The *Decision Process* indicates that stormwater quantity should be managed to preserve pre-development peak flow rates. This should be achieved by providing adequate storage within the site boundaries.

The guidance documents listed were reviewed to determine the likely data requirements for the area within the proponent's landholdings, which are proposed for future urban development. These documents point to the need for accurate baseline data prior to urban development. Comprehensive baseline data ensures that any future development is able to fulfil the stormwater management

requirements of DoW and engineering standards specified by the ToK, but will also ensure that realistic water quality criteria that are practically achievable are adopted.

1.4 LWMS Objectives

This LWMS for the LSP has been developed to meet the following major objectives:

- Provide a broad level stormwater management framework to support future urban development;
- Incorporate appropriate BMPs into the drainage systems that address the environmental and stormwater management issues identified;
- Minimise development construction costs, which will result in reduced land costs for future home owners;
- Minimise ongoing operation and maintenance costs for the land owners and ToK;
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area; and
- Gain support from the DoW and ToK for the proposed method to manage stormwater within Lot 27 and Lot 201 and potential impacts on downstream areas.

2 Proposed Development

The LSP is shown in **Appendix A**. The LSP area has a mixture of residential housing densities and POS areas. A mixture of low density R20 and medium density R40 dwelling types are proposed to be used in the Lot 27 and Lot 201 development with an assumed total of approximately 330 households across an area of 17.31ha. A mixture of road and laneways are proposed to be used within the development with 15m wide reserves utilised for most of the development. The 6m wide laneways are proposed behind the R40 style lots while a 25m wide road reserve running north to south provides an entrance for the development off Mortimer Road.

A significant portion of land along the eastern and north eastern boundaries is dedicated to an easement for Western Power transmission lines. Some minor portions of the easement are proposed to be used for major event mitigation storage. A Conservation Category Wetland (CCW) is located on the north east boundary of Lot 201 with its buffer zone encroaching onto the Western Power easement. The easement therefore acts as an additional buffer between the proposed development and the wetland.

The form of the northern portion of the development has been guided by the need to retain established trees within POS areas. The trees are proposed to be retained in order to provide vegetation and infrastructure that will block the views of the transmission lines. Retention of established native vegetation is consistent with the draft LBS (ToK, 2007).

The 'Peel Sub N Drain' runs along the south eastern boundary of Lot 201. Surface water flows from the north and east of the LSP area will discharge to the Peel Sub N Drain which discharges to the Peel Main Drain to the west of the Kwinana Freeway.

3 Pre-development Environment

3.1 Sources of Information

The following sources of information were used to provide a broad provide a broad regional environmental context to Lot 27 and Lot 201:

- *The Impact of Residential Urban Areas on Groundwater Quality: Swan Coastal Plain, Western Australia* (Gerritse *et al.*, 1990);
- *National Water Quality Management Strategy* (ANZECC, 2000);
- *Snapshot survey of the Serpentine, Murray and Harvey Catchments of the Peel Harvey Estuary* (MAFRL, 2003);
- *Groundwater Modelling to Assess Effects of Climatic Variations, and Planned Urban Development* (Rockwater, 2006);
- *Modelling Water Level Criteria for the Development of Urban Drainage and Water Management Strategy within the Peel Main Drain Catchment* (URS, 2007);
- *Ecological Water Requirements of Selected Wetlands within the Peel Main Drain Catchment* (Ecoscape, 2007);
- *Regional 1:50 000 Geology Map Sheet* (Gozzard, 1983); and
- *WA Atlas* (Landgate, 2009).

In addition to the above information, site-specific investigations have been conducted. These have aimed at providing more detail to the existing regional information. These site-specific investigations include:

- *Surface and Groundwater Monitoring Sampling and Analysis Plan, First Annual Report* (Cardno BSD, 2005);
- *Surface and Groundwater Monitoring Sampling and Analysis Plan, Second Annual Report* (Cardno BSD, 2007);
- *Wellard East Surface and Groundwater Monitoring Sampling and Analysis Plan, Final Report* (Cardno, 2009b);
- *Preliminary Site Investigation (PSI) Amex Corporation Wellard East* (Cardno, 2008a); and
- *Spring Flora and Vegetation Survey and Wetland Assessment* (Cardno, 2008b).

The above studies have been consulted to determine any potential capacity limitations of local surface water flow paths (i.e. those within the Town of Kwinana) and existing surface and groundwater levels. This is important, as both can have implications for the stormwater management measures and the extent of earthworks that may be required to facilitate subdivision.

3.2 Climate

The Cascade development experiences a dry Mediterranean climate of hot dry summers and cool wet winters. Long term climatic averages indicate that Lot 27 and Lot 201 is located in an area of moderate to high rainfall, receiving 745mm on average annually (BOM, 2009) with the majority of rainfall received between June and August. The region experiences rainfall for 82 days annually (on average), however high evaporation rates and temperatures throughout the summer months drastically reduce flow within the Peel Branch Drain. The drying out of waterways during summer and the flooding of these drainage lines in winter requires careful planning to ensure that development of Lot 27 and Lot 201 does not increase flow or nutrient loads to the Peel Main Drain post development.

3.3 Geotechnical Conditions

3.3.1 Topography

Lot 27 and Lot 201 is generally undulating and slopes gently from an elevation of 21mAHD near the centre of Lot 201 (close to the western border) to an elevation of 9mAHD within the southern portion of Lot 201. Lot 27 slopes inward from a height of 13m to 10m at the Peel Sub N1 Drain (refer to **Section 3.7.1**). Topographic contours of Lot 27 and Lot 201 are shown in **Figure 3**.

3.3.2 Soils

Geomorphologic classification for Lot 27 and Lot 201 reported in *The Perth Metropolitan Region 1:50,000 Environmental Geology Series Rockingham (Part of Sheets 2033 II and 2033 III)* (Gozzard, 1983) indicates that the majority of Lot 27 and Lot 201 consists of Bassendean Sand (212Bs), of Pleistocene origin. A small part of the eastern boundary of Lot 201 is classified as thin Bassendean Sand over Guilford formation. Bassendean Sand is described as very light grey at the surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted and of eolian origin (Gozzard, 1983). The permeability of the Bassendean Sand is classified as high (Gozzard, 1983). The distribution of these soil types throughout Lot 27 and Lot 201 is illustrated in **Figure 4**.

Observations regarding the soil stratigraphy were recorded by JDA Consulting Hydrologists (JDA, 2002) and Cardno BSD (Cardno BSD, 2005) during the installation of groundwater monitoring wells within Lot 27 and Lot 201. Both investigations reported soil profiles consistent with Bassendean Sand soil type, as predicted by the geological mapping. It is therefore considered likely that the superficial groundwater aquifer underlying Lot 27 and Lot 201 exists within an unconfined aquifer. The infiltration capacity of this soil type is generally high.

3.3.3 Acid Sulfate Soils

The *WA Atlas* (Landgate, 2009) Acid Sulfate Soil (ASS) risk mapping classifies the majority of Lot 27 and Lot 201 as a having a 'moderate to low risk of ASS occurring within 3m of the natural soil surface'. A portion of the eastern part of Lot 201 and the north-west region of Lot 27, associated with the adjacent wetlands, is classified as having a 'high to moderate risk of ASS occurring within 3m of the natural soil surface'. However, it is not proposed for these portions of Lot 27 and Lot 201 to be developed. ASS risk mapping is presented within **Figure 5**.

3.4 Wetlands

The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there are two wetlands mapped as part of the dataset within Lot 27 and Lot 201, with a number of other wetlands within the immediate vicinity. The location of the wetlands is presented in **Figure 6**.

The Mortimer Road Wetland 12918 is classified as a 'Conservation Category Wetland' (CCW), which is the highest quality rating of a wetland in this classification system. This wetland is also represented in the EPP wetland data set; however, the boundary of the wetland has not correctly been presented. This is common with the EPP data set and thus the Geomorphic Wetlands of the Swan Coastal Plain dataset should be used in preference for determining the wetland extents.

Wetland 12917 is classified as a 'Resource Enhancement Wetland' (REW). Located adjacent to the Mortimer Road Wetland, the REW resides within a significant portion of Lot 27, but is significantly degraded in regions. The environmental values within REW 12917 do not reflect the attributes and functions expected of a REW and it is more representative of a Multiple Use Wetland (MUW). In June 2010 Cardno submitted an application to the DEC requesting an amendment to the *Geomorphic*

Wetlands of the Swan Coastal Plain dataset. The application is to amend the current REW wetland boundaries to that shown within the Local Structure Plan and **Figure 7**, with the majority of the current REW proposed to be changed to a MUW, with the man-made drain retaining a REW management category. The DEC recently (June 2010) provided preliminary advice to Cardno outlining their support for the proposed amendment to the wetland management category boundaries, with a formal assessment to be completed by September 2010. The supported wetland management category is shown in **Figure 7**.

No development is proposed within 50m of the CCW or within the realigned REW and thus these wetlands will not affect the design of the structure plan. Wetland 12921 is classified as a 'Multiple Use Wetland' (MUW) and is located along existing drain connecting the Mortimer Wetland to the culverts where the Peel Sub N Drain discharges under the freeway.

3.5 Flora

Lot 201 is predominantly cleared apart from a few areas of remnant vegetation and the intrusion of the Mortimer Road CCW along the north-west boundary of Lot 201. An Environmentally Sensitive Area (ESA) is listed in association with the CCW and its 50m buffer zone (see **Figure 6**).

A field survey of Wellard East for lots 201 and 379 was conducted by two botanists on the 7th August, 23rd September and 17th November 2008 (Cardno, 2008b). The survey was conducted in accordance with EPA *Guidance Statement No. 51 – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (2004). Two of the visits were undertaken in spring, which is the optimal flowering period for a majority of flowering plants in the south-west of Western Australia.

A total of 94 taxa (including subspecies and varieties) from 78 genera and 31 families were recorded within Wellard East. Of the 94 taxa, 45 were introduced (exotic) species and an additional five species were planted species that do not usually occur within the area. No Declared Rare Flora (DRF) or Priority Flora (PF) were recorded.

Lot 27 and Lot 201 retains very little remnant vegetation due to historic clearing and subsequent grazing of livestock. Areas that still retain remnant vegetation include the mapped Wetland 12918 and Wetland 12917 and a small portion of vegetation within the southern portion of Lot 201 adjacent to the Kwinana Freeway. Most of Lot 27 and Lot 201 is in a 'Completely Degraded' condition due to historic clearing, high disturbance and weed invasion. Vegetation associated with Wetland 12918 has not been historically cleared and is in a 'Good' to 'Very Good' condition. Remaining patches of native vegetation in the southern portion of Lot 201 are in a 'Degraded' condition.

3.6 Fauna

Detailed fauna survey work has not been undertaken for Lot 27 and Lot 201. Given that 'Good' to 'Very Good' condition vegetation exists within the ESA portion of Lot 27 and Lot 201, potential habitat is available for native fauna. However, as no development is proposed within the potential fauna habitat area, no further fauna studies are considered necessary at this stage.

3.7 Hydrology

A LWMS requires a good understanding of the quantity and quality of the surface and subsurface water across the proposed development. A sound understanding of the constraints and opportunities enables management strategies to be determined.

The groundwater levels across Lot 27 and Lot 201 are required to determine the optimal post-development land use, e.g. areas of shallow water table are more suitable for POS than for dwellings or infiltration Flood Storage Areas (FSA). The quality of the groundwater leaving Lot 27 and Lot 201 will affect the environmental health of the surface water body it drains into, as does the quality of the surface runoff. Understanding the quality of this water is the first step to managing discharges to acceptable water quality standards.

The quantity of the surface runoff is the most visually obvious constraint to management, yet it should be considered equally as important as the groundwater quantity and quality, and surface water quality. The management of surface runoff is important to protect areas from flooding and from potential erosion.

3.7.1 Surface Water Quantity

Surface runoff is estimated using accurate data on topography, infiltration rates, vegetation and existing surface channels. This information is used in a hydraulic and hydrologic model to calculate discharges, volume of runoff and flow paths. A site specific pre-development model (XPSWMM) was created to provide a basis from which a comparison with the post-development peak discharges and volumes can be made. The XPSWMM model was calibrated to the regional stormwater model developed in InfoWorks CS by the Water Corporation for the JDWMP.

3.7.1.1 Existing Drainage Network

There no local drains within Lot 201. All runoff from Lot 27 and Lot 201 will be via sheet flow to the major Water Corporation Drains. The Peel Sub N1 Drain conveys runoff from upstream catchments (North of Mortimer Road) through Lot 27 and into the Mortimer Wetland. Runoff from the northern portion of Lot 201 will flow via sheet flow into the wetland. The Mortimer Wetland provides detention storage, slowing the flows before discharging in a south west direction into the Peel Sub N Drain. Approximately 200m south of this location, the Peel Sub N2 drain joins the Peel Sub N1 Drain to form the Peel Sub N Drain. The Peel Sub N Drain is a steep sided trapezoid drain approximately 1m deep and 4m wide. This drain joins the Peel Sub N1A drain at the 2x1050 pipe culverts under Kwinana Freeway. The flow that passes through these culverts is conveyed approximately 200m and joins the Peel Main Drain. The hydrological features are shown in **Figure 8**.

3.7.1.2 Pre-development Sub-catchments

The pre-development model is based on the Water Corporation's InfoWorks CS model presented in the *Draft Jandakot Structure Plan Area Drainage and Water Management Plan* (DoW, 2008a). The sub-catchments from the InfoWorks CS model were adopted in the pre-development XPSWMM model, which was in turn used to model the post-development environment (see **Section 7**). This provides a basis for a direct comparison of results for the two models, and a validation of the use of the XPSWMM model against the broader regional Water Corporation model. Lots 27 and 201 are divided into three sub-catchments: Catchment N3A, Catchment N6 and CatchmentN6A. The latter two sub-catchments drain to the Mortimer wetland in the north east, while Catchment N3a drains directly into the Peel Sub N Drain to the south east. The pre-development sub-catchments are shown in **Figure 8**.

3.7.1.3 Pre-development Modelling Parameters

An 'initial loss - proportional loss' infiltration model was adopted to generate stormwater runoff hydrographs in the hydraulic and hydrological model XPSWMM. This approach is consistent with the methodology employed by the Water Corporation in modelling for the JDWMP. The loss values were selected based on Cardno's experience with similar soil types and catchments and calibrated to

ensure the InfoWorks CS and XPSWMM models produced consistent results. The infiltration rates for the different soil and land types are presented in **Appendix B**.

3.7.1.4 Pre-development Modelling Results

Results provided by the Water Corporation from the modelling process indicated the critical 10 year and 100 year ARI storm events were 24 hours in duration each. The XPSWMM model was run for the 1 year, 5 year, 10 year and 100 year events. The InfoWorks CS input flows from Peel Sub N1 and Peel Sub N1A drains were included in the XPSWMM model to ensure a direct comparison can be made with the results from the InfoWorks CS model. A comparison of results for the 10 year and 100 year ARI events from the InfoWorks CS and XPSWMM models within the culvert underneath the Kwinana Freeway is shown in **Table 3.7.1.a**.

Table 3.7.1.a Comparison of Pre-Development Discharge Flow Rates

Model	Peak Discharge Exiting Site (m^3/s)		Average Discharge per Unit Area ($m^3/s/ha$)	
	10 year ARI	100 year ARI	10 year ARI	100 year ARI
InfoWorks CS Model	0.75	1.07	72.89	104.00
XPSWMM Model	0.60	0.93	58.22	90.59

Due to the conservative approach incorporated into the Water Corporation modelling, the XPSWMM model results are slightly lower but not significantly different than the Water Corporation results. With a more detailed modelling approach, the XPSWMM model results are considered appropriately calibrated and suitable for use in the post-development scenario as they are within an acceptable range of comparison with the regional modelling results. The pre-development peak discharges from the XPSWMM catchments are shown in **Table 3.7.1.b**.

Table 3.7.1.b XPSWMM Pre-Development Peak Discharge

XPSWMM Catchments	Peak Discharge (m^3/s)		
	5 year ARI	10 year ARI	100 year ARI
1	0.012	0.014	0.021
3	0.026	0.031	0.051
5	0.048	0.058	0.082

3.7.2 Surface Water Quality

Surface water quality monitoring was undertaken at seven locations across the greater Wellard area. Two of those monitoring locations were located on the boundary of Lot 201 (see **Figure 9**). The upstream location was positioned at the junction of the Peel Sub N1 and Peel Sub N2 drains (the upstream location of the Peel Sub N Drain, immediately south of Mortimer wetland – referred to as PBD1) and at the downstream location of the Peel Sub N Drain at the southern corner of Lot 201 (referred to as PBD3). Monitoring was only conducted when surface water was seen to be present and flowing (water that was considered stagnant and not flowing were not sampled). The majority of sampling was conducted between June and October over a period of three winters although flowing surface water was not observed within all of the months.

Results from PBD1 indicates 'low' TN, NO_X, NH_4, TP and ORP concentrations that were generally slightly above or below the ANZECC (2000) default trigger values. Concentrations recorded downstream at PBD3 indicated 'low' to 'moderate' NO_X, TN and NH_4 values while TP and ORP

concentrations ranged from 'moderate' to 'high' indicating concentrations up to and greater than five times the default values.

As the surface water only flowed during the late winter/spring months when groundwater levels were at their highest and the catchment was saturated, surface water was therefore considered to be an expression of groundwater rather than a direct response to rainfall. Results from the surface water quality monitoring are contained in **Appendix C**.

3.7.3 Groundwater Levels

Site specific groundwater contours were developed by Cardno during a three year investigation into underlying groundwater conditions, which concluded in November 2008. Groundwater depths were recorded by Cardno from the gauging of 10 shallow groundwater monitoring bores, three of which were initially installed by JDA Consultant Hydrologists in 2002, as part of a separate groundwater level investigation. Seven groundwater monitoring bores were located within the Cascade development as seen in **Figure 9**. Hydrographs from the three years of monitoring conducted by Cardno are contained in **Appendix C** and further information concerning groundwater level monitoring can be found within the three annual monitoring reports (Cardno BSD, 2005; Cardno BSD, 2007; Cardno, 2009b).

Groundwater elevations recorded by Cardno ranged from approximately 11.5mAHD in the north of Lot 201 to approximately 8mAHD in the south (Cardno, 2009b). Depth to groundwater ranged from less than 1.2m below ground surface (BGS) in the south west region of Lot 201 to 9mBGS in the north west of Lot 201. The depth to groundwater for the majority of Lot 27 is also less than 1.2mBGS.

The measured data from within Lot 27 and Lot 201 was referenced to the long term DoW monitoring Bore 3057, to determine the long term Annual Average Maximum Groundwater Level (AAMGL) and Maximum Groundwater Level (MGL) specifically for Lot 27 and Lot 201. The referenced MGL levels for Lot 27 and Lot 201 were approximately 0.7m above the AAMGL. The referenced AAMGL contours are presented in **Figure 9** with the depth to groundwater shown in **Figure 10**.

3.7.4 Groundwater Quality

Groundwater quality was measured at the 10 shallow and one deep bore across Lot 27, Lot 201 and lot 379 on a quarterly basis for a period of two years. The groundwater quality monitoring results are summarised in the following paragraphs. It should be noted that nutrient concentrations have been compared to default trigger values from the *National Water Quality Management Strategy* (ANZECC, 2000), which are intended for surface water. Therefore, where there are apparent exceedences of these levels this is not necessarily a cause for concern; rather it provides an indication of the relative concentrations of nutrients across Lot 27 and Lot 201.

In situ field chemistry parameters were measured and these indicated groundwater conditions were slightly to moderately acidic. Electrical conductivity (EC) values were generally of a similar magnitude across Lot 27 and Lot 201 with little variation between monitoring events. The exception to this were two bores located to the south, within Lot 379, that recorded EC values significantly greater than the other bores and exhibited a wider variation of readings throughout the monitoring events.

The majority of measured groundwater TN concentrations across Lot 27 and lot 201 were 'low' to 'moderate'. Several bores reported 'high' or 'very high' concentrations at times throughout the year. Given the inferred groundwater flow direction, the TN distribution of Lot 27 and Lot 201 suggests that a nutrient source upstream of the northern border of Lot 27 and Lot 201 may be contributing to elevated nutrient concentrations within Lot 27 and Lot 201. The TN distribution indicates that there are elevated nutrient concentrations in the southern portion of Lot 201 that may have resulted from

within or immediately to the east of Lot 27 and Lot 201. The biologically available component of the TN concentrations were higher than would be expected for a slightly disturbed ecosystem, as many bores reported 'high' or 'very high' mono-nitrogen oxides (NO_X) or ammonium (NH_4) concentrations. Average TN concentrations for the greater Wellard area are shown in **Figure 11**.

TP concentrations across Lot 27 and Lot 201 often exceeded the respective default trigger value by more than the TN concentrations. Bores which reported 'high' or 'very high' TP concentrations were, in the main, located in the southern and less elevated region of Lot 201. This distribution of elevated TP concentrations was consistent throughout the two years of groundwater quality monitoring. Given the calculated groundwater flow direction underlying Lot 27 and Lot 201 and surface water flow direction within Peel Sub N2 Drain, the TP distribution suggests the elevated TP concentrations over the southern portion of Lot 201 may have resulted from an existing phosphorous source within or immediately to the east of Lot 27 and Lot 201. The TP concentrations are largely biologically unavailable with only five bores, all located in the southern part of Lot 201 and Lot 379, reporting 'high' or 'very high' oxidation reduction potential (ORP) concentrations. Average TP concentrations for the greater Wellard area are shown in **Figure 12**.

The migration of nutrients through the aquifer can be inferred through comparison between shallow and deep bore nutrient concentrations. TN concentrations at the deep bore locations were in the order of 50% lower than at the equivalent shallow bore location. TP concentrations at location WE2 were higher within the deep bore than the shallow bore. From this it can be inferred that there may be some interaction between the shallow and deep parts of the superficial aquifer. The comparison of nutrients between the deep and shallow portions of the aquifer is similar to that observed during the first year of monitoring. It is likely, given the geology of Lot 27 and Lot 201, that nutrient migration through the aquifer is primarily horizontal; with low vertical migration resulting in the lower TN concentrations observed in the deeper parts of the aquifer. Results from the groundwater quality monitoring are shown in **Appendix C**.

3.8 Current and Historical Land Uses

The development site has been cleared and used for rural agricultural purposes. There are no existing buildings on Lot 201. A Western Power easement traverses the site along the east side of Lot 201 (see **Figure 2**). No significant development is proposed within this easement and it therefore provides an additional buffer between the Mortimer Wetland and the development of Lot 27 and Lot 201.

3.9 Ethnographic Considerations

The DWMS reports that a search of the Department of Indigenous Affairs Register of Known Sites of Significance (DIA, 2007) was conducted and this indicated that there are no known sites of significance recorded within Lot 27 and Lot 201.

3.10 Summary of Existing Environment

In summary, the environmental investigations conducted to date indicate that:

- Lot 27 and Lot 201 receives 745mm of average annual rainfall with the majority of rainfall received between June and August;
- Lot 201 ranges from 21mAHD to 9mAHD in elevation, with a generally southerly aspect;
- The soil types encountered during investigations were consistent with Bassendean Sand soil types;

- ASS risk maps suggest that the proposed development area of Lot 201 has been classified as having a moderate to low risk of encountering ASS to depths of 3mBGS. A portion of Lot 27 is classified as having a moderate to high risk of encountering ASS to depths of 3mBGS;
- The Peel Sub N Drain borders the south east boundary of Lot 201;
- The long sections provided in the JDWMP provide peak flows for both the 10 year and 100 year ARI events at the discharge point of the Peel Sub N Drain of 0.75m^3/s and 1.07m^3/s respectively;
- Modelling conducted using XPSWMM resulted in peak discharges from the Peel Sub N Drain of 0.60m^3/s and 0.93m^3/s for the 10 and 100 year ARI events respectively;
- Surface water quality indicates that existing conditions exceed relevant default trigger values;
- Surface water flow is considered to be an expression of the groundwater;
- Groundwater underlying Lot 27 and Lot 201 flows in a south to south easterly direction;
- Groundwater levels underlying Lot 27 and Lot 201 range between 7.5mBGS to less than 1.2mBGS. The depth to groundwater is less than 1.2m for the majority of the Lot 27 and the south west portion of the Lot 201;
- Groundwater quality underlying the majority of Lot 27 and Lot 201 has 'moderate' to 'high' nutrient concentrations;
- The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there is a CCW within the site boundary to the north east of Lot 201, a REW across Lot 27 and a MUW within Lot 201 to the south east;
- No portion of the proposed development area of Lot 27 and Lot 201 is classified as an Environmentally Sensitive Area (ESA);
- Lot 27 and Lot 201 has historically been used for rural agricultural purposes; and
- There are no known sites of Aboriginal Heritage significance recorded within Lot 27 and Lot 201.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this LWMS and future UWMPs must achieve. The objectives and design criteria are both general water management philosophies that reflect state-wide principles and are site specific, taking into account the local environment. The water management strategy covers all aspects of water use, including stormwater management, groundwater management and water consumption.

4.1 Total Water Cycle Management

The *State Water Strategy* (Government of WA, 2003) endorses the promotion of total water cycle management and application of WSUD principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies.

Total water cycle management recognises the finite limit to a region's water resources, and the inter-relationships between the uses of water and its role in the natural environment.

Key principles of total water cycle management include:

- Considering all water sources, including wastewater, stormwater and groundwater;
- Using all water sources sustainable;
- Allocating and using water equitably; and
- Integrating water use with natural water processes, including maintaining environmental flows and water quality.

Total water cycle management therefore addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Stormwater management design objectives should therefore seek to deliver better outcomes in terms of:

- Potable water consumption.
- Stormwater quality management.
- Shallow groundwater management.
- Flood mitigation.

A fundamental first step in applying total water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines and site specific studies undertaken in and around the Lot 27 and Lot 201 development. These were detailed in **Sections 1.3** and **3.1**.

The overall objective for preparing total water cycle management plans for proposed residential developments is to minimise pollution and maintain an appropriate water balance. This objective is central to the Lot 27 and Lot 201 LWMS.

4.2 Water Conservation

It is widely thought that the local climate is undergoing a drying trend, and that as Perth's population grows and demands for potable water sources increase, significant attention should be focused on the manner in which the resources currently available are utilised. This consideration is acknowledged and the use of water within the development will be minimised wherever possible. The water conservation design criteria have been determined and presented in the JDWMP and DWMS; these design criteria are:

- Ensure the efficient use of all water resources in newly developing urban form;
- Use water more efficiently; and
- Consumption target for potable water of 100kL/person/year for residential areas.

In addition, the development will aim to mimic the natural environment and will minimise the net use of water, by maximising surface aquifer recharge. The manner in which these objectives will be achieved is further detailed in **Section 5**.

4.3 Groundwater Management

Through the guidance documents of the Wellard East DWMS and JDWMP, the design objectives for groundwater management that will be adopted for this LWMS within Lot 27 and Lot 201 are as follows:

- Lots should have a clearance to the referenced AAMGL of at least 1.2m. Where the AAMGL is at or within 1.2m of the surface, the importation of clean fill and/or the provision of subsoil drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved;
- The site specific CGL will be set at the referenced AAMGL;
- The bio-retention system, FSA and drainage inverts (including subsoil drains) are set at or above the site specific CGL (which equals the referenced AAMGL) although existing inverts below the referenced CGL may remain (e.g. Peel Sub N1 Drain);
- The clean fill imported onto Lot 27 and Lot 201 for bio-retention areas is to incorporate a band of material that will reduce phosphorus export via soil leaching, while also meeting soil permeability and soil compaction criteria specified by the local government authority;
- Avoid intersection with groundwater;
- Where development is associated with an ecosystem that is dependent on a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of the Department of Environment and Conservation.

Where subsoil drainage is proposed to be used, the following groundwater design criteria are to be set:

- Subsoil drainage is to be installed at or above the referenced CGL;
- Sufficient fill should be provided such that a clearance of 1.2m is achieved between the phreatic surface and the finished lot level; and
- Subsoil drainage must be designed with free-draining outlets.

Where development is associated with a waterway or open drain that intersects the shallow water table and may discharge pollutants from the shallow groundwater to receiving environments, and a computer quality modelling program is used, the following interim targets will be adopted until such time as appropriate site-specific targets are developed:

- As compared with a development that does not actively manage water quality, it must achieve:
  - At least 60% reduction of total phosphorous; and
  - At least 45% reduction of total nitrogen.

4.4 Surface Water Management

The overall guiding document for development of stormwater management strategies within urban areas is the *Stormwater Management Manual for Western Australia* (DoW, 2007); with the *Decision Process for Stormwater Management in WA* (DoW, 2009) providing guidance as to how urban developments can achieve compliance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for WA*.

4.4.1 Stormwater Quantity

Through the guiding documents and those presented in the DWMS and JDWMP, stormwater management design criteria for Lot 27 and Lot 201 include:

- Retain the 1 year - 1 hour duration ARI rainfall event at source or as close as practicable (this is primarily a stormwater quality criteria but will assist in achieving the stormwater design objectives);
- The post-development critical 5 year and 100 year ARI peak flows and volumes shall be generally consistent with the pre-development environment at the discharge points of all subdivisions into waterways and at the discharge points from each sub-catchment;
- Design the pipe network based on the 5 year ARI rainfall event;
- Minor Roads should remain passable in the 5 year ARI event;
- Ensure that the 100 year ARI rainfall event conveyance can be contained within road reserves;
- Defined major arterial roads should remain passable in the 100 year ARI event;
- Development areas along the Peel Sub N2 Drain will have a finished floor level with a minimum of 0.5m clearance above the 100 year flood level described in the JDWMP; and
- FSAs should operate as dry basins with a minimum clearance of 0.3m between the AAMGL and the invert of the FSA.

4.4.2 Stormwater Quality

Better Urban Water Management (WAPC, 2008a) advocates a water quality management approach that establishes pre-development water quality standards and then sets targets for post-development scenarios that reflect the pre-development water quality parameters. The stated principle is that existing surface and groundwater quality should be maintained as a minimum, and preferably improved prior to discharge from the development area.

Better Urban Water Management (WAPC, 2008a) indicates that if the pollutant outputs of the development could exceed catchment ambient conditions, and that if ambient conditions have not been determined, water quality targets should be derived from the water quality guidelines contained in the *National Water Quality Management Strategy* (ANZEC, 2000). Therefore, water quality targets have been derived from the *National Water Quality Management Strategy* and in consideration of the measured levels provided in **Section 3.7.2** and the groundwater and surface water annual monitoring reports (Cardno BSD, 2005; Cardno BSD, 2007; Cardno, 2009b).

Better Urban Water Management (WAPC, 2008a) recommends that where pre-development water quality data is not available and "If it is proposed to use a computer stormwater modelling tool to demonstrate compliance with design objectives, the following design modelling parameters are recommended (as compared to a development that does not actively manage stormwater quality):

- At least 80% reduction of Total Suspended Solids (TSS);
- At least 60% reduction of Total Phosphorous (TP);
- At least 45% reduction of Total Nitrogen (TN); and
- At least 70% reduction in gross pollutants" (WAPC, 2008a).

An alternative design criterion is for bio-retention areas to be sized at 2% of the connected impervious area.

The design criteria that will be adopted to ensure that the above objectives are met will include:

- Retaining the 1 year - 1 hour duration ARI rainfall event onsite as close to source as practicably possible; and
- Apply appropriate structural and non-structural measures to reduce applied nutrient loads.

In addition to those already proposed, the Lot 27 and Lot 201 LWMS proposes the following further criteria for design of retention/infiltration FSAs:

- Bio-pockets will have a maximum water depth no greater than approximately 0.3m; and
- There must be a minimum depth of 0.3m of high infiltration sand under the FSA to encourage infiltration. Where possible this should have an appropriate Phosphorus Retention Index (PRI)

5 Water Source Allocation, Infrastructure and Fit for Purpose

5.1 Water Conservation Strategy

Water is a valuable resource that must be managed sustainably. Conservation of water through fit-for-purpose use and best management practices is encouraged so that water is not wasted. The term fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water. Fit-for-purpose principles have been utilised in the water conservation strategy for the Wellard East development

The development of Lot 27 and Lot 201 will utilise Rainwater Tanks, Groundwater for POS irrigation, Water Efficient Gardens (WEG) and Water Efficient Appliances (WEA) to ensure that the development uses water conservatively. Details of these measures are further discussed in **Section 5.2**.

A water balance study was conducted to determine the effectiveness of the water conservation strategy when compared to a standard development without a water conservation strategy. Thus the strategies presented in the water balance (**Section 5.3**) are:

- Option 1 – Business as Usual (BAU).
- Option 2 – Rainwater Tanks, Groundwater, Water Efficient Gardens and Water Efficient Appliances.

The water conservation objectives stated in **Section 4.2** will be further achieved in the Lot 27 and Lot 201 development by:

- Minimising the water requirements for establishment of POS. This will be achieved by retaining native vegetation where possible. This will provide shade, reduce water requirements during POS establishment and will assist in providing buffers for waterways. Native plants should be used in landscaping as well as soil conditioning and mulching to reduce water use and loss. Turfed areas require large quantities of water and therefore these areas should be minimised wherever possible;
- Increasing community awareness of water conservation. This will be achieved by promoting waterwise practices, fixtures and fittings at the point of sale;
- Minimise water requirements for POS maintenance. This will be achieved by implementing an appropriate management and maintenance program for POS areas. This will be further detailed at the UWMP stage; and
- Minimise net use of water by maximising surface aquifer recharge. Recharging the groundwater through infiltration of stormwater could minimise potential drawdown of the aquifers where these are used during dry periods. Methods to increase infiltration include; infiltration basins, swales, bio-pockets, tree-pits, subsurface storage basins, soakwells and reducing impervious areas (e.g. by using porous pavement). Treatment trains will be employed to encourage infiltration, which ensure the water quality of the groundwater is not reduced.

5.2 Water Conservation Measures

5.2.1 Rainwater Tanks

Collection of runoff from roof surfaces can be undertaken, with this water stored within rainwater tanks for later use. This water is of high quality; however, in urban environments it is advised that this water

is considered non-potable. In Perth, 90% of the rainfall occurs in the seven month period from April to October. The remainder of the year has little rainfall but collection is still possible. Therefore stored rainwater will be used for irrigation but will need to be supplemented with scheme water during the lower rainfall months. During the higher rainfall months, the majority of the stored rainwater will be used to supplement internal building non-potable uses. The water efficiency strategy recommends that the rainwater is used in washing machines, toilets and hot water systems.

The use of rainwater tanks can be mandated by the local council through the building licence. Information can also be provided to the lot purchaser by the developer at point-of-sale. It is proposed that all lots have at least a 3kL rainwater tank.

5.2.2 Water Efficient Appliances

Significant reduction in in-house water uses can be achieved with the use of water efficient appliances. The following **Table 5.2** gives an example of the water uses of typical appliances verses water efficient appliances. These water use rates have been used in the water balance investigation.

Table 5.2 Water Efficient Appliances

Appliance	Water use	
	Standard Device	Water Saving Device
Toilet	12 Litres/Flush	4 Litres/Flush
Washing Machine	130 Litres/Wash	40 Litres/Wash
Shower Head	15-25 Litres/Minute	6-7 Litres/Minute
Taps	15-18 Litres/Minute	5-6 Litres/Minute

(Australian Government, 2009 & Melbourne Water, 2008)

The water conservation strategy proposes that all dwellings use water efficient appliances. This can be encouraged by state and local government rebates, as well as education and additional incentives from the developers.

5.2.3 Water Efficient Gardens

Studies by the Water Corporation (WC, 2003) have found that for a typical dwelling, 56% of the water consumed by the lot is used on the gardens. Therefore, reductions in water irrigation by employing water efficiency measures can significantly reduce the total water usage of the lot. The following water efficiency measures should be used on lot gardens:

- Where required, soil shall be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted and a minimum depth of 300mm for garden beds (for entry statement only);
- The irrigation system shall be designed and installed according to best water efficient practices. The controller must be able to irrigate different zones with different irrigation rates. Emitters must disperse coarse droplets or be subterranean;
- Installing adequate irrigation control systems to ensure that water can be applied selectively;
- Utilise subsoil irrigation where appropriate;
- Limiting the amount of turfed areas;
- The turf species used should be a genotype endorsed by the UWA Turf Industries Research Steering Committee (e.g. Couch grass – *Cynodon dactylon*); and
- Garden beds to be mulched to 75mm with a product certified to Australian Standard AS4454.

Water conservation can also be reduced on a development scale within POS areas. As well as using the lot scale garden measures on POS gardens, the following additions measures should be utilised:

- Retention of remnant native trees within POS areas where possible. This will reduce demands for water during establishment of POS areas;
- Minimise the proportion of turfed areas within the POS;
- Provision of some smaller lot sizes that will require less landscaping;
- Turf species will be low water and nutrient requiring;
- Entry statements should include a 1:1 mix of hardstand areas to turfed areas and garden beds.
- The adoption of Xeriscaped POS gardens, where garden beds within POS and community areas are landscaped using 'waterwise plants', which are local native species from regions with similar climates that require less water inputs than exotic species; and
- Managing irrigation practises within POS areas to minimise losses to evaporation (e.g. amount applied is not excessive, timing irrigation to avoid wastage, etc.).

5.2.4 Groundwater

Non-potable groundwater can be used for irrigation of POS areas. Turfed areas require 7,500kL/ha/year; therefore the 4.22ha of unrestricted POS would require a maximum of 32ML a year. This provides a conservative estimate of the water required for the POS area, a more precise calculation of the water required can be produced at UWMP once the POS landscape design is complete and the proportion of the POS turfed is calculated.

The DoW advised on the 11th of February 2010 that Lot 27 and Lot 201 is within the Serpentine Groundwater Area, subarea of the Jandakot Mound 2. This aquifer was (on the date of contact) 61% allocated with 744ML available for new licences. Of this amount, there was 427ML of new licences being processed. There is still however at least 316ML still available and not being assessed for new licences. The required conservative amount of 32ML/year for irrigation of the POS can be potentially supplied from the underlying aquifer. This water source should be secured through a licence with the DoW prior to completing the UWMP.

5.2.5 Waste Water Reuse

Waste water can be recycled and used as potable or non-potable water (depending on the quality of the treatment). However, the costs involved can be significant and are not justified for developments such as Lot 27 and Lot 201 that are within the metropolitan area and are thus close to existing sewerage infrastructure. Therefore, waste water reuse is not recommended for this development.

5.2.6 Grey Water Reuse

Grey water can be described as all the waste water use in the home besides the water from toilets (and potentially kitchens). This water has moderate concentrations of solids and nutrients. Grey water can be used for subsoil irrigation and in some other non-potable water uses. However, there is the potential of nutrient leaching if the water is used for irrigation. If there are nearby surface water bodies, these could potentially be contaminated with the nutrients from the grey water. Within the vicinity of Lot 27 and Lot 201, there are numerous wetlands systems including the Mortimer CCW, Serpentine River and Peel-Harvey Estuary. For this reason, it is not recommended that grey water be used on a development scale to conserve water.

5.3 Water Balance

The water balance analysis has been based on the rates and calculation methodology presented in the Water Corporation Spreadsheet *AltWaterSupply_Water_Use_Model.xls*. This spreadsheet has been adapted to model the effects of using water efficient appliances and gardens. The water balance analysis has assumed that there would be on average 2.9 people per dwelling. This value has been calculated from data provided by Australian Bureau of Statistics for new housing

developments in Perth (ABS, 2007). The water balance has also been calculated for the various lot densities and contemporary dwelling sizes. These contemporary lots typically have smaller garden areas when compared to traditional lots and therefore the lot water consumption rates (due to garden watering) are lower than those reported for traditional lots (WC, 2003).

The lot scale water consumption for the two water conservation strategies is presented in **Table 5.3.a**.

Table 5.3.a Total Development Lot Water Consumption

	Option 1 BAU	Option 2 Rainwater Tanks, Groundwater, WEG and WEA
Total Scheme Water Required (ML/year)	127.6	68.1
Scheme Water Required per Capita (kL/year/person)	132.9	70.95

The results of the water balance indicate that on average in the development, a dwelling not using any water conservation strategies will exceed the 100kL/year/person water consumption target. If all the dwellings in the development use rainwater tanks, water efficient gardens and water efficient appliances (groundwater is used for irrigation of POS and thus does not reduce the lot scale water consumption), then the dwelling will use on average 70.95kL/year/person. This achieves the state water consumption target of no more than 100kL/year/person.

The development has 4.22ha of unrestricted POS area. It is conservatively assumed at the LWMS stage that all of this area will be turfed. Therefore this area would require approximately 32ML/year of water for irrigation. This water will be supplied with non-potable groundwater (**Section 5.2.4**) to reduce the scheme water required for the development. A comparison of the total scheme water required by the development for the BAU and Water Conservation Strategy Option 2 are presented in **Table 5.3.b**.

Table 5.3.b Development Scheme Water Required

	Option 1 Standard	Option 2 Rainwater Tanks, Groundwater, WEG and WEA
Total Development Scheme Water Required (ML/year)	159.2	68.1

The above **Table 5.3.b** shows that the Water Conservation Strategy Option 2 can reduce the total water consumed within Lot 27 and Lot 201 by one third, when compared to a development with no water conservation strategy.

5.4 Wastewater Management

The wastewater generated from the Cascade development will be managed by connecting the entire development to deep sewer.

6 Groundwater Management Strategy

The principle behind the groundwater management strategy is to maintain the existing groundwater hydrology. The treatment and infiltration of stormwater runoff will ensure groundwater conditions remain unaffected post-development. The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4.3**.

6.1 Groundwater Level Management

The primary objective for groundwater level management is to ensure the final lot levels are at least 1.2m above the AAMGL (see **Section 4.3**). As shown in **Figure 10**, the clearance to the referenced AAMGL is greater than 1.2m across the majority of the site. The CGLs presented in the JDWMP (DoW, 2010) are generally consistent with the referenced AAMGLs across the site, though the CGL is slightly above the AAMGL in some places.

The control of groundwater by subsoil drainage is not likely to be necessary across the majority of the study area due to a clearance of 1.2m form the AAMGL. Subsoil drainage may be required within the Lot 27 and the southern portion of Lot 201. The subsoils will be positioned at the AAMGL and will be used in protection of a rise in groundwater beyond the annual peak levels rather than lowering the groundwater table.

Should sand fill be required for anywhere in Lot 27 and Lot 201 (after the final earthworks strategy has been undertaken), this could potentially be sourced from within Lot 201. Lot 201 is elevated and has up to 8m clearance to the measured and referenced AAMGL. The soil mapping and bore logs indicate that the soil is Bassendean Sand and thus potentially suitable for sand fill. The final earthworks levels for Lot 27 and Lot 201 must be determined and presented at UWMP stage.

While design criteria for subsoil drainage are proposed in **Section 4.3**, it is not anticipated that subsoil drainage will be required for the Lot 27 and Lot 201 development as the soils are sandy and will have high infiltration, and there is adequate clearance to groundwater. Stormwater will be encouraged to infiltrate at source wherever practicably possible to be consistent with the existing hydrological regime. A concept design showing the potential alignment of subsoil drains (should these be required) is shown in **Appendix D**. The subsoils will have free draining outlets which will discharge into a vegetated rock pitched area. Additional filter media is not proposed as the water draining from the subsoils will either be groundwater peak levels or stormwater that has previously been infiltrated through bio-pockets, tree pits, swales or FSAs and hence will not require additional treatment.

6.2 Groundwater Quality Management

The main objective of the management of the groundwater quality is to maintain or improve the existing groundwater quality. This can be achieved by reducing the total nutrient load into the groundwater that originates from the development and by improving the groundwater via treatment of the surface runoff prior to infiltrating to the groundwater.

The reduction of nutrient load to the groundwater should be achieved in the development by:

- Minimising the use of fertilisers to establish and maintain vegetation within POS areas and road verges;
- Selection of drought tolerant turf species that require minimal water and nutrients;
- Use of roll-on turf within the POS areas and road verges, to prevent the high nutrient input requirement during establishment of the turf;

- Direct stormwater to vegetated (with native wetland species) treatment areas including tree-pits, swales and bio-pockets. These treatment areas will improve the quality of the water prior to it infiltrating into the underlying groundwater; and
- Garden beds should not be immediately adjacent to the infiltration FSA /swales or bio-pockets to reduce nutrient transportation into these infiltration areas.

7 Stormwater Management Strategy

Surface water runoff will be managed both on a development scale and at a lot scale. The principles behind the stormwater management strategy are to maintain the existing hydrology by retaining or detaining surface flows and to infiltrate the stormwater runoff as close to source as possible. The development drainage system has been designed to achieve the objectives and criteria stated in **Section 4.4**.

7.1 Development Drainage System

The storm water runoff from the 1 year - 1 hour ARI rainfall event will be retained as close to source as practicably possible; only rainfall events greater than this event will discharge from Lot 27 and Lot 201, as is consistent with the pre-development environment and the design criteria (see **Section 4.4**). The retention storage will be provided through treatment trains including bio-pockets, tree-pits, subsurface storage basins, swales and vegetated retention areas. The vegetation and the infiltration process within the soil column will remove a large portion of the contaminants (nutrients, gross pollutants, suspended sediments, etc) within the stormwater runoff. Rainfall events greater than the 1 year - 1 hour ARI event will be conveyed by overland flow or pipe network to a FSA. The FSA will detain the large event runoff so that the peak discharge is comparable to the pre-development discharge rate. The size of the detention storage will be minimized due to the retention storage provided higher up in the catchment. All discharge from the FSA will be directed towards the existing Peel Sub N Drain. The stormwater drainage system for the development (including nominal locations for swales, bio-pockets, tree-pits and FSAs) is provided within **Figure 13**.

7.1.1 Tree-Pits

It is proposed to use tree-pits on suitable roads to assist in treating runoff prior to discharge into subsurface storage devices or alternative retention measures. Tree-pits will be located within the verge, on the boundary of two lots or central to lots to minimise the interference with lot driveways and landscaping (see **Appendix B** for additional assumptions). Runoff from the road will be directed to the tree-pits and the stormwater will infiltrate through the Tree-pit to an offline subsurface storage (e.g. Stormtech Cells). The stormwater will be retained within this storage and slowly infiltrated into the soil and ultimately the underlying groundwater. The storage of the tree-pits and subsurface storage will retain the 1 year - 1 hour event from the contributing catchment where possible. For runoff events exceeding the capacity of the tree-pits and subsurface storage, the excess runoff will be conveyed by overland flow and/or pipe network to an alternative retention or detention area. The feasibility of incorporating tree-pits within the treatment train is subject to further investigation with details to be provided within the UWMP.

7.1.2 Swales

Swales provide both conveyance of stormwater and retention/detention storage. It is proposed to utilise swales alongside the road adjacent to POS areas. Stormwater will be directed into the swale via flush kerbing or the concrete pipe network. The swales will be approximately 0.3m deep and 4m wide (detailed designs to be finalised at UWMP). The swale will provide a large surface area for the stormwater to infiltrate into the underlying sandy soil (high infiltration rate will be achieved due to the large separation distance to groundwater and the highly permeable sand soils). This swale will ensure that the 1 year - 1 hour rainfall event is retained at or near source. For larger rainfall events, runoff will be diverted to FSAs. A conveyance swale will be positioned perpendicular to the Western Power easement to convey runoff from Sub-catchment 5 to the FSA for major event storage.

7.1.3 Bio-pockets

Stormwater can be retained in vegetated 'bio-pockets' within selected verges. The location of bio-pockets is optimally suited to the side of corner lots so that they do not interfere with driveways, services and lot landscaping. The bio-pockets were assumed to have a depth of 0.3m and contain amended soil with a high Phosphorous Retention Index (PRI).

7.1.4 Flood Storage Areas

FSAs are utilised to detain major event flows in order to maintain post-development peak flows and volumes to pre-development conditions. Unlike a wetland, FSAs are not designed to be permanently wet. Discharge from these areas would be via a controlled outlet (weir or similar) to the Peel Sub N Drain. This would be done at a rate that approximates the pre-development environment. At the same time the stormwater will infiltrate into the soil (the rate of infiltration is dependent on the design criteria).

7.2 Lot Drainage System

Rainfall on the front and backyards of lots (garden areas) will either infiltrate directly at-source or, in large rainfall events (i.e. 5 year), a portion of the runoff may discharge to the road network. The runoff from roof areas will be directed to rainwater tanks with excess runoff to soakwells, which will infiltrate into the sandy soil and ultimately the groundwater. A nominal soakwell of 1.5m x 1.5m (diameter x height) and 3kL rainwater tank with a low flow discharge outlet to ensure 1,500L storage capacity have been proposed for the Lot 27 and Lot 201 development based a roof size of 250m^2.

7.3 Post-development Surface Runoff Modelling

As described in **Section 7.1**, the Lot 27 and Lot 201 LWMS proposes to utilise bio-pockets, soakwells, tree-pits, rainwater tank storage, FSA and/or swales to ensure post-development peak discharges are comparable to the pre-development peak discharges. The calculation of these discharges is best achieved via a computational model. The post-development modelling uses the same methodology and parameters as pre-development modelling (described in **Appendix B**).

7.3.1 Minor Rainfall Event Modelling Results

It is required to retain the 1 year - 1 hour rainfall event onsite to satisfy the water quality design criteria (**Section 4.4.1**). The location and size of the proposed retention storage required to achieve the design criteria is presented in **Figure 13** and in **Table 7.3.1**.

Table 7.3.1 1 year - 1 hour Retention Storage

Sub-catchment	Tree-Pits/Subsurface Storage		Swales		Bio-pockets	
	Storage (m^3)	Area (m^2)	Storage (m^3)	Area (m^2)	Storage (m^3)	Area (m^2)
1a	0	0	30	200	0	0
1b	0	0	22.5	150	0	0
2a	0	0	10	170	0	0
2b	19	19	0	0	63	210
3a	0	0	30	200	0	0
3b	15	15	0	0	24	80
4	0	0	85	570	0	0
5	8	8	35	230	0	0
6a	0	0	153	1,020	0	0
6b	50	50	0	0	69	230
6c	34	34	0	0	0	0
6d	9	9	0	0	42	140
7a	0	0.0	179	1, 190	0	0
7b	43	43	0	0	66	220
7c	18	18	0	0	0	0
8a	5	5	44	290	0	0
8b	23	23	0	0	51	170
Total	224	224	588.5	2,830	315	1,050

The total size of the bio-retention system, achieved through at-source retention storage provided by the tree-pits/subsurface storage, swales and bio-pockets, is equal to 13% of the connected impervious area. Vegetation will be used for areas equal to 2% connected impervious area to ensure nutrient uptake is undertaken. The remainder of the bio-retention area will be utilised for the retention of the 1 year - 1 hour ARI event, and will only require turf to ensure infiltration of the stormwater runoff occurs. This provides some flexibility at detailed design stage to accommodate other considerations (e.g. landscaping, parking and services).

Through the at-source retention storage, no vegetated retention area is required within the detention FSA. The inundated area within the Cascade development for the 1 year - 1 hour ARI event is shown in **Figure 14**. Note that the number of tree-pits, swales and bio-pockets can be modified at detailed design stage, provided the assumed storages detailed in **Table 7.3.1** are maintained. The Landscape Masterplan, provided in **Appendix E**, shows how the development is intended to be vegetated.

7.3.2 Major Rainfall Event Modelling Results

The post-development peak discharge from the entire LSP area must be comparable to the pre-development peak discharge for rainfall events greater than the 5 year ARI. This is achieved in the Lot 27 and Lot 201 development by the use of at-source retention and detention storage. The retention storage within the development (soakwells, rainwater tanks, bio-pockets, tree-pits and swales) contributes to reducing the peak discharge from the post-development environment. However, additional detention storage is typically required to achieve the peak discharge design requirement, particularly for sandy sites. The FSAs proposed for the Lot 27 and Lot 201 development

to ensure the post-development peak flows and volumes and maintained to pre-development conditions are shown in **Figure 13**. The assumed characteristics of the FSAs are provided within **Table 7.3.2.a**.

Table 7.3.2.a Detention Flood Storage Area Characteristics

Catchment	Total Depth (m)	Base Area (m^2)	Top Surface Area (m^2)	FSA Volume (m^3)	FSA Invert (mAHD)	Weir Invert (mAHD)	Underlying AAMGL (mAHD) – referenced site measurements	Approximate Underlying CGL (mAHD) – from Jandakot DWMP
2	0.5	15	100	200	14.5	15.0	10.4	11.0
5	0.3	800	1015	270	11.7	12.0	10.1	11.0
6	1.0	250	775	485	10.0	11.0	9.7	9.9
7	0.5	500	800	325	9.6	10.1	9.5	9.4
8	1.0	100	485	270	9.0	10.0	8.9	8.0
Total	-	1,665	3,175	1,550	-	-	-	-

Note that the above FSA characteristics are nominal, and will need to be confirmed/revised following outcomes of the geotechnical investigation and the development of the detailed earthworks strategy. The depths of the FSAs differ due to the associated depth to groundwater and availability of space within the POS areas. The FSA for Catchment 5 will be located within the Western Power easement. Approval has been sought from Western Power to provided major event storage mid way between the towers to a depth of 0.3m.

The size of the detention storage within the FSA was calculated so that the post-development peak discharge from the sub-catchment is comparable to the pre-development peak discharge. This comparison can be completed on a sub-catchment scale (to ensure FSA are sized appropriately) and on a development scale (to ensure the overall discharge from the development is comparable to the overall pre-development peak discharger from the LSP area). A comparison of pre- and post-development peak discharge at the culverts under the Kwinana Freeway is presented in **Table 7.3.2.b** which includes flows from upstream catchments. The FSA sizes and dimensions are nominal and will be further detailed at the UWMP stage.

Table 7.3.2.b Overall Post-development Peak Discharge and Volume

Model	Peak Discharge Exiting Site (m^3/s)		Peak Volume Exiting Site (m^3)	
	10 year ARI	100 year ARI	10 year ARI	100 year ARI
Pre-development	0.599	0.932	106,235	133,275
Post-development	0.515	0.842	100,075	112,625

A comparison of the post-development peak discharge to the pre-development peak discharge on a sub-catchment scale was completed by comparing the peak discharge per unit area. Since the pre- and post-development sub-catchments have been modified, a direct comparison is not possible. The discharge per unit area comparison, presented in **Appendix B** (**Table B.1**), identifies some sub-catchments where discharge is greater under post-development conditions. However with the use of retention swales and FSAs at the bottom of the treatment trains, the overall post-development peak discharge is equivalent to the pre-development environment. The 5 year and 100 year inundation areas are shown in **Figure 15** and **Figure 16** respectively.

7.4 Peel Sub N Design

It is understood that the current intention for the Peel Sub N Drain immediately adjacent to Lot 201 is for it to be transferred into the ownership of the Town of Kwinana. This is consistent with the Jandakot DWMP and subsequent discussions with the Water Corporation, Town of Kwinana and DoW. While this LWMS does not cover the land occupied by this drain the eventual upgrade will need to tie in with the development of lots immediately adjacent.

The current form of the Peel Sub N Drain is very artificial and is more consistent with a constructed drain. This reflects the fact that the drain is essentially an excavated groundwater control structure.

It is proposed that the development of the entire Wellard East cell will eventually include converting the Peel Sub N Drain into a 'living stream'. This section of the LWMS provides a concept strategy and methodology for designing the living stream. It is anticipated that the Town of Kwinana will progress the concept designs through to detailed designs. The most effective approach for this would be to undertake the detailed designs for the living stream concurrent with the detailed designs of the areas immediately adjacent to the drain.

According to relevant literature, a living stream should have a meander wave length of 7 to 15 times the bank full width and a radius of curvature of 2.3 to 2.7 times the bank full width (WRC, 2001). The bank full width is the width required to convey the 1.5yr ARI event. By comparing the 100 year ARI ($0.61m^3/s$) and 10 year ARI ($0.49m^3/s$) peak discharges in the Peel Sub N Drain from the Jandakot DWMP on a log plot, the 1.5 year ARI peak discharge is estimated as being $0.35m^3/s$. Therefore depending on the depth of the streamline, the meander and wavelength of the living stream can be calculated. The shallower the living stream, the wider the required bank full width and the wider the meander. The meander width is limited by the corridor width, which is in turn limited by the minimal corridor side slopes of 1:6 and requirements to convey the 100 year ARI flow.

Based on the above design criteria, a preliminary design could see the living stream being 0.4m deep, have a bottom channel width of 1.05m and a meander width of 12.2m. The bottom area of the MUC, where the streamline would meander, would have a minimum side slope of 1:100 and a depth of 0.05m. This channel cross section would have capacity to convey $0.7m^3/s$. Based on the above design parameters, the meander wavelength would be approximately 15m. This wavelength is very short in comparison to the stream width and results in an unnatural streamline form. This is due to the very low flow rates experienced in the Drain. The low flow rates are reflective of the hydrology of the drain (i.e. it is an excavated shallow groundwater control structure rather than a natural streamline which has been modified). It is therefore proposed that the meander wavelength is lengthened to approximately 30 times bank full width. Variation to the meander width will be utilised to assist in providing a more natural streamline, and to facilitate retention of key established trees.

The living stream may require additional side slopes (which would provide additional flow capacity) to batter up to development earthworks levels. This detail would not be available until detailed design stage. The invert of the living stream is proposed to be consistent with those proposed in the Jandakot DWMP. The conceptual living stream design is presented in **Appendix F**. This conceptual design shows how the FSAs will be linked to the streamline, and their relation to the underlying CGL and AAMGL.

8 Subdivision and Urban Water Management Plans

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of the UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW, 2008b).

While strategies have been provided within this LWMS that address planning for water management within Lot 27 and Lot 201, it is a logical progression that future subdivision designs and supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further clarification within future UWMPs include:

- Modelling of local road drainage network;
- Flood storage area configurations and outlet structures;
- Detailed geotechnical investigation;
- ASS Investigation;
- Clean fill and subsoil drainage requirements;
- Approval of wetland boundary modification;
- Implementation of water conservation strategies;
- Non-structural water quality improvement measures;
- Management and maintenance requirements;
- Construction period management strategy; and
- Monitoring and evaluation program.

These are further detailed in the following sections. As stated above, ongoing monitoring of groundwater will be detailed in the UWMP. However, in this LWMS it is outlined in **Section 9**.

8.1 Modelling of Local Road Drainage Network

It is acknowledged that the peak flows described in previous sections, and consequently the drainage strategies documented in this LWMS, are based upon broad-scale assumptions and regional data. These assumptions are considered adequate for development of the proposed basin sizes and of an appropriate level of detail; however verification of proposed subdivision drainage designs within the LSP area should be undertaken by modelling the piped drainage network. Such modelling will allow verification that the development undertaken within the LSP area is consistent with this LWMS. The design of the drainage system to date has been undertaken at an appropriate level for local structure planning and runoff-routing computer modelling of the stormwater drainage system should be reviewed once detailed drainage design has commenced for the area. It is anticipated that this will occur during the subdivision design process and detailed within the future UWMPs.

8.2 Flood Storage Area Configurations and Outlet Structures

While the LSP area drainage catchments have been defined based on the existing topography and the current LSP, it is possible that these could undergo some change to accommodate stakeholder feedback prior to final subdivision design. The exact location and shape of the FSAs will still need to be specified and presented within the future UWMPs.

In order to review the final FSA configurations, the hydrological model that has been developed to support this LWMS may need to be refined in light of stakeholder feedback. It is expected that the FSAs will be designed to a level that provides detailed cross-sections, sizes of storage areas, pipe sizes, inverts, etc. The ultimate aim of revising the hydrological model will be to confirm that the post-development runoff volumes and peak flows are able to meet the performance requirements detailed

within this LWMS. A conceptual diagram showing how the FSAs would integrate into the POS and adjacent living stream is shown in **Appendix F**.

8.3 Detailed Geotechnical Investigation

A detailed geotechnical investigation will need to be conducted to determine site classification and to confirm the regional geological mapping discussed in this LWMS. A number of test pits will be required to be installed at depths just below the ground surface to determine the soil characteristics and how this could impact on the proposed development. The investigation should include but not limited to the following:

- Infiltration tests;
- Soil types;
- Suitability of soils for development and if treatment is required;
- Requirement of soil treatment;
- Settlement tests;
- Bearing ratios; and
- Hydraulic conductivity.

8.4 ASS Investigation

Lot 27 and Lot 201 is mapped as having areas of moderate to high risk of ASS being found within three meters of the natural surface associated with the REW in Lot 27 and the CCW in lot 201. An investigation is required to determine the actual presence or otherwise of the ASS and extent throughout Lot 27. As the region that is classified as potentially having a high risk of ASS in Lot 201 is not proposed to be developed, ASS investigation within this area are not required. If ASS are found within the areas that are proposed to be developed or disturbed due to excavation for installation of services, then appropriate management plans will be a likely requirement of future development. These requirements should be clarified and/or summarised at UWMP stage once detailed earthworks designs and depths of trenching/excavation are known.

8.5 Clean Fill and Subsoil Drainage Requirements

As discussed in **Section 7.3.2**, the use of clean fill and/or subsoil drainage may be required to ensure the FSAs remain as dry basins sufficient clearance to groundwater is maintained. The clean fill and/or subsoil requirements will be determined following outcomes of the geotechnical investigation and the development of the earthworks strategy. If clean fill is used, it is recommended that soils with a high Phosphorous Retention Index (PRI) are positioned beneath the bio-retention areas and FSAs to ensure at source nutrient retention leading to the protection of downstream water bodies.

8.6 Approval of Wetland Boundary Modification

As discussed in **Section 3.4**, a preliminary wetland assessment conducted by Cardno found that the environmental values within REW 12917 did not reflect the attributes and functions expected of a REW and that it was likely to be a Multiple Use Wetland (MUW) instead. In June 2010 Cardno submitted an application to the DEC requesting an amendment to the *Geomorphic Wetlands of the Swan Coastal Plain* dataset. The application was to amend the current REW wetland boundaries to that shown within the Local Structure Plan and **Figure 7**, with the majority of the current REW proposed to be changed to a MUW, and the man-made drain retaining a REW management category. The DEC (in June 2010) provided preliminary advice to Cardno outlining their support for the proposed amendment to the wetland management category boundaries, with a formal assessment to be completed by September 2010.

It is expected that the future UWMPs will provide an update as to the progress of the boundary and management category reassessment

8.7 Implementation of Water Conservation Strategies

A number of potential measures to conserve water have been presented within this LWMS. These water conservation management strategies should be incorporated into the design and the ongoing maintenance of all POS areas. Landscape design measures that will be incorporated into the water conservation strategy should be further detailed within the future UWMPs produced for the development. The manner in which the developer intends to promote water conservation measures discussed in this LWMS to future lot owners should be discussed within future UWMPs.

8.8 Non-Structural Water Quality Improvement Measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007). Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of subdivisions and the POS areas. It is expected that the future UWMPs will provide reference to measures such as public education (through measures such as signage that may be implemented to raise awareness).

8.9 Management and Maintenance Requirements

The management measures to be implemented to address surface water quality, such as the use of vegetation within bio-pockets and FSAs will require ongoing maintenance. It is therefore expected that the future UWMPs will provide detailed management and maintenance plans that will set out maintenance actions (e.g. gross pollutant removal), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Given that approval from the ToK and DoW will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

In addition to management requirements within the subdivision, there will be some maintenance required of the streamline immediately adjacent. Where the UWMP and detailed design is undertaken concurrent with the detailed design of the living stream, it is expected that estate management actions would tie in with those of the living stream and MUC.

8.10 Construction Period Management Strategy

It is anticipated that the construction stage may require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). In particular, dust generation has the potential to cause significant public disturbance during construction works. Given the sandy nature of the soils underlying Lot 27 and Lot 201, it is anticipated that some dust suppression will be required during the subdivision stage with the implementation of the appropriate management measures, such as:

- Not undertaking earthworks during dry, windy conditions where practicable;
- Watering down cleared areas will occur as necessary during dry dusty periods;
- Covering materials during construction to reduce dust emissions where practicable; and
- Undertaking revegetation as soon as practicably possible to ensure that soils are protected from wind erosion.

The management measures undertaken for dust suppression and construction management will be addressed either in future UWMPs or a separate Construction Management Plan (CMP).

8.11 Monitoring and Evaluation Program

It will be necessary to confirm that the management measures that are implemented are able to fulfil their intended management purpose, and are in a satisfactory condition at a point of management hand-over to the ToK. A post-development monitoring program should be developed to provide this confirmation, and it should include details of objectives of monitoring, relevant issues and information, proposed methodology, monitoring frequency and reporting obligations. These monitoring programs are discussed in **Section 9** of this LWMS and will be further detailed at the UWMP stage.

8.12 Groundwater Licence Status

Application has been made to DOW for an allocation of groundwater to facilitate irrigation of POS areas. This application is still pending and it is expected that future UWMPs will demonstrate that adequate allocation of water has been obtained to irrigate POS within the development, or that an appropriate contingency plan has been established in the event that a reduced water allocation is obtained.

8.13 Peel Sub N Drain Land Transfer

As indicated previously, the stated intention of Water Corporation and ToK is to transfer the current drainage reserve containing the Peel Sub N Drain into ToK ownership. Future UWMP documents should provide an update of the status of the transfer where it is immediately adjacent to the subdivision area.

9 Monitoring

The aim of this section is to assess the effectiveness of the pre-development monitoring that has been undertaken and make recommendations regarding future post-development monitoring. It is anticipated that the post-development monitoring would be consistent with the pre-development monitoring of hydrological conditions (as documented in earlier sections), with the addition that the BMPs should also be monitored to ensure their continued effectiveness. It will be necessary to confirm that the structural management measures that are implemented are able to fulfil their intended management purpose and are in a satisfactory condition at a point of management hand-over to the ToK. These monitoring programs will be further detailed at the UWMP stage.

The groundwater monitoring was conducted at ten locations. The collected data included groundwater levels, sampling of physio-chemical parameters *in situ* and laboratory analysis of nutrients. Surface water monitoring was conducted at seven locations and includes sampling of physio-chemical parameters *in situ* and laboratory analysis for nutrients and nutrient species. The SAP was developed and implemented following consultation with the DoW in 2005.

The pre-development Sampling and Analysis Plan (SAP) of surface water quality, groundwater levels and groundwater quality conditions was concluded in November 2008 after a three year monitoring period. The results of this monitoring have provided baseline data that will enable verification of future detailed designs at the subdivision stage. The results of the SAP are summarised in **Section 3** of this LWMS and can be found in more detail in the annual monitoring reports (Cardno BSD, 2005; Cardno BSD, 2007; Cardno, 2009b).

9.1 Recommended Program for UWMP

The existing groundwater bores should be maintained post-development where possible. Where this is not possible, bores should be re-installed, post-development, at locations that can provide comparable results. In addition, the discharge to the FSAs should be monitored.

The SAP reported surface water only flowed during the late winter/spring period when groundwater levels were at their highest and/or the catchment was saturated (Cardno, 2009b). It was concluded that surface water flow in the Peel Branch Drain is an expression of groundwater. With the tendency for the surface water to be an expression of groundwater, and considering the catchment area for the two surface water drains is much larger than the LSP, post-development surface water monitoring in the Peel Main/Branch Drains is not proposed to be conducted as it will not provide any significant or site specific results that will help to assess and monitor the effectiveness of the stormwater drainage system within the LSP area.

The groundwater monitoring indicates two separate regions of groundwater quality within the LSP. The eastern portion of the LSP area was reported as containing low to moderate nutrient concentrations, whereas the western portion was dominated by high nutrient concentrations centred around bore WL7 (see **Figure 11** and **Figure 12**). The proposed post-development monitoring locations will therefore be positioned in both upstream and downstream locations of the POS and FSAs within the two management areas, as shown in **Figure 17**. Groundwater quality monitoring will be conducted on a quarterly basis. A summary of the post-development monitoring program is shown in **Table 9.1**. The post-development monitoring should be conducted for three years and include at least one year of monitoring when 80% of the development is complete.

Table 9.1 Monitoring Program Summary

Monitoring Type	Locations	Frequency	Parameters
Groundwater	Network of monitoring bores providing a suitable spatial representation of Lot 27 and Lot 201.	Quarterly (typically Jan, April, July, Oct).	*In situ* pH, EC, dissolved oxygen, temperature. Sample pH, TSS, TN, TKN, NH_4, NO_X, TP, FRP.

9.2 Contingency Action Plan

A Contingency Action Plan (CAP) should be detailed and implemented as a part of each UWMP. The CAP is effectively a plan of steps that will be undertaken should certain water quality criteria be reached.

9.2.1 Trigger Criteria

The groundwater trigger values are to be derived from pre-development groundwater monitoring conducted and in consideration of the *National Water Quality Management Strategy* (ANZECC, 2000). As discussed in **Section 9.1**, there are two separate groundwater monitoring regions (east and west) and as such two separate sets of trigger value criteria will be used to assess the impact of an urban post-development environment on the local groundwater. The trigger criteria were derived from a combination of temporal median values from Lot 27 and Lot 201 specific data and the ANZECC (2000) default trigger values. The trigger criteria are shown in **Table 9.2.1**.

Table 9.2.1 Post-Development Trigger Values

Groundwater Area	TN (µg/L)	TP (µg/L)	ORP (µg/L)	NH_4 (µg/L)	NO_X (µg/L)	TKN (µg/L)	pH	EC (mS/cm)
East	1,600	65	40	200	150	1,700	6.0-8.0	120-300
West	5,500	1,500	1,200	220	300	2,500	6.0-8.0	120-300

9.2.2 Contingency Actions

If the results from the initial monitoring occasion and successive follow-up monitoring indicate that action is required to address the issue, a number of contingency measures may be employed. The first action that should be undertaken if groundwater trigger criteria are exceeded is to conduct a site-specific comparison of long term background data with the collected data from the SAP. There is some amount of variability (both spatially and temporally) in nutrient concentrations experienced across the Wellard East area and the trigger values may need to be modified to accommodate background levels. This information should then be used as a management tool in consultation with DoW to determine if the trigger values should be revised.

If the trigger values are deemed to be appropriate the following actions should be undertaken in relation to nutrients if the groundwater trigger criteria are exceeded:

- Identify source if possible;
- Remove source if possible (e.g. fertiliser input, etc.);
- Remove sediment-bound nutrients by removing basin sediments;
- Review implementation of open space management practices; and
- Manual removal of plant material from bio-pockets and FSAs to facilitate further nutrient uptake.

The need for fertiliser application will be determined through periodic leaf and tissue analysis of plants within the FSAs. Additional measures in response to other parameters will be assessed on a case-by-case basis and it is anticipated that this would be undertaken in conjunction with ToK.

9.3 Reporting

The pre-development SAP has been finalised and all reports presented to the proponent and are available to the DoW on request. A summary of the results is shown in this LWMS and will be presented in future UWMPs. Post-development monitoring reports will be published and provided on an annual basis to the ToK and the DoW on request.

10 Implementation

The LWMS is a key supportive document for the LSP. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with the total water cycle management approach described in the document. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future UWMPs.

10.1 Roles and Responsibility

The LWMS provides a framework that the proponent can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the ToK. The responsibility for working within the framework established within the LWMS rests with the subdividers, although it is anticipated that future UWMP documents will be developed in consultation with the ToK and DoW and in consideration of other relevant policies and documents.

Due to the size of the Lot 27 and Lot 201, it is most likely that the area will not be developed as a single parcel. Staged development will therefore be required. It will be the responsibility of the developer to prepare detailed subdivision designs and supportive UWMPs at the appropriate time (i.e. at subdivision stage). It is also the responsibility of the developer to demonstrate that the proposed subdivision designs and supportive UWMPs not only comply with the objectives and management approaches provided in this LWMS, but that they can also achieve the water quantity and quality objectives and criteria set by this LWMS.

10.2 Funding

As Lot 27 and Lot 201 constitutes a single landholding, the management strategies outlined in this LWMS will be borne solely by the proponent. The ToK has not advised of any funding contributions required for the development to discharge to the existing regional stormwater network. However, it is anticipated that the proponent will work with the ToK to reach a mutually agreeable outcome where required.

10.3 Review

Armana Holdings Pty Ltd landholdings in Wellard East extend to Lot 379, south of Lot 201. This lot is not covered by this LWMS however in the future it is anticipated that this would be required. It is therefore proposed that this LWMS is revised to accommodate additional areas in Wellard East as the need arises. Alternatively an addendum to this document could be provided to address the same requirements.

The next stages of water management are anticipated to be lot planning through subdivision. Subdivision approvals should be supported by a UWMP. The UWMP is largely an extension of the LWMS, as it should provide detail to the designs proposed within this LWMS. In addition to the issues detailed in **Section 8**, the UWMPs should address:

- Compliance with design objectives within the LWMS;
- Detailed stormwater management design;
- Specific structural and non-structural methods to be implemented and their manner of implementation; and
- Details of proposed roles and responsibilities for the above measures.

The next stage of development following the UWMP is single lot or multiple dwelling developments. It is recognised that certain elements of the LWMS and the UWMP will not be implemented until this late stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage, their implementation could be encouraged by the ToK through policy (or modification of these where necessary), building licence or awareness programs (such as the Water Corporation's Waterwise program).

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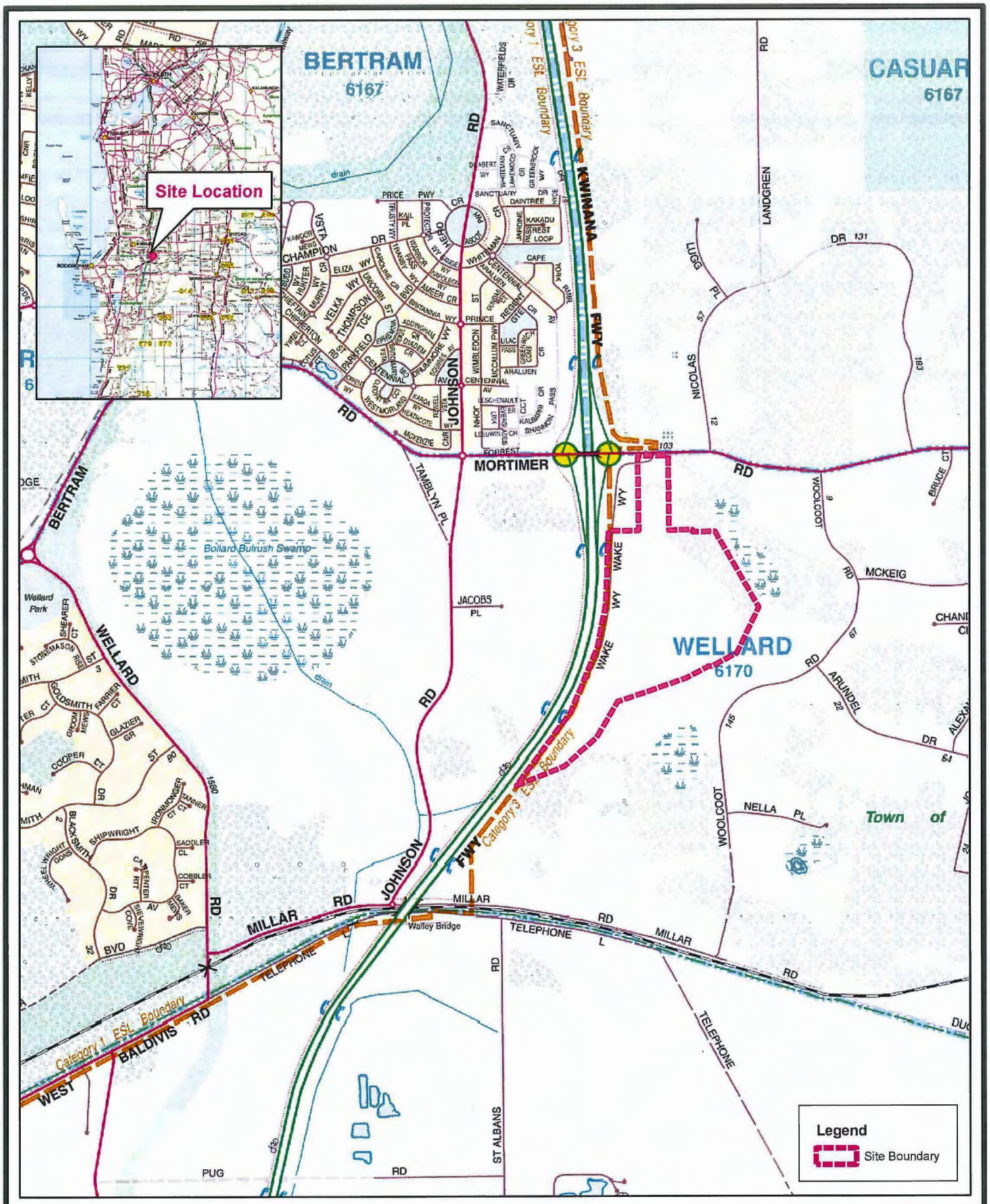
Figures



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Scale: 1:20,000

0 250 500 1,000 1,500 2,000 Metres

PROJECT Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE FIGURE 1 : Locality Plan

PRINCIPAL Armana Holdings Pty Ltd

This drawing has been prepared in accordance to Cardno Quality Management System. It remains the property of Cardno WA Pty. Ltd. and shall not be used without permission. The drawing shall be preliminary only and/or not for construction until signed approved.

Project Number V8041

Original A4

Drawing Number SK01

Revision 03

Designed SLC

Checked SLC

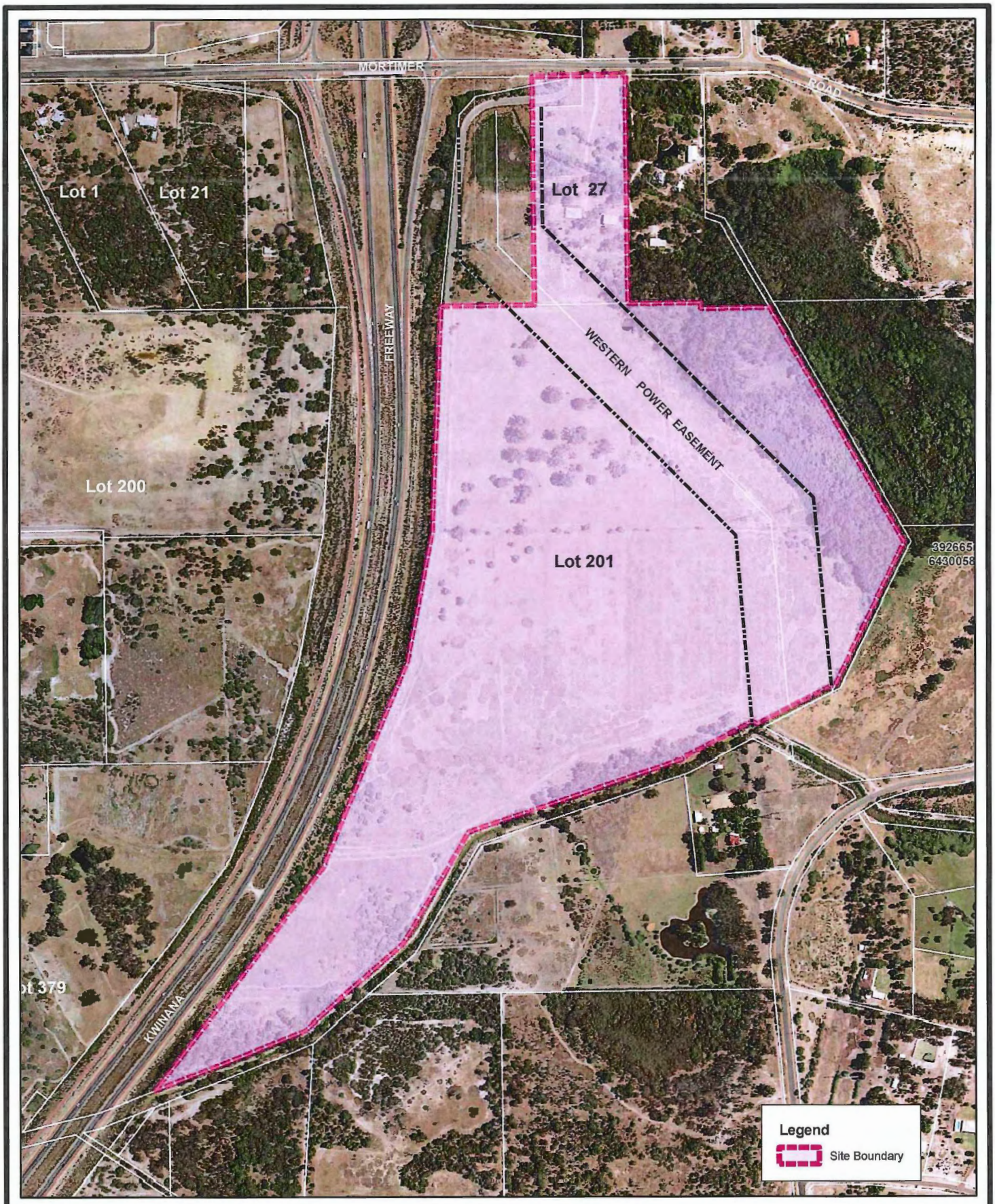
Drawn MGW

Approved DC

Local Authority Town of Kwinana

Sheet 1 of 1

Date 20/08/10



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Scale: 1:6,500

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PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 2 : Site Plan

PRINCIPAL: Armana Holdings Pty Ltd

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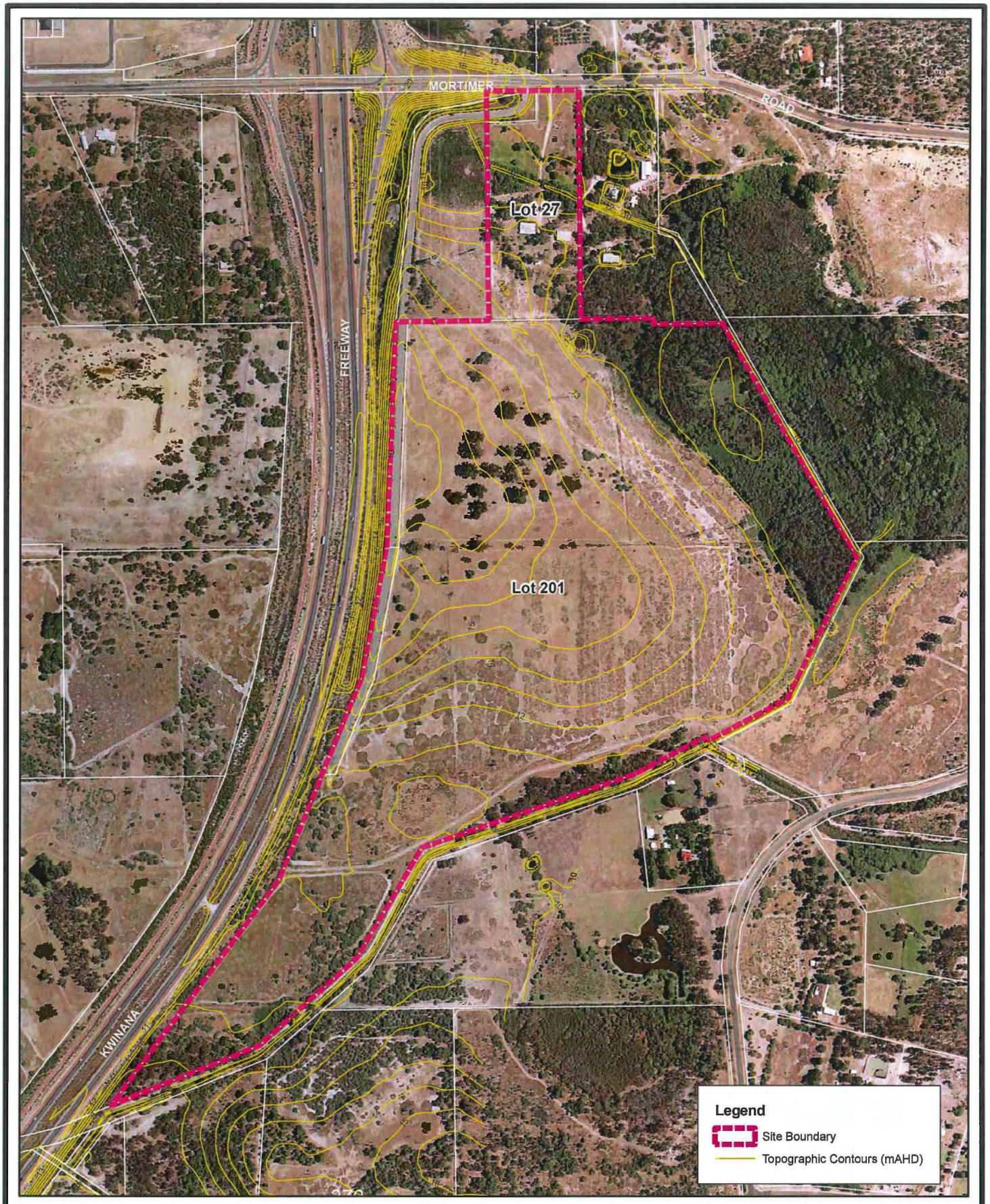
Project Number: V8041
Original: A4
Drawing Number: SK02
Revision: 03
Designed: SLC
Checked: SLC
Drawn: MGW
Approved: DC
Local Authority: Town of Kwinana
Sheet 1 of 1
Date: 20/08/10



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PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 3 : Topographic Contours

PRINCIPAL: Armana Holdings Pty Ltd

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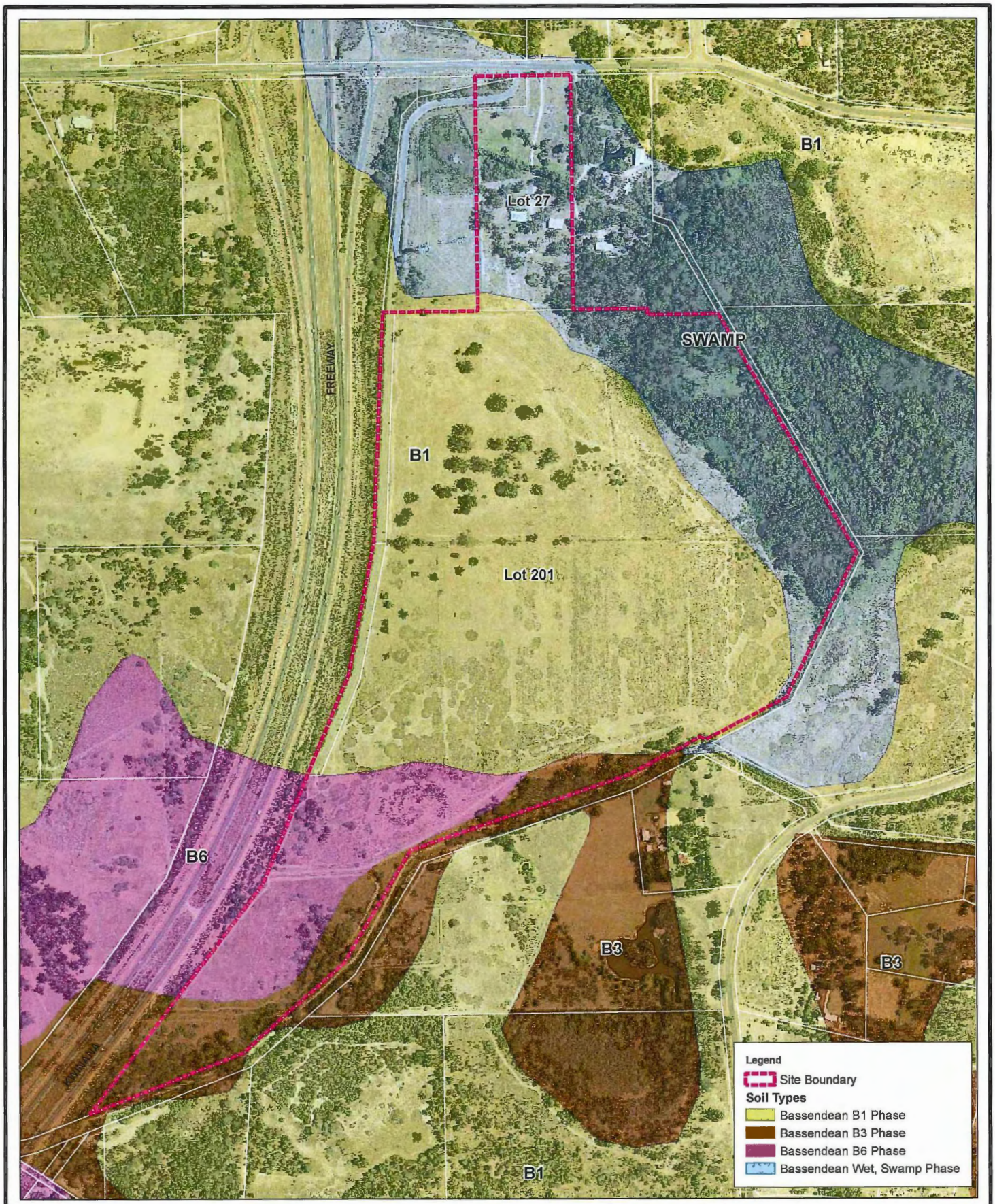
Project Number: V8041
Original: A4
Drawing Number: SK03
Revision: 03
Designed: SLC
Checked: SLC
Drawn: MGW
Approved: DC
Local Authority: Town of Kwinana
Sheet 1 of 1
Date: 20/08/10



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Scale: 1:4,500 (0 50 100 200 300 400 500 600 700 Metres)

PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 4 : Soil Types

PRINCIPAL: Armana Holdings Pty Ltd

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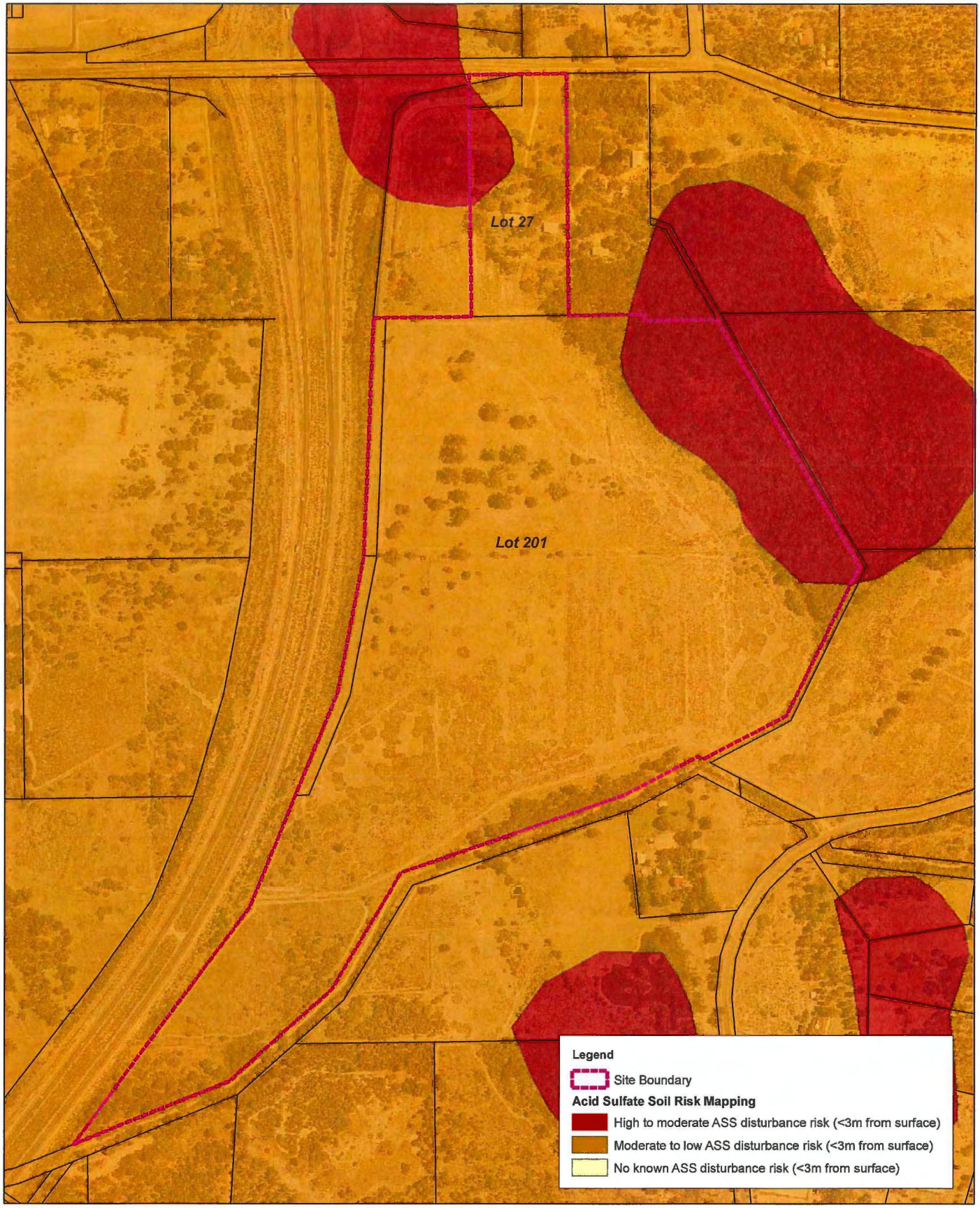
Project Number: V8041
Original: A3
Drawing Number: SK04
Revision: 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10



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Scale: 1:4,500 (0 50 100 200 300 400 500 600 700 Metres)

PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 5: Acid Sulfate Soil Risk Mapping

PRINCIPAL: Armana Holdings Pty Ltd

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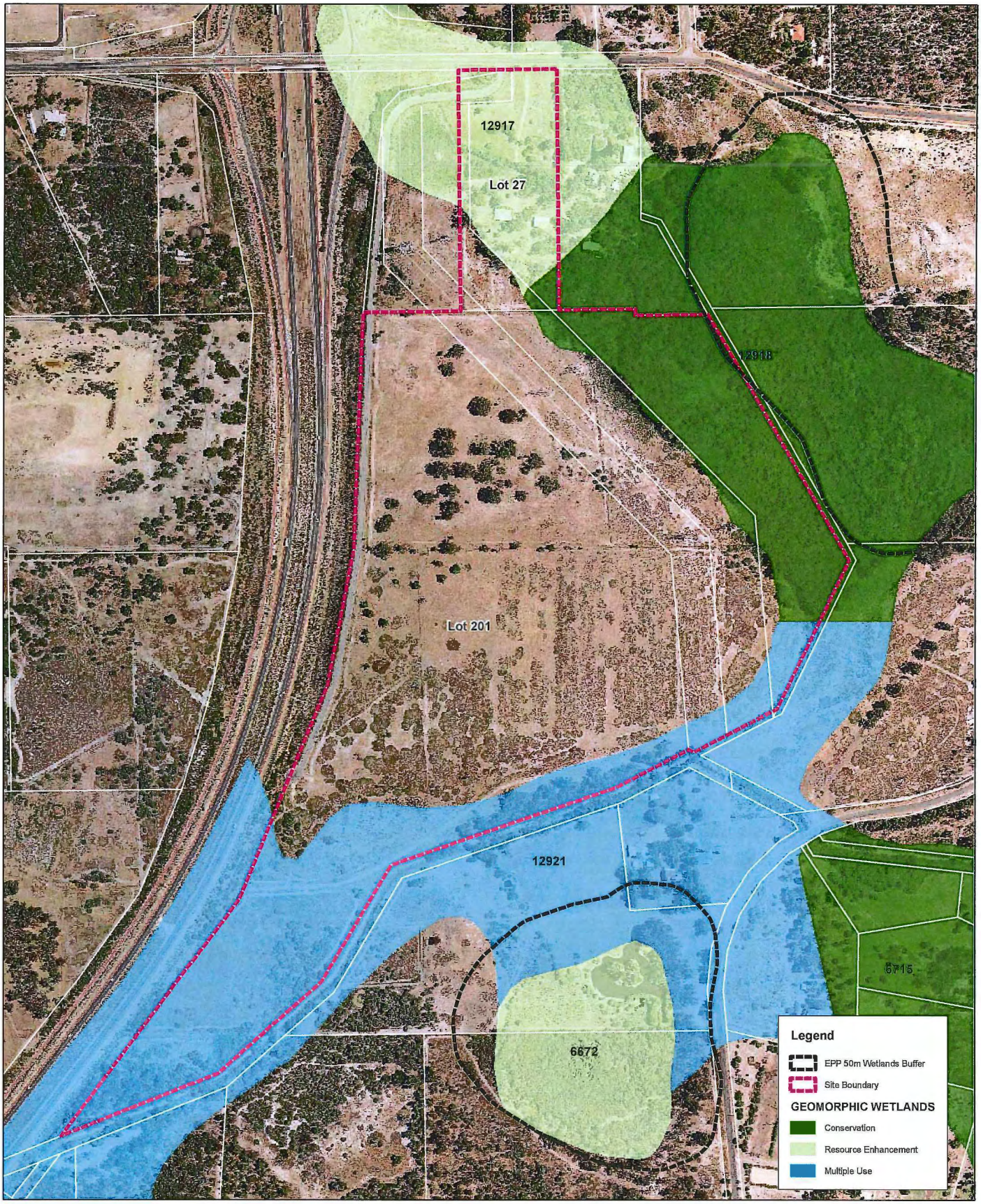
Project Number: V8041
Original: A3
Drawing Number: SK05
Revision: 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10



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Scale: 1:4,500 0 50 100 200 300 400 500 600 700 Metres

PROJECT Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE FIGURE 6: Wetlands

PRINCIPAL Armana Holdings Pty Ltd

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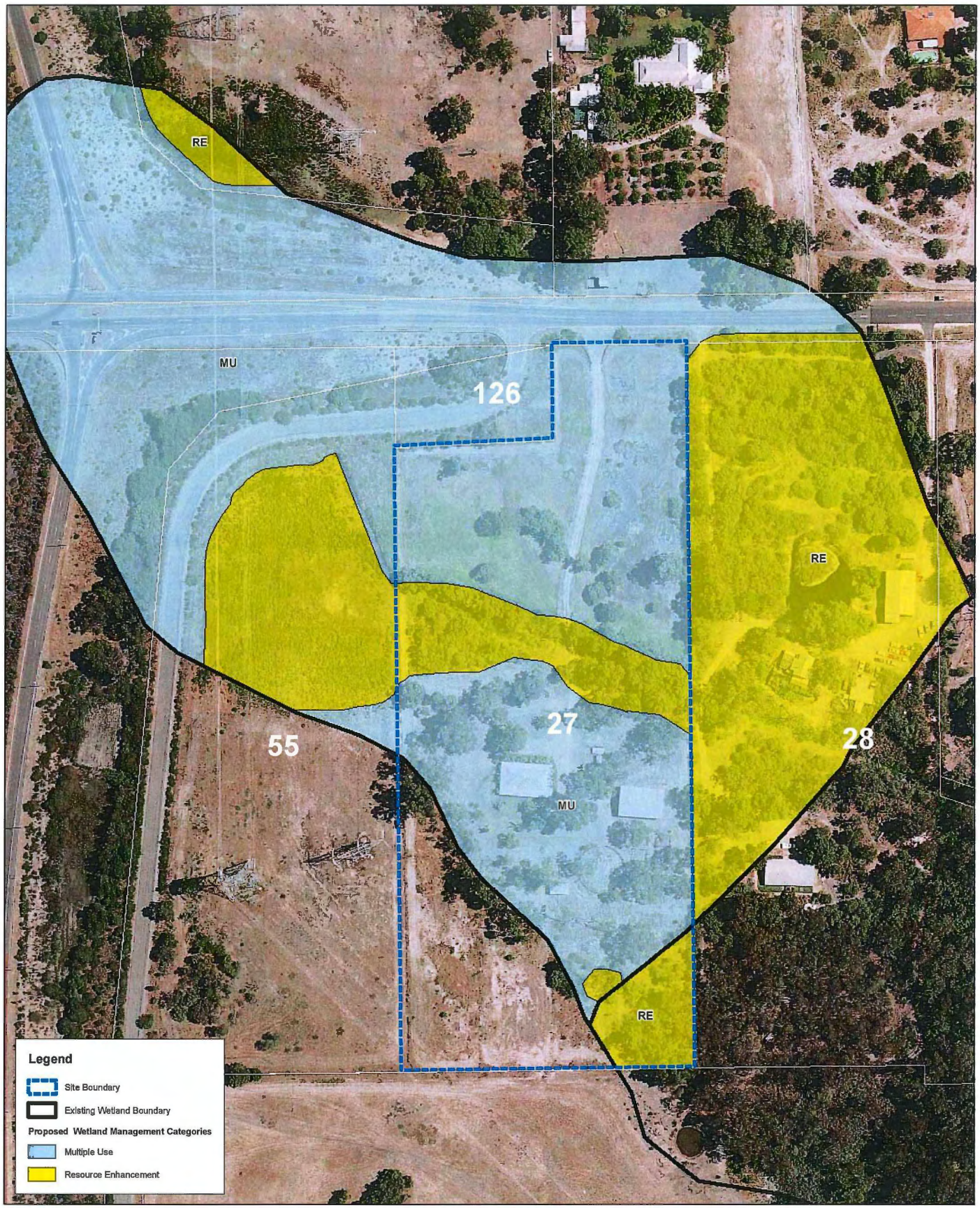
Project Number V8041
Original A3
Drawing Number SK06
Revision 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10



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Scale: 1:1,500 (0 12.5 25 50 75 100 125 150 175 200 225 Metres)

PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 7: Proposed Wetlands Alignment

PRINCIPAL: Armana Holdings Pty Ltd

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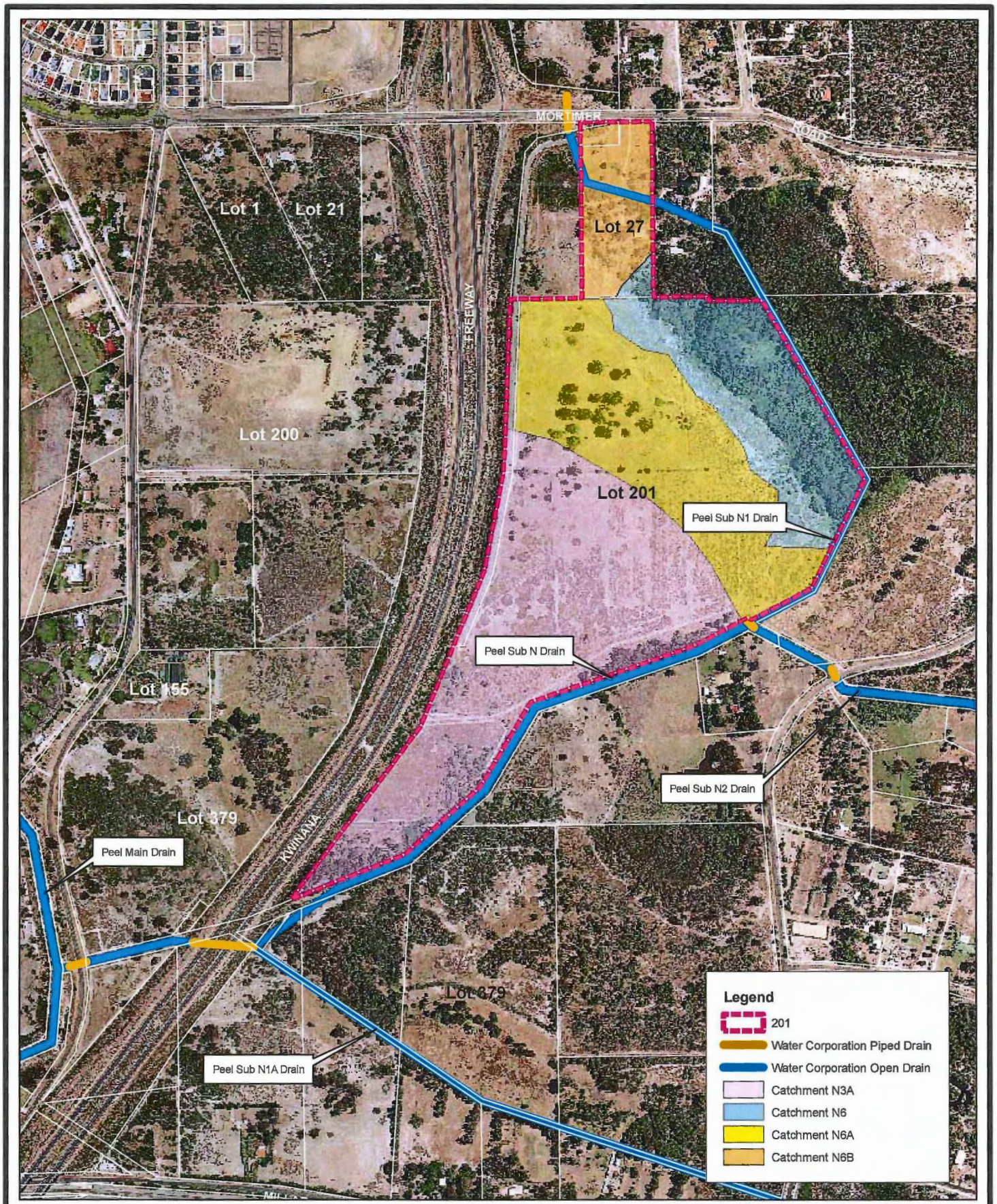
Project Number: V8041
Original: A3
Drawing Number: SK23
Revision: 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10



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Scale: 1:8,500

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PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 8 : Pre-development Sub-Catchments

PRINCIPAL: Armana Holdings Pty Ltd

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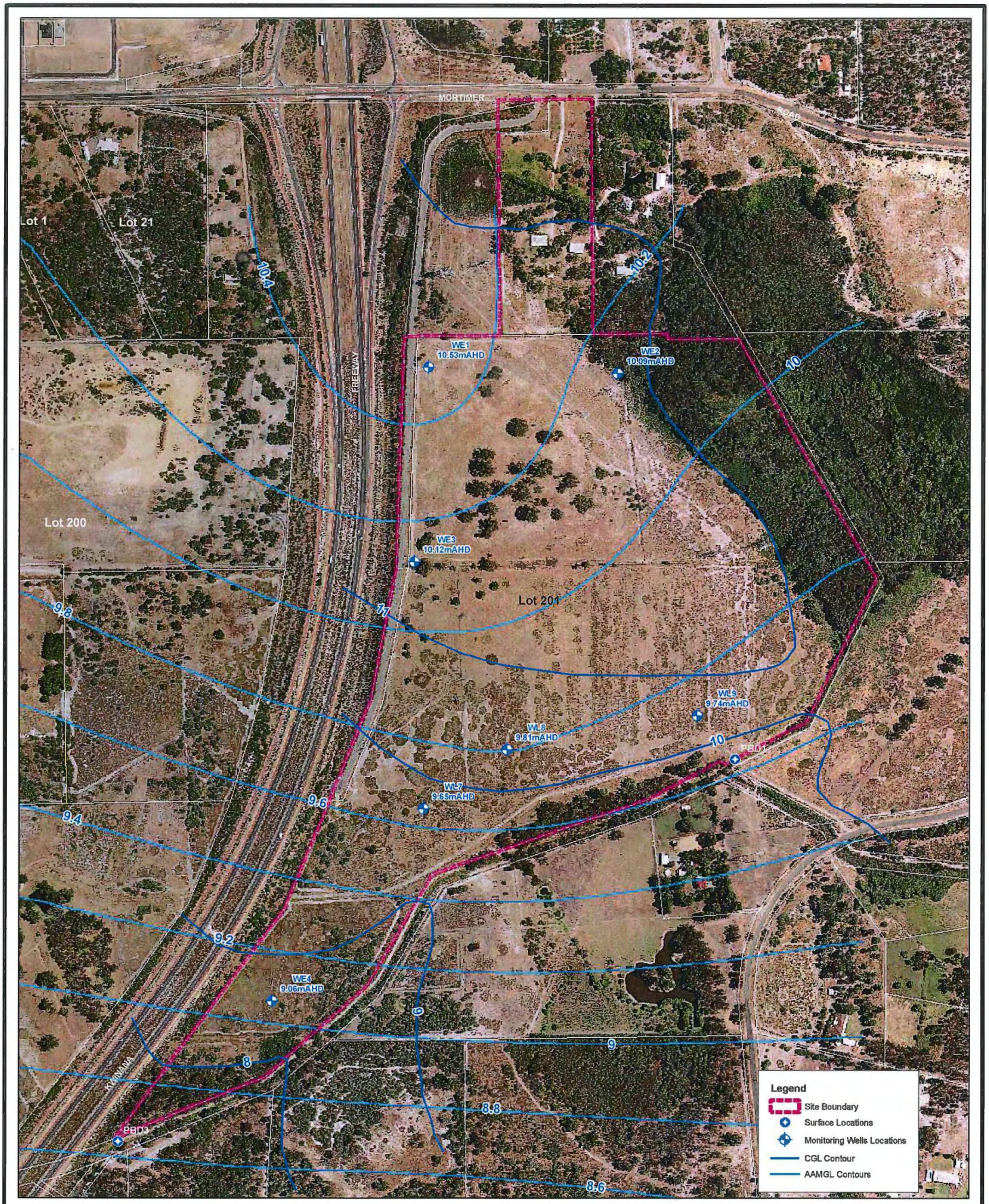
Project Number: V8041
Original: A4
Drawing Number: SK07
Revision: 03
Designed: SLC
Checked: SLC
Drawn: MGW
Approved: MGW
Local Authority: Town of Kwinana
Sheet 1 of 1
Date: 20/08/10



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Scale: 1:4,500

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PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 9 : AAMGL Contours

PRINCIPAL: Armana Holdings Pty Ltd

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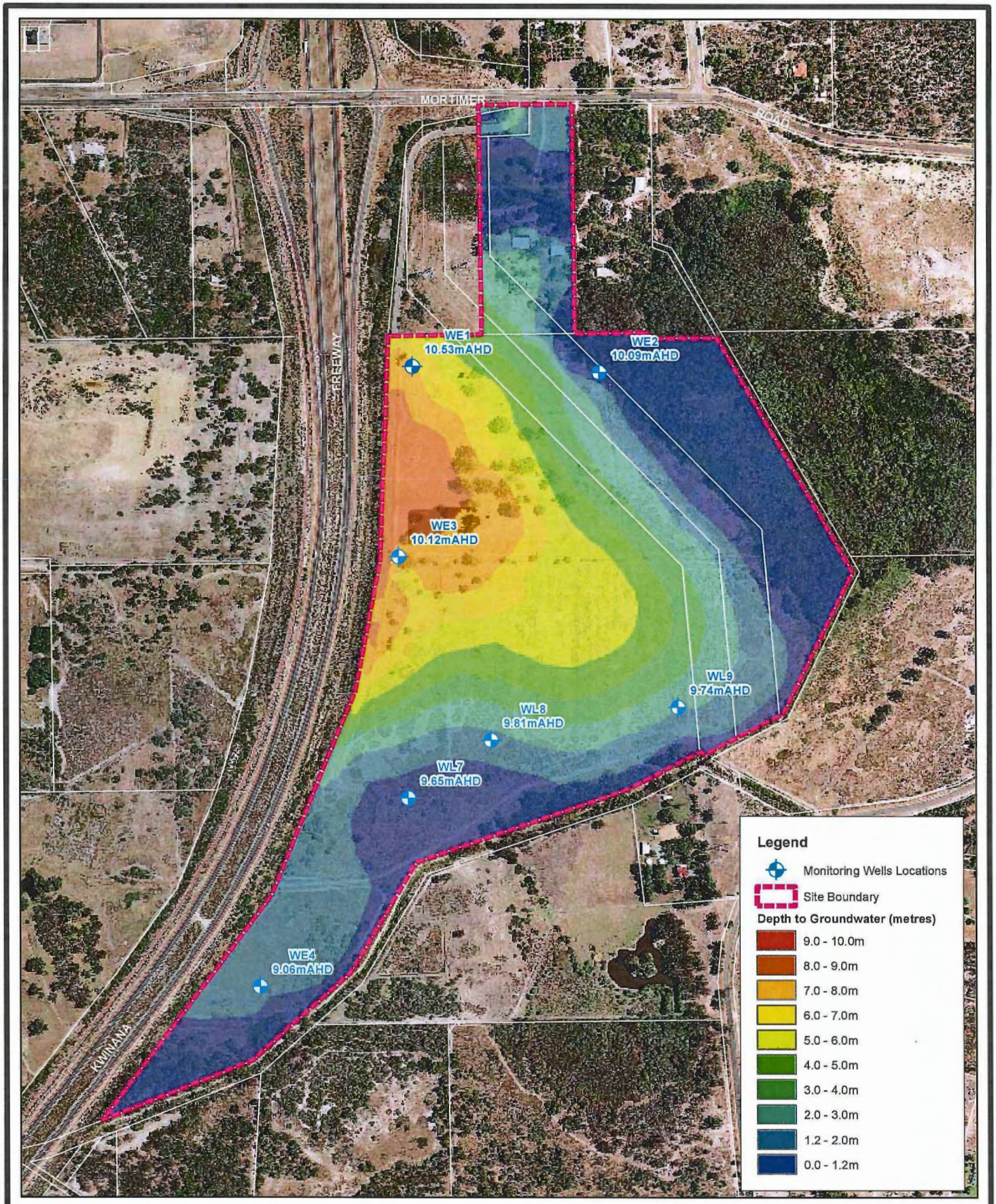
Project Number: V8041
Original: A3
Drawing Number: SK09
Revision: 03
Designed: SLC
Checked: SLC
Drawn: MGW
Approved: DC
Local Authority: Town of Kwinana
Sheet 1 of 1
Date: 20/08/10



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PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 10 : Depth to Groundwater

PRINCIPAL: Armana Holdings Pty Ltd

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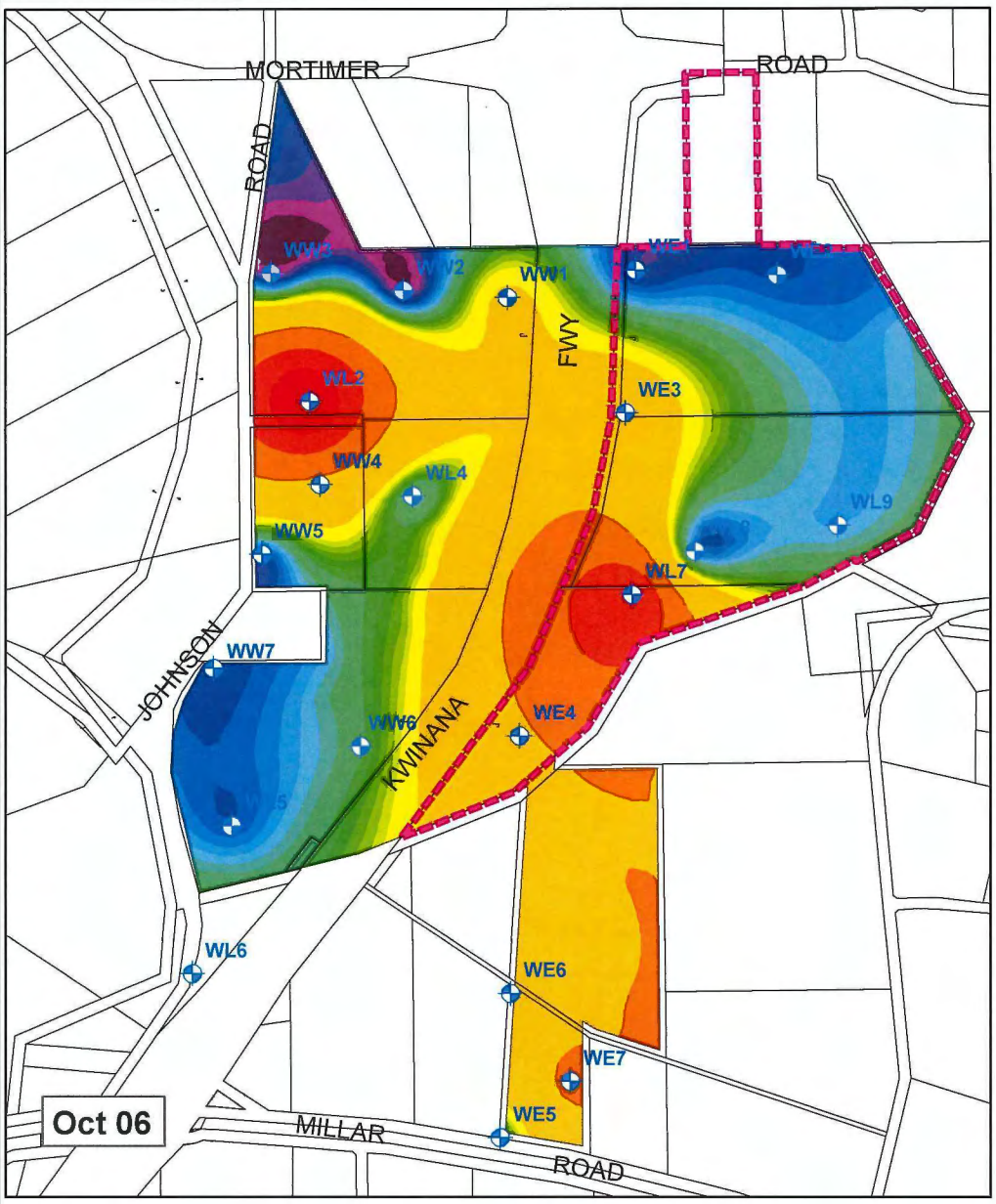
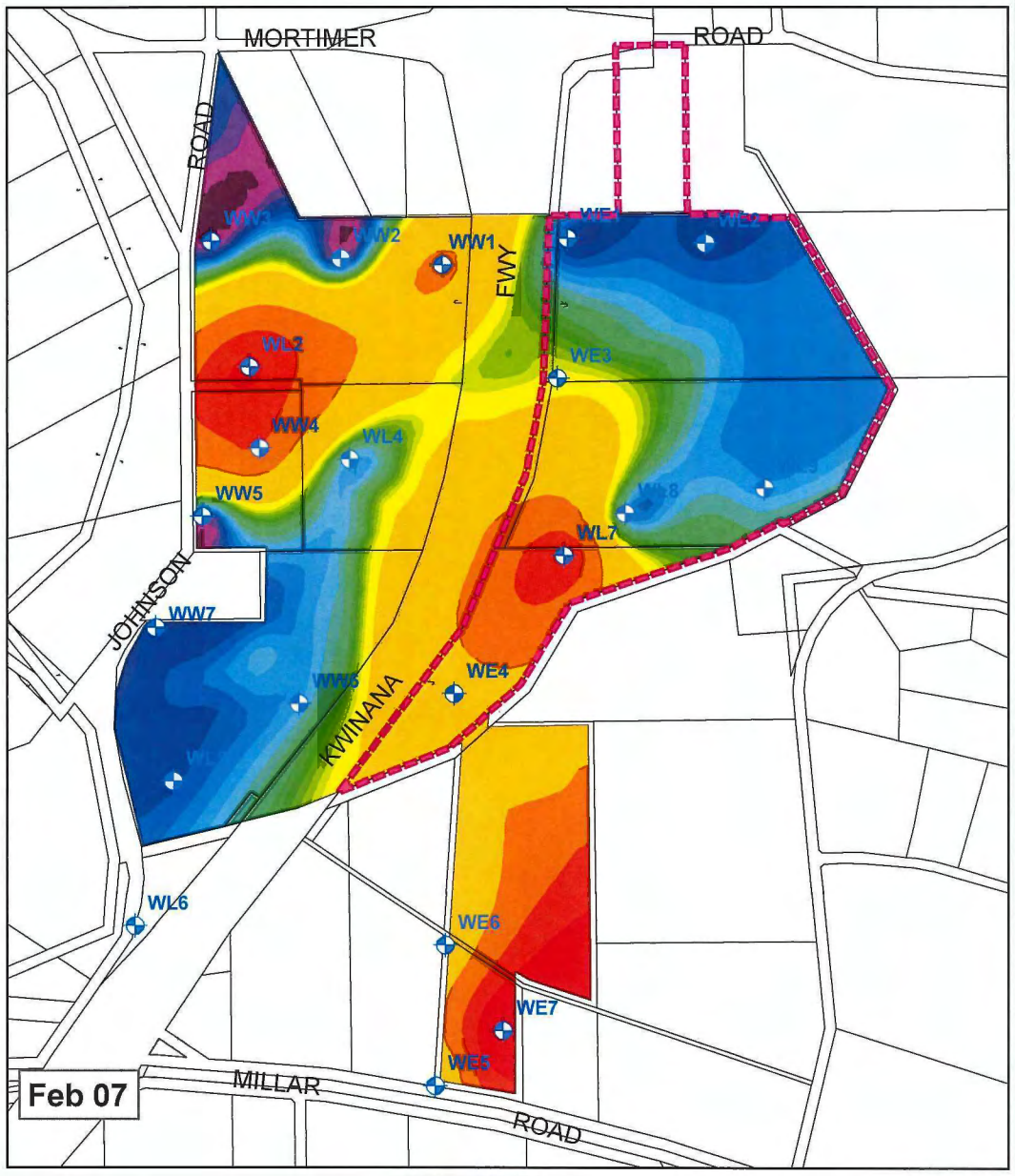
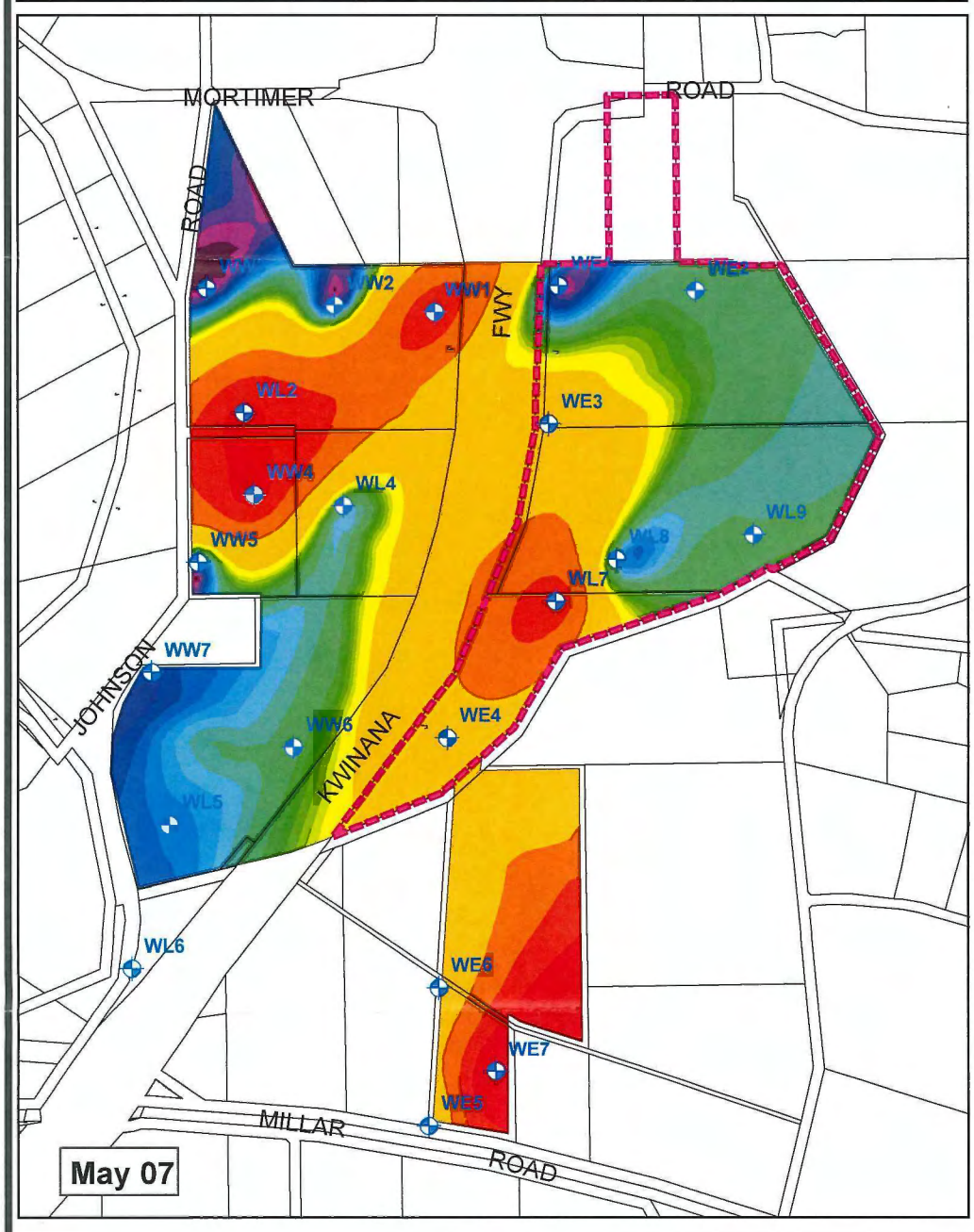
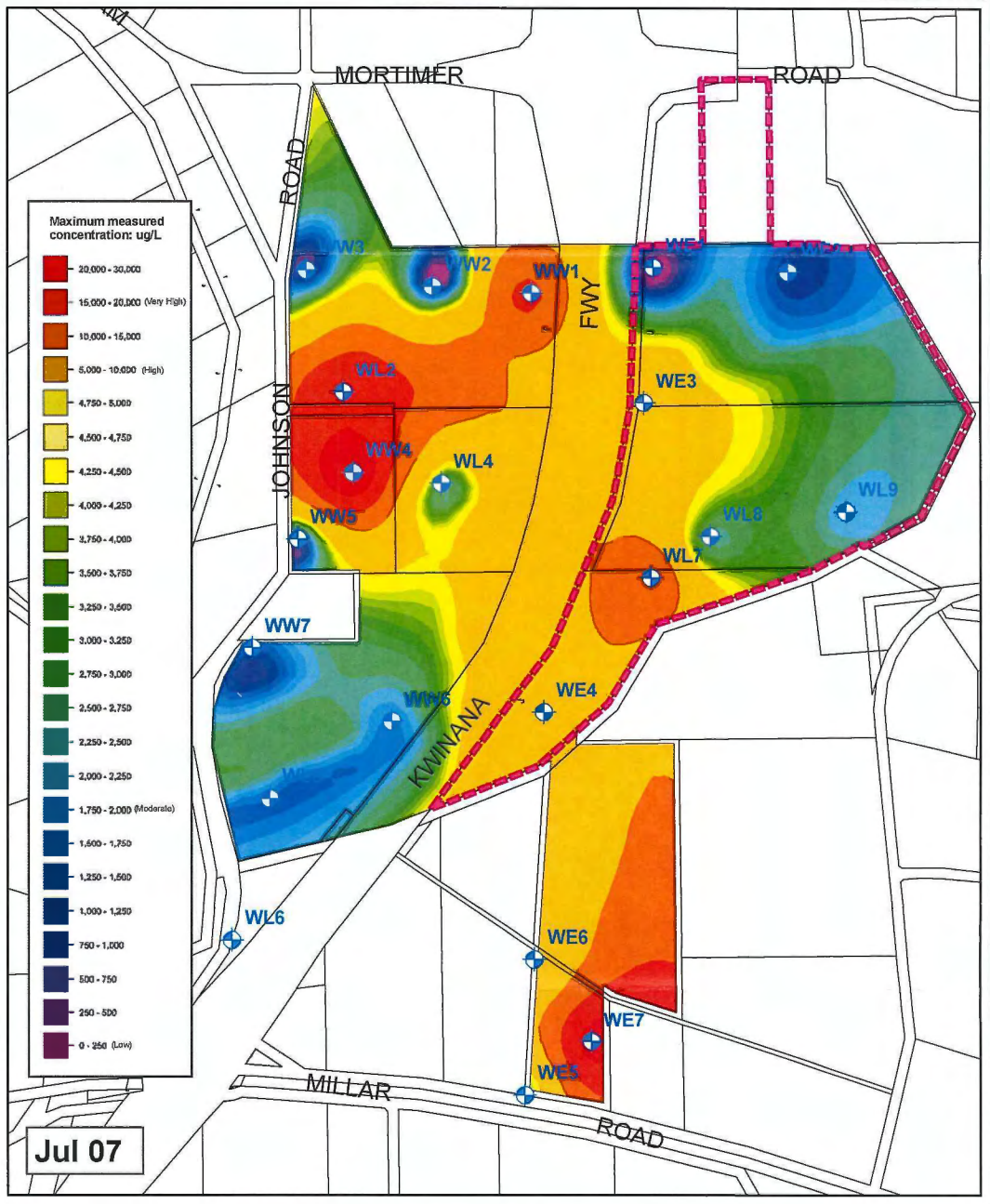
Project Number: V8041
Original: A4
Drawing Number: SK13
Revision: 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10









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Scale: 1:12,500

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PROJECT **Lot 27 & Lot 201 Mortimer Road - LWMS**

DRAWING TITLE **FIGURE 11: Total Nitrogen Distribution Mapping**

PRINCIPAL **Armana Holdings Pty Ltd**

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Project Number **V8041**

Original **A3**

Drawing Number **SK14**

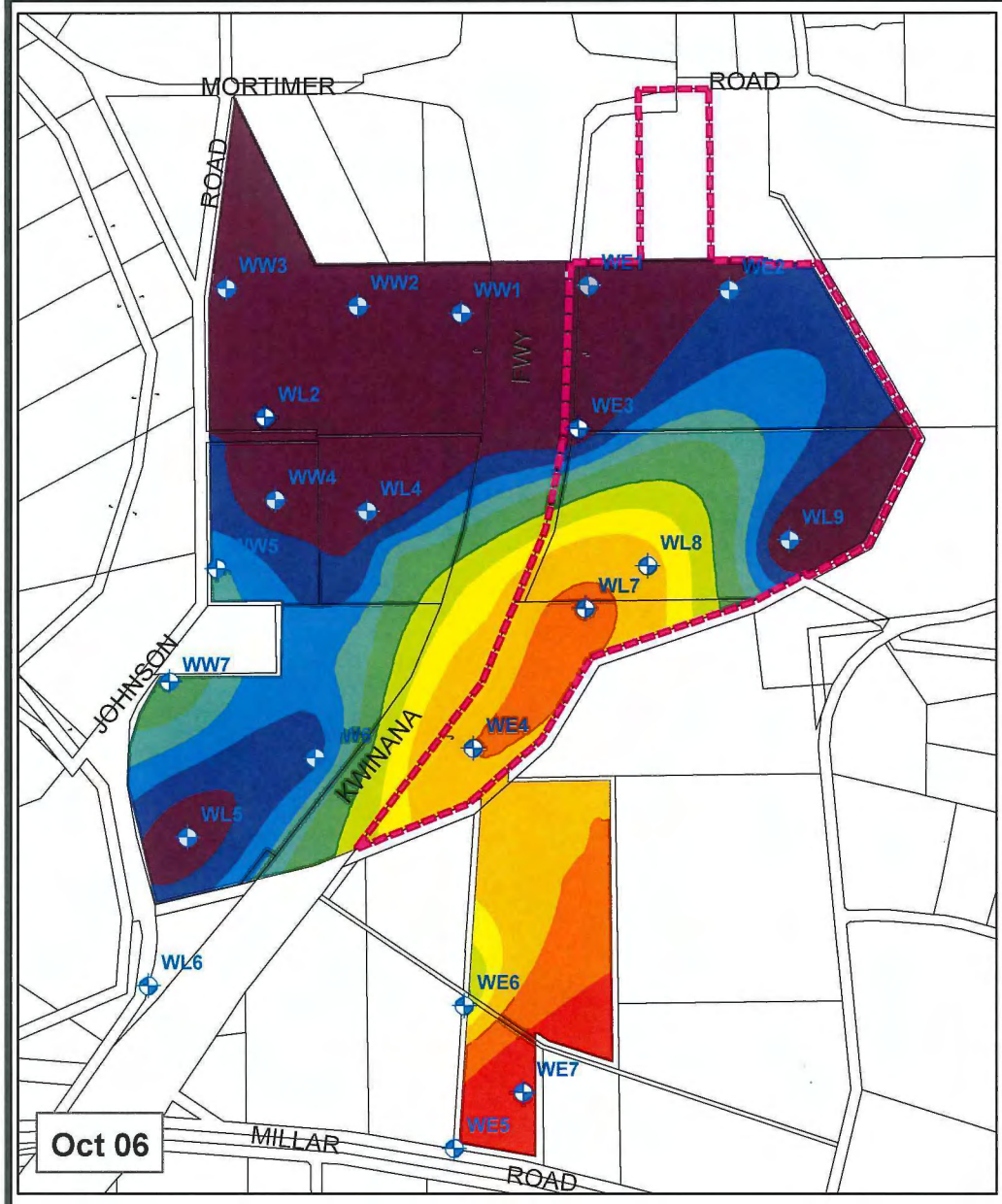
Revision **03**

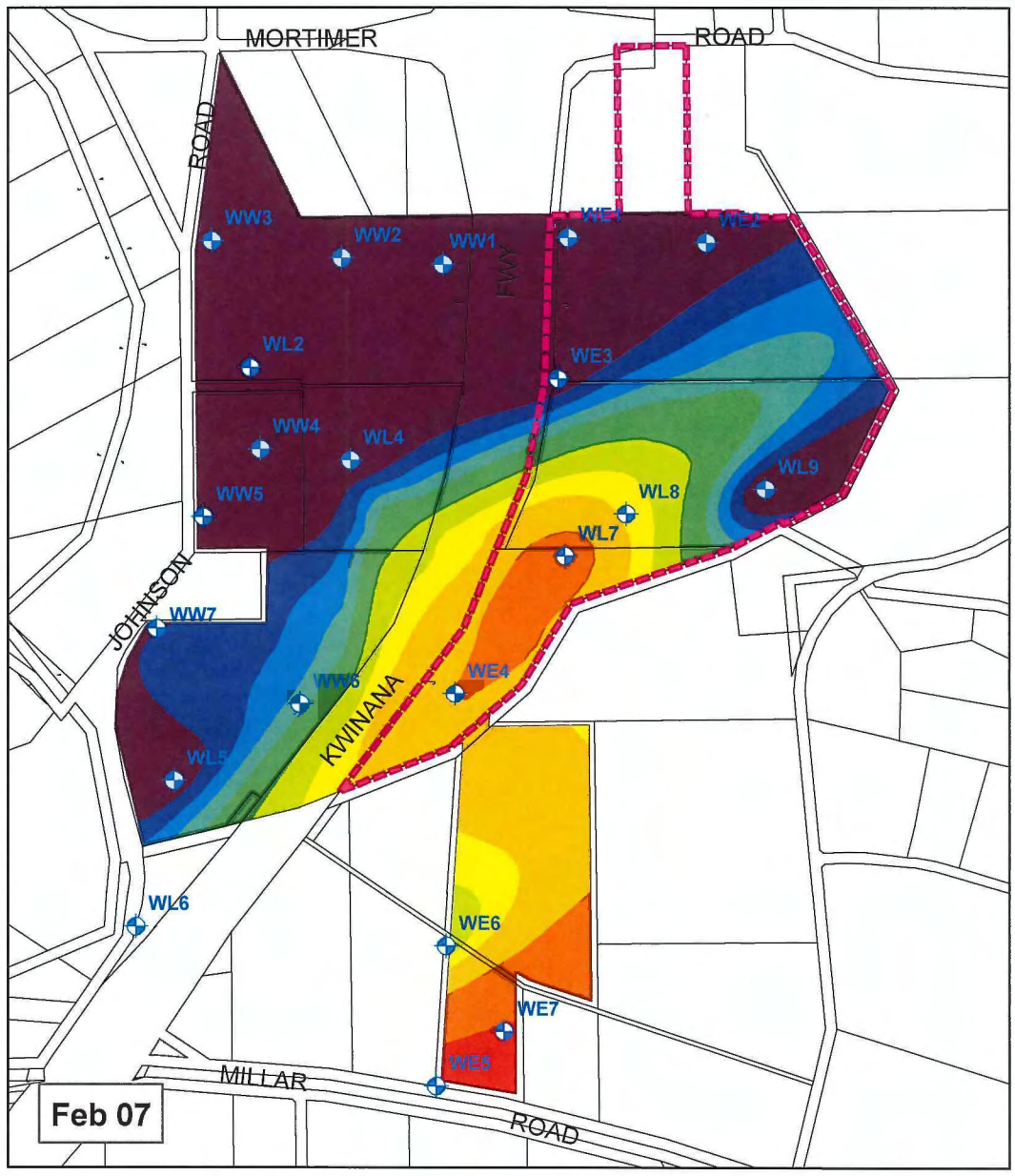
Designed SLC Checked SLC

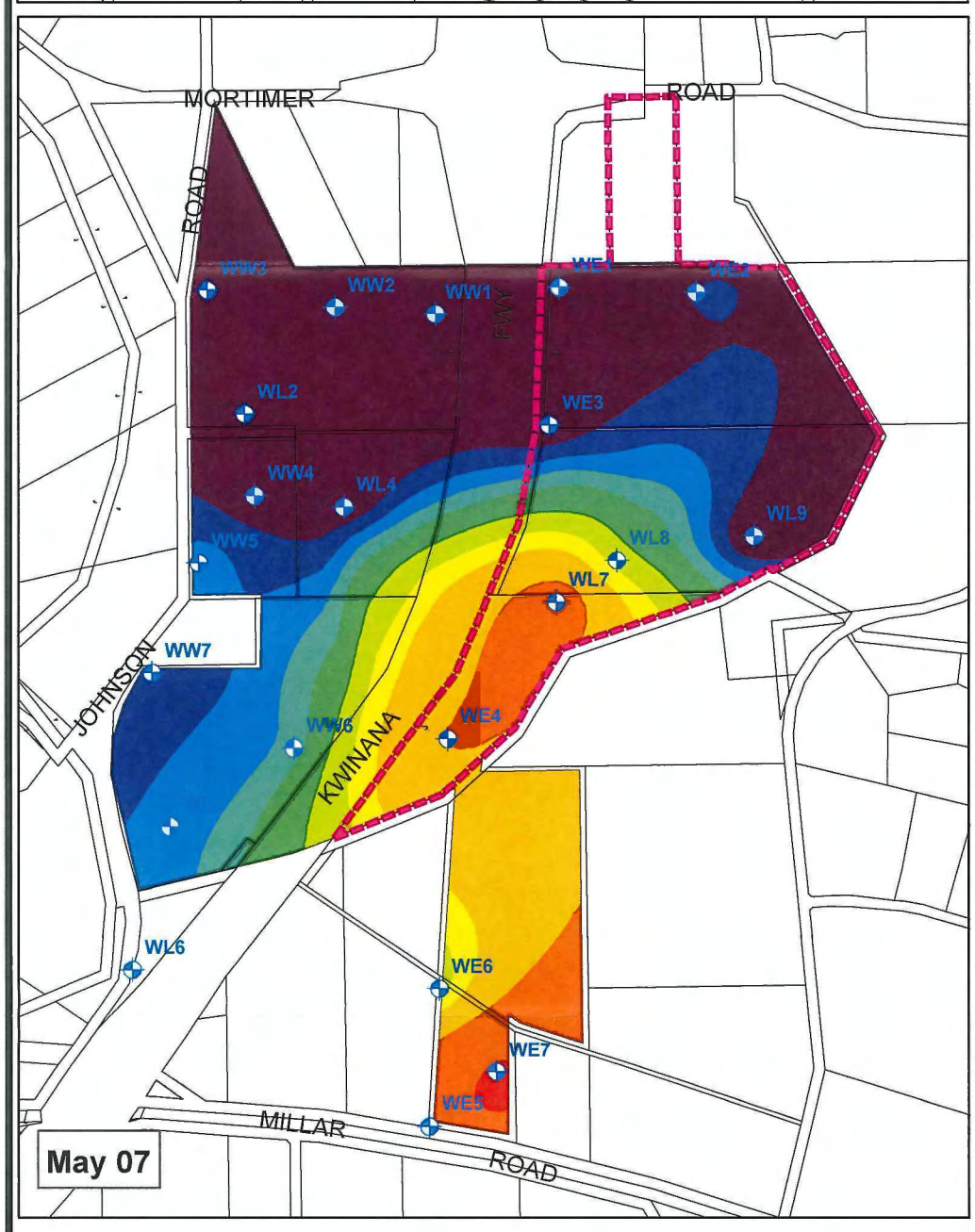
Drawn MGW Approved DC

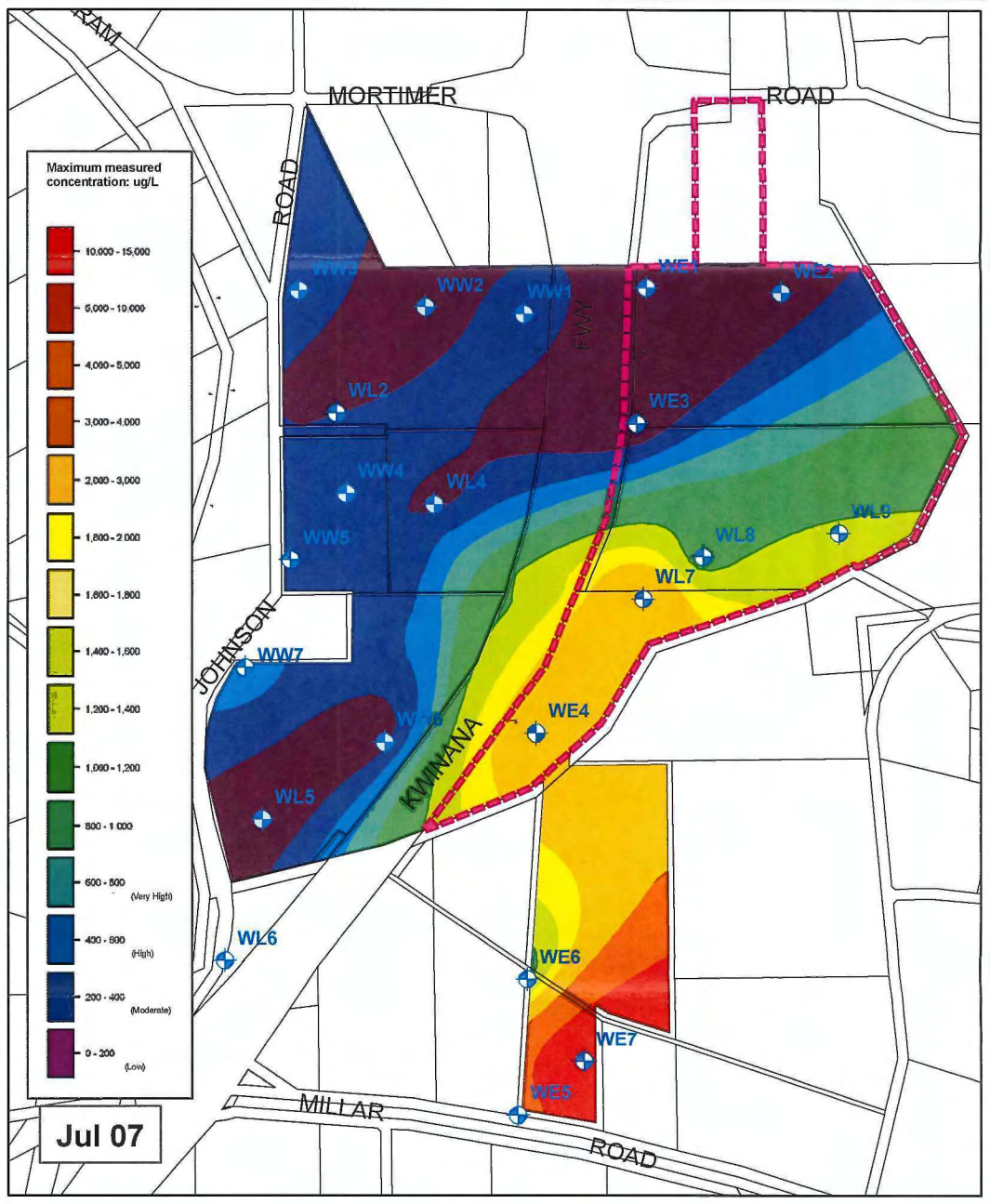
Local Authority Town of Kwinana

Sheet 1 of 1 Date 20/08/10









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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:12,500

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PROJECT **Lot 27 & Lot 201 Mortimer Road - LWMS**

DRAWING TITLE **FIGURE 12: Total Phosphorus Distribution Mapping**

PRINCIPAL **Armana Holdings Pty Ltd**

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Project Number **V8041**

Original **A3**

Drawing Number **SK15**

Revision **03**

Designed SLC Checked SLC

Drawn MGW Approved DC

Local Authority Town of Kwinana

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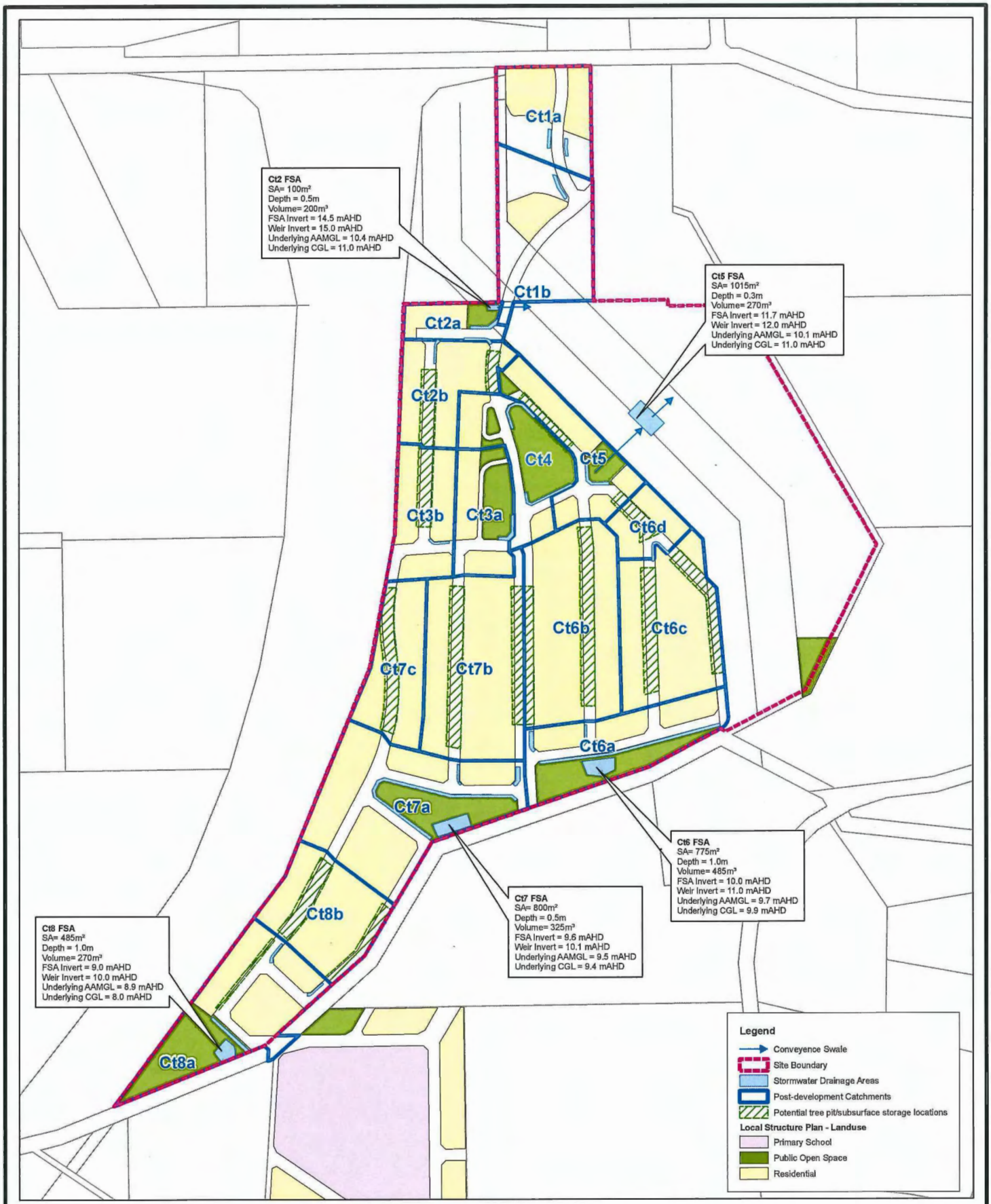

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PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 13 : Stormwater Drainage System

PRINCIPAL: Armana Holdings Pty Ltd

Project Number: V8041
Original: A3
Drawing Number: SK10
Revision: 03
Designed SLC
Checked SLC
Drawn MGW
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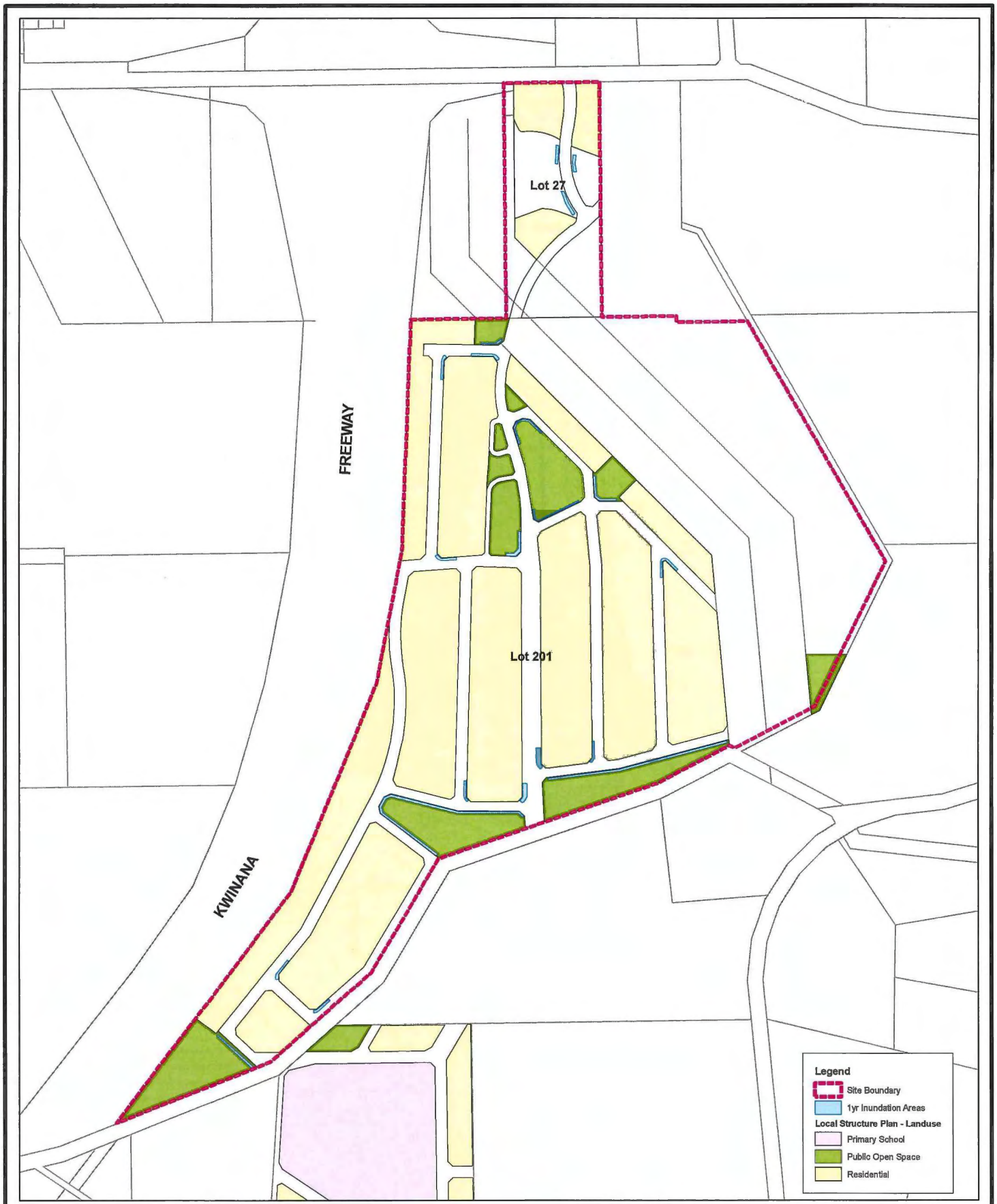

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Scale: 1:4,500

0 50 100 200 300 400 500 600 700 Metres

PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 14 : 1yr Inundation Areas

PRINCIPAL: Armana Holdings Pty Ltd

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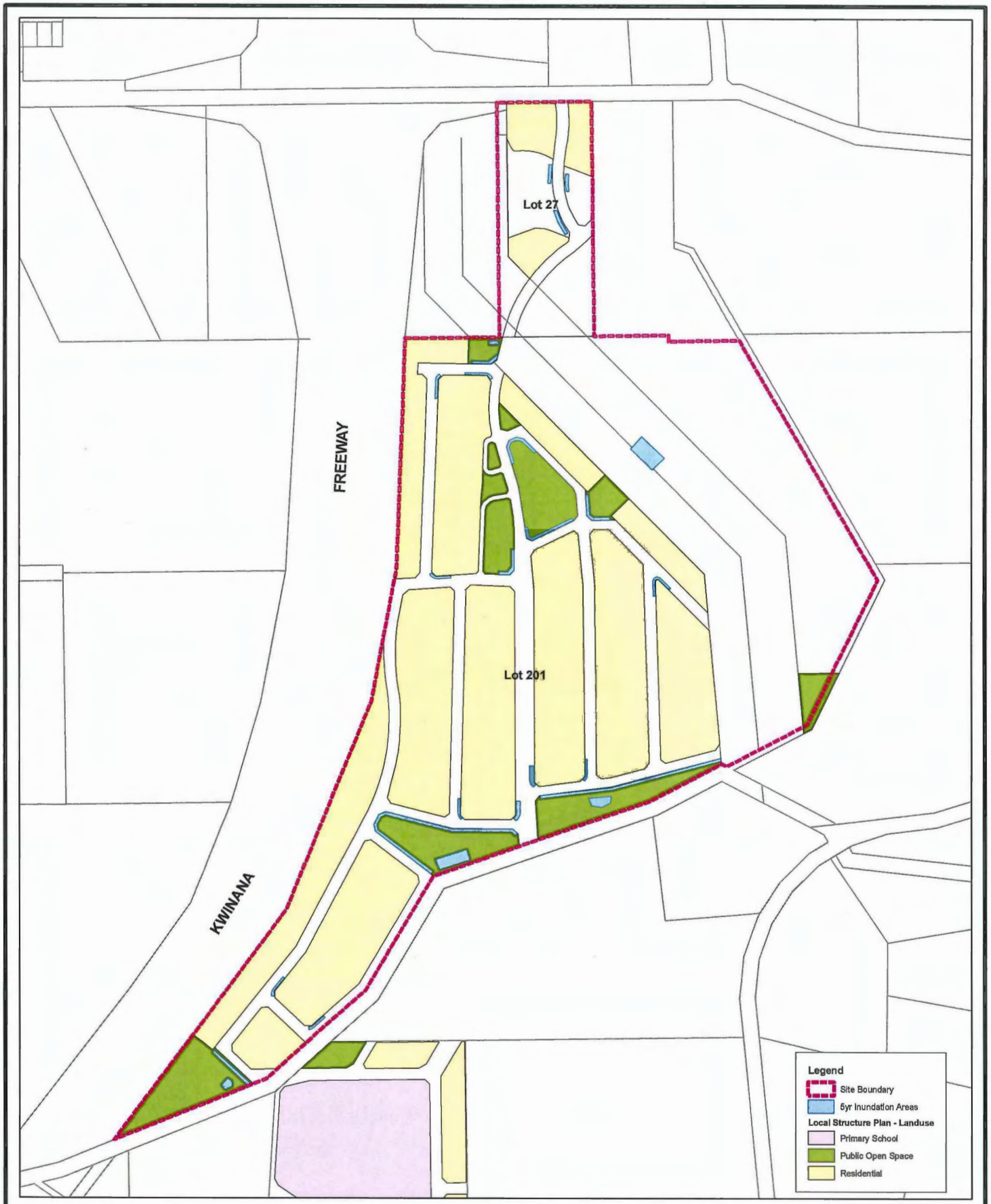
Project Number: V8041
Original: A3
Drawing Number: SK12
Revision: 03
Designed: SLC
Checked: SLC
Drawn: MGW
Approved: DC
Local Authority: Town of Kwinana
Sheet 1 of 1
Date: 20/08/10



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:4,500

0 50 100 200 300 400 500 600 700 Metres

PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 15 : 5yr Inundation Areas

PRINCIPAL: Armana Holdings Pty Ltd

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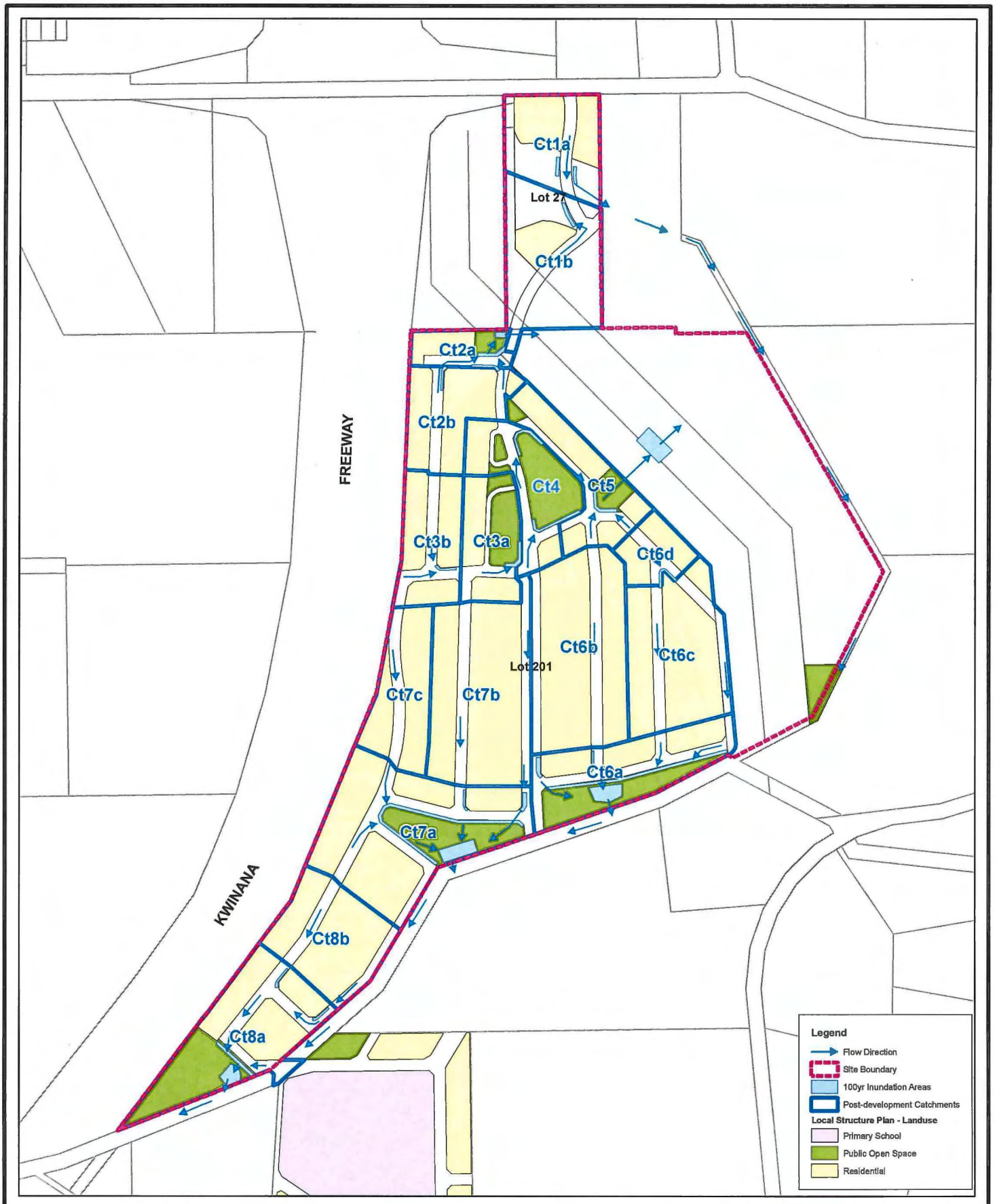
Project Number: V8041
Original: A3
Drawing Number: SK20
Revision: 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10



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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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0 50 100 200 300 400 500 600 700 Metres

PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 16: 100yr Inundation Areas

PRINCIPAL: Armana Holdings Pty Ltd

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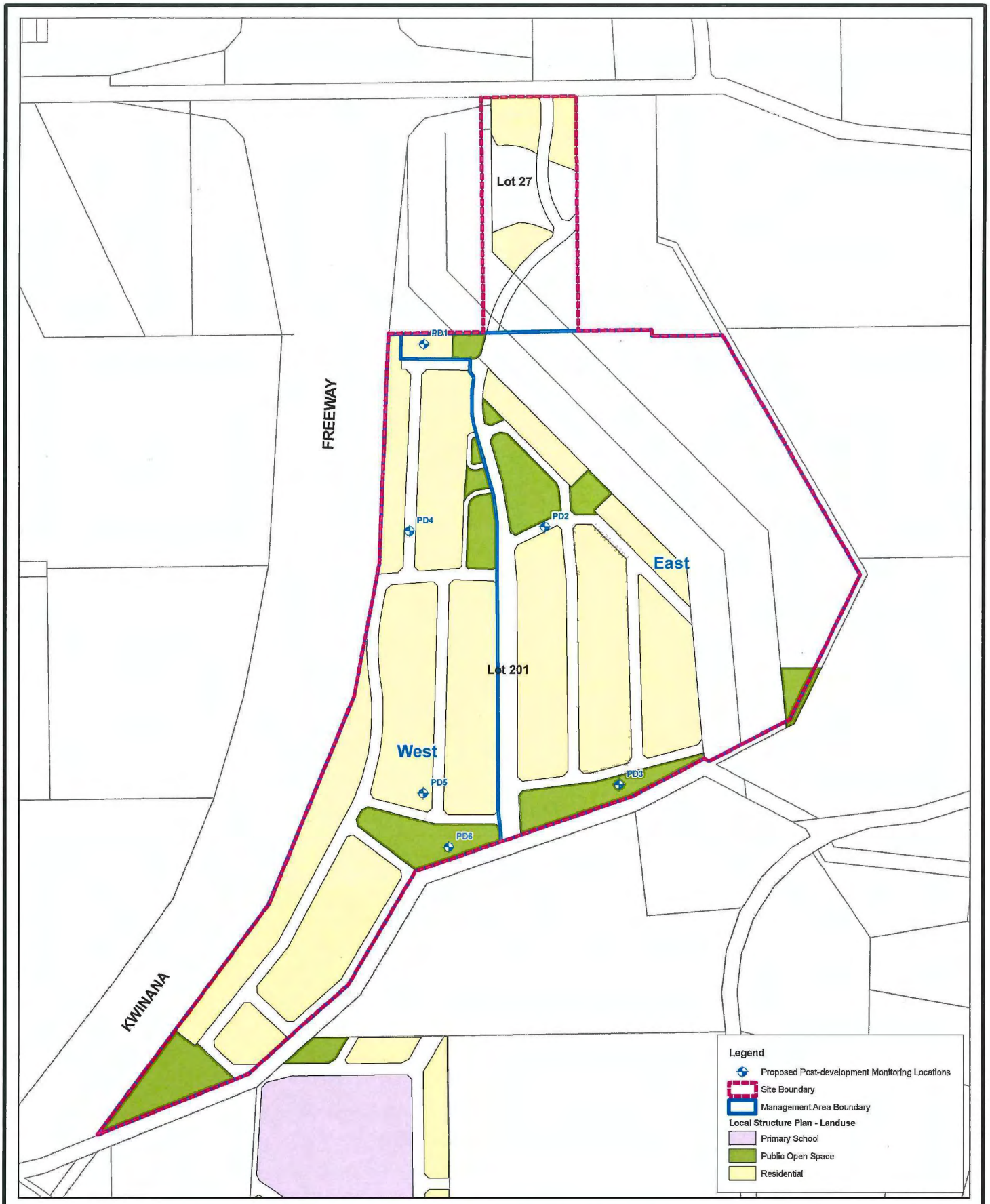
Project Number: V8041
Original: A3
Drawing Number: SK21
Revision: 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD	DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

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Scale: 1:4,500 (0 50 100 200 300 400 500 600 700 Metres)

PROJECT: Lot 27 & Lot 201 Mortimer Road - LWMS

DRAWING TITLE: FIGURE 17 : Proposed Post-Development Monitoring Locations & Management Areas

PRINCIPAL: Amex Coporation Pty Ltd.

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Project Number V8041
Original A3
Drawing Number SK18
Revision 03
Designed SLC
Checked SLC
Drawn MGW
Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1
Date 20/08/10

Appendix A

Local Structure Plan

LEGEND

- Low Density Residential (R20)
- Medium Density Residential (R30/40)
- POS — Public Open Space
- Wetland Core
- Conservation Category Wetland Buffer (50m)
- Proposed Resource Enhancement Wetland Core
- Primary School
- Marsupial Rehabilitation Clinic
- Community Centre
- Existing Trees
- Wellard East Cell Boundary
- Local Structure Plan Boundary
- Indicative Public Transport Route/ Principal Shared Path (PSP)
- Indicative Footpath Network
- Controlled Fencing
- Potential Home Store (max 100m²)



Development Principles

1. The LSP [illegible] applies to the land described as Lots 27 and 201 Mortimer Road that is currently zoned 'Urban' under the Metropolitan Region Scheme (MRS) and 'Rural' under the City of Kwinana Town Planning Scheme No. 2 (TPS2). The design of the Wellard East Local Structure Plan has been prepared in accordance with the Cockburn-Kwinana Industrial Area Concept Plan (CKIA Plan). The boundaries of the Wellard East Cell is subject to further investigations.
2. The LSP has been prepared in accordance with Clause 4.12 of Town Planning Scheme No. 2 (TPS2) and provides the framework for the subdivision and development of the land. The Plan broadly identifies the following key elements: [illegible] POS and [illegible] to create Liveable Neighbourhoods.
3. Detailed Area Plans (DAPs) will be prepared for all medium density coded lots.
4. The development areas and local street network for Lots 27 and 201 Mortimer Road will be subject to further refinement and finalisation of the Detailed Area Plan (DAP) and subdivision stages respectively.
5. Detailed acoustic reports to be prepared [illegible] in accordance with the Western Australian Planning Commission's Draft Guidelines for Planning in Bushfire Prone Areas and Draft Guidelines for Preparing Bushfire Management Plans. The detailed acoustic reports shall be prepared in accordance with [illegible] Considerations in Land Use Planning.
6. Controlled Fencing: As depicted on the LSP, fencing to be constructed to ensure appropriate interface with POS (Western Power Easement).

SUPERSEDED

Wellard East Cell
Local Structure Plan

robertsday

LEGEND

- A — Public Open Space
- Wetland Core
- Conservation Category Wetland Buffer (50m)
- Proposed Resource Enhancement Wetland Core
- Proposed Resource Enhancement Wetland Buffer (30m)
- Existing Trees
- Wellard East Cell Boundary
- Local Structure Plan Boundary



Public Open Space (POS) Schedule

Gross Area of LSP Area	38 907ha
Deductions	
	14 861ha
Net Site Area	24 046ha
Public Open Space @ 10%	2 405ha

POS may comprise

Minimum 80% Unrestricted POS	1 924ha
Maximum 20% Restricted POS	0 481ha
Unrestricted POS Areas	
	2 360ha
Restricted POS	0 241ha
Public Open Space Provision	2 601ha (10 8%)

SUPERSEDED

Wellard East Cell
Local Structure Plan - Public Open Space Schedule

Appendix B

Modelling Assumption, Parameters and Results

Modelling Assumptions, Parameters and Results

Surface water runoff from rainfall events can be estimated using relationships between the surface slope, area, roughness, infiltration and rainfall. The interaction of runoff from areas with different characteristics and the routing of this runoff through a catchment can be very complex; it is for these reasons that computation models are used to ensure the accuracy and speed of the calculations.

For the calculation of the surface water runoff from Lot 27 and Lot 201, the XPSWMM hydrologic and hydraulic modelling software was used. The hydrologic component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. The Laurenson runoff-routing method assumes that runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment. Sub-catchment areas and slopes are determined from topographical data. The infiltration rates and percentage imperviousness can be determined from field experiments or experience with model preparation with similar soil conditions. The runoff from each sub-catchment is routed though the catchment using the hydraulic component of XPSWMM.

Modelling Parameters

The total volume of runoff from an area is determined by the amount of rainfall less the losses (largely from infiltration). The rate of runoff is determined by the slope and roughness (Manning's n) of the surface.

An "initial loss - proportional loss" infiltration model was adopted for the pre-development, with loss values chosen based on Cardno's experience with similar vegetation and soil types to those found within Lot 27 and Lot 201 (**Sections 3.3**, **3.4** and **3.5**). The XPSWMM model was calibrated to regional modelling conducted in InfoWorks CS by the Water Corporation. The post-development model used an "initial loss - continuing loss" infiltration parameters that were influence by the existing loss rates used in the pre-development environment and by Cardno's experience with other residential development modelling. The Infiltration Land Types (ILT) used in the XPSWMM modelling are summarised in **Table B.1**. Each catchments land use area and fraction impervious is shown in **Table B.2**.

Table B.1 Infiltration Loss Parameters for XPSWMM Hydrological Modelling

Infiltration Land Type		Initial Loss (mm)	Proportional Loss	Continuing Loss (mm/hr)	Catchment Roughness
Pre-development	Sand-Sparse	15	0.80	-	0.20
	Sand-Sparse-North	15	0.75	-	0.20
	Sand-Medium	25	0.90	-	0.30
	Wetland-dry	25	0.10	-	0.20
	Wetland-wet	2	-	0.50	0.20
Post-development	Road	1	-	0.10	0.02
	Verge	9	0.80	-	0.15
	Lot Impervious	1	-	0.10	0.02
	Garden	20	0.80	-	0.20
	Roof	7	-	0.10	0.10
	POS	12	0.80	-	0.02

Table B.2 Catchment Land Use Area and Fraction Impervious

Catchment	Catchment Area (ha)	Road Bitumen (ha)	Road Verge (ha)	Lot Roof (ha)	Lot Paved (ha)	Lot Garden (ha)	POS (ha)	Undeveloped (ha)	Fraction Impervious
1a	1.518	0.169	0.253	0.200	0.076	0.227	0.436	0.158	0.293
1b	2.296	0.158	0.237	0.150	0.041	0.122	0.581	1.007	0.152
2a	0.614	0.073	0.109	0.125	0.043	0.128	0.137	0.000	0.391
2b	1.463	0.126	0.188	0.550	0.150	0.449	0.000	0.000	0.564
3a	1.232	0.089	0.134	0.350	0.054	0.162	0.443	0.000	0.400
3b	1.349	0.143	0.215	0.525	0.117	0.350	0.000	0.000	0.582
4	1.574	0.179	0.268	0.175	0.044	0.131	0.778	0.000	0.252
5	1.456	0.168	0.252	0.375	0.113	0.338	0.210	0.000	0.450
6a	2.080	0.238	0.358	0.400	0.068	0.205	0.811	0.000	0.340
6b	3.125	0.275	0.412	1.325	0.278	0.835	0.000	0.000	0.601
6c	2.528	0.221	0.332	0.925	0.263	0.788	0.000	0.000	0.557
6d	0.654	0.070	0.105	0.225	0.064	0.191	0.000	0.000	0.548
7a	3.662	0.338	0.508	0.850	0.282	0.846	0.838	0.000	0.402
7b	3.151	0.284	0.427	1.175	0.316	0.949	0.000	0.000	0.564
7c	1.473	0.122	0.183	0.450	0.180	0.539	0.000	0.000	0.510
8a	2.560	0.213	0.319	0.575	0.147	0.440	0.000	0.866	0.365
8b	1.814	0.140	0.210	0.575	0.222	0.667	0.000	0.000	0.517

Modelling Assumptions

The infiltration rates used were predominantly based upon the following assumptions:

- There will be no infiltration on roads, pavements and driveways. There will however be some minor adsorption storage loss and this is reflected in an initial loss of 1mm and continuing loss of 0.1mm/h;
- Rainwater tanks were assumed to be incorporated within the development and accounted for within the initial loss of the roof. The average roof area of a lot is assumed to be 250m^2. The rainwater tanks used for the modelling were sized at 3kL with a low flow discharge to ensure 1,500L storage capacity is provided for capture of the 1 year - 1 hour ARI storm event.
- Soakwells were assumed to be incorporated within the development and accounted for with storage and infiltration within the model. The sizes of the soakwells were equal to 2.65m^3 per 250m^2 of roof area.
- Garden areas will have high infiltration rates as it is likely that sand or mulch will be used. Residential lots will have little slope (flat) and pockets of storage are likely. This will effectively increase the initial loss (storage) and overall infiltration rate (continuing loss). For these reasons, it is anticipated that the Initial Loss and Continuing loss will be higher than the pre-development environment;

- POS areas will likely contain dense vegetation of turf over a sand base. This turfed area will become compacted over time and reduce initial infiltration rates. For these reasons, it is anticipated that the Initial Loss and Continuing Loss will be higher than the pre-development Sandy Soil Low Infiltration areas but less than the pre-development Sandy Soil High Infiltration areas;
- The verge area is similar to POS areas except that it will also have an impervious footpath portion. For this reason, it is anticipated that the averaged Initial Loss and Continuing Loss will be lower than the POS rates; and
- Infiltration was assumed from the bio-retention system of bio-pockets, tree-pits and swales. A hydraulic conductivity of 5×10^{-5}m/s was assumed for the infiltration of soakwells and bio-retention systems with a 50% clogging factor for the bio-pockets, tree-pits and swales.

From analysis of aerial imagery of residential areas, the proportion of land uses were determined for typically areas such as residential lots and schools. Through this analysis, it was assumed that the lots on average would be consistent with other Perth new developments and have 250m^2 roof areas with the remainder of the lots paved (25%) and pervious garden (75%). The road reserve was assumed to contain 60% pervious verge and 40% impervious bitumen.

Modelling Results

The design criteria (**Section 4**) states that the peak discharge flows and volumes for the 5 year ARI and the 100 year ARI critical duration rainfall events must be generally consistent with the pre-development environment. A comparison was conducted for the post-development and pre-development runoff volumes for the catchments that discharge into the Peel Sub N Drain downstream of the Mortimer Wetland. The Mortimer Wetland provides detention storage and thus a comparison downstream of the wetland enables a more accurate analysis of the effect of the development on the runoff volumes from Lot 27 and Lot 201.

The overall post-development peak discharge, shown in **Table 7.3.2.b**, shows peak flows equivalent to the pre-development discharge rates. The average discharge per unit area from each sub-catchment is shown in **Table B.3**.

Table B.3 Sub-catchment Peak Discharge Comparison

Sub-catchment	Average Discharge per Unit Area ($m^3/s/ha$)					
	5 year ARI		10 year ARI		100 year ARI	
	Pre-Dev	Post-Dev	Pre-Dev	Post-Dev	Pre-Dev	Post-Dev
1a	0.004	0.018	0.004	0.022	0.007	0.030
1b	0.008	0.015	0.009	0.018	0.013	0.024
2a	0.004	0.000	0.005	0.000	0.008	0.011
2b	0.003	0.000	0.003	0.000	0.005	0.050
3a	0.005	0.027	0.006	0.060	0.009	0.088
3b	0.003	0.021	0.003	0.039	0.005	0.052
4	0.008	0.005	0.009	0.028	0.015	0.107
5	0.011	0.000	0.013	0.000	0.021	0.032
6a	0.020	0.004	0.025	0.005	0.035	0.055
6b	0.007	0.059	0.008	0.086	0.012	0.120
6c	0.008	0.110	0.010	0.095	0.014	0.125
6d	0.001	0.000	0.002	0.000	0.003	0.001
7a	0.019	0.005	0.023	0.005	0.032	0.186
7b	0.007	0.069	0.008	0.087	0.012	0.117
7c	0.003	0.035	0.004	0.041	0.006	0.054
8a	0.010	0.000	0.012	0.001	0.017	0.009
8b	0.004	0.000	0.005	0.036	0.007	0.059

As discussed in **Section 3.7.1**, the XPSWMM model was calibrated to the InfoWorks CS model as published *Jandakot Structure Plan Area Drainage and Water Management Plan (Jandakot DWMP)*. The figure below shows the pre- and post-development hydrographs within the Peel Sub N drain underneath the Kwinana Freeway. The 10 year and 100 year peak flows in the drain at this location is recorded as $0.70m^3/s$ and $0.93m^3/s$ respectively, as recorded in Figure 5.5c of Appendix C of the *Jandakot DWMP*. This corresponds with peak flows of $0.60m^3/s$ and $0.93m^3/s$ for the 10 year and 100 year ARI events for the XPSWMM model as shown in the figure below (**Figure B.1**).

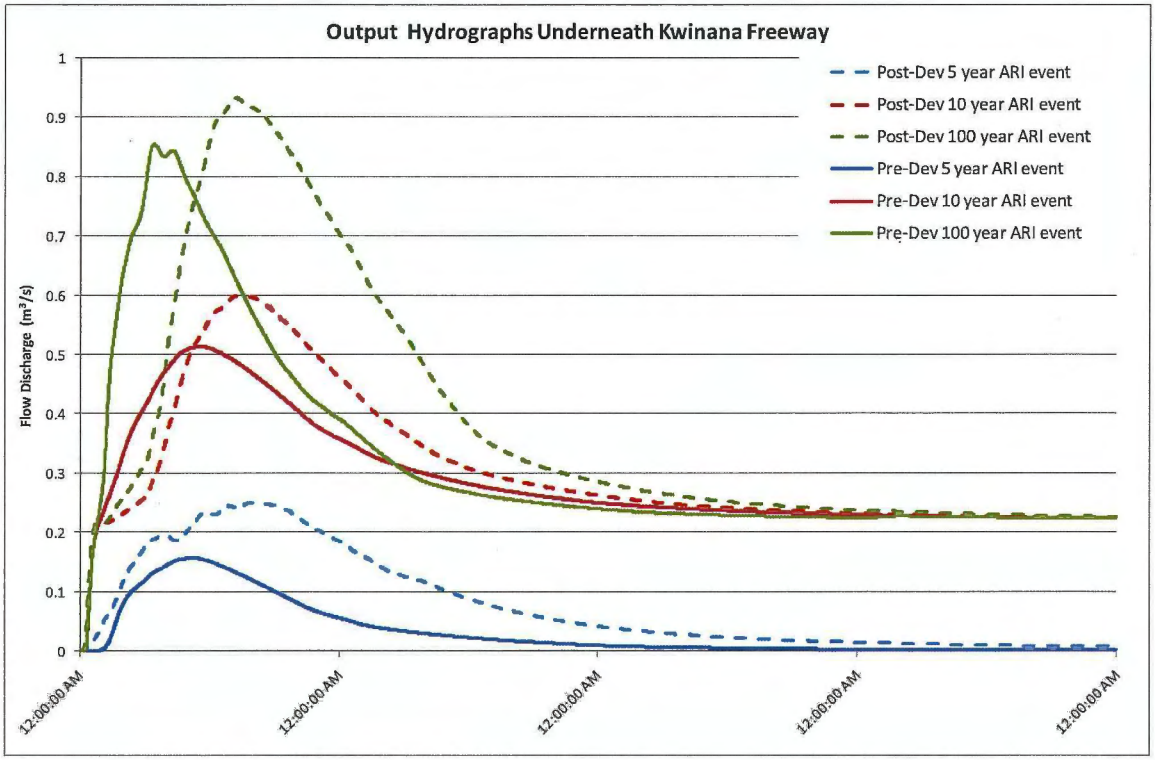


Figure B.1 **Pre- and Post-Development Hydrographs within Peel Sub N Drain beneath Kwinana Freeway**

The maximum water level and flooded surface area within each FSA is shown in **Table B.4**. **Table B.5** below summarises all of the drainage area within POS areas required in the Lot 27 and Lot 201 development for the calculation of the POS credits.

Table B.4 **Maximum Water Level within FSA**

Catchment	5yr Depth (m)	5yr Area (m^2)	10yr Depth (m)	10yr Area (m^2)	100yr Depth (m)	100yr Area (m^2)
2	0.37	70	0.40	75	0.50	100
5	0.10	870	0.18	925	0.30	1,015
6	0.31	380	0.60	530	1.00	775
7	0.31	680	0.50	800	0.50	800
8	0.11	130	0.35	200	1.00	455
Total	-	2,130	-	2,530	-	3,145

Table B.5 Inundated Areas for POS Credit Calculation

Sub-catchment	Inundated Area within POS (m^2)		
	1 year – 1 hour ARI	5 year ARI	100 year ARI
2a	50	200	270
3a	150	200	200
4	250	525	580
5	160	235	235
6a	575	1,315	1,790
7a	875	1,830	1,995
8a	165	420	775
Total	2,225	4,725	5,845

Appendix C

Groundwater and Surface Water Quality Results and Hydrographs

Table C.1 Groundwater Bore WE1

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	1,200	1,900	1,500	730	960	1,200	700	250
TP - µg/L	160	130	76	47	15	26	15	10
Ortho-P - µg/L	6	6	4	4	<2	3	4	4
NH_4 - µg/L	4	8	<3	<3	23	13	8	<3
NO_2+NO_3 - µg/L	1,200	1,400	1,200	600	850	1,000	600	160
TKN - µg/L	<200	400	300	<200	<200	200	<200	<200
DO (mg/l)	-	8.9	9.16	3.17	4.98	7.19	2.93	2.28
pH	4.95	5.33	5.73	5.46	3.97	6.23	6.63	4.41
Cond (mS/cm)	0.11	0.27	0.16	0.164	0.196	0.150	0.176	0.212
Redox	323	36	239	226	282	201	159	275
Salinity (ppt)	0.06	0.13	0.08	0.08	0.09	0.07	0.09	0.1
Turbidity (ntu)	573	31	333	30	15	2.4	25	2.1
Temp (℃)	21.39	18.81	21.4	20.99	21.6	21.49	20.78	20.63

Table C.2 Groundwater Bore WE2

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	4,100	3,000	1,700	610	1,200	1,300	2,700	1,100
TP - µg/L	160	200	540	370	33	51	200	64
Ortho-P - µg/L	9	4	5	3	9	3	4	9
NH_4 - µg/L	100	250	210	150	130	130	210	170
NO_2+NO_3 - µg/L	160	<2	27	3	9	5	3	33
TKN - µg/L	4,000	3,000	1,700	600	1,200	1,300	2,700	1,100
DO (mg/l)	0.13	0.04	1.10	2.30	1.33	1.74	1.59	1.77
pH	5.60	5.00	5.33	5.46	5.06	4.94	5.30	5.62
Cond (mS/cm)	0.27	0.30	0.23	0.24	0.44	0.47	0.27	0.29
Redox	319	25	-92	29	-8	80	6	6
Salinity (ppt)	0.13	0.15	0.11	0.11	0.21	0.22	0.13	0.14
Turbidity (ntu)	29	53	636	330	14	240	980	490
Temp (℃)	17.19	18.7	20.12	16.04	18.49	20.75	19.63	16.4

Table C.3 Groundwater Bore WE3

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	5,000	4,300	5,300	6,700	7,200	4,500	7,400	8,300
TP - µg/L	1,200	1,100	440	110	78	91	43	66
Ortho-P - µg/L	5	5	5	6	4	6	8	61
NH_4 - µg/L	7	<3	4	<3	<3	6	<3	<3
NO_2+NO_3 - µg/L	4,700	3,200	4,700	5,700	3,300	3,900	7,200	6,900
TKN - µg/L	400	1,200	600	1,000	4,000	600	200	1,500
DO (mg/l)	-	0.92	3.97	4.57	5.34	4.85	4.19	5.37
pH	6.12	5.33	5.70	5.86	5.49	6.05	6.01	5.61
Cond (mS/cm)	0.20	0.31	0.22	0.21	0.21	0.20	0.21	0.22
Redox	311	398	63	220	213	196	154	225
Salinity (ppt)	0.10	0.15	0.10	0.10	0.10	0.09	0.10	0.10
Turbidity (ntu)	573	19	617	280	150	120	120	120
Temp (℃)	20.31	17.6	20.32	19.93	20.95	20.55	20.17	20.24

Table C.4 Groundwater Bore WE4

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	7,200	9,600	7,900	7,700	9,300	9,500	7,200	8,100
TP - µg/L	2,200	2,700	2,200	2,900	2,500	3,000	3,000	2,500
Ortho-P - µg/L	2,200	2,300	1,900	2,200	2,500	2,800	2,300	2,200
NH_4 - µg/L	1,800	5,700	4,200	3,000	4,300	4,600	4,100	3,200
NO_2+NO_3 - µg/L	180	85	58	70	99	97	55	68
TKN - µg/L	7,100	9,500	7,800	7,700	9,200	9,400	7,200	8,000
DO (mg/l)	-	0.11	0.48	2.28	1.51	0.98	0.69	2.37
pH	6.28	4.67	5.40	5.49	5.54	5.12	5.39	5.84
Cond (mS/cm)	0.41	0.60	0.49	0.46	0.49	0.49	0.46	0.46
Redox	276	186	-111	-106	-55	-25	-63	-44
Salinity (ppt)	0.20	0.30	0.24	0.22	0.24	0.24	0.22	0.22
Turbidity (ntu)	374	96	92	110	91	78	22	89
Temp (℃)	17.55	16.4	19.23	17.89	18.84	20.08	20.02	17.75

Table C.5 Groundwater Bore WE5

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	2,200	3,800	2,400	2,900	3,200	4,300	4,500	3,500
TP - µg/L	1,700	2,800	2,800	4,100	4,700	6,400	4,600	4,200
Ortho-P - µg/L	1,600	2,200	1,700	3,400	3,100	5,000	2,800	3,400
NH_4 - µg/L	170	320	440	1,100	120	1,700	1,400	1,000
NO_2+NO_3 - µg/L	6	6	16	7	24	8	5	8
TKN - µg/L	2,200	3,800	2,400	2,900	3,200	4,300	4,500	3,500
DO (mg/l)	-	0.03	0.74	1.71	1.60	1.66	0.83	1.86
pH	6.35	4.72	6.70	6.64	6.72	6.33	6.51	6.63
Cond (mS/cm)	0.62	0.62	0.63	0.71	0.64	0.75	0.74	0.83
Redox	230	107	-104	-74	-57	-46	-89	-20
Salinity (ppt)	0.31	0.31	0.31	0.34	0.31	0.36	0.36	0.40
Turbidity (ntu)	143	26	150	38	55	210	-	31
Temp (℃)	19.55	19.5	21.43	19.23	3200	22.19	21.67	2 0.09

Table C.6 Groundwater Bore WE6

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	5,600	4,300	4,300	3,800	6,000	5,600	5,600	4,800
TP - µg/L	890	950	920	610	1,100	1,300	1,400	1,000
Ortho-P - µg/L	110	90	190	170	170	230	200	110
NH_4 - µg/L	420	650	470	450	410	430	440	450
NO_2+NO_3 - µg/L	15	13	17	13	15	20	15	15
TKN - µg/L	5,600	4,300	4,300	3,700	5,900	5,600	5,500	4,800
DO (mg/l)	-	0.04	6.01	2.40	1.22	5.25	2.52	0.90
pH	6.59	6.12	6.89	6.85	6.85	6.87	6.93	7.05
Cond (mS/cm)	2.87	3.02	3.09	2.94	2.22	1.71	1.04	2.77
Redox	206	58	-159	-172	-123	-110	-139	-117
Salinity (ppt)	1.50	1.58	1.64	1.52	1.13	0.85	0.51	1.43
Turbidity (ntu)	573	37	981	1100	920	380	2400	2400
Temp (℃)	18.4	18.5	20.6	18.6	19.53	21.07	21.07	18. 98

Table C.7 Groundwater Bore WE7

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	16,000	21,000	15,000	13,000	11,000	28,000	17,000	22,000
TP - µg/L	7,200	11,000	9,200	6,100	5,000	5,400	5,200	8,000
Ortho-P - µg/L	6,000	3,000	5,900	4,500	5,000	4,400	2,000	980
NH_4 - µg/L	280	450	690	600	660	470	890	340
NO_2+NO_3 - µg/L	49	29	21	16	19	26	15	16
TKN - µg/L	16,000	21,000	15,000	13,000	11,000	28,000	17,000	22,000
DO (mg/l)	-	0.04	1.72	1.80	1.94	1.18	3.93	2.33
pH	6.67	6.11	6.66	6.57	6.89	6.47	6.55	6.73
Cond (mS/cm)	1.68	2.50	2.28	2.31	1.59	5.12	4.29	4.13
Redox	206	-18	-136	-149	104	-91	-119	-94
Salinity (ppt)	0.86	1.30	1.16	1.18	0.79	2.74	2.27	2.18
Turbidity (ntu)	573	6.7	327	61	31	24	190	480
Temp (℃)	18.4	19.2	21.05	17.5	18.8	21.84	21.1	17.84

Table C.8 Groundwater Bore WL7

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	10,000	15,000	16,000	16,000	20,000	19,000	18,000	14,000
TP - µg/L	3,700	3,500	3,100	3,300	3,600	3,800	3,700	3,000
Ortho-P - µg/L	2,800	1,100	2,800	3,200	2,800	3,400	3,200	2,800
NH_4 - µg/L	1,600	940	2,400	2,300	2,400	2,800	3,200	1,900
NO_2+NO_3 - µg/L	79	320	160	240	250	320	200	470
TKN - µg/L	10,000	14,000	16,000	16,000	20,000	19,000	18,000	14,000
DO (mg/l)	-	0.49	3.67	3.23	1.95	2.79	5.16	3.70
pH	6.30	4.40	5.34	5.25	5.23	5.15	5.36	5.75
Cond (mS/cm)	0.31	0.39	0.39	0.40	0.42	0.40	0.40	0.42
Redox	325	327	-90	-29	-22	-5	-32	-12
Salinity (ppt)	0.18	0.19	0.19	0.19	0.20	0.19	0.19	0.20
Turbidity (ntu)	573	33	946	260	210	170	690	340
Temp (℃)	17.89	19.6	20.2	15.54	19.2	22.37	20.18	16.53

Table C.9 Groundwater Bore WL8

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	2,800	2,900	1,900	2,700	3,500	2,500	2,800	2,600
TP - µg/L	1,300	1,600	1,200	2,000	2,300	2,000	1,600	1,100
Ortho-P - µg/L	1,300	2,100	1,200	1,500	1,900	2,000	1,400	950
NH_4 - µg/L	130	870	230	190	260	260	300	190
NO_2+NO_3 - µg/L	280	480	11	19	30	29	12	19
TKN - µg/L	2,600	2,500	1,900	2,700	3,500	2,500	2,700	2,600
DO (mg/l)	-	0.36	4.76	2.84	1.92	3.27	6.02	2.42
pH	6.32	4.41	5.10	5.10	4.93	5.12	5.75	5.56
Cond (mS/cm)	0.36	0.31	0.22	0.14	0.17	0.14	0.19	0.21
Redox	391	368	35	138	73	103	47	93
Salinity (ppt)	0.18	0.16	0.10	0.07	0.08	0.07	0.09	0.10
Turbidity (ntu)	573	6.5	655	97	35	92	3,000	320
Temp (℃)	17.97	17.4	20.21	17.75	19.74	20.39	20.46	17.65

Table C.10 Groundwater Bore WL9

	Nov-05	Jan-06	Apr-06	Jul-06	Oct-06	Feb-07	May-07	Jul-07
TN - µg/L	2,000	5,000	3,300	1,900	2,000	1,900	2,600	2,100
TP - µg/L	110	460	180	49	30	36	310	37
Ortho-P - µg/L	100	36	8	9	7	6	5	10
NH_4 - µg/L	440	610	520	380	530	600	640	780
NO_2+NO_3 - µg/L	660	16	7	7	5	7	5	6
TKN - µg/L	1,400	4,900	3,300	1,900	2,000	1,900	2,600	2,100
DO (mg/l)	n/a	0.03	7.10	2.89	1.80	1.83	2.96	2.19
pH	6.33	4.66	5.95	5.08	5.10	4.81	5.73	5.43
Cond (mS/cm)	0.22	0.28	0.20	0.17	0.22	0.23	0.22	0.25
Redox	353	239	-9	90	43	93	58	58
Salinity (ppt)	0.11	0.14	0.10	0.08	0.11	0.11	0.11	0.12
Turbidity (ntu)	132	52	191	23	9.7	22	170	8.4
Temp (℃)	18.33	17.2	20.56	18.2	18.88	20.49	20.31	18.45

Table C.11 Surface Water Location PBD1

	Nov-05	Jul-06	Aug-06	Aug-07	Sep-07	Jul-08	Aug-08	Oct-08
TN - µg/L	1,400	900	1,300	1,400	1,200	1,800	1,500	1,500
TP - µg/L	36	46	44	40	43	50	52	52
Ortho-P - µg/L	9	5	7	9	10	15	10	6
NH_4 - µg/L	20	15	31	130	47	130	100	39
NO_2+NO_3 - µg/L	13	15	14	10	7	27	26	8
TKN - µg/L	1,400	900	1,200	1,400	1,200	1,800	1,500	1,500
DO (mg/l)	-	7.81	6.02	3.61	3.63	3.7	-	3.14
pH	6.49	6.84	5.28	6.30	5.93	5.47	6.19	5.77
Cond (mS/cm)	0.72	0.813	0.93	1.21	1.12	0.8	0.782	0.758
Redox	272	93	191	167	145	205	115	173
Salinity (ppt)	0.38	0.4	0.44	0.66	0.45	0.39	0.38	0.37
Turbidity (ntu)	-	-	-	-	-	7.6	-	-
Temp (℃)	19.7	12.03	17.5	16.97	18.2	12.61	12.25	20 .58

Table C.12 Surface Water Location PBD2

	Nov-05	Jul-06	Aug-06	Aug-07	Sep-07	Jul-08	Aug-08	Oct-08
TN - µg/L	11,000	-	2,500	-	7,100	7,600	23,000	-
TP - µg/L	420	-	130	-	680	1,500	4,100	-
Ortho-P - µg/L	120	-	81	-	180	1000	2600	-
NH_4 - µg/L	190	-	110	-	66	91	740	-
NO_2+NO_3 - µg/L	100	-	30	-	19	29	94	-
TKN - µg/L	11,000	-	2,400	-	7,100	7,600	23,000	-
DO (mg/l)	-	-	6.11	-	2.39	4.5	6.93	-
pH	-	-	-	-	-	-	65.4	-
Cond (mS/cm)	6.4	-	5.75	-	6.81	5.01	5.82	-
Redox	0.57	-	1.04	-	0.36	0.65	6.93	-
Salinity (ppt)	323	-	175	-	86	156	70	-
Turbidity (ntu)	0.31	-	0.51	-	0.18	0.32	0.31	-
Temp (℃)	4.7	-	4.4	-	-	2.6	-	-

Table C.13 Surface Water Location PBD3

	Nov-05	Jul-06	Aug-06	Aug-07	Sep-07	Jul-08	Aug-08	Oct-08
TN - µg/L	1,700	-	1,400	2,400	6,400	2,500	-	2,500
TP - µg/L	200	-	160	230	920	250	-	360
Ortho-P - µg/L	130	-	120	150	110	200	-	210
NH_4 - µg/L	48	-	23	44	50	130	-	65
NO_2+NO_3 - µg/L	22	-	16	17	29	96	-	25
TKN - µg/L	1,700	-	1,400	2,400	6,300	2,400	-	2,400
DO (mg/l)	-	-	5.48	5.29	6.98	6.63	-	5.5
pH	-	-	5.54	6.74	5.47	5.47	-	5.64
Cond (mS/cm)	-	-	0.892	1.21	0.93	0.75	-	0.589
Redox	-	-	189	93	124	156	-	160
Salinity (ppt)	-	-	0.44	0.60	0.45	0.36	-	0.28
Turbidity (ntu)	-	-	-	3.9	-	6.8	-	-
Temp (℃)	-	-	16.83	19.04	17.91	14.04	-	22

Table C.14 Surface Water Location PBD4

	Nov-05	Jul-06	Aug-06	Aug-07	Sep-07	Jul-08	Aug-08	Oct-08
TN - µg/L	1,700	-	1,300	2,700	3,000	4,700	2,200	2,300
TP - µg/L	190	-	290	320	140	540	220	230
Ortho-P - µg/L	140	-	230	220	46	370	210	110
NH_4 - µg/L	38	-	18	57	38	83	94	35
NO_2+NO_3 - µg/L	19	-	8	21	15	78	32	13
TKN - µg/L	1,600	-	1,300	2,700	3,000	4,600	2,200	2,300
DO (mg/l)	-	-	5.60	5.10	6.39	6.31	6.95	4.21
pH	-	-	5.98	6.80	1.4	0.92	1.149	7.06
Cond (mS/cm)	-	-	0.92	-	93	195	123	0.753
Redox	-	-	197	-	0.7	0.48	0.57	162
Salinity (ppt)	-	-	0.44	-	-	8.6	-	0.37
Turbidity (ntu)	-	-	-	6.1	20.18	14.98	25.71	-
Temp (℃)	-	-	17.28	19.11	6.39	6.31	6.95	22.81

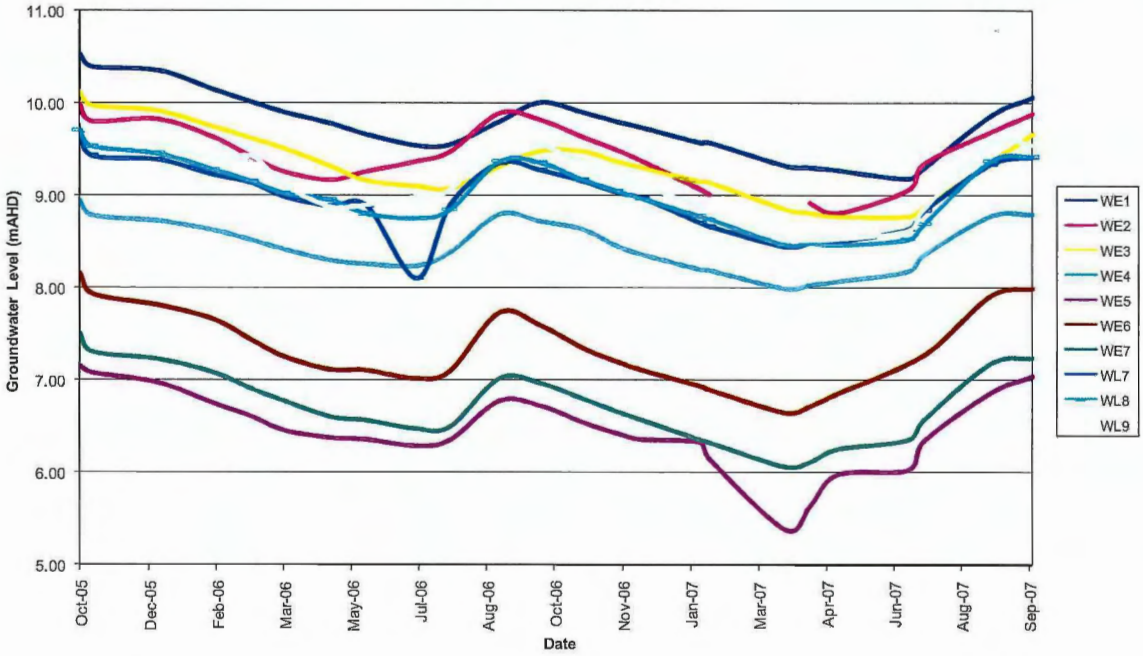
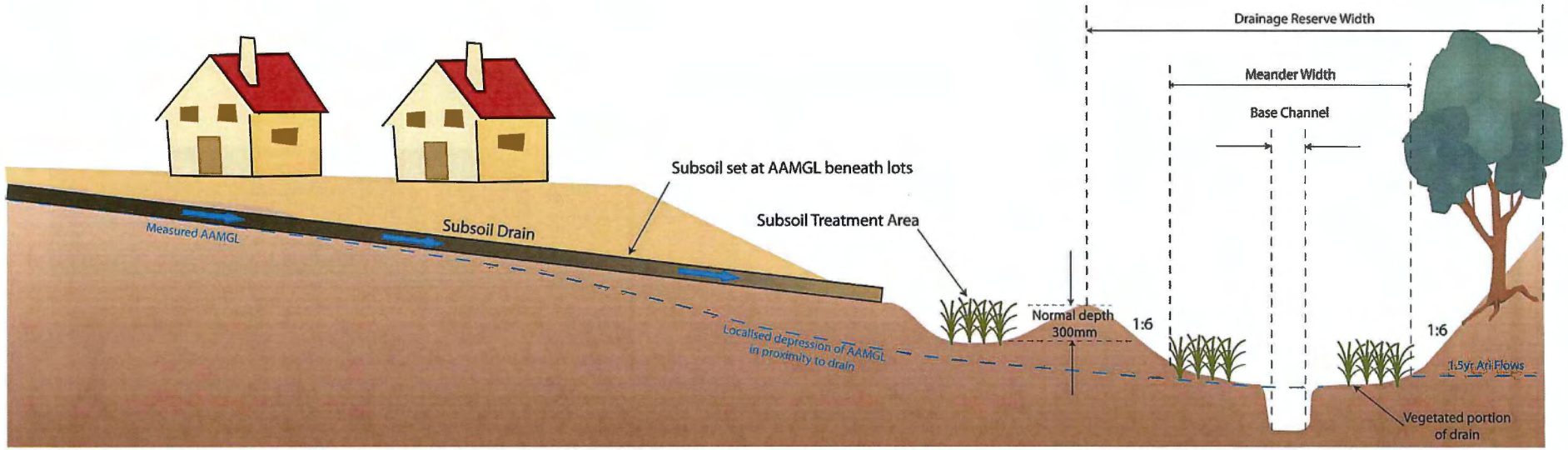


Figure C1 Groundwater Hydrographs

Appendix D

Subsoil Concept Designs



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **Lot 27 & Lot 201 Mortimer Road - LWMS**

DRAWING TITLE **FIGURE 3 : Appendix D1 - Subsoil Drain Discharge to Channel**

PRINCIPAL **Armana Holdings Pty Ltd**

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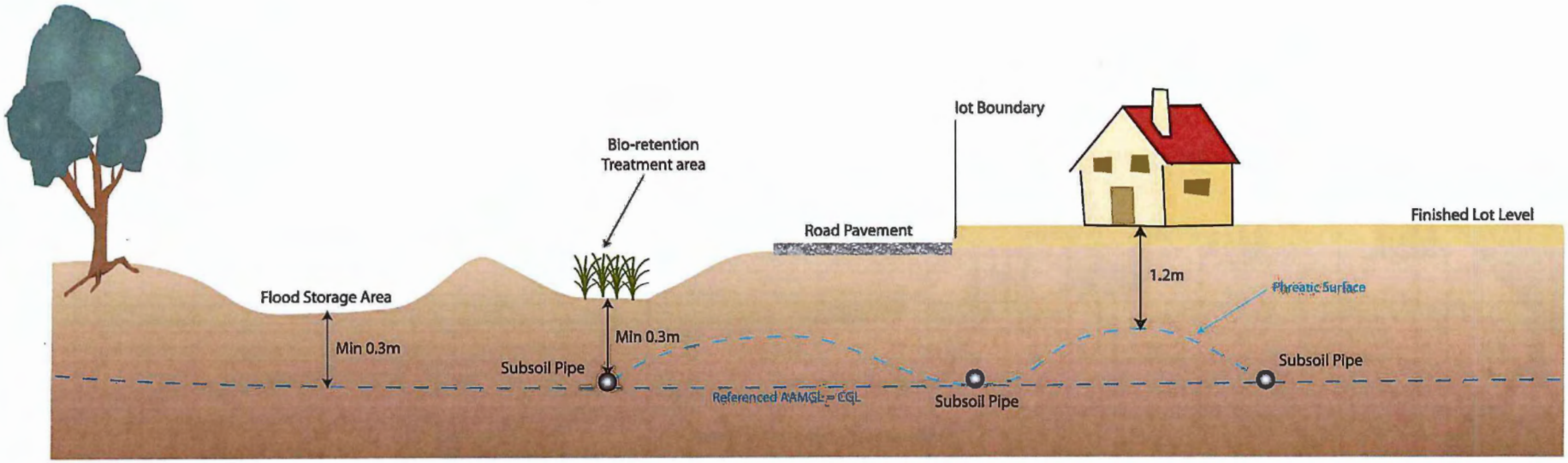
Scale:

Cardno
CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Cardno Centre 2 Bagot Road
P.O. Box 155 Subiaco
Western Australia 6904
Telephone (08) 9273 3888
Facsimile (08) 9388 3831

Project Number	Drawing Number	Revision	Original
V8041	SK00	03	A3

Designed SLC Checked SLC Date 20/08/10
Drawn MGW Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1



DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **Lot 27 & Lot 201 Mortimer Road - LWMS**

DRAWING TITLE **FIGURE 3 : Appendix D2 - Concept Plan Subsoil Drains**

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Western Australia 6904
Telephone (08) 9273 3888
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Project Number	Drawing Number	Revision	Original
V8041	SK24	03	A3

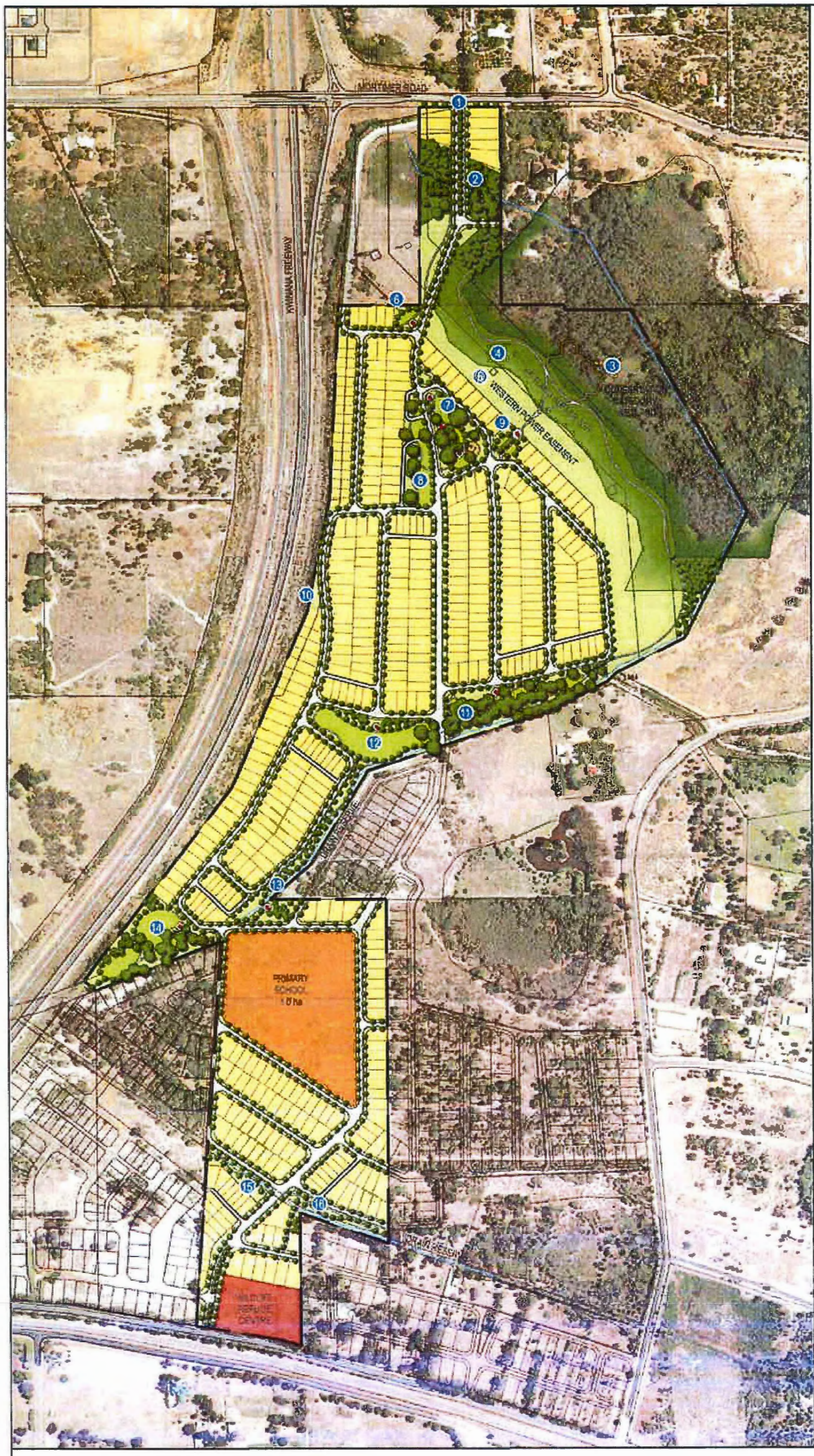
Designed SLC Checked SLC Date 20/08/10
Drawn MGW Approved DC
Local Authority Town of Kwinana
Sheet 1 of 1

Appendix E

Landscape Master Plan

Appendix F

Living Stream Concept Design



1. ENTRY STATEMENT
   - SIGNAGE INTO ESTATE AND HIGH PROFILE PLANTING
   - DISPLAY HOMES AND SALES OFFICE
2. RESOURCE ENHANCEMENT AREA - 13,710 sqm
   - ENHANCEMENT BUFFER SUBJECT TO REDUCTION
   - EXISTING TREES TO BE RETAINED
   - LIVING STREAM / MULTIPLE USE CORRIDOR
3. CONSERVATION CATEGORY WETLAND (CCW) - 61,095 sqm
   - MINIMAL LANDSCAPE WORKS TO OCCUR
   - WEED ERADICATION AND REVEGETATION
   - POSSIBLE ACCESS THROUGH BOARDWALK AND OVERLOOK
4. WETLAND BUFFER - 39,755 sqm
   - NATIVE NON-IRRIGATED PLANTING
   - PEDESTRIAN PATH SYSTEMS COMPRISING OF SEALED PATHS, VIEWING PLATFORMS, AND BOARDWALKS
   - VEGETATION BUFFERS
   - INTERPRETATIVE SIGNAGE
5. WESTERN POWER EASEMENT - 36,365 sqm
   - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
   - TYPICALLY NO TREE PLANTING
   - IRRIGATED AND NON-IRRIGATION AREAS WITH NATIVE PLANTING
   - PUBLIC ART ON KEY AXIS TO DISTRACT FROM PYLONS
6. POCKET PARK 6 - 1,670 sqm
   - KEY SHELTER OR ART ON AXIS TO DISTRACT FROM PYLONS ON ENTRY ROAD
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - BORE IRRIGATION
7. PUBLIC OPEN SPACE 7 - 9,015 sqm
   - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
   - RECREATION FACILITIES SUCH AS SHADE SHELTERS BBQ, PICNIC TABLES, FURNITURE AND PLAY EQUIPMENT
   - EXISTING TREES TO BE RETAINED
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - BORE IRRIGATION
8. PUBLIC OPEN SPACE 8 - 6,520 sqm
   - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
   - RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, PUBLIC ART, AND FURNITURE
   - EXISTING TREES TO BE RETAINED
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - BORE IRRIGATION
9. PUBLIC OPEN SPACE 9 - 2,330 sqm
   - PEDESTRIAN LINKS TO CCW AND POWER EASEMENT
   - RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, AND FURNITURE
   - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
   - INTERPRETIVE SIGNAGE
   - BORE IRRIGATION
10. POCKET PARK 10 - 1,410 sqm
    - NATIVE PLANTING AND BORE IRRIGATION
    - SEATING
11. PUBLIC OPEN SPACE 11 - 14,590 sqm
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, AND FURNITURE
    - LIVING STREAM / MULTIPLE USE CORRIDOR
    - EXISTING TREES TO BE RETAINED
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - INFORMAL KICKABOUT AREA
    - STORMWATER TREATMENT AREA
    - BORE IRRIGATION
12. PUBLIC OPEN SPACE 12 - 11,880 sqm
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - RECREATION FACILITIES SUCH AS SHADE SHELTERS BBQ, PICNIC TABLES, AND FURNITURE
    - LIVING STREAM / MULTIPLE USE CORRIDOR
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - INFORMAL KICKABOUT AREA
    - STORMWATER TREATMENT AREA
    - BORE IRRIGATION
13. PUBLIC OPEN SPACE 13 - 9,525 sqm
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, AND FURNITURE
    - LIVING STREAM / MULTIPLE USE CORRIDOR
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - STORMWATER TREATMENT AREA
    - BORE IRRIGATION
14. PUBLIC OPEN SPACE 14 - 13,115 sqm
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - RECREATION FACILITIES SUCH AS SHADE SHELTERS BBQ, PICNIC TABLES, PLAY EQUIPMENT AND FURNITURE
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - INFORMAL KICKABOUT AREA
    - STORMWATER TREATMENT AREA
    - BORE IRRIGATION
15. PUBLIC OPEN SPACE 15 - 3,020 sqm
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - LIVING STREAM / MULTIPLE USE CORRIDOR
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - STORMWATER TREATMENT AREA
    - BORE IRRIGATION
16. PUBLIC OPEN SPACE 16 - 4,890 sqm
    - PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
    - LIVING STREAM / MULTIPLE USE CORRIDOR
    - MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
    - STORMWATER TREATMENT AREA
    - BORE IRRIGATION

WELLARD CASCADES

Landscape Masterplan

Armana Holdings Pty Ltd.

SUPERSEDED

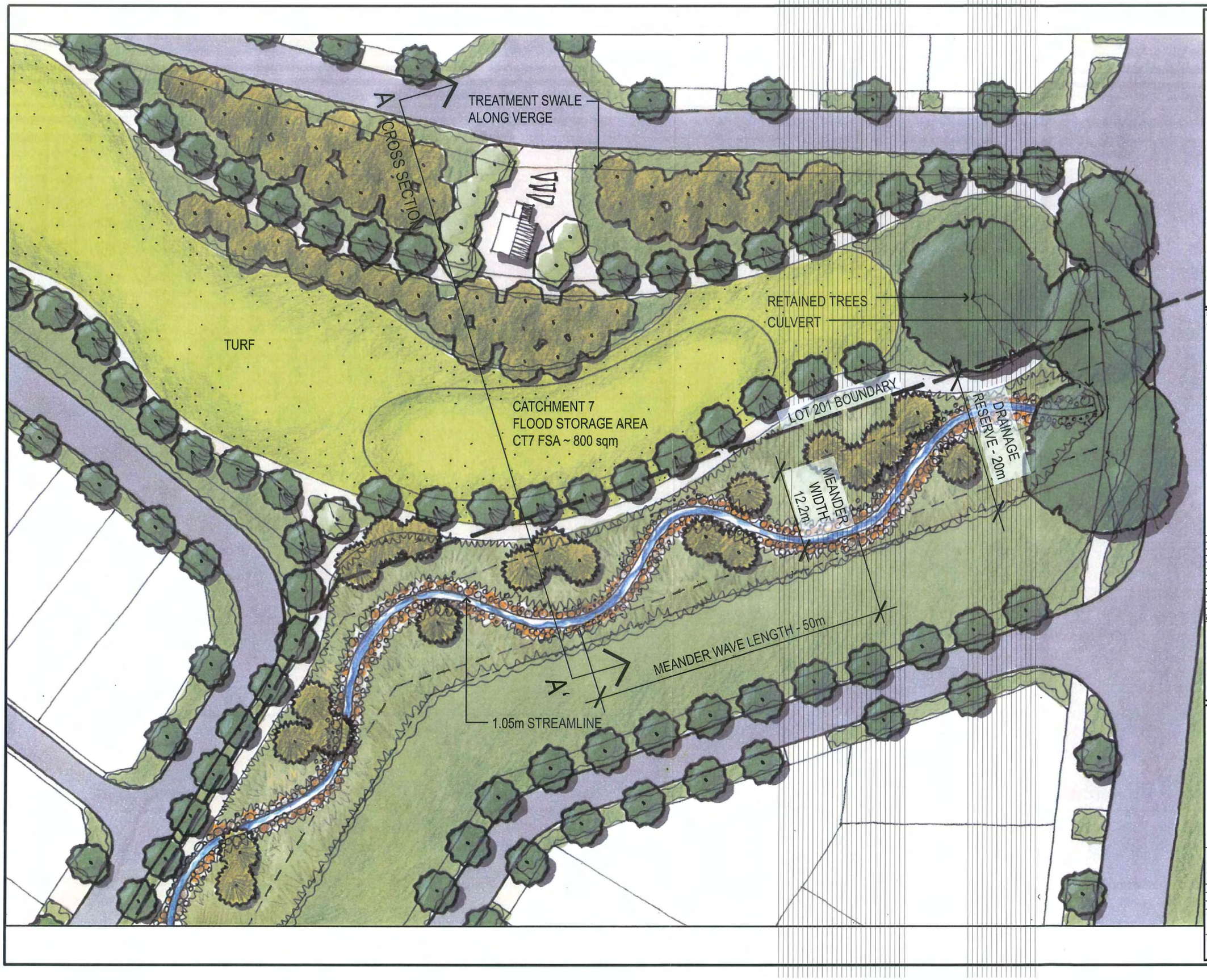
LEGEND

- FEATURE STRUCTURE ELEMENT OR FACILITY SET ON AXIAL VIEW
- FORMAL PUBLIC OPEN SPACE
- WETLAND BUFFER
- LIVING STREAM
- EXISTING TREES TO BE RETAINED

mnla

Scale 1:3000 at A1

Rev B 29 March 2010



STANDARD NOTES

1. **SET OUT & DIMENSIONS.** THE CONTRACTOR SHALL SET OUT ALL PATHS, WALLS, HARD SURFACES AND ELEMENTS EITHER ON OR OFFSITE PRIOR TO CONSTRUCTION AND SHALL OBTAIN THE SUPERINTENDENTS SET OUT APPROVAL PRIOR TO WORKS COMMENCING. WRITTEN DIMENSIONS SHALL TAKE PRECEDENCE OVER SCALE. CHECK ALL DRAWING SCALES IN CONJUNCTION WITH DRAWING SIZE.
2. **SERVICES & SITE ASSETS.** THE CONTRACTOR SHALL INVESTIGATE THE NATURE AND LOCATION OF ALL EXISTING SERVICES AND RETAINED SITE ASSETS AFFECTED BY THEIR WORKS. FAILURE TO TAKE DUE CARE SHALL NOT LIMIT THE CONTRACTORS LIABILITIES.
3. **REFERENCE.** THE CONTRACTOR SHALL REFER TO ALL CONTRACT DOCUMENTS, THE SPECIFICATION AND DRAWINGS PRIOR TO AND DURING THE WORKS.
4. **DISCREPANCIES.** NOTIFY SUPERINTENDENT OF ANY SUSPECTED OR KNOWN DISCREPANCIES OR ERRORS PRIOR TO THE ORDERING OF AFFECTED MATERIALS AND OR CONSTRUCTION OF AFFECTED WORKS.
5. **RELEVANT STANDARDS.** THE CONTRACTOR SHALL UNDERTAKE ALL PRICING AND WORKS IN ACCORDANCE WITH CURRENT INDUSTRY BEST PRACTICE AND ALL RELEVANT AUSTRALIAN STANDARDS.
6. **SERVICE LOCATOR.** THE CONTRACTOR SHALL UNDERTAKE A DIAL BEFORE YOU DIG PROCESS PRIOR TO COMMENCING WORKS ON SITE. THE CONTRACTOR SHALL ENGAGE A SERVICE LOCATOR TO MAP THE SPECIFIC LOCATIONS AND DEPTH OF ALL SERVICES AND ADVISE ALL RELEVANT STAFF AND SUBCONTRACTORS IN WRITING PRIOR TO COMMENCING WORKS ON SITE.

REV	DATE	BY	ISSUE OR AMENDMENT
A	11.08.10	MD	ISSUE FOR COMMENT

THIS IS AN UNCONTROLLED DOCUMENT ISSUED FOR INFORMATION ONLY UNLESS SIGNED BELOW AT EACH RELEVANT STAGE.

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STAGE OR PHASE
LWMP

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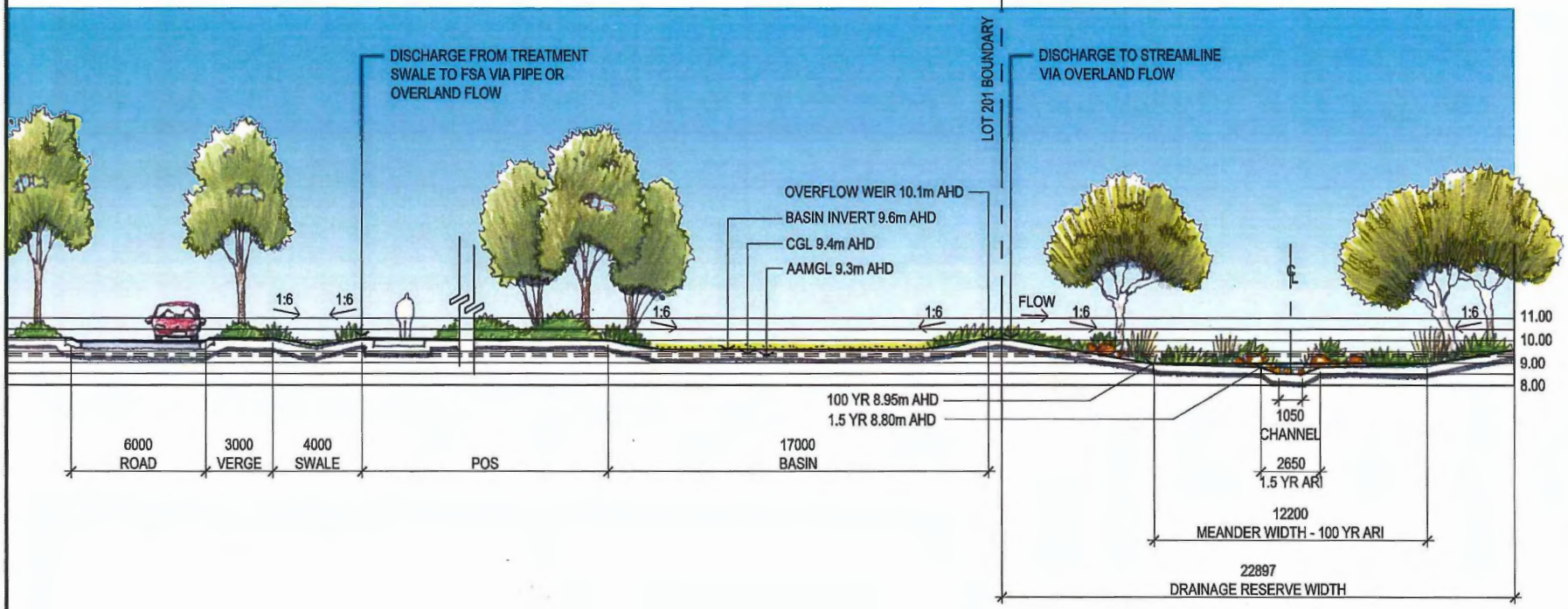

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Part Lot 9001 Mortimer Road
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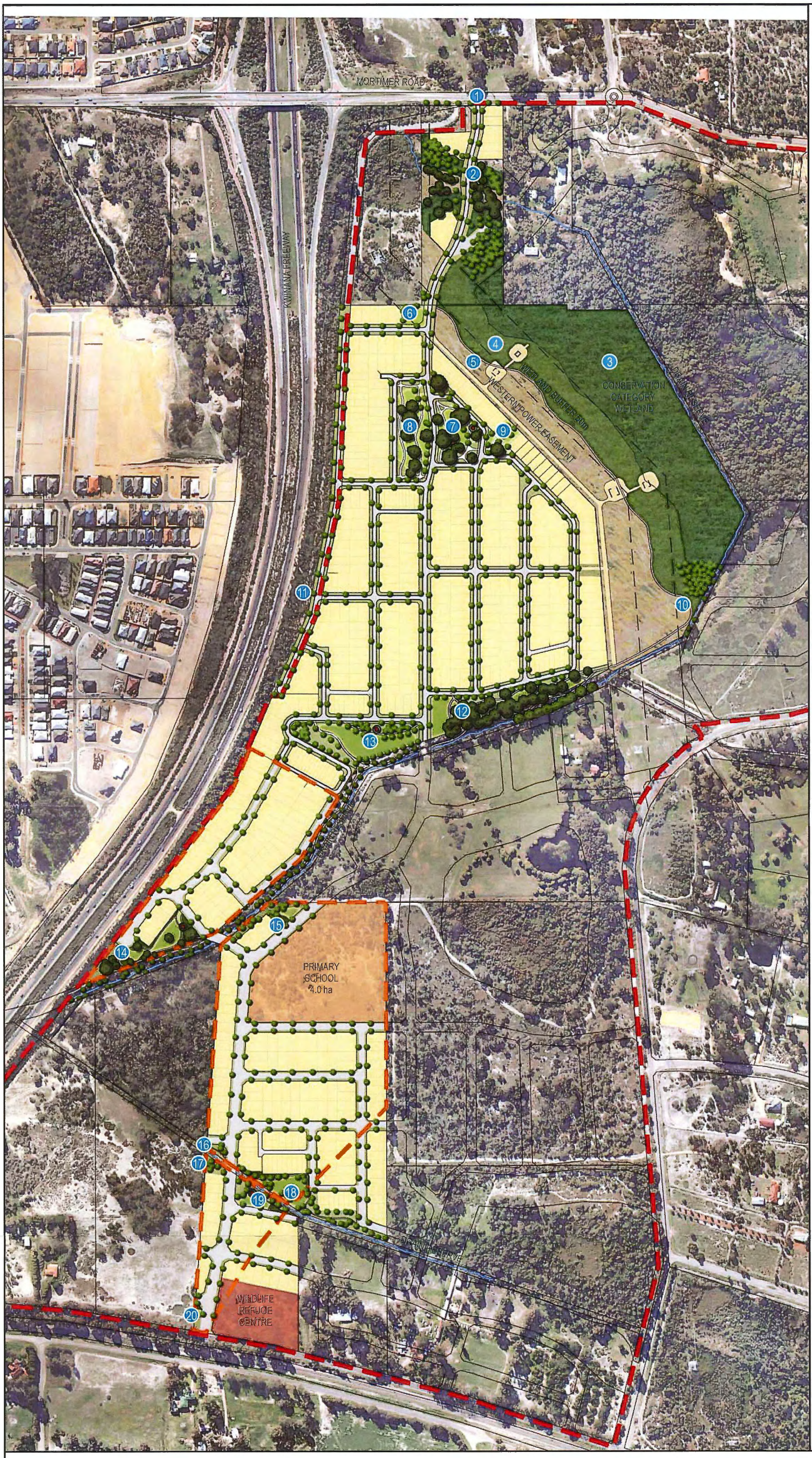
(East) Local Structure Plan

APPENDIX G
LANDSCAPE MASTERPLAN



1 ENTRY STATEMENT
- SIGNAGE INTO ESTATE AND HIGH PROFILE PLANTING

2 RESOURCE ENHANCEMENT AREA
- LIVING STREAM / MULTIPLE USE CORRIDOR
- EXISTING TREES TO BE RETAINED

3 CONSERVATION CATEGORY WETLAND (CCW)
- MINIMAL LANDSCAPE WORKS TO OCCUR
- WEED ERADICATION AND REVEGETATION

4 WETLAND BUFFER
- NATIVE NON-IRRIGATED PLANTING & REVEGETATION
- LIMESTONE FIREBREAKS
- VEGETATION BUFFERS

5 WESTERN POWER EASEMENT
- WESTERN POWER LIMESTONE MAINTENANCE ACCESS AND FIREBREAKS
- TYPICALLY NO TREE PLANTING
- NON-IRRIGATED NATIVE PLANTING & REVEGETATION

6 PUBLIC OPEN SPACE 6
- KEY SHELTER OR ART ON AXIS TO DISTRACT FROM PYLONS ON ENTRY ROAD
- MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
- BORE IRRIGATION

7 PUBLIC OPEN SPACE 7
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, FURNITURE, AND PLAY EQUIPMENT
- EXISTING TREES TO BE RETAINED
- MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
- BORE IRRIGATION

8 PUBLIC OPEN SPACE 8
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- RECREATION FACILITIES SUCH AS SHADE SHELTERS, BBQ, PICNIC TABLES, PUBLIC ART, AND FURNITURE
- EXISTING TREES TO BE RETAINED
- MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
- PASSIVE POS WITH DRAINAGE CAPABILITIES
- BORE IRRIGATION

9 PUBLIC OPEN SPACE 9
- MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
- PASSIVE POS WITH DRAINAGE CAPABILITIES
- BORE IRRIGATION

10 PUBLIC OPEN SPACE 10
- LIMESTONE FIREBREAKS
- NATIVE NON-IRRIGATED PLANTING

11 ROAD RESERVE
- NATIVE PLANTING AND BORE IRRIGATION
- INCLUDES DRAINAGE FUNCTIONS

12 PUBLIC OPEN SPACE 12
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- EXISTING TREES TO BE RETAINED
- PASSIVE POS WITH PREDOMINANTLY SOFT LANDSCAPE TREATMENTS
- INCLUDES DRAINAGE FUNCTIONS
- BORE IRRIGATION

13 PUBLIC OPEN SPACE 13
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- RECREATION FACILITIES SUCH AS PLAY ELEMENTS AND FURNITURE
- MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
- INFORMAL KICKABOUT AREA
- INCLUDES DRAINAGE FUNCTIONS
- BORE IRRIGATION

14 PUBLIC OPEN SPACE 14
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- RECREATION FACILITIES SUCH AS FURNITURE
- SOME EXISTING TREES TO BE RETAINED
- MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
- INCLUDES DRAINAGE FUNCTIONS
- BORE IRRIGATION

15 PUBLIC OPEN SPACE 15
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- PASSIVE POS WITH PREDOMINANTLY SOFT LANDSCAPE TREATMENTS
- INCLUDES DRAINAGE FUNCTIONS
- BORE IRRIGATION

16 17 PUBLIC OPEN SPACE 16 and 17
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- PASSIVE POS WITH PREDOMINANTLY SOFT LANDSCAPE TREATMENTS
- INCLUDES DRAINAGE FUNCTIONS
- BORE IRRIGATION

18 19 PUBLIC OPEN SPACE 18 and 19
- PEDESTRIAN LINKS TO ADJACENT RESIDENTIAL AND POS
- RECREATION FACILITIES SUCH AS PLAY EQUIPMENT AND FURNITURE
- INFORMAL KICKABOUT AREA
- MIXTURE OF SOFT AND HARDSCAPE TREATMENTS
- INCLUDES DRAINAGE FUNCTIONS
- BORE IRRIGATION

20 ROAD RESERVE
- SIGNAGE INTO ESTATE AND HIGH PROFILE PLANTING
- INCLUDES DRAINAGE FUNCTIONS
- BORE IRRIGATION

SUNRISE AT WELLARD

Landscape Masterplan

Armana Holdings Pty Ltd.

LEGEND

- WELLARD EAST BOUNDARY
- LSP BOUNDARY
- RECREATION FACILITY
- PUBLIC OPEN SPACE & VERGE AREAS
- LIVING STREAM
- WETLAND BUFFER
- WESTERN POWER EASEMENT
- EXISTING TREES TO BE RETAINED

NOTE: PROPOSED LOT BOUNDARIES ARE INDICATIVE ONLY

emerge ASSOCIATES
Integrated Science & Design

Scale 1:6000 at A3
Rev L November 2013

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX H
NOISE ASSESSMENT

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Transportation Noise Assessment

Part Lot 9001 Mortimer Road and Lot 379 Millar Road

Reference: 13072450-01

Prepared for:
Armana Holdings

Member Firm of Association of Australian Acoustical Consultants

Reference: 13072450-01

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Prepared By:	Daniel Lloyd 
Position:	Project Director
Verified	Terry George 
Date:	6 May 2014

Table of Contents

1 INTRODUCTION 1

2 CRITERIA 2

3 METHODOLOGY 3

3.1.1 Ground Topography, Road Design & Cadastral Data 3

3.1.2 Traffic Data 4

3.1.3 Ground Attenuation 4

3.1.4 Parameter Conversion 4

4 RESULTS 5

5 ASSESSMENT 8

5.1 Rail Noise 8

5.2 Road Noise 8

6 CONCLUSION 13

List of Tables

Table 2-1 Outdoor Noise Criteria 2

Table 3-1 Noise Relationship Between Different Road Sources 4

Table 3-2 Traffic Information Used in the Modelling 4

Table 3-3 Traffic Measurement Parameter Conversion 5

List of Figures

Figure 1-1 Assessment Area 1

Figure 4-1 Future Noise Contour Plot for Rail Noise 6

Figure 4-2 Future Noise Contour Plot for Road Noise 7

Figure 5-1 Rail Noise Predictions Assuming 2m High Noise Wall on Property Boundary 9

Figure 5-2 Facade Protection Package Requirements For Rail Noise Assuming No Noise Wall 10

Figure 5-3 Road Noise Predictions Assuming 3m High Noise Wall on Development Boundary 11

Figure 5-4 Facade Protection Package Requirements For Road Noise 12

Appendices

A Deemed-to-Satisfy Construction Standards

B Terminology

1 INTRODUCTION

This report has been prepared to assess the transportation noise impact to the Sunrise Estate, Wellard structure plan within the areas shown below in Figure 1.1.



Figure 1-1 Assessment Area

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

2 CRITERIA

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives of the Policy are to:

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

The Policy's outdoor noise criteria are shown below in *Table 2.1*. These criteria applying at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

The 5 dB difference between the *target* and *limit* is referred to as the *margin*.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this policy is to achieve -

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

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

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

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

3 METHODOLOGY

The computer programme *SoundPLAN 7.2* was utilised incorporating the *Calculation of Road Traffic Noise* (CoRTN) algorithms, for road noise and the Nordic Rail Prediction Method (Kilde Rep. 130) for rail noise. Both algorithms were modified to reflect Australian conditions. The modifications included the following:

Road Noise

- Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. By splitting the noise source into three allows for less barrier attenuation for high level sources where barriers are to be considered. Note that corrections are applied to the exhaust of –8.0 dB (based on Transportation Noise Reference Book, Paul Nelson, 1987) and to the engine source of –0.8 dB, so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;

Rail Noise

- The Nordic Rail Prediction Method (Kilde Rep. 130) algorithm is for generic train types in Europe and requires modification to align with measured noise levels of locomotives and wagons used in the Perth region. In addition, to accurately predict the effect of barriers (buildings or walls), the noise source height of the locomotive was raised from the model standard of 0.5 metres to 4.0 metres above the railhead.

Noise predictions are made at heights of 1.4 metres above ground floor level and at 1.0 metre from an assumed building façade (resulting in a + 2.5 dB correction due to reflected noise).

Various input data are included in the modelling such as ground topography, road and rail design, traffic volumes, train movements, etc. These model inputs are discussed below.

3.1.1 Ground Topography, Road Design & Cadastral Data

Topographical data was based on contours being in 0.5 metre intervals.

Buildings have also been included as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. All single storey buildings are assumed to have a height of 4.0 metres. Where double storey buildings are assumed, these have a height of 7.0 metres.

3.1.2 Traffic Data

Traffic data includes:

- Road Surface

  The noise relationship between different road surface types is shown below in *Table 3.1*.

Table 3-1 Noise Relationship Between Different Road Sources

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

  The existing and future road surface is open graded asphalt.

- Vehicle Speed

  Existing and future (15 to 20 years) posted speeds are 100 km/h.

- Traffic Volumes

  Traffic volume data used in the modelling is shown below in *Table 3.2*. The existing volumes were estimated from recent traffic counts and the future (15 to 20 years) volumes were obtained from Main Roads.

Table 3-2 Traffic Information Used in the Modelling

Parameter	Scenario	
	Existing	Future
24 Hour Volume	45,000	80,000
% Heavy	8%	8%

3.1.3 Ground Attenuation

The ground attenuation has been assumed to be 0.25 (25%) within the road reserve, 0.75 (75%) throughout the subdivision. Note 0.0 represents hard reflective surfaces such as water and 1.00 represents absorptive surfaces such as grass.

3.1.4 Parameter Conversion

The CoRTN algorithms used in the *SoundPlan* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. The WAPC Policy however uses $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$. The

relationship between the parameters varies depending on the composition of traffic on the road (volumes in each period and percentage heavy vehicles). As noise monitoring was undertaken, the relationship between the parameters is based on the results of the monitoring. These are as follows:

Table 3-3 Traffic Measurement Parameter Conversion

$L_{A10\ (18\ hour)}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
60 dB	58 dB	53 dB

4 RESULTS

The noise modelling assuming no consideration of noise control is provided in *Figures 4-1 and 4-2.*

Figure 4-1

Length Scale

0 12.5 25 50 75 100 m

Signs and symbols

- House
- Railway
- Study Area

Rail Noise level
$L_{Aeq,(Night)}$ dB

	<=	50	Noise Target
50 <	<=	55	Above Noise Target - Below Noise Limit
55 <	<=	60	Above Noise Limit
60 <			



Part Lot 9001 Mortimer Rd and Lot 379 Millar Rd - Railway Noise - No Noise Mitigation
$L_{Aeq,(Night)}$ Noise Level Contours

Lloyd George Acoustics
by Daniel Lloyd
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Figure 4-2

Length Scale

0 20 40 80 120 160 m

Signs and symbols

House

Study Area

Traffic Noise level
$L_{Aeq,(Day)}$ dB

	<=	55	Noise Target
55 <	<=	60	Above Noise Target - Below Noise Limit
60 <	<=	65	Above Noise Limit
65 <			



Part Lot 9001 Mortimer Rd and Lot 379 Millar Rd - Road Taffic Noise - No Noise Mitigation

$L_{Aeq,(Day)}$ Noise Level Contours

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5 ASSESSMENT

The objectives of the criteria are for noise at all houses to be no more than the *limit* and preferably no more than the *target*. Noise levels above the *limit* are generally considered unacceptable for residential use. Where the *target* is achieved, no further controls are required. Where the *limit* is achieved or noise levels are within the *margin* (between the *limit* and *target*), further controls are necessary.

From the results presented in *Figures 4-1 and 4-2*, it can be seen that the predicted noise levels at the nearest houses for both rail and road will be above the *target* and therefore under the Policy, noise control must be considered. It should be noted that compliance with the Policy is controlled by noise during the day period for the Kwinana Freeway and the night period for the freight line on Millar Road.

5.1 Rail Noise

For rail noise, it can be seen that assuming no noise control the predicted noise at the nearest residents located in the study area would be in the margin between the *target* and the *limit*. Therefore a noise wall or facade protection would be required.

If it were considered practicable to install a noise barrier, then a 2.0m high barrier on the property boundary would achieve the *target* criteria. The barrier would need to have a surface density of at least 15 kg/m^2 and this can be achieved using compressed fibre cement or masonry. The results assuming a noise barrier are provided in *Figure 5-1*.

Should the installation of a noise barrier be considered impracticable, facade protection could be used. Under this scenario, future houses within the margin will be required to implement "Package A" deemed-to-satisfy construction standards, as given by the Policy Guidelines (refer *Appendix A*). The lots requiring the facade package, assuming there is no noise wall, are shown in *Figure 5-2*.

5.2 Road Noise

For road noise, it can be seen that assuming no noise control the predicted noise at the nearest residents located in the study area would be above the *limit*.

In line with the development to the north of the study area, it is proposed to install a 3.0m high noise barrier on the road reserve boundary. The predicted noise levels assuming this scenario are provided in *Figure 5-3*. It can be seen that with the barrier installed, traffic noise levels are predicted to be within margin between the *target* and the *limit* for a number of lots (orange contour in *Figure 5-3*). Therefore, future houses within the margin will be required to implement "Package A" deemed-to-satisfy construction standards (refer *Appendix A*). The lots requiring the facade package are shown in *Figure 5-4*.

Figure 5-1

Length Scale

0 12.5 25 50 75 100 m

Signs and symbols

- House
- Railway
- Study Area
- Wall

Rail Noise level
$L_{Aeq,(Night)}$ dB

	<=	50	Noise Target
50 <	<=	55	Above Noise Target - Below Noise Limit
55 <	<=	60	Above Noise Limit
60 <			



Part Lot 9001 Mortimer Rd and Lot 379 Millar Rd - Railway Noise
2.0m High Noise Wall on Property Boundary
$L_{Aeq,(Night)}$ Noise Level Contours

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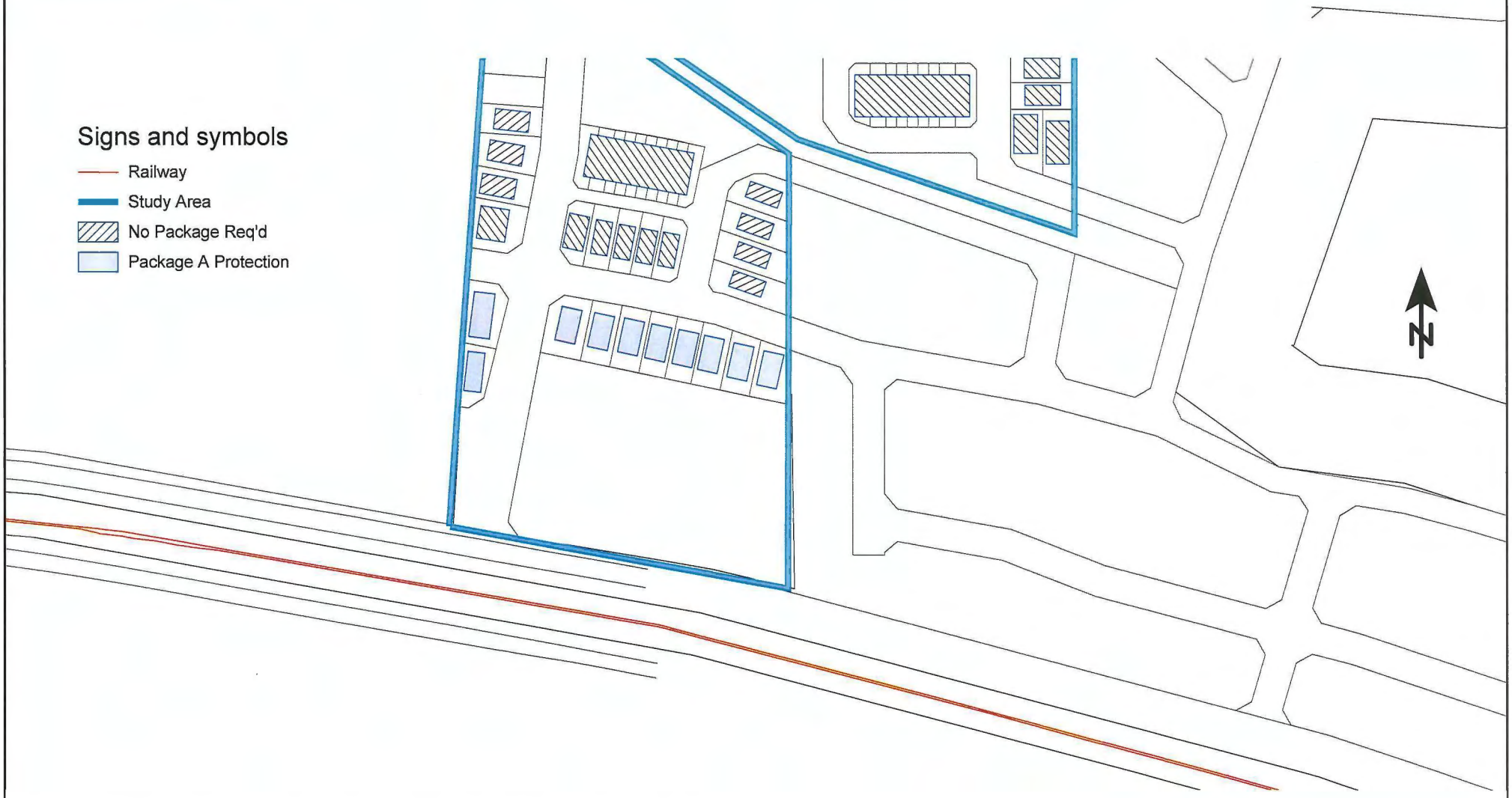
Figure 5-2

Length Scale

0 12.5 25 50 75 100 m



Part Lot 9001 Mortimer Rd and Lot 379 Millar Rd - Railway Noise
Facade Packages Assuming No Noise Walls

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Figure 5-3

Length Scale

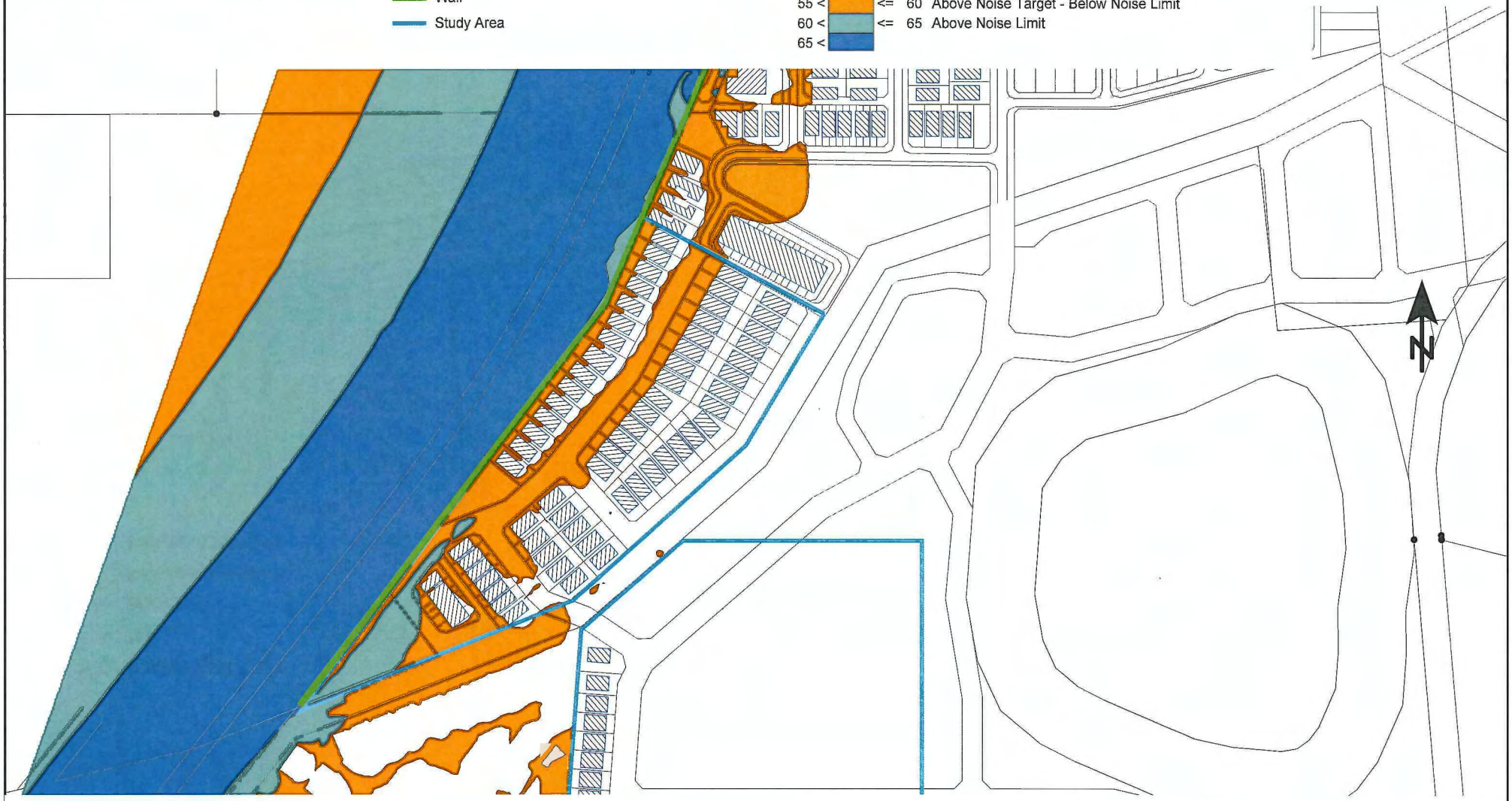
0 20 40 80 120 160 m

Signs and symbols

- House
- Wall
- Study Area

Traffic Noise level
$L_{Aeq,(Day)}$ dB

	<=	55	Noise Target
55 <	<=	60	Above Noise Target - Below Noise Limit
60 <	<=	65	Above Noise Limit
65 <			



Part Lot 9001 Mortimer Rd and Lot 379 Millar Rd - Road Taffic Noise
Assumes a 3m High Noise Wall on Development Boundary
$L_{Aeq,(Day)}$ Noise Level Contours

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Figure 5-4



Part Lot 9001 Mortimer Rd and Lot 379 Millar Rd - Road Taffic Noise
Facade Packages Assuming a 3m High Noise Wall on Development Boundary

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6 CONCLUSION

This assessment has shown that under the requirements of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning*, noise control in the form of a noise barrier and house facade protection will be required to address rail and road noise.

Appendix A

DEEMED TO SATISFY CONSTRUCTION STANDARDS

Package A: Noise levels within the *margin*

The following noise insulation package is designed to meet the indoor noise standards for residential developments in areas where noise levels exceed the noise *target* but are within the *limit*.

Area type	Orientation	Package A measures
Indoors		
Bedrooms	Facing road/rail corridor	• 6mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • No external doors • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning[1]
	Side-on to corridor	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Living and work areas[2]	Facing corridor	• 6mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • 35mm (minimum) solid core external doors with acoustic seals[3] • Sliding doors must be fitted with acoustic seals • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning
	Side-on to corridor	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Other indoor areas	Any	No requirements

[1] See section on Mechanical ventilation/airconditioning for further details and requirements.
[2] These deemed-to-comply guidelines adopt the definitions of indoor spaces used in AS 2107-2000. A comparable description for bedrooms, living and work areas is that defined by the Building Code of Australia as a "habitable room". The Building Code of Australia may be referenced if greater clarity is needed. A living or work area can be taken to mean any "habitable room" other than a bedroom. Note that there are no noise insulation requirements for utility areas such as bathrooms. The Building Code of Australia describes these utility spaces as "non-habitable rooms".
[3] Glazing panels are acceptable in external doors facing the transport corridor. However these must meet the minimum glazing requirements.

Mechanical ventilation/airconditioning

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

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

- evaporative airconditioning systems will not meet the requirements for Packages A and B because windows need to remain open;
- refrigerative airconditioning systems need to be designed to achieve fresh air ventilation requirements;
- air inlets need to be positioned facing away from the transport corridor where practicable;
- ductwork needs to be provided with adequate silencing to prevent noise intrusion.

Notification

Notifications on certificates of title and/or advice to prospective purchasers advising of the potential for noise impacts from road and rail corridors can be effective in warning people of the potential impacts of transport noise. Such advice can also bring to the attention of prospective developers the need and opportunities to reduce the impact of noise through sensitive design and construction of buildings and the location and/or screening of outdoor living areas.

Notification should be provided to prospective purchasers, and required as a condition of subdivision (including strata subdivision) for the purposes of noise-sensitive development or planning approval involving noise-sensitive development, where external noise levels are forecast or estimated to exceed the "target" criteria as defined by the Policy. In the case of subdivision and development, conditions of approval should include a requirement for registration of a notice on title, which is provided for under section 165 of the Planning and Development Act 2005 and section 70A of the Transfer of Land Act. An example of a suitable notice is given below.

Notice: This property is situated in the vicinity of a transport corridor, and is currently affected, or may in the future be affected, by transport noise. Further information about transport noise, including development restrictions and noise insulation requirements for noise-affected property, are available on request from the relevant local government offices.

Appendix B

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)

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

A-Weighting

An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1

An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}

An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}

An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}

The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$

The $L_{A10,18\,hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$

The $L_{Aeq,24\,hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\,(Night)}$

The $L_{Aeq\,(Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\,(Day)}$

The $L_{Aeq\,(Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

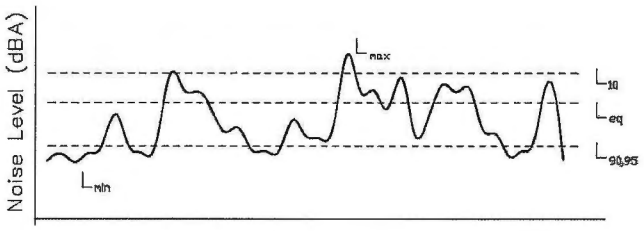
Satisfactory Design Sound Level

The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level

The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



Austroads Vehicle Class

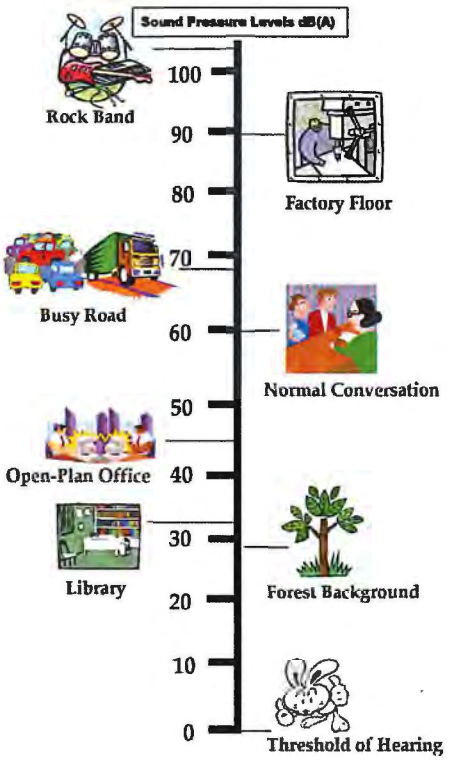
AUSTROADS Vehicle Classification System

Level 1 Length	Level 2 Axles and Axle Groups		Level 3 Vehicle Type	AUSTROADS Classification		
Type	Axles	Groups	Typical Description	Class	Parameters	Typical Configurations
			LIGHT VEHICLES			
Short		1 or 2	Short - Sedan, wagon, 4WD, Utility, Panel Van, Motor vehicle with a single rear axle and single rear wheels, Short - Towing, Trailer, Caravan, Boat, etc.	1	d(1) ≤ 3.2m and axles = 2	
	3 or 4	3		2	groups = 3 d(1) ≤ 3.2m, d(2) ≤ 3.2m d(2) ≥ 2.1m and axles = 3 or 4	
			HEAVY VEHICLES			
Medium 5.5m to 14.5m	2	2	Two Axle Truck or Bus	3	d(1) > 3.2m and axles = 2	
	3	2	Three Axle Truck or Bus	4	axles = 3 and groups = 2	
	≥3	3	Four Axle Truck	5	axles = 4 and groups = 3	
Long 11.5m to 19.0m	3	2	Three Axle Articulated, Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) ≤ 3.2m, axles = 3 and groups = 2	
	4	≥ 3	Four Axle Articulated, Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) > 2.1m and d(1) + 2.1m ≤ d(3) ≤ 3.2m, axles = 4 and groups = 2	
	5	≥ 3	Five Axle Articulated, Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) > 2.1m and d(1) + 2.1m ≤ d(3) ≤ 3.2m, axles = 5 and groups = 2	
	≥ 6	≥ 3	Six Axle Articulated, Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups = 3 or axles = 5 and groups = 3	
Medium Combination 17.5m to 36.0m	≥ 6	4	B Double, B Double, or Heavy Truck and Trailer	10	groups = 4 and axles = 6	
	≥ 6	5 or 6	Double Road Train, Double road train or Medium articulated vehicle and one trailer (M.A.V.)	11	groups = 5 or 6 and axles = 6	
Large Combination Over 33.5m	≥ 9	≥ 9	Triple Road Train, Triple road train or Heavy Truck and three trailers	12	groups = 9 and axles = 9	

Definitions: Group: Axle group where adjacent axles are less than 2.1m apart; Groups: Number of axle groups; Axles: Number of axles (maximum as a spacing of 13.0m)

d(1): Distance between first and second axle
d(2): Distance between second and third axle

Typical Noise Levels



Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX I

LSP AND WELLARD EAST CELL POS SCHEDULES

OVERALL PUBLIC OPEN SPACE PROVISION
(includes credited and uncredited areas of public open space)
ENTIRE WELLARD EAST CELL
(TO BE READ IN CONJUNCTION WITH FIGURE 16)

POS No.	Gross Area (HA)	1:1 Year Event - Drainage (HA)	1:5 Year Event (Restricted POS) (HA)	Net POS (HA)
Unrestricted Public Open Space				
Area A	0.693	0.0276	0	0.6654
Area B	0.4541	0.0108	0	0.4433
Area C	0.18	0.0179	0.0537	0.1084
Area D	0.9432	0.042	0.0995	0.8017
Area E	0.8471	0.0972	0.3333	0.4166
Area O	3.629	0.037	0.018	3.574
Area Q	0.548	0.0371	0.0374	0.4735
Area V (refer to note 4)	0.4636	0.057	0.0756	0.331
Area W (refer to note 4)	0.7104	0.0903	0.0983	0.5218
Area X (refer to note 4)	0.8907	0.0875	0.2766	0.5266
Area CC (refer to note 4)	0.3204	0.0326	0.1001	0.1877
Area Z	0.6002	0.077	0.0856	0.4376
Area BB	0.2126	0.0118	0.0216	0.1792
Area DD	0.8349	0.0608	0.034	0.7401
Sub Total	**11.3272**	**0.6866**	**1.2337**	**9.4069**
Restricted Public Open Space				
Area F** (REW buffer)	0.685	0.0264	0.0993	0.6586
Area G (Conservation Category Wetland Buffer external to the WP Easement)	0.0565	0	0	0.0565
Area H (Conservation Category Wetland Buffer)	0.425	0	0	0.425
Area L (Conservation Category Wetland Buffer)	7.708	0	0	7.708
Area I	0.142	0	0	0.142
Area J **(REW Core)	0.535	0	0	0.535
Area K	0.0214			0.0214
Area P (REW buffer)	0.0761			0.0761
Area M	0.2245			0.2245
Area N	0.1			0.1
Area R (REW Core)	4.9361			4.9361
Area S (REW buffer)	6.487			6.487
Area T (REW Core) (refer to note 4)	4.2093			4.2093
Area U (REW buffer) (refer to note 4)	3.95	0.077		3.873
Area C (refer to note 3)			0.0537	0.0537
Area D (refer to note 3)			0.0995	0.0995
Area E (refer to note 3)			0.3333	0.3333
Area O (refer to note 3)			0.018	0.018
Area Q (refer to note 3)			0.0374	0.0374
Area V (refer to note 3)			0.0756	0.0756
Area W (refer to note 3)			0.0983	0.0983
Area X (refer to note 3)			0.2766	0.2766
Area Z (refer to note 3)			0.0856	0.0856
Area BB (refer to note 3)			0.0216	0.0216
Area CC (refer to note 3)			0.1001	0.1001
Area DD (refer to note 3)			0.034	0.034
Area Y	1.73			1.73
Sub-total	**31.2859**	**0.1034**	**1.333**	**32.4162**
Total Unrestricted and Restricted POS (HA)	**42.6131**	**0.79**	**1.333**	**41.8231**

Overall Public Open Space Schedule - Wellard East Cell		
Gross Site Area		
(Wellard East Cell area)		170.3208
Deductions		
D1 (CCW Wetland Core)	19.64	
D2 (Western Power Easement) (refer to note 2)	11.2	
D3 (Northern Drainage Reserve)	2.9115	
D4 (Southern Drainage Reserve)	0.79	
D5 (School)	4	
D6 (Existing Marsupial Rehabilitation Clinic)	1.08	
Drainage Basins (1:1 year storm event)	0.79	
Surplus Restricted Open Space (not credited)	30.42	
Total Deductions		70.8315
Net subdivisable area		99.4893
Required Public Open Space (10%)		9.94893
Public Open Space Contibution		
Unrestricted public open space – minimum 80%	7.959144	
Restricted public open space – maximum 20%	1.989786	
Total		9.94893
PUBLIC OPEN SPACE PROVISION		
Unrestricted Public Open Space		
Total Credited Unrestricted Public Open Space		9.4069
Restricted Public Open Space		
Total Restricted Public Open Space		32.4162
Restricted POS (not credited) (refer to note 5)		30.42641
Total Credited Restricted POS		1.989786
Total Credited Restricted and Unrestricted POS		11.39669
Percentage of Credited POS (Unrestricted and Restricted POS Contribution)		11.5%

Notes:

1. To be read in conjunction with the LSP Public Open Space Plan – Figure 16.
2. Western Power (WP) Easement area excludes the CCW core and the Primary Regional Road Reserve (Wake Way) but includes parts of the CCW buffer where it falls within the WP Easement.
3. The 1:5yr drainage component within public open space areas D, E, N, O, Q, V, W, X, Z and BB are calculated as restricted POS in accordance with Liveable Neighbourhoods Policy.
4. Areas T, U, X, W, CC and V all exclude the southern Peel sub drain which dissects these areas. The peel sub drain is included as a deduction (ie. D4).
5. Surplus restricted open space (excess of 20% maximum) has been calculated as a deduction, in accordance with Liveable Neighbourhoods Policy.
6. POS areas over the cell are approximate only and are subject to future Local Structure Plans and subdivision plans.

PUBLIC OPEN SPACE PROVISION
(includes credited and uncredited areas of public open space)
WELLARD EAST LOCAL STRUCTURE PLAN
PART LOTS 9001 and LOT 379
(TO BE READ IN CONJUNCTION WITH FIGURE 16)

POS NO.	GROSS AREA (HA)	1-1 YEAR EVENT – DRAINAGE (HA)	1:5 YEAR EVENT DRAINAGE (RESTRICTED POS) (HA)	NET POS (HA)
Unrestricted Public Open Space				
Area Q	0.548	0.0371	0.0374	0.4735
Area X (within LSP Area only)	0.5913	0.0875	0.2766	0.2272
Area BB	0.2126	0.0118	0.0216	0.1792
Sub-total	**1.3519**	**0.1364**	**0.3356**	**0.8799**
Restricted Public Open Space				
Area Q (refer to Note 3)			0.0374	0.0374
Area X (within LSP Area only)(refer to Note 3)			0.2766	0.2766
Area BB (refer to Note 3)			0.0216	0.0216
Sub-total	-	-	**0.3356**	**0.3356**
Total Unrestricted and Restricted POS (ha)	**1.3519**	**0.1364**	**0.3356**	**1.2155**

Public Open Space Schedule for Part Lots 9001 and 379, Wellard East Local Structure Plan

Gross Site Area (HA) (LSP approval area) (exclude buffer area within Lot 379)		16.67
Deductions		
Drainage Basins (1:1 year storm event)	0.1364	
D5 (Portion of school site within Lot 379)	3.1741	
Surplus Restricted Open Space (not credited)	0.069	
Total Deductions		3.3795
Net subdividable area		13.2905
Required Public Open Space (10%)		1.32905
Public Open Space Contibution		
Unrestricted public open space – minimum 80%	1.06324	
Restricted public open space – maximum 20%	0.26581	
Total		1.32905
PUBLIC OPEN SPACE PROVISION		
Unrestricted Public Open Space		
Total Credited Unrestricted Public Open Space		0.8799
Restricted Public Open Space		
Total Restricted Public Open Space		0.3356
Restricted POS (not credited) (refer to note 5)		0.06979
Total Credited Restricted POS		0.26581
Total Credited Unrestricted and Restricted Public Open Space		1.14571
Percentage of Credited POS (Unrestricted and Restricted POS Contibution)		8.6%

1. To be read in conjunction with the LSP Public Open Space Plan – Figure 16.
2. The Unrestricted net POS equals gross area minus drainage provision (1:1yr event and 1:5yr event).
3. Restricted public open space areas Q, BB and DD are calculated as 1:5yr drainage component of the overall POS area.

Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX J
FAUNA ASSESSMENT

Fauna Assessment



Part Lot 379 Millar Road
and
Lot 9001 Mortimer Road

Wellard East

APRIL 2014

Version 2

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TABLE OF CONTENTS

SUMMARY

1. INTRODUCTION 1

2. DEVELOPMENT PROPOSAL 1

3. SCOPE OF WORKS 1

4. METHODS 2

4.1 POTENTIAL FAUNA INVENTORY - DESKTOP STUDY 2

4.1.1 Database Searches 2

4.1.2 Previous Fauna Surveys in the Area 2

4.1.3 Existing Publications 3

4.1.4 Fauna of Conservation Significance 4

4.1.5 Invertebrate Fauna of Conservation Significance 6

4.1.6 Taxonomy and Nomenclature 6

4.2 SITE SURVEYS 6

4.2.1 Fauna Habitat Assessment 7

4.2.2 Opportunistic Fauna Observations 7

4.2.3 Black Cockatoo Habitat Assessment 7

5. SURVEY CONSTRAINTS 8

6. RESULTS 9

6.1 POTENTIAL FAUNA INVENTORY - DESKTOP STUDY 9

6.2 SITE SURVEYS 10

6.2.1 Fauna Habitat Assessment 10

6.2.2 Opportunistic Fauna Observations 12

6.2.3 Black Cockatoo Habitat Assessment 13

6.3 FAUNA INVENTORY – SUMMARY 14

6.3.1 Vertebrate Fauna 14

6.3.2 Vertebrate Fauna of Conservation Significance 15

6.3.3 Invertebrate Fauna of Conservation Significance 18

7. FAUNA VALUES 18

7.1 CONSERVATION SIGNIFICANCE OF THE STUDY AREA 18

7.2 VALUE OF THE STUDY AREA AS AN ECOLOGICAL LINKAGE/WILDLIFE CORRIDOR 19

8. POTENTIAL IMPACTS AND DEVELOPMENT CONSIDERATIONS 19

8.1 POTENTIAL IMPACTS OF DEVELOPMENT 19

8.2 CONSIDERATIONS FOR PLANNING AND DEVELOPMENT 21

9. CONCLUSION 22

10. BIBLIOGRAPHY 24

TABLES

TABLE 1: Main Fauna Habitats within the Study Area

TABLE 2: Summary of Potential Vertebrate Fauna Species (as listed in Appendix B)

TABLE 3: Likelihood of Occurrence and Possible Impacts – Fauna Species of Conservation Significance

FIGURES

FIGURE 1: Study Area & Surrounds

FIGURE 2: Study Area - Air Photo

FIGURE 3: Fauna Habitats

FIGURE 4: Habitat Trees (DBH>50cm)

APPENDICES

APPENDIX A: Conservation Categories

APPENDIX B: Fauna Observed or Potentially in Study Area

APPENDIX C: DPaW & *EPBC* Database Search Results

APPENDIX D: Black Cockatoo Habitat Tree Details

APPENDIX E: Significant Species Profiles

Acronyms/Abbreviations:

BA: Birdlife Australia (Formerly RAOU, Birds Australia).

°C: Degrees Celsius.

CALM: Department of Conservation and Land Management (now DPaW), WA Government.

CAMBA: China Australia Migratory Bird Agreement 1998.

CBD: Central Business District.

DEC: Department of Environment and Conservation (now DPaW), WA Government.

DEH: Department of Environment and Heritage (now DoE), Australian Government.

DEP: Department of Environment Protection (now DER), WA Government.

DER: Department of Environment Regulation (formerly DEC, DoE), WA Government.

DEWHA: Department of the Environment, Water, Heritage and the Arts (now DoE), Australian Government

DMP: Department of Mines and Petroleum (formerly DoIR), WA Government.

DoE: Department of Environment (now DER/DPaW), WA Government.

DoE: Department of the Environment (formerly SEWPaC, DWEHA, DEH), Australian Government.

DoIR: Department of Industry and Resources (now DMP), WA Government.

DPaW: Department of Parks and Wildlife (formerly DEC, CALM, DoE), WA Government.

EP Act: *Environmental Protection Act 1986*, WA Government.

EPA: Environmental Protection Authority, WA Government.

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999,* Australian Government.

ha: Hectare (10,000 square metres).

IBRA: Interim Biogeographic Regionalisation for Australia.

IUCN: International Union for the Conservation of Nature and Natural Resources – commonly known as the World Conservation Union.

JAMBA: Japan Australia Migratory Bird Agreement 1981.

km: Kilometre.

m: Metre.

mm: Millimetre.

ROKAMBA: Republic of Korea-Australia Migratory Bird Agreement 2007.

RAOU: Royal Australia Ornithologist Union.

SEWPaC: Department of Sustainability, Environment, Water, Population and Communities (now DoE, formerly DEH, DEWHA), Australian Government

SSC: Species Survival Commission, International.

WA: Western Australia.

WAM: Western Australian Museum, WA Government.

WC Act: *Wildlife Conservation Act 1950*, WA Government.

SUMMARY

This report details the results of a fauna assessment of an area of land made up of parts of Lot 379 Millar Road and Lot 9001 Mortimer Road, located in Wellard East (Figure 1). The study area is situated approximately 35 kilometres south of Perth within the City of Kwinana and is approximately 17 hectares in size (Figure 2).

It is understood that the proponents (Armana Holdings Pty Ltd) are currently undertaking local structure planning to support future development within the study area. A range of investigations, including this fauna survey, have been undertaken in order to fully understand the suite of environmental attributes and values across the area.

The scope of works was to conduct a level 1 fauna survey as defined by the Environmental Protection Authority (EPA 2004). As some listed threatened species (i.e. several species of black cockatoo) are known to occur in the general area, the scope of the survey work was expanded to include targeted assessment of the study area's significance to these particular species. The assessment has included a desktop study and single daytime reconnaissance survey including a black cockatoo habitat tree assessment.

Descriptions of the broadly defined fauna habitats, mainly based on the remaining vegetation units, soils and landform within the study area are provided below, with the extent of each identified unit being shown in Figure 3. The approximate area (hectares) covered by each unit, based on canopy cover evident in an air photo, is also provided

- Low lying woodland-forest (medium height) of *Eucalyptus rudis – Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielsia stenostachya - Opercularia hispidula - *Zantedeschia aethiopica* on grey sandy loam. ~1.1 ha in extent;

- Low upland woodland (>10m) of *Corymbia calophylla - Eucalyptus marginata* over *Agonis flexuosa - Casuarina obesa - Banksia menzeisii - Banksia grandis* over *Eremaea pauciflora - Calothamnus quadrifidus* over *Conostylis aculeata - Kennedia prostrata - *Ehrharta longiflora - *Lolium rigidum - *Carpobrotus edulis* on grey sand. ~1.5 ha in extent;

- Tall Scrub (to 10m) of *Kunzea glabrescens - Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis* on grey sand. Some emergent *Eucalyptus gomphocephala* and none-endemic eucalypts. ~2.3 ha in extent;

- Open woodland of *Eucalyptus rudis – Melaleuca preissiana* over pasture grasses/weeds on grey sandy loam. Seasonally inundated/waterlogged. ~0.5 ha in extent;

- Planted endemic and non-endemic trees and shrubs over pasture grasses/weeds on grey sand. ~0.9 ha in extent; and

- Cleared (open grassland, bare sand) with scattered trees. ~10.3 ha in extent

Overall fauna habitat values and biodiversity at the study area have been severely compromised by the total or partial clearing of native vegetation, historical livestock grazing, dieback and weed invasion. Most areas lack any natural attributes and are now only utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in highly disturbed habitats.

Opportunistic fauna observations are listed in Appendix B. A total of 23 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the study area during the single day time survey. Signs of two introduced species were also seen.

Evidence of one listed threatened species was observed (Carnaby's black-cockatoo or the forest red-tailed black cockatoo (chewed jarrah fruits – actual species of black cockatoo responsible uncertain). Diggings attributed to the southern brown bandicoot (DPaW Priority 5 species) were found within the area of flooded gum in the north east section of the area and several rainbow bee-eaters, a listed migratory species, were observed foraging near the eastern boundary of the study area during the survey period.

The habitat tree assessment identified 69 specimens within the study area that meet DoE's (SEWPaC 2012) criteria for black cockatoo breeding habitat (i.e. suitable tree species with a diameter at breast height (DBH) of >50cms) (Figure 4). It should be noted that a small number (seven) of these trees are located just outside of the currently propose local structure plan boundary but have been included due to uncertainty related to GPS accuracy/and or the final structure plan boundary.

Thirty three (33) of the 69 trees were observed to contain hollows of some type with one (1) dead tree being assessed at the time to possibly have large enough hollows for black cockatoos to use for nesting though this assessment was based on the size of the entrance into an apparent hollow only. No actual evidence of any hollows being used by black cockatoos for nesting (currently or previously) was seen.

Additional details on each observed "habitat tree" can be found in Appendix D.

Only one example of foraging evidence was observed during the field survey. This was in the form of chewed jarrah fruits under a single tree. The lack of evidence suggests that the study area is not frequented by black cockatoos often.

No existing roosting trees (trees used at night by black cockatoos to rest) were positively identified during the survey.

With respect to native vertebrate fauna, eleven mammals (including eight bat species), 81 bird, 16 reptile and eight frog species have previously been recorded in the general area, some of which have the potential to occur in or utilise sections of the study area at times.

Of the 116 native animals that are listed as potentially occurring in the study area, three are considered to be endangered/vulnerable or in need of special protection under State and/or Federal law, these being two species of black cockatoo (Carnaby's and the forest red-tailed) and the peregrine falcon. In addition, three migratory species (great egret, cattle egret and the rainbow bee-eater) may also utilise the study area at times. Two DPaW priority species are also known from the general vicinity and are likely to be present in areas of suitable habitat (southern brown bandicoot and Perth lined lerista).

Most of the study area is cleared of native vegetation and/or highly degraded and therefore direct impacts on fauna of conservation significance or natural fauna habitat that may occur as a consequence of future development at any scale are anticipated to be minimal/negligible. No significant impact on any fauna species is considered likely.

The study area does contain areas of potential breeding and foraging habitat for black cockatoos. No evidence of past or present use for breeding was observed and foraging evidence was limited to one example. This apparent lack/limited level of utilisation can be attributed to the fact that the study area is not within a documented breeding area for any of the black cockatoo species and the area of foraging habitat is limited in extent and relatively poor in quality.

At this stage no referral to the DoE with respect to listed *EPBC Act* threatened fauna species is considered necessary however this conclusion should be reviewed once plans for development are finalised or have progressed to a stage where the anticipated small scale of impacts can be more accurately demonstrated.

1. INTRODUCTION

This report details the results of a fauna assessment of an area of land made up of parts of Lot 379 Millar Road and Lot 9001 Mortimer Road, located in Wellard East (Figure 1). The study area is situated approximately 35 kilometres south of Perth within the City of Kwinana and is approximately 17 hectares in size (Figure 2).

2. DEVELOPMENT PROPOSAL

It is understood that the proponents (Armana Holdings Pty Ltd) are currently undertaking local structure planning to support future development within the study area.

A range of investigations, including this fauna survey, have been undertaken in order to fully understand the suite of environmental values across the study area. The findings of this fauna survey and other investigations will be used to inform and support the development of a Local Structure Plan, with the primary aim of minimising potential environmental impacts as much as reasonable and practicable.

It is also anticipated that the information presented will be used by regulatory authorities to assess the potential impact of the proposal on fauna and fauna habitats as part of any required approval process.

3. SCOPE OF WORKS

The scope of works was to conduct a level 1 fauna survey as defined by the EPA (EPA 2004). As some listed threatened species (i.e. several species of black cockatoo) are known to occur in the general area, the scope of the survey work was expanded to include targeted assessment of the study area's significance to these species.

The fauna assessment has therefore included:

1. Level 1 Fauna Survey (to EPA standard).

2. Black Cockatoo Habitat Assessment ("habitat trees" = DBH >50cm, existing and potential nest hollows, foraging and roosting habitat); and

3. Report summarising results with management/planning recommendations.

Note: For the purposes of this report the term black cockatoo is in reference to Carnaby's black-cockatoo *Calyptorhynchus latirostris* and the forest red-tailed black-cockatoo *Calyptorhynchus banksii naso*.

4. METHODS

4.1 POTENTIAL FAUNA INVENTORY - DESKTOP STUDY

4.1.1 Database Searches

Searches of the following databases were undertaken to aid in the compilation of a list of vertebrate fauna potentially occurring within the study area:

- DPaW's NatureMap Database Search (Area search - 8 km buffer)(combined data from DPaW, Western Australian Museum, Birds Australia and consultants reports) (DPaW 2014); and
- Protected matters search tool (Point Search - 0 km buffer) (Department of the Environment – DoE 2014).

It should be noted that these lists are based on observations from a broader area than the study area and therefore may include species that would only ever occur as vagrants in the actual study area due to a lack of suitable habitat or the presence of only marginal habitat. The databases also often included very old records and in some cases the species in question have become locally or regionally extinct.

Information from these sources should therefore be taken as indicative only and local knowledge and information needs also to be taken into consideration when determining what actual species may be present within the specific study area being investigated.

4.1.2 Previous Fauna Surveys in the Vicinity

Fauna surveys, assessments and reviews have been undertaken in nearby areas in the past, though not all are publically available and could not be referenced. The most significant of those available have been used as the primary reference material for compiling the potential fauna assemblage for the study area.

Those reports referred to included, but were not limited to:

- ENV (2009). Jandakot Airport Fauna Survey. Unpublished report for Jandakot Airport Holdings Pty Ltd.
- Harewood, G. (2005). Fauna Assessment, Mandogalup. Unpublished report for Cardno BSD.

- Harewood, G. (2008). Fauna Assessment (Level 1), Wellard West. Unpublished report for Cardno BSD.

- Harewood, G. (2009). Fauna Survey (Level 2) East Rockingham WWTP Site & Pipeline Corridors. Unpublished report for ERM.

- Harewood, G. (2011). Fauna Assessment - Lots 447, 459 and 709 Baldivis Road, Baldivis. Unpublished report for Emerge Associates.

- Phoenix Environmental Sciences (2011). Vertebrate Fauna Survey for the Roe Highway Extension Project. Unpublished report for South Metro Connect.

As with the databases searches some reports refer to species that would not occur in the study area due to a lack of suitable habitat (extent and/or quality) and this fact was taken into consideration when compiling the potential fauna species list. It should also be noted that the NatureMap database is likely to include some records from previous fauna surveys in the wider area including some of those listed above.

4.1.3 Existing Publications

The following represent the main publications used to identify and refine the potential fauna species list for the study area:

- Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers, Sydney.

- Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Victoria.

- Bush, B., Maryan, B., Browne-Cooper, R. & Robinson, D. (2007). Reptiles and Frogs in the Bush: Southwestern Australia. UWA Press, Nedlands.

- Churchill, S. (2008). Australian Bats. Second Edition, Allen & Unwin.

- Cogger, H.G. (2014). Reptiles and Amphibians of Australia. 7th Edition. CSIRO Publishing.

- Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds: Volume 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth Western Australia.

- Johnstone, R.E. and Storr, G.M. (2004). Handbook of Western Australian Birds: Volume 2 – Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth Western Australia.
- Menkhorst, P. and Knight, F. (2011). A Field Guide to the Mammals of Australia. Oxford University Press, Melbourne.
- Morgan, D.L., Beatty, S.J., Klunzinger, M.W, Allen, M.G. and Burnham, Q.E (2011). Field Guide to the Freshwater Fishes, Crayfishes and Mussels of South Western Australia. Published by SERCUL.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1983). Lizards of Western Australia II: Dragons and Monitors. WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1990). Lizards of Western Australia III: Geckos and Pygopods. WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1999). Lizards of Western Australia I: Skinks. Revised Edition, WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (2002). Snakes of Western Australia. Revised Edition, WA Museum, Perth.
- Tyler M.J. & Doughty P. (2009). Field Guide to Frogs of Western Australia, Fourth Edition, WA Museum, Perth.
- Van Dyck, S., Gynther, I. & Baker, A. Eds (2013). Field Companion to The Mammals of Australia. Queensland Museum.
- Wilson, S. and Swan, G. (2013). A Complete Guide to Reptiles of Australia. Reed, New Holland, Sydney.

4.1.4 Fauna of Conservation Significance

The conservation significance of fauna species has been assessed using data from the following sources:

- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). Administered by the Australian Government Department of the Environment (DoE);
- *Wildlife Conservation Act 1950 (WC Act).* Administered by the Western Australian Department of Parks and Wildlife (DPaW) (Govt. of WA 2013);

- Red List produced by the Species Survival Commission (SSC) of the World Conservation Union (also known as the IUCN Red List - the acronym derived from its former name of the International Union for Conservation of Nature and Natural Resources). The Red List has no legislative power in Australia but is used as a framework for State and Commonwealth categories and criteria; and the

- DPaW Priority Fauna list. A non-statutory list maintained by the DPaW for management purposes (DPaW 2013).

The *EPBC Act* also requires the compilation of a list of migratory species that are recognised under international treaties including the:

- Japan Australia Migratory Bird Agreement 1981 (JAMBA);

- China Australia Migratory Bird Agreement 1998 (CAMBA);

- Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA); and

- Bonn Convention 1979 (The Convention on the Conservation of Migratory Species of Wild Animals).

(Note - Species listed under JAMBA are also protected under Schedule 3 of the *WC Act.*)

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as matters of national environmental significance under the *EPBC Act.*

The conservation status of all vertebrate fauna species listed as occurring or possibly occurring in the vicinity of the study area has been assessed using the most recent lists published in accordance with the above-mentioned instruments and is indicated as such in the fauna listings of this report. A full listing of conservation codes are provided in Appendix A.

A number of other species not listed in official lists can also be considered of local or regional conservation significance. These include species that have a restricted range, those that occur in breeding colonies and those at the limit of their range.

While not classified as rare, threatened or vulnerable under any State or Commonwealth legislation, a number of bird species have been listed as being of significance on the Swan Coastal portion of the Perth Metropolitan Region (Bush Forever - Government of Western Australia 1998 and 2000). The bird species are often referred to as Bush Forever Decreaser Species. The three categories used for birds within the Bush Forever documents are:

- Habitat specialists with reduced distribution on the Swan Coastal Plain (code Bh);
- Wide ranging species with reduced population's on the Swan Coastal Plain (code Bp); and
- Extinct in the Perth region (code Be).

The presence of Bush Forever species should be taken into some consideration when determining the fauna values of an area. Bush Forever decreaser species are indicated as such within the species list held in Appendix B.

4.1.5 Invertebrate Fauna of Conservation Significance

It can be difficult to identify what may be significant invertebrate species (e.g. Short Range Endemics - SREs) as there are uncertainties in determining the range-restrictions of many species due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. Where invertebrates are collected during surveys, a high percentage are likely to be unknown, or for known species there can be limited knowledge or information on their distribution (Harvey 2002).

For this project, the assessment for conservation significant invertebrates has been limited to those listed by the DPaW and *EPBC Act* database searches (which rely on distribution records and known habitat preferences). No assessment of the potential for SREs to be present has been made.

4.1.6 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report is generally taken from the DPaW's WA Fauna Census Database which is assumed to follow Aplin and Smith (2001) for amphibians and reptiles, How *et al.* (2001) for mammals and Johnstone (2001) for birds.

Common names are taken from the Western Australia Museum (WAM) recognised primary common name listings when specified, though where common names are not provided they have been acquired from other publications. Sources include Cogger (2014), Wilson and Swan (2013), Van Dyck & Strahan (2013), Christidis and Boles (2008), Bush *et al.* (2010), Bush *et al.* (2007), Tyler *et al.* (2000), and Glauret (1961). Not all common names are generally accepted.

4.2 FIELD SURVEYS

A daytime reconnaissance survey of the study area was carried out on the 5 March, 2014. All survey work was carried out by Greg Harewood (B.Sc. Zoology).

4.2.1 Fauna Habitat Assessment

The communities identified during a flora and vegetation survey of sections of the study area carried out by Cardno (WA) Pty Ltd (Cardno 2008) have been used as the basis for a classification of areas into broad fauna habitat types. This information has been supplemented with observations made during the fauna assessment.

The main aim of the habitat assessment was to determine if it was likely that any species of conservation significance would be utilising the areas that may be impacted on as a consequence of development. The habitat information obtained was also used to aid in finalising the overall potential fauna list.

As part of the desktop literature review, available information on the habitat requirements of the species of conservation significance listed as possibly occurring in the study area was researched. During the field survey the habitats present were assessed and specific elements identified to determine the likelihood of listed threatened species being present and the value of the study area to them.

4.2.2 Opportunistic Fauna Observations

Opportunistic observations of fauna species were made during all field survey work which involved a series of transects across the study area during the day while searching microhabitats such as logs, rocks, leaf litter and observations of bird species with binoculars. Secondary evidence of a species presence such as tracks, scats, skeletal remains, foraging evidence or calls were also noted if observed/heard.

4.2.3 Black Cockatoo Habitat Assessment

The black cockatoo habitat assessment included a:

- Habitat tree survey: This involved the identification of all suitable tree species within the study area that have a Diameter at Breast Height (DBH) of over 50cm (irrespective of the presence/absence of suitable hollows – DoE criteria (SEWPaC 2012)). The location of each tree identified was recorded with a GPS and details on tree species, number and size of hollows (if any) noted. Trees with hollows were marked with "H" using spray paint.

  Target tree species included marri (*Corymbia calophylla*) and jarrah *(Eucalyptus marginata*) or any other endemic *Corymbia/Eucalyptus* species of a suitable size that may be present. Peppermints (*Agonis flexuosa*), *Banksia*, sheoak (*Allocasuarina* sp.) and *Melaleuca* tree species (for example) were not assessed as they typically do not develop hollows that are used by black cockatoos.

For the purposes of this study a potential cockatoo nest hollow was defined as:

Generally any tree which is alive or dead that contains one or more visible hollows (cavities within the trunk or branches) suitable for occupation by any of the three black cockatoo species for the purpose of nesting/breeding. Hollows that had an entrance greater than about 12cm in diameter and would allow the entry of a cockatoo (white tailed or red-tailed) into a suitably orientated and sized branch/trunk, were recorded as a "potential nest hollow".

Identified hollows were examined using binoculars for evidence of actual use by black cockatoos (e.g. chewing around hollow entrance, scarring and scratch marks on trunks and branches). As the survey was carried out within the documented breeding season of black cockatoo's, trees with possible nest hollows were also scratched and raked with a large stick/pole to flush any sitting birds from hollows and calls of chicks were also listened for.

- Black cockatoo foraging assessment: The location and nature of black cockatoo foraging evidence (e.g. chewed fruits around the base of trees) observed during the field survey was recorded along with an assessment of the extent and quality of foraging habitat present, based on mapped vegetation units.

- Roosting habitat survey: Direct and indirect evidence of black cockatoos roosting within trees in the study area was noted if observed (e.g. branch clippings, droppings or moulted feathers).

5. SURVEY CONSTRAINTS

No seasonal sampling has been carried out as part of this fauna assessment. The conclusions presented are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the study area at the time of the field assessments. It should also be recognised that conditions within the study area can change with time.

Some fauna species are reported as potentially occurring within the study area based on there being suitable habitat (quality and extent) present. With respect to opportunistic observations, the possibility exists that certain species may not have been detected during field investigations due to:

- seasonal inactivity during the field survey;
- species present within micro habitats not surveyed;
- cryptic species able to avoid detection; and
- transient wide-ranging species not present during the survey period.

Lack of observational data on some species should therefore not necessarily be taken as an indication that a species is absent from the study area.

The habitat requirements and ecology of many of the species known to occur in the wider area are often not well understood or documented. It can therefore be difficult to exclude species from the potential list based on a lack of a specific habitat or microhabitat within the study area. As a consequence of this limitation the potential fauna list produced is most likely an overestimation of those species that actually utilise the study area for some purpose. Some species may be present in the general area but may only use the study area itself on rare occasions or as vagrants/transients.

In recognition of survey limitations, a precautionary approach has been adopted for this assessment. Any fauna species that would possibly occur within the study area (or immediately adjacent), as identified through ecological databases, publications, discussions with local experts/residents and the habitat knowledge of the Author, has been assumed to potentially occur.

During the black cockatoo habitat survey a search was conducted for trees with hollows. It should be noted that identifying hollows suitable for fauna species from ground level has limitations. Generally the full characteristics of any hollow seen are not fully evident (e.g. internal dimensions). It is also difficult to locate all hollows within all trees as some are not observable from ground level.

The location of observations was recorded using a handheld GPS. The accuracy of the GPS cannot be guaranteed above a level of about 5 to 10 metres, though it should be noted that in some circumstance the accuracy can increase or decrease beyond this range.

6. RESULTS

6.1 POTENTIAL FAUNA INVENTORY - DESKTOP STUDY

A list of fauna species considered most likely to occur in the study area has been compiled from information obtained during the desktop study and is presented in

Appendix B. This listing was refined after information gathered during the study area reconnaissance survey was assessed. The results of some previous fauna surveys carried out in the general area are summarised in this species listing as are the DPaW NatureMap database search results. The raw database search results from NatureMap (DPaW 2014) and the Protected Matters Search Tool (DoE 2014) are contained within Appendix C.

The list of potential fauna takes into consideration that firstly the species in question is not known to be locally extinct and secondly that suitable habitat for each species, as identified during the habitat assessment, is present within the study area, though compiling an accurate list has limitations (see Section 5 above) and therefore as discussed the listing is likely to be an overestimation of the fauna species actually present within the study area at any one time.

6.2 FIELD SURVEYS

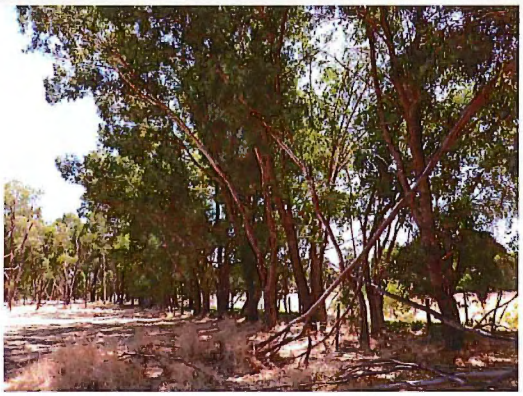
6.2.1 Fauna Habitat Assessment

Descriptions of the broadly defined fauna habitats, mainly based on the remaining vegetation units, soils and landforms within the study area are provided in Table 1 below, with the extent of each identified unit being shown in Figure 3. The approximate area (hectares) covered by each unit, based on canopy cover evident in an air photo, is also provided within Table 1.

Table 1: Main Fauna Habitats within the Study Area (* indicates introduced species)

No.	Fauna Habitat Description	Example Image
1	Low lying woodland-forest (medium height) of *Eucalyptus rudis – Melaleuca preissiana* over *Kunzea glabrescens - Pultenaea reticulata* over *Dielsia stenostachya - Opercularia hispidula - *Zantedeschia aethiopica* on grey sandy loam. ~1.1 ha in extent.	

No.	Fauna Habitat Description	Example Image
2	Low upland woodland (>10m) of *Corymbia calophylla- Eucalyptus marginata* over *Agonis flexuosa - Casuarina obesa - Banksia menzeisii - Banksia grandis* over *Eremaea pauciflora - Calothamnus quadrifidus* over *Conostylis aculeata - Kennedia prostrata - *Ehrharta longiflora - *Lolium rigidum - *Carpobrotus edulis* on grey sand. ~1.5 ha in extent.	
3	Tall Scrub (to 10m) of *Kunzea glabrescens - Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis* on grey sand. Some emergent *Eucalyptus gomphocephala* and none-endemic eucalypts. ~2.3 ha in extent.	
4	Open woodland of *Eucalyptus rudis – Melaleuca preissiana* over pasture grasses/weeds on grey sandy loam. Seasonally inundated/waterlogged. ~0.5 ha in extent.	

No.	Fauna Habitat Description	Example Image
5	Planted endemic and non-endemic trees and shrubs over pasture grasses/weeds on grey sand. ~0.9 ha in extent.	
6	Cleared (open grassland, bare sand) with scattered trees. ~10.3 ha in extent.	

Overall fauna habitat values and biodiversity within the study area have been severely compromised by the total or partial clearing of native vegetation, historical livestock grazing, dieback and weed invasion. Most areas lack any natural attributes and are now only utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in highly disturbed habitats.

These observations are consistent with the flora and vegetation survey which reported a low diversity of plant species. This indicates that vegetation quality and extent within the study area does not represent the original vegetation values and therefore supports reduced ecological functions (Cardno 2008).

6.2.2 Opportunistic Fauna Observations

Opportunistic fauna observations are listed in Appendix B. A total of 23 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the study area during the single day time survey. Signs of two introduced species were also seen.

Evidence of one listed threatened species was observed (Carnaby's black-cockatoo or the forest red-tailed black cockatoo (chewed jarrah fruits – actual species of black cockatoo responsible uncertain). Diggings attributed to the southern brown bandicoot (DPaW Priority 5 species) were found within the area of flooded gum in the north east section of the study area and several rainbow bee-eaters, a listed migratory species, were observed foraging near the eastern boundary of the study area during the survey period.

6.2.3 Black Cockatoo Habitat Assessment

The habitat tree assessment identified 69 specimens within the study area that meet DoE's (SEWPaC 2012) criteria for black cockatoo breeding habitat (i.e. suitable tree species with a diameter at breast height (DBH) of >50cms) (Figure 4). It should be noted that a small number (seven) of these trees are located just outside of the currently proposed local structure plan boundary but have been included due to uncertainty related to GPS accuracy/and or the final structure plan boundary.

Most of the trees were either flooded gum (*E. rudis* - 21 specimens) or jarrah (*E. marginata* – 21 specimens) with the balance being unidentifiable dead specimens (17 specimens, most likely jarrah killed by dieback), tuart (*E. gomphocephala* – 7 planted specimens) and marri (*C. calophylla* – 3 specimens).

Thirty three (33) of the 69 trees were observed to contain hollows of some type with one (1) dead tree being assessed at the time to possibly have large enough hollows for black cockatoos to use for nesting though this assessment was based on the size of the entrance into an apparent hollow only. No actual evidence of any hollows being used by black cockatoos for nesting (currently or previously) was seen.

Additional details on each observed "habitat tree" can be found in Appendix D.

Only one example of foraging evidence was observed during the field survey. This was in the form of chewed jarrah fruits under a single tree. The lack of evidence suggests that the study area is not frequented by black cockatoos often. This could primarily be attributed to the limited extent of vegetation containing favoured foraging species (e.g. jarrah, marri, *Banksia*, Sheoak) and the limited density of some of these species in respective vegetation units (e.g. marri and *Banksia* while present, persist in very low numbers).

Fauna habitat unit number 2 (see Table 1) contains most of the species known to be utilised for foraging by black cockatoos but only covers an area of about 1.5 ha and it is debatable as to whether this area represent "quality" foraging habitat as defined by the DoE (SEWPac 2012) given apparent effects of dieback on key species (i.e. jarrah and *Banksia*) and is likely to only provide sufficient resources to support a

very small number (one or two) of black cockatoos per year based on studies carried out in areas containing similar habitat (Valentine and Stock 2008, Bamford 2011).

No existing roosting trees (trees used at night by black cockatoos to rest) were positively identified during the survey.

6.3 FAUNA INVENTORY – SUMMARY

6.3.1 Vertebrate Fauna

Table 2 summarises the number of vertebrate fauna species potentially occurring within or utilising at times the study area, based on results from the desktop study and observations made during the field assessment. A complete list of vertebrate fauna possibly inhabiting or frequenting the study area is located in Appendix B.

Not all species listed as potentially occurring within the study area in existing databases and publications (i.e. *EPBC Act* Threatened Fauna and Migratory species lists, DPaW's NatureMap database, various reports and publications) are shown in the expected listing in Appendix B. Some species have been excluded from this list based largely on the lack of suitable habitat at the study area and in the general area or known local extinction even if suitable habitat is present.

Despite the omission of some species it should be noted that the list provided is still very likely an over estimation of the fauna species utilising the study area (either on a regular or infrequent basis) as a result of the precautionary approach adopted for the assessment. At any one time only a subset of the listed potential species are likely to be present within the bounds of the study area.

Table 2: Summary of Potential Vertebrate Fauna Species (as listed in Appendix B)

Group	Total number of potential species	Potential number of specially protected species	Potential number of migratory species	Potential number of priority species	Number of species observed - field survey
Fish	0	0	0	0	0
Amphibians	8	0	0	0	0
Reptiles	16	0	0	1	1
Birds	87[6]	3	3	0	20[1]
Non-Volant Mammals	9[6]	0	0	1	4[1]
Volant Mammals (Bats)	8	0	0	0	0
Total	**128[12]**	**3**	**3**	**2**	**25[2]**

Superscript = number of introduced species included in total.

6.3.2 Vertebrate Fauna of Conservation Significance

A review of the *EPBC Act* threatened fauna list, DPaW's Threatened Fauna Database and Priority List, unpublished reports and scientific publications identified over 30 specially protected, priority or migratory vertebrate fauna species as potentially occurring in the general vicinity of the study area. Of these species, most that have no potential whatsoever to utilise the study area for any purpose have been omitted from the potential list (Appendix B), principally due to lack of suitable habitat (including extent and/or quality) or known local/regional extinction.

Two vertebrate fauna species of conservation significance were positively identified as utilising the study area for some purpose during the survey period, this being:

- *Merops ornatus* Rainbow Bee-eater – S3 (*WC Act*), Migratory (*EPBC Act*) Several individuals were observed during the field survey. This species is a common seasonal visitor to the south west. Possibly breeds in some sections of the study area where ground conditions permit (e.g. sandy areas) though population levels would not be significant as it usually breeds in pairs, rarely in small colonies (Johnstone and Storr 1998).

- *Isoodon obesulus fusciventer* Southern Brown Bandicoot – P5 (DPaW Priority Species)
  Evidence of this species foraging (i.e. diggings) in some sections of the study area was observed during the field survey. Potentially present within the study area wherever dense shrubby groundcover occurs, though extent of suitable habitat is limited.

A limited amount of evidence attributed to black cockatoos foraging within the study area was observed though it was not possible to determine which species was responsible. The two species of black cockatoos known to frequent the general area are:

- *Calyptorhynchus banksii naso* Forest Red-tailed Black-Cockatoo – S1 (*WC Act*), Vulnerable (*EPBC Act*)
  Foraging evidence possibly left by this species (or Carnaby's) was found during the field survey (chewed jarrah fruits). Remnant vegetation containing jarrah, marri and sheoak within the study area represents potential foraging habitat for this species though it is limited in extent and quality.

  The small number of larger trees (>50cm DBH) may also be considered by the DoE as potential breeding habitat, based on their criteria for black cockatoo breeding habitat, though only one tree was observed to actually contain hollows of a size possibly suitable for this purpose. In reality the possibility of any of these trees being used for breeding proposes now or in the future can be considered to be extremely low. This species may also roost within the study area on occasions, though no evidence of this was seen.

- *Calyptorhynchus latirostris* Carnaby`s Black-Cockatoo – S1 (*WC Act*), Endangered (*EPBC Act*)
  Foraging evidence possibly left by this species (or the FRTBC) was found during the field survey (chewed jarrah fruits). Remnant vegetation containing jarrah, marri and *Banksia* within the study area represents potential foraging habitat for this species though it is limited in extent and quality.

  The small number of larger trees (>50cm DBH) may also be considered by the DoE as potential breeding habitat, based on their criteria for black cockatoo breeding habitat, though only one tree was observed to actually contain hollows of a size possibly suitable for this purpose. In reality the possibility of any of these trees being used for breeding proposes now or in the future can be considered to be extremely low. This species may also roost within the study area on occasions, though no evidence of this was seen.

Based on the habitats present and current documented distributions it is considered possible that five additional species may use the study area for some purpose at times, though, as no evidence of any using the study area at the time of the field survey was found, the status of some in the study area remains uncertain. Habitat for some of these species within the study area, while considered possibly suitable, may be marginal in extent/quality and the species listed may only visit the study area for short periods, or as rare/uncommon vagrants/transients.

These species are:

- *Lerista lineata* Perth Lined Lerista – P3 (DPaW Priority Species)
  Some areas of habitat appear to be suitable for this species to persist despite it's generally degraded state and it has been recorded in larger bush remnants nearby (ENV 2009, Phoenix 2010). Known to inhabit gardens (Nevill 2005, Bush *et al.* 2010) so may persist in degraded areas and subsequent to development.

- *Ardea alba* Great Egret – S3 (*WC Act*), Migratory (*EPBC Act*)
  May utilise the waterlogged, low lying areas and manmade drains during winter months for foraging at times, but only in low numbers and for brief periods. Unlikely to breed within the study area.

- *Ardea ibis* Cattle Egret – S3 (*WC Act*), Migratory (*EPBC Act*)
  May utilise the waterlogged, low lying areas and manmade drains during winter months for foraging at times, but only in low numbers and for brief periods. Unlikely to breed within the study area.

- *Falco peregrinus* Peregrine Falcon - S4 (*WC Act*)
  Individuals of this species potentially utilise some sections of the study area as part of a much larger home range but would only occur rarely.

A number of other species of conservation significance, while possibly present in the wider area (e.g. Leda Nature Reserve, Jandakot Airport bushland or Bibra Lake bushland), are not listed as potential species due to known localised extinction (and no subsequent recruitment from adjoining areas), lack of suitable habitat and/or the presence of feral predators. Details on conservation significant species and reasons for the omission of some from the potential listing are provided in Appendix E and Table 3.

Twenty six (26) bird species that potentially frequent or occur in the study area are noted as Bush Forever Decreaser Species in the Perth Metropolitan Region (six were sighted/identified as having used the study area during the survey). Decreaser species (mainly sedentary birds) are a significant issue in biodiversity conservation in the Perth section of the coastal plain as there have been marked reductions in

range and population levels as a consequence of disturbance and land clearing (Dell & Hyder-Griffiths 2002).

6.3.3 Invertebrate Fauna of Conservation Significance

One invertebrate species of conservation significance appeared in the DPaW database search (DPaW 2014), this being the graceful sun moth (*Synemon gratiosa* – Priority 4) (DPaW 2013 and 2014).

A spring flora and vegetation survey of the study area in 2008 by Cardno (Cardno 2008) did not identify the presence of any *Lomandra* plant species and therefore it is considered very unlikely that the graceful sun moth could persist within the study area. Additional information on this species can be found in Appendix E.

7. FAUNA VALUES

7.1 CONSERVATION SIGNIFICANCE OF THE STUDY AREA

The conservation significance of the study area has been determined by applying specific criteria such as:

- Fauna species and/or habitat present that is poorly represented in the general vicinity of the study area;
- Fauna habitat within the study area supporting species of conservation or other significance; and
- Fauna habitat in better condition than other similar locations in the general vicinity of the study area.

Natural areas within the south west of Western Australia have been significantly altered since European settlement in the 1830's and a variety of environmental factors, in particular habitat fragmentation and fire, will continue to threaten many species of fauna with local extinction. As the local development of land progresses the significance of any remnant vegetation increases.

Almost the entire study area has been used for livestock grazing over many years. Habitat degradation as a result of total or partial clearing, altered fire regimes and the presence of introduced predators would have had a significant effect on species diversity within the study area including the smaller bush remnants. The majority of the study area is totally cleared with only scattered trees remaining and as a consequence the diversity of fauna species would have been significantly reduced from its original natural levels.

Because of these factors the study area cannot be regarded as having any local conservation significance to fauna.

7.2 VALUE OF THE STUDY AREA AS AN ECOLOGICAL LINKAGE/WILDLIFE CORRIDOR

Perth Greenways Mapping (Government of Western Australia 2000a, Map 6). Shows "linkage No. 75" encompassing the middle to upper portion of Lot 379 and the southern corner of Lot 9001 (see Figure 3, Cardno 2008). Since the identification of these linkages occurred significant development has occurred in the general area and the value of the linkage has been compromised to a certain extent.

For example the construction of the Kwinana Freeway across the linkage directly to the west of the study area represent a significant barrier to fauna movement. The poor quality of the vegetation/habitat within the study area also limits the value of the corridor at this location given that fauna species diversity has been significantly reduced from natural levels.

8. POTENTIAL IMPACTS AND DEVELOPMENT CONSIDERATIONS

8.1 POTENTIAL IMPACTS OF DEVELOPMENT

The most likely potential impacts of the proposed development within the study area are:

- The loss of fauna habitat, some of which may be used by fauna of conservation significance,
- Fragmentation of vegetation/fauna habitat which may restrict the movement of some fauna species,
- Death or injury of fauna during clearing and construction.

The possible impacts on specific species of conservation significance previously recorded in the general area are provided in the Table 3 below. Additional information on those species listed is provided in Appendix E.

Table 3: Likelihood of Occurrence and Possible Impacts – Fauna Species of Conservation Significance (continues on following pages).

Common Name	Genus & Species	Conservation Status (See Appendix A for codes)	Habitat Present	Likelihood of Occurrence	Possible Impacts
Graceful Sun Moth	*Synemon gratiosa*	P4	No	Unlikely	No impact.
Perth Lined Lerista	*Lerista lineata*	P3	Yes/Marginal	Possible	Loss/modification of areas of marginal habitat. No significant impact likely.
Black-striped Snake	*Neelaps calonotos*	P3	No	Unlikely	No impact.
Southern Carpet Python	*Morelia spilota imbricata*	S4	No	Unlikely	No impact.
Malleefowl	*Leipoa ocellata*	S1 VU Mig	No	Unlikely - species locally extinct.	No Impact.
Great Egret	*Ardea alba*	S3 Mig	Yes/Marginal	Possible	Loss/modification of areas of very marginal habitat. No significant impact likely.
Cattle Egret	*Ardea ibis*	S3 Mig	Yes/Marginal	Possible	Loss/modification of areas of marginal habitat. No significant impact likely.
Little Bittern	*Ixobrychus minutus*	P4	No	Unlikely	No impact.
Glossy Ibis	*Plegadis falcinellus*	Mig	No/Very Marginal	Unlikely	No impact.
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	S3 Mig	No	Unlikely	No impact.
Osprey	*Pandion haliaetus*	Mig	No	Unlikely	No impact.
Peregrine Falcon	*Falco peregrinus*	S4	Yes	Possible but only rarely.	Loss/modification of small areas of degraded natural habitat. No significant impact likely.
Migratory Shorebirds/Wetland Species	Various	Mig, Various	No	Unlikely	No impact.
Painted Snipe	*Rostratula benghalensis*	S1 S3 Mig EN	No	Unlikely	No impact.
Bush Stone Curlew	*Burhinus grallarius*	P4	No	Unlikely - species locally extinct.	No Impact.
Hooded Plover	*Charadrius rubricollis*	P4	No	Unlikely	No impact.
Fairy Tern (Australian)	*Sternula nereis nereis*	VU	No	Unlikely	No impact.
Carnaby`s Black Cockatoo	*Calyptorhynchus latirostris*	S1 EN	Yes	Possible	Loss/modification of some areas of natural habitat.
Baudin`s Black Cockatoo	*Calyptorhynchus baudinii*	S1 VU	No	Unlikely	No impact.

Common Name	Genus & Species	Conservation Status (See Appendix A for codes)	Habitat Present	Likelihood of Occurrence	Possible Impacts
Forest Red-tailed Black Cockatoo	*Calyptorhynchus banksii naso*	S1 VU	Yes	Possible	Loss/modification of some areas of natural habitat.
Fork-tailed Swift	*Apus pacificus*	S3 Mig	Yes	Unlikely, Flyover only.	No impact.
Rainbow Bee-eater	*Merops ornatus*	S3 Mig	Yes	Known to occur.	Loss/modification of areas of man-made and natural habitat. No significant impact likely.
Chuditch	*Dasyurus geoffroii*	S1 VU	No	Unlikely	No impact.
Southern Brush-tailed Phascogale	*Phascogale tapoatafa ssp*	S1	No/Very Marginal	Unlikely	No impact.
Southern Brown Bandicoot	*Isoodon obesulus fusciventer*	P5	Yes	Known to occur.	Loss/modification of small areas of marginal natural habitat. No significant impact likely.
Western Ringtail Possum	*Pseudocheirus occidentalis*	S1 VU	No	Unlikely - species locally extinct.	No Impact.
Quokka	*Setonix brachyurus*	S1 VU	No	Unlikely - species locally extinct.	No Impact.
Western Brush Wallaby	*Macropus irma*	P4	No	Unlikely	No impact.
Western False Pipistrelle	*Falsistrellus mackenziei*	P4	No/Marginal	Unlikely	No Impact.
Water Rat	*Hydromys chrysogaster*	P4	No	Unlikely	No impact.

8.2 CONSIDERATIONS FOR PLANNING AND DEVELOPMENT

With respect to vertebrate fauna in general, no substantial impacts are anticipated as a consequence of development within the study area. In cases where some impact is anticipated, the degree of the impact is expected to be low and relates to the loss of small areas of habitat. As most species are common and widespread no overall change in their conservation status is anticipated, despite a possible localised reduction in habitat extent. It should also be noted that the habitat remnants within the study area are small and as a consequence it would be difficult to maintain or improve existing ecological values without considerable effort. The value of the study area to fauna if left as is, is therefore likely to continue to deteriorate in the long term.

The assessment does indicate that any considerations required during ongoing development planning are likely to be limited to the presence of habitat used or potentially used by some threatened fauna species in particular those listed under the *EPBC Act*, namely two species of black cockatoo. However, despite the

presence of some black cockatoo habitat, it has a limited extent and its quality appears to be low. With this in mind it is considered unlikely that impacts on black cockatoos that may occur as a result of development at any scale would result in a "significant impact" as defined by the Federal DoE (DoE 2013).

This conclusion is primarily based on the fact that most of the study area (~62%) is totally cleared or almost totally cleared of vegetation and therefore doesn't contain significant areas of potential cockatoo habitat. Where some habitat is present it is limited in extent. For example the foraging habitat present in the more connected vegetated areas (primarily jarrah, marri banksia woodland – in total ~1.5 ha only) is only likely to provide sufficient food to support no more than one or two black cockatoos per year based on studies carried out in areas containing similar habitat (Valentine and Stock 2008, Bamford 2011).

The study area is also not located in a documented black cockatoo breeding area, and while some trees present are classified as "potential breeding habitat" (based on DoE criteria for black cockatoo breeding habitat, (SEWPaC 2012)) the probability of any tree developing hollows that would then be used by black cockatoos for breeding can be considered to be extremely low. The study area is also unlikely to be considered of specific importance for the recovery of black cockatoos in the long term. For example the population growth of the Carnaby's black-cockatoo is primarily limited by factors associated with breeding, and consequently priority areas for the recovery of the species are currently focused on known breeding sites (Cale 2003).

So, while the retention of areas of vegetation should be considered during the planning process, based on the assessment above it is not likely to represent a constraint to development as information gathered as part of this assessment suggest that removal of small areas of vegetation is unlikely to result in a "significant impact" on black cockatoos as defined by the DoE.

9. CONCLUSION

The fauna assessment within the study area was undertaken for the purposes of categorising the fauna assemblages and identifying fauna habitats present. A targeted assessment of black cockatoo habitat within the study area was also carried out.

Overall fauna habitat values and biodiversity within the study area have been severely compromised by the total or partial clearing of native vegetation and historical livestock grazing. Most areas lack any natural attributes and are now only

utilised by generally common and widespread fauna species with non-specific requirements which allow them to persist in highly disturbed habitats.

With respect to native vertebrate fauna, eleven mammals (including eight bat species), 81 bird, 16 reptile and eight frog species have previously been recorded in the general area, some of which have the potential to occur in or utilise sections of the study area at times.

Of the 116 native animals that are listed as potentially occurring in the study area, three are considered to be endangered/vulnerable or in need of special protection under State and/or Federal law, these being two species of black cockatoo (Carnaby's and the forest red-tailed) and the peregrine falcon. In addition, three migratory species (great egret, cattle egret and the rainbow bee-eater) may also utilise the study area at times. Two DPaW priority species are also known from the general vicinity and are likely to be present in areas of suitable habitat (southern brown bandicoot and Perth lined lerista).

Most of the study area is cleared of native vegetation and/or highly degraded and therefore direct impacts on fauna of conservation significance or natural fauna habitat that may occur as a consequence of future development at any scale are anticipated to be minimal/negligible. No significant impact on any fauna species is considered likely.

The study area does contain areas of potential breeding and foraging habitat for black cockatoos. No evidence of past or present use for breeding was observed and foraging evidence was limited to one example. This apparent lack/limited level of utilisation can be attributed to the fact that the study area is not within a documented breeding area for any of the black cockatoo species and the area of foraging habitat is limited in extent and relatively poor in quality.

At this stage no referral to the DoE with respect to listed *EPBC Act* threatened fauna species is considered necessary however this conclusion should be reviewed once plans for development are finalised or have progressed to a stage where the anticipated small scale of impacts can be more accurately demonstrated.

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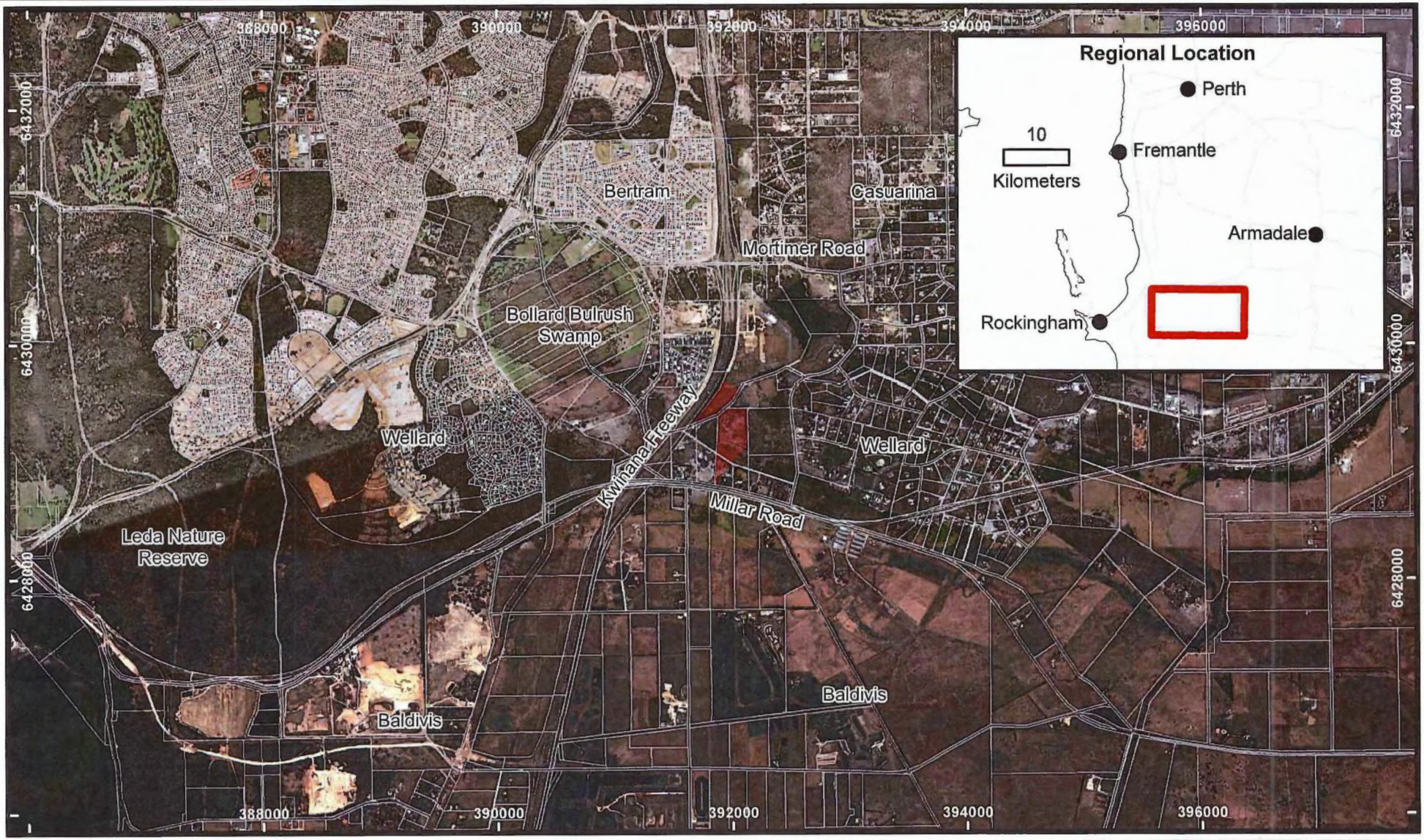
FIGURES



Legend

Local Structure Plan Area

0 1 2 3 4 5

Kilometres

MGA Zone 50

Fauna Survey

DRAWN:G Harewood

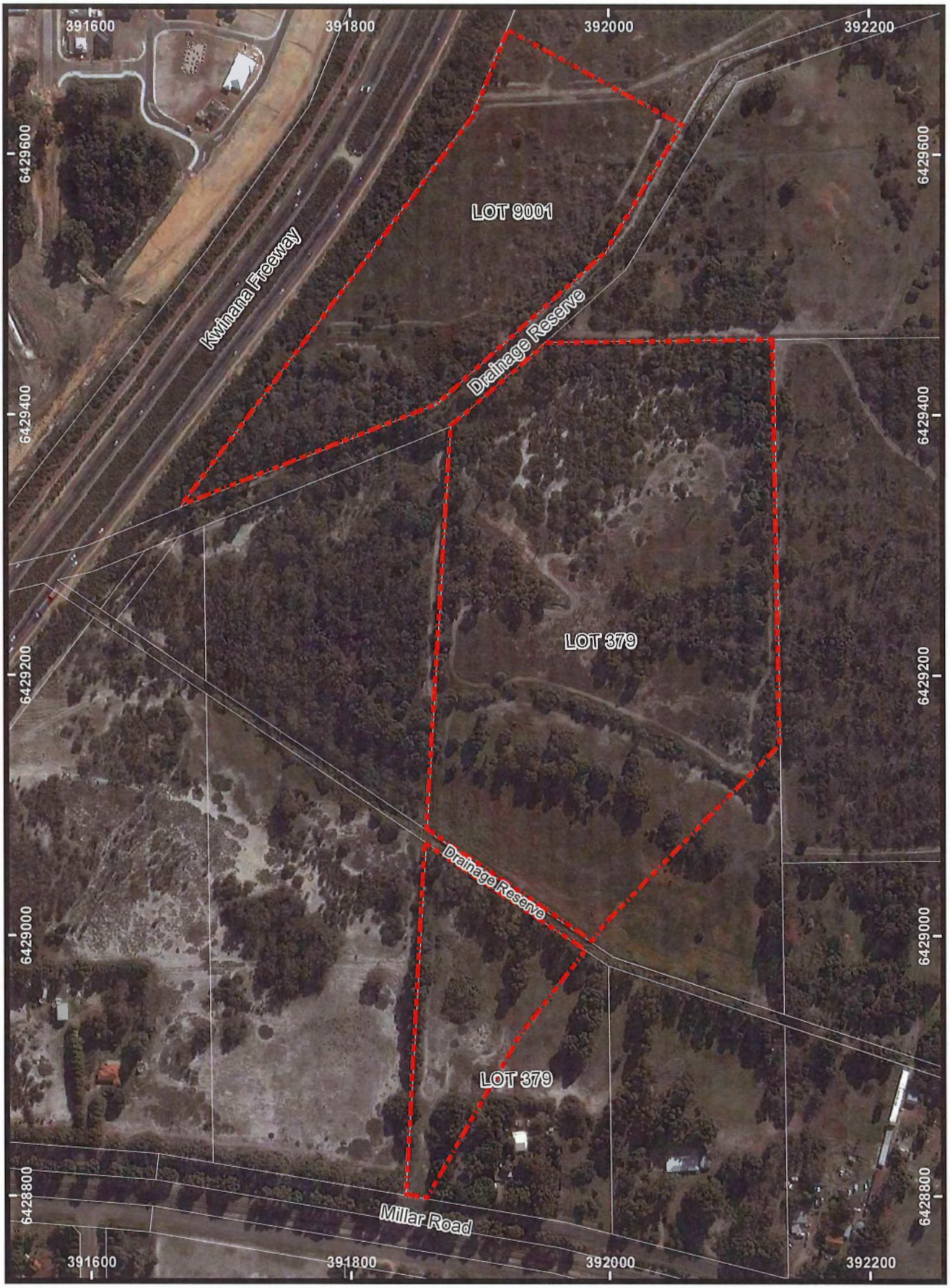
DATE : April 2014

SCALE: 1:45,000

Part Lots 379 and 9001 Wellard East

Study Area and Surrounds

Figure: 1



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Local Structure Plan Area

0 100 200

Meters

MGA Zone 50

Fauna Survey

DRAWN:G Harewood

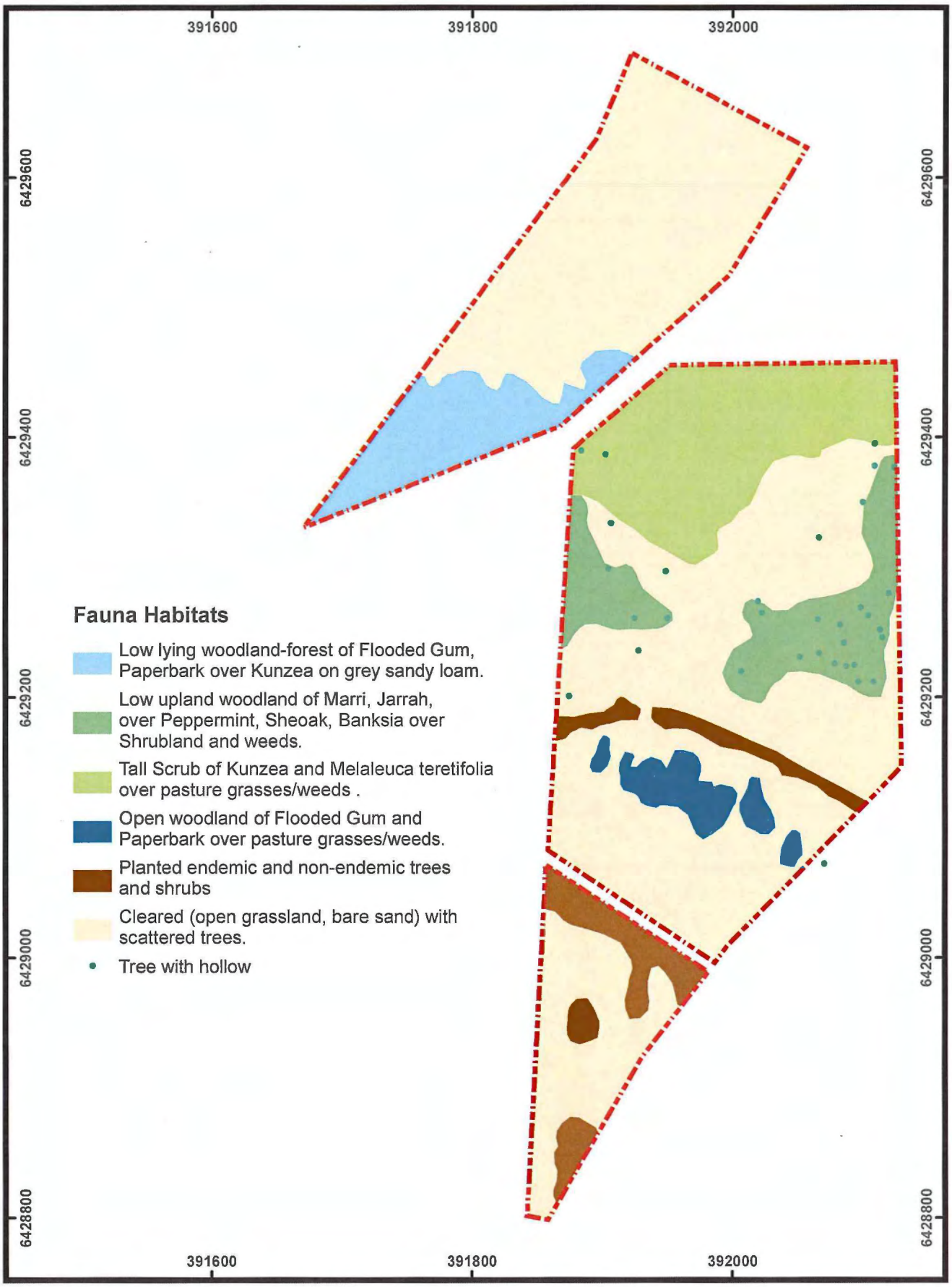
DATE : April 2014

SCALE: 1:4,000

Part Lots 379 and 9001 Wellard East

Air Photo

Figure: 2



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Local Structure Plan Area

N

0 100 200

Meters

MGA Zone 50

Fauna Survey

DRAWN:G Harewood

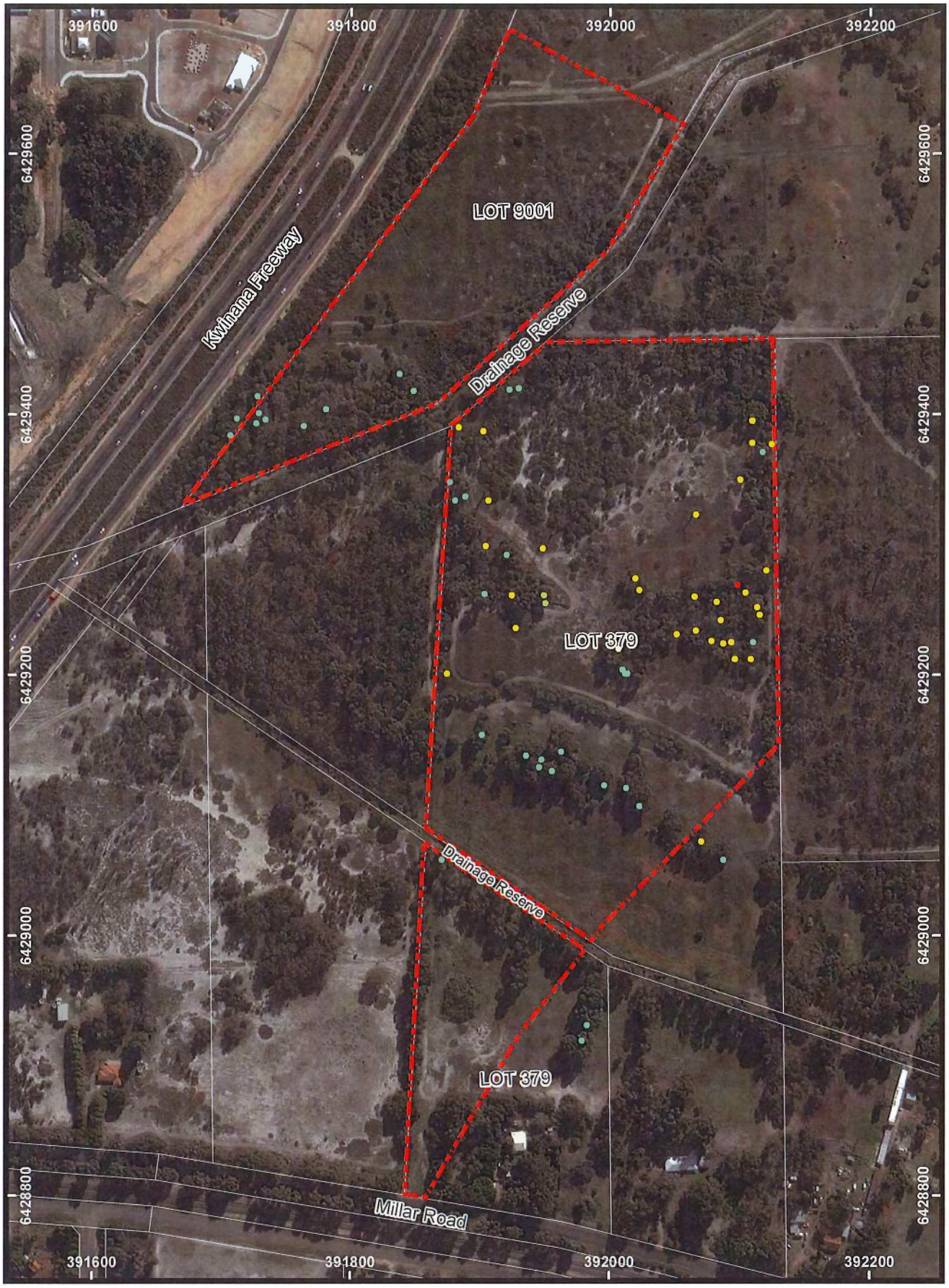
DATE : April 2014

SCALE: 1:4,000

Part Lots 379 and 9001 Wellard East

Fauna Habitats

Figure: 3



Legend

- Local Structure Plan Area
- Tree >50cm DBH, no hollows seen
- Tree >50cm DBH, one or more hollows seen
- Tree >50cm DBH, one or more hollows possibly suitable for a Black Cockatoo

N

0 100 200

Meters

MGA Zone 50

Fauna Survey

DRAWN:G Harewood

DATE : April 2014

SCALE: 1:4,000

Part Lots 379 and 9001 Wellard East

Habitat Trees (DBH>50cm)

Figure: 4

APPENDIX A

CONSERVATION CATEGORIES

EPBC Act (1999) Threatened Fauna Categories

Category	Code	Description
Extinct	E	There is no reasonable doubt that the last member of the species has died.
*Extinct in the wild	EW	A species (a) is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
*Critically endangered	CE	A species is facing an extremely high risk of extinction in the wild in the immediate future.
*Endangered	EN	A species: (a) is not critically endangered; and (b) is facing a very high risk of extinction in the wild in the near future.
*Vulnerable	VU	A species (a) is not critically endangered or endangered; and (b) is facing a high risk of extinction in the wild in the medium-term future.
Conservation dependent	CD	A species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered
*Migratory	Migratory	(a) all migratory species that are: (i) native species; and (ii) from time to time included in the appendices to the Bonn Convention; and (b) all migratory species from time to time included in annexes established under JAMBA, CAMBA and ROKAMBA; and (c) all native species from time to time identified in a list established under, or an instrument made under, an international agreement approved by the Minister.
Marine	Ma	Species in the list established under s248 of the EPBC Act

Note: Only species in those categories marked with an asterix are matters of national environmental significance under the *EPBC Act*.

Western Australian Wildlife Conservation Act (1950) Threatened Fauna Categories

Category	Code	Description
Schedule 1	S1	Fauna which is rare or likely to become extinct Threatened fauna (Schedule 1) are further ranked by the DEC according to their level of threat using IUCN Red List criteria: **CR: Critically Endangered** - considered to be facing an extremely high risk of extinction in the wild. **EN: Endangered** - considered to be facing a very high risk of extinction in the wild. **VU: Vulnerable** - considered to be facing a high risk of extinction in the wild.
Schedule 2	S2	Fauna which is presumed extinct
Schedule 3	S3	Birds which are subject to an agreement between the governments of Australia and Japan (JAMBA) relating to the protection of migratory birds and birds in danger of extinction
Schedule 4	S4	Fauna that is otherwise in need of special protection

Western Australian DPaW Priority Fauna Categories

Category	Code	Description
Priority 1	P1	Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes..
Priority 2	P2	Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
Priority 3	P3	Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
Priority 4	P4	(a) **Rare**. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands. (b) **Near Threatened**. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
Priority 5	P5	Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

IUCN Red List Threatened Species Categories

Category	Code	Description
Extinct	EX	Taxa for which there is no reasonable doubt that the last individual has died.
Extinct in the Wild	EW	Taxa which is known only to survive in cultivation, in captivity or and as a naturalised population well outside its past range and it has not been recorded in known or expected habitat despite exhaustive survey over a time frame appropriate to its life cycle and form.
Critically Endangered	CR	Taxa facing an extremely high risk of extinction in the wild.
Endangered	EN	Taxa facing a very high risk of extinction in the wild.
Vulnerable	VU	Taxa facing a high risk of extinction in the wild.
Near Threatened	NT	Taxa which has been evaluated but does not qualify for CR, EN or VU now but is close to qualifying or likely to qualify in the near future.
Least Concern	LC	Taxa which has been evaluated but does not qualify for CR, EN, VU, or NT but is likely to qualify for NT in the near future.
Data Deficient	DD	Taxa for which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.

A full list of categories and their meanings are available at:

http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

APPENDIX B

FAUNA OBSERVED OR POTENTIALLY IN STUDY AREA

Fauna Observed or Potentially in Study Area

Part Lots 379 and 9001, Wellard East

Compiled by Greg Harewood - April 2014
Approximate centroid = 32.268532°S 115.853195°E
Recorded (Sighted/Heard/Signs/Captured) = X

A = Harewood, G. (2014). Fauna Assessment of Part Lots 379 and 9001 Wellard East. Unpublished report for Amex Corporation.

B = ENV (2009). Jandakot Airport Fauna Survey. Unpublished report for Jandakot Airport Holdings Pty Ltd.

C = Phoenix Environmental Sciences (2011). Vertebrate Fauna Survey for the Roe Highway Extension Project. . Unpublished report for South Metro Connect.

D = Harewood, G. (2009) Fauna Survey (Level 2) East Rockingham WWTP Site and Pipeline Corridors. Unpublished report for ERM.

E = DPaW (2014). NatureMap Database search. "By Circle" 115°51' 11" E, 32°16' 08" S – Study area (plus 8km buffer), 31/03/2014.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Amphibia							
Myobatrachidae Ground or Burrowing Frogs							
Crinia georgiana	Quacking Frog	LC		X	X		
Crinia glauerti	Clicking Frog	LC			X		X
Crinia insignifera	Squelching Froglet	LC			X		X
Geocrinia leai	Ticking Frog	LC					
Heleioporus eyrei	Moaning Frog	LC			X		X
Limnodynastes dorsalis	Western Banjo Frog	LC		X	X		X

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DPaW Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Hylidae Tree or Water-Holding Frogs							
Litoria adelaidensis	Slender Tree Frog	LC		X	X		X
Litoria moorei	Motorbike Frog	LC			X		X
Reptilia							
Gekkonidae Geckoes							
Christinus marmoratus	Marbled Gecko				X	X	
Pygopodidae Legless Lizards							
Aprasia repens	Sandplain Worm Lizard				X		X
Lialis burtonis	Burton's Legless Lizard				X	X	X
Varanidae Monitor's or Goanna's							
Varanus tristis	Racehorse Monitor					X	

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Scincidae Skinks							
Acritoscincus trilineatum	Southwestern Cool Skink			X	X		
Cryptoblepharus buchananii	Fence Skink		X	X	X	X	X
Ctenotus fallens	West Coast Ctenotus				X	X	X
Hemiergis quadrilineata	Two-toed Mulch Skink			X	X	X	X
Lerista elegans	West Coast Four-toed Lerista			X	X	X	X
Lerista lineata	Perth Lined Lerista	P3			X		X
Menetia greyii	Dwarf Skink			X	X	X	X
Morethia lineoocellata	West Coast Pale-flecked Morethia				X	X	
Morethia obscura	Shrubland Pale-flecked Morethia				X	X	
Tiliqua rugosa	Bobtail			X	X	X	X
Elapidae Elapid Snakes							
Notechis scutatus	Tiger Snake				X		X
Pseudonaja affinis	Dugite			X	X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Aves							
Phasianidae Quails, Pheasants							
Coturnix pectoralis	Stubble Quail	LC					X
Coturnix ypsilophora	Brown Quail	LC		X			
Anatidae Geese, Swans, Ducks							
Anas gracilis	Grey Teal	LC			X		X
Anas superciliosa	Pacific Black Duck	LC		X	X		X
Chenonetta jubata	Australian Wood Duck	LC					X
Tadorna tadornoides	Australian Shelduck	LC			X		X
Ardeidae Herons, Egrets, Bitterns							
Ardea alba	Great Egret	S3 Mig CA JA			X		
Ardea ibis	Cattle Egret	S3 Mig CA JA					X
Ardea novaehollandiae	White-faced Heron	LC			X		
Ardea pacifica	White-necked Heron	LC					X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Accipitridae Kites, Goshawks, Eagles, Harriers							
Accipiter cirrocephalus	Collared Sparrowhawk	Bp LC		X		X	X
Accipiter fasciatus	Brown Goshawk	Bp LC			X	X	X
Aquila audax	Wedge-tailed Eagle	Bp LC			X		X
Aquila morphnoides	Little Eagle	Bp LC		X		X	X
Circus assimilis	Spotted Harrier	LC					
Elanus caeruleus	Black-shouldered Kite	LC		X	X	X	
Haliastur sphenurus	Whistling Kite	Bp LC	X		X	X	X
Hamirostra isura	Square-tailed Kite	Bp LC					X
Falconidae Falcons							
Falco berigora	Brown Falcon	Bp LC					X
Falco cenchroides	Australian Kestrel	LC		X	X	X	X
Falco longipennis	Australian Hobby	LC		X	X	X	X
Falco peregrinus	Peregrine Falcon	S4 Bp LC				X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Columbidae Pigeons, Doves							
Columba livia	Domestic Pigeon	Introduced			X		X
Ocyphaps lophotes	Crested Pigeon	LC		X	X		X
Phaps chalcoptera	Common Bronzewing	Bh LC		X		X	X
Streptopelia chinensis	Spotted Turtle-Dove	Introduced		X	X		X
Streptopelia senegalensis	Laughing Turtle-Dove	Introduced		X	X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Psittacidae Parrots							
Cacatua roseicapilla	Galah	LC		X	X	X	X
Cacatua sanguinea	Little Corella	LC		X	X		X
Cacatua tenuirostris	Eastern Long-billed Corella	Introduced					X
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	S1 VU Bp VU A2c+3c+4c		X	X		X
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	S1 EN Bp EN A2bcde+3bcde+4bcde		X	X	X	X
Neophema elegans	Elegant Parrot	LC			X		X
Platycercus icterotis icterotis	Western Rosella (western ssp)	Bp LC					X
Platycercus spurius	Red-capped Parrot	LC	X	X	X	X	X
Platycercus zonarius	Australian Ringneck Parrot	LC	X	X	X	X	X
Polytelis anthopeplus	Regent Parrot	LC					X
Trichoglossus haematodus	Rainbow Lorikeet	Introduced		X	X		X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Cuculidae Parasitic Cuckoos							
Cacomantis flabelliformis	Fan-tailed Cuckoo	LC		X			X
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	LC		X		X	X
Chrysococcyx lucidus	Shining Bronze Cuckoo	LC		X	X		
Cuculus pallidus	Pallid Cuckoo	LC					
Strigidae Hawk Owls							
Ninox novaeseelandiae	Boobook Owl	LC			X		X
Tytonidae Barn Owls							
Tyto alba	Barn Owl	LC				X	X
Podargidae Frogmouths							
Podargus strigoides	Tawny Frogmouth	LC					X
Caprimulgidae Nightjars							
Eurostopodus argus	Spotted Nightjar	LC					

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Aegothelidae Owlet-nightjars							
Aegotheles cristatus	Australian Owlet-nightjar	LC			X		
Halcyonidae Tree Kingfishers							
Dacelo novaeguineae	Laughing Kookaburra	Introduced	X		X	X	X
Todiramphus sanctus	Sacred Kingfisher	LC			X		X
Meropidae Bee-eaters							
Merops ornatus	Rainbow Bee-eater	S3 Mig JA LC	X		X	X	X
Maluridae Fairy Wrens, GrassWrens							
Malurus splendens	Splendid Fairy-wren	Bh LC	X	X	X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Acanthizidae Thornbills, Geryones, Fieldwrens & Whitefaces							
Acanthiza apicalis	Broad-tailed Thornbill	Bh LC	X		X	X	X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Bh LC	X	X	X		X
Acanthiza inornata	Western Thornbill	Bh LC			X	X	X
Gerygone fusca	Western Gerygone	LC	X	X	X	X	X
Sericornis frontalis	White-browed Scrubwren	Bh LC			X	X	X
Smicrornis brevirostris	Weebill	Bh LC	X		X	X	X
Pardalotidae Pardalotes							
Pardalotus punctatus	Spotted Pardalote	LC			X		X
Pardalotus striatus	Striated Pardalote	LC		X	X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Meliphagidae Honeyeaters, Chats							
Acanthorhynchus superciliosus	Western Spinebill	LC		X	X		X
Anthochaera carunculata	Red Wattlebird	LC	X	X	X	X	X
Lichenostomus virescens	Singing Honeyeater	LC		X	X	X	
Lichmera indistincta	Brown Honeyeater	LC	X	X	X	X	X
Phylidonyris nigra	White-cheeked Honeyeater	Bp LC		X	X		
Phylidonyris novaehollandiae	New Holland Honeyeater	Bp LC	X	X	X	X	X
Petroicidae Australian Robins							
Petroica multicolor	Scarlet Robin	Bh LC				X	
Neosittidae Sitellas							
Daphoenositta chrysoptera	Varied Sittella	Bh LC			X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers							
Colluricincla harmonica	Grey Shrike-thrush	Bh LC		X	X	X	X
Pachycephala pectoralis	Golden Whistler	Bh LC		X			X
Pachycephala rufiventris	Rufous Whistler	LC	X	X	X	X	X
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo							
Grallina cyanoleuca	Magpie-lark	LC		X	X	X	X
Rhipidura fuliginosa	Grey Fantail	LC	X		X	X	
Rhipidura leucophrys	Willie Wagtail	LC	X	X	X	X	X
Campephagidae Cuckoo-shrikes, Trillers							
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC	X	X	X	X	X
Lalage tricolor	White-winged Triller	LC					

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Artamidae Woodswallows, Butcherbirds, Currawongs							
Artamus cinereus	Black-faced Woodswallow	Bp LC					X
Artamus cyanopterus	Dusky Woodswallow	Bp LC			X		X
Cracticidae Currawongs, Magpies & Butcherbirds							
Cracticus tibicen	Australian Magpie	LC	X	X	X	X	X
Cracticus torquatus	Grey Butcherbird	LC	X	X	X	X	X
Corvidae Ravens, Crows							
Corvus coronoides	Australian Raven	LC		X	X	X	X
Motacillidae Old World Pipits, Wagtails							
Anthus australis	Australian Pipit	LC				X	
Dicaeidae Flowerpeckers							
Dicaeum hirundinaceum	Mistletoebird	LC					X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Hirundinidae Swallows, Martins							
Hirundo neoxena	Welcome Swallow	LC			X	X	X
Hirundo nigricans	Tree Martin	LC		X	X	X	
Sylviidae Old World Warblers							
Cincloramphus cruralis	Brown Songlark	LC					X
Cincloramphus mathewsi	Rufous Songlark	LC					
Zosteropidae White-eyes							
Zosterops lateralis	Silvereye	LC	X	X	X	X	X
Mammalia							
Peramelidae Bandicoots							
Isoodon obesulus fusciventer	Southern Brown Bandicoot	P5 LC	X	X	X	X	
Phalangeridae Brushtail Possums, Cuscuses							
Trichosurus vulpecula	Common Brushtail Possum	LC	X		X		X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Macropodidae Kangaroos, Wallabies							
Macropus fuliginosus	Western Grey Kangaroo	LC	X	X	X	X	X
Molossidae Freetail Bats							
Mormopterus planiceps	Southern Freetail-bat	LC			X	X	X
Tadarida australis	White-striped Freetail-bat	LC		X	X		X
Vespertilionidae Ordinary Bats							
Chalinolobus gouldii	Gould's Wattled Bat	LC		X	X	X	X
Chalinolobus morio	Chocolate Wattled Bat	LC					
Nyctophilus geoffroyi	Lesser Long-eared Bat	LC			X		X
Nyctophilus gouldi	Gould's Long-eared Bat	LC					
Nyctophilus major	Western Long-eared Bat	LC				X	
Vespadelus regulus	Southern Forest Bat	LC		X	X	X	X

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Class **Family** *Species*	Common Name	Conservation Status	A	B	C	D	E
Muridae Rats, Mice							
Mus musculus	House Mouse	Introduced		X	X	X	X
Rattus rattus	Black Rat	Introduced		X	X	X	X
Canidae Dogs, Foxes							
Canis lupus familiaris	Dog	Introduced				X	
Vulpes vulpes	Red Fox	Introduced		X	X	X	
Felidae Cats							
Felis catus	Cat	Introduced		X	X	X	X
Leporidae Rabbits, Hares							
Oryctolagus cuniculus	Rabbit	Introduced	X	X	X	X	X

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DPaW Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

APPENDIX C

DPaW & EPBC DATABASE SEARCH RESULTS

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Greg Harewood on 31/03/2014

Kingdom Animalia
Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115°51' 11" E,32°16' 08" S
Buffer 8km
Group By Species Group

Species Group	Species	Records
Amphibian	6	58
Bird	134	4705
Fish	1	2
Invertebrate	39	104
Mammal	19	263
Reptile	34	354
TOTAL	233	5486

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Amphibian					
1.	25399	*Crinia glauerti (Clicking Frog)*			
2.	25400	*Crinia insignifera (Squelching Froglet)*			
3.	25410	*Heleioporus eyrei (Moaning Frog)*			
4.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
5.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
6.	25388	*Litoria moorei (Motorbike Frog)*			
Bird					
7.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
8.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
9.	24262	*Acanthiza inornata (Western Thornbill)*			
10.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
11.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
12.	24281	*Accipiter cirrocephalus subsp. cirrocephalus (Collared Sparrowhawk)*			
13.	25536	*Accipiter fasciatus (Brown Goshawk)*			
14.	24282	*Accipiter fasciatus subsp. fasciatus (Brown Goshawk)*			
15.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
16.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
17.	24312	*Anas gracilis (Grey Teal)*			
18.	24315	*Anas rhynchotis (Australasian Shoveler)*			
19.	24316	*Anas superciliosa (Pacific Black Duck)*			
20.	24561	*Anthochaera carunculata (Red Wattlebird)*			
21.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
22.	25554	*Apus pacificus (Fork-tailed Swift)*		IA	
23.	24285	*Aquila audax (Wedge-tailed Eagle)*			
24.	24286	*Aquila morphnoides subsp. morphnoides (Little Eagle)*			
25.	25558	*Ardea ibis (Cattle Egret)*		IA	
26.	41324	*Ardea modesta (Eastern Great Egret)*		IA	
27.	24341	*Ardea pacifica (White-necked Heron)*			
28.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
29.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
30.	24318	*Aythya australis (Hardhead)*			
31.	24319	*Biziura lobata (Musk Duck)*			
32.	24359	*Burhinus grallarius (Bush Stone-curlew)*		P4	
33.	25715	*Cacatua roseicapilla (Galah)*			
34.	25716	*Cacatua sanguinea (Little Corella)*			
35.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
36.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
37.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
38.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*		IA	
39.	24784	*Calidris ferruginea (Curlew Sandpiper)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
				T	
40.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
41.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
42.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
43.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo (short-billed black-cockatoo), Carnaby's Cockatoo)*		T	
44.	24376	*Charadrius rubricollis (Hooded Plover)*		P4	
45.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
46.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
47.	24431	*Chrysococcyx basalis (Horsfield's Bronze Cuckoo)*			
48.	24833	*Cincloramphus cruralis (Brown Songlark)*			
49.	24288	*Circus approximans (Swamp Harrier)*			
50.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
51.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
52.	24399	*Columba livia (Domestic Pigeon)*	Y		
53.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
54.	25592	*Corvus coronoides (Australian Raven)*			
55.	24671	*Coturnix pectoralis (Stubble Quail)*			
56.	25595	*Cracticus tibicen (Australian Magpie)*			
57.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
58.	25596	*Cracticus torquatus (Grey Butcherbird)*			
59.	24322	*Cygnus atratus (Black Swan)*			
60.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
61.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
62.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
63.	24567	*Epthianura albifrons (White-fronted Chat)*			
64.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
65.	25621	*Falco berigora (Brown Falcon)*			
66.	25622	*Falco cenchroides (Australian Kestrel)*			
67.	24472	*Falco cenchroides subsp. cenchroides (Australian Kestrel)*			
68.	25623	*Falco longipennis (Australian Hobby)*			
69.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
70.	25727	*Fulica atra (Eurasian Coot)*			
71.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
72.	25530	*Gerygone fusca (Western Gerygone)*			
73.	24443	*Grallina cyanoleuca (Magpie-lark)*			
74.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*		IA	
75.	25541	*Haliastur indus (Brahminy Kite)*			
76.	24295	*Haliastur sphenurus (Whistling Kite)*			
77.	24296	*Hamirostra isura (Square-tailed Kite)*			
78.	25734	*Himantopus himantopus (Black-winged Stilt)*			
79.	24491	*Hirundo neoxena (Welcome Swallow)*			
80.	25563	*Ixobrychus minutus (Little Bittern)*		P4	
81.	25661	*Lichmera indistincta (Brown Honeyeater)*			
82.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
83.	25654	*Malurus splendens (Splendid Fairy-wren)*			
84.	24583	*Manorina flavigula (Yellow-throated Miner)*			
85.	25758	*Megalurus gramineus (Little Grassbird)*			
86.	24598	*Merops ornatus (Rainbow Bee-eater)*		IA	
87.	25693	*Microeca fascinans (Jacky Winter)*			
88.	24738	*Neophema elegans (Elegant Parrot)*			
89.	25748	*Ninox novaeseelandiae (Boobook Owl)*			
90.	24798	*Numenius madagascariensis (Eastern Curlew)*		T	
91.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
92.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
93.	24328	*Oxyura australis (Blue-billed Duck)*			
94.	25679	*Pachycephala pectoralis (Golden Whistler)*			
95.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
96.	24693	*Pachyptila desolata (Antarctic Prion)*			
97.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
98.	25682	*Pardalotus striatus (Striated Pardalote)*			
99.	24630	*Pardalotus striatus subsp. westraliensis (Striated Pardalote)*			
100.	24642	*Passer montanus (Eurasian Tree Sparrow)*	Y		
101.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
102.	24659	*Petroica goodenovii (Red-capped Robin)*			
103.	25697	*Phalacrocorax carbo (Great Cormorant)*			
104.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
105.	25699	*Phalacrocorax varius (Pied Cormorant)*			
106.	24409	*Phaps chalcoptera (Common Bronzewing)*			
107.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
108.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
109.	24842	*Platalea regia (Royal Spoonbill)*			
110.	25720	*Platycercus icterotis (Western Rosella)*			
111.	24747	*Platycercus spurius (Red-capped Parrot)*			
112.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
113.	24750	*Platycercus zonarius subsp. semitorquatus (Twenty-eight Parrot)*			
114.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
115.	25703	*Podargus strigoides (Tawny Frogmouth)*			
116.	25704	*Podiceps cristatus (Great Crested Grebe)*			
117.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
118.	25722	*Polytelis anthopeplus (Regent Parrot)*			
119.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
120.	25732	*Porzana pusilla (Baillon's Crake)*			
121.	24771	*Porzana tabuensis (Spotless Crake)*			
122.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
123.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
124.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
125.	30948	*Smicrornis brevirostris (Weebill)*			
126.	25597	*Strepera versicolor (Grey Currawong)*			
127.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
128.	30951	*Streptopelia chinensis subsp. tigrina (Spotted Turtle-Dove)*	Y		
129.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
130.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
131.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
132.	24844	*Threskiornis molucca (Australian White Ibis)*			
133.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
134.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
135.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
136.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
137.	24808	*Tringa nebularia (Common Greenshank)*		IA	
138.	24849	*Turnix varia subsp. varia (Painted Button-quail)*			
139.	24852	*Tyto alba subsp. delicatula (Barn Owl)*			
140.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			
Fish					
141.	34028	*Galaxias occidentalis (Western Minnow)*			
Invertebrate					
142.	-12407	*Afraflacilla huntorum*			Y
143.	-12895	*Aname mainae*			
144.	-11966	*Aname tepperi*			
145.	-12931	*Antichiropus variabilis*			
146.	-12293	*Araneus cyphoxis*			
147.	-11820	*Araneus senicaudatus*			
148.	-1797	*Argiope protensa*			
149.	-12440	*Artoria flavimana*			
150.	-13423	*Artoria linnaei*			
151.	-12506	*Artoriopsis expolita*			
152.	-12420	*Backobourkia brounii*			
153.	-11741	*Cercophonius sulcatus*			
154.	-12659	*Cormocephalus novaehollandiae*			
155.	-12272	*Cyclosa trilobata*			
156.	-12211	*Dingosa serrata*			
157.	-11734	*Eriophora biapicata*			
158.	-12921	*Holasteron perth*			
159.	-11716	*Holconia westralia*			
160.	-12201	*Idiommata blackwalli*			
161.	-12943	*Idiosoma sigillatum*			
162.	-12890	*Isopeda leishmanni*			
163.	-1741	*Lampona cylindrata*			
164.	-11740	*Lycosa ariadnae*			
165.	-1670	*Nicodamus malnae*			
166.	-13078	*Ocrisiona parmeliae*			
167.	-13106	*Ommatoiulus moreletii*			
168.	-13415	*Phryganoporus candidus*			
169.	-13362	*Pinkfloydia harveii*			
170.	-12492	*Raveniella peckorum*			
171.	-12623	*Servaea melaina*			
172.	-12858	*Servaea spinibarbis*			
173.	-13029	*Simaetha tenuior*			
174.	-12602	*Steatoda grossa*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
175.	33992	*Synemon gratiosa (Graceful Sunmoth)*		P4	
176.	-12436	*Tamopsis distinguenda*			
177.	-12435	*Tamopsis perthensis*			
178.	-13404	*Tetragnatha valida*			
179.	-11701	*Urodacus novaehollandiae*			
180.	-1706	*Zebraplatys fractivittata*			
Mammal					
181.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
182.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
183.	24041	*Felis catus (Cat)*	Y		
184.	24215	*Hydromys chrysogaster (Water-rat)*		P4	
185.	25478	*Isoodon obesulus (Southern Brown Bandicoot)*		P5	
186.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P5	
187.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
188.	24133	*Macropus irma (Western Brush Wallaby)*		P4	
189.	24184	*Mormopterus planiceps (Southern Freetail-bat)*			
190.	24223	*Mus musculus (House Mouse)*	Y		
191.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
192.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
193.	24099	*Phascogale tapoatafa subsp. tapoatafa (Southern Brush-tailed Phascogale, Wambenger)*		T	
194.	24245	*Rattus rattus (Black Rat)*	Y		
195.	24185	*Tadarida australis (White-striped Freetail-bat)*			
196.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
197.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
198.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
199.	24206	*Vespadelus regulus (Southern Forest Bat)*			
Reptile					
200.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
201.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			
202.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
203.	30893	*Cryptoblepharus buchananii*			
204.	25020	*Cryptoblepharus plagiocephalus*			
205.	30899	*Ctenophorus adelaidensis (Southern Heath Dragon, Western Heath Dragon)*			
206.	25027	*Ctenotus australis*			
207.	25039	*Ctenotus fallens*			
208.	25040	*Ctenotus gemmula (Jewelled South-west Ctenotus (Swan Coastal Plain pop P3), skink)*			
209.	25766	*Delma fraseri (Fraser's Legless Lizard)*			
210.	24999	*Delma grayii*			
211.	25119	*Hemiergis quadrilineata*			
212.	25366	*Hydrophis elegans (Elegant Seasnake, Bar-bellied Seasnake)*			
213.	43384	*Hydrophis platurus (Yellow-bellied Seasnake)*			
214.	25131	*Lerista distinguenda*			
215.	25133	*Lerista elegans*			
216.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
217.	25005	*Lialis burtonis*			
218.	25184	*Menetia greyii*			
219.	25249	*Neelaps calonotos (Black-striped Snake)*		P3	
220.	25252	*Notechis scutatus (Tiger Snake)*			
221.	25253	*Parasuta gouldii*			
222.	25007	*Pletholax gracilis subsp. gracilis (Keeled Legless Lizard)*			
223.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
224.	25511	*Pseudonaja affinis (Dugite)*			
225.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
226.	42416	*Pseudonaja mengdeni (Western Brown Snake)*			
227.	25271	*Ramphotyphlops australis*			
228.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
229.	25267	*Simoselaps littoralis (West Coast Banded Snake)*			
230.	25203	*Tiliqua occipitalis (Western Bluetongue)*			
231.	25519	*Tiliqua rugosa*			
232.	25207	*Tiliqua rugosa subsp. rugosa*			
233.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3

Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area

4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

Australian Government
Department of the Environment

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 31/03/14 22:04:12

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 0.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	18
Listed Migratory Species:	6

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	7
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	36
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (RAMSAR)	[Resource Information]
Name	Proximity
Peel-yalgorup system	Upstream from Ramsar

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir [25911]	Vulnerable	Species or species habitat may occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat may occur within

Name	Status	Type of Presence area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat likely to occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Invasive Species		[Resource Information]
Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.		
Name	Status	Type of Presence
Birds		
Acridotheres tristis		
Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos		
Mallard [974]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur

Name	Status	Type of Presence within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Coordinates

-32.26896 115.85324

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX D

BLACK COCKATOO HABITAT TREE DETAILS

Habitat Trees (DBH >50cm) - Wellard

Waypoint Number	Zone	mE	mN	Tree Species	Tree Height (m)	DBH (cm)	Number of Hollows	Hollow Type 1	Hollow Size 1 (cm)	Hollow Type 2	Hollow Size 2 (cm)	Hollow Type 3	Hollow Size 3 (cm)	Hollow Type 4	Hollow Size 4 (cm)	Hollow Type 5	Hollow Size 5 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Comments
wpt001	50H	391707	6429384	Flooded Gum	20+	>50	0											No Signs	No Signs	No	
wpt002	50H	391712	6429397	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt003	50H	391727	6429393	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt004	50H	391734	6429396	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt005	50H	391729	6429401	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt006	50H	391728	6429414	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt007	50H	391764	6429391	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt008	50H	391781	6429404	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt009	50H	391838	6429431	Marri	15-20	>50	0											No Signs	No Signs	No	
wpt010	50H	391849	6429418	Marri	15-20	>50	0											No Signs	No Signs	No	
wpt011	50H	392110	6429395	Jarrah	15-20	>50	1	Knot Hole	5-12									No Signs	Parrots	No	Depth of hollows unknown
wpt012	50H	392110	6429378	Dead Unknown	15-20	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt013	50H	392118	6429371	Tuart	20+	>50	0											No Signs	No Signs	No	
wpt014	50H	392125	6429377	Dead Jarrah	15-20	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt015	50H	392101	6429350	Jarrah	15-20	>50	5+	Branch	<5	Branch	<5	Branch	<5	Branch	<5	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt016	50H	392067	6429323	Dead Unknown	15-20	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt017	50H	392121	6429280	Dead Jarrah	20+	>50	5+	Knot Hole	<5	Branch	<5	Branch	<5	Branch	<5	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt018	50H	392099	6429269	Dead Unknown	15-20	>50	5+	Knot Hole	12-20	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	No Signs	No Signs	Yes	Depth of hollows unknown
wpt019	50H	392105	6429263	Dead Jarrah	15-20	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt020	50H	392083	6429256	Dead Unknown	10-15	>50	2	Spout Branch	12-20	Spout Trunk	12-20							No Signs	No signs	No	Too shallow
wpt021	50H	392066	6429260	Dead Unknown	15-20	>50	5+	Branch	5-12	Branch	5-12	Branch	5-12	Branch	5-12	Branch	5-12	No Signs	No Signs	No	Depth of hollows unknown
wpt022	50H	392086	6429242	Dead Unknown	15-20	>50	1	Knot Hole	5-12									No Signs	No Signs	No	Depth of hollows unknown
wpt023	50H	392111	6429225	Dead Jarrah	15-20	>50	0											No Signs	No Signs	No	
wpt024	50H	392114	6429252	Jarrah	20+	>50	3	Knot Hole	5-12	Branch	5-12	Branch	5-12					No Signs	No Signs	No	Depth of hollows unknown
wpt025	50H	392116	6429246	Dead Jarrah	15-20	>50	5+	Fissure	5-12	Branch	5-12	Branch	5-12	Branch	5-12	Branch	5-12	No Signs	No Signs	No	Depth of hollows unknown
wpt026	50H	392109	6429212	Dead Jarrah	10-15	>50	1	Knot Hole	<5									Bees	No Signs	No	Depth of hollows unknown
wpt027	50H	392097	6429212	Dead Unknown	15-20	>50	5+	Branch	5-12	Branch	5-12	Branch	5-12	Branch	5-12	Branch	5-12	No Signs	No Signs	No	Depth of hollows unknown
wpt028	50H	392094	6429225	Dead Jarrah	20+	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt029	50H	392088	6429224	Dead Jarrah	15-20	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt030	50H	392079	6429226	Dead Jarrah	15-20	>50	5+	Knot Hole	<5	Branch	<5	Branch	<5	Branch	<5	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt031	50H	392067	6429234	Dead Jarrah	15-20	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt032	50H	392052	6429231	Dead Jarrah	20+	>50	5+	Branch	<5		5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt033	50H	392023	6429265	Jarrah	15-20	>50	1	Branch	<5									No Signs	No Signs	No	Depth of hollows unknown
wpt034	50H	392007	6429220	Dead Jarrah	20+	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt035	50H	392012	6429201	Dead Jarrah	15-20	>50	0											No Signs	No Signs	No	
wpt036	50H	392014	6429201	Dead Jarrah	15-20	>50	0											No Signs	No Signs	No	
wpt037	50H	392010	6429204	Jarrah	10-15	>50	0											No Signs	No Signs	No	
wpt038	50H	391875	6429201	Dead Unknown	5-10	>50	1	Fissure	5-12									No Signs	No Signs	No	Depth of hollows unknown
wpt039	50H	391902	6429154	Marri	20+	>50	0											No Signs	No Signs	No	
wpt040	50H	391936	6429138	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt041	50H	391948	6429135	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt042	50H	391946	6429129	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt043	50H	391956	6429126	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt044	50H	391963	6429141	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt045	50H	391996	6429115	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt046	50H	392013	6429113	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt047	50H	392023	6429099	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt048	50H	392071	6429072	Flooded Gum	15-20	>50	5+	Knot Hole	5-12	Branch	5-12	Branch	5-12	Branch	5-12	Branch	5-12	No Signs	Parrots	No	red-capped parrots
wpt049	50H	392088	6429058	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt050	50H	391983	6428931	Tuart	20+	>50	0											No Signs	No Signs	No	
wpt051	50H	391979	6428919	Tuart	20+	>50	0											No Signs	No Signs	No	
wpt052	50H	391871	6429058	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt053	50H	391904	6429262	Tuart	15-20	>50	0											No Signs	No Signs	No	
wpt054	50H	391925	6429261	Dead Unknown	5-10	>50	2	Branch	5-12	Branch	5-12							No Signs	No Signs	No	Depth of hollows unknown
wpt055	50H	391951	6429255	Jarrah	20+	>50	0											No Signs	No Signs	No	
wpt056	50H	391928	6429236	Dead Unknown	5-10	>50	1	Spout Branch	5-12									No Signs	No Signs	No	Depth of hollows unknown
wpt057	50H	392020	6429274	Dead Unknown	20+	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt058	50H	391950	6429261	Dead Unknown	15-20	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt059	50H	391949	6429297	Dead Unknown	20+	>50	5+	Fissure	5-12	Branch	5-12	Branch	5-12	Branch	5-12	Branch	5-12	No Signs	No Signs	No	Depth of hollows unknown
wpt060	50H	391921	6429292	Tuart	15-20	>50	0											No Signs	No Signs	No	
wpt061	50H	391905	6429299	Dead Unknown	20+	>50	5+	Knot Hole	<5	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	No Signs	No Signs	No	Depth of hollows unknown

Waypoint Number	Zone	mE	mN	Tree Species	Tree Height (m)	DBH (cm)	Number of Hollows	Hollow Type 1	Hollow Size 1 (cm)	Hollow Type 2	Hollow Size 2 (cm)	Hollow Type 3	Hollow Size 3 (cm)	Hollow Type 4	Hollow Size 4 (cm)	Hollow Type 5	Hollow Size 5 (cm)	Occupancy	Chew Marks	Potential Cockatoo Nest Hollow	Comments
wpt062	50H	391907	6429334	Dead Unknown	20+	>50	5+	Knot Hole	5-12	Branch	<5	Branch	5-12	Branch	<5			No Signs	No Signs	No	Depth of hollows unknown
wpt063	50H	391889	6429337	Tuart	20+	>50	0											No Signs	No Signs	No	
wpt064	50H	391881	6429334	Jarrah	15-20	>50	0											No Signs	No Signs	No	
wpt065	50H	391877	6429348	Tuart	20+	>50	0											No Signs	No Signs	No	
wpt066	50H	391884	6429390	Dead Unknown	15-20	>50	5+	Branch	<5	Branch	5-12	Spout Branch	5-12	Spout Branch	5-12	Spout Branch	5-12	No Signs	No Signs	No	Depth of hollows unknown
wpt067	50H	391903	6429387	Dead Unknown	20+	>50	5+	Branch	<5	Branch	5-12	Branch	<5	Branch	5-12	Branch	<5	No Signs	No Signs	No	Depth of hollows unknown
wpt068	50H	391923	6429419	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	
wpt069	50H	391930	6429420	Flooded Gum	15-20	>50	0											No Signs	No Signs	No	

APPENDIX E

SIGNIFICANT SPECIES PROFILES

Graceful Sun Moth *Synemon gratiosa*

Status and Distribution: Listed as Priority 4 by the DPaW.

The Graceful Sun Moth (GSM) was up until a few years ago thought to be confined to a small number of bush reserves in the northern suburbs of Perth. Targeted survey work since that time by a number of consultants and DPaW have extended the known range of the species north to Leeman and south as far as Binningup (Bishop *et al.* 2010b).

Survey work carried out in 2010 expanded the previously document area of occupancy of the GSM from 18km^2 to 43 km^2 and the extent of occurrence from 230km^2 to 2,015km^2. The area of occupancy is potentially a conservative estimate at this stage and if habitat anticipated to be occupied by GSM is included, the area of occupancy may be as high as 119 km^2 (Bishop *et al.* 2010b). Additional surveys have been carried out in 2011 north and south of the known range and these may also expand the species range (results not as yet publically available).

The conservation status of the graceful sun-moth was changed at a state level in 2012 from Schedule 1 to Priority 4 and it has also been delisted from the *EPBC Act* threatened species list altogether as a consequence of the additional information illustrating the species much greater range and abundance.

Habitat: The graceful sun-moth is currently only known from two general vegetation types:

- Banksia woodland/woolly bush on deep sands, in the northern suburbs of Perth on the Swan Coastal Plain. In these sites the GSM breeds on *Lomandra hermaphrodita*, which often occurs in low numbers.

- Open areas of herbland, heathland and shrubland on Quindalup soils (sand and limestone) close to the coast where it breeds on *Lomandra maritima*, which is often present in reasonable numbers and may even be a dominant understorey herb. Sites on limestone may have both *Lomandra* species present.

The presence of *Lomandra* species therefore provides a good indication of prospective habitat, however, sufficient numbers and densities of these plants are thought to be necessary to sustain a viable breeding colony of Graceful Sun-Moths.

Likely presence in study area: A spring flora and vegetation survey of the study area in 2008 by Cardno (Cardno 2008) did not identify the presence of any *Lomandra* plant species and therefore it is considered very unlikely that GSM could persist within the study area.

Potential impact of development: No impact on this species or its preferred habitat is considered likely to occur as a consequence of development within the study area occurring.

Perth Lined Lerista *Lerista lineata*

Status and Distribution: Listed as Priority 3 by DPaW. Found in the lower west coast from north of Perth south to Leschenault Peninsula/Kemerton. It has also been found at Rottnest Island and Garden Island (Storr *et al.* 1999). Found in the southern suburbs of Perth (Bush *et al.* 2002).

Habitat: This small species of skink inhabits white sands (Storr *et al.* 1999) under areas of shrubs and heath where it inhabits loose soil and leaf litter (Nevill 2005) particularly in association with banksias (Bush *et al.* 2002).

Likely presence in study area: Some areas of habitat appear to be suitable for this species to persist despite it's generally degraded state and it has been recorded in larger bush remnants nearby (ENV 2009, Phoenix 2010). Known to inhabit gardens (Nevill 2005, Bush *et al.* 2010) so may persist in degraded areas and subsequent to development.

Potential impact of development: Loss/modification of small areas of degraded habitat.

Southern Carpet Python *Morelia spilota imbricata*

Status and Distribution: The south western population is classified Schedule 4 under the *WC Act*. This subspecies has wide distribution within the south west but is uncommon. Occurs north to Geraldton and Yalgoo and east to Pinjin, Kalgoorlie, Fraser Range and Eyre (Storr *et al.* 2002).

Habitat: This species has been recorded from semi-arid coastal and inland habitats, Banksia woodland, Eucalypt woodlands, and grasslands. Most often found utilising hollow logs in addition the burrows of other animals for shelter. Often arboreal and will use tree hollows for refuge.

Likely presence in study area: Occurs in low densities and therefore the relatively small size and/or fragmented nature of bush remnants in the study area would make it difficult for a population of this species to persist. Near Perth, carpet pythons are more often found in areas of substantial undisturbed bushland such as Yanchep and Neerabup National Parks in the north and Yalgorup National Park to the south along with catchment areas/forest reserves located in the Darling Range (Bush *et al.* 2010). This species is therefore considered very unlikely to occur.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Black-striped Snake *Neelaps calonotos*

Status and Distribution: Listed as Priority 3 by DPaW. Found in the lower west coast from Lancelin to Mandurah. It is locally abundant but is under threat due to land clearing (Storr *et al.* 1999).

Habitat: This species of snake favours sandy soils supporting heath and banksia/eucalypt woodland (Nevill 2005).

Likely presence in study area: Status in the study area is difficult to determine, however the lack of recent records in the wider area despite several detailed surveys (e.g. Rockingham, East Rockingham, Bibra Lake, Jandakot) suggests that it no longer persists in the southern Perth suburbs. Not listed as a potential species.

Potential impact of development: No impact anticipated as this species is considered unlikely to be present.

Malleefowl *Leipoa ocellata*

Status and Distribution: This species is listed as Schedule 1 under the *WC Act* and as Vulnerable and Migratory under the *EPBC Act.* Originally common, but now generally rare to uncommon and patchily distributed.

Current distribution mainly southern arid and semi-arid zones, north to Shark Bay, Jingemarra, Colga Downs and Yeelirrie, east to Earnest Giles Range, Yeo Lake, lower Ponton Creek and to Eucla and west and south to Cockleshell Gully, the Wongan Hills, Stirling Range, Beaufort Inlet, Hatters Hill, Mt Ragged and Point Malcolm (Johnstone and Storr 1998).

Habitat: Mainly scrubs and thickets of mallee *Eucalyptus* spp., boree *Melaleuca lanceolata* and bowgada *Acacia linophylla*, also dense litter forming shrublands.

Likely presence in study area: This species is regionally extinct and would never, under normal circumstances occur anywhere on the Swan Coastal Plain.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Great Egret *Ardea alba*

Status and Distribution: This species of egret is listed as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory.

The Great Egret is common and very widespread in any suitable permanent or temporary habitat (Morcombe 2004).

Habitat: Wetlands, flooded pasture, dams, estuarine mudflats, mangroves and reefs (Morcombe 2004).

Likely presence in study area: May utilise the waterlogged, low lying areas and manmade drains during winter months for foraging at times, but only in low numbers and for brief periods. Unlikely to breed within the study area.

Potential impact of development: Loss or modification of some marginal habitat. No significant impact likely.

Cattle Egret *Ardea ibis*

Status and Distribution: This species of egret is listed as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Cattle Egret is common in the north sections of its range but is an irregular visitor to the better watered parts of the state (Johnstone and Storr 1998). The population is expanding (Morcombe 2004).

Habitat: Moist pastures with tall grasses, shallow open wetlands and margins, mudflats (Morcombe 2004).

Likely presence in study area: May utilise the waterlogged, low lying areas and manmade drains during winter months for foraging at times, but only in low numbers and for brief periods. Unlikely to breed within the study area.

Potential impact of development: Loss or modification of some marginal habitat. No significant impact likely.

White-bellied Sea Eagle *Haliaeetus leucogaster*

Status and Distribution: This species is listed as Schedule 3 under the *WC Act* and as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. White-bellied sea eagles are moderately common to common on Kimberley and Pilbara islands, coasts and estuaries, on Bernier, Dorre and Dirk Hartog Is., in Houtman Abrolhos and in the Archipelago of the Recherche; rare to uncommon elsewhere (Johnstone and Storr 1998). Also found in New Guinea, Indonesia, China, southeast Asia and India. Scarce near major coastal cities (Morcombe 2004).

Habitat: They nest and forage usually near the coast over islands, reefs, headlands, beaches, bays, estuaries, mangroves, but will also live near seasonally flooded inland swamps, lagoons and floodplains, often far inland on large pools of major rivers. Established pairs usually sedentary, immatures

dispersive (Morcombe 2004). White-bellied Sea-Eagles build a large stick nest, which is used for many seasons in succession.

Likely presence in study area: May fly over on rare occasions given presence of nearby lake systems and ocean but there is no suitable habitat for this species inside the study area.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Osprey *Pandion haliaetus*

Status and Distribution: This species is listed as Migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. Moderately common to very common in sheltered seas around the north and west coast islands south to 31°S; uncommon to common on mainland coasts, estuaries and large rivers north of tropic, rare to uncommon elsewhere (Johnstone and Storr 1998).

Habitat: Coasts, estuaries, bays, inlets, islands, and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Ascends larger rivers (Pizzey & Knight 2012). Construct nests on prominent headland, large trees, communication towers (Simpson & Day 2010).

Likely presence in study area: May fly over on rare occasions given presence of nearby lake systems and ocean but there is no suitable habitat for this species inside the study area.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Peregrine Falcon *Falco peregrinus*

Status and Distribution: This species is listed as Schedule 4 under the *WC Act*. Individuals of this species are uncommon/rare but wide ranging across Australia. Moderately common at higher levels of the Stirling Range, uncommon in hilly, north west Kimberley, Hamersley and Darling Ranges; rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Diverse from rainforest to arid shrublands, from coastal heath to alpine (Morcombe 2004). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr 1998). The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.

Likely presence in study area: Individuals of this species potentially utilise some sections of the study area as part of a much larger home range but would only occur rarely.

Potential impact of development: Loss/modification of some areas of foraging habitat. Very unlikely to breed within the study area. No significant impact likely.

Glossy Ibis *Plegadis falcinellus*

Status and Distribution: This species is listed as Migratory under the *EPBC Act (1999)* and under international agreements to which Australia is a signatory. The Glossy Ibis frequents swamps and lakes throughout much of the Australian mainland, but is most numerous in the north. It is a non-breeding visitor to Tasmania and the south-west of Western Australia. The Glossy Ibis is both migratory and nomadic. Its range expands inland after good rains, but its main breeding areas seem to be in the Murray-Darling Basin of New South Wales and Victoria, the Macquarie Marshes in New South Wales, and in southern Queensland. Glossy Ibis often move north in autumn, then return south to their main breeding areas in spring and summer (Pizzey & Knight 2012).

Habitat: Well vegetated wetlands, wet pastures, rice fields, floodwaters, floodplains, brackish or occasionally saline wetlands, mangroves, mudflats, occasionally dry grasslands (Pizzey & Knight 2012).

Likely presence in study area: May utilise the waterlogged low lying areas and manmade drains during winter months for foraging at times, however the frequency of occurrence would be very low and then only for brief periods, and hence not listed as a potential species.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Little Bittern *Ixobrychus minutus*

Status and Distribution: Listed as Priority 4 by DPaW. Occurs north to Moora and east to Two Peoples Bay; accidental or on migration further north and east and on Rottnest Island and central district (Condingup district) (Johnstone and Storr 1998).

Habitat: Dense vegetation surrounding/within freshwater pools, swamps and lagoons, well screened with trees. Shelters in dense beds of *Typha*, *Baumea* and tall rushes in freshwater swamps around lakes and along rivers (Johnstone and Storr 1998).

Likely presence in study area: No suitable habitat.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Bush Stone Curlew *Burhinus grallarius*

Status and Distribution: Listed as Priority 4 by DPAW. Occurs over much of the western half of the state (and Kimberley) but rare to uncommon in the south of its range due to fox predation (Johnstone and Storr 1998).

Habitat: Lightly wooded country (including partly cleared forests) near daytime shelter e.g. thickets or long grass (Johnstone and Storr 1998).

Likely presence in study area: This species is regionally extinct and would never occur in this section of the Swan Coastal Plain.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Migratory Shorebirds

A number of migratory shorebirds are listed as potentially occurring in the general area. Not all specific species are discussed in detail.

Status and Distribution: Migratory shorebirds are listed under the *EPBC Act* and under international agreements to which Australia is a signatory. All species are either widespread summer migrants to Australia or residents. State and Federal conservation status varies between species.

Habitat: Varies between species but includes beaches and permanent/temporary wetlands varying from billabongs, swamps, lakes, floodplains, sewerage farms, saltwork ponds, estuaries, lagoons, mudflats sandbars, pastures, airfields, sports fields and lawns.

Likely presence in study area: No suitable habitat.

Potential impact of development: No significant impact on this species or its preferred habitat will occur.

Painted Snipe *Rostratula benghalensis*

Status and Distribution: This species is listed as Schedule 1 and 3 under the *WC Act* and as Endangered and Migratory under the *EPBC Act*. Sparsely distributed in better watered regions: Kimberley, North West and South Western divisions. Also eastern Australia and Tasmanian (Johnstone and Storr 1998).

Habitat: Well vegetated shallows and margins of wetlands, dams, sewerage ponds, wet pastures, marshy areas, irrigation systems, lignum, tea tree scrub, open timber. Requires dense low cover (Morcombe 2004).

Likely presence in study area: There is no suitable habitat for this species within the study area.

Potential impact of development: No impact on this species or its preferred habitat will occur as a consequence of development the study area.

Fairy Tern (Australian) *Sternula nereis nereis*

Status and Distribution: Classified as Vulnerable under the *EPBC Act.* The total number of mature Fairy Terns (Australian) has been estimated at 3000–9000 individuals (Baling *et al.* 2009). Within Australia, the Fairy Tern occurs along the coasts of Victoria, Tasmania, South Australia and Western Australia; occurring as far north as the Dampier Archipelago near Karratha (Birdlife International 2010).

Habitat: Fairy Terns utilise a variety of habitats including offshore, estuarine or lacustrine (lake) islands, wetlands, beaches and spits. Fairy Terns nest above the high water mark often in clear view of the water and on sites where the substrate is sandy and the vegetation low and sparse (Birdlife International 2010).

Likely presence in study area: The study area contains no suitable habitat for this species to utilise.

Potential impact of development: No impact on this species will occur.

Hooded Plover *Charadrius rubricollis*

Status and Distribution: Listed as Priority 4 by DPaW. In WA coastally west from Israelite Bay north to Jurien Bay and inland salt lakes more than 100km from the coast. In eastern Australia confined to suitable habitat from Jervis Bay (NSW) through Bass Strait and Tasmanian and west to Great Australian Bight in South Australia.

Habitat: Broad sandy ocean beaches and bays, coastal and inland salt lakes (Pizzey & Knight 2012).

Likely presence in study area: No suitable habitat.

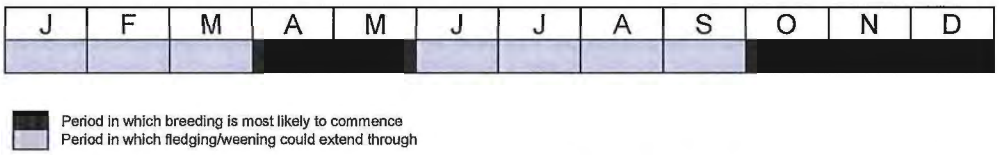
Potential impact of development: No impact on this species will occur as a consequence of any development at the study area.

Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Found in the humid and subhumid south west, mainly hilly interior, north to Gingin and east to Mt Helena, Christmas Tree Well, North Bannister, Mt Saddleback, Rock Gully and the upper King River (Johnstone and Storr 1998).

Habitat: Eucalypt forests, feeds on Marri, Jarrah, Blackbutt, Karri, Sheoak and Snottygobble. The forest red-tailed black-cockatoo (FRTBC) nests in the large hollows of Marri, Jarrah and Karri (Johnstone and Kirkby 1999). In Marri, the nest hollows of the Forest Red-tailed Black Cockatoo range from 8-14m above ground, the entrance is 12 – 41cm in diameter and the depth is one to five metres (Johnstone and Storr 1998).

Breeding commences in winter/spring. There are few records of breeding in the Forest Red-tailed Black Cockatoo (Johnstone and Storr 1998), but eggs are laid in October and November (Johnstone 1997; Johnstone and Storr 1998). Recent data however indicates that breeding in all months of the year occurs with peaks in spring and autumn–winter (Ron Johnstone pers. comm.). Incubation period 29 – 31 days. Young fledge at 8 to 9 weeks (Simpson and Day 2010).



Likely presence in study area: Foraging evidence possibly left by this species (or Carnaby's) was found during the field survey (chewed Jarrah fruits). Remnant vegetation containing Jarrah, Marri and Sheoak within the study area represents potential foraging habitat for this species.

The small number of larger trees (>50cm DBH) are also considered by the DoE as potential breeding habitat, though only one tree was observed to actually contain hollows of a size possibly suitable for this purpose. In reality the possibility of any of these trees being used for breeding proposes now or in the future can be considered to be extremely low. This species may also roost within the study area on occasions, though no evidence of this was seen.

Potential impact of development: Loss/modification of small areas of habitat.

Baudin's Black- Cockatoo *Calyptorhynchus baudinii*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Confined to the south-west of Western Australia, north to Gidgegannup, east to Mt Helena, Wandering, Quindanning,

Kojonup, Frankland and King River and west to the eastern strip of the Swan Coastal Plain including West Midland, Byford, Nth Dandalup, Yarloop, Wokalup and Bunbury (Johnstone and Storr 1998). On the southern Swan Coastal Plain this cockatoo is in some areas resident but mainly a migrant moving from the deep south-west to the central and northern Darling Range. Between March and September most flocks move north and are concentrated in the northern parts of the Darling Range. During this period birds forage well out onto the southern Swan Coastal Plain to areas such as Harvey, Myalup, Bunbury, Capel, Dunsborough and Meelup. While generally more common in the Darling Range this species can also be common on parts of the southern Swan Coastal Plain especially in mid-August – September when flocks begin to return to their breeding quarters (Johnstone 2008).

Habitat: Mainly eucalypt forests where it feeds primarily on the Marri seeds, (Morcombe 2004), Banksia, Hakeas and *Erodium* sp. Also strips bark from trees in search of beetle larvae (Johnstone and Storr 1998). This species of cockatoo nests in large tree hollows, 30–40 cm in diameter and more than 30 cm deep (Saunders 1974).

Baudin's Black-Cockatoo breeds in late winter and spring, from August to November or December (Gould 1972; Johnstone 1997; Saunders 1974; Saunders *et al.* 1985). Eggs laid in October (Johnstone and Storr 1998). Based on observations at currently known nest sites breeding mainly occurs within the October-December period (Ron Johnstone pers comms). Incubation is 28 – 30 days. Young fledge at 8 to 9 weeks (Simpson and Day 2010).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend through

Likely presence in study area: No direct evidence of this species using the study area was observed. This species is only rarely recorded in this section of the coastal pain so it is considered unlikely to frequent the study area except on rare occasions.

Potential impact of development: No impact on this species or its preferred habitat is anticipated.

Carnaby's Black- Cockatoo *Calyptorhynchus latirostris*

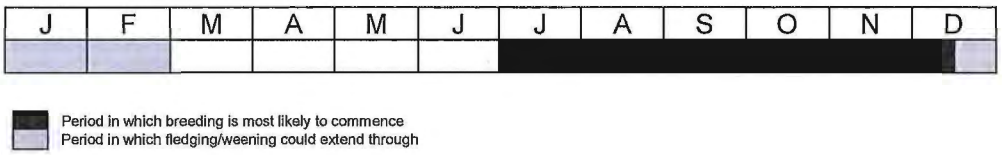
Status and Distribution: Carnaby's black-cockatoo is listed as Scheduled 1 under the *WC Act* and as Endangered under the *EPBC Act*. Confined to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar (Moorine

Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Condingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998).

Habitat: Forests, woodlands, heathlands, farms; feeds on Banksia, Hakeas and Marri. Carnaby's black-cockatoo has specific nesting site requirements. Nests are mostly in smoothed-barked eucalypts with the nest hollows ranging from 2.5 to 12m above the ground, an entrance from 23-30cm diameter and a depth of 0.1-2.5m (Johnstone and Storr, 1998).

Breeding occurs in winter/spring mainly in eastern forest and wheatbelt where they can find mature hollow bearing trees to nest in (Morcombe, 2003). Judging from records in the Storr-Johnstone Bird Data Bank, this species is currently expanding its breeding range westward and south into the Jarrah – Marri forest of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain including the region between Mandurah and Bunbury. Carnaby's black-cCockatoo has been known to breed close to the town of Mandurah, as well as at Dawesville, Lake Clifton and Baldivis (Ron Johnstone pers. comm.) and there are small resident populations on the southern Swan Coastal Plain near Mandurah, Lake Clifton and near Bunbury. At each of these sites the birds forage in remnant vegetation and adjacent pine plantations (Johnstone 2008).

Carnaby's black-cockatoo lays eggs from July or August to October or November, with most clutches being laid in August and September (Saunders 1986). Birds in inland regions may begin laying up to three weeks earlier than those in coastal areas (Saunders 1977). The female incubates the eggs over a period of 28-29 days. The young depart the nest 10–12 weeks after hatching (Saunders 1977; Smith & Saunders 1986).



Likely presence in study area: Foraging evidence possibly left by this species (or the FRTBC) was found during the field survey (chewed Jarrah fruits). Remnant vegetation containing Jarrah, Marri and *Banksia* within the study area represents potential foraging habitat for this species.

The small number of larger trees (>50cm DBH) are also considered by the DoE as potential breeding habitat, though only one tree was observed to actually contain hollows of a size possibly suitable for this purpose. In reality the possibility of any of these trees being used for breeding proposes now or in the

future can be considered to be extremely low. This species may also roost within the study area on occasions, though no evidence of this was seen.

Potential impact of development: Loss/modification of small areas of habitat.

Fork-tailed Swift *Apus pacificus*

Status and Distribution: The fork-tailed swift is listed as Schedule 3 under the *WC Act* and as migratory under the *EPBC Act* as migratory under the *EPBC Act 1999* and under international agreements to which Australia is a signatory. It is a summer migrant (Oct-Apr) to Australia (Morcombe 2004).

Habitat: Low to very high airspace over varied habitat from rainforest to semi desert (Morcombe 2004).

Likely presence in study area: It is potentially an occasional summer visitor to the study area but is entirely aerial and largely independent of terrestrial habitats. Not listed as a potential species given it would only occur over head on very rare occasions for brief periods.

Potential impact of development: No impact on this species will occur.

Rainbow Bee-eater *Merops ornatus*

Status and Distribution: This species is listed as Schedule 3 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Rainbow Bee-eater is a common summer migrant to southern Australia but in the north they are resident (Morcombe 2003).

Habitat: Open Country, of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest, farmlands (Morcombe 2004). Breeds underground in areas of suitable soft soil firm enough to support tunnel building.

Likely presence in study area: Observed foraging during the field survey. This species is a common seasonal visitor to south west. Population numbers at any one location would however never be significant as the species usually breeds in pairs and only rarely in small colonies (Johnstone and Storr 1998).

Potential impact of development: Modification and/or loss of a small area of habitat but impacts will not be significant.

Chuditch *Dasyurus geoffroii*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act.* Formerly occurred over nearly 70 per cent of Australia. The chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of southwest Western Australia. Also

occurs in very low numbers in the Midwest, Wheatbelt and South Coast Regions with records from Moora to the north, Yellowdine to the east and south to Hopetoun.

Habitat: Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts. Riparian vegetation appears to support higher densities of chuditch, possibly because food supply is better or more reliable and better cover is offered by dense vegetation. Chuditch appear to utilise native vegetation along road sides in the wheatbelt (CALM 1994). The estimated home range of a male chuditch is over 15 km^2 whilst that for females is 3-4 km^2 (Sorena and Soderquist 1995).

Likely presence in study area: Generally regarded as locally extinct in this section of the Swan Coastal Plain. Very occasional transient individuals recorded further south (Anketell/Karnup) (DPaW 2014).

Potential impact of development: No impact on this species or its preferred habitat will occur.

Southern Brush-tailed Phascogale *Phascogale tapoatafa tapoatafa*

Status and Distribution: Listed as Scheduled 1 under the WC Act (1950). Present distribution is believed to have been reduced to approximately 50 per cent of its former range. Now known from Perth and south to Albany, west of Albany Highway. Occurs at low densities in the northern Jarrah forest. Highest densities occur in the Perup/Kingston area, Collie River valley, and near Margaret River and Busselton (DPaW information pamphlet). Records are less common from wetter forests.

Habitat: This subspecies has been observed in dry sclerophyll forests and open woodlands that contain hollow-bearing trees but a sparse ground cover. A nocturnal carnivore relying on tree hollows as nest sites. The home range for a female Brush-tailed Phascogale is estimated at between 20 and 70 ha, whilst that for males is given as twice that of females. In addition, they tend to utilise a large number (approximately 20) of different nest sites throughout their range (Soderquist, 1995).

Likely presence in study area: The current status of this species in general area is difficult to determine but the degraded and fragmented nature of native vegetation in and surrounding the study area would make it very difficult for a population of this species to persist in the study area and therefore it is considered very unlikely to be present. This conclusion is supported by the lack of recent records in the general area despite several detailed surveys in recent

years (Rockingham, East Rockingham, Bibra Lake, Jandakot). Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated as it is unlikely to be present.

Southern Brown Bandicoot *Isoodon obesulus fusciventer*

Status and Distribution: Listed as Priority 5 by DPaW. Widely distributed in the south west from near Cervantes north of Perth to east of Esperance, patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. Has been translocated to Julimar State Forest, Hills Forest Mundaring, Tutanning Nature Reserve, Boyagin Nature Reserve, Dongolocking Nature Reserve, Leschenault Conservation Park, and Karakamia and Paruna Sanctuaries (DPaW information pamphlet) and Nambung National Park (DPaW pers. coms.)

Habitat: Dense scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Populations inhabiting Jarrah and Wandoo forests are usually associated with watercourses. Quendas can thrive in more open habitat subject to exotic predator control (DPaW information pamphlet).

Likely presence in study area: Evidence of this species foraging (i.e. diggings) in some sections of the study area was observed during the field survey. Potentially present within the study area wherever dense shrubby groundcover occurs, though extent if suitable habitat is limited.

Potential impact of development: Loss of some existing and potential habitat. Some possibility that individuals maybe killed or injured during clearing operations.

Western Ringtail Possum *Pseudocheirus occidentalis*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Common in suitable habitat (de Tores 2008). The highest densities of this species are recorded in Peppermint habitat near Busselton area; relatively high densities are found in Jarrah/Marri forest at Perup (de Tores 2008).

The western ringtail possum (WRP) has a restricted distribution in south-western Western Australia. Most known populations (natural and translocated) are now restricted to near coastal areas of the south west from the Dawesville area to the Waychinicup National Park. Inland, it is also known to be relatively common in a

small part of the lower Collie River valley, the Perup Nature Reserve and surrounding forest blocks near Manjimup.

Habitat: The western ringtail possum was once located in a variety of habitats including Coastal Peppermint, Coastal Peppermint-Tuart, Jarrah-Marri associations, Sheoak woodland, and eucalypt woodland and mallee. Coastal populations mostly inhabit Peppermint-Tuart associations with highest densities in habitats with dense, relatively lush vegetation. Inland, the largest known populations occur in the Upper Warren area east of Manjimup (Wayne *et al* 2005). In this area the peppermint tree is naturally absent and jarrah-marri associations constitute the species refuge and foraging habitat. In areas where Peppermint is absent or rare WRPs have been observed feeding predominately on young Jarrah, *Nuytsia floribunda* and *Allocasuarina fraseriana* (G Harewood pers. obs.).

Likely presence in study area: This species is locally extinct.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Quokka *Setonix brachyurus*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Rare and restricted in south west W.A. from south of Perth to Two Peoples Bay. The distribution of the quokka includes Rottnest and Bald Islands, and at least 25 known sites on the mainland, including Two Peoples Bay Nature Reserve, Torndirrup National Park, Mt Manypeaks National Park, Walpole-Nornalup National Park, and various swamp areas through the south-west forests from Jarrahdale to Walpole.

Habitat: Mainland populations of this species are currently restricted to densely vegetated coastal heaths, swamps, riverine habitats including tea-tree thickets on sandy soils along creek systems where they are less vulnerable to predation. The species is nocturnal.

Likely presence in study area: This species is locally extinct.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Western Brush Wallaby *Macropus irma*

Status and Distribution: Listed as Priority 4 by DPaW. The western brush wallaby is distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid (DPaW information pamphlet nd).

Habitat: The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heathland, and is uncommon in karri forest (DPaW information pamphlet nd).

Likely presence in study area: Recorded in Jandakot (ENV 2009) and possibly present in small numbers in other larger remnants in the wider area but given the fragmented nature of remnant vegetation in and near the study area it is unlikely to ever occur.

Potential impact of development: No impact on this species or its preferred habitat will occur.

Western False Pipistrelle *Falsistrellus mackenziei*

Status and Distribution: Listed as Priority 4 by DPaW. Listed as vulnerable by the ICUN. Confined to south west W.A. south of Perth and east to the wheat belt. Most records from Karri forests but also recorded in wetter stands of jarrah and tuart and woodlands on the Swan Coastal Plain (Menkhorst and Knight 2011). Range appears to be contracting southwards, presumably due to drying climate. Not recorded north of Collie in recent times (Bob Bullen 2010, pers. comm.)

Habitat: This species of bat occurs in high forest and coastal woodlands. It roosts in small colonies in tree hollows and forages at canopy level and in the cathedral-like spaces between trees.

Likely presence in study area: Rarely recorded in this general area in recent times. Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated.

Water Rat *Hydromys chrysogaster*

Status and Distribution: Listed as Priority 4 by DPaW. The water rat is widely distributed around Australia and its offshore islands, New Guinea and some adjacent islands. It occurs in fresh brackish water habitats in the south-west of Western Australia, but occurs in marine environments along the Pilbara coastline and offshore islands. Previous survey work in the south west suggested this species was relatively common and widespread though difficult to capture (Christensen *et al* 1985, How *et al* 1987).

Habitat: The water rat occupies habitat in the vicinity of permanent water, fresh, brackish or marine. Likely to occur in all major rivers and most of the larger streams as well as bodies of permanent water in the lower south west (Christensen *et al* 1985).

Likely presence in study area: No suitable habitat.

Potential impact of development: No impact on this species will occur.

DISCLAIMER

This fauna assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Greg Harewood ("the Author"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints. In accordance with the scope of services, the Author has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

Within the limitations imposed by the scope of services, the field assessment and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

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Part Lot 9001 Mortimer Road
and Part Lot 379 Millar Road, Wellard
(East) Local Structure Plan

APPENDIX K
FIRE MANAGEMENT PLAN

emerge ASSOCIATES | Bushfire Safety CONSULTING

FIRE MANAGEMENT PLAN

PART LOT 9001 MORTIMER ROAD AND LOT 379 MILLAR ROAD, WELLARD EAST

Project Number EP11-011



Prepared for Armana Holdings Pty Ltd
July 2015

Document Control

DOC NAME	FIRE MANAGEMENT PLAN – PART LOT 9901 MORTIMER ROAD AND LOT 379 MILLAR ROAD				
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Executive Summary

This Fire Management Plan (FMP) has been prepared for Armana Holdings Pty Ltd to support the preparation of the Local Structure Plan (LSP) for Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard (herein referred to as "the site"). The site is 16.8 ha in size and is located 36 km south of the Perth Central Business District within the City of Kwinana. The location of the site is shown in **Figure 1.**

The site is zoned "Urban" under the Metropolitan Region Scheme (MRS) and "Development" under the City of Kwinana Town Planning Scheme (TPS) No. 2. Historically the site has been cleared and utilised for grazing and is now characterised by large areas of pasture weed grasses with smaller areas of remnant vegetation comprised mainly of an overstorey of native species with an understorey of weed grasses (see **Figure 2**). The site is bound by urban development to the north, the Kwinana Freeway and land intended for urban development to the west, Millar Road and a marsupial rehabilitation centre to the south and land intended for future urban development to the east.

The purpose of the FMP is to outline potential bushfire risk that is likely to apply to the site and determine whether the LSP provides for future development that will support acceptable solutions and responses to the bushfire risk.

The proposed LSP (shown conceptually in **Figure 3**) provides a guide for residential development within the site and creates a framework for the future urban subdivision of the site into anticipated residential lots, a school site and areas of Public Open Space (POS). A separate structure planning and subdivision processes is underway for landholdings immediately north, west and east of the site, consistent with the broader Wellard East Concept Plan (see **Figure 4**).

Following development, while areas of remnant vegetation will be cleared within the site to facilitate development, the majority of the remnant vegetation outside of the site is likely to remain in the short to long term, and will therefore pose varying bushfire hazards to development within the site. Landholdings to the north, east and west of the site are intended for future urban development in accordance with the Wellard East Concept Plan and therefore pose only temporary bushfire hazard considerations. Permanent bushfire hazard considerations are posed by the remnant vegetation within the Kwinana Freeway to the northwest of the site, and vegetation associated with a Resource Enhancement Wetland to the east of the site.

All vegetation within 100m of the site boundary have classified in accordance with *AS3959 Construction of Buildings in Bushfire Prone Areas* (AS3959:2009) and the applicable bushfire hazard rating levels determined. It has been determined that all proposed future dwellings resulting from the LSP will fall within an acceptable level of risk. The temporary and permanent Building Protection Zones (BPZ) requirements have been assessed and shown in **Figure 12**. An indicative Bushfire Attack Levels (BALs) assessment was completed as part of the FMP and indicates that the BAL for proposed future lots does not exceed BAL-29. The potential shielding for radiant heat flux from the acoustic wall, to be located along the boundary of the site adjacent to the Kwinana Freeway, has not been considered as part of this FMP.

Any new dwellings constructed within 100m of identified classified vegetation will require consideration of the potential need for increased construction requirements to address AS3959:2009. In order to pre-empt this requirement, a BAL assessment will be undertaken as part of the subdivision process to determine the BAL ratings for each individual new lot created. BAL ratings should not be determined for future lots at the LSP stage, as the ultimate lot locations/boundaries will be determined through the

subdivision process, and temporary hazards (or even hazards that were expected to be permanent) may not remain. A detailed and specific BAL assessment will need to be completed at the subdivision approval stage for all lots currently determined to be within "Bushfire Prone Areas" (see **Figure 11)**. As part of the subdivision process, any lots deemed to require fire management responses through the BAL assessment, will be subject to a notification pursuant to section 70A of the *Transfer of Land Act 1893* placed on the certificate(s) of title indicating that the lot is subject to the requirements of this FMP and increased construction standards to meet the BAL ratings.

It is expected that the preparation of BAL assessment as a part of subdivision, and implementation of this FMP, will reduce the threat to future residents, visitors and fire fighters in the areas proposed for urban development associated with this FMP.

Table of Contents

1 Introduction 1
1.1 Aim 1
1.2 Statutory and Policy Framework 1
1.2.1 Bush Fires Act 1954 1
1.2.2 State Planning Policy No. 3.4 Natural Hazards and Disasters 2
1.2.3 Planning for Bush Fire Protection Guidelines (2010) 2
1.2.4 Draft State Planning Policy 3.7 Planning for Bushfire Risk Management and draft Planning for Bushfire Risk Management Guidelines (2014) 2

2 Proposal and Objectives 3

3 Description of Area 4
3.1 General 4
3.2 Climate and Fire Weather 4
3.3 Topography and Effective Slope 7
3.4 Bushfire Fuels 7
3.5 Land Use 7
3.6 Assets 8
3.7 Access 8
3.8 Water Supply 8

4 Fire Problem 9
4.1 Bushfire History 9
4.2 Bushfire Risk 9
4.3 Bushfire Hazard 10
4.3.1 Vegetation Type and Structure 11
4.3.2 Vegetation in Public Open Spaces 14
4.3.3 Slope 14
4.3.4 Bushfire Hazard Assessment – Pre-development 14
4.3.5 Bushfire Hazard Assessment – Post-development 15
4.4 Bushfire Threat 16
4.5 Summary of Bushfire Potential Issues 16

5 Fire Mitigation Strategies 18
5.1 Hazard Management 18
5.2 Bushfire Risk Management 18
5.2.1 Element: Location of the Development 18
5.2.1.1 Intent 18
5.2.1.2 Acceptable Solution 19
5.2.2 Element: Vehicular Access 19
5.2.2.1 Intent 19
5.2.2.2 Background 19
5.2.2.3 Acceptable Solution A2.1: Two Access Routes 19
5.2.2.4 Acceptable Solution A2.2: Public Roads 20
5.2.2.5 Acceptable Solution A2.3: Cul-de-sacs (including dead end roads) 20
5.2.3 Element: Water 20
5.2.3.1 Intent 20
5.2.3.2 Acceptable Solution A3.1: Reticulated Water 20
5.2.4 Element: Siting of the Development 21

5.2.4.1 Intent 21
5.2.4.2 Background 21
5.2.4.3 Building Siting and Predicted Bushfire Attack Levels 22
5.2.4.4 Methodology and Assumptions 22
5.2.4.5 Indicative BAL Outcome 22
5.2.4.6 Landscaping Considerations 24
5.2.4.7 Acceptable Solution A4.1: Hazard Separation 24
5.2.4.8 Acceptable Solution A4.3: Building Protection Zone 25
5.2.5 Element: Design of the Development 26
5.2.5.1 Performance Criteria 26
5.2.5.2 Acceptable Solution A5.2: Performance Criterion P5 Compliance 26
5.3 Future Development 26
5.4 Access and Fire Breaks 26
5.5 Public Education and Community Awareness 26
5.6 Fire Safer Areas 26
5.7 Assessment of Fire Management Plan 27
5.8 Implementing the Fire Management Plan 27
5.8.1 Developer's Responsibilities 27
5.8.2 Property Owner/Occupier's Responsibilities 28
5.8.3 City of Kwinana's Responsibilities 28
5.8.4 Water Corporation's Responsibilities 29
6 Conclusions 30
7 References 31
8 Glossary 33

List of Tables

Table 1: Indicative Bushfire Attack Level assessment for exposed interface areas 23

List of Plates

Plate1: Mean maximum recorded temperatures for the Medina Research Centre Bureau of Meteorology Station between 1983 and 2014 (Bureau of Meteorology 2014) 5
Plate 2: Mean rainfall for the Medina Research Centre Bureau of Meteorology Station between 1983 and 2014 (Bureau of Meteorology 2014) 5
Plate 3: Rose of wind direction and wind speed in km/h for December, January and February between 1996 and 2010 at the Medina Research Centre Bureau of Meteorology Station (Bureau of Meteorology 2014) 6
Plate 4: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007) 11
Plate 5: Kunzea scrub fuels to the far south 11
Plate 6: Eucalyptus rudis open forest with intermediate scrub fuels and elevated weed fuels to the far south 11
Plate 7: Pasture grasses in southern section 12
Plate 8 Shelterbelt strip of Eucalypt woodland 12
Plate 9: Slashed grass on roadside verge and single row of eucalypts on Millar Road 12
Plate 10 Eucalypt and understorey fuels between the railway and Millar Road 12
Plate 11: Eucalypt dominated woodland 13

Plate 12 Low banksia woodland in the southern section 13
Plate 13: Jarrah woodland exhibiting disease with regrowth base of tree 13
Plate 14 Low grass fuels in pasture paddock 13
Plate 15: Elevated fuel loads of scrub vegetation 14
Plate 16 Strip of elevated scrub and managed grass fuels along freeway reserve 14
Plate 17: Acoustic wall installed in the northern portion of Lot 9001 Mortimer Road, adjacent to the Kwinana Freeway showing firebreak and interface with vegetation. 16
Plate 18 Acoustic wall likely to be installed adjacent to north-west boundary of the site, approximately 3m high with 3m-wide firebreak 16

Figures

Figure 1: Site Location
Figure 2: Site Plan
Figure 3: Proposed LSP
Figure 4: Wellard East Concept Plan
Figure 5: Local Context and Surrounding Land Use
Figure 6: Site Topography and Effective Slope
Figure 7: Existing Site Conditions – AS3959 Vegetation Classification
Figure 8: Existing Site Conditions – Bushfire Hazard Assessment
Figure 9: Post Development Conditions –AS3959 Vegetation Classification
Figure 10: Post Development Conditions – Bushfire Hazard Assessment
Figure 11: Post Development Conditions – Bushfire Prone Areas
Figure 12: Building Protection Zone Requirements

Appendices

Appendix A
Compliance Checklist

1 Introduction

This Fire Management Plan (FMP) has been prepared for Armana Holdings Pty Ltd to support the Local Structure Plan (LSP) for Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard, herein referred to as "the site". The site is 16.8 hectares (ha) in size and is located 36 km south of the Perth Central Business District within the City of Kwinana. The location of the site is shown in **Figure 1**.

The site has been historically cleared and utilised for grazing and is now characterised by large areas of pasture weed grasses with smaller areas of remnant vegetation comprised mainly of overstorey species with an understorey of weed grasses (as shown in **Figure 2**). The site is bound by urban development to the north, the Kwinana Freeway and land intended for urban development to the west, a marsupial rehabilitation centre, Millar Road and rural land uses to the south and land intended for future urban development to the east.

The site is currently zoned as "Urban" under the Metropolitan Region Scheme (MRS) (WAPC 2010), see, and "Development" under the City of Kwinana Town Planning Scheme (TPS) No. 2. The proposed LSP, as shown in **Figure 3** provides a projected development within the site which includes residential lots, public open space (POS) areas, part of a primary school and part of a marsupial rehabilitation centre. The proposed LSP for the site occurs within the Wellard East Cell, for which a concept plan has been prepared, and is provided in **Figure 4**.

An approved LSP exists over the northern portion of Lot 9001, and urban development in this area is being progressed by Armana Holdings Pty Ltd in accordance with the applicable subdivision approval. Areas to the east and west of the site are also proposed for urban development, with an LSP and subdivision currently progressing through the planning approval system for the land to the west. The rural land use south of Millar Road is likely to remain in the long term.

1.1 Aim

The aim of this FMP is to outline potential bushfire risk that is likely to apply to the site and determine whether the LSP provides for future development that will support acceptable solutions and responses to reduce the occurrence of and minimise the impact of bushfires within the site, thereby reducing the threat to life, property and the environment.

1.2 Statutory and Policy Framework

The following key legislation, policies and guidelines are relevant to the preparation of fire management plans.

1.2.1 Bush Fires Act 1954

The *Bush Fires Act 1954* sets out provisions to reduce the dangers resulting from bushfires; prevent, control and extinguish bushfires; and for other purposes. The Act addresses various matters including prohibited burning times, enabling Local Government to require landowners and/or occupiers to plough or clear fire breaks, to control and extinguish bushfires and establish and maintain Bush Fire Brigades.

Accordingly, the City of Kwinana publishes annual Firebreak Notices that can be downloaded from: http://www.kwinana.wa.gov.au/your-property/fire---emergency-services/hazard-reduction---fire-breaks.

1.2.2 State Planning Policy No. 3.4 Natural Hazards and Disasters

The objectives of the *State Planning Policy No. 3.4 Natural Hazards and Disasters Policy* are to:

- Include planning for natural disasters as a fundamental element when preparing all statutory and non-statutory planning documents, specifically town planning schemes and amendments, and local planning strategies.
- Use these planning instruments to minimise the adverse effects of natural disasters on communities, the economy and the environment.

The Policy determines those areas that are most vulnerable to bushfire and where development is appropriate and not appropriate. The provisions and requirements contained in *Planning for Bush Fire Protection Guidelines - Edition 2* (WAPC *et al.*, 2010) are used in this determination.

1.2.3 Planning for Bush Fire Protection Guidelines (2010)

The *Planning for Bush Fire Protection Guidelines - Edition 2* was prepared by the Department of Fire and Emergency Services (DFES), the Western Australian Planning Commission (WAPC) and the Department of Planning and Infrastructure. The guidelines are the foundation for fire risk management planning on private land in Western Australia.

The guidelines address important fire risk management and planning issues and set out performance criteria and acceptable solutions to minimise the risk of bushfires in new subdivisions and developments. The guidelines also address management issues including location, design, the development site, setback requirements, Bushfire Attack Level (BAL) ratings, vehicular access and water.

1.2.4 Draft State Planning Policy 3.7 Planning for Bushfire Risk Management and draft Planning for Bushfire Risk Management Guidelines (2014)

The Department of Planning have recently released draft *State Planning Policy 3.7 Planning for Bushfire Risk Management* (2014) and the draft *Planning for Bushfire Risk Management Guidelines* (2014). The requirements of these documents are largely accommodated within this FMP.

The draft *State Planning Policy 3.7 Planning for Bushfire Risk Management* (2014) is intended to inform and guide decision makers, referral authorities and proponents to achieve acceptable bushfire protection outcomes, including expectations at the different stages of planning.

The draft *Planning for Bushfire Risk Management Guidelines* (2014) provides an update on *Planning for Bush Fire Protection Guidelines - Edition 2* (WAPC *et al*, 2010) to ensure necessary bushfire management measures are incorporated into proposed development.

2 Proposal and Objectives

The proposed LSP, provided in **Figure 3**, provides a framework for residential development within the site and has been prepared in accordance with the Wellard East Concept Plan.

Community bushfire safety is a shared responsibility between governments, fire agencies, communities and individuals. The planning and building controls outlined in this FMP, when implemented, will reduce the risk to people and property. How future residents interpret the risk, prepare and maintain the property and buildings and what decisions and actions they take (i.e. evacuate early or stay and defend or other) greatly influence the outcome in a bushfire.

The objective of this FMP is to address bushfire management issues within the proposed LSP. Achievable and measurable goals of this plan include ensuring:

- The development is located in an area where the bushfire hazard does not present an unreasonable level of risk to life and property.
- Vehicular access to the development is safe if a bushfire occurs.
- Water is available to the development, so that life and property can be protected from bushfire.
- The development is sited to minimise the effects of a bushfire.
- The development design will minimise the effects of a bushfire.

This document sets out the roles and responsibilities of the developer, future residents, the City of Kwinana and DFES. It is important that the measures and procedures outlined in this FMP are adopted across the various stages of the land use planning and dwelling construction approvals processes and is reviewed as necessary.

This FMP includes:

- A description of the site, the surrounding area, fire climate and bushfire history.
- A summary of research into the related effects of a bushfire.
- A bushfire hazard assessment.
- Means of addressing vehicular access.
- Siting of buildings to include building protection and hazard separation zones;
- Detail on water supply.
- Maps and plans of fire reduction measures.

3 Description of Area

3.1 General

The site has historically been used for grazing/agricultural uses and has been largely cleared of remnant vegetation. Within the site, the most intact vegetation occurs in the southern portion of part Lot 9001 where open forest exists over a degraded understorey layer. In the northern portion of Lot 379, remnant vegetation within the site is highly degraded comprised of low open woodland and scrub over a weed grass understorey. A number of small areas of vegetation identified as degraded open forest, woodland and scrub occur in the central and southern portion of Lot 379.

Within the immediate surrounds of the site:

- The area of land to the north of the site is currently undergoing urban development by Armana Holdings in accordance with an approved subdivision plan.
- The Kwinana Freeway is located directly to the northwest of the site and within the freeway reserve there are several strips of planted shrubland and scrub immediately adjacent to the site, and is shown in **Figure 5**.
- The area to the west of the site is predominantly comprised of pasture grasses with areas of remnant degraded woodland, open forest and scrub, and is shown in **Figure 5**. A separate local structure planning and subdivision process is being progressed for these areas, with development anticipated to commence within a similar timeframe to the site.
- Areas of scrub, woodland and a smaller area of open forest interspersed by pasture are located to the east of the site, see **Figure 5**. Urban development is proposed to occur to the east of the site, however the development timeframe is not known.
- Millar Road is located to the south of the site, with the South West Main freight railway, located further south. Multiple strips of woodland are located between the site, Millar Road and the railway.

3.2 Climate and Fire Weather

The behaviour of bushfires is significantly affected by weather conditions and they burn more aggressively when high temperatures combine with low humidity and strong winds. In Perth and surrounding coastal areas, the fire risk is greatest from summer through autumn when the moisture content in vegetation is low. Summer and autumn days with high temperatures, low humidity and strong winds are particularly conducive to the spread of fire. This threat is increased if thunderstorms develop, accompanied by lightning and little or no rain.

Research indicates that virtually all house losses occur during severe, extreme or catastrophic conditions (i.e. when the Fire Danger Index is over 50) (Blanchi *et al.*, 2010).

The Bureau of Meteorology (2014) states that extreme fire weather conditions in the Perth region typically occur with strong easterly or north-easterly winds associated with a strong high to the south of the state and a trough offshore. Easterly winds represent approximately 60% of extreme fire weather days (events) compared to fewer than 5% associated with southerly winds. About 15% of Perth events occurred in a westerly flow following the passage of a trough.

Very dangerous fire weather conditions often follow a sequence of hot days and easterly winds that culminate when the trough deepens near the coast and moves inland. Winds can change from easterly to northerly and then to westerly during this sequence of climatic events.

Data from the Medina Research Centre (6 km northwest of the site) indicate the area experiences warm dry summers and cool wet winters (see **Plate1** and **Plate 2**), and is classified as a Mediterranean climate. Mean maximum temperatures vary from 31°C in February to 19°C in July.

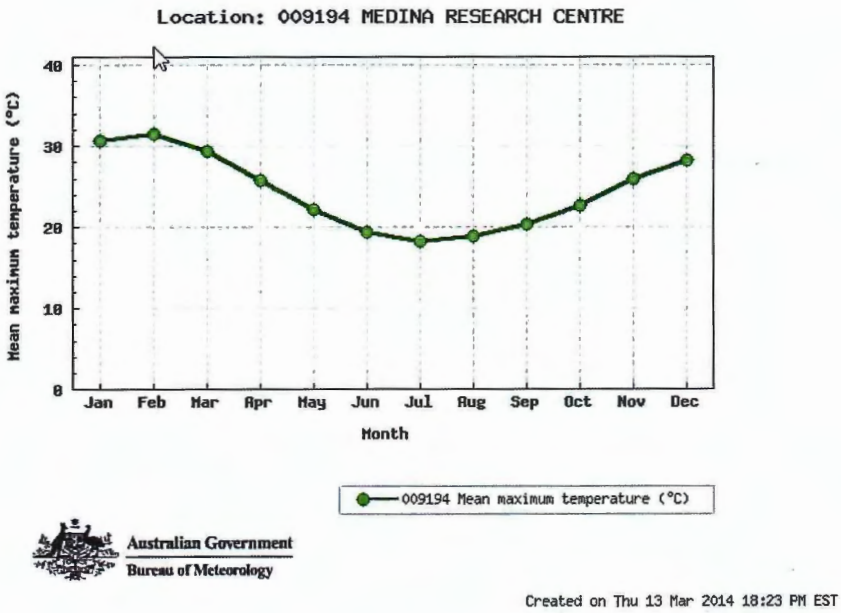

Plate1: Mean maximum recorded temperatures for the Medina Research Centre Bureau of Meteorology Station between 1983 and 2014 (Bureau of Meteorology 2014)

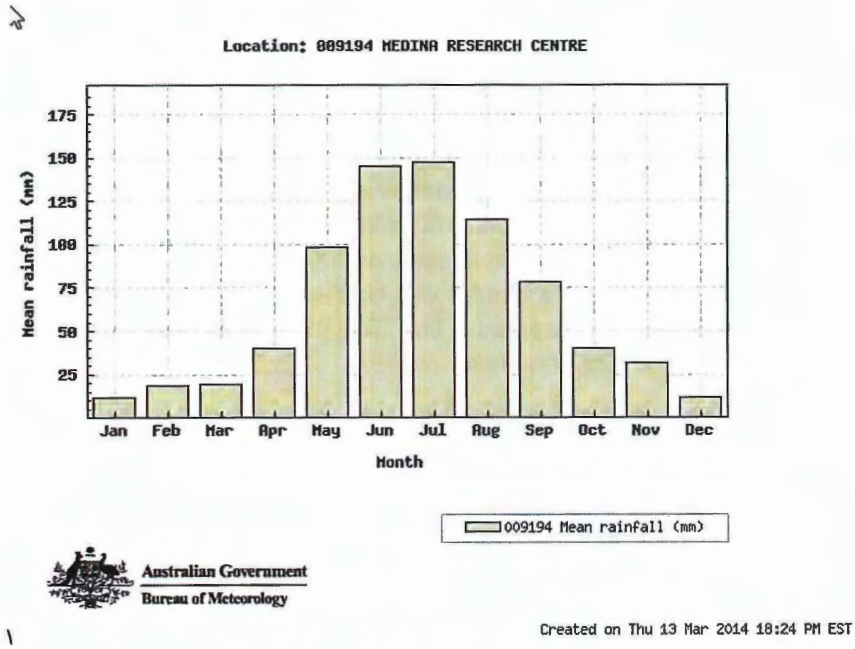

Plate 2: Mean rainfall for the Medina Research Centre Bureau of Meteorology Station between 1983 and 2014 (Bureau of Meteorology 2014)

Data from the weather station indicate that the predominant winds near the site in the summer months at 3 pm are south-westerly, as shown in **Plate 3**, with easterly and south-easterly winds more common in February. Wind strength, direction and frequency from the west and southwest are dominant and occur 40-50 per cent of the time.

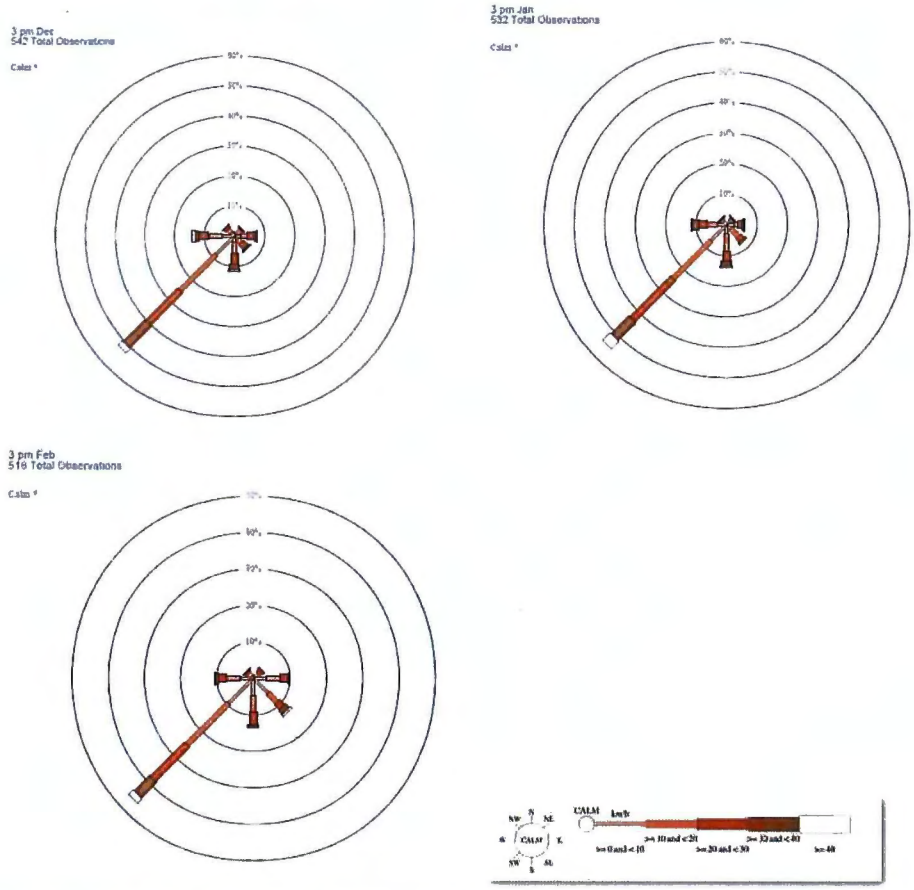

Plate 3: Rose of wind direction and wind speed in km/h for December, January and February between 1996 and 2010 at the Medina Research Centre Bureau of Meteorology Station (Bureau of Meteorology 2014)

Interpreting Plate 3 – wind speed vs. direction plot

Wind roses summarise the occurrence of winds at a location, showing their strength, direction and frequency. The percentage of calm conditions is represented by the size of the centre circle - the bigger the circle, the higher the frequency of calm conditions. Each branch of the rose represents wind coming from that direction, with north found at the top of the diagram. Eight directions are used. The branches are divided into segments of different thickness and colour, which represent wind speed ranges in that direction. Speed ranges of 10 km/h are used. The length of each segment within a branch is proportional to the frequency of winds blowing within corresponding range of speeds from that direction (BOM, 2010).

3.3 Topography and Effective Slope

The natural landscape is gently undulating, generally in a south-westerly direction, with the site sloping towards the two drainage reserves, one intersecting the southern-central portion of the site and the other located along the north-eastern boundary of the site. Site elevations range from the highest point of 14m Australian Height Datum (AHD) in the central-eastern portion of the site to 8m AHD within the southern portion of the site, associated with the drainage reserve.

The effective slope of the land surrounding the site is either downslope 0 – 5 degrees or flat, and is shown in **Figure 6**.

3.4 Bushfire Fuels

The site has historically been used for livestock grazing/agricultural uses and as a result there is limited remnant vegetation present within the site. The vegetation within the site has been subject to high levels of historical clearing, stock grazing and weed invasion and as a result is composed of large areas of pasture grasses. At the time of the preparation of this FMP, pasture grasses within the site appeared to be largely unmanaged. Vegetation consists of scattered remnant native trees and exotic planted species. Some patches of intact remnant vegetation exist within the site and include:

- Low woodland-forest of *Eucalyptus rudis* and *Melaleuca preissiana* over *Kunzea glabrescens – Pultenaea reticulata* over *Dielsia stenostachya – Opercularia hispidula - *Zantedeschia aethiopica* within the south-west portion of Lot 9001.
- Low woodland of *Corymbia calophylla – Eucalyptus marginata* over *Agonis flexuosa – Casuarina obesa – Banksia menziesii – Banksia grandis* over *Eremaea pauciflora – Calothamnus quadrifidus* over *Conostylis aculeate subsp. cygnorum – Kennedia prostrate - *Ehrharta longiflora - *Lolium rigidum - *Carpobrotus edulis* within the central portion of Lot 379.
- Tall Scrub of *Kunzea glabrescens – Melaleuca teretifolia* over pasture grasses and **Carpobrotus edulis* within the north-east portion of Lot 379.

Within these areas the understorey vegetation has in the main been removed and replaced by grassy weeds.

There are several areas of vegetation surrounding the site that pose bushfire hazards to the LSP and include:

- Areas of scrub and woodland identified to the west of the site, which are proposed to be developed for urban purposes.
- Scrub vegetation within the Kwinana Freeway to the northwest of the site.
- Areas of woodland and scrub to the east of the site, associated with a resource enhancement wetland.

3.5 Land Use

The site is undeveloped having historically been used for agricultural purposes except for the existing marsupial rehabilitation centre located along the southern boundary of the site. The site is currently zoned "Urban" under the MRS and "Development" under the City of Kwinana TPS 2 (see **Figure 5**).

Land to the north, west and east of the site is generally zoned "Urban" under the MRS and "Development" under the City of Kwinana TPS 2. A portion of Lot 379 Millar Road and land to the east of the site is located within the recommended separation distance for a livestock holding facility (see **Figure 4**) and is zoned "Urban Deferred" under the MRS and "Cluster/Communal Rural Settlement"

under the City of Kwinana TPS No. 2. Land to the south of the site, is zoned "Rural" under the MRS and "Special Rural" under the City of Rockingham TPS No. 2.

3.6 Assets

In accordance with the proposed LSP, the site will support the development of residential lots, several POS areas and part of a primary school. Once completed the site will be form part of an urban environment.

Future dwellings exposed to any bushfire hazard will be those located around the perimeter of the site and within 100 m of classified vegetation that is likely to remain in the medium to long-term.

3.7 Access

The site has extensive access to both existing and proposed future surrounding public roads, including a north-south road that will cross the drainage reserve and provide access to Mortimer Road to the north and Millar Road to the south (see **Figure 4**). Internally, the site has an interconnected road system to ensure all residents and fire fighters have at least two access options at all times. Two public roads will be available for residents and emergency services prior to the creation of lots.

Prior to the creation of lots residents and emergency services will have access to two public roads, namely Sunrise Boulevard (and Mortimer Road) within the northern portion of Lot 9001 and Millar Road to the south of the site.

3.8 Water Supply

Reticulated water will be provided to the entire development. Fire hydrants will be spaced according to Water Corporation and DFES standards and will provide emergency services with access to an adequate water supply.

Public buildings such as schools will require the relevant management body to outline the compliance with current standards. The process to determine hydrant coverage and compliance for commercial buildings with Australian and DFES standards is outlined in DFES guideline *GL-07 Submission of documents to DFES for assessment* which can be downloaded at: http://www.dfes.wa.gov.au/regulationandcompliance/buildingplanassessment/Guidelines/GL-07-SubmissionOfDocumentsToDFESForAssessment.pdf

School buildings are Class 9 buildings in the Building Code of Australia (BCA) and require compliance with the BCA, in particular criteria E1.5 including the specifications and AS 2118.4 together with AS 2419.1. Noting that hydraulic water supplying both systems (hydrant and sprinklers) will need to achieve flow rates simultaneously.

4 Fire Problem

4.1 Bushfire History

Fires have been common on the Swan Coastal Plain for thousands of years and the anthropological and historical evidence suggests that Aborigines regularly burnt this area (Hallam, 1975; Abbott, 2003).

A recent study has concluded that bushfires may have been in the Australian landscape for 50 million years longer than previously thought. The adaption of eucalypts that allows them to recover from bushfires has been traced back more than 60 million years (Crisp *et al.*, 2011) indicating fire has been in the Australian landscape since that time.

Bushfires are common in the City of Kwinana and some recent bushfire history includes:

- On March 16 2014, 40 firefighters from eight stations attended a fire in bushland to the west of the Kwinana Freeway, between Wellard Road and the Kwinana Freeway. Approximately 16.5 hectares was burnt.
- On December 29, 2012, the Kwinana Freeway was closed in both directions as 100 firefighters and 3 helitacs battled a fire near Bertram Primary School. Approximately 35 ha were burnt with no threat to homes or lives.
- On February 24, 2010, 40 fire fighters and three helitacs responded to a fire through the afternoon near Meares and Gilmore Avenues. Approximately 10 ha were burnt.

Areas of native vegetation adjacent to residential estates are susceptible to frequent bushfires due to the high risk of arson and great potential for accidental ignitions (Walker 1981, Burrows and Abbott 2003).

Given that bushfires are common in the City of Kwinana, this FMP plays an important role in ensuring that the development of the land appropriately mitigates the risk and threat from fire.

4.2 Bushfire Risk

The risk management process described in AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines* is a systematic method for identifying, analysing, evaluating and treating emergency risks.

Bushfire risk is determined by assessing:

- Bushfire hazard (i.e. vegetation).
- Threat level (i.e. proximity of the hazard to assets and people).
- Vulnerability of the asset.
- Consequence rating (i.e. a rating for the potential outcome once the "incident" has occurred).
- Likelihood rating (i.e. the chance of an event).

It is beyond the scope of this report to detail a comprehensive bushfire risk assessment according to AS/NZS ISO 31000:2009, however a comprehensive bushfire hazard assessment is outlined in **Section 4.3**. The threat level is assessed in later sections of this FMP by determining indicative Bushfire Attack Levels (BALs) for exposed areas of the development.

The vulnerability of assets such as dwellings is impacted by several factors. Some relate to the way a bushfire behaves at a site, others to the design and construction materials in the building and siting of surrounding elements. Infrastructure, utilities and human behaviour are also factors. Leonard (2009) identified the following factors:

- Terrain (slope).
- Vegetation (overall fuel load, steady state litter load and bark fuels, etc.).
- Weather (temperature, relative humidity and wind speed).
- Distance of building from unmanaged vegetation.
- Individual elements surrounding the building that are either a shield or an additional fuel source.
- Proximity to surrounding infrastructure.
- Building design and maintenance.
- Human behaviour (ability to be present and capacity to fight the fire).
- Access to the building and how that influences human behaviour.
- Water supply for active and/or passive defence.
- Power supply.

It is likely that buildings are lost because of their vulnerability to the mechanisms of bushfire attack. Buildings constructed to *Australian Standard 3959:2009 Construction of buildings in bushfire-prone areas* (AS3959:2009) are more likely to survive a bushfire than buildings that do not conform to construction standards however building survival is not guaranteed.

The vulnerability of people is determined by several factors, including age, fitness levels, gender, level of preparation, and number of occupants who can actively defend a property.

The development is comprised of residential dwellings, POS areas and a portion of a marsupial rehabilitation centre. The site also contains a portion of a primary school which is considered a vulnerable asset and it is expected that the primary school will develop an appropriate Bushfire Risk Management Plan in line with WAPC's *Planning for Bushfire Risk Management Guidelines* (draft) (WAPC 2014), DFES and the Department of Education policies and guidelines.

Vulnerability, consequence and likelihood ratings are all determined using a risk assessment matrix which is beyond the scope of this report.

4.3 Bushfire Hazard

Assessing bushfire hazards at a strategic level takes into account the predominant class of vegetation on the site and surrounding area for a minimum of 100m, as shown in **Figure 7**. The fuel layers in a typical forest environment can be broken-down into five segments as illustrated in **Plate 4** below. These defined fuel layers are used in the following descriptions regarding vegetation types, fuel structure and bushfire hazard levels.

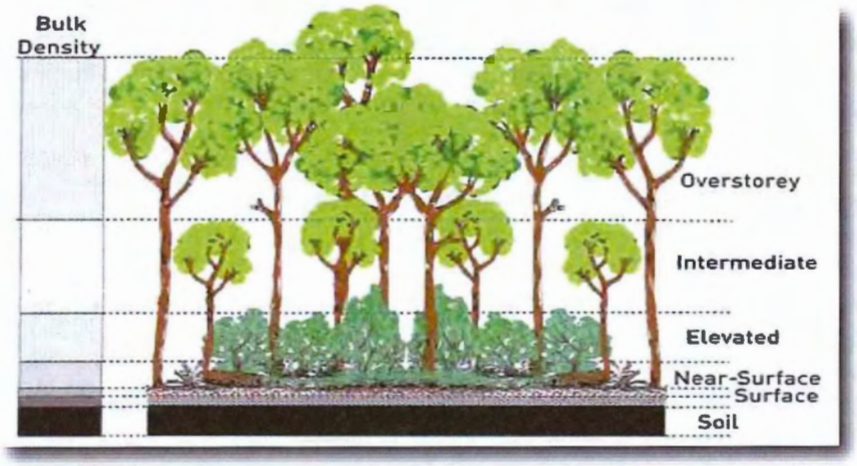

Plate 4: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

4.3.1 Vegetation Type and Structure

The classification of vegetation and description of site conditions is based the information captured during the site visit, completed on the 9th and 17th April 2014. The vegetation classification is shown in **Figure 7.**

The northern portion of the site has been largely cleared and is composed of mineral earth. A small area within the southern portion of Lot 9001 contains *Kunzea* scrub with intermediate fuels (see **Plate 5**) and *Eucalyptus rudis* open forest with some intermediate scrub fuels and elevated weed fuels (see **Plate 6**). Generally the understorey in these areas is "Degraded" (based on the Keighery (1994) scale) but contains accumulated surface fine fuels in the form of bark and leaf litter.



Plate 5: Kunzea scrub fuels to the far south



Plate 6: Eucalyptus rudis open forest with intermediate scrub fuels and elevated weed fuels to the far south

The southern portion of the site contains large areas of pasture grasses which reflect the previous agricultural land use (see **Plate 7**) and appears to be grazed by horses at the present time and contains limited surface fuels. Single rows of Eucalypt trees were located in this portion of the site as well as shelterbelt strips of vegetation along the fence lines (see **Plate 8**).



Plate 7: Pasture grasses in southern section



Plate 8 Shelterbelt strip of Eucalypt woodland

Within 100m of the site and directly to the south, a row of eucalypts over slashed pasture grasses has been identified along Millar Road (see **Plate 9**) and in the area of road reserve between Millar Road and the railway, shown in **Plate 10**.



Plate 9: Slashed grass on roadside verge and single row of eucalypts on Millar Road



Plate 10 Eucalypt and understorey fuels between the railway and Millar Road

Woodland areas extend east and west of the site and include areas dominated by Eucalypts, Banksia and Sheoak, see **Plate 11**. The understorey in these areas is "Degraded" but contains accumulated surface fine fuels in the form of bark and leaf litter. The areas dominated by Banksia species form a low woodland class of vegetation with intermediate fuels (see **Plate 12**).



Plate 11: Eucalypt dominated woodland



Plate 12 Low banksia woodland in the southern section

Jarrah woodland exists directly east of the site which exhibits diseased trees that are reshooting near the base of the tree, and is shown in **Plate 13**. This area contains elevated fuels. The area to the northeast of the site is largely grazed by cattle and grass fuels are well managed in a low fuel condition (see **Plate 14**). Scrub vegetation also occurs in this area which contains elevated fuel loads.



Plate 13: Jarrah woodland exhibiting disease with regrowth base of tree



Plate 14 Low grass fuels in pasture paddock

The Kwinana freeway reserve contains strips of elevated scrub vegetation and near-surface grass fuels (see **Plate 15**). The height of the scrub varies from an average of four metres where the road reserve interfaces with the north-western boundary of the site, to 1.5 metres where the vegetation interfaces with the road pavement. The grass fuels adjacent to the road lanes are shown in **Plate 16**. These areas are managed by Main Roads Western Australia (MRWA) in accordance with *Operational Guideline 94 Roadside Vegetation Management and Fire Hazard Control*. Strips of scrub also occur in the centre of the freeway reserve and along the western boundary of the freeway reserve. These strips of vegetation are not separated by more than 20 metres.



Plate 15: Elevated fuel loads of scrub vegetation



Plate 16 Strip of elevated scrub and managed grass fuels along freeway reserve

4.3.2 Vegetation in Public Open Spaces

The location of the areas of POS and drainage reserves are shown within **Figure 3.** Landscape concept plans have been prepared for the POS areas by Emerge Associates, with the areas of POS and drainage reserves to be designed and managed in accordance with the definition of low threat vegetation types, as defined within AS 3959:2009. Consequently these areas are not considered to be a bushfire risk or require further consideration.

4.3.3 Slope

The effective slope of the land within the 100m assessment area surrounding the site is either downslope 0 – 5 degrees or flat (see **Figure 6**). The effective slope under the vegetation identified within the Kwinana Freeway reserve is flat, and adjacent to southern and south-eastern boundary of the site the effective slope is upslope. The effective slope of the vegetation adjacent to the western and eastern boundary in the central portion of the site is either flat or downslope at 0 – 5 degrees.

4.3.4 Bushfire Hazard Assessment – Pre-development

The vegetation class map (see **Figure 7**) outlines the existing vegetation classes within the site and the surrounding area within 100m as identified in AS 3959:2009. Descriptions of the vegetation types, structure and fuel layers are outlined in **Section 4.3.1**.

The bushfire hazard assessment levels were determined using Appendix 1 of the *Planning for Bushfire Protection Guidelines - Edition 2* (WAPC *et al.*, 2010).

Most areas within the site have a low bushfire hazard rating due to extensive presence of grassland vegetation and mineral earth from construction works (see **Figure 8**). However areas of 'Extreme" and "Moderate" hazard have been identified within the southern portion of Lot 9001 and the northern portion of Lot 379. These are associated with the areas of vegetation identified as scrub and woodland vegetation.

The vegetated areas within the 100m assessment boundary pose the majority of bushfire hazard applicable to the site. To the northwest of the site, the Kwinana Freeway reserve contains several strips of scrub vegetation (shown in **Figure 7**) that are rated as an "Extreme" hazard (see **Figure 8**).

Areas of woodland and scrub vegetation are located to the west, east and northeast of the site also have an "Extreme" hazard rating, and are shown in **Figure 8**.

4.3.5 Bushfire Hazard Assessment – Post-development

The post-development vegetation class map for the site is shown in **Figure 9,** and outlines the vegetation types that will remain within the site and surrounding area (within 100m) after development within the site has been completed.

The bushfire hazard assessment levels were determined using Appendix 1 of the *Planning for Bushfire Protection Guidelines - Edition 2* (WAPC *et al.*, 2010).

The post-development bushfire hazard rating changes substantially compared to the pre-development conditions due to the removal of all vegetation within the site to accommodate urban development. The areas of remnant vegetation retained within the areas of POS and drainage reserve will be managed in accordance with low threat vegetation (as per *AS3959:2009*).

Post-development bushfire hazard rating levels for the surrounding area within 100m of the site ranges from "Low" to "Extreme". The post-development bushfire hazard rating conditions are outlined in **Figure 10**. The "Extreme" hazard rating is associated with the areas of woodland and scrub vegetation located to the west, east and northeast of the site.

It is understood that a large proportion of the identified vegetation surrounding the site will be removed following urban development of the surrounding areas (in accordance with the Wellard East Concept Plan, see **Figure 4**). Vegetation in these areas is therefore considered to be a temporary hazard to the site and once the vegetation is removed to accommodate urban development, the hazard will no longer apply.

An exception to this is the vegetation within the Kwinana Freeway to the northwest of site and the vegetation associated with the resource enhancement wetland to the east of the site. Future residential lots will be separated from the vegetation within the Kwinana Freeway by a three-metre firebreak to be maintained along the eastern boundary of the Kwinana Freeway and an acoustic wall which is likely to provide shielding to the adjacent properties from the bushfire hazard (and associated radiant heat flux), see **Plate 17** and **Plate 18** below. The remnant vegetation associated with the resource enhancement wetland is expected to be retained as part of future urban development, and is likely to include remnant vegetation within the proposed wetland buffer area.



Plate 17: Acoustic wall installed in the northern portion of Lot 9001 Mortimer Road, adjacent to the Kwinana Freeway showing firebreak and interface with vegetation.



Plate 18 Acoustic wall likely to be installed adjacent to north-west boundary of the site, approximately 3m high with 3m-wide firebreak

4.4 Bushfire Threat

Bushfires are common in the City of Kwinana and there is a possibility of a small bushfire impacting the site from the Kwinana Freeway to the northwest of the site and the vegetation associated with the resource enhancement wetland to the east of the site. Vegetation located to the east and west of the site will also be a potential source of bushfire until such time as the vegetation (and therefore hazard) is removed as per separate planning and approvals processes being undertaken for those lots.

The bushfire threat is best determined by undertaking a Bushfire Attack Level (BAL) assessment. An indicative BAL assessment has been undertaken for the site and is outlined in **Section 5.2.4**. The indicative maximum long-term predicted radiant heat flux exposure for a small number of dwellings in this development is BAL-29. The indicative BAL does not include consideration of the shielding of these dwellings from radiant heat flux by the acoustic wall (to be located between the site and vegetation within the Kwinana Freeway) and it is expected that the shielding assessment will reduce the BAL for these dwellings. The vertical shielding assessment along the Kwinana Freeway interface will be undertaken at subdivision when final lot levels and the anticipated height of dwellings is known, allowing the predicted exposure (to bushfire) to be accurately measured.

4.5 Summary of Bushfire Potential Issues

At the completion of this development and the surrounding urban development to the north, east and west of the site, the bushfire hazard will be concentrated to the northwest and east of the site and will

be associated with the strips of vegetation in the Kwinana Freeway (to the northwest) and resource enhancement wetland (to the east).

Vegetation east, west and north of the site is subject to separate planning and approvals processes and will pose only a temporary hazard to the site. The hazard will be removed when vegetation is removed to accommodate urban development.

These areas of classified vegetation up to 100m surrounding the site are identified in **Figure 9.**

5 Fire Mitigation Strategies

This report adopts an acceptable solution and performance-based system of control for each bushfire hazard management issue. This approach is consistent with Appendix 2 of the *Planning for Bushfire Protection Guidelines - Edition 2* (WAPC *et al.* 2010). The management issues are:

- Location of the development.
- Vehicular access.
- Water.
- Siting of the development.
- Design of the development.

Acceptable solutions are proposed for four out of the five management issues and each illustrates a means of satisfactorily meeting the corresponding performance criteria. A performance-based approach is proposed for the remaining management issue.

5.1 Hazard Management

There are pasture grass hazards presently within the site. Slashing of the grass fuels within 100m of the development stages prior to the bushfire season will ensure any excessive grass fuel loads are maintained and managed and result in a low bushfire hazard rating. The areas of scrub, woodland and forest that occur on the site will need to be modified and fuel reduced if they occur within 100m of the development stages to ensure temporary bushfire hazards do not impose an unreasonable level of risk.

The mitigation of hazards within areas proposed as POS (including drainage reserves) will be largely addressed through the detailed landscape design and the selection of suitable plants species, including consideration of species outlined within DFES *Plant Guide within the Building Protection Zone for the Swan Coastal Plain of Western Australia* (DFES, 2011). The City of Kwinana will manage the parkland and reserves that occur within POS areas in the long-term.

This is addressed further in **Section 5.2.4**.

5.2 Bushfire Risk Management

It is not in the scope of this report to detail a comprehensive bushfire risk assessment as per AS/NZS ISO 31000:2009 *Risk management – Principles and guidelines*.

Land use planning bushfire risk mitigation strategies are comprehensively detailed in the following sections, with each section responding to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in the *Planning for Bushfire Protection Guidelines - Edition 2* (WAPC *et al.* 2010).

The compliant checklist is attached as **Appendix A**.

5.2.1 Element: Location of the Development

5.2.1.1 Intent

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

5.2.1.2 Acceptable Solution

The site has areas of "Low" bushfire hazard ratings due to existing grassland vegetation and mineral earth. There are also low bushfire hazard ratings for land immediately to the north, south and small sections to the east and west of the site due to the presence of developed land or grassland vegetation. The majority of "Extreme" bushfire hazard is located within the freeway reserve, immediately northwest of the site and areas of scrub and woodland vegetation to the west and east of the site. There are also areas of "Extreme" hazard (associated with areas of woodland) within the site which will be appropriately mitigated during the development stage.

Following development of the site and the land to the north, east and west, bushfire threat will remain to the northwest of the site within the Kwinana freeway reserve and to the east of the site within vegetation associated with the resource enhancement wetland. Without considering the shielding potential of the acoustic wall, the indicative maximum Bushfire Attack Level (BAL) is predicted to be BAL -29 for dwelling directly adjacent to the Kwinana Freeway (along the northwest boundary of the site). This BAL should decrease when the shielding assessment is finalised as part of detailed subdivision design.

The exposed dwellings located in the Bushfire Prone Area (discussed further in **Section 5.2.4** and shown in **Figure 11**) will have the threat mitigated by ensuring those dwellings are compliant with AS 3959:2009.

The site will be provided with an adequate water supply and has adequate vehicular access for future residents and fire fighters.

5.2.2 Element: Vehicular Access

5.2.2.1 Intent

To ensure vehicular access serving a subdivision development is safe if a bushfire occurs.

5.2.2.2 Background

The road network is outlined in the LSP (see **Figure 3**). The road network integrates with the existing roads to the north and south of the site, with internal roads proposed to integrate with roads to the east and west, as shown in the Wellard East Concept Plan (see **Figure 4**).

Loop roads are common, providing two access routes, and the interconnected roads create a permeable grid-like pattern. The proposed road network also reflects the anticipated traffic volumes.

5.2.2.3 Acceptable Solution A2.1: Two Access Routes

The interconnected loop road system provides all residents and fire fighters with two road options at all times. Two access roads will be available for residents and emergency services before the creation of any titles.

The LSP for the site shows one intersection with Millar Road and one with Mortimer Road to the north, providing future residents with two access routes to and from the site. The LSP prepared for the landholdings to the west of the site shows a second connection to Millar Road, which will connect with internal roads within the site. Further public roads will connect with future development to the north, east and west when development in those areas occurs.

5.2.2.4 Acceptable Solution A2.2: Public Roads

Surrounding public roads and all new public roads and laneways within the site will comply with the minimum standards. The public road standards which will be achieved include:

- Minimum trafficable surface: 6 metres.
- Horizontal clearance: 6 metres.
- Vertical clearance: 4 metres.
- Maximum grades: 1 in 8.
- Maximum grades over <50 metres: 1 in 5.
- Maximum average grade: 1 in 7.
- Minimum weight capacity: 15 tonnes.
- Maximum crossfall: 1 in 33.
- Minimum inner radius of curves: 12 metres.

A road crossing will be built across the drainage reserve, connecting the northern portion of the LSP with the southern portion of the LSP. This road will connect to Mortimer Road in the north and Millar Road in the south.

5.2.2.5 Acceptable Solution A2.3: Cul-de-sacs (including dead end roads)

Where a temporary or permanent cul-de-sac (or dead-end road) is proposed within the LSP or occurs as part of the development process, the cul-de-sac head will be a minimum of 21 metres in diameter to provide fire appliances the ability to turn around. The following standards will be achieved:

- Maximum length: 200 metres, but can be extended to 600 metres if less than eight lots are serviced and if alternative emergency access is provided.
- Minimum trafficable surface: 6 m.
- Horizontal clearance: 6 m.
- Maximum grades: 1 in 8.
- Maximum grades over 50 m: 1 in 5.
- Maximum average grade: 1 in 7.
- Minimum weight capacity: 15 tonnes.
- Maximum crossfall: 1 in 33.
- Minimum inside radius of curves: 12 m.
- Turn around area requirements: (21m cul-de-sac head).

5.2.3 Element: Water

5.2.3.1 Intent

To ensure water is available to the development to enable life and property to be defended from bushfire.

5.2.3.2 Acceptable Solution A3.1: Reticulated Water

The development is located within an Emergency Services Levy (ESL) Category 3 area. Fire services require ready access to an adequate water supply during fire emergencies.

The site will be provided with a reticulated water supply and with fire hydrants that will meet the specifications of Water Corporation Design Standard DS 63 and the DFES. Fire hydrants on land zoned as residential are required to be sited at or within 200 m of residential dwellings (Class 1a).

Public buildings such as schools will require the relevant management authority at the time of development to outline the compliance with current standards. The process to determine hydrant coverage and compliance for commercial buildings with Australian and DFES Standards is outlined in *DFES guideline GL-07 Submission of documents* which can be downloaded at:

http://www.dfes.wa.gov.au/regulationandcompliance/buildingplanassessment/Guidelines/GL-07-SubmissionOfDocumentsToDFESForAssessment.pdf

School buildings are Class 9 buildings in the Building Code of Australia (BCA) and require compliance with the BCA, in particular E1.5 including the Specifications and AS 2118.4 together with 2419.1 – also noting that hydraulic water supplying both systems (hydrant and sprinklers) will need to achieve flow rates simultaneously.

The Water Corporation is responsible for all hydrant repairs.

5.2.4 Element: Siting of the Development

5.2.4.1 Intent

To ensure the siting of the development minimises the level of bushfire impact.

5.2.4.2 Background

The extent of post-development classified vegetation is shown in **Figure 9** and is restricted to the following main areas:

- Strips of closed scrub situated in the freeway road reserve, adjacent to the northwest boundary of the site. This vegetation is likely to pose permanent hazard considerations.
- Open forest, woodland and open and closed scrub to the west, east and northeast of the site. This vegetation is likely to pose temporary hazard considerations, subject to proposed urban development.
- Woodland and open scrub to the east of the site. A portion of this vegetation is likely to pose permanent hazard considerations and is associated with a resource enhancement wetland.
- Woodland over a managed understorey to the south of the site, within the Millar Road and the adjacent railway reserve. This vegetation is likely to pose permanent hazard considerations.

All other POS and drainage areas will be landscaped and managed as maintained public reserves and parklands, and are therefore considered as low threat vegetation areas and classified as "Low" bushfire hazard.

Strips or small clumps of vegetation identified as an "Extreme" hazard may or may not be a threat to the development as the bushfire hazard posed by vegetation needs to be considered in the context of fuel loads, and the siting and orientation of the development compared to the vegetation. For this reason AS 3959:2009 considers some strips and isolated clumps of vegetation identified as "Extreme" hazard as being in fact "low threat". Vegetation that does not trigger a BAL assessment according to AS 3959:2009 (i.e. it is classed as "low threat") includes one or more of the following:

- Vegetation of any type more than 100 m from the site.
- Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.
- Multiple areas of vegetation less than 1 ha in area and not within 20 m of the site or each other.

- Strips of vegetation less than 20 m wide (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.
- Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.
- Low threat vegetation, including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parkland, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and wind breaks.

5.2.4.3 Building Siting and Predicted Bushfire Attack Levels

AS 3959:2009 has six categories of Bushfire Attack Level (BAL) which are BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

The objective of AS 3959:2009 is *"to prescribe particular construction details for buildings to reduce the risk of ignition from a bushfire while the front passes".*

The BAL categories are based on heat flux exposure thresholds and provide detail on the required dwelling setback and building construction standard.

5.2.4.4 Methodology and Assumptions

An indicative BAL assessment has been undertaken to indicate the BAL of lots that are exposed to bushfire attack once surrounding land has been developed. This indicative BAL assessment was undertaken by assessing the post-development classified vegetation and effective slope.

The criteria to determine the indicative BAL is outlined as follows:

- Designated FDI: 80
- Flame Temperature: 1090
- Slope: Upslope or flat, downslope (See Table 1)
- Vegetation Class: Forest, Woodland, Scrub
- Setback distances: Shown in **Table 1** below

5.2.4.5 Indicative BAL Outcome

The following indicative BAL assessment for exposed areas of the development (see **Table 1**) was determined using the methodology in Appendix A of AS 3959:2009. This methodology is also outlined in the *Planning for Bush Fire Protection - Edition 2* (WAPC *et al.* 2010).

Taking into consideration the Building Protection Zone (BPZ), which is discussed further below, there are no areas of development exposed to a BAL rating above BAL-29. The indicative BAL assessment does not include consideration of the shielding of dwellings from radiant heat flux by the acoustic wall (to be located between the site and vegetation within the Kwinana Freeway). The detailed engineering and planning design, to be undertaken as part of the subdivision process, is required before this assessment can be completed. A preliminary shielding assessment suggests that the BAL for the dwellings adjacent to the Kwinana Freeway will be reduced. The majority of exposed lots are rated as BAL-12.5.

Table 1: Indicative Bushfire Attack Level assessment for exposed interface areas

AREA OF CLASSIFIED VEGETATION	VEGETATION CLASS	SETBACK DISTANCE	EFFECTIVE SLOPE (°)	BAL RATING
Northwest (associated with the Kwinana Freeway reserve) and east of site	Scrub	13-<19 metres	Upslope	BAL-29
		19-<27 metres	Upslope	BAL -19
		27-<100 metres	Upslope	BAL-12.5
Northeast and west of the site	Scrub	13-<19 metres	Flat	BAL-29
		19-<27 metres	Flat	BAL -19
		27-<100 metres	Flat	BAL-12.5
East (associated with the resource enhancement wetland) and west of site	Scrub	15-<22 metres	Downslope 0-5°	BAL-29
		22-<31 metres	Downslope 0-5°	BAL -19
		31-<100 metres	Downslope 0-5°	BAL-12.5
East (associated with the resource enhancement wetland) of the site	Woodland	14-<20 metres	Upslope	BAL-29
		20-<29 metres	Upslope	BAL-19
		29-<100 metres	Upslope	BAL-12.5
East (associated with the resource enhancement wetland) and west of site	Woodland	14-<20 metres	Flat	BAL-29
		20-<29 metres	Flat	BAL-19
		29-<100 metres	Flat	BAL-12.5
East (associated with the resource enhancement wetland), south-east and west of the site	Woodland	17-<25 metres	Downslope 0-5°	BAL-29
		25-<35 metres	Downslope 0-5°	BAL-19
		35-<100 metres	Downslope 0-5°	BAL-12.5
West of site	Forest	27-<37 metres	Downslope 0-5°	BAL-29
		37-<50metres	Downslope 0-5°	BAL-19
		50-<100 metres	Downslope 0-5°	BAL-12.5

Note: See Appendix 10 for AS 3959:2009 Construction Zone details.

An assessment of BAL-29 means the risk is considered to be moderate. It is expected that the construction elements will be exposed to a heat flux not greater than 29 kW/m^2. There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level of radiant heat (AS 3959:2009). In this case, the recommended construction sections in AS 3959:2009 are 3 and 7.

An assessment of BAL-19 means the risk is considered to be moderate. It is expected that the construction elements will be exposed to a radiant heat flux not greater than 19 kW/m^2. There is a risk of ember attack and burning debris ignited by wind borne embers and a likelihood of exposure to radiant heat (AS 3959:2009). The recommended construction sections in AS 3959:2009 are 3 and 6.

An assessment of BAL-12.5 means the risk is considered to be low. It is expected that the construction elements will be exposed to a radiant heat flux not greater than 12.5 kW/m2. There is a

risk of ember attack and burning debris ignited by wind borne embers and a likelihood of exposure to radiant heat (AS 3959:2009). The recommended construction sections in AS 3959:2009 are 3 and 5.

This indicative BAL assessment demonstrates that all proposed dwellings and structures will occur within the acceptable level of risk (i.e. BAL-29 and lower). Any new dwellings constructed within 100 m of identified classified vegetation will require consideration of the need for increased construction requirements to address AS 3959:2009.

BAL ratings should not be determined for future lots at the LSP stage, as the ultimate lot locations/boundaries will be determined through the subdivision process, and temporary hazards (or even hazards that were expected to be permanent) may not remain at that time, particularly within neighbouring sites currently undergoing separate planning and approvals processes. If subdivision proceeds within those areas of the site designated as Bushfire Prone Area due to temporary bushfire hazards prior to the hazards being removed, bushfire hazard management measures (i.e. increased construction standards to meet increased BAL ratings) will be required. At subdivision, accurate detailed information will be available regarding final lot levels and likely height of dwellings in relation to the acoustic wall and scrub vegetation within the Kwinana Freeway reserve. This will enable a detailed examination of the vertical shielding provided by the acoustic wall to be undertaken and will influence the predicted exposure of adjacent dwellings. Therefore a detailed and specific BAL assessment will need to be completed at the subdivision approval stage for all lots determined to be within a "Bushfire Prone Area", as shown within **Figure 11**.

As part of the subdivision process any lots deemed to require fire management responses through the BAL assessment will be subject to a notification on the certificate(s) of title pursuant to section 70A of the Transfer of Land Act 1893, indicating that the lot is subject to the requirements of a fire management plan (i.e. increased construction standards to meet increased BAL ratings).

5.2.4.6 Landscaping Considerations

Landscaping can both assist in the survival of a dwelling and be a determining factor in its destruction. Landscaping can protect buildings by forming a barrier or deflector for wind-borne debris and radiant heat. It can also bring the fire directly to the dwelling. Therefore, a degree of care needs to be exercised when selecting and locating landscaping.

All plants will burn under the right conditions and plants do not attain a "fire resistance level" that meets requirements of the Building Code of Australia (BCA). Placing plants too close to a building, under timber decks or next to windows will provide a direct threat to the building. Having a clearance around the building will achieve the desired effect of creating a break between the vegetation and the building. A pathway around buildings may be one way to achieve this requirement. Landscaping can then be established at a suitable distance from the building.

5.2.4.7 Acceptable Solution A4.1: Hazard Separation

A Hazard Separation Zone (HSZ) is an additional fuel managed zone to create further separation between dwellings and bushfire hazard. It can extend out to 100 m from buildings. In the LSP proposal, a HSZ does not fit within the design of the proposed development. The requirement for a HSZ is offset by an increase in construction standards and compliance with AS3959:2009 and BAL-29 is not exceeded.

The indicative BAL assessment demonstrated that the proposed BPZ combined with increased dwelling construction standards will achieve acceptable levels of risk for the development.

5.2.4.8 Acceptable Solution A4.3: Building Protection Zone

One of the most important fire protection measures influencing the safety of people and property is to create a Building Protection Zone (BPZ) around buildings. The BPZ is a low fuel area immediately surrounding a building. Non-flammable features such as irrigated landscapes, gardens, driveways and roads can form parts of a BPZ.

Recent research into land management and house losses during the Black Saturday Victorian bushfires concluded that the action of private landholders who managed fuel loads close to their houses was the single most important factor in determining house survival when compared with other land management practices, such as broad scale fuel reduction burning remote from residential areas (Gibbons *et al.*, 2012).

This FMP addresses two important bushfire setback strategies issues. The first strategy involves an adequate perimeter BPZ where the site is immediately adjacent to external bushfire hazard. Creating a perimeter BPZ will ensure vegetation and fuels within close proximity to buildings are managed to reduce predicted levels of radiant heat flux and improve the survival of buildings.

The second strategy involves the management of risk at each stage of development. Each development stage is provided with acceptable setbacks from temporary bushfire hazards to reduce bushfire attack mechanisms impacting on any completed dwellings. Creating a temporary BPZ during each stage of the development will ensure dwellings on the perimeter of each stage are not exposed to unnecessary risk from a temporary hazard.

The creation of the BPZ areas will ensure the predicted radiant heat flux exposure levels remains at or below BAL-29 for all dwellings.

Managing vegetation in the BPZ has two main purposes:

- To reduce direct flame contact and radiant heat from igniting the building during the passage of a fire front.
- To reduce ember attack and provide a safer space for people to defend (if required) before, during and after a fire front passes.

The BPZ within the site varies depending upon the indicative BAL and the classified vegetation adjacent to the site. The permanent BPZ proposed adjacent to the Kwinana Freeway has a minimum internal BPZ of 13m. A temporary 20m minimum internal BPZ (see **Figure 12**) has been shown for those proposed lots within the site that are adjacent to classified vegetation but are within areas proposed for future urban development. No BPZ has been provided for proposed lots adjacent to areas of 'low threat' vegetation as defined under AS 3959:2009.

The BPZ must be established and maintained to the following standards:

- Width: Variable depending on BAL and as identified in **Figure 12**.
- Fuel load: Reduced to and maintained at 2 tonnes per hectare.
- All tree crowns (or clumps of crowns) are a minimum of 10 metres apart.
- All trees to have lower branches pruned to a height of 2 metres.
- All tall shrubs or trees are not to be located within 2 metres of a building (including windows).
- No tree crowns or foliage (including existing trees and shrubs and new plantings) is to be within 2 metres of any building.
- All fences and sheds are constructed of non-combustible materials (i.e. Colourbond, brick or limestone).

- All shrubs to contain no dead material within the plant.
- No tall shrubs are to be in clumps within 3 metres of any building.
- No trees are to contain dead material in the crown or on the bole.

It is the responsibility of the developer to ensure the BPZ is created by appropriate design and that construction of buildings is restricted within the identified zone.

5.2.5 Element: Design of the Development

5.2.5.1 Performance Criteria

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

5.2.5.2 Acceptable Solution A5.2: Performance Criterion P5 Compliance

The development complies with AS 3959:2009 and BAL-29 is not exceeded for any dwelling.

5.3 Future Development

The FMP is expected to inform the BAL assessment that will be prepared and implemented as part of the future subdivision approval stage. The post-development Bushfire Prone Area map (provided in **Figure 11**) will be used to guide the requirement for further BAL assessment.

5.4 Access and Fire Breaks

Compliance with the City of Kwinana Firebreak Notice is required within the site and public road access must provide two access options at all stages of development. This may include a temporary trafficable road which can be used in the case of an emergency until such time that the permanent public road is developed.

5.5 Public Education and Community Awareness

Community bushfire safety is a shared responsibility between individuals, the community, government and fire agencies. DFES has an extensive Community Bushfire Education Program including a range of publications, a website and Bushfire Ready Groups. The booklet *Prepare Act Survive* (DFES, 2012) provides excellent advice on preparing for and surviving the bushfire season. Other downloadable brochures are available from http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/pages/publications.aspx.

The City of Kwinana also provides bushfire safety advice to residents and is available from their website http://www.kwinana.wa.gov.au/bushfires. Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in high risk areas.

5.6 Fire Safer Areas

There are no designated Community Fire Refuges in the City of Kwinana, However, at the time of an emergency the relevant authorities can select an evacuation centre and DFES, the City of Kwinana and Police will provide this information to residents.

A predetermined centre cannot be nominated because there are no purpose-built structures (such as bunkers) designed to withstand the impacts of a bushfire. This means that the location of an evacuation centre is not determined until the position of the fire and the characteristics of a specific

event are considered by authorities. Primarily this is because there would be nothing more dangerous than sending residents to a centre which is in the direct path of a fire.

The safest place to be during a bushfire is away from it. Where to go is an important element when people are relocating during a time of emergency (NSW Rural Fire Service 2004). The preferred option for residents is to designate a destination that is not in a bushfire-prone area and will be safe to travel to before a bushfire attack.

Those who find themselves threatened by a bushfire need options and this may be because their plan to leave is no longer possible, they cannot reach a place away from the fire front, or their plan to defend their property fails (VBRC 2009). Residents may also be caught away from their home when a bushfire threatens.

The concept of a "Neighbourhood Safer Place" and "Neighbourhood Safer Precincts" has arisen from recommendations by the Victorian Bushfire Royal Commission into the Black Saturday bushfires.

There are many areas within the City of Kwinana that are not bushfire-prone, including landscaped open spaces and urban areas, but they have not been declared. Obviously a non-bushfire-prone area can provide a safe location for people during a bushfire, but there are no official criteria in Western Australia to determine these areas. As there are no specific criteria to guide this process, general advice from DFES is that when household bushfire survival plans have failed, residents should go to a safer place such as a local open space or building to seek shelter from a bushfire (DFES 2012).

5.7 Assessment of Fire Management Plan

Following development of the site and the land to the north, east and west, the bushfire hazard that could threaten future development will remain to the northwest of the site within the Kwinana Freeway reserve and to the east of the site within vegetation associated with the resource enhancement wetland. Without considering the shielding potential of the acoustic wall, the indicative maximum BAL is predicted to be BAL -29 for dwellings directly adjacent to the Kwinana Freeway (along the northwest boundary of the site). The exposed dwellings which are located in a Bushfire Prone Area (where still applicable) will have the threat mitigated by ensuring those dwellings are compliant with AS 3959:2009.

Grassland fuels in the public road reserves on the southern interface of the site will be managed through the City of Kwinana's roadside slashing program. Fuels within POS and drainage reserves will be managed as "low threat" vegetation.

Fire response operations will utilise the reticulated water supply and the extensive loop road network to defend property and life.

5.8 Implementing the Fire Management Plan

5.8.1 Developer's Responsibilities

To maintain a reduced level of risk from bushfire, the developer's responsibilities are to:

- Install the public roads to standards outlined in **Section 5.2.2**.
- On all vacant land under the developer's control, comply with the City of Kwinana Firebreak Notices as published.
- Install reticulated water supply and hydrants to Water Corporation, DFES and City of Kwinana standards.

- Design and landscape all managed POS areas in accordance with 'low threat' vegetation pursuant to AS 3959:2009 and where appropriate utilise DFES-approved species to create a low threat environment.
- Prepare a BAL assessment as part of subdivision which will assess proposed BAL for lots by a qualified consultant. The assessment recommendations should be submitted to the City Kwinana as part of seeking title clearances.
- For each property within this development that will be exposed to AS 3959:2009 construction standards, lodge a Section 70A Notification on the Certificate of Title in order to alert purchasers and successors in title of the responsibilities of this Fire Management Plan and bushfire building construction requirements.
- Establish and maintain the Building Protection Zones within the site to the standards specified in this document.
- Ensure 100 m of vegetation is managed from the perimeter of each construction stage within the overall development site to ensure temporary hazard does not threaten any subdivision stage.
- At subdivision approval stage, the developer is to provide detailed hydrant plans to the City of Kwinana and DFES local fire station for monitoring.
- Supply a copy of this FMP and the *Homeowners Bush Fire Survival Manual, Prepare, Act, Survive* (or similar suitable documentation) and the City of Kwinana's Fire Control Notice to each lot owner subject to AS 3959:2009 construction standards.

5.8.2 Property Owner/Occupier's Responsibilities

The owners/occupiers of the site, as created by the LSP and following subdivision approval process, are to maintain a reduced level of risk from bushfire, and will be responsible for undertaking, complying and implementing measures to protect their own assets (and people under their care) from the threat and risk of bushfire. Site owners and occupiers will be responsible for:

- Ensuring that all lots comply with City of Kwinana's Fire Control Notice as published.
- Maintaining each property in good order to minimise bushfire fuels.
- Ensuring that where hydrants are located, they are not obstructed and remain visible at all times.
- Ensuring construction of dwellings complies with AS 3959:2009 if required. As part of the building license application, the property owner may seek to have the proposed buildings reassessed for BAL by a qualified consultant (at the time of construction) to confirm the requirement for specific construction standards, with results to be submitted to the City of Kwinana.
- If dwellings are subject to additional construction in the future, such as renovations, AS 3959:2009 compliance is required.

5.8.3 City of Kwinana's Responsibilities

The responsibility for compliance with the law rests with individual property owners and occupiers, and the following conditions are not intended to unnecessarily transfer some of the responsibilities to the City of Kwinana.

The City of Kwinana shall be responsible for:

- Providing fire prevention and preparedness advice to landowners upon request.
- Ensuring bushfire hazard remains low in the internal POS areas and roadside grassland vegetation is slashed in the annual roadside slashing program.
- Monitoring fuel loads in road reserves and liaising with relevant stakeholders to maintain fuel loads at safe levels.

- Maintaining public roads to appropriate standards and ensuring compliance with the City of Kwinana Firebreak Notices.
- Reviewing the FMP and subsequent fire management plan as necessary.

5.8.4 Water Corporation's Responsibilities

The Water Corporation is responsible for the repair of water hydrants, as needed.

6 Conclusions

This FMP demonstrates that the proposed LSP provides acceptable solutions and responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in *Planning for Bushfire Protection Guidelines - Edition 2* (WAPC *et al.* 2010). However, community bushfire safety is a shared responsibility between governments, fire agencies, communities and individuals.

Dwellings located in the bushfire prone area (i.e. within 100 m of classified vegetation) will have the risk mitigated via compliance with AS 3959:2009 standards. The indicative BAL assessment shows that BAL-29 is not exceeded and a BPZ is incorporated where necessary. Loop roads and reticulated water supply and hydrants are provided.

Overall, the proposed development will achieve an acceptable level of risk and BAL assessment will be prepared as part of subdivision detailing bushfire mitigation measures.

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8 Glossary

AS	Australian Standard
AS 3959	Australian Standard 3959-2009 Construction of buildings in bushfire prone areas
AHD	Australian Height Datum
BAL	Bushfire Attack Level
BCA	Building Code of Australia
BOM	Bureau of Meteorology
BPZ	Building Protection Zone
DFES	Department of Fire and Emergency Services (was FESA)
ESL	Emergency Services Levy
FESA	Fire and Emergency Services (now DFES)
FMP	Fire Management Plan
HSZ	Hazard Separation Zone
LPS17	Local Planning Scheme No. 17
LSP	Local Structure Plan
POS	Public Open Space
TPS	Town Planning Scheme
VBRC	Victorian Bushfires Royal Commission
WAPC	Western Australian Planning Commission

FIGURES

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Figure 1: Site Location

Figure 2: Site Plan

Figure 3: Proposed LSP

Figure 4: Wellard East Concept Plan

Figure 5: Local Context and Surrounding Land Use

Figure 6: Site Topography and Effective Slope

Figure 7: Existing Site Conditions – AS3959 Vegetation Classification

Figure 8: Existing Site Conditions – Bushfire Hazard Assessment

Figure 9: Post Development Conditions –AS3959 Vegetation Classification

Figure 10: Post Development Conditions – Bushfire Hazard Assessment

Figure 11: Post Development Conditions – Bushfire Prone Areas

Figure 12: Building Protection Zone Requirements

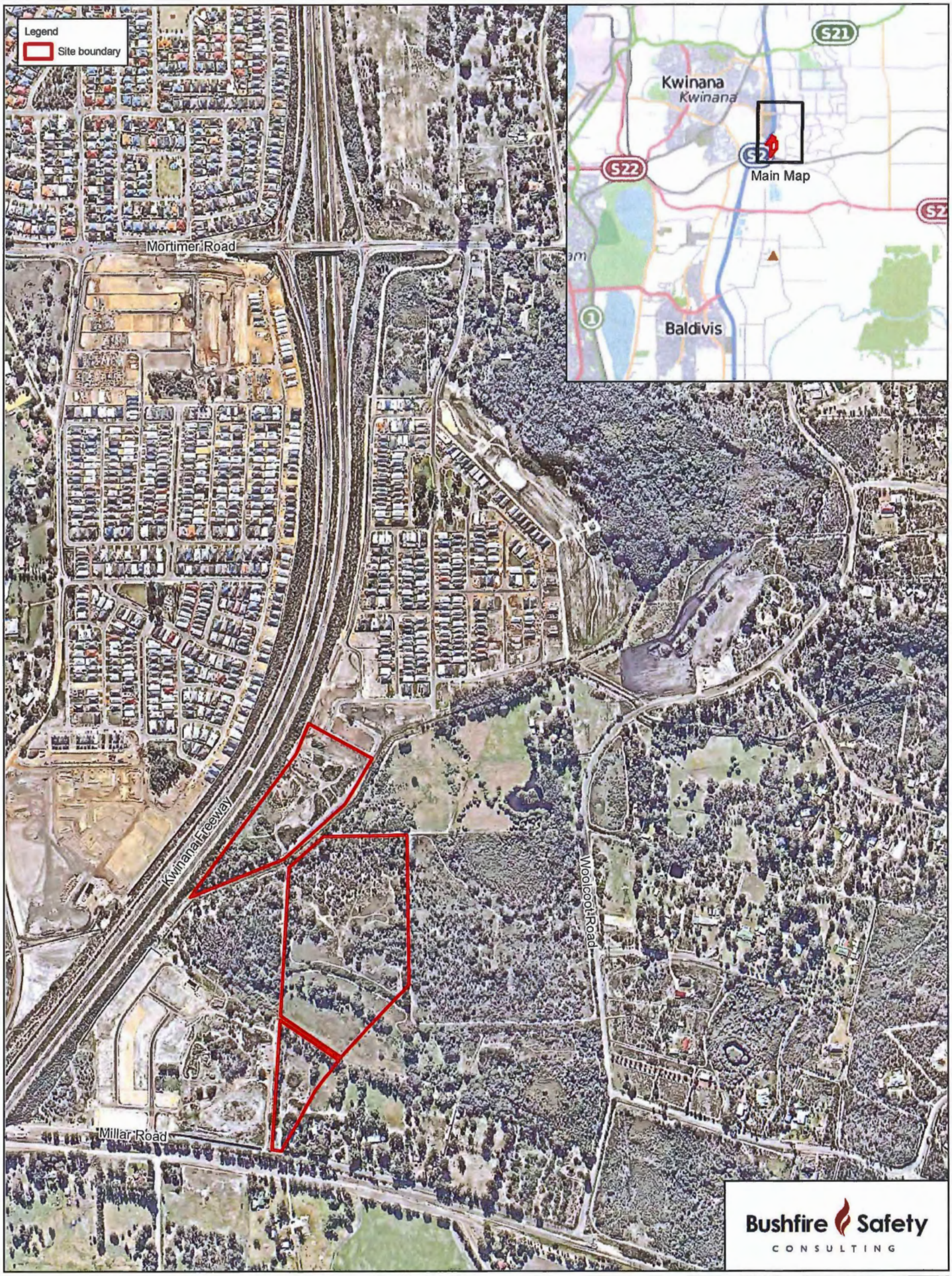

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Figure 1:	**Site Location**	**Plan Number: EP11-011(09)--F78a**	
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard	Drawn: ADB	Date: 29/07/15
		Approved: KK	Date: 30/07/15
Client:	Armana Holdings Pty Ltd	Checked: KK	Scale: 1:10,000@A4

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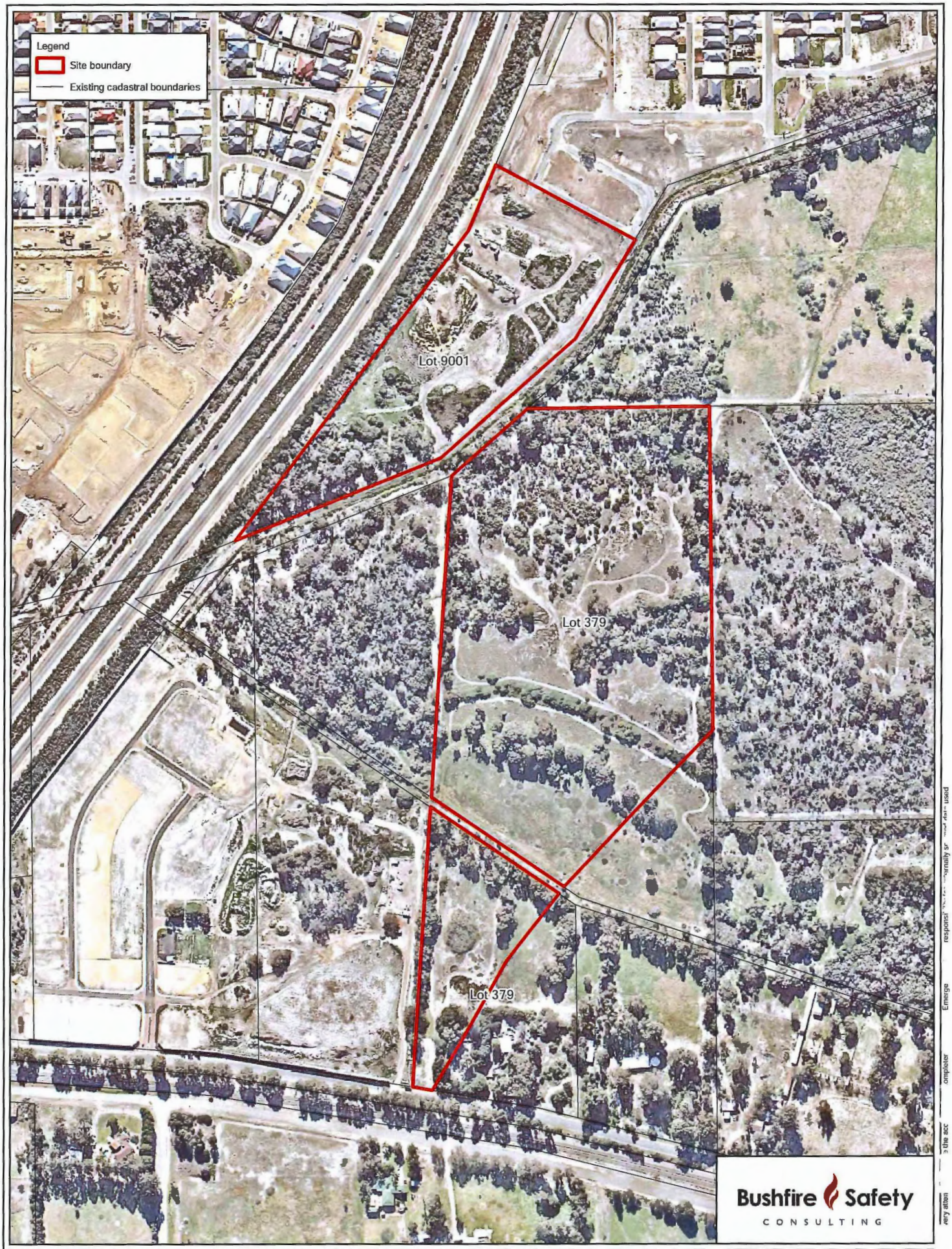

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Figure 2:	Site Plan	Plan Number: EP11-011(09)--F79a	
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard	Drawn: ADB	Date: 29/07/15
		Approved: KK	Date: 30/07/15
Client:	Armana Holdings Pty Ltd	Checked: KK	Scale: 1:4,500@A4

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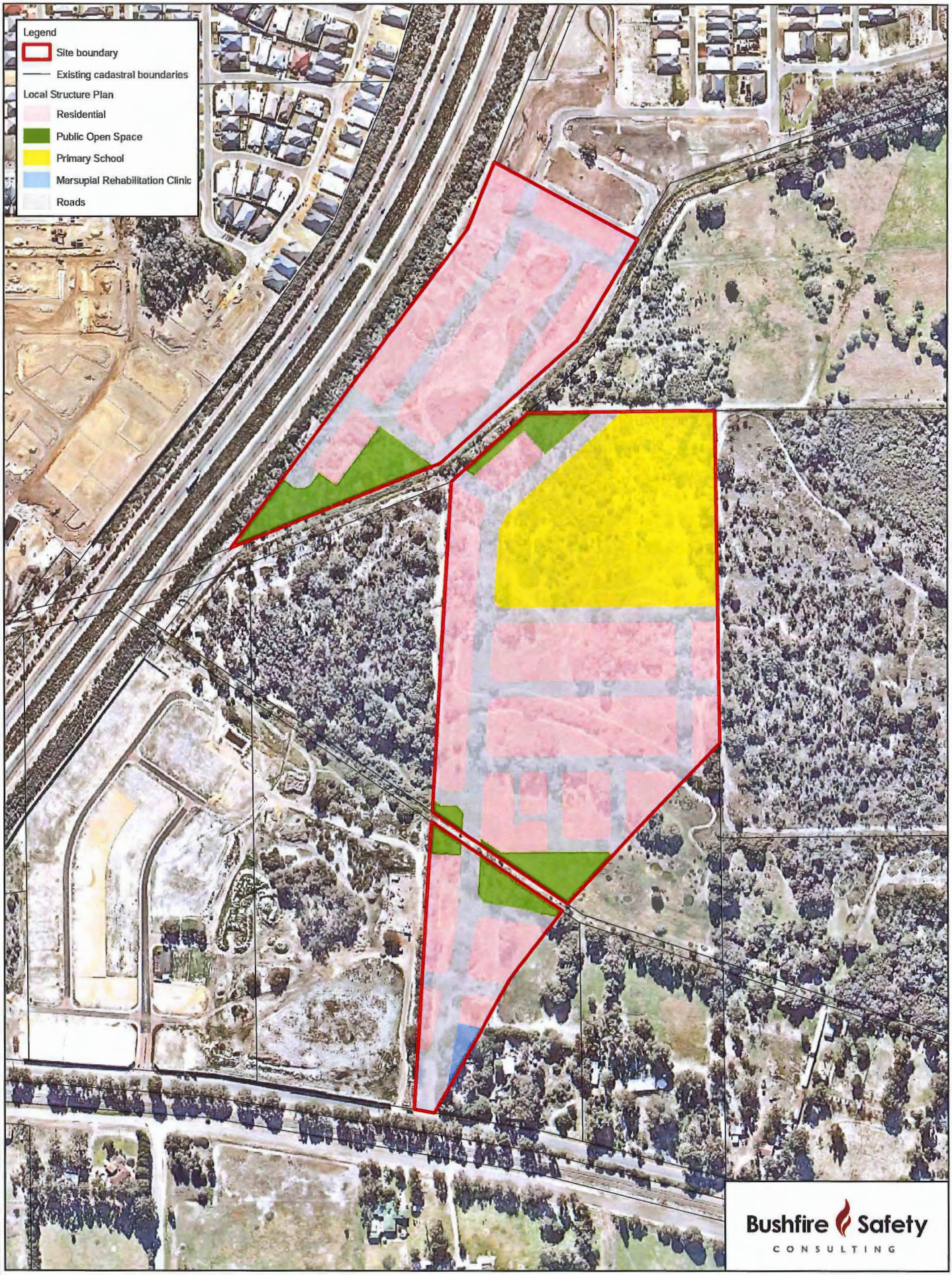

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Figure 3:	Proposed Local Structure Plan
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F80a			
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Figure 4:	Wellard East Concept Plan	Plan Number: EP11-011(09)--F92a	
		Drawn: ADB	Date: 29/07/15
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard	Approved: KK	Date: 30/07/15
		Checked: KK	Scale: NTS@A4
Client:	Armana Holdings Pty Ltd		

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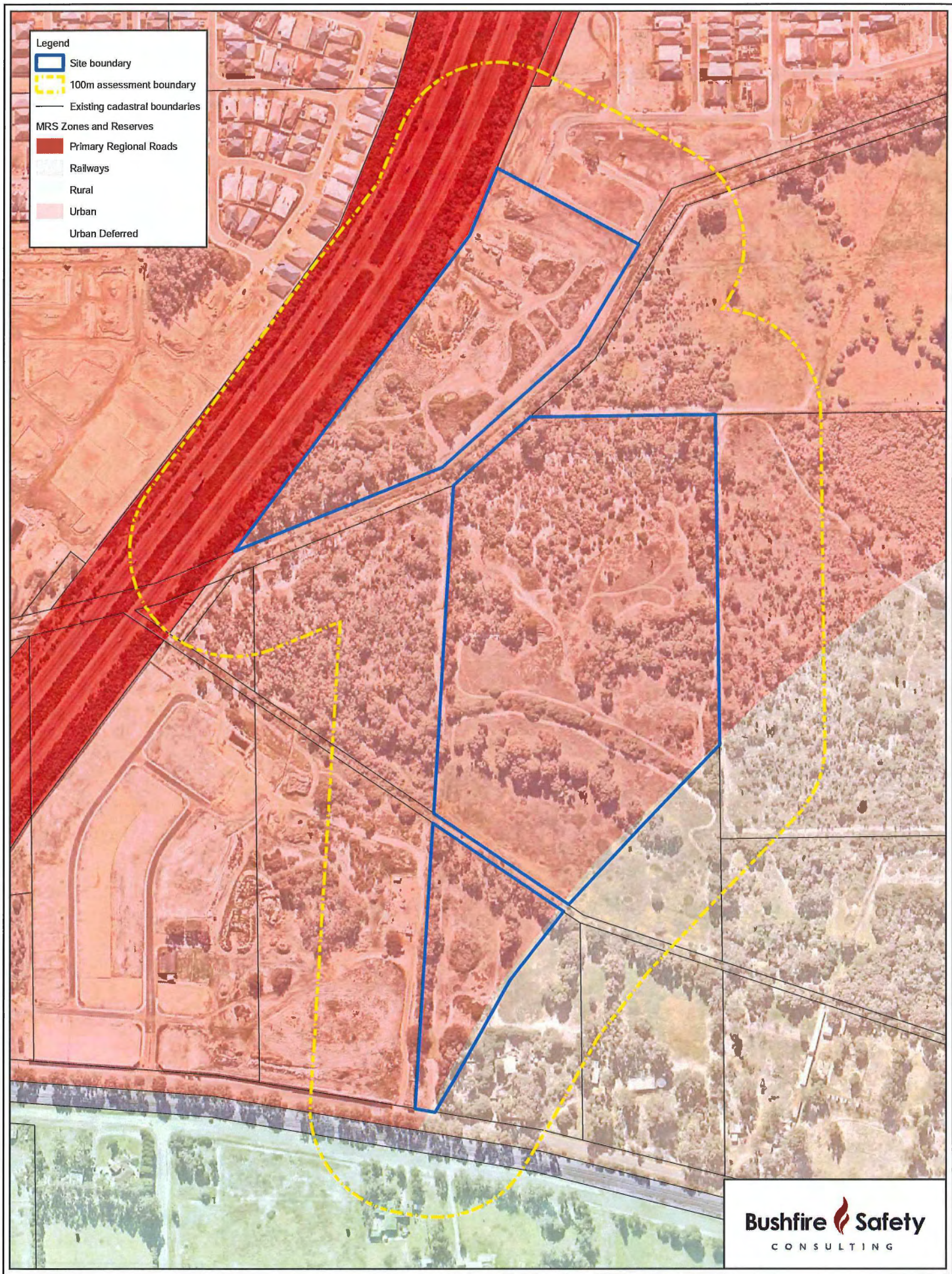

Figure 5:	Local Context and Surrounding Land Uses
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F82a			
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Sources: The following datasets were used in the production of this map: MRS Zones and Reserves - DoP (2015)

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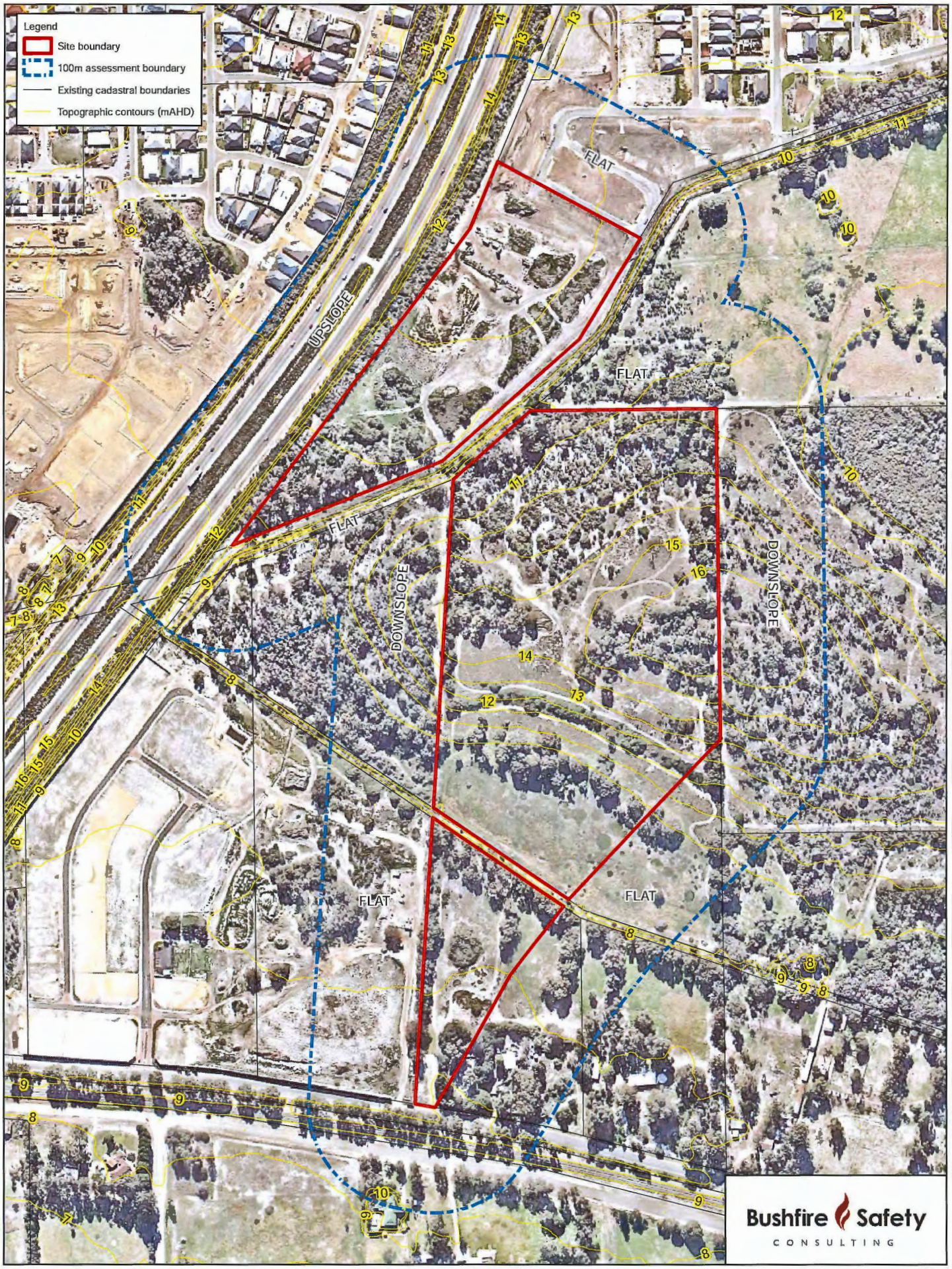

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Figure 6:	Site Topography and Effective Slope
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F83a			
Drawn:	ADB	Date:	29/07/15
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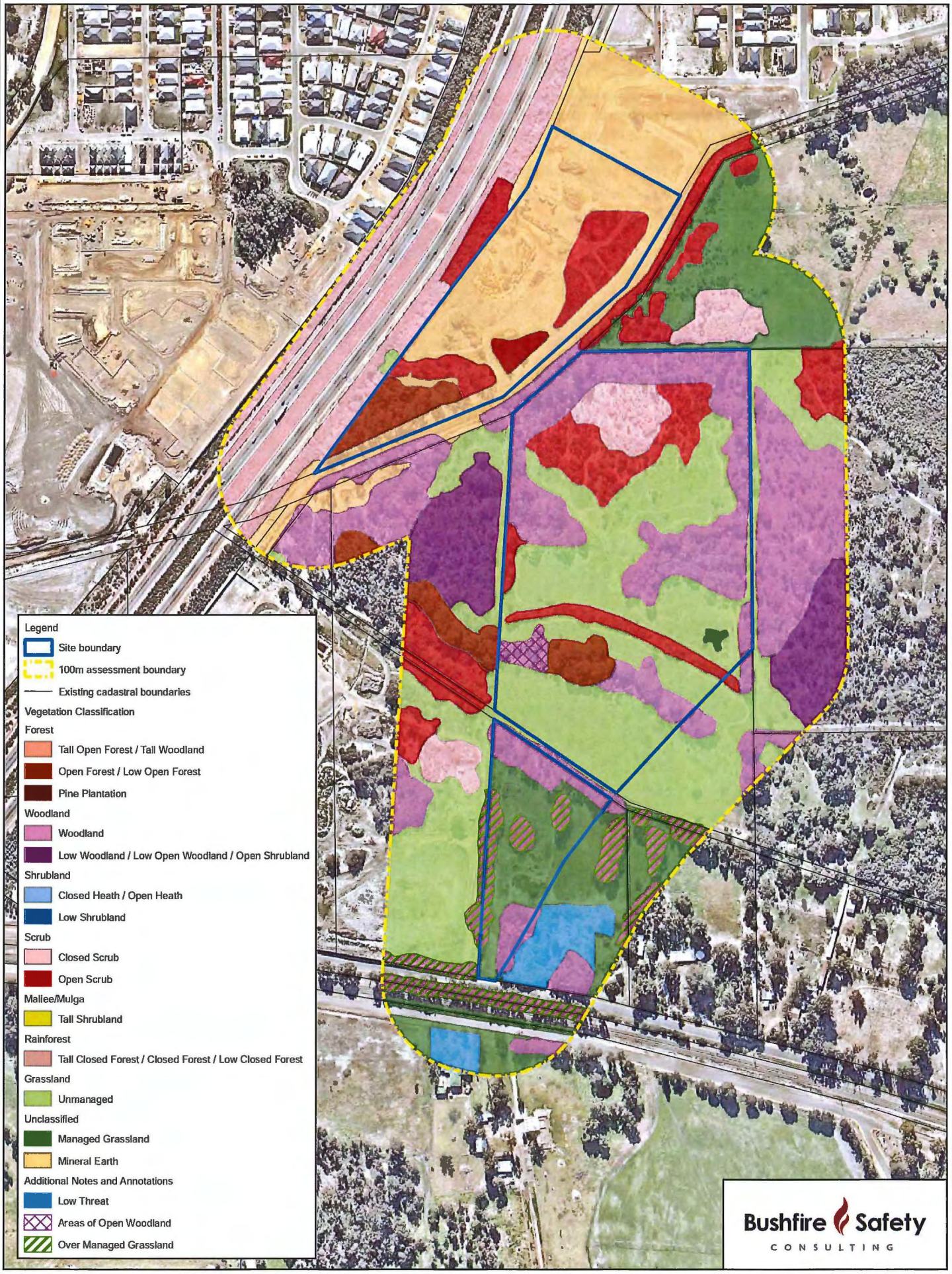

Figure 7:	Existing Site Conditions - AS3959 Vegetation Classification
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F85a			
Drawn:	ADB	Date:	29/07/15
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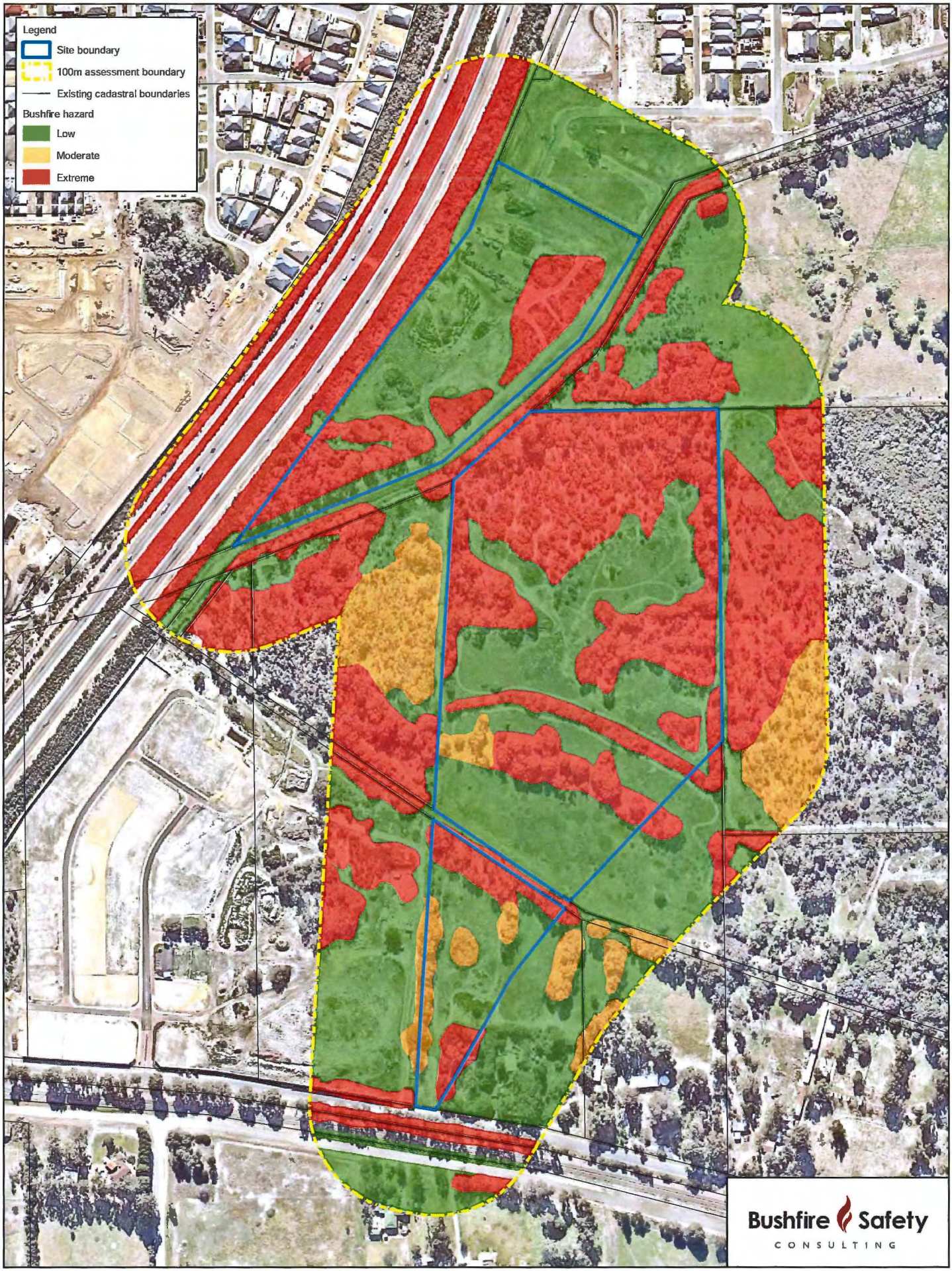

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Figure 8:	Existing Site Conditions - Bushfire Hazard Assessment	Plan Number: EP11-011(09)--F86a	
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard	Drawn: ADB	Date: 29/07/15
		Approved: KK	Date: 30/07/15
Client:	Armana Holdings Pty Ltd	Checked: KK	Scale: 1:4,500@A4

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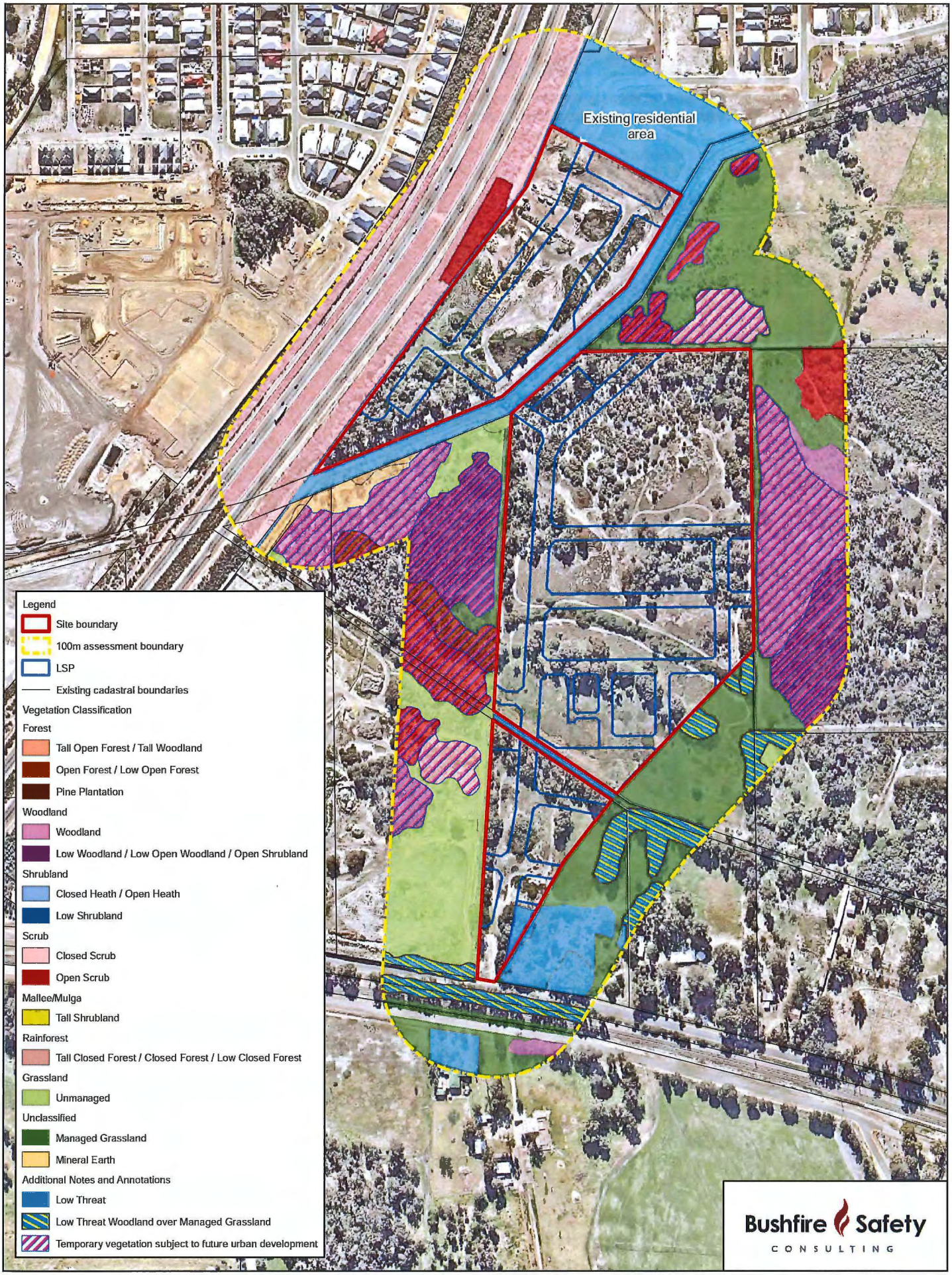

Figure 9:	Post Development Site Conditions - AS3959 Vegetation Classification
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F87a			
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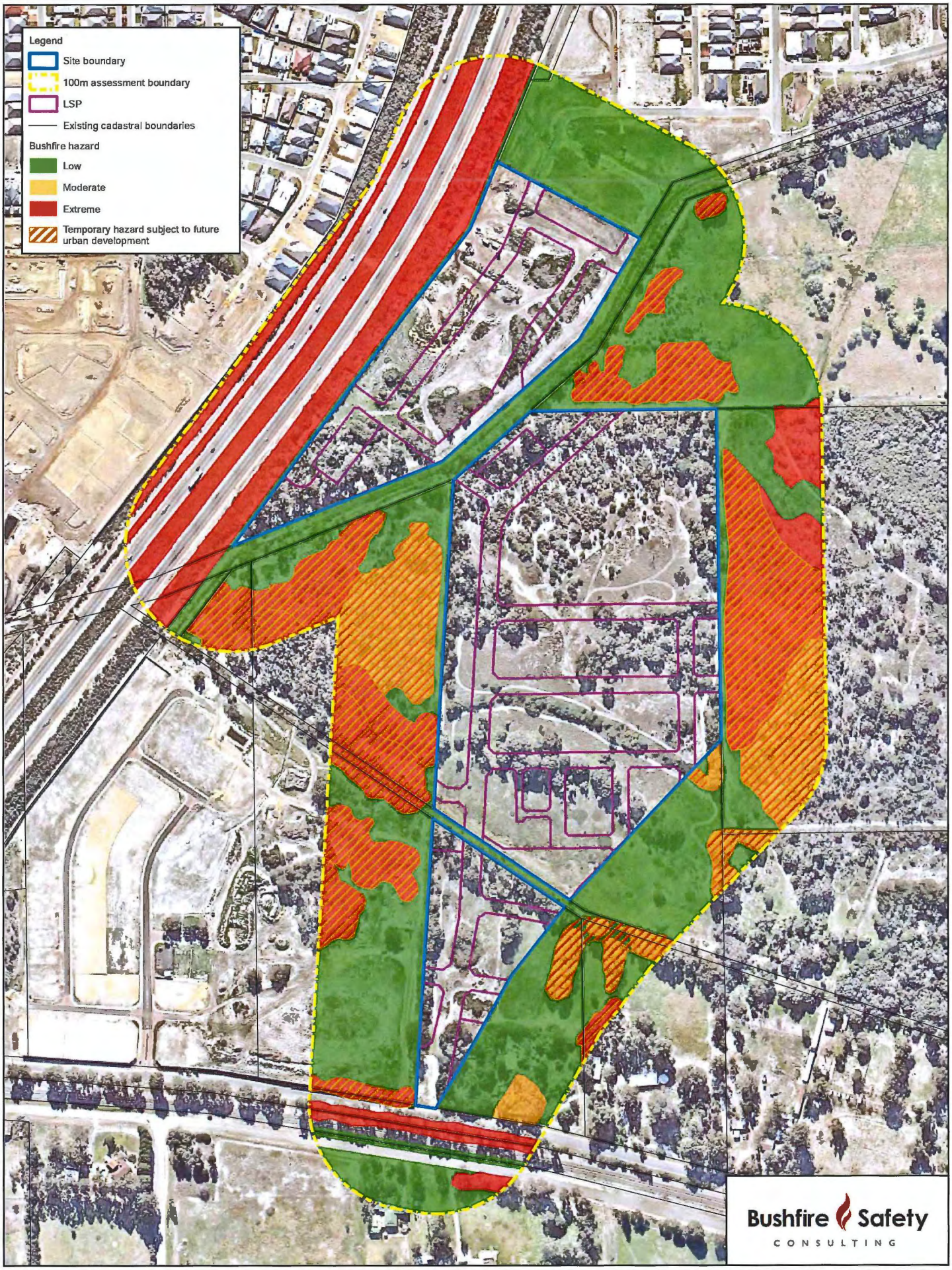

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Figure 10:	Post Development Site Conditions - Bushfire Hazard Assessment	Plan Number: EP11-011(09)--F88a	
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard	Drawn: ADB	Date: 29/07/15
Client:	Armana Holdings Pty Ltd	Approved: KK	Date: 30/07/15
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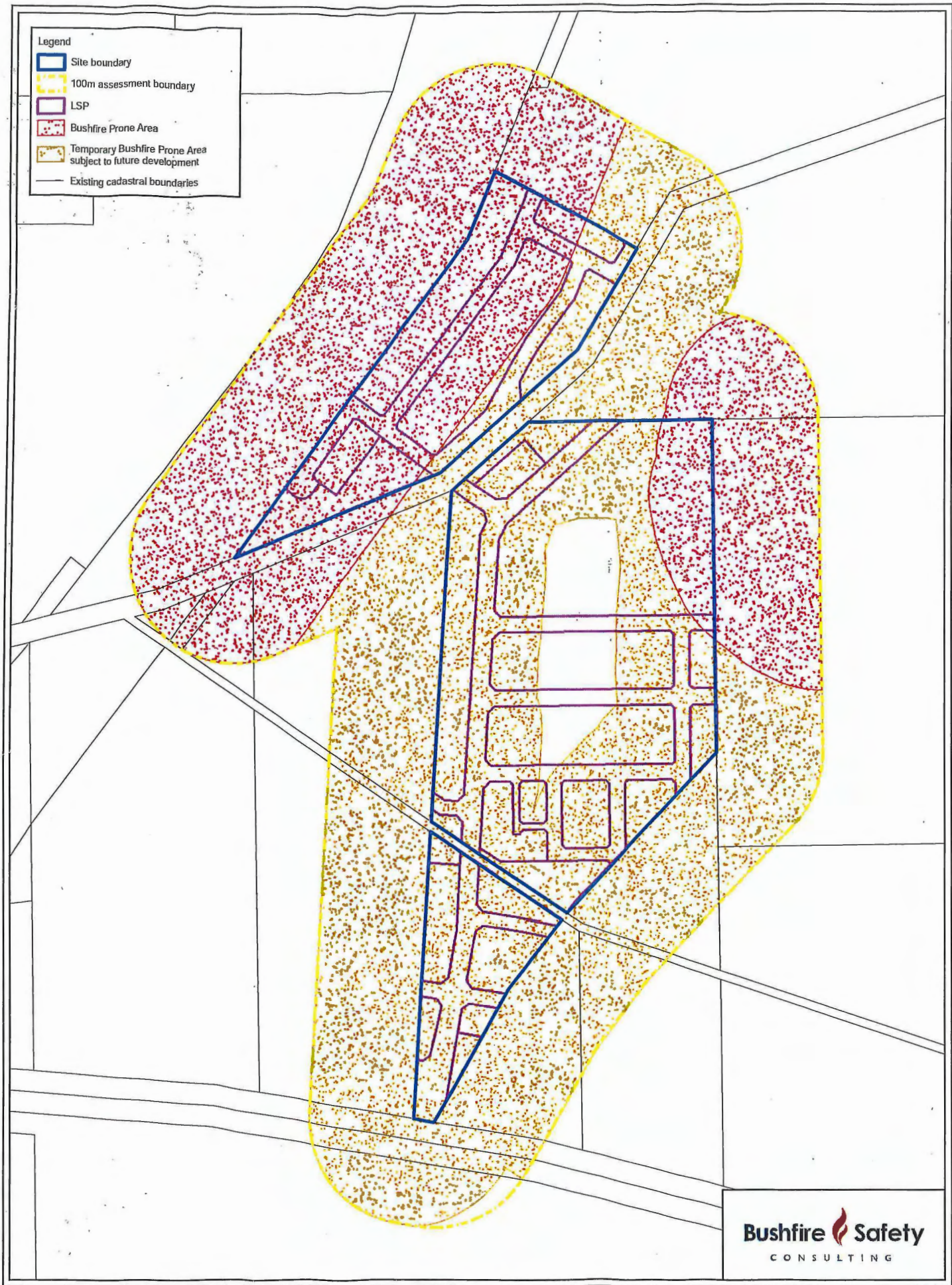

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Figure 11:	Post Development Site Conditions - Bushfire Prone Areas
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard
Client:	Armana Holdings Pty Ltd

Plan Number: EP11-011(09)--F89a			
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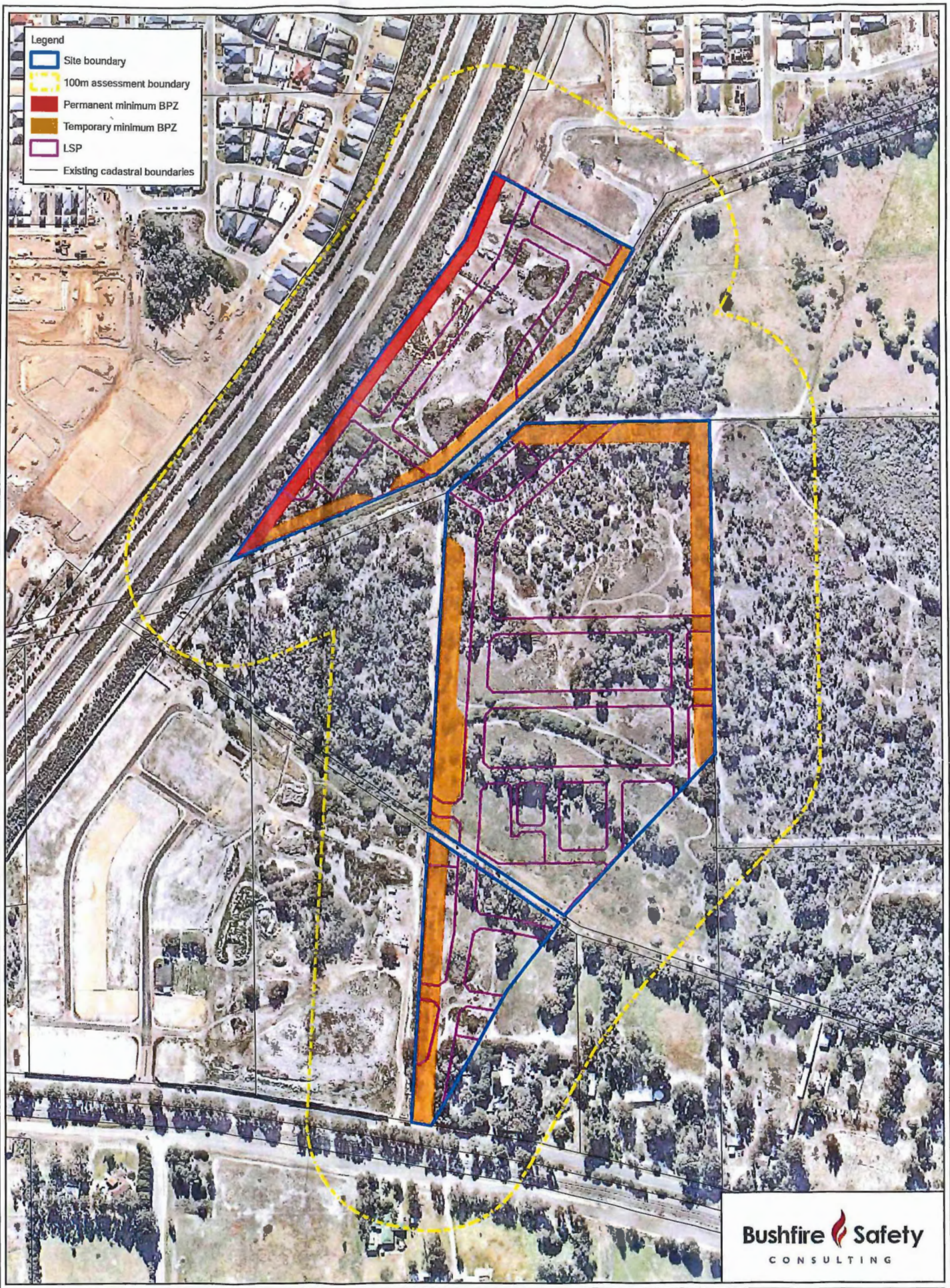

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Figure 12:	Building Protection Zone Requirements	Plan Number: EP11-011(09)--F91a	
Project:	Fire Management Plan Part Lot 9001 Mortimer Road and Lot 379 Millar Road, Wellard	Drawn: ADB	Date: 29/07/15
Client:	Armana Holdings Pty Ltd	Approved: KK	Date: 30/07/15
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APPENDIX A

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COMPLIANCE CHECKLIST

Compliance Checklist

ELEMENT/QUESTION	RESPONSE
1: Location	
Does the proposal comply with the performance criteria by applying acceptable solution A1.1?	Yes.
2: Vehicular access	
Does the proposal comply with the performance criteria by applying acceptable solution A2.1?	Yes.
Does the proposal comply with the performance criteria by applying acceptable solution A2.2?	Yes.
Does the proposal comply with the performance criteria by applying acceptable solution A2.3?	Yes.
Does the proposal comply with the performance criteria by applying acceptable solution A2.4?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A2.5?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A2.6?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A2.7?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A2.8?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A2.9?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A2.10?	Not applicable.
3: Water	
Does the proposal comply with the performance criteria by applying acceptable solution A3.1?	Yes.
Does the proposal comply with the performance criteria by applying acceptable solution A3.2?	Not applicable.
Does the proposal comply with the performance criteria by applying acceptable solution A3.3?	Not applicable.
4: Siting of the Development	
Does the proposal comply with the performance criteria by applying acceptable solution A4.1?	Yes.
Does the proposal comply with the performance criteria by applying acceptable solution A4.2?	No. However, the grassland vegetation is classed as low hazard and is expected to be grazed or slashed prior to the fire season each year to maintain a low hazard in perpetuity.

ELEMENT/QUESTION	RESPONSE
Does the proposal comply with the performance criteria by applying acceptable solution A4.3?	No. However the performance criteria P4 is achieved because all dwellings with reduced setbacks to classified vegetation will achieve compliance with AS 3959:2009 and BAL-29 is not exceeded.
Does the proposal comply with the performance criteria by applying acceptable solution A4.4?	No. However, the performance criteria P4 is achieved, because all dwellings within 100 m of classified vegetation will comply with AS 3959-2009 and BAL-29 is not exceeded.
Does the proposal comply with the performance criteria by applying acceptable solution A4.5?	Not applicable.
5: Design of the Development	
Does the proposal comply with the performance criteria by applying acceptable solution A5.1?	No. However, the proposal does comply with the performance criteria P5, because building construction standards will be increased to comply with AS 3959-2009 to offset the requirement for a full 20m BPZ or HSZ; BAL-29 is not exceeded.
Does the proposal comply with the performance criteria by applying acceptable solution A5.2?	Yes.

Applicant Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Signature:



Name: Rohan Carboon

Date: 30/07/15

