Structure Plan

Lot 81 South Western Highway, Davenport

December 2021

PREPARED BY

LB PLANNING
TOWN PLANNING | URBAN DESIGN | LAND DEVELOPMENT CONSULTING

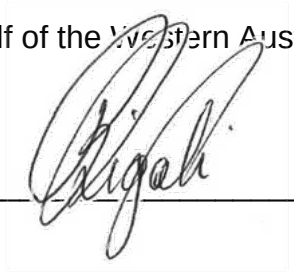
Endorsement page

This Structure Plan is prepared under the provisions of the City of Bunbury Local Planning Scheme No.8

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

11 January 2022 Date

Signed for and on behalf of the Western Australian Planning Commission



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

 Witness

12 January 2022 Date

11 January 2032 Date of Expiry

DISCLAIMER:

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Table of amendments

Amendment No.	Summary of the Amendment	Amendment type	Date approved by Commission

EXECUTIVE SUMMARY

This Structure Plan has been prepared to guide the subdivision and development of land contained within Lot 81 South Western Highway, Davenport.

The Structure Plan area comprises 41.83 hectares and is located approximately 8km south east of the Bunbury CBD. It forms part of the City of Bunbury local government area and is identified under both the Local and Regional Planning Scheme's for industrial land use.

The landowner (NBR Investments) purchased the property in 2005 and now seeks to subdivide the land into six large industrial lots to facilitate industrial development, as intended by the relevant planning framework.

The consultant project team involved with the preparation of this Structure Plan is as follows:

- LB Planning - Town Planning and Design;
- Development Engineering Consultants - Civil Engineering & Local Water Management Strategy;
- Ecoscape – Environmental Assessment;
- Shawmac- Traffic and Transport Assessment; and
- Ecosystem Solutions - Bushfire Assessment.

The Structure Plan has been designed to support industrial land use and development of the site, based on larger lots to serve the industrial needs of the City of Bunbury.

The key planning objectives that have been applied to formulate the plan are as follows:

- Provision of large industrial lots generally ranging between 5 to 8 hectares in size with each being capable of supporting larger scale industrial operations where large areas of space required for equipment storage, parking and machinery placement;
- 25 metre wide central road reserve with connection to South Western Highway;
- Suitable separation distances from adjoining bushland and the Preston River Foreshore;
- Strategic location of designated flood storage areas and drainage swales to ensure sustainable stormwater management in accordance with the objectives of the Local Water Management Strategy; and
- Un-sewered development with restriction on the types of industrial activity permitted on the site (i.e. dry industry only).

The proposed Structure Plan outlines the planned industrial layout for the land and also identifies wetland areas, associated buffers, bush fire prone land and proposed drainage design, supported by a Local Water Management Strategy.

It has been prepared in accordance with the relevant planning framework and will provide appropriate guidance to future subdivision and development assessment of the land.

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Appendix I	Certificate of Title

Part One

IMPLEMENTATION

1 STRUCTURE PLAN AREA

This Structure Plan shall apply to Lot 81 South Western Highway, Davenport, being the land contained within the inner edge of the broken black line shown on the Structure Plan Map.

For the purposes of this report, it is referred to as the *Structure Plan.*

2 STRUCTURE PLAN CONTENT

This Structure Plan report comprises two parts being:

- **Part One (Implementation)** – This section contains the Structure Plan Map including requirements to be applied when assessing subdivision and development applications within the Structure Plan Area.
- **Part Two (Explanatory Section)** – This section provides an explanation of the Structure Plan including planning background, site conditions, constraints, land use and servicing. Part Two is to be used as a reference guide to interpret and justify the implementation of Part One. This section also includes all specialist consultant's reports used to inform and prepare the Structure Plan.

3 OPERATION

This Structure Plan commences operation on the date it is approved by the Western Australian Planning Commission and is valid for a period of ten years from such time. Due regard to its intent and specific provisions shall be given when considering future subdivision and development of the land.

4 SUBDIVISION & DEVELOPMENT REQUIREMENTS

Development Requirements

1. No development is to be carried out within the floodway area depicted on the Structure Plan map.
2. Any on-site sewage disposal system should not be located within 100 metres of a waterway or a significant wetland.
3. A detailed Site and Soil Evaluation and details of the proposed on-site sewage disposal system is to be submitted to the City of Bunbury as part of any application for development approval.
4. Where connection to reticulated sewer is not provided, any industrial development on Lot 81, will be restricted to 'Dry Industry'. Dry industry is any industrial use permitted by the City of Bunbury's Local Planning Scheme where it can be demonstrated that the quality and volume of effluent to be disposed of on-site can be successfully disposed of, without adverse environmental or health effects, utilising sewage disposal systems approved by the Health Department of Western Australia and the Department of Water and Environmental Regulation, in accordance with the

requirements of the Government Sewerage Policy.

5. No development is permitted to be carried out within the Conservation Category Wetland buffer.
6. Prior to the approval of any development within areas identified as Resource Enhancement Wetland, approval will first need to be sought for the reclassification of the wetland from the Department of Biodiversity, Conservation and Attractions.

Subdivision Requirements

Prior to or in conjunction with any subdivision application, the following information is to be provided, in addition to any other information required by the Western Australian Planning Commission:

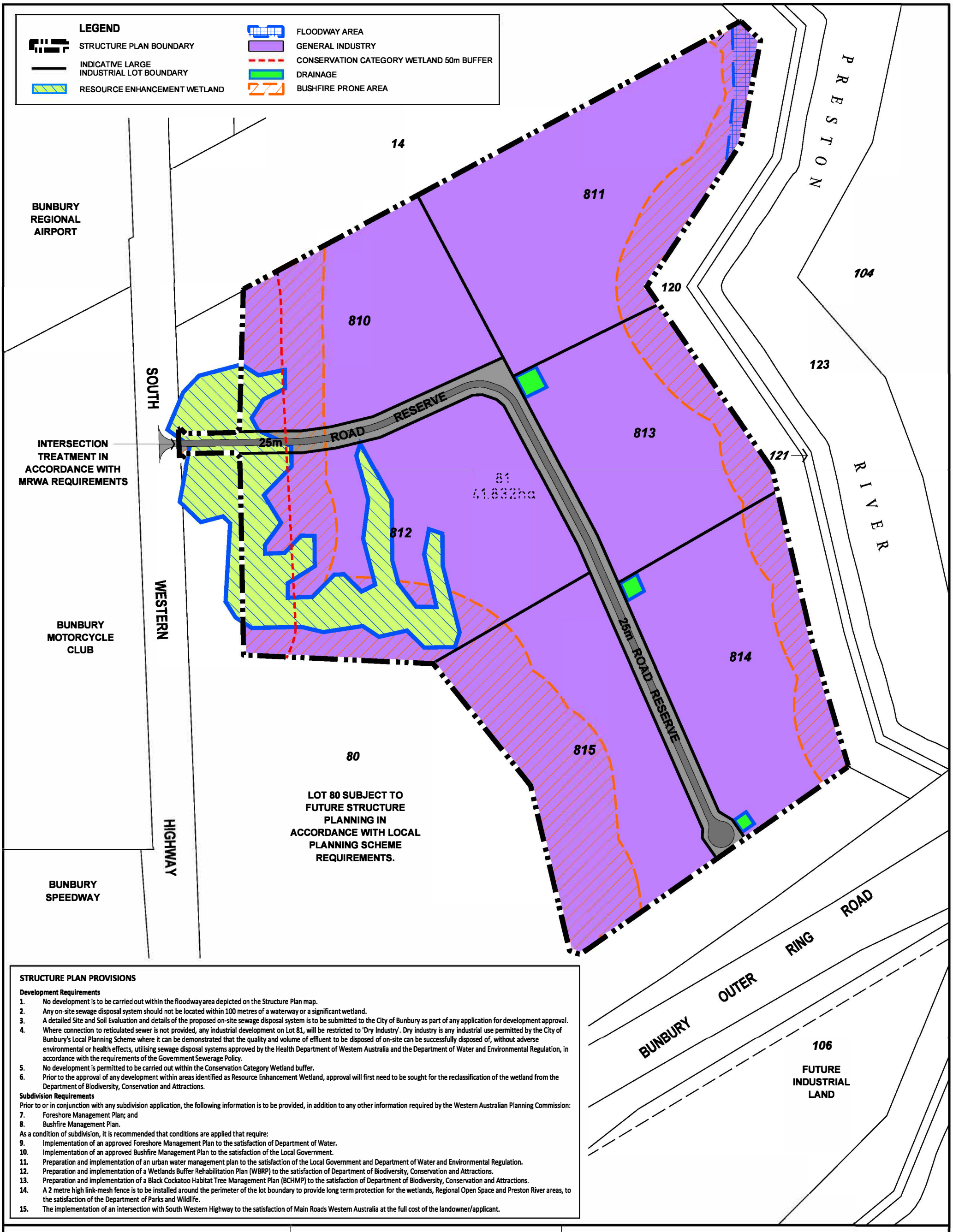
7. Foreshore Management Plan; and
8. Bushfire Management Plan.

As a condition of subdivision, it is recommended that conditions are applied that require:

9. Implementation of an approved Foreshore Management Plan to the satisfaction of Department of Water and Environmental Regulation.
10. Implementation of an approved Bushfire Management Plan to the satisfaction of the Local Government.
11. Preparation and implementation of an urban water management plan to the satisfaction of the Local Government and Department of Water and Environmental Regulation.
12. Preparation and implementation of a Wetlands Buffer Rehabilitation Plan (WBRP) to the satisfaction of Department of Biodiversity, Conservation and Attractions.
13. Preparation and implementation of a Black Cockatoo Habitat Tree Management Plan (BCHMP) to the satisfaction of Department of Biodiversity, Conservation and Attractions.
14. A 2 metre high link-mesh fence is to be installed around the perimeter of the lot boundary to provide long term protection for the wetlands, Regional Open Space and Preston River areas, to the satisfaction of the Department of Biodiversity, Conservation and Attractions.
15. The implementation of an intersection with South Western Highway to the satisfaction of Main Roads Western Australia at the full cost of the landowner/applicant.

5 OTHER REQUIREMENTS

Prior to the issue of any planning approval for development on the site, specific land use and development controls shall be included in the “Additional Site and Development Requirements” table of the Scheme text, by way of an amendment to the Scheme, in order to undertake ‘dry industry’.



STRUCTURE PLAN PROVISIONS

Development Requirements

1. No development is to be carried out within the floodway area depicted on the Structure Plan map.
2. Any on-site sewage disposal system should not be located within 100 metres of a waterway or a significant wetland.
3. A detailed Site and Soil Evaluation and details of the proposed on-site sewage disposal system is to be submitted to the City of Bunbury as part of any application for development approval.
4. Where connection to reticulated sewer is not provided, any industrial development on Lot 81, will be restricted to 'Dry Industry'. Dry industry is any industrial use permitted by the City of Bunbury's Local Planning Scheme where it can be demonstrated that the quality and volume of effluent to be disposed of on-site can be successfully disposed of, without adverse environmental or health effects, utilising sewage disposal systems approved by the Health Department of Western Australia and the Department of Water and Environmental Regulation, in accordance with the requirements of the Government Sewerage Policy.
5. No development is permitted to be carried out within the Conservation Category Wetland buffer.
6. Prior to the approval of any development within areas identified as Resource Enhancement Wetland, approval will first need to be sought for the reclassification of the wetland from the Department of Biodiversity, Conservation and Attractions.

Subdivision Requirements

Prior to or in conjunction with any subdivision application, the following information is to be provided, in addition to any other information required by the Western Australian Planning Commission:

7. Foreshore Management Plan; and
8. Bushfire Management Plan.

As a condition of subdivision, it is recommended that conditions are applied that require:

9. Implementation of an approved Foreshore Management Plan to the satisfaction of Department of Water.
10. Implementation of an approved Bushfire Management Plan to the satisfaction of the Local Government.
11. Preparation and implementation of an urban water management plan to the satisfaction of the Local Government and Department of Water and Environmental Regulation.
12. Preparation and implementation of a Wetlands Buffer Rehabilitation Plan (WBRP) to the satisfaction of Department of Biodiversity, Conservation and Attractions.
13. Preparation and implementation of a Black Cockatoo Habitat Tree Management Plan (BCHMP) to the satisfaction of Department of Biodiversity, Conservation and Attractions.
14. A 2 metre high link-mesh fence is to be installed around the perimeter of the lot boundary to provide long term protection for the wetlands, Regional Open Space and Preston River areas, to the satisfaction of the Department of Parks and Wildlife.
15. The implementation of an intersection with South Western Highway to the satisfaction of Main Roads Western Australia at the full cost of the landowner/applicant.

0 40 80 120 160
metres

NOTES

Base data supplied by Harley Dykstra

Projection - GDA94

Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

SCALE	:	*1:4,000 @ A3*
DATE	:	*10 November 2020*
PLAN No	:	*81DavenportLSP_V1.0_20201110*
REVISION	:	*A*
PLANNER	:	*SLB*
DRAWN	:	*BL*

STRUCTURE PLAN

Lot 81 South Western Highway, Davenport

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Part Two

EXPLANATORY SECTION

1 INTRODUCTION

LB Planning has been appointed by NBR Investments (the landowner) to prepare a Structure Plan in respect of Lot 81 South Western Highway, Davenport (the site) in accordance with its zoning.

A copy of the Certificate of Title in respect of the site is contained in Appendices Section of the report.

The land is zoned 'Development Zone (Industrial)' pursuant to the City of Bunbury Local Planning Scheme No. 8 (the Scheme) and requires an approved Structure Plan to facilitate comprehensive planning and development of the land for industrial purposes.

While a previous structure plan in relation to the site was adopted by Council and endorsed by the Western Australian Planning Commission (WAPC) in 2000, subsequent Environmental Protection Authority (EPA) advice to the Minister of the Environment regarding the Greater Bunbury Region Scheme and identified Preston Industrial Park (in context with the site) has undermined the current approved structure plan and its design philosophy.

Accordingly, a Structure Plan has been prepared (in consultation with the City of Bunbury and Department for Planning, Lands and Heritage) by a consultancy team whose investigation findings and recommendations (in support of the proposal) are incorporated as part of this report. The project team is as follows:

- Planning and Design – LB Planning
- Environmental – Ecoscape
- Bushfire Assessment – Ecosystem Solutions
- Engineering and Drainage Design– Development Engineering Consultants
- Transport Assessment - Shawmac

The proposal will enable the landowner to progress a viable industrial development in a rational and appropriate manner to service the growing industrial needs of Greater Bunbury and the broader South West Region.

Details contained with this report are based on the structure planning design outcomes, technical investigation findings and information sourced from the City of Bunbury and WAPC, including relevant policy documents, reports and formal advice.

2 SITE DESCRIPTION

The subject land is identified as Lot 81, South Western Highway, Davenport and is approximately 41.83 hectares. It is located approximately 8 kilometres south east of the Bunbury CBD and falls within the City of Bunbury local government area **(Figure1)**.

Historically the site has been used for broad acre farming and does not contain any existing dwellings or outbuildings. The land has been cleared and pastured and its topography is generally flat (14m to 11m AHD) with a gradual fall from west to east.

The site is bordered by South Western Highway to the west, a portion of the Bunbury Outer Ring Road to the south, an airport expansion area to the north and the Preston River to the east **(Figure 2)**.

Surrounding land uses include of the Bunbury Speedway, the Bunbury Airport, Motorcycle Club, Go-kart club, Bunbury Regional Prison to the west and various rural land uses. Land further north is already developed for industrial purposes (i.e. Bunbury Business Park, Halifax & Picton) and areas to the east and south are either strategically identified or proposed as future industrial land.

The subject land is identified within the “Preston Industrial Park” area and in the context of its surrounds is well suited for the proposed future industrial land use activity.

Directly abutting the subject land and South Western Highway to the west is a large vegetated area known as Lot 80. This area of land formed part of the original lot parcel (Lot 15) which was subdivided in June 2015 (WAPC No 144945) into current Lots 80 & 81.

The majority of the Lot 80 is characterised by an elevated portion of land in the south western corner comprising approximately 15 hectares of remnant peppermint woodland. The remaining land is largely characterised by an identified Conservation Category Wetland (CCW) area located along the South Western Highway boundary and a Resource Enhancement (RE) wetland near the access leg to Lot 81.

The RE wetland also extends into the north-west corner of Lot 81 and while this potentially constrains future industrial use in some portions of the subject land, the large nature of proposed lots will enable appropriate measures to control land use in any sensitive areas at the development approval stage.

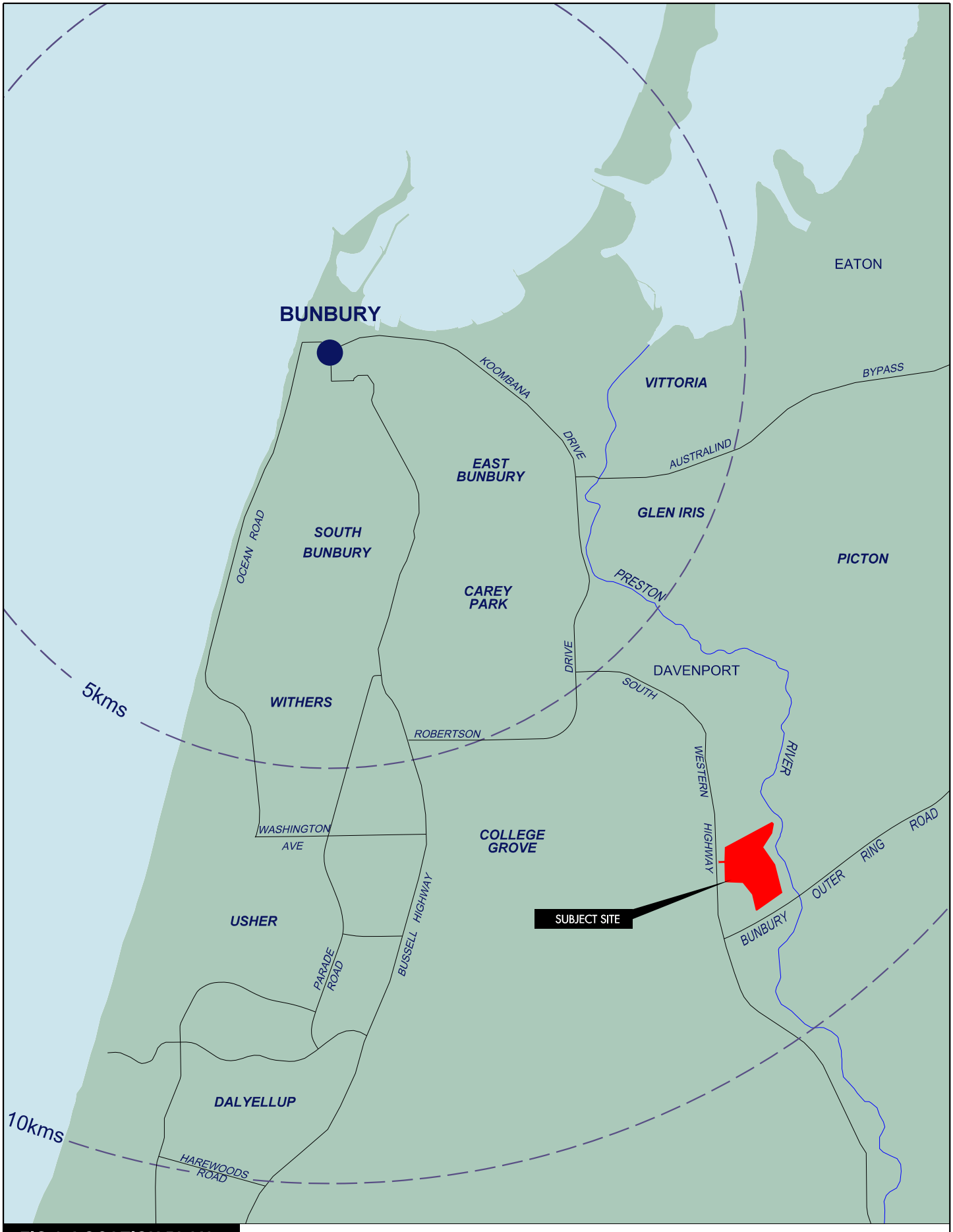

FIG 1: LOCATION PLAN

Lot 81 South Western Highway, DAVENPORT

CLIENT	:	-
SCALE	:	1:60,000
DATE	:	12 July 2016
PLAN No	:	Locn.dgn
REVISION	:	A
PLANNER	:	SLB
DRAWN	:	BL

LEGEND

SUBJECT SITE

0 600 1200 1800 2400

metres

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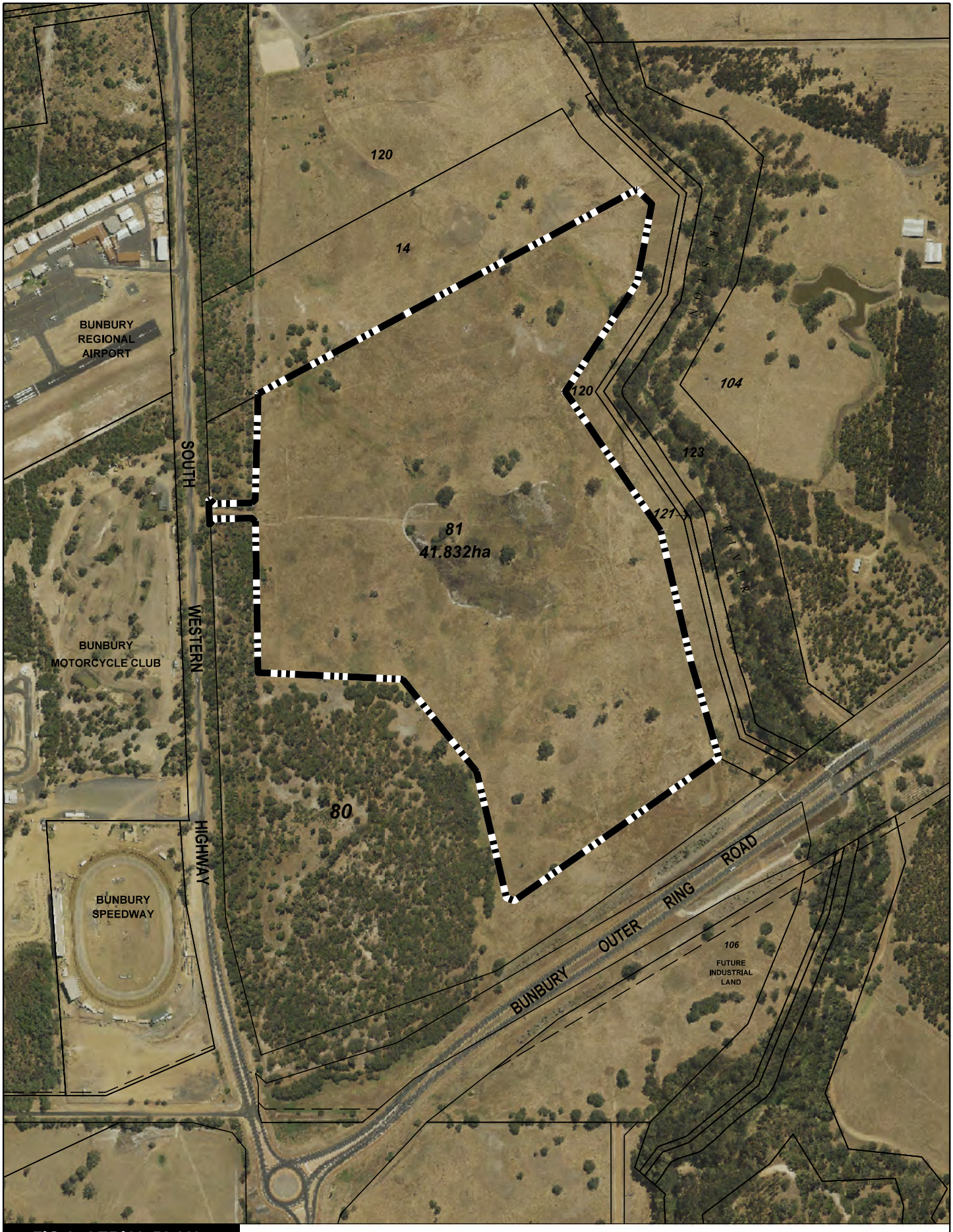

FIG 2: AERIAL PLAN

Lot 81 South Western Highway, DAVENPORT

CLIENT	:	-
SCALE	:	*1:7,500*
DATE	:	*12 July 2016*
PLAN No	:	*Aerial.dgn*
REVISION	:	*A*
PLANNER	:	*SLB*
DRAWN	:	*BL*

LEGEND

SUBJECT SITE

0 75 150 225 300

metres

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3 LOCAL PLANNING FRAMEWORK

3.1 City of Bunbury Local Planning Scheme No.8

Pursuant to the City of Bunbury Local Planning Scheme No. 8 the site is zoned 'Industrial Development'.

Clause 16 of the Scheme contains objectives of the 'Industrial Development' zone under Table 2 which reads as follows:

• To designate land for future industrial development.

• To provide a basis for future detailed planning in accordance with the structure planning provisions of this Scheme.

• To provide an intermediate transitional zone following the lifting of an industrial deferred zoning within the Greater Bunbury Region Scheme.

Further, an Additional Zone Development Requirements Table (Table 8) under Schedule 5 of the Scheme specifies the requirement for a structure plan and it reads as follows:

"A structure plan is required to be endorsed for land included in the Urban Development Zone or Industrial Development Zone prior to subdivision and/or development.

Note: Also refer to the Planning and Development (Local Planning Schemes) Regulations 2015, Schedule 2 Deemed provisions for local planning schemes, Part 4 Structure plans."

Accordingly, a Structure Plan has been prepared and is contained in Part One of this report. The Structure Plan has been prepared in accordance with Schedule 2 of the *Planning and Development (Local Planning Schemes) Regulations 2015* which outlines the deemed provisions and requirements in relation to the preparation and approval of structure plans. It sets out the broad infrastructure framework to facilitate intended subdivision and industrial development of the site. The Structure Plan also responds to issues such as road layout, types of industry, servicing, drainage, environmental considerations and access. The Structure Plan is required to be approved by the City of Bunbury and the WAPC.

'Development Requirement 4' of the Structure Plan, is proposed to ensure that in the event reticulated sewer is not provided, then only dry industrial uses will be permitted on the site. However, in order to enforce this requirement via the Scheme, an amendment to the Scheme is also proposed by inserting a requirement into the 'Additional Site and Development Requirements Table 6' contained in Schedule 3 of the Scheme, to restrict land use on the site to dry industry only, until such time the site is connected to reticulated sewer.

3.2 Local Planning Policy – Development in Flood Effected Areas

This policy influences the development and use of land within the Preston River Floodway and Flood Fringe areas.

In respect of the site, the policy stipulates developers and subdividers shall be required not to develop lower than the recommended Minimum Finished Floor Level, as identified in flood studies carried out from time to time and in accordance with the Bunbury Flood Management Strategy.

Information provided by the Department of Water and Environmental Regulation (DWER) identifies the 1 in 100 year flood level for the Preston River adjacent to the development falling from approximately RL12.85 at the north-eastern (upstream) corner of the site to RL 12.18 at the north-western (downstream) corner of the site. Accordingly, no filling is allowed within the floodway area, which only impacts upon a very small area on the far north-eastern corner of the site however it is required that all buildings be sited at least 500mm above the 1 in 100 year flood level elsewhere.

In this regard, future development will be guided by an approved Local Water Management Strategy (LWMS) and subsequent Urban Water Management Plan (UWMP) at the subdivision stage

As part of this proposal a LWMS has been prepared by Development Engineering Consultants is contained in **Appendix A** of this report.

In summary, the LWMS maintains certain levels of fill shall be required where buildings are proposed, with the full extent to be determined at the development approval stage with drainage, hard stand and/or open storage areas to be maintained at natural ground level.

3.3 Endorsed Structure Plan

A local structure plan in respect of the subject land and adjoining Lot 80 was adopted by Council on 26 September 2000 and endorsed by the WAPC on 25 October 2000.

The approved plan provided the framework to progress intended subdivision and development of the site for industrial purposes and identified various development precincts and lot configuration guidelines for future industrial lots.

A plan of subdivision, based on the endorsed Structure Plan was approved by the WAPC on 6 November 2000, (WAPC No. 113318) including development over the identified “Conservation Category Wetland” on the western boundary and remnant vegetation located in the south west corner of the site.

Under its current zoning, the Structure Plan is the only existing approved planning document in relation to future subdivision and development of the subject land.

3.4 City Vision Strategy

The City Vision Strategy and associated City Vision Action Plan, was adopted by the Bunbury City Council in September 2007,

The intent of the Strategy aims to establish broad direction for the future of the “Industry Vision Focus Area” covering the localities of Davenport, Preston and the Bunbury Airport precinct.

The proposed Structure Plan supports the intent of the City Vision Strategy and its Action Plan.

4 STATE PLANNING FRAMEWORK

4.1 State Planning Strategy 2050

The State Planning Strategy 2050 was released in June 2014 and it provides the strategic context for planning and development decisions throughout the State.

It also guides an informs local community plans, growth plans and local planning schemes and strategies with structure planning and development assessments and it aspires to ensure all strategic industrial areas are developed to an approved structure plan.

Accordingly, this proposal is aligned with the intent of the Strategy.

4.2 State Planning Policies

Relevant State Planning Policies to this proposal are as follows:

SPP 2.9 – Water Resources

With respect to water resources, the relevant issues are addressed in the Local Water Management Strategy contained in **Appendix A** of this report.

SPP 3.7 – Planning in Bushfire Prone Areas

Both the eastern and western perimeters of the subject land are identified as Bushfire Prone and accordingly a Bushfire Management Plan has been prepared by Ecosystem Solutions and is contained in **Appendix B** of this report.

In summary, it was found that only the very edges of Lot 81 will be subject to radiant heat flux greater than 29 kW/m2 (i.e. BAL-29).

The *"Guidelines for Planning in Bushfire Prone Areas"* advocates that development is kept where the radiant heat flux is less than BAL-29. Accordingly, provided any structure is built outside the BAL-29 contour and appropriate separation distances from Class G – Grassland vegetation are established and maintained, no building within the proposed development will require a BAL assessment that exceeds BAL-29.

SPP 4.1: State Industrial Buffer Policy

Given that existing and proposed residential land uses are not within two kilometres of the subject land, the need to consider industrial buffers to sensitive land uses in this instance is not required.

4.3 WAPC DC 4.1 – Industrial Subdivision

Clause 3.7.2 of the policy states that;

Connection to a reticulated sewerage system is a normal requirement of industrial subdivision. However, where a reticulated sewerage connection is not available and is not in early prospect, this requirement may be dispensed with when the Commission:

a) is satisfied that development will be limited to 'dry' industry, and

b) is advised by the relevant authorities that sod conditions allow for efficient on-site disposal of effluent on a long-term basis.

The nearest sewer pressure main is approximately 2km away from the site and the cost to install a Type 90 WWPS (as suggested by Watercorp) for only six industrial lots would make the proposal unviable. Preliminary investigation findings also confirm that the resulting flow rate would be insufficient for the WWPS to function properly in any case.

In relation to the estimated infrastructure delivery timeframe for the locality, advice from Watercorp confirms that the planned Type 90 WWPS is not programmed at this point in time nor is it likely to be within the next and 10 years.

Accordingly, it is proposed to only permit dry industry on the subject land, until such time reticulated sewer is made available. Land use controls to ensure this occurs is proposed by way of scheme amendment and details regarding suitably for on-site effluent disposal are outlined in the Environmental Assessment contained in **Appendix C** of this report.

4.4 Bunbury – Wellington Region Plan

The Bunbury-Wellington Region Plan (1995) was the guiding document for the preparation of the Greater Bunbury Region Scheme (GBRS).

A component of the Bunbury-Wellington Region Plan is the Greater Bunbury Structure Plan, which separates the Greater Bunbury Region into various planning unit areas and provides policy guidelines for each of those areas.

The Greater Bunbury Structure Plan identifies the northern portion of the subject land within “Planning Unit P8: Davenport”.

Relevant statements from the planning policies and guidelines of this planning unit are:

• Landscape buffers, conservation and tree planting areas should be promoted in accordance with the approved structure plan; and

• Industrial development should satisfy environmental assessment requirements relating to gaseous emissions, dust, noise, groundwater pollutants and provide

safeguards for both worker and resident health and safety.

This Structure Plan responds to the abovementioned planning unit provisions.

4.5 Greater Bunbury Region Scheme

The Greater Bunbury Region Scheme (GBRS) is a statutory scheme which covers the City of Bunbury and the Shire's of Harvey, Dardanup and Capel. The GBRS became operative in 2007.

The GBRS is a large scheme which designates general zones and reservations of land. It is a statutory requirement that all local planning schemes must be consistent with regional planning schemes.

The site is designated as 'Industrial' under the GBRS, and therefore the proposed structure plan is consistent with this Scheme.

There are a number of policies relevant to the GBRS, one of which is the *Greater Bunbury Region Scheme Flood Management Policy 2005.* In summary the policy outlines how flood risk needs to be considered to help decrease the impact of flooding through inappropriately located land use and development.

In the context of the site, the policy identifies the eastern portion of the land, adjacent to the Preston River, as part of the "Flood Fringe" which is defined *as* follows:

"..land that would be prone to flooding in a 1 in 100- year flood event, where development would normally be permitted subject to a specified minimum habitable floor level above the relevant 1 in 100-year flood level to provide adequate flood protection."

Accordingly, and as mentioned previously, any future development of the site will be guided by an approved LWMS to ensure certain levels of fill shall be required and maintained where buildings are proposed, including those within the "Flood Fringe".

4.6 Industry 2030

In 2000 the WAPC carried out a series of studies regarding industry and transport within the Greater Bunbury Region and subsequently released a report called 'Industry 2030 Greater Bunbury Industrial Land and Port Access Planning'.

The report identifies major industrial and port access zones within the Bunbury area, including the subject land.

The report also sets out a strategic planning framework to provide direction for investment in the region to ensure suitably located industrial areas and transport routes meet the needs of industry in the Greater Bunbury Region.

An Interim Strategy Plan is contained within the report which identifies the subject land as 'transitional industry precinct' and it notes that further technical investigations are required in the following areas:

• Environmental impact modelling;

• Water and drainage management strategy (incorporating liquid waste disposal);

• Vegetation survey;

• Wetlands survey;

• Road access studies.

This Structure Plan is supported by a number of technical investigations to address the above and investigation findings are appended at the back of this Report.

4.7 Greater Bunbury Strategy

The Greater Bunbury Strategy 2013 is a strategic plan to manage the growth of Greater Bunbury over the medium to long term planning horizon. It provides for population growth in Greater Bunbury from 83,598 people (2011 Census) to at least 150,000 people through urban infill, and some additional greenfields urban expansion areas. This is anticipated to cater for growth beyond the year 2050.

The Strategy supersedes the portion of the Bunbury Wellington Region Plan that relates to land use within the Shires of Harvey, Capel and Dardanup and the City of Bunbury.

The Strategy will also form part of Statement of Planning Policy No. 1: State Planning Framework and its outcomes will be implemented through relevant statutory documents, being the Greater Bunbury Region Scheme, Local Planning Strategies and Schemes.

The Strategy incorporates the *Greater Bunbury Structure Plan 2013* which identifies the subject land as 'industrial undeveloped land' with a short to medium term priority to more efficiently use the land for the purpose to which it is zoned.

This Structure Plan, will enable intended subdivision and industrial development of the land to proceed.

4.8 Government Sewerage Policy

The above policy was implemented in 2019. It establishes the Western Australian Government's position on the provision of sewerage services in the State through the planning and development of land. It requires reticulated sewerage to be provided during the subdivision and development of land. In instances where reticulated sewerage cannot be provided, it adopts a best practice approach to the provision of on-site sewage treatment and disposal, in accordance with *Australian/New Zealand Standard 1547 On-site domestic*

wastewater management.

Schedule 1 Clause 2 of the policy requires any application for a local structure plan to specify how sewage will be treated and disposed via a local water management strategy (LWMS), to be prepared in accordance with Better Urban Water Management (WAPC 2008) and information about sewage disposal is to be incorporated. This should include a site water balance and details on the proposed servicing strategy for water supply, sewage management and stormwater management.

As mentioned previously, an LWMS has been prepared to support this Structure Plan and is contained at **Appendix A** of this report. The LWMS adheres to the above and has subsequently been approved by both DWER and the City of Bunbury.

In relation to the ongoing requirements of the policy (including the need for a site and soil evaluation prior to development occurring on the land) various provisions have been incorporated into part of Part One of this report and the Structure Plan itself to read as follows:

(2) Any on-site sewage disposal system should not be located within 100 metres of a waterway or a significant wetland.

(3) A detailed Site and Soil Evaluation and details of the proposed on-site sewage disposal system is to be submitted to the City of Bunbury as part of any application for development approval.

(4) Where connection to reticulated sewer is not provided, any industrial development on Lot 81, will be restricted to 'Dry Industry'. Dry industry is any industrial use permitted by the City of Bunbury's Local Planning Scheme where it can be demonstrated that the quality and volume of effluent to be disposed of on-site can be successfully disposed of, without adverse environmental or health effects, utilising sewage disposal systems approved by the Health Department of Western Australia and the Department of Water and Environmental Regulation, in accordance with the requirements of the Government Sewerage Policy.

5 ENVIRONMENTAL ISSUES

5.1 Environmental Assessment

An environmental assessment to support this Structure Plan has been undertaken by Ecoscape and its findings are contained in **Appendix C** of this report.

The investigation used previous information in relation to the site, gathered and reported on in 2010 and further supported by an additional field assessment completed in August 2016.

The key relevant environmental issues and subsequent findings are outlined below.

5.2 Hydrology

The site is located in the Middle Preston Surface Water Management Sub Area (DWER 2008).

Natural drainage is generally from the south west to the east and there are no defined streamlines, with flows consisting broad surface movements. The Preston River flows in close proximity to the eastern boundary of the site.

Groundwater level monitoring over recent years, through strategically placed bores, indicates groundwater levels close to the surface and in some cases, less than 1 metre below the existing ground level. It is proposed that drainage will be managed by using bio-retention swales and specific flood storage areas in the form of drainage basins. The location of the proposed flood storage areas and swales are identified within the LWMS.

The LWMS is a key supporting document for the Structure Plan and has been prepared with the intention of providing an outcome whereby subsequent development can occur consistent with an appropriate water cycle management approach. The LWMS also provides overall guidance to the general stormwater management principles for the area in order to guide eventual development at the time of subdivision.

5.3 Acid Sulfate Soils

Mapping of potential acid sulphate soils (ASS) via Department of Environment Regulation datasets indicates that the entirety of the site has a moderate to low risk of containing ASS.

5.4 Vegetation and Flora

Given the site is generally cleared and pastured and due to its completely degraded bushland condition (Keighery 1994), the lack of any native vegetation understory and history of grazing, it is considered highly unlikely that any conservation or significant flora is present.

5.5 Fauna

The environmental assessment finds the site devoid of any remnant native vegetation with sufficient structure to provide fauna habitat value, other than large hollow bearing trees.

Accordingly, a Black Cockatoo survey of the study area was conducted by Ecoscape on 19 July 2016. The entire study area was traversed on foot and all trees with Diameter Breast Height of 500 mm or greater were recorded and described.

These scattered and isolated trees were assessed by Ecoscape for value as potential Black Cockatoo breeding trees. It was found that there are potential Black Cockatoo habitat breeding trees within the study area (Refer Map 01 of Ecoscape Report) and it is intended to retain these trees where possible. In the event the trees cannot be retained, then a referral to the Commonwealth will be carried out by the subdivider. In this regard it is considered that a sufficiently large number of similar trees can be found in the nearby natural areas, including adjacent Lot 80.

In addition, a Black Cockatoo Habitat Tree Management Plan was also prepared, at the request of DBCA and is contained at the rear of this report **(Appendix E)**.

5.6 Land Capability

As part of the environmental assessment Ecoscape investigated the land capability factors of the site, based on soil mapping. Its findings indicate that the land has a capability of Class 4 Low whereby its most limiting factor is in relation to high waterlogging. The high risk of this generally relates to the soils having low ability to absorb water combined with shallow depth to groundwater.

Accordingly, it is recommended that on-site sewage disposal systems are used for effluent disposal on site in accordance with the Government Sewerage Policy (2019) and in-conjunction with the required land fill for future building areas, as proposed by this Structure Plan.

5.7 Wetlands and Preston River

There is a Resource Enhancement (RE) wetland recorded within the site, which was recorded as Multiple Use (MU) in 2010 and then later modified by the DBCA. This wetland occurs in the North West corner of the site and may potentially constrain the site's development potential in this particular location.

Ecoscape recommends that a request for modification be lodged with the DBCA to alter the classification of the portions of this RE wetland that lie within the site.

A Conservation Category Wetland (CCW) is also located on adjoining Lot 80 to the west. CCW areas incorporate a buffer zone of at least 50 metres which has been nominally identified on the proposed Structure Plan. The buffer zone reduces the amount of developable area along the western boundary of the proposal, and while some rationalisation of the boundary is required in order to accommodate the proposed Structure

Plan design, there is no intention to challenge the location of the wetland boundaries or its classification status. While some discretion will be required, the separation of 50 metres from the CCW can generally be achieved and is to be applied along with the management of the boundary, including fencing where necessary. To further address this issue and at the request of DBCA, a Wetland Buffer Rehabilitation Plan has also been prepared and is attached at the rear of this report **(Appendix D)**.

Finally, due to the site's proximity to the Preston River, a Foreshore Management Plan has also been prepared and is attached **Appendix F** at the rear of this report.

6 PROPOSED STRUCTURE PLAN

The Structure Plan has been designed to support industrial land use and development of the site, based on larger lots to serve the industrial needs for the City of Bunbury.

Planning objectives that have been applied to formulate the plan are as follows:

- Provision of large industrial lots generally ranging between 5 to 8 hectares in size with each being capable of supporting larger scale industrial operations where large areas of space required for equipment storage, parking and machinery placement;
- 25 metre wide central road reserve with connection to South Western Highway;
- Suitable separation distances from adjoining bushland and the Preston River Foreshore;
- Strategic location of designated flood storage areas and drainage swales to ensure sustainable stormwater management in accordance with the objectives of the Local Water Management Strategy; and
- Un-sewered development with restriction on the types of industrial activity permitted on the site (i.e. dry industry only).

6.1 Traffic

A transport assessment of the site and the proposed Structure Plan has been carried out by Shawmac and its findings are contained in **Appendix G** of this report.

In summary Shawmac concludes the following:

1. Under the intended development of the land, the subdivision will yield 6 industrial lots with a single access road.
2. The predicted traffic flows are approximately 5,032 vehicles per day.
3. The new intersection with South Western Highway is predicted to operate at acceptable levels of service for the predicted development year, 2018 and for 10 years beyond the development year.
4. The new road within the subdivision area will be constructed as *Access Road* to an industrial standard, with a 10m wide carriageway and all 8.5m truncated corners. All other cross section details, line marking, intersection control and local area traffic management measures are to be addressed during the detailed subdivision design stages.
5. Pedestrian and cyclist facilities should be provided within the subdivision to allow for future connections on South Western Highway.
6. Public Transport services are not currently available however given the nature of the subdivision this is unlikely to affect the future development operations.

6.2 Fire Assessment

A Bushfire Management Plan has been prepared by Ecosystem Solutions to inform this proposal and is supported by the City of Bunbury.

This plan provides Acceptable Solutions or achieves the intent of the Performance Principle for the criteria outlined in the Guidelines for Planning in Bushfire Prone Areas (WAPC, Dec 2017).

The layout and design of the development is such that no structure will be required to be exposed to a radiant heat flux in excess of 29kW/m2 (BAL-29) provided the management as outlined in the plan is adopted.

The plan acknowledges the proposal is for the development of industrial lots with associated facilities to be developed within the site and that here are no habitable buildings to be constructed within the site.

A summary of the Bushfire Management Strategies to be implemented is provided in Figure 7 of the plan which is attached at **Appendix B**.

6.3 Servicing Considerations

The necessary services to support proposed land use and development of the site are either of very limited capacity or currently not available and will need to be extended / upgraded at the developer's cost from west of the site via South Western Highway.

Accordingly, the servicing requirements have been considered by Development Engineering Consultants as part of this proposal and its report is attached at **Appendix H**. Details of its findings are summarised below.

6.3.1 Roadworks

The subdivisional road will be designed and constructed to City of Bunbury industrial standards, and will be a substantial pavement in width and depth. It is expected that this road will be fully kerbed, with stormwater being collected in roadside swales using suitably designed / constructed "kerb breaks".

No works are envisaged to South Western Highway apart from new intersection treatment at the entrance of the site.

6.3.2 Sewer

The site is not currently connected to sewer and the closest Water Corporation sewer infrastructure is located approximately 2 km west of the site at Dodson Road.

Water Corporation sewer planning for this area shows a future main Type 90 Waste Water Pumping Station (WWPS Bunbury "G") to be located north of the Preston River. No planning or funding has been planned at this stage.

It is also advised that a temporary WWPS will not be approved, and that it would not be workable due to the 2km pumping distance in a small main, leading to problems with stale or septic discharge, paucity of flow needing topping up with scheme water for hydraulic reasons. Therefore, it is obvious that site disposal of wastewater should be affected by the use of ATU's for each site sized to suit.

Discharge from ATU's should be as per Health Department regulations, at least 100 metres from the Preston River, and at least 2 metres above the groundwater/ clay level. This may require filling with suitable granular material (sand with a PRI greater than 10) for lots north of the subdivision road, and locations along the southern boundaries of the lots south of the subdivisional road where the land is higher and depth to clay is suitable.

6.3.3 Water

At present there is a 100mm water main along South Western Highway which appears to be a dedicated main serving the Bunbury Regional Prison. This main is located on the southern verge of South Western Highway according to the plan supplied by Aqwest. It is therefore proposed that a new 150mm water main be extended along South Western Highway to the development from Halifax Drive, approximately 1.5Km west of the site.

Water services are controlled by the Aqwest (Bunbury Water Board), and all design and construction will be to their approval. It is anticipated that a hydraulic study will be required at the cost of the developer to determine the specific requirements of supply of potable and fire- fighting water, street hydrants etc.

6.3.4 Drainage

The eastern boundary of the site is adjacent to the Preston River.

In this regard, the 1 in 100 year flood level of the Preston River will have an impact on the development drainage and minimum fill levels, as a minimum of 500mm height above the estimated 1 in 100 year floodway is required for all areas within developed lots that are to contain significant or critical infrastructure.

The development site will essentially be divided into three stormwater catchments, each directing extreme flow events towards three overflow channels, as described in greater detail in the LWMS report.

Typically fill will need to be placed approximately 1.2 metres above the clay layer, with on-site detention & site soakage required for each industrial lot. Each industrial lot will be provided with an outlet overflow connection pipe which will similarly direct all appropriately detained extreme event overflows into the three "east-west" overflow channels that meet up with three existing natural channels that currently directs all flows into the Preston River.

All stormwater drainage design and construction will be done to the City of Bunbury specification and approval.

Three basin sites will detain the design storm runoff from the proposed road reserve and all lots within the estate will be required to detained flows within their lots to pre-development conditions as outlined in the LWMS report - by way of soak wells, rainwater tanks, underground storage devices &/or detention basins.

6.3.5 Power

A north-south high voltage (HV) aerial line runs within the eastern portion of the site adjacent to the Preston River and has two spur lines near the central-eastern part of lot 81. One of the spur lines heads east over the Preston River and one that heads west to service the existing “dirt bike” track on the west side of Southwestern Highway. Underground HV cables run along the western portion of Bunbury Outer Ring Rd (where it abuts lot 80) and another short length runs along the west side of SW Hwy heading towards the airport. These underground cables are fed from two HV switchgear units on the north side of the Outer Ring Rd - one close to the NE corner of the SW Hwy/Outer Ring Rd intersection & another roughly mid-way between this intersection & the Preston River.

All internal power reticulation lines and transformer installations (& under-grounding / relocation of any existing infrastructure) will be completed at the cost of the developer – including the upgrading (as necessary) of any existing HV switchgear units and the maintenance of supply to all existing / surrounding properties.

It is recommended that the subdivision should be serviced by a transformer at each lot - servicing to at least a WP minimum servicing requirement of 200kVA/ha. The location of each transformer site will be determined at the detailed subdivision design stage.

6.3.6 Telecommunications

Telstra services exist in the area along Southwester Highway adjacent to the site. Some upgrading/ augmentation will be involved. If Telstra is to be the servicing authority, Telstra normally requires twelve months’ notice of the commencement of the development starting in order to ascertain any upgrading requirements.

NBN services are not available

6.3.7 Groundwater and Flood Levels

According to the plans supplied by the Department of Water (DoW), site levels fall from RL 14m AHD along the southern boundary of the site to generally RL 12m AHD along the Preston River frontage.

The previous LWMS report prepared as part of the 2010 Structure Plan proposal has derived AAMGL’s over the site which falls from RL 14.5 on the western boundary to RL 10.0 along a major part of the eastern boundary, adjacent to the Preston River.

The DoW plan also shows the 1 in 100 year flood level for the Preston River adjacent to the development falls from approximately RL12.85 at the north-eastern (upstream) corner of the site to RL 12.18 at the north-western (downstream) corner of the site. At this point the floodway impinges some 25 to 30 metres into the north eastern corner of the site. No filling is allowed within the floodway area which only impacts upon a very small area on the far north-eastern corner of the site.

There is a requirement for any buildings to be sited at least 500mm above the 1 in 100 year flood level. Fill over and above this stipulation will be placed, where required, for this development to provide the required site building classification and allow site soak wells to function. The fill will need to consist of clean free draining sand.

7 CONCLUSION

This Structure Plan has been prepared in alignment with the industrial zoning of the site and the relevant local and state planning framework.

It is envisaged that this Structure Plan will achieve the following:

- Provide appropriate and efficient use of land for industrial purposes to serve the Greater Bunbury Region until 2030 and beyond in accordance with the intentions of the Bunbury Wellington Region Plan, Industry 2030 and the City of Bunbury Town Planning Scheme No. 7;
- Satisfy any shortfall of industrial land in the Greater Bunbury Region and provide opportunity for the delivery of larger industrial lots;
- Facilitate the efficient development of under-utilised land in an economically and environmentally sustainable manner;
- Provide land use opportunities that will complement the existing industrial land to the north and the Bunbury Regional Airport;
- Facilitate the provision of infrastructure to the site;
- Apply environmentally sound local water management design principles in accordance with the proposed Local Water Management Strategy;
- Embrace the intent and fundamental objective to balance economic and environmental values with a rational land use development outcome; and
- Provide a suitable level of detail and planning framework to ensure appropriate subdivision and development of the land.

The proposed Structure Plan is a strategic planning document and informs future subdivision and development of the site for industrial land use and has been prepared pursuant to the provisions of the Scheme as it relates to the Development Zone (‘Industrial’).

The proposal provides a large lot design approach combined with suitable environmental and infrastructure measures to ensure an appropriate planning and development outcome for the site.

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Appendix B:	**Bushfire Assessment**
Appendix C:	**Environmental Assessment**
Appendix D:	**Wetland Buffer Rehabilitation Plan**
Appendix E:	**Black Cockatoo Habitat Tree Management Plan**
Appendix F:	**Foreshore Management Plan**
Appendix G:	**Transport Assessment**
Appendix H:	**Servicing Report**

Appendix A

Local Water Management Strategy

Prepared by Development Engineering Consultants

REPORT

NBR INVESTMENTS
LOT 81 SOUTHWESTERN HIGHWAY
DAVENPORT

LOCAL WATER MANAGEMENT STRATEGY

JULY 2021

DEVELOPMENT
ENGINEERING
CONSULTANTS

Revision History:

Revision	Description	Checked	Approved	Date
0	**Original Issue**	**RDG**	**DNW**	**20/10/2016**
1	**Updated to address items raised in DoW email of 14/11/16**	**RDG**		**10/02/2017**
2	**Updated to address items raised in DoW email of 01/03/2017**	**RDG**		**01/03/2017**
3	**Updated to include current approved secondary treatment systems and aerated wastewater treatment systems**	**RDG**		**13/05/2021**
4	**Updated to address items raised in DWER email of 15/6/2021 (plus general updates / review of all drainage terminology, calculations etc.)**	**RDG**		**30/07/2021**

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- Summary Drainage Analysis of the 1% AEP event
- Summary Drainage Analysis of the 1% AEP event
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Appendix C: Reference Documents
- TME Geotechnical Report – August 2001
- Cardno (Unapproved) LWMS (Lot 15 SW Hwy) – October 2010
- City of Bunbury Information Guide – Stormwater Drainage Plan – March 2012
- Additional Groundwater Monitoring Results – July to Oct 2016
- Approved Aerobic Treatment Units

Executive Summary

Development design strategy: - *To achieve a water sensitive solution in accordance with this LWMS report and the satisfaction of the City of Bunbury.*

This outcome is to be achieved by implementing the following design objectives:-

- Storm water run-off from the road reserve within the proposed development will first be directed into road side table drains to capture "first-flush" nutrients.
- All drainage systems within the proposed road reserve will be designed to manage stormwater run-off generated by at least the 10% AEP (~1 in 10 year ARI) year storm event.
- Stormwater run-off from road reserves will be detained in the table drain by the use of regularly spaced rock spall mounds so that pre- and post-development flows essentially remain unchanged for flows from most common storm events.
- All stormwater run-off from each lot will need to be installed in accordance with any other Council drainage requirements / guidelines and detained / managed "on-site" so that pre- and post-development flows also essentially remain unchanged.
- The natural ground surface of each proposed lot will be re-graded so the finished / re-shaped land evenly follows the existing topography. Lot outlet / connection points will also be provided to proposed lots 810, 812 & 815 to allow post-development extreme event by-pass flows, matched to estimated pre-development flows, and then directed into a suitable outlet channel / pipe system.
- Each lot owner will be responsible to ensure that their finished lot level, where buildings and critical infrastructure will be erected, is filled / raised at least:-
  (i) ~1.2 – 1.5m above the highest recorded groundwater level;
  (ii) At least 0.3m above all estimated 1% AEP (~1 in 100 year ARI) by-pass flows (i.e. lowest adjacent road gutter level or constructed outlet channel / V-drain); **and**
  (iii) At least 0.5m above the 1% AEP flood level of the Preston River.
- Information Packages can be provided to all lot purchasers to:
  (a) Inform owners of their lot fill level constraints / building requirements;
  (b) To inform owners to treat, detain & manage "on-site" all post development flows to pre-development levels (& to any other Council requirement);
  (c) To use of rainwater tanks (plumbed in to their building);
  (d) To install water efficient devices & appliances; and
  (e) To plant Water-wise & Nutrient-wise plants.

1 Introduction

This LWMS report has been prepared in order to achieve a viable storm water management outcome over the proposed subdivision of Lot 81 Southwestern Highway in Davenport. The document will be used to guide the design and construction of the proposed drainage solution for the subdivision of lot 81 as detailed in Appendix A of this report.

1.1 Total Water Cycle Management - Principles and Design Objectives

Total water cycle management can be achieved by completing a water balance study to account for all water volumes that enter and leave the site (in 3-dimensional space) over a specified period of time. Under existing land use activities all water that enters the site would (obviously) closely match the amount of water leaving the site (over a specified period of time). Once the site is fully developed, it is anticipated that this situation could essentially remain unchanged provided:-

- All scheme water entering the site is permitted to leave the site in a relatively similar time frame. This is typically most readily achieved via a standard piped wastewater disposal system. However, for this project, a pipe sewer system is not a viable option, so "on-site" effluent treatment solutions will be used. This means that the time taken for the used scheme water to leave the site will be much longer compared to a standard piped wastewater disposal system.

  All collected rainwater &/or captured surface run-off used to minimize scheme usage or used around the property for irrigation / cleaning purposes etc., will also typically re-enter the system via infiltration. Furthermore it is unlikely that all property owners / operators will refrain entirely from using scheme water outside of their premises - meaning additional water is expected to enter the fully developed site over time. If ground levels and climate factors were to remain constant, his would cause groundwater levels to rise, but in reality, the impact from any rise in ground water levels will be relatively small provided the land is appropriately raised (where required) using suitable free-draining fill material.
- All storm water run-off from impervious surfaces should be appropriately detained so pre & post development flows remain unchanged, or at least temporarily captured, used &/or infiltrated on-site in accordance with Council requirements / guidelines.

The following water sensitive design criteria will therefore be implemented as part of the proposed development of Lot 81 Southwestern Highway:

- ***Water Conservation & Water Efficiency***
  Principal#1: To minimise the use of scheme water outside of the premises and to use all scheme water as efficiently as possible.
  Objective#1: All lot purchasers will be encouraged to install rain water tanks (preferably plumbed into their premises); to use water efficient devices and appliances and to plant "Water-wise" and "Nutrient-wise" gardens.
- ***Water Quantity Management***
  Principal#2: To ensure that all storm water is disposed into appropriately sized facilities as close as possible to where the run-off is generated.
  Objective#2: All drainage facilities in road reserves and lots will all be designed to manage flows up to and including at least the 10% AEP storm event.
- ***Water Quality Management***
  Principal#3: To improve the overall surface & groundwater quality of the water leaving the estate (compared to pre-existing conditions or conventional pipe drainage systems).

Objective#3: Ensure that the total installed (bio-retention) swales in the development represent at least 2% of the total constructed impervious area (CIA) – both within public road reserve and all properties within the estate.

1.2 Planning Background

Lot 81 Southwestern Highway, Davenport is located on the eastern side of the Southwestern Highway – approximately 8km from the Central Business District of Bunbury, just south-east of the Bunbury Airport. The land is zoned "Development Zone – Industrial" under the City of Bunbury's Town Planning Scheme (TPS) No. 7.

1.3 Previous Studies

The most recent drainage study prepared over lot 81 (formerly part of lot 15) was completed by Cardno (for NBR Investments Pty Ltd) in October 2010 to support a Local Structure Plan for a proposed industrial subdivision with lots ranging in size between approximately 1200m^2 and 5200m^2 (Refer to copy included in Appendix C). **Note:** Cardno's October 2010 LWMS report has actually never been approved by DoW and should therefore only be considered as a "Draft" / "unapproved" version. Nonetheless, the report does outline / recommend the use of Water Sensitive Urban Design (WSUD) techniques including:

- Detention of storm water rather than rapid conveyance;
- Use of vegetation for filtration / nutrient stripping purposes; and
- Adoption of water efficient landscaping & other water sensitive initiatives.

2 Proposed Development

2.1 Key Elements of the Proposed Development

Lot 81 lies between Southwestern Highway (to the west) and the Preston River (to the East) as shown in the subdivision plans contained in Appendix A. The site is to be developed into 6 large industrial lots ranging in size from ~5 to 9 ha.

All storm water run-off is to be managed in accordance with current Department of Water "Water Sensitive Design Guidelines" – where disposal of storm water run-off is managed to mimic pre-development hydrology. On this project, this will be achieved via installing road-side table drains as requested by Council. The table drain will help capture nutrients and other pollutants ("as close to source" as possible) and enable extreme by-pass flows to reach the Preston River. Regularly spaced mounds within the road-side table drain will help detain and infiltrate all small and minor storm events and thereby help ensure that post-development flows, for these events, closely match estimated pre-development flows rates.

2.2 Previous Land Use

The site consists of cleared farmland with isolated trees and is being used for grazing livestock on an ad hoc basis. The land now mostly comprises re-vegetated grasses – refer to the aerial photo in Appendix A.

2.3 Finished Lot Levels

The natural ground surface of each proposed lot will be re-graded so the finished / re-shaped land evenly follows the existing topography. This will ensure that all pre-development surface flows can travel unimpeded over the existing in-situ material.

Each lot owner will be responsible to ensure that their finished lot level, where buildings and other critical infrastructure will be erected, is filled / raised :-

(i) ~1.2 - 1.5m above the highest recorded groundwater level (Refer sec. 6.5);

(ii) At least 0.3m above all estimated 1% AEP by-pass flows (i.e. lowest adjacent road gutter level or constructed outlet channel / v-drain) and;

(iii) At least 0.5m above the 1% AEP flood level of the Preston River.

3 Design Criteria

The drainage requirements for developments within the City of Bunbury (CoB) are controlled by specific design standards and it is expected that the following design parameters will apply to the drainage strategy on this proposed development:

Item	Description	Requirement	Source / Comment
1	Table drains	To retain at least the 1st 15mm of the storm event	Standard DoW requirement for (most) developments.
2	Road drainage – pipes, table drains & verge detention swales	To accommodate at least the 10% AEP storm event	Standard Council requirement for (most) industrial developments.
3	Min. lot freeboard	0.5m (above 1% AEP flood level / flow path)	Standard Council &/or DoW requirement (most) developments.
4	Swale / basin batters - Vegetated:	Max. 1 in 3.0	Standard Council requirement for (most) unfenced basins / swales.
	Grassed:	From 1 in 6.0 to 8.0	
	Fenced:	1 in 1.5 with max. 1 in 4.0 maintenance access ramp	Typical fenced sump details (Not used)
5	Road reserve run-off coefficients	Varies 0.6 - 0.80	Typical / standard values
6	Commercial / Industrial lots	In accordance with CoB Information Guide	Refer Appendix C

4 Pre-development Environment

4.1 Existing Information / Infrastructure and Design Constraints

Existing services include scheme water, sealed roads, power and telecommunication services. Existing three phase voltage overhead power lines traverse the property and will need to be relocated as part of the proposed subdivision. Due to the high power demand from industrial uses it is expected the power supply will need to be upgraded. While there are existing Telstra services located along Southwestern Highway adjacent to the site, it is extremely unlikely that these services will have sufficient capacity to serve this proposed development. Telstra's network is therefore expected to be extended from the corner of Halifax Drive and Endeavour Road (approximately 1.5 kilometers north of the site) in order to properly service this subdivision.

This means that Lot 81 has no significant servicing or infrastructure constraints to prevent the proposed industrial subdivision from proceeding.

4.2 Site Conditions

Lot 81 mainly consists of material derived from a Guildford formation overlaying a Cretaceous Leederville formation. Land elevations fall relatively evenly across the property - ranging from RL 15m AHD (to the west) to RL 11m AHD (to the east).

Site contours and other existing features are shown on plans in Appendices A & C.

4.3 Geotechnical Characteristics

A preliminary geotechnical investigation was carried out over the site by Thomas McRobert Edgeloe Group (TME, Aug 2001) which indicated that the subsurface soil type derived from a Guildford formation comprises an alluvial clay / silt / sand mixture. The content of silt & clay can vary significantly to produce infiltration rates ranging between 1×10^{-4}m/s (~8.65m/day) and 1×10^{-7}m/s (~0.01 m/day). TME's report also concluded that due to the presence of a shallow (perched) water table, fill may be required up to 1.2m in some areas in order to achieve a satisfactorily separation from existing groundwater levels. Furthermore, estimated Preston River flood levels indicate that areas to accommodate permanent buildings will also need to

be filled to at least ~RL13.3m AHD near the south-eastern boundary and ~RL12.7m AHD near the north-eastern boundary in order to achieve a minimum 0.5m freeboard above the expected 1% AEP flood level (should these lot owners actually wish to place any critical infrastructure within or near these "lower-lying" areas).

The WA Atlas for Acid Sulfate Soil (ASS) risk mapping classifies the study area as having a "low-moderate risk of ASS occurring within 3m of the natural soil surface".

4.4 Environmental Assets and Water-Dependent Ecosystems

The major part of lot 81 has been classified as "Multiple Use Wetlands" (MUW) and abuts some environmentally sensitive / "Conservation Category Wetland" (CCW) areas – namely the buffer area to the west and the existing buffer strip around the Preston River to the east of the site. The Preston River is a proclaimed waterway under the Rights in Water and Irrigation Act 1914 and is also classified as a Conservation Category Wetland on the Geomorphic Wetland dataset. The foreshore / buffer distances will therefore need to be assessed in accordance with Operational policy 4.3: Identifying and establishing waterways foreshore areas (DoW 2013) and Guideline for the Determination of Wetland Buffer Requirements: draft for public comment (WAPC 2005).

All stormwater run-off from the proposed subdivision roads will be directed into rod side table drains in order to capture as much nutrients (& other pollutants) to minimise untreated flows reaching the CCW area during most common storm events.

4.5 Surface Water Aspects

Cardno's (unapproved) Oct 2010 LWMS report included pre-development surface water discharge results based upon site specific hydrological and hydraulic modelling. Cardno's surface water discharge results (for their two eastern catchments) covered the whole of lot 81 and have therefore been used to establish the values to initially be adopted as the pre-development flows (within the proposed road reserves & lots) for this proposed subdivision. These initial adopted values are shown in Table 1 below.

Table 1 –Surface Water Discharge Flows

Estimated pre-development flows :– from proposed lots & road reserve(1 & 2)					**Estimated max. allowable flows along proposed outlet channel / V-drain(2):**					**Approx. V-drain Details** <--- with 1 in 4 batters --->	
Lot / Road Catchment Name	~Area Ha	**63% AEP** l/s	**20% AEP** l/s	**1% AEP** l/s	**1% AEP event**	**Max. Flow**	**Likely Flow**	**Design Flow**	**Approx grade**	**~required x-sect area**	**~required depth**
Lot 81	**41.83**	**58**	**265**	**639**							
lot 810	5.23	7	33	80						Side slopes	1 in 4
lot 812-N	4.45	6	28	68						Base width	0.3m
lot 812-S	4.45	6	28	68						Max. width	3m
lot 815-N	3.28	5	21	50						- Refer channel	flow calcs
lot 815-S	3.28	5	21	50	**V-Drain in:**	**l/s**	**l/s**	**l/s**	**1 in**	**m²**	**m**
lot 811	7.75	11	49	118	N –in L811	235	167	250	180	0.24	0.33
lot 813	5.17	7	33	79	C –in L813	247	129	250	200	0.24	0.33
lot 814	5.71	8	36	87	S –in L814	107	57	150	180	0.16	0.23
RR-N	1.25	2	8	19							
RR-C	0.74	1	5	11	**Note:** Each channel (including a min. 3m wide maintenance access way)						
RR-S	0.47	1	3	7	Is to be fully contained in at least a 6.0m wide* easement.						
Other	0.06	0	0	1	*(**Actual easement width is subject to final approved detailed design drawings**)						
Totals	**41.83**	**58**	**265**	**639**							

Notes:- (1) All values interpolated from the discharge rates in TME Groundwater Monitoring Report – Dec 2009
(2) All flows to be confirmed as part of detailed design submission / subdivision approval.
RR = Road Reserve; N = Northern; C = Central; S = Southern

4.6 Groundwater Aspects

A total of 15 bores were monitored by Thompson McRobert Edgeloe Group (TME, 2009) between December 2007 and November 2009 capturing two years of peak groundwater level data over the entire area of lot 81. The depth to groundwater ranged between 0.01m and 2.10m below existing ground surface. The AAMGLs range between 14.5m AHD and 11.0m AHD as outlined in TME's Dec 2009 report. (Refer Appendix D of Cardno's October 2010 LWMS report).

Note:- There is no current known information available that specifically details the quality of the existing ground water moving under &/or across lot 81.

5 Water Sustainability Initiatives

5.1 Water Efficiency Measures

In terms of water conservation, everyone recognises that water is rapidly becoming a valuable natural resource. Much of the water conservation effort is now focusing on encouraging the community to use water saving devices and appliances; promoting the use of appropriate planting to suit the local environment, and by providing on-going information &/or community education on water conservation initiatives.

The current state government's requirement to increase the efficiency of water use in new developments to a target of under 100kL per person per year. Consequently water conservation will be encouraged through the promotion of native, water-wise gardens and water efficient devices & appliances. All requirements for the purchaser can be outlined in their purchase contract and associated information handouts. The information can also outline the benefits to lot owners to conserve water and to even encourage them to install rainwater tanks plumbed into their premises / buildings etc.

5.2 Water Supply

A standard Water Corporation reticulated water supply service is to be to be provided to this development.

5.3 Wastewater Management

A standard Water Corporation reticulated sewer system is not a viable option within this development, so "on-site" effluent solutions will need to be installed by each property / business owner, in accordance with their specific business / operational needs and to the satisfaction of the City of Bunbury (CoB) and Department of Health.

Appendix C provides a list of several approved Department of Health standard Aerobic treatment units (ATU's) – some of which could potentially be used in commercial solutions, provided they are installed and operated in accordance specific codes and regulations. It is expected that several of the ATU's contained in this list would be capable of achieving CoB / DoW requirements including but not limited to specific infiltration constraints, separation to the highest known groundwater table, horizontal buffer distance to the Preston River and associated CCW areas, etc.

6 Stormwater Management Strategy

6.1 Post - Development Hydrology

The drainage strategy for all road reserves is to dispose of stormwater by detention and soakage using WSUD methods. In general, stormwater runoff from road pavements will be directed into road side table drains with regularly spaced mounds.

All road storm water run-off will initially be captured in road-side table drains as indicated in the post-development catchment plan contained in Appendix A. All road reserve extreme event by-pass flows will then be diverted into suitably design / located outlet channels &/or piped drainage systems that will in turn help allow all flows to continue to reach the Preston River.

The base of all road side table drains will be constructed with free-draining sand to be at least 0.2m above the re-shaped in-situ material (which will effectively be very close to the maximum / perched groundwater level).

All lot owners will be required to implement similar stormwater management / detention strategies. i.e. Roof run-off from buildings can be collected in rainwater tanks for internal & external use (watering plants, flushing toilets etc.) and all overflows from the roof collection tanks, parking &/or hardstand areas either be infiltrated in soak wells, underground storage facilities &/or "on-site" detention swales or basins so that the water can either be re-used or at least sufficiently detained in order for post development flows to approximately match or mimic pre-development conditions. The strategies that will be used / adopted by each lot owner will of course be influenced by many factors: - including the actual portion of their lot area they wish or require to actively use in order to run their proposed business operation; the building area required, the amount of hard stand areas, the amount of clean sand fill each owner wants to provide to achieve adequate effluent treatment, landscaping needs, flood protection etc. etc. Recommended minimum finished fill levels over the entire site are indicated in Cardno's (unapproved) October 2010 LWMS report – but these can be reviewed / refined subject to detailed design and actual individual property owner specific operational requirements.

Lot outlet / connection points will also be provided to proposed lots 810, 812 & 815 to allow post-development extreme event by-pass flows (matched to estimated pre-development flows) to be directed into a specific outlet channel / pipe system.

Scour protection facilities will also be provided to accommodate / manage by-pass flows resulting from events up to and including the 1% AEP storm event from each outlet channel / pipe system that is to direct flow to the Preston River.

6.2 Frequent events

All storm water run-off from the public road reserve will first be directed in to a road side table drain which will be designed to accommodate at least the 1st 15mm from each storm event and most likely even the 63% AEP event. Mounds will be installed in the road side table drains at regular intervals – approximately every 33m.

These shallow table drains will be used to capture "first-flush" flows and allow higher magnitude flows to simply by-pass once fully inundated with water. All drainage facilities will be constructed / installed to Council requirements.

Similarly, all lot owners will also be required to fully retain, re-use and fully treat (as the case may be) at least the 1st 15mm of run-off "on-site". This can be achieved in a number of ways – including the use of rainwater tanks, soak-wells, underground storage, landscaped swales or a combination of one or more of these or similar devices – depending upon the nature of their proposed business / operation etc. Ideally, wherever possible all installed treatment devices should be designed so that by-pass flows from major event storms do not re-mobilise any captured nutrients.

6.3 10% AEP event

All drainage systems in the industrial estate will be designed to detain at least the 10% AEP (~1 in 10 year ARI) ARI event. Note: Calculations shown in Appendix B (conservatively) assume a C_{10} runoff coefficient of 0.75 for the proposed 25m subdivision road reserve (based on a 10m wide pavement & 2 x 7.5m wide verges).

Stormwater run-off from events exceeding the 10% AEP event will be directed towards appropriately sized outlet channel / pipe system that will join into the existing natural channels that currently allows all surface flows to reach the Preston River.

6.4 1% AEP event

All roads &/or channels within the estate will be designed to fully accommodate and direct extreme event outlet flows to the Preston River.

Indicative overland flow paths are shown on the post-development catchment plan in Appendix A.

6.5 Finished Lot Levels (Relative to the 1% AEP flood levels)

All areas to accommodate permanent buildings or other critical infrastructure will need to be raised / filled to 0.3m above all estimated 1% AEP by-pass flows (i.e. lowest adjacent road-side kerb level or constructed outlet channel / pipe system) and at least 0.5m above the 1% AEP flood level of the Preston River. **Note:** There may also be other authority constraints that impacts the minimum fill requirement for each lot other than that for flood control – e.g. Minimum fill requirements for the installation / use of approved secondary treatment systems and aerated wastewater treatment systems – for example (Appendix C for references to relevant Australian Standards) – Refer also to section 2.3 of this report.

6.6 Best Management Practices Water Quality Targets

The DoW's Stormwater Manual provides guidelines and information on best management practices that should be applied to land development and construction sites in order to improve stormwater management and environmental performance.

Poorly managed land development sites can often be a major source of stormwater pollution. Certain construction activities can allow pollutants to be transported (via existing stormwater systems or over-land flow) to adjoining receiving water bodies.

Common sources of pollutants from construction activities include those from:

- Litter & waste storage areas - that allow materials to be blown by wind or washed away by rainfall into existing water ways.
- Wash-down areas - poor practices can allow materials to enter water ways.
- Placement & storage of delivered products - particularly sand and soil stockpiles where such materials may be tracked by vehicles onto roads, or blown, or washed on to roads which then get into existing stormwater systems / water ways.
- Dewatering activities– which can cause sulfide minerals in the soil to oxidise and leach acidity, heavy metals & aluminum into groundwater where the contaminated groundwater can then adversely impact on existing receiving water bodies.

Consequently no contractor will be permitted to commence any subdivision construction activity until an Environmental Management Plan (EMP) is submitted; reviewed & approved by Council that fully addresses:

- litter and waste management practices (non-hazardous & hazardous materials);

- vehicle & equipment washing-down practices;
- water conservation practices;
- erosion and sediment control (based upon based on site conditions);
- product placement & storage practices;
- any other practices that may adversely impact upon water dependent eco-systems.

Current water quality management best management practices require that installed drainage treatment facilities at least achieve the following design targets:

(i.) The total surface area of installed bio-retention swales to be sized at no less than 2% of the total constructed impervious area (CIA) they receive runoff from; **OR**

(ii.) At least reductions in: 80% of total suspended solids; 60% of total phosphorus; 45% of total nitrogen and 70% of gross pollutants is achieved when compared to a conventional drainage system.

The first design target method above has been used to demonstrate that the proposed road side table drain system will readily achieve this desired target – refer also to the summary swale information sheet in Appendix B.

7 Groundwater Management Strategy

7.1 Groundwater Level Management

The base of all proposed table drains will be constructed with a base that will be at least 0.2m above the re-shaped in-situ material and the entire road reserve will be created on top of a 0.6 – 1.0m layer of clean free-draining sand. No other groundwater management controls systems are considered necessary. Similarly, lot owners will be required to import sufficient clean free-draining fill material to suit their proposed business operation / area to be developed and to implement drainage strategies as outlined in this report. i.e. All areas on a lot, to accommodate buildings and other similar critical facilities, will need to be filled 0.3m above all estimated 1% AEP by-pass flows (i.e. lowest adjacent road gutter level or constructed outlet channel) or filled to at least 0.5m above the 1% AEP flood level of the Preston River.

7.2 Drainage Retention System(s) & Drainage Inverts

Typically (depending upon Council's current design standards / guidelines), all table drains / channels etc. are expected to be designed to have a maximum depth of around 0.5m (relative the adjoining front or side property boundary level or abutting road gutter level). The invert levels for drainage pipes are generally around 1.0m below the finished ground / pavement level with typically at least 600mm cover – but the cover over these pipes and the consequent depths to invert levels can be reduced by using stronger / higher class pipes.

7.3 Sub-soil Drainage Design

Sub-soil drainage lines will be avoided as they are not intended to be used / required within the road reserve of this proposed subdivision. The entire road pavement will be constructed to a suitable strength / thickness and raised to a sufficient level using suitable imported clean sand fill to eliminate the need to use any sub-soil drainage.

7.4 Groundwater Quality Management Strategies

Vegetated road-side table drains will be used to treat the required 2% of the CIA – in an effort to at least achieve reductions in: 80% of total suspended solids; 60% of total phosphorus; 45% of total nitrogen and 70% of gross pollutants - compared to a conventional drainage system.

Lot purchasers will also be required to achieve these minimum standards and will also be advised that a minimum of 10–50cm deep band of blended top soil (with a Phosphorous Retention Index > 15 & a Phosphorous Retention Capacity > 80%) be used over all grassed &/or planted areas (particularly those areas that are to be used to receive recycled &/or treated waste water etc.).

7.5 Discharge to Water Dependent Eco-systems

A prime concern for the nutrients emanating from the development is the long term health of the below ground water that will ultimately reach the Preston River. Hence all stormwater run-off from roads will be captured in "first-flush" road-side table drains and as such, the opportunity for nutrients from within this proposed road reserve to impact on the ground water should be minimal. Obviously, the lower the concentrations of nutrients in run-off, the lower the net nutrient export will be from the site – so it is important that all stakeholders are made aware of this basic fact. i.e. The major source of nutrients in the storm water system is likely to be from the application of garden fertilisers and eroded particulate matter – particularly during the building construction phase.

Minimisation of nutrient loading can be achieved through:

a) Education of local residents and Council maintenance personnel; and
b) By implementing frequent street sweeping & stormwater maintenance programs.

7.6 Specifications for Imported Fill

The fill material to be used to achieve all final compacted finished road levels shall comprise of clean free-draining sand containing less than 3% fines – particularly in the base of verge swales / infiltration areas where the effective "K_h" permeability value of the compacted fill material will be targeted to be at least 5m/day.

7.7 Finished Lot Levels

All lot owners will be required to fill their lots (with clean free-draining sand containing less than 3% fines & an effective "K_h" permeability value >5m/day) to finished levels ~1.2m above the highest recorded groundwater level (on that lot); 0.3m above all estimated 1% AEP by-pass flows (i.e. lowest adjacent road gutter level or outlet channel and at least 0.5m above the 1% AEP flood level of the Preston River where permanent buildings or other critical infrastructure is to be erected.

8 Future Subdivision and Urban Water Management Plan

It is anticipated that the development of lot 81 will be completed as a single stage and it could be argued that a formal Urban Water Management Plan may not be necessary provided that the final drainage solution for the development complies with the basic strategies as outlined in this document **and** is implemented to the full satisfaction of the Council. An UWMP can be prepared as a condition of subdivision but preferably just fully incorporated / addressed as part of the detailed engineering design drawings - that will obviously need to be approved by Council prior to the commencement of any subdivision works anyway.

9 Monitoring

Due to the small scale of this development and the proposed drainage solution (using road-side table drains) any "site-specific" on-going monitoring of water quality would not be expected to provide any significant benefit / meaningful results with respect to flows generated from the road reserve. Lot owners may however be required to demonstrate over regular periods that the amount and quality of the

discharge from their operations are complying with specific / readily measurable (Council &/or DWER) requirements.

If in the event that any water quality parameter (particularly nitrogen & phosphorous levels) were measured and happen to exceed specific levels, then corrective action could be readily initiated – including:

1. Reduction in fertiliser application rates including the review of required use, timing or manner in which the fertilisers were being applied.
2. Additional soil amendment / augmentation in high nutrient inundation areas.
3. Increased planting of water & "nutrient thirsty" plants in / around the created infiltration basins / swales or other associated infiltration areas etc.

10 Implementation

The proposed drainage system will incorporate several objectives and principals for managing stormwater disposal "at source" – including the installation of vegetated swales and the provision of water conservation advice - via information brochures distributed at the time of land sale / execution of the contract of sale etc.

All water management strategies (as outlined in this report) can readily be implemented throughout this proposed development.

10.1 Commitments

The developer is committed to:

- Installing table drains within the road reserve of the estate to maximise storm water capture "at source" and to help pre-treat at least the "first-flush" storm event prior to any stormwater flowing towards the Preston River.
- Extreme event by-pass flows (typically in excess of the 10% AEP event from the road reserve & possibly from some lots) will all continue to be directed straight to the Preston River via suitably sized / designed outlet channel(s) or pipe system capable of accommodating by-pass flows generated from events up to the 1% AEP storm event; and to:
- Providing Information Packages to all lot purchasers so as to fully inform:
  (a) Owners of lot fill level constraints & other associated building requirements;
  (b) To inform owners to treat, detain & manage "on-site" all post development flows to pre-development levels & to any other Council requirement(s);
  (c) To consider the use of rainwater tanks (plumbed in to their building);
  (d) To install water efficient devices & appliances; and
  (e) To plant Water-wise & Nutrient-wise plants.

10.2 Maintenance Schedules (Incl. Roles & Responsibilities)

Each property owner will be encouraged to regularly inspect and clean-out their rainwater tanks, storage devices &/or soakage pits / devices – on at least an annual basis. (This could, for example, very easily be achieved by providing some form of notification as part of Councils issuing their regular rate payment notices).

Initially all table drains / drainage facilities installed in the development will need to be maintained on a regular 6 monthly basis. Eventually (after most building construction is complete) the only long-term maintenance requirements will be the removal of deposited wind-bourn materials and the removal of sediment build-up in the base of each drainage facility (which will be minimised through lot owner and Council's regular maintenance programs / pavement sweeping etc.).

Over the summer period, particulate matter may also build up in storm water drainage system. In the initial years of building construction, this will be from soil washed into the storm water system, while leaves, litter and grass clippings etc. impacting the system in the longer term. Furthermore, small volumes of litter and leaves left in the drainage system or in the trapped pits for long periods of time can break down and contribute to higher nutrient outflows from the site and therefore the following maintenance programs are recommended:

a) Cleaning of drainage infrastructure. By regular removal of all trapped debris from drainage pits and silt traps. In the long term particulate matter may build up in the drainage facilities and may also require some cleaning. To account for this the swales / table drains can be installed with an additional / extra "sacrificial depth" or designed to function with a "clogged" layer to allow for the effects of some sediment build up to occur – which will help minimise the regularity of cleaning these facilities.
b) Regular road sweeping to remove particulate build-up on road surfaces & gutters (particularly during building construction phase).
c) Appropriate disposal or composting of green waste to ensure that such material does not reach downstream storm water systems.

Drainage infrastructure maintenance should at least occur on a biannual basis - just prior to winter & again in the middle of winter and obviously more regularly during periods of major building construction. Maintenance of silt traps (& street sweeping) will probably need to occur at ~3 - 6 month intervals depending on the loading.

It is anticipated that only standard Council checks and cleaning maintenance requirements will need to be applied to the drainage system proposed for this estate – with suggested inspection / maintenance frequencies as outlined in the table below:

Table 2 – Drainage Maintenance Inspection Frequency Requirements

#	Drainage Element:	Possible Maintenance and Inspection Frequency:	Responsibility:
1	Rainwater tank(s) & other "on-lot" facilities.	Annually inspection & clean-out (as necessary) – just prior to winter rains.	Lot Owner
2	Vegetated (bio-retention) swales, landscaped table drains and unfenced basins.	<u>During developer maintenance / defects period</u>: Inspect, clean-out & maintain plants ~3 - 6 month intervals (depending on loading) – as part of standard estate maintenance works / defects period.	Developer
		<u>After developer maintenance period</u>: Inspect, clean-out & maintain plants (as required) as part of Council's regular bi-annual / annual maintenance program.	Council
3	Drainage culverts, vegetated drainage channels, pipes, pits & fenced basins.	<u>During developer maintenance / defects period</u>: Inspect, clean-out & maintain structures annually – just prior to winter (& then again in Aug / Sept as necessary).	Developer
		<u>After developer maintenance period</u>: Inspect, clean-out & maintain structures at least annually – just prior to winter – but inspection frequency will need to be higher during building construction phase.	Council

10.3 Funding

The developer will be funding the installation of all drainage infrastructure as well as the initial maintenance and monitoring costs associated with each of these facilities for the periods as outlined in section 10.2 above.

10.4 Review

Once approved / accepted by Council - there will not be a need to review this LWMS for this development particularly as any minor adjustments can easily be addressed under the WAPC subdivision approval process or as part of the detailed engineering design submission process to Council.

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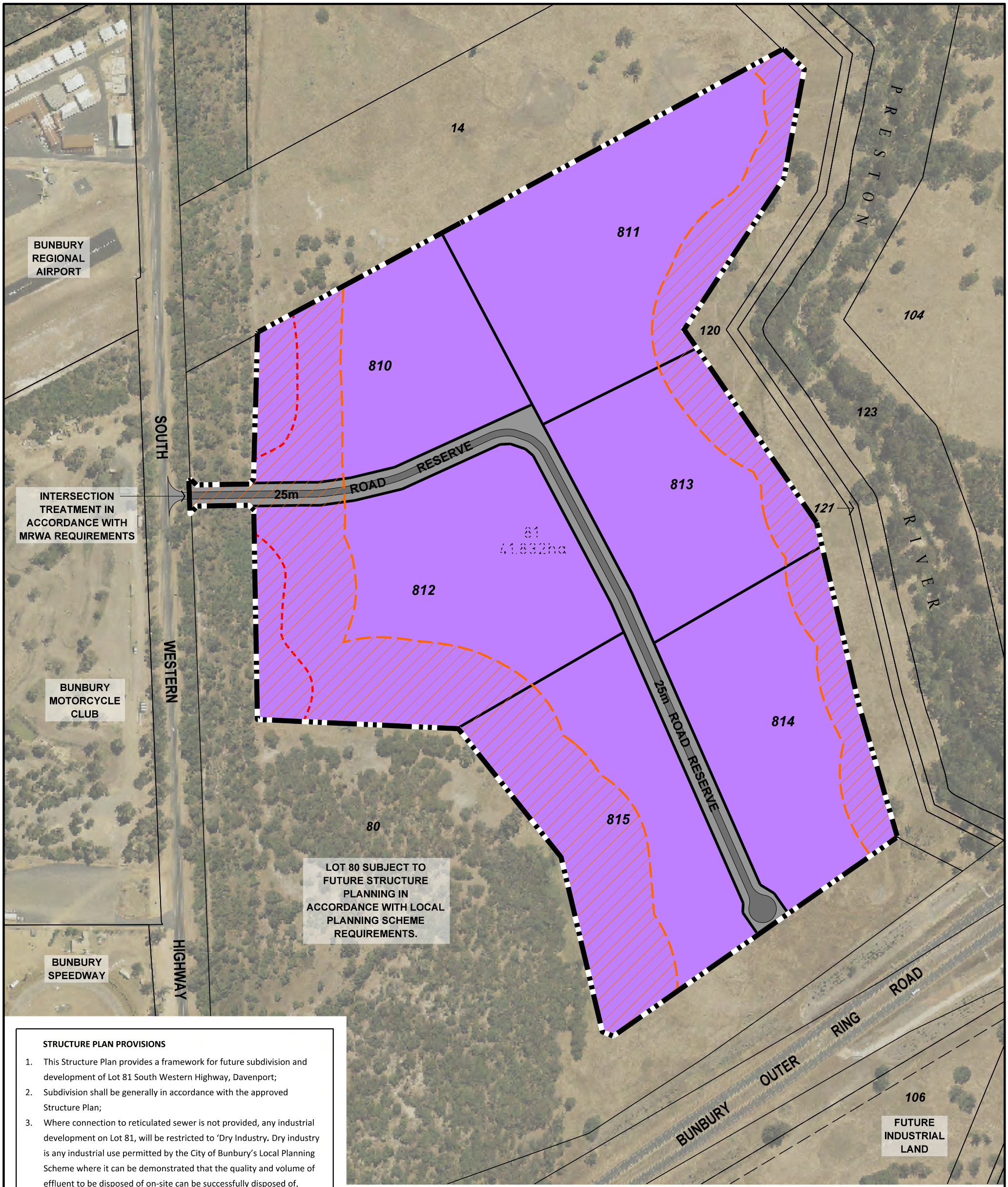
APPENDIX A – SUBDIVISION PLANS

- Structure Plans
- Locality plan
- Aerial Photo
- Pre-development Catchment plan
- Post-development Catchment plan
- Typical Drainage Details
- Estimated 1% AEP Floodway Levels for the Preston River



STRUCTURE PLAN PROVISIONS

1. This Structure Plan provides a framework for future subdivision and development of Lot 81 South Western Highway, Davenport;
2. Subdivision shall be generally in accordance with the approved Structure Plan;
3. Where connection to reticulated sewer is not provided, any industrial development on Lot 81, will be restricted to 'Dry Industry. Dry industry is any industrial use permitted by the City of Bunbury's Local Planning Scheme where it can be demonstrated that the quality and volume of effluent to be disposed of on-site can be successfully disposed of, without adverse environmental or health effects, utilising effluent disposal systems approved by the Health Department of Western Australia, the Department of Environment Regulation and the Department of Water. In addition, development will be restricted to the type which is predicted to generate wastewater intended for disposal on site at a daily volume not exceeding 540 litres per 2000m².

LEGEND

- STRUCTURE PLAN BOUNDARY
- INDICATIVE LARGE INDUSTRIAL LOT BOUNDARY
- INDUSTRY
- CONSERVATION CATEGORY WETLAND 50m BUFFER
- DRAINAGE
- BUSHFIRE PRONE AREA

0 40 80 120 160
metres

NOTES

Base data supplied by Harley Dykstra

Projection - GDA94

Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

SCALE	:	*1:4,000 @ A3*
DATE	:	*10 October 2016*
PLAN No	:	*81DavenportLSP_V1.0_20161010*
REVISION	:	*A*
PLANNER	:	*SLB*
DRAWN	:	*BL*

STRUCTURE PLAN

Lot 81 South Western Highway, Davenport

LB PLANNING
TOWN PLANNING | URBAN DESIGN | LAND DEVELOPMENT CONSULTING

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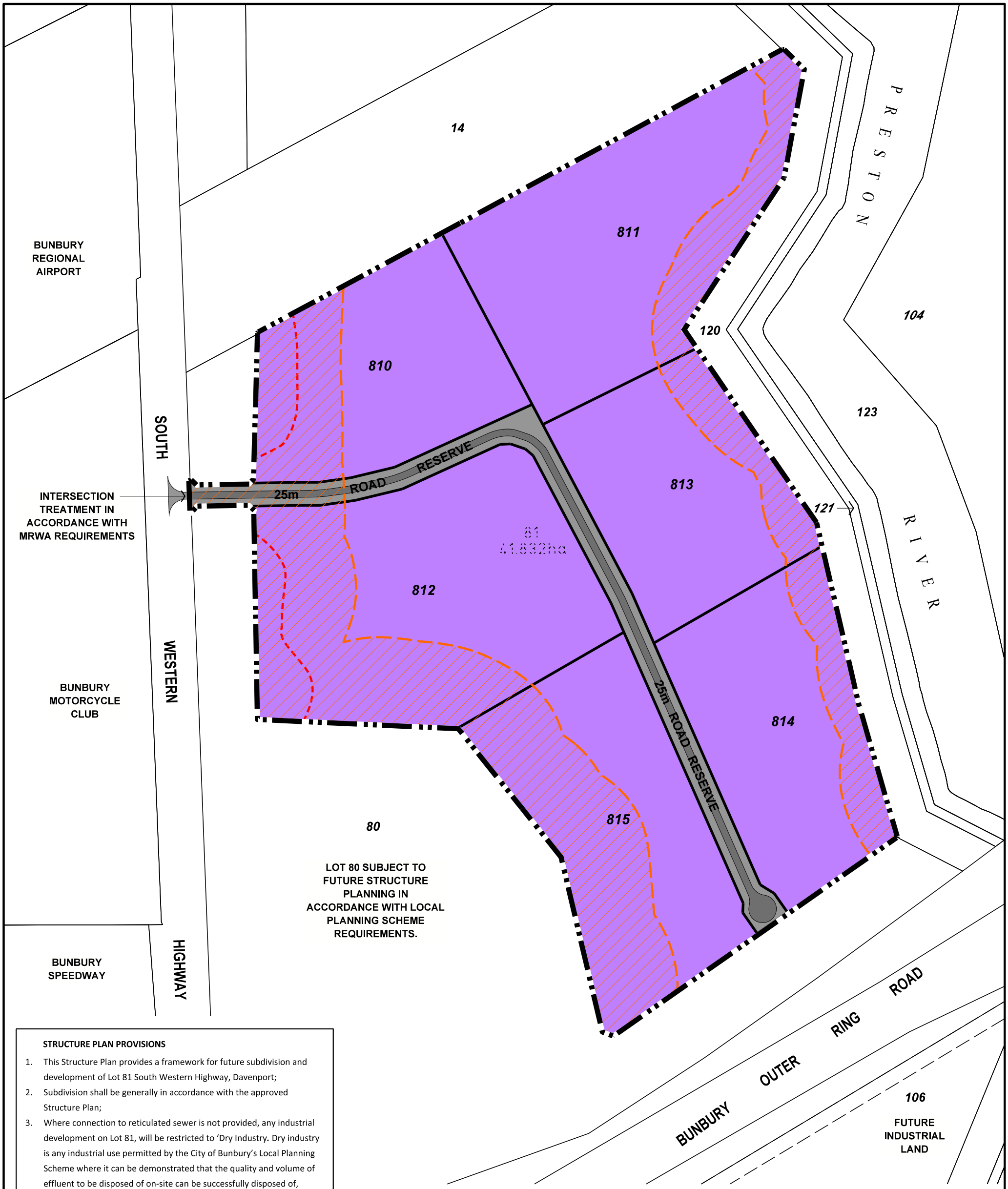

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STRUCTURE PLAN

Lot 81 South Western Highway, Davenport

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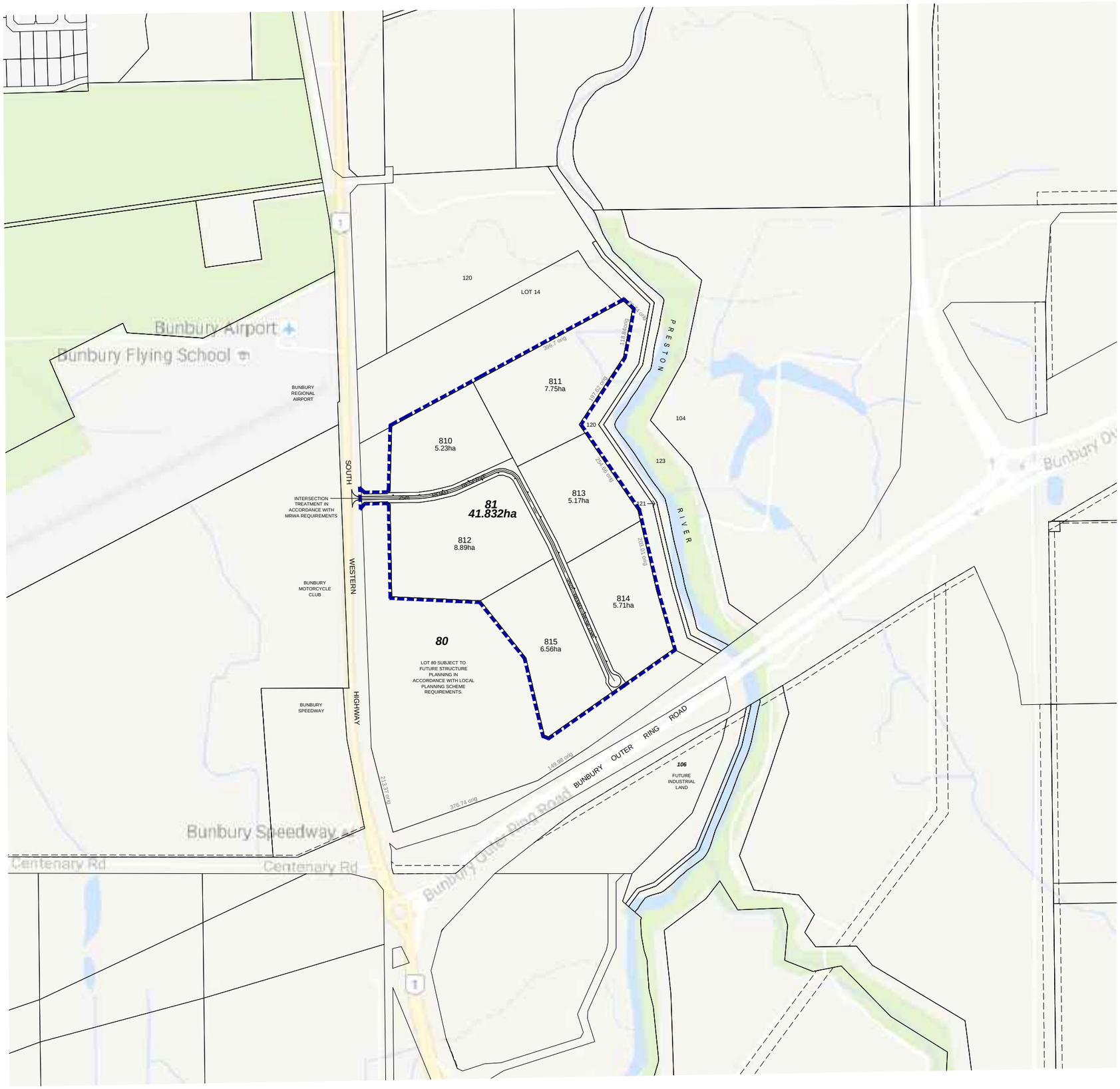

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No.	DATE	BY	REVISION	
A	6/10/16	JEG	INITIAL ISSUE	RDG

CLIENT: **NBR INVESTMENTS**

DEVELOPMENT ENGINEERING CONSULTANTS

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Fax: (08) 9481 1700

PROJECT: **LOT 81 SOUTH WESTERN HIGHWAY DAVENPORT**

W.A.P.C. No. -

DRAWING: **LOCAL WATER MANAGEMENT STRATEGY LOCALITY PLAN**

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SCALE	DRAWN	CHECK	REV No.
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DATE	DESIGNED	APPROVED	
14/9/16	JEG	RDG	

PROJECT NUMBER **PRO1069** DRAWING NUMBER **L01**

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CLIENT: **NBR INVESTMENTS**

DEVELOPMENT ENGINEERING CONSULTANTS
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Fax: (08) 9481 1700

PROJECT: **LOT 81 SOUTH WESTERN HIGHWAY DAVENPORT**
W.A.P.C. No. -

DRAWING: **LOCAL WATER MANAGEMENT STRATEGY AERIAL PHOTO**

SCALE	DRAWN	CHECK	REV No.
1:5000	JEG	RDG	A
DATE	DESIGNED	APPROVED	
14/9/16	JEG	RDG	

PROJECT NUMBER **PRO1069** DRAWING NUMBER **L02**

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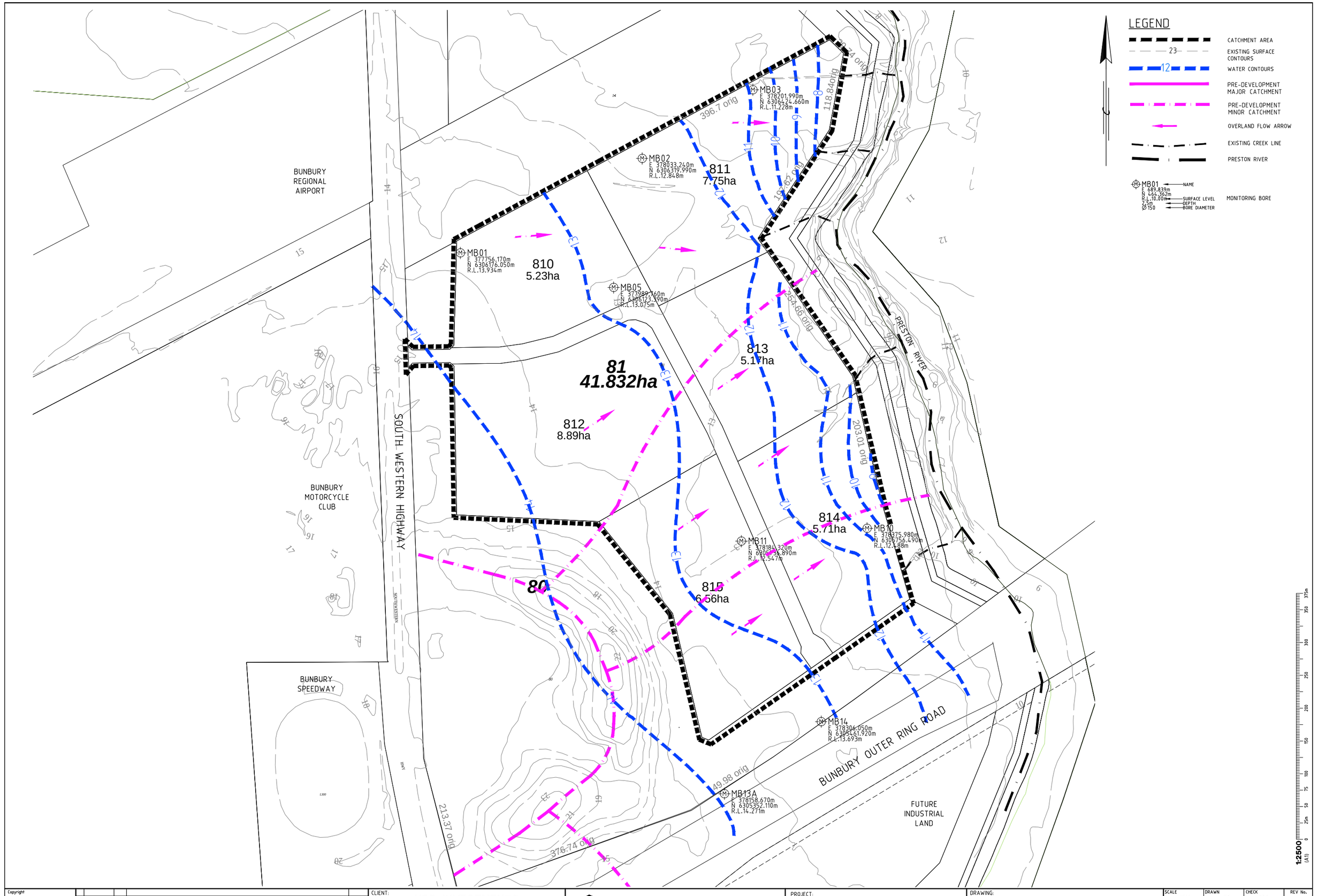

No.	DATE	BY	REVISION	
B	7/2/17	JEG	CREEK LINES ADDED, PREDEVELOPMENT CATCHMENT AMENDED	RDG
A	6/10/16	JEG	INITIAL ISSUE	RDG

CLIENT: **NBR INVESTMENTS**

DEVELOPMENT ENGINEERING CONSULTANTS
SUITE 3, 123A COLIN ST, WEST PERTH, 6005 WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOT 81 SOUTH WESTERN HIGHWAY DAVENPORT**
W.A.P.C. No. -

DRAWING: **LOCAL WATER MANAGEMENT STRATEGY PRE-DEVELOPMENT CATCHMENT PLAN**

SCALE	DRAWN	CHECK	REV No.
1:2500	JEG	RDG	B
DATE	DESIGNED	APPROVED	
14/9/16	JEG	RDG	

PROJECT NUMBER **PRO1069** DRAWING NUMBER **L03**

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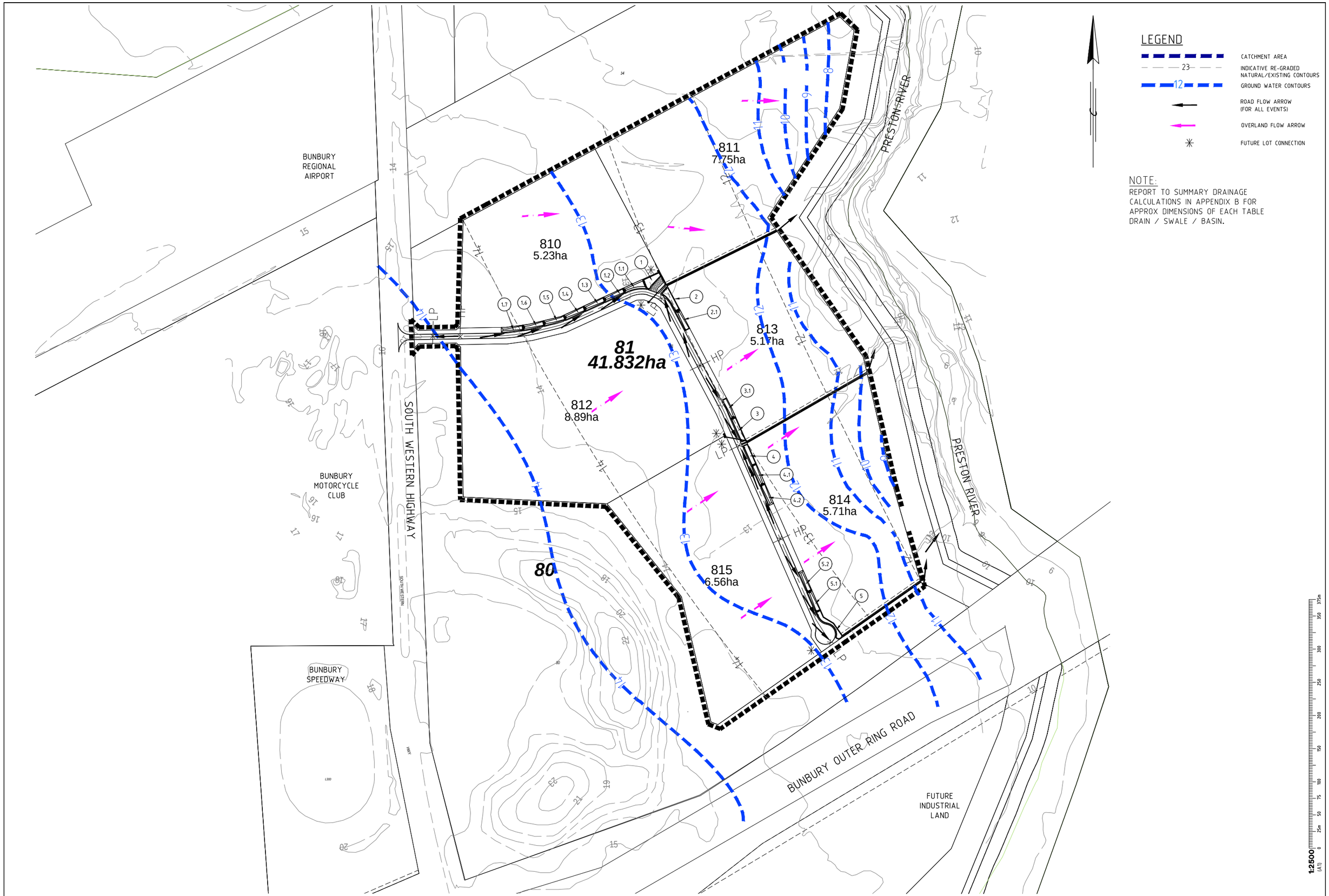

No.	DATE	BY	REVISION	
C	29/7/21	JEG	REDESIGN OF SWALES AND BASINS	RDG
B	7/2/17	JEG	DRAINAGE AMENDED	RDG
A	6/10/16	JEG	INITIAL ISSUE	RDG

CLIENT: **NBR INVESTMENTS**

DEVELOPMENT ENGINEERING CONSULTANTS
SUITE 3, 123A COLIN ST, WEST PERTH, 6005 WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOT 81 SOUTH WESTERN HIGHWAY DAVENPORT**
W.A.P.C. No. -

DRAWING: **LOCAL WATER MANAGEMENT STRATEGY POST DEVELOPMENT CATCHMENT PLAN**

SCALE	DRAWN	CHECK	REV No.
1:2500	JEG	RDG	C
DATE	DESIGNED	APPROVED	
14/9/16	JEG	RDG	

PROJECT NUMBER **PRO1069** DRAWING NUMBER **L04**

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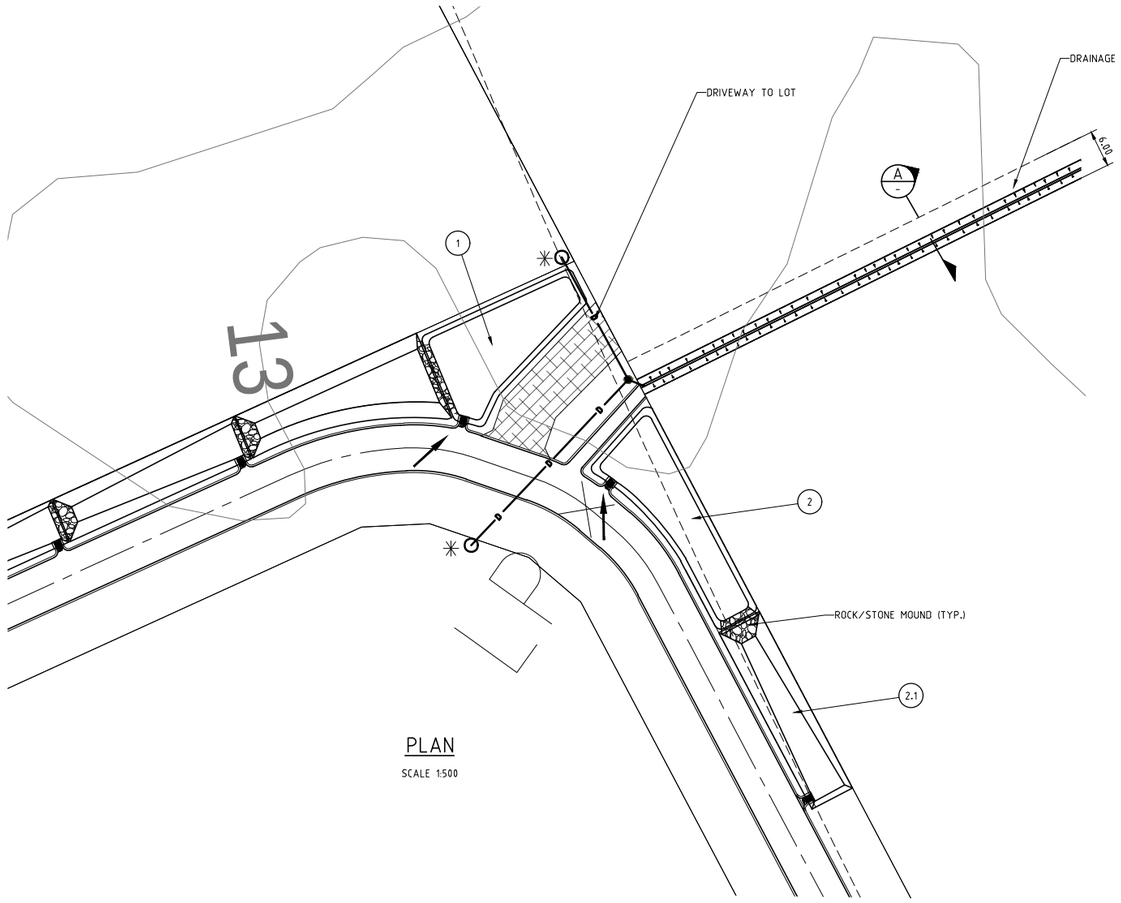
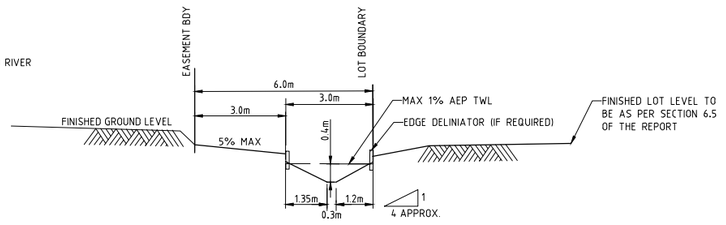


PLAN

SCALE 1:500

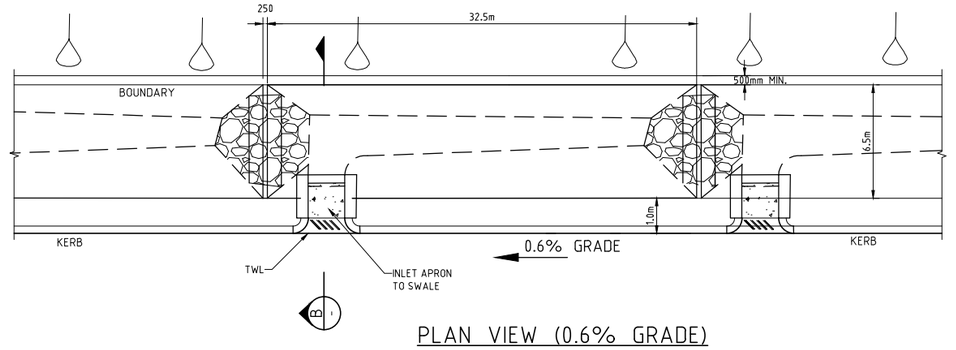


TYPICAL SECTION THROUGH CHANNEL

SECTION A N.T.S.

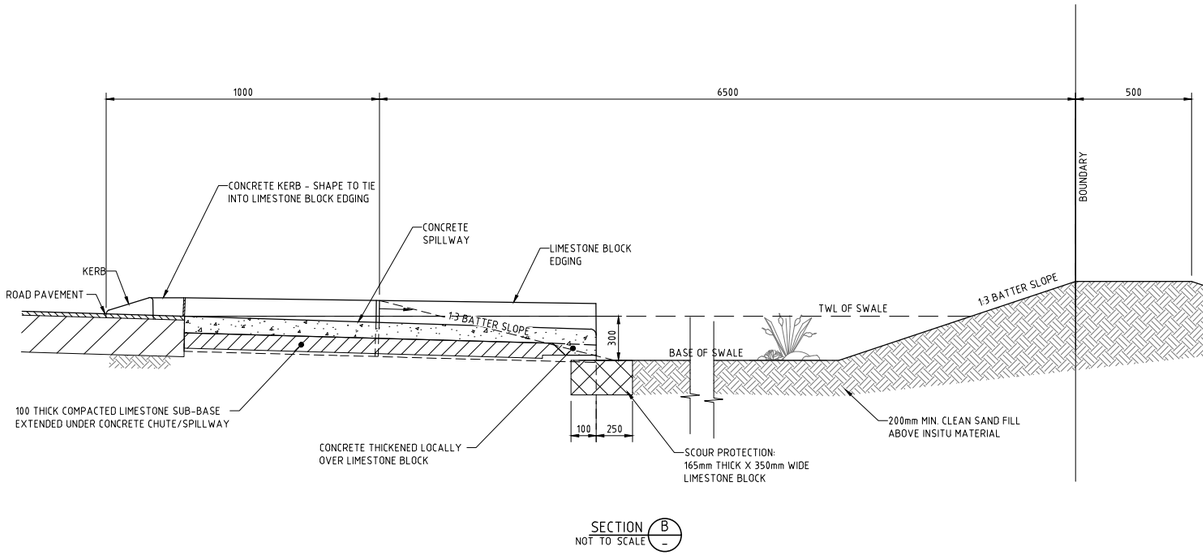
LEGEND

- CATCHMENT AREA
- 23 — INDICATIVE RE-GRADED NATURAL/EXISTING CONTOURS
- 2.90 — GROUND WATER CONTOURS
- FLOW ARROW
- FUTURE LOT CONNECTION

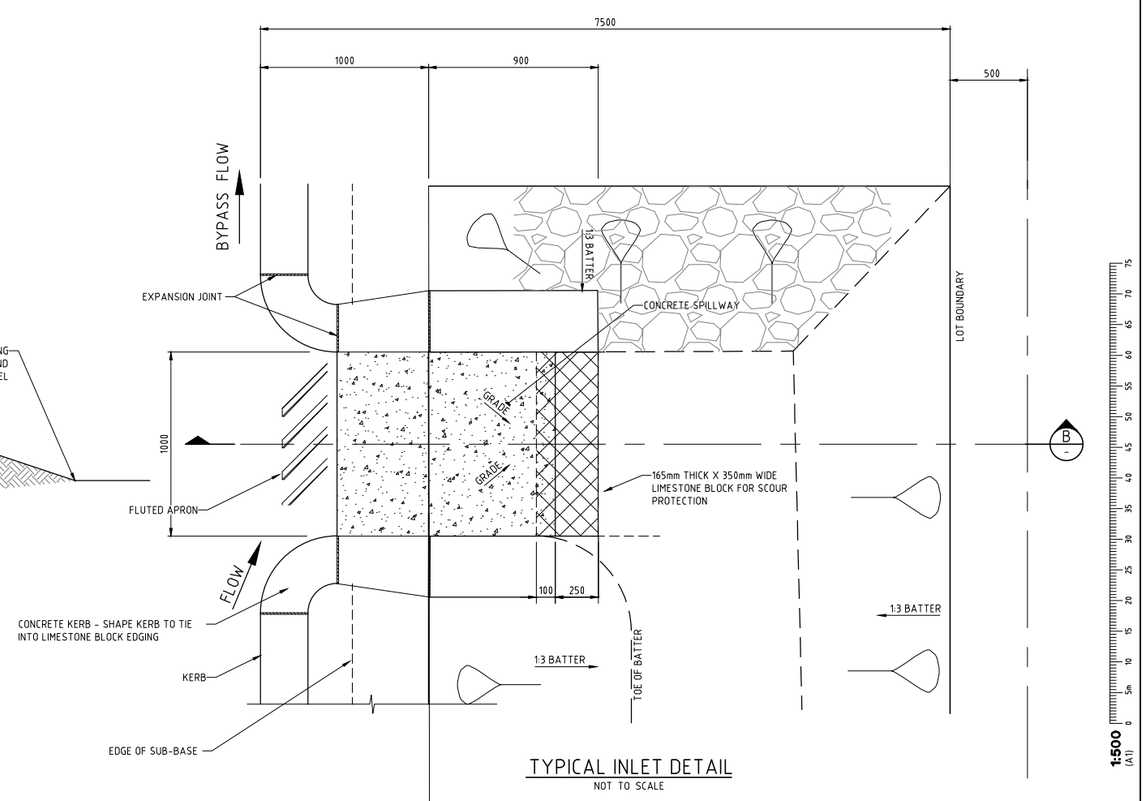


PLAN VIEW (0.6% GRADE)

NOT TO SCALE



SECTION B NOT TO SCALE



TYPICAL INLET DETAIL

NOT TO SCALE

No.	DATE	BY	REVISION	
C	29/7/21	JEG	SWALE AND BASIN REDESIGN	RDG
B	7/2/17	JEG	DRAINAGE AMENDED	RDG
A	6/10/16	JEG	INITIAL ISSUE	RDG

CLIENT: **NBR INVESTMENTS**

DEVELOPMENT ENGINEERING CONSULTANTS
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Ph: (08) 9481 1900
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PROJECT: **LOT 81 SOUTH WESTERN HIGHWAY DAVENPORT**

W.A.P.C. No. -

DRAWING: **LOCAL WATER MANAGEMENT STRATEGY SWALE / CHANNEL DETAILS**

SCALE	DRAWN	CHECK	REV No.
1:500	JEG	RDG	C
DATE 6/10/16	DESIGNED JEG	APPROVED RDG	

PROJECT NUMBER **PRO1069** DRAWING NUMBER **L05**

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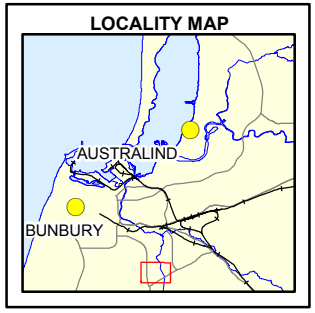
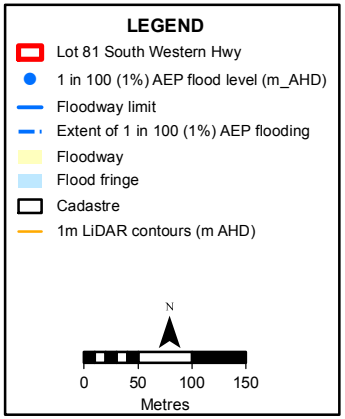
Lot 81 South Western Hwy
DAVENPORT





Datum and Projection Information
Vertical Datum: AHD71
Horizontal Datum: GDA94
Projection: MGAz50
Spheroid: GRS80

Project Information
Client: DEC - Robert Graieg
Map Author: Andrew Watson
Task ID: B1305
Compilation date: 31/08/2016
Edition: Version 1

SOURCES

The Department of Water acknowledges the following datasets and their custodians in the production of this map:

Railways - Landgate - 09/02/2010
Road Centrelines, DLI - Landgate - 01/02/2016
Spatial Cadastral Database - Landgate – 02/05/2016
Bunbury 2013 50cm z50 - Landgate - 13/12/2013

Government of Western Australia
Department of Water

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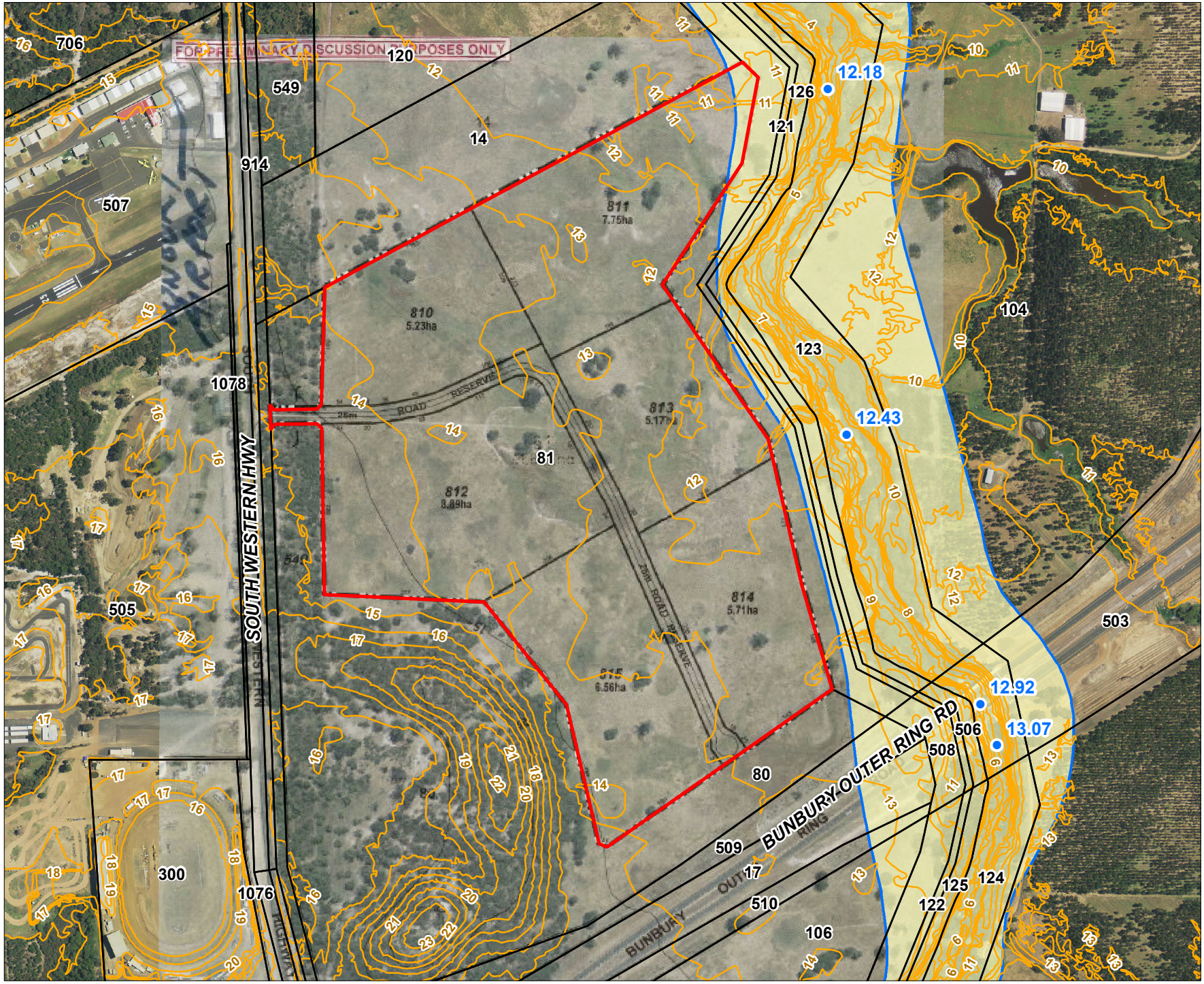
This map was produced with the intent that it be used for display purposes at the scale of 1:7,000 when printing at A4.

While the Department of Water has made all reasonable efforts to ensure the accuracy of this data, the department accepts no responsibility for any inaccuracies and persons relying on this data do so at their own risk.



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DEVELOPMENT
ENGINEERING
CONSULTANTS

APPENDIX B – DRAINAGE CALCULATIONS

- Summary Drainage Analysis of the 1% AEP event
- Summary Drainage Analysis of the 10% AEP event
- Summary Drainage Analysis of the 20% AEP event
- Summary Drainage Analysis of the 63% AEP event
- Indicative outlet channel flow calculations

Summary Drainage Results for: Lot 81 SW Highway **1% AEP** (~ equivalent to a ARI 1 in 100 year storm event)

Sheet / Tab or Catchment Name / Ref:	Basin / Swale Name / Description	Basin / Swale Characteristics ~RL_{Base} (m)	~A_{base} (m^2)	~RL_{TWL} (m)	~A_{TWL} (m^2)	~RL_{Top} (m)	~A_{Top} (m^2)	~Vol_{Top} (m^3)	Contributing Impervious Area A_{imp} (m^2) - CIA	Average Run-off Co-eff	TWL Area % of CIA	Basin / Swale Properties ~K_h (m/day)	Tc (mins)	~Peak Q_{in} (l/s)	~Vol_{TWL} (m^3)	~A_{TWL} (m^2)	Max. Depth of Water (m)	~Fill Depth (m)	~Time to Soak (hrs)	~$Q_{by\text{-}pass}$ (l/s)	~Weir Width (m)	~"H" over Weir (mm)
Northern Road Catchment	Basin 2-Adj L813N	0.00	270.00	0.30	278.57	0.30	278.57	82.50	1665	0.90	> 10	2.50	60.00	33.80	82.50	278.57	0.30	0.30	2.89	2.95	1.00	14
Northern Road Catchment	Swale 2.1 -Adj L813N	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1463	0.90	> 10	2.50	9.00	62.32	20.65	165.00	0.14	0.14	1.34	26.84	5.00	20
Northern Road Catchment	Basin 1 -Adj. L810	0.00	160.00	0.25	176.67	0.25	176.67	42.50	837	0.90	> 10	2.50	45.00	26.79	42.50	176.67	0.25	0.25	2.42	6.18	1.00	22
Northern Road Catchment	Swale 1.1 -Adj. L810	0.00	85.00	0.19	119.00	0.19	119.00	19.38	1463	0.90	8.14	2.50	9.00	62.32	19.38	119.00	0.19	0.19	1.82	23.48	5.00	19
Northern Road Catchment	Swale 1.2 -Adj. L810	0.00	130.00	0.13	163.39	0.14	165.00	20.65	0	-	N/A	2.50	45.00	11.56	19.70	163.39	0.14	0.13	1.29	0.00	5.00	0
Northern Road Catchment	Swale 1.3 -Adj. L810	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1463	0.90	> 10	2.50	9.00	62.32	20.65	165.00	0.14	0.14	1.34	19.81	5.00	17
Northern Road Catchment	Swale 1.4-Adj L810	0.00	130.00	0.13	163.39	0.14	165.00	20.65	0	-	N/A	2.50	45.00	11.56	19.70	163.39	0.14	0.13	1.29	0.00	5.00	0
Northern Road Catchment	Swale 1.5-Adj L810	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1463	0.90	> 10	2.50	9.00	62.32	20.65	165.00	0.14	0.14	1.34	19.81	5.00	17
Northern Road Catchment	Swale 1.6-Adj. L810	0.00	130.00	0.13	163.39	0.14	165.00	20.65	0	-	N/A	2.50	45.00	11.56	19.70	163.39	0.14	0.13	1.29	0.00	5.00	0
Northern Road Catchment	Swale 1.7-Adj. L810	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1463	0.90	> 10	2.50	9.00	62.32	20.65	165.00	0.14	0.14	1.34	19.81	5.00	17
Central Road Catchment	Basin 3-Adj. L813S	0.00	260.00	0.25	272.50	0.25	272.50	66.88	1463	0.90	> 10	2.50	60.00	28.91	66.88	272.50	0.25	0.25	2.41	2.63	1.00	13
Central Road Catchment	Swale 3.1-Adj. L813S	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1463	0.90	> 10	2.50	9.00	62.32	20.65	165.00	0.14	0.14	1.34	19.81	5.00	17
Central Road Catchment	Basin 4-Adj L814N	0.00	220.00	0.25	236.67	0.25	236.67	57.50	1913	0.90	> 10	2.50	45.00	32.17	57.50	236.67	0.25	0.25	2.42	4.27	1.00	18
Central Road Catchment	Swale 4.1-Adj L814N	0.00	85.00	0.14	165.00	0.14	165.00	17.50	0	-	N/A	2.50	45.00	11.56	17.50	165.00	0.14	0.14	1.34	1.47	5.00	3
Central Road Catchment	Swale 4.2-Adj L814N	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1463	0.90	> 10	2.50	9.00	62.32	20.65	165.00	0.14	0.14	1.34	19.81	5.00	17
Southernl Road Catchment	Basin 5-Adj L814S	0.00	325.00	0.30	333.57	0.30	333.57	99.00	3078	0.90	> 10	2.50	60.00	41.14	99.00	333.57	0.30	0.30	2.89	4.12	1.00	17
Southernl Road Catchment	Swale 5.1-Adj L814S	0.00	130.00	0.14	165.00	0.14	165.00	20.65	0	-	N/A	2.50	60.00	10.19	20.65	165.00	0.14	0.14	1.34	0.19	5.00	1
Southernl Road Catchment	Swale 5.2-Adj L814S	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1463	0.90	> 10	2.50	9.00	62.32	20.65	165.00	0.14	0.14	1.34	19.81	5.00	17

Summary Drainage Results for: Lot 81 SW Highway **10% AEP** (~ equivalent to a ARI 1 in 10 year storm event)

Sheet / Tab or Catchment Name / Ref:	Basin / Swale Name / Description	Basin / Swale Characteristics ~RL_{Base} (m)	~A_{base} (m^2)	~RL_{TWL} (m)	~A_{TWL} (m^2)	~RL_{Top} (m)	~A_{Top} (m^2)	~Vol_{Top} (m^3)	Contributing Impervious Area A_{imp} (m^2) - CIA	Average Run-off Co-eff	TWL Area % of CIA	Basin / Swale Properties ~K_h (m/day)	Tc (mins)	~Peak Q_{in} (l/s)	~Vol_{TWL} (m^3)	~A_{TWL} (m^2)	Max. Depth of Water (m)	~Fill Depth (m)	~Time to Soak (hrs)	~$Q_{by\text{-}pass}$ (l/s)	~Weir Width (m)	~"H" over Weir (mm)
Northern Road Catchment	Basin 2-Adj L813N	0.00	270.00	0.09	272.55	0.30	278.57	82.50	1388	0.75	> 10	2.50	30.00	21.52	24.56	272.55	0.30	0.09	0.87	0.00	1.00	0
Northern Road Catchment	Swale 2.1 -Adj L813N	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1219	0.75	> 10	2.50	30.00	16.39	20.65	165.00	0.14	0.14	1.34	2.86	5.00	5
Northern Road Catchment	Basin 1 -Adj. L810	0.00	160.00	0.08	165.18	0.25	176.67	42.50	698	0.75	> 10	2.50	45.00	9.67	13.21	165.18	0.25	0.08	0.78	0.00	1.00	0
Northern Road Catchment	Swale 1.1 -Adj. L810	0.00	85.00	0.19	119.00	0.19	119.00	19.38	1219	0.75	9.76	2.50	30.00	16.39	19.38	119.00	0.19	0.19	1.82	2.67	5.00	4
Northern Road Catchment	Swale 1.2 -Adj. L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	1.74	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.3 -Adj. L810	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1219	0.75	> 10	2.50	45.00	12.59	20.65	165.00	0.14	0.14	1.34	0.68	5.00	2
Northern Road Catchment	Swale 1.4-Adj L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	1.74	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.5-Adj L810	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1219	0.75	> 10	2.50	45.00	12.59	20.65	165.00	0.14	0.14	1.34	0.68	5.00	2
Northern Road Catchment	Swale 1.6-Adj. L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	1.74	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.7-Adj. L810	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1219	0.75	> 10	2.50	45.00	12.59	20.65	165.00	0.14	0.14	1.34	0.68	5.00	2
Central Road Catchment	Basin 3-Adj. L813S	0.00	260.00	0.06	263.17	0.25	272.50	66.88	1219	0.75	> 10	2.50	30.00	17.03	16.96	263.17	0.25	0.06	0.62	0.00	1.00	0
Central Road Catchment	Swale 3.1-Adj. L813S	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1219	0.75	> 10	2.50	45.00	12.59	20.65	165.00	0.14	0.14	1.34	0.68	5.00	2
Central Road Catchment	Basin 4-Adj L814N	0.00	220.00	0.12	227.77	0.25	236.67	57.50	1594	0.75	> 10	2.50	30.00	21.43	26.82	227.77	0.25	0.12	1.15	0.00	1.00	0
Central Road Catchment	Swale 4.1-Adj L814N	0.00	85.00	0.00	85.00	0.14	165.00	17.50	0	-	N/A	2.50	N/A	1.74	0.00	85.00	0.14	0.00	0.00	0.00	5.00	0
Central Road Catchment	Swale 4.2-Adj L814N	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1219	0.75	> 10	2.50	45.00	12.59	20.65	165.00	0.14	0.14	1.34	0.68	5.00	2
Southernl Road Catchment	Basin 5-Adj L814S	0.00	325.00	0.14	328.98	0.30	333.57	99.00	2565	0.75	> 10	2.50	45.00	26.51	45.93	328.98	0.30	0.14	1.35	0.00	1.00	0
Southernl Road Catchment	Swale 5.1-Adj L814S	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	1.74	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Southernl Road Catchment	Swale 5.2-Adj L814S	0.00	130.00	0.14	165.00	0.14	165.00	20.65	1219	0.75	> 10	2.50	45.00	12.59	20.65	165.00	0.14	0.14	1.34	0.68	5.00	2

Summary Drainage Results for: Lot 81 SW Highway **20% AEP** (~ equivalent to a ARI 1 in 5 year storm event)

Sheet / Tab or Catchment Name / Ref:	Basin / Swale Name / Description	Basin / Swale Characteristics ~RL_{Base} (m)	~A_{base} (m^2)	~RL_{TWL} (m)	~A_{TWL} (m^2)	~RL_{Top} (m)	~A_{Top} (m^2)	~Vol_{Top} (m^3)	Contributing Impervious Area A_{imp} (m^2) - CIA	Average Run-off Co-eff	TWL Area % of CIA	Basin / Swale Properties ~K_h (m/day)	Tc (mins)	~Peak Q_{in} (l/s)	~Vol_{TWL} (m^3)	~A_{TWL} (m^2)	Max. Depth of Water (m)	~Fill Depth (m)	~Time to Soak (hrs)	~$Q_{by\text{-}pass}$ (l/s)	~Weir Width (m)	~"H" over Weir (mm)
Northern Road Catchment	Basin 2-Adj L813N	0.00	270.00	0.05	271.42	0.30	278.57	82.50	1318	0.71	> 10	2.50	15.00	23.03	13.67	271.42	0.30	0.05	0.48	0.00	1.00	0
Northern Road Catchment	Swale 2.1 -Adj L813N	0.00	130.00	0.14	163.77	0.14	165.00	20.65	1158	0.71	> 10	2.50	45.00	10.20	19.93	163.77	0.14	0.14	1.30	0.00	5.00	0
Northern Road Catchment	Basin 1 -Adj. L810	0.00	160.00	0.04	162.43	0.25	176.67	42.50	663	0.71	> 10	2.50	15.00	11.58	6.20	162.43	0.25	0.04	0.37	0.00	1.00	0
Northern Road Catchment	Swale 1.1 -Adj. L810	0.00	85.00	0.19	119.00	0.19	119.00	19.38	1158	0.71	> 10	2.50	60.00	8.46	19.38	119.00	0.19	0.19	1.82	0.12	5.00	1
Northern Road Catchment	Swale 1.2 -Adj. L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.3 -Adj. L810	0.00	130.00	0.11	157.50	0.14	165.00	20.65	1158	0.71	> 10	2.50	30.00	13.28	16.23	157.50	0.14	0.11	1.08	0.00	5.00	0
Northern Road Catchment	Swale 1.4-Adj L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.5-Adj L810	0.00	130.00	0.11	157.50	0.14	165.00	20.65	1158	0.71	> 10	2.50	30.00	13.28	16.23	157.50	0.14	0.11	1.08	0.00	5.00	0
Northern Road Catchment	Swale 1.6-Adj. L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.7-Adj. L810	0.00	130.00	0.11	157.50	0.14	165.00	20.65	1158	0.71	> 10	2.50	30.00	13.28	16.23	157.50	0.14	0.11	1.08	0.00	5.00	0
Central Road Catchment	Basin 3-Adj. L813S	0.00	260.00	0.04	262.13	0.25	272.50	66.88	1158	0.71	> 10	2.50	15.00	20.23	11.39	262.13	0.25	0.04	0.42	0.00	1.00	0
Central Road Catchment	Swale 3.1-Adj. L813S	0.00	130.00	0.11	157.50	0.14	165.00	20.65	1158	0.71	> 10	2.50	30.00	13.28	16.23	157.50	0.14	0.11	1.08	0.00	5.00	0
Central Road Catchment	Basin 4-Adj L814N	0.00	220.00	0.09	225.67	0.25	236.67	57.50	1514	0.71	> 10	2.50	30.00	17.37	19.57	225.67	0.25	0.09	0.84	0.00	1.00	0
Central Road Catchment	Swale 4.1-Adj L814N	0.00	85.00	0.00	85.00	0.14	165.00	17.50	0	-	N/A	2.50	N/A	0.00	0.00	85.00	0.14	0.00	0.00	0.00	5.00	0
Central Road Catchment	Swale 4.2-Adj L814N	0.00	130.00	0.11	157.50	0.14	165.00	20.65	1158	0.71	> 10	2.50	30.00	13.28	16.23	157.50	0.14	0.11	1.08	0.00	5.00	0
Southernl Road Catchment	Basin 5-Adj L814S	0.00	325.00	0.10	327.88	0.30	333.57	99.00	2437	0.71	> 10	2.50	30.00	27.95	33.28	327.88	0.30	0.10	0.98	0.00	1.00	0
Southernl Road Catchment	Swale 5.1-Adj L814S	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Southernl Road Catchment	Swale 5.2-Adj L814S	0.00	130.00	0.11	157.50	0.14	165.00	20.65	1158	0.71	> 10	2.50	30.00	13.28	16.23	157.50	0.14	0.11	1.08	0.00	5.00	0

Summary Drainage Results for: Lot 81 SW Highway **63.2% AEP** (~ equivalent to a ARI 1 in 1 year storm event)

Sheet / Tab or Catchment Name / Ref:	Basin / Swale Name / Description	Basin / Swale Characteristics ~RL_{Base} (m)	~A_{base} (m^2)	~RL_{TWL} (m)	~A_{TWL} (m^2)	~RL_{Top} (m)	~A_{Top} (m^2)	~Vol_{Top} (m^3)	Contributing Impervious Area A_{imp} (m^2) - CIA	Average Run-off Co-eff	TWL Area % of CIA	Basin / Swale Properties ~K_h (m/day)	Tc (mins)	~Peak Q_{in} (l/s)	~Vol_{TWL} (m^3)	~A_{TWL} (m^2)	Max. Depth of Water (m)	~Fill Depth (m)	~Time to Soak (hrs)	~$Q_{by\text{-}pass}$ (l/s)	~Weir Width (m)	~"H" over Weir (mm)
Northern Road Catchment	Basin 2-Adj L813N	0.00	270.00	0.02	270.57	0.30	278.57	82.50	1110	0.60	> 10	2.50	9.00	18.01	5.50	270.57	0.30	0.02	0.20	0.00	1.00	0
Northern Road Catchment	Swale 2.1 -Adj L813N	0.00	130.00	0.06	144.93	0.14	165.00	20.65	975	0.60	> 10	2.50	30.00	7.75	8.81	144.93	0.14	0.06	0.62	0.00	5.00	0
Northern Road Catchment	Basin 1 -Adj. L810	0.00	160.00	0.01	160.93	0.25	176.67	42.50	558	0.60	> 10	2.50	9.00	9.06	2.37	160.93	0.25	0.01	0.14	0.00	1.00	0
Northern Road Catchment	Swale 1.1 -Adj. L810	0.00	85.00	0.09	100.58	0.19	119.00	19.38	975	0.60	> 10	2.50	30.00	7.75	8.88	100.58	0.19	0.09	0.92	0.00	5.00	0
Northern Road Catchment	Swale 1.2 -Adj. L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.3 -Adj. L810	0.00	130.00	0.05	141.84	0.14	165.00	20.65	975	0.60	> 10	2.50	15.00	11.78	6.98	141.84	0.14	0.05	0.49	0.00	5.00	0
Northern Road Catchment	Swale 1.4-Adj L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.5-Adj L810	0.00	130.00	0.05	141.84	0.14	165.00	20.65	975	0.60	> 10	2.50	15.00	11.78	6.98	141.84	0.14	0.05	0.49	0.00	5.00	0
Northern Road Catchment	Swale 1.6-Adj. L810	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Northern Road Catchment	Swale 1.7-Adj. L810	0.00	130.00	0.05	141.84	0.14	165.00	20.65	975	0.60	> 10	2.50	15.00	11.78	6.98	141.84	0.14	0.05	0.49	0.00	5.00	0
Central Road Catchment	Basin 3-Adj. L813S	0.00	260.00	0.02	260.84	0.25	272.50	66.88	975	0.60	> 10	2.50	9.00	15.82	4.47	260.84	0.25	0.02	0.16	0.00	1.00	0
Central Road Catchment	Swale 3.1-Adj. L813S	0.00	130.00	0.05	141.84	0.14	165.00	20.65	975	0.60	> 10	2.50	15.00	11.78	6.98	141.84	0.14	0.05	0.49	0.00	5.00	0
Central Road Catchment	Basin 4-Adj L814N	0.00	220.00	0.04	222.34	0.25	236.67	57.50	1275	0.60	> 10	2.50	15.00	15.41	8.08	222.34	0.25	0.04	0.35	0.00	1.00	0
Central Road Catchment	Swale 4.1-Adj L814N	0.00	85.00	0.00	85.00	0.14	165.00	17.50	0	-	N/A	2.50	N/A	0.00	0.00	85.00	0.14	0.00	0.00	0.00	5.00	0
Central Road Catchment	Swale 4.2-Adj L814N	0.00	130.00	0.05	141.84	0.14	165.00	20.65	975	0.60	> 10	2.50	15.00	11.78	6.98	141.84	0.14	0.05	0.49	0.00	5.00	0
Southernl Road Catchment	Basin 5-Adj L814S	0.00	325.00	0.04	326.20	0.30	333.57	99.00	2052	0.60	> 10	2.50	15.00	24.80	13.83	326.20	0.30	0.04	0.41	0.00	1.00	0
Southernl Road Catchment	Swale 5.1-Adj L814S	0.00	130.00	0.00	130.00	0.14	165.00	20.65	0	-	N/A	2.50	N/A	0.00	0.00	130.00	0.14	0.00	0.00	0.00	5.00	0
Southernl Road Catchment	Swale 5.2-Adj L814S	0.00	130.00	0.05	141.84	0.14	165.00	20.65	975	0.60	> 10	2.50	15.00	11.78	6.98	141.84	0.14	0.05	0.49	0.00	5.00	0

Open Channel Flow Calcs -
Lot 81 SW Highway - 1% AEP

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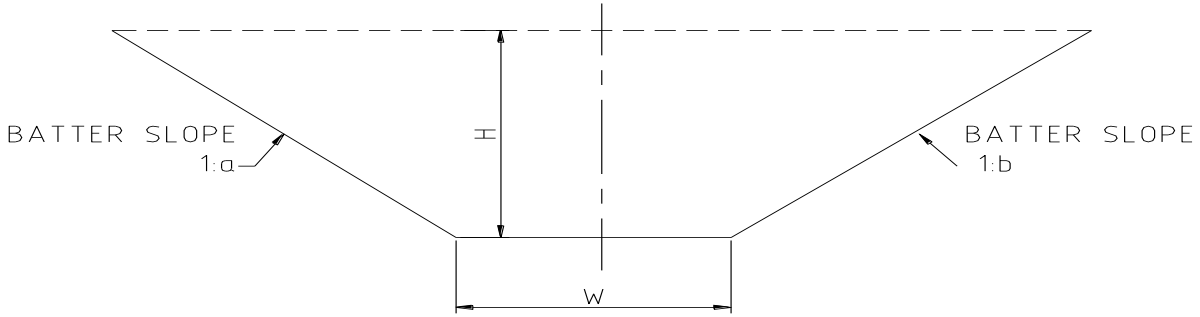


INPUT

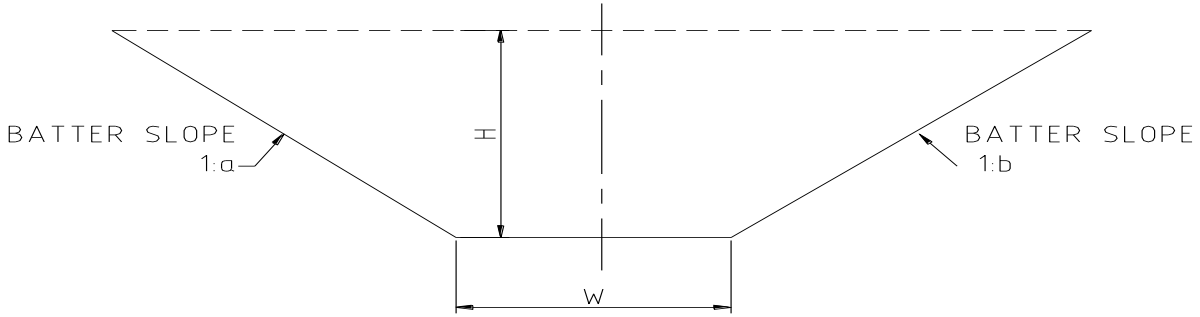
a	0.25		or	25.00	%		**AEP :**	**1**	**%**	
b	0.25		or	25.00	%		**t_{Total} :**	30.00	**mins**	
W	0.3	m					**I :**	28.60	**mm/hr**	
n	0.03									
S_o (Channel grade)	0.00500	m/m	or	0.50	%	1 in	200		Approx. flow width	~H(m)
Q (Discharge)	0.250	m^3/sec					0.250		2.90	0.325

0.05

H (m)	**T(m)**	**A(m^2)**	**P(m)**	**R**	**V(m/s)**	**Q(m^3/s)**	**Froud No**		4	50
0.1	0.35	0.065	0.51	0.13	0.59995241	0.039	0.113	-		1
0.15	0.375	0.10125	0.61	0.17	0.71247811	0.072	0.139	-		2
0.2	0.4	0.14	0.71	0.20	0.79677589	0.112	0.161	-		3
0.25	0.425	0.18125	0.82	0.22	0.86491376	0.157	0.180	Normal depth	0.25	4
0.3	0.45	0.225	0.92	0.24	0.92280531	0.208	0.198	Normal depth	0.3	5
0.35	0.475	0.27125	1.02	0.27	0.97373102	0.264	0.214	Normal depth	0.35	6
0.4	0.5	0.32	1.12	0.28	1.01966984	0.326	0.230	Normal depth	0.4	7
0.45	0.525	0.37125	1.23	0.30	1.06189158	0.394	0.246	-		8
0.5	0.55	0.425	1.33	0.32	1.10125097	0.468	0.261	-		9

Open Channel Flow Calcs -
Lot 81 SW Highway - 1% AEP

DEVELOPMENT ENGINEERING CONSULTANTS



INPUT

a	0.25		or	25.00	%		**AEP :**	**1**	**%**	
b	0.25		or	25.00	%		**t_{Total} :**	30.00	**mins**	
W	0.3	m					**I :**	28.60	**mm/hr**	
n	0.03									
S_o (Channel grade)	0.00556	m/m	or	0.56	%	1 in	180		Approx. flow width	~H(m)
Q (Discharge)	0.150	m^3/sec					0.150		2.10	0.225

0.05

H (m)	**T(m)**	**A(m^2)**	**P(m)**	**R**	**V(m/s)**	**Q(m^3/s)**	**Froud No**		4	50
0.1	0.35	0.065	0.51	0.13	0.63240537	0.041	0.119	-		1
0.15	0.375	0.10125	0.61	0.17	0.75101787	0.076	0.147	Normal depth	0.15	2
0.2	0.4	0.14	0.71	0.20	0.83987553	0.118	0.170	Normal depth	0.2	3
0.25	0.425	0.18125	0.82	0.22	0.91169916	0.165	0.190	Normal depth	0.25	4
0.3	0.45	0.225	0.92	0.24	0.97272221	0.219	0.208	Normal depth	0.3	5
0.35	0.475	0.27125	1.02	0.27	1.02640262	0.278	0.226	-		6
0.4	0.5	0.32	1.12	0.28	1.07482639	0.344	0.243	-		7
0.45	0.525	0.37125	1.23	0.30	1.119332	0.416	0.259	-		8
0.5	0.55	0.425	1.33	0.32	1.16082045	0.493	0.275	-		9

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APPENDIX C – REFERENCE DOCUMENTS

- TME Geotechnical Report – August 2001
- Cardno LWMS (Lot 15 SW Hwy) – October 2010
- CoB Information Guide – Stormwater Drainage Plan – March 2012
- Additional Groundwater Monitoring Results – July to Oct 2016
- Approved Aerobic Treatment Units

THOMPSON McROBERT EDGELOE

BUNBURY INDUSTRIAL PARK

SHALLOW SOIL INVESTIGATION

01041
AUGUST 2001

CONTENTS

1.0 Introduction

2.0 Site Description

3.0 Investigation Work

4.0 Site Geology

5.0 Laboratory Work

6.0 Results of Investigation

6.1 Subsurface Profile
6.2 Groundwater Assessment

7.0 Conclusions

8.0 Scope and Limits of Investigation

Figure 1 – Extract, Bunbury – Burekup Geology Series

APPENDICES

A Excavation Logs & Location Plan

1.0 Introduction

A preliminary shallow backhoe pit investigation was carried out in March 2001 on the site of the proposed Bunbury Industrial Park development. The site is part Lot 15 Leschenault Location 12. The site is located approximately 8.0 kilometres South East of the Bunbury City centre opposite the Bunbury City Regional Speedway complex.

The proposed development as outlined by Planning Solutions Subdivision Plan SK-12, 03 August 2000, comprises 144 industrial lots ranging in size from 2000 m2 to 4.5 hectares.

The purpose of the investigation was to provide:

- General soil conditions.
- Estimate the peak winter water table level.

2.0 Site Description

The investigation area comprises approximately 70 ha, bounded by the Preston River to the east, the Bunbury Airport to the North, the proposed Bunbury Outer Ring Road to the south and South West Highway to its west.

The land consists of cleared farmland with isolated paddock trees with a patch of native vegetation in the South West corner of the site and degraded vegetation associated with the foreshore area of the Preston River.

The surface profile consists generally of flat terrain that rises several metres in the southwest corner that is associated with the area of native vegetation. There are several low areas that show signs of inundation during the winter months. The foreshore area has low undulations and flow paths associated with runoff from the minor catchment areas flowing to the Preston River.

3.0 Investigation Work

Investigation work was conducted on 22nd March 2001 and consisted of:

- 18 backhoe excavations

Additional to the above, it was endeavoured to locate and measure the existing monitoring bores that were placed over the site several years ago.

The test pits were excavated utilising a Case 580K Backhoe equipped with a 600mm wide bucket.

Upon completion of the investigation all test pits were backfilled and nominally compacted using the bucket and self-weight of the machine.

All tests were supervised and logged by an engineer from TME.

4.0 Site Geology

The 1 : 50000 Bunbury – Burekup Geological survey of Western Australia indicates the subsurface soil type as generally Guildford Formation overlaying the Cretaceous Leederville formation. The vegetated southwestern corner is indicated as Bassendean Sand, low rounded dunes with the river and immediate surroundings as Alluvium, younger river terraces. Refer Figure 1.

The Guildford Formation is generalised as an alluvial clay / silt / sand mixture in which the content of silt / clay can vary significantly. A high silt / clay content, combined with alternative wetting and drying cycles can produce significant shrink and swell movement.

5.0 Laboratory Work

No samples were taken for testing from the investigative work, as the scope of work required a soil profile investigation only.

6.0 Results of Investigation

6.1 Subsurface Profile

Based on the investigation the subsurface conditions were found to be consistent with the Guildford Formation as outlined in the Geological Survey map.

From the test pit logs the soil profile can be generalised as followings;

Sand, Grey, poorly graded to depths of 1.0m.
Sandy Clay, yellow / green / brown.

The sand quantity within the clay was found to vary quite considerably with levels silt present at many locations. Gravels were also noted at some locations. Areas of rock were encountered on two occasions causing refusal at shallow depths.

Complete investigation logs are contained within appendix A.

6.2 Groundwater Assessment

Visually it can be observed that the low-lying areas of the site are subject to winter waterlogging / inundation. Evidence of the high water table was indicated in the test pits, with soil discoloration at levels just below the surface. It was also noted that the site had a high water table at the end of summer, at which point the water table would be at it's lowest.

Gravel and course sands were indicative of areas containing a perched water table perching on a layer of clay. In some cases water was encountered at shallow depths that seeped at a high rate into the excavation once the clay layer below was removed. These gravels / course sand locations had trench collapse within minutes due to the volume of water.

This presence of surface water over the site was confirmed after consultation with several local people to the area.

7.0 Conclusions

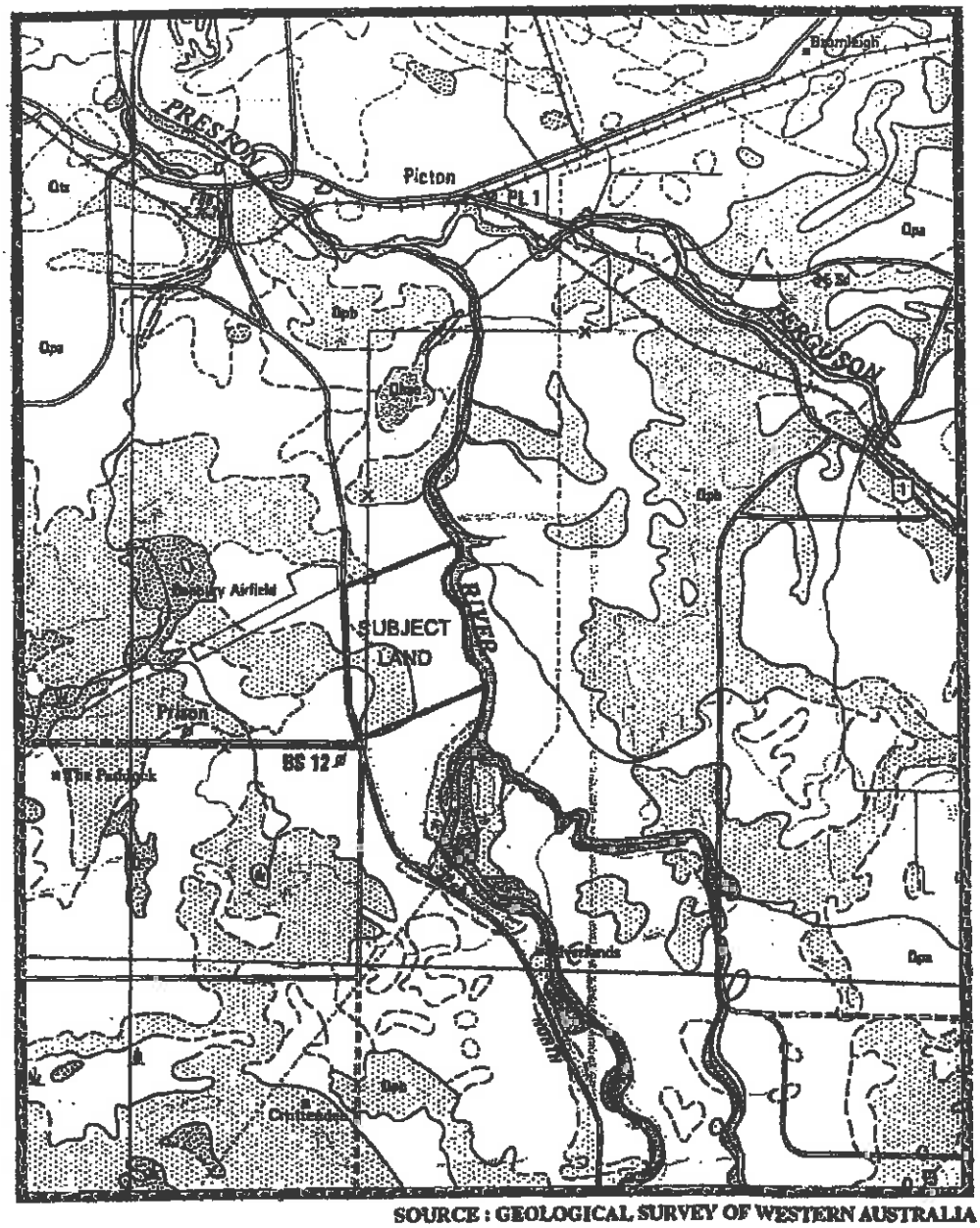
The soil investigation provides preliminary information enabling an accurate assessment of the earthwork requirements of the site.

The sub surface material indicates that a full geotechnical survey of the site will be required to determine structural requirements of proposed buildings. The presence of clay / silt material may necessitate the need for an amended footing design. It is not anticipated that the underlying soils will affect the construction of required infrastructure, given that substantial filling over the site will be required.

The presence of the shallow water table especially in winter months indicates that filling will be required in some areas upto 1.2m in depth, ensuring a satisfactory separation for any development from the current groundwater level. Additional filling may also be required to satisfy the flood provisions of the Preston River.

The presence of the high water table will require contractors to provide localised dewatering during construction. Increasing the applicable construction costs.

It is recommended that a complete geotechnical survey be completed over the site, including deep probe tests to determine any applicable settlements. Ideally this testing should take place before the completion of detailed estimates are prepared.



SOURCE : GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

REFERENCE

	PROBABLE MAXIMUM THICKNESS (m)	
Qhz	28	SAFETY BAY SAND : Mobile dunes
	40	Calcareous quartz sand dunes
Qhw	7.5	Swamp deposits, mainly peaty sand
Qhz	3	younger river terraces
		Alluvium
	2.8	older river terraces
Qtz	30	Sand associated with Tamala Limestone, high dunes
Qtl	40	TAMALA LIMESTONE : eolian and marine calcarenite
Qpb	15	BASSENDEAN SAND : low rounded dunes
Qpb Qps	5	Thin Bassendean Sand over Guildford Formation
Qps	20	GUILDFORD FORMATION : mainly alluvial sandy clay
Qpry	15	YOGANUP FORMATION : younger element
Qpr Qpry	12	YOGANUP FORMATION : including ferruginised lateritic layer

EXTRACT FROM

BUNBURY - BUREKUP

URBAN GEOLOGICAL MAP

FIGURE 1

APPENDIX A

EXCAVATION LOGS

THOMPSON McROBERT EDGELOE

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EXCAVATION LOG

PIT NUMBER 1

SHEET 1 OF 18

26 WITTENOOM STREET
BUNBURY
POSTAL ADDRESS
P.O.BOX 733
BUNBURY. W.A. 6231
PHONE: (08) 97914411
FAX: (08) 97914412
EMAIL:
tmebunbury@tmebunbury.com

CLIENT : ARCENTA
PROJECT : BIA
PIT LOCATION :

JOB NUMBER : 01041
DATE : 22/3/01
TIME COMMENCED :
SUPERVISED BY : CRAIG

EQUIPMENT : CASE 580K

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL			
			2		0.1			GREY SAND	D	L	
			2		0.9			LIGHT BROWN SAND	D	L	
			3		1.2			LIGHT BROWN SAND WITH LATERITE BOULDERS	D	D	
			4		1.5			REFUSAL			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

THOMPSON McROBERT EDGELOE

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26 WITTENOOM STREET
BUNBURY
POSTAL ADDRESS
P.O.BOX 733
BUNBURY. W.A. 6231
PHONE: (08) 97914411
FAX: (08) 97914412
EMAIL:
tmebunbury@tmebunbury.com

EXCAVATION LOG

PIT NUMBER 2

SHEET 2 OF 18

CLIENT : ARGENTA
PROJECT : B.I.P
PIT LOCATION :

JOB NUMBER : 01406
DATE : 22/3/01
TIME COMMENCED :
SUPERVISED BY : CRAIG

EQUIPMENT : CASE 580K

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL			
			1		0.2			GREY SAND	D	L	
			2		1.0			LIGHT BROWN SAND	D	L	
			2		1.8			YELLOW SANDY CLAY WITH GRAVEL	M	F	
			2/3		1.3			YELLOW / BROWN CLAY WITH SAND	M/W	F	
					2.2			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

THOMPSON McROBERT EDGELOE

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EXCAVATION LOG

PIT NUMBER 3

SHEET 3 OF 18

CLIENT: ARGENTA
PROJECT: B.I.P.
PIT LOCATION:

JOB NUMBER: 01011E
DATE: 22/3/01
TIME COMMENCED:
SUPERVISED BY: CRAIG

EQUIPMENT: CASE 580K.

DIMENSIONS OF EXCAVATION:

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL			
			2		0.1	SP		GREY SAND	D	L	
			N		0.5			LIGHT BROWN SAND	D	L	
		W	2	SAMPLE	1.0			GREEN SILTY CLAY WITH MINOR SAND	M	F	
			2		2.0			YELLOW CLAY MATRIX GRAVEL	M	F	
					2.5			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

THOMPSON McROBERT EDGELOE

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EXCAVATION LOG

PIT NUMBER 4

SHEET 4 OF 10

CLIENT: ARGENTA
PROJECT: B.I.P.
PIT LOCATION:

JOB NUMBER: OVOLLE
DATE: 22/3/01
TIME COMMENCED:
SUPERVISED BY: CRAIG

EQUIPMENT: CASE 580K

DIMENSIONS OF EXCAVATION:

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
					0			TOPSOIL			
			2		0.2		SP	GREY SAND	D	L	
			2		1.2		SP	BROWN SAND WITH GREY.	M	L	L/MD
			2		1.4		SP	GREY SAND	W	L	
					2.1			COLLAPSE & PUNCTO			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FR - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 5

SHEET 5 OF 13

CLIENT : ARGENTO
PROJECT : B.I.P
PIT LOCATION :

JOB NUMBER : 01011E
DATE : 22/3/01
TIME COMMENCED :
SUPERVISED BY : CRAIG

EQUIPMENT : CASE 580K.

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			N		0			TOPSOIL			
			E		0.1			DARK BROWN SILT	D	VST	
			E		1.6			BROWN GREY SANDY C.S.I.	D	VST	MINOR ORGANICS
			E		1.8			YELLOW BROWN CLAYEY SAND	D	VST	
			E		2.4			YELLOW BROWN CLAYEY SAND WITH LATERITE GRAVEL	D/M	VST	
		GNE			2.6			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX

VS - Very Soft	FB - Friable
S - Soft	VL - Very Loose
F - Firm	L - Loose
ST - Stiff	MD - Med. Dense
VST - Very Stiff	D - Dense
H - Hard	VD - Very dense

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EXCAVATION LOG

PIT NUMBER 6

SHEET 6 OF 18

CLIENT : PROCENTIA
PROJECT : B.I.P.
PIT LOCATION :

JOB NUMBER : 010446
DATE : 22/3/01
TIME COMMENCED :
SUPERVISED BY : CRAIG

EQUIPMENT : CASE 580 K.

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL			
			2		0.2			GREY SAND.	D	L	
			2		0.6			LIGHT BROWN SAND.	D	L	
			3		1.2			DARK COFFEE ROCK.			
					1.2			REFUSAL			

KEY TO LOG

METHOD
- Natural
- Backhoe Excavation
- Bucket Excavation
- Bulldozer Blade

SUPPORT
- Shoring
- Sheet Pile

WATER
- Water Level
- Water Inflow
- Water Outflow

GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX

VS - Very Soft	FR - Friable
S - Soft	VL - Very Loose
F - Firm	L - Loose
ST - Stiff	MD - Med. Dense
VST - Very Stiff	D - Dense
H - Hard	VD - Very dense

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EXCAVATION LOG

PIT NUMBER 8

SHEET 8 OF 18

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CLIENT : ARGENTA
PROJECT : B.I.P.
PIT LOCATION :

JOB NUMBER : 01QWE
DATE : 22/3/01
TIME COMMENCED :
SUPERVISED BY : CRAIG.

EQUIPMENT : CASE 580K

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
				0				TOPSOIL			
			2	0.1				GREY SAND.	D	VL	
			2	0.9				LIGHT BROWN SAND.	M	L	
			2	1.2				DARK BROWN SAND	W	MD	
			2	1.3				GREEN SANDY LIMT.	W	F	
			2	1.7				YELLOW GREENISH GREY	W	F	
			2	1.9				DARK GREY SAND.	W	L	
					2.6			LIMIT.			

KEY TO LOG

METHOD
- Natural
- Existing Excavation
- Bucket Excavation
- Bulldozer Blade

SUPPORT
- Timbering
- Steel Sheet Pile

WATER
- Water Level
- Water Inflow
- Water Outflow

GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 9

SHEET 9 OF 18

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CLIENT : ARGENTA
PROJECT : B.I.P.
PIT LOCATION :

JOB NUMBER : 01011E
DATE : 22/3/01
TIME COMMENCED :
SUPERVISED BY : CRAIG

EQUIPMENT : CASE 580K.

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			2		0			TOPSOIL			
				0.1				GREY SAND.	D		
			2	0.9				LIGHT BROWN SAND	M		
			2	1.1				GREEN WATER SAND	W		
			2					YELLOW BROWN GRAVELLY CLAY.	MW		POCKETS ONLY NOT LAYER.
		SEEP	2	2.4				GREY SAND LIMIT	W		
		GNE	NO GROUNDWATER SEEPAGE AS INFLOW HOWEVER SOILS WET								

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 10

SHEET 10 OF 13

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CLIENT: ARGENTA
PROJECT: B.I.P.
PIT LOCATION:
JOB NUMBER: OWIIE.
DATE:
TIME COMMENCED:
SUPERVISED BY: CAK.

EQUIPMENT: CASE 580K.

DIMENSIONS OF EXCAVATION:

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
					0			TOPSOIL		VL	
			2		0.1			GREY SAND	D	L	
			2		1.4			LIGHT BROWN SAND	M	L	
			2		1.6			GREY SANDY CLAY.	W	F	
					2.8			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 11

SHEET 11 OF 13

CLIENT : ARGENTA
PROJECT : B.I.P.
PIT LOCATION :

JOB NUMBER : OVLLE.
DATE : 22/3/01
TIME COMMENCED :
SUPERVISED BY : CRAIG

EQUIPMENT : CASE 580K
DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
					0			TOPSOIL			
					0.1			GREY SAND	D	L	
					0.9			LIGHT BROWN SAND	M	L/MD	
		▽		SAMPLE	1.6			GREEN/YELLOW SILTY CLAY	W	F	
					2.5			LIMIT.			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 12

SHEET 12 OF 18

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CLIENT: ARCENTA.
PROJECT:
JOB NUMBER:
DATE:
PIT LOCATION:
TIME COMMENCED:
SUPERVISED BY:

EQUIPMENT:

DIMENSIONS OF EXCAVATION:

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL	D		
			2		0.2			BROWN - DARK YELLOW SAND	D		
			2		0.5			YELLOW SAND	D		
			2	SAMPLE	1.1			BROWN SILTY CLAY WITH COBBLES/SANDY CLAY POCKETS	D/M		
			GNE		2.1			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 13

SHEET 13 OF ____

CLIENT :
PROJECT :

PIT LOCATION :

JOB NUMBER :
DATE :
TIME COMMENCED :
SUPERVISED BY :

EQUIPMENT :

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL	D		
			2								
					0.1			DARK BROWN SILT	D	F	
			2		1.2			YELLOW/BROWN SILT	D	F	
			GNE		2.5			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX

VS - Very Soft	FR - Friable
S - Soft	VL - Very Loose
F - Firm	L - Loose
ST - Stiff	MD - Med. Dense
VST - Very Stiff	D - Dense
H - Hard	VD - Very dense

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EXCAVATION LOG

PIT NUMBER 14

SHEET 14 OF ____

CLIENT :
PROJECT :

JOB NUMBER :
DATE :
TIME COMMENCED :
SUPERVISED BY :

PIT LOCATION :

EQUIPMENT :

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL	D	L	
			2		0.1			LIGHT BROWN SAND	D	L	
			2		0.8			YELLOW SAND TRACE OF BROWN GRAVEL	D/M	L	
			2		1.5			YELLOW GRAVELLY SAND TRACE OF CLAY	W	L	LIGHT INFLOW
			3		1.6			GREEN BROWN, YELLOW SANDY CLAY.	M	F	
					2.1			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 15

SHEET ___ OF ___

CLIENT :
PROJECT :

PIT LOCATION :

JOB NUMBER :
DATE :
TIME COMMENCED :
SUPERVISED BY :

EQUIPMENT :

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
					0			TOPSOIL			
			2	0.1				LIGHT BROWN SAND	D	VL	
			2	1.3				DARK BROWN SILT WITH CLAY. MINOR COARSE GRAVEL	D/M	F	SOME ROOTS.
			2	2.6				YELLOW BROWN GRAVELLY/SANDY CLAY.	M		
		GW		2.3				REFUSAL. COFFEE ROCK.			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 16

SHEET 16 OF ____

CLIENT :
PROJECT :

JOB NUMBER :
DATE :
TIME COMMENCED :
SUPERVISED BY :

PIT LOCATION :

EQUIPMENT :

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL	D	L	RH SIDE
			2		0.1			GREY SAND	D	L	
			2		0.8			YELLOW/BROWN SAND	D	L	NOTE
			2		0.9			DARK BROWN SANDY SILT	M	L	LEVELS NOT ACCURATE DUE TO LARTING SOILS
			2		1.3	SP		SAND GREY COURSE	W	VL	
		▽	2.0m								
			2/		2.2			GREEN SANDY CLAY	M	F	
					2.4			LIMIT			
					0			TOPSOIL			LH SIDE
					0.5			GREY SAND	D		
					0.9			YELLOW SAND	D		
					1.2			YELLOW GRAVELLY SILT	M/D		
					1.3			BROWN SANDY SILT	M/D		
					1.5			GREY SAND FINE	M		
					1.8			GREEN/GREY SANDY CLAY	M		
		GNE									

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense

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EXCAVATION LOG

PIT NUMBER 17

SHEET ____ OF ____

CLIENT :
PROJECT :

PIT LOCATION :

JOB NUMBER :
DATE :
TIME COMMENCED :
SUPERVISED BY :

EQUIPMENT :

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
					0			TOPSOIL	D		
					0.1			GREY SAND	D		
					0.8			YELLOW/BROWN SILTY CLAY	M		
								YELLOW/BROWN SILTY CLAY WITH GRAVEL	M		IN POCKETS
					1.7			DK BROWN GRAVEL WITH SILT	W		
								DK BROWN GRAVEL WITH CLAY AND BOULDERS	W		POCKETS
					2.4			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX

VS - Very Soft	FR - Friable
S - Soft	VL - Very Loose
F - Firm	L - Loose
ST - Stiff	MD - Med. Dense
VST - Very Stiff	D - Dense
H - Hard	VD - Very dense

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EXCAVATION LOG

PIT NUMBER 18

SHEET 1 OF ____

CLIENT : ARGENTA.
PROJECT :

PIT LOCATION :

JOB NUMBER :
DATE :
TIME COMMENCED :
SUPERVISED BY :

EQUIPMENT :

DIMENSIONS OF EXCAVATION :

METHOD	SUPPORT	WATER	EXCAVATION RESISTANCE	SAMPLES TESTS	DEPTH (m)	GRAPHIC LOG	US CI SYMBOL	MATERIAL, SOIL TYPE, COLOUR, CHARACTERISTICS	MOISTURE CONDITION	CONSISTENCY DENSITY INDEX	NOTES, TEST RESULTS, OBSERVATIONS
			1		0			TOPSOIL	D		
			2		0.1			DARK BROWN SILT	D		
			2		0.8			DARK BROWN SANDY SILT	D		
			2		1.0			DARK BROWN SILT WITH SAND MINOR CLAY	M		
			2		1.9			GREY/BROWN SAND WITH GREEN CLAY	M M	MD VST	
		GNE			2.2			LIMIT			

KEY TO LOG

METHOD
N - Natural
E - Existing Excavation
BE - Bucket Excavation
B - Bulldozer Blade

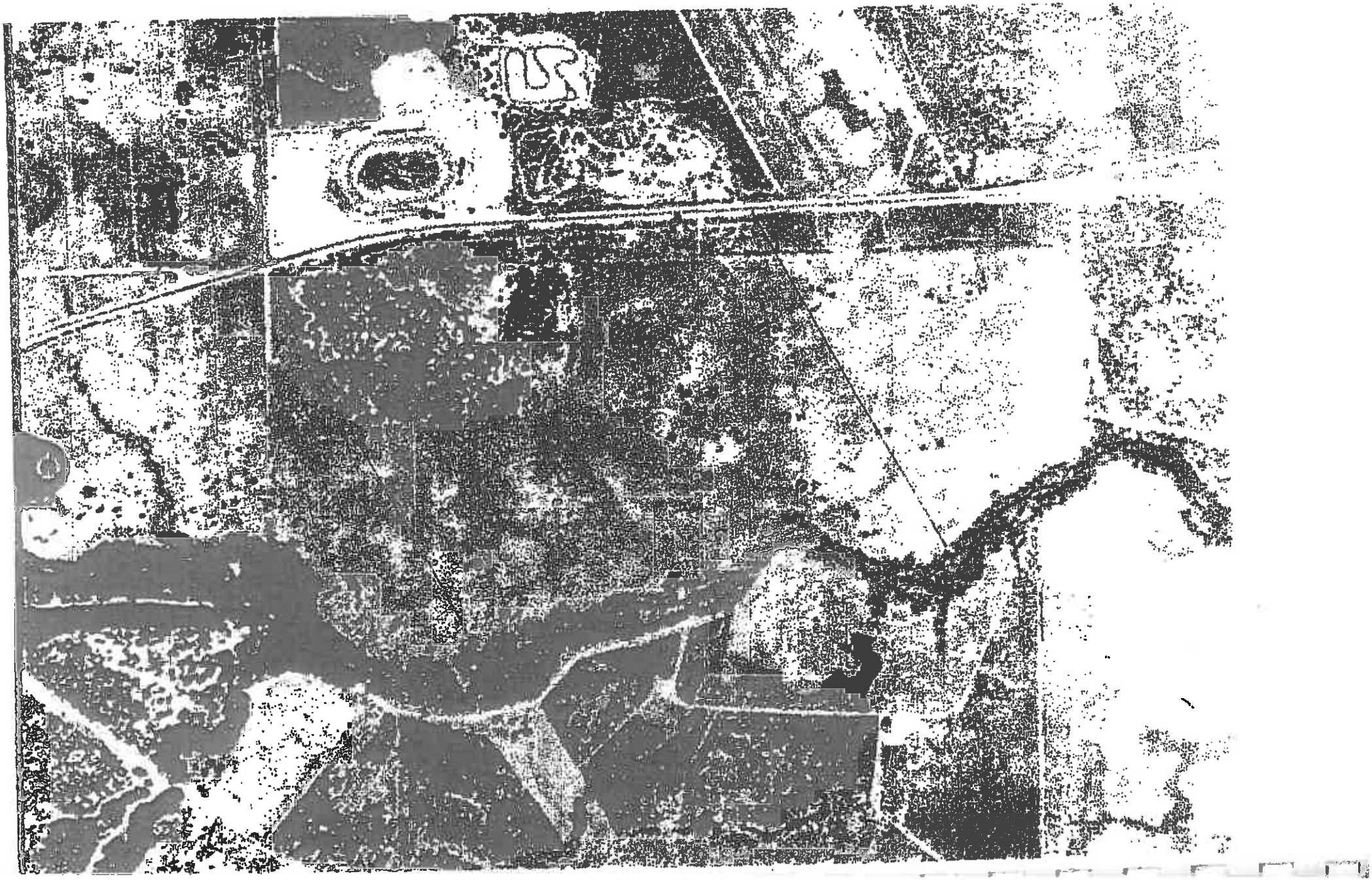
SUPPORT
T - Timbering
S - Steel Sheet Pile

WATER
Water Level
Water Inflow
Water Outflow
GNE Groundwater Not Encountered

EXCAVATION RESISTANCE
1 No Resistance
2
3
4 Refusal

MOISTURE CONDITION
D - Dry
M - Moist
W - Wet

CONSISTENCY/DENSITY INDEX
VS - Very Soft
S - Soft
F - Firm
ST - Stiff
VST - Very Stiff
H - Hard
FB - Friable
VL - Very Loose
L - Loose
MD - Med. Dense
D - Dense
VD - Very dense



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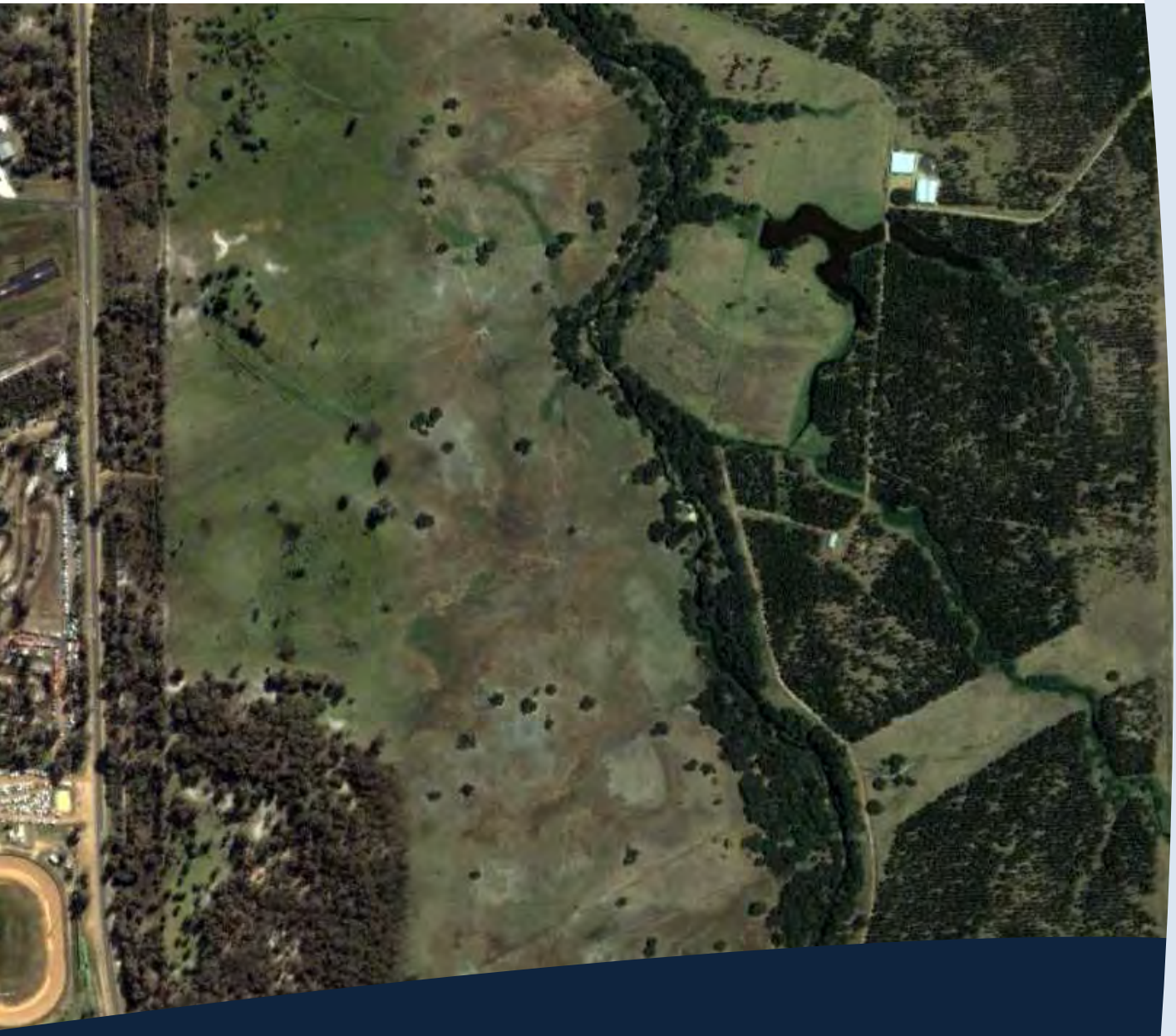

Lot 15 South West Highway, Davenport

Local Water Management Strategy

Prepared for NBR Investments

October 2010

Project Number B10007

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Executive Summary

NBR Investments has commenced structure planning for a 72.1ha parcel of land situated in the locality of Davenport, within the City of Bunbury (CoB). 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 Lot 15 South West Highway, Davenport Local Structure Plan (LSP). 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 land owners.
- Minimise ongoing operation and maintenance costs for the land owners and CoB.
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area.
- Gain support from the DoW and CoB for the proposed method to manage stormwater within the LSP area 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 the Lot 15 study area and provide an indication of the issues requiring further investigation. Further, a number of site-specific investigations into various aspects of the Lot 15 study area have recently been conducted as a part of the LSP preparation process. In summary, the investigations conducted to date indicate that:

- The LSP area receives 727mm of average annual rainfall with the majority of rainfall received between June and August.
- The geologically mapped soil units include the Guildford Formation and Bassendean Sand.
- ASS risk maps indicate the LSP area as having a moderate to low risk of encountering ASS to depths of 3mBGS.
- No Declared Rare or Priority Flora species are present within the study area.
- The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there are five MUW and two CCW and their associated buffer zones that are located within the LSP area.
- Part of the study area is an ESA associated with the CCW and 50m buffer on the western boundary.
- The study area does not contain any streamlines within the site boundary. The Preston River runs adjacent to the study area along the eastern boundary.
- The peak discharges for the pre-development hydrological catchments range between 0.01-0.05m^3/s, 0.04-0.22m^3/s and 0.09-0.55m^3/s for the critical 1, 5 and 100 year ARI storm events.
- The AAMGL ranges between 14.5mAHD and 11.0mAHD with the depth to the AAMGL less than 1.2m across the majority of the study area.

- The generally 'Poor' vegetation condition of the study area is consistent with the historical agricultural and grazing land uses.

The LWMS has determined appropriate Stormwater Management, Groundwater Management and Water Conservation design criteria based on overarching documents, requirements of the CoB, DoW and similar developments.

The stormwater management objectives for Lot 15 is to retain the 10 year ARI storm event on each lot and to mitigate post-development peak discharge rates from the overall development to pre-developments rates for the 1, 5 and 100 year critical ARI storm events. This LWMS provides the location and size of all retention and detention storage areas. Vegetation is proposed within the detention basins at a minimum of at least 2% of the connected impervious area to ensure stormwater quality treatment prior to infiltration into groundwater and discharge into the Preston River.

Stormwater flows will be distributed to retention and detention storage areas via a conventional piped drainage network designed to convey the 5 year ARI flows and via overland flow designed to convey the 100 year ARI storm event. A combination of roadside swales and flood storage areas (FSAs) will be used to 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 South West of WA 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:

- Minimise water requirements for establishment of surface water quality treatment areas and landscaping.
- Minimise water requirements for surface water quality treatment areas and landscaping maintenance.
- Minimise net use of water by capture and utilisation of roof runoff in rainwater tanks.

The preferred strategy to maintain groundwater levels throughout the Lot 15 development will be to use subsoil drainage to ensure the groundwater does not rise through the imported fill that is required to provide a separation distance of 1.2m from the AAMGL.

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.
- Non-structural water quality improvement measures.
- Clarification of Environmental Sensitive Area clearing permit requirements.
- Management and maintenance requirements.
- Construction period management strategy.
- Monitoring and evaluation program.

Pre-development monitoring of hydrological conditions for Lot 15 study area has been undertaken and completed. Groundwater quality monitoring will need to be undertaken in order to set site specific trigger criteria for the development. It is anticipated that the post-development monitoring of 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 15 LWMS provides a framework that future landowners can follow to assist in establishing stormwater management methods that have been based upon site-specific investigations and are consistent with relevant State and Local Government policies. 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 CoB, 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
Water Conservation	Minimise water requirements for establishment of surface water quality treatment areas and landscaping	Roll on turf will be used to minimise water consumption and reduce nutrient inputs.
	Minimise water requirements for surface water quality treatment areas and landscaping maintenance	Native turf and vegetation species will be utilised that are suitable for sustained periods of dry drought following by periods of inundation.
Groundwater Management	Provide clearance to the Average Annual Maximum Groundwater Level (AAMGL) of at least 1.2m to finish lot levels.	The depth to the AAMGL is less than 1.2m across the majority of the study area. Imported clean fill will be utilised within the study area to achieve a separation of 1.2m to the AAMGL. The area requiring fill within the study area is shown in **Figure 17**.
	Ensure a separation distance of 1.2m from the controlled groundwater level (CGL) is to be achieved with the use of subsoil drainage.	The CGL is proposed to equal the AAMGL. Subsoil drainage will be set at the AAMGL. Imported clean fill will be used to achieve a separation of 1.2m to the AAMGL and therefore the CGL (see **Section 7**).
	The bio-retention system, FSA and drainage inverts are set with a clearance of 300mm to the AAMGL	The importation of clean fill and the use of subsoil drainage ensure the flood storage areas (FSAs) maintain a 300mm clearance to the AAMGL.
	A clearance of 500mm from the obvert of the flood storage area will be provided to the 100 year flood level in the adjacent river	Clean fill will be imported into the study area to ensure a clearance of 500mm from the FSA obverts to the 100 year flood levels in Preston River (see **Section 7**).
Surface Water Management	Retain the 10 year ARI storm event on site for each lot	The 10 year ARI storm event will be retained on site for each lot in a combination of rainwater tanks and/or soakwells. The rainwater tanks are nominally sized at 3kL per 250m^2 with a low flow discharge to maintain 1,500L dedicated airspace. Overflow from the rainwater tanks will be retained within soakwells (see **Section 6**).
	The post-development peak flows for the critical 1, 5 and 100 year ARI storm events shall be generally consistent with the pre-development environment	Combinations of roadside swales, vegetated treatment areas and FSAs have been sized to mitigate flows to pre-development conditions (see **Section 6**).

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1 Introduction

1.1 Background

NBR Investments has commenced structure planning for a 72.1ha parcel of land situated in the locality of Davenport, within the City of Bunbury (CoB). The location of the site is shown in **Figure 1**. A local structure plan (LSP) has been developed covering Lot 15 South West Highway, Davenport. The LSP area is bounded by South West Highway to the west and Preston River to the east. The boundaries of the LSP area are shown in **Figure 2**.

1.2 Town Planning Context

Planning at a local level is guided buy the 'higher level' strategic planning (at both the Regional and District level). The LSP is intended to further detail developments outlined in the Regional and District planning process. The site is currently zoned 'Development' (industrial) pursuant to the City of Bunbury Town Planning Scheme (TPS) No. 7.

1.3 Policy Framework

There a number of State Government policies of relevance to the LSP area. These policies include:

- *State Water Strategy* (Government of WA, 2003)
- *State Planning Policy 2.9 Water Resources* (WAPC, 2006)
- *Australian Runoff Quality* (Engineers Australia, 2006)
- *Draft Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA, 2005)
- *Liveable Neighbourhoods Edition 4* (WAPC, 2007a)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC, 2007b)

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 development's should aim to achieve. These are key inputs that relate either directly or indirectly to Lot 15 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)
- *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 CoB, but will also ensure that realistic water quality criteria that are practically achievable are adopted.

1.4 LWMS Objectives

The LWMS for the Lot 15 South West Highway 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 land owners.
- Minimise ongoing operation and maintenance costs for the land owners and CoB.
- Develop a water conservation strategy for the area that will accommodate existing groundwater allocation constraints for the area.
- Gain support from the DoW and CoB for the proposed method to manage stormwater within the LSP area and potential impacts on downstream areas.

2 Proposed Development

The development will cater for industrial and commercial land uses. The LSP is shown in **Appendix A**. Features of the proposed development include:

- Industrial lots ranging in size between approximately 1200m^2 and 5200m^2.
- A Conservation Category Wetland and Buffer have predominantly been accommodated within a landscape buffer zone along the western border.
- 100m wide ecological link along the northern boundary.
- Floodway reserve in the south east corner of the development.
- The future Bunbury outer ring road will be situated outside the LSP are along the southern boundary.
- Preston River and a flood reserve are located outside the LSP area on the eastern boundary.

3 Pre-Development Environment

3.1 Sources of Information

A number of broad level information sources that include the study area and provide a regional environmental context for the LWMS. These were reviewed in order to provide suitable background information for the area, and also to provide an indication of the issues requiring further and more detailed investigation. The background information was sourced from a variety of references, including:

- *Climate Statistics for Australian Locations* (BOM, 2010)
- *Bunbury – Burekup Sheet 2031 III & Part of Sheet 2031 II* (Geological Survey of Western Australia, 1981)
- *Planning Bulletin 64: Acid Sulfate Soils* (WAPC, 2008)
- *Geomorphic Wetlands of the Swan Coastal Plain* (Landgate, 2010)
- *Clearing Areas – Environmental Sensitive Areas* (Landgate, 2010)

Site-specific investigations have been undertaken to provide more detail than the regional mapping information as listed above. These site-specific investigations include:

- *Environmental Study – Lot 15 South West Highway, Davenport – Draft* (Ecoscape, 2008)
- *Groundwater Levels Monitoring Report Lot 15 South Western highway, Davenport* (TME, 2009)
- *Bunbury Industrial Park Shallow Soil Investigation* (TME, 2001)

3.2 Climate

The long term climatic averages indicate the LSP is located in an area of moderate to high rainfall, receiving 727mm on average annually (BOM, 2010) with the majority of rainfall received between June and August. The region experiences rainfall for 88 days annually (on average).

3.3 Geotechnical Conditions

3.3.1 Topography

The topography of the study area ranges from 23mAHD in the south-west corner of the site to 10mAHD adjacent to the Preston River on the east of the study area. The study area is generally flat with the majority of the site containing a easterly aspect. The topographic contours are shown in **Figure 3**.

3.3.2 Soils

Geomorphological classification for the Lot 15 LSP area reported in the *Bunbury – Burekup Sheet 2031 III & Part of Sheet 2031 II* (Geological Survey of Western Australia, 1981) identifies two main soil classifications Guildford Formation (Qpa) and Bassendean Sand (Qpb).

Guildford Formation is described as an alluvial lay/silt/sand mixture in which the silt/clay content can vary significantly. High silt/clay content, combined with alternative wetting and drying cycles can produce significant shrink and swell movement. Bassendean Sand is described as fine to medium sand, cohensionless and grey to off-white at the surface. Bassendean Sand is very permeable and well drained and is not subject to shrinkage (Geological Survey of Western Australia, 1981). The soil mapping is shown in **Figure 4**.

A preliminary geotechnical investigation was carried out by Thomas McRobert Edgeloe Group (TME, 2001). A total of 18 backhoe excavations and analysis of the subsurface profile were conducted. The results of the test pit logs are generalised as "Grey Sand poorly graded to depths of 1m underlain by Sandy Clay (yellow, green and brown)". The TME report included that presence of clay layers overlain by gravel and course sand resulted in a perched water table. The infiltration capacity of such soil types can range between 1×10^{-4}m/s and 1×10^{-7}m/s.

3.3.3 Acid Sulfate Soils

The *WA Atlas* (Landgate, 2010) Acid Sulfate Soil (ASS) risk mapping classifies the study area as having a 'low to moderate risk of ASS occurring within 3m of the natural soil surface'. The ASS risk mapping is shown in **Figure 5**.

3.4 Flora

An environmental assessment of Lot 15 was undertaken by Ecoscape (2008). A desktop analysis and site survey were undertaken to identify any Declared Rare or Priority Flora species present within the study area. A total of 18 Declared Rare Flora species were recorded as potentially being present within the study area; however the site survey did not identify any Declared Rare or Priority Flora species present within the study area boundary.

The remnant vegetation within the study area ranged between 'Very Good – Excellent' to 'Poor'. Two vegetation complexes were identified within the study area:

- Swan – Fringing woodland of *Eucalyptus Rudis – Melaleuca rhaphiophylla* with localised occurrence of low open forest of *Casuarina obesa* and *M. cuticularis*.
- Southern River – Open Woodland of *E. calophylla – E. marginata – Banksia* spp. with fringing woodland of *E. rudis – M. rhaphiophylla* along the creek beds (*Heddle et al.*, 1980).

The significance of the remaining vegetation was considered 'significant at Regional and Local levels' as the vegetation communities present on site are not adequately represented in the local conservation reserve system. The vegetation mapping condition is shown in **Appendix B**.

3.5 Environmentally Assets

3.5.1 Wetlands

The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there are a number of wetlands within the LSP area. The Palusplain 14285 and 15451 wetlands are classified as 'Conservation Category Wetlands' (CCW. The Palusplain 14324 wetland is classified as a Resource Enhancement Wetland (REW) while the Palusplain 14283, 1325, 1249, 1327 and 15450 wetlands are classified as 'Multiple Use Wetlands' (MUW). The location of the wetlands is presented in **Figure 6**.

3.5.2 Environmentally Sensitive Areas

The *Clearing Areas – Environmental Sensitive Areas* dataset (Landgate, 2010) classifies part of Lot 15 as an Environmentally Sensitive Area (ESA). The location of the ESA corresponds with the CCW and the 50m buffer as shown in **Figure 7**.

3.6 Hydrology

3.6.1 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 hydrological and hydraulic model to calculate discharges, volume of runoff and flow paths. The XPSWMM hydrological and hydraulic model was used to create a site specific pre-development model to provide a basis from which a comparison with the post-development peak discharges can be made.

3.6.1.1 Existing Drainage Network

There are no streamlines within the study area boundaries however the site does contain some erosion channels that drain water from the site to the Preston River which runs adjacent to the study area along the eastern boundary. The hydrological features are shown in **Figure 8**.

3.6.1.2 Pre-Development Sub-Catchments

The study area is divided into a total of four sub-catchments with runoff from the sub-catchments directed to Preston River to the east or South West Highway to the west. The pre-development sub-catchments are shown in **Figure 8**.

3.6.1.3 Pre-Development Modelling Parameters

An 'initial loss - continuing loss' infiltration model was adopted to generate stormwater runoff hydrographs in the hydraulic and hydrological model XPSWMM. The loss values were selected based on Cardno's experience with similar soil types and catchments. The infiltration rates for the different soil and land types are presented in **Appendix C**.

3.6.1.4 Pre-Development Modelling Results

A multi storm analysis was run to determine the critical storm event for the 1, 5 and 100 year ARI events. The duration of the three events is equal to 48, 48 and 6 hours respectively. The pre-development peak flows are shown in **Table 3.6.1**.

Table 3.6.1 Pre-Development Surface Water Discharge Flows

Discharge Catchment	Corresponding Area (ha)	Peak Discharge (m^3/s)		
		1 year	5 year	100 year
1	42.549	0.046	0.217	0.548
2	10.827	0.019	0.101	0.249
3	2.014	0.010	0.038	0.085
4	16.704	0.036	0.158	0.357

3.6.2 Surface Water Quality

There are no streamlines or surface water channels within the study area and therefore no surface water quality data is available to report on.

3.6.3 Groundwater Levels

Groundwater monitoring was undertaken by Thompson McRobert Edgeloe Group (TME, 2009). A total of 15 bores were monitored between December 2007 and November 2009 capturing two years

of peak groundwater level data. The maximum groundwater level (MGL) in 2008 was recorded in July whereas the MGL in 2009 was recorded in September. The depth to groundwater ranged between 0.01m below ground surface (BGS) and 2.10mBGS. The average annual maximum groundwater level (AAMGL) was calculated and referenced to long-term monitoring data from the DOW Bore 1543 (see **Appendix D**). The AAMGLs range between 14.5mAHD and 11.0mAHD as shown in **Figure 9**. The depth to the AAMGL is shown in **Figure 10**.

3.6.4 Groundwater Quality

No groundwater quality sampling has been conducted within the study area.

3.7 Current and Historical Land Uses

The study area has been used for agricultural purposes and grazing over an extended period of time. The vegetation condition of the study area reflects the historical use of the site in that it is predominately in 'Poor' condition (Ecoscape, 2008).

3.8 Summary of Existing Environment

In summary, the environmental investigations conducted to date indicate that:

- The LSP area receives 727mm of average annual rainfall with the majority of rainfall received between June and August.
- The geologically mapped soil units include the Guildford Formation and Bassendean Sand.
- ASS risk maps indicate the LSP area as having a moderate to low risk of encountering ASS to depths of 3mBGS.
- No Declared Rare or Priority Flora species are present within the study area.
- The *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicates that there are five MUW and two CCW and their associated buffer zones that are located within the LSP areas.
- Part of the study area is an ESA associated with the CCW and 50m buffer on the western boundary.
- The study area does not contain any streamlines within the site boundary. The Preston River runs adjacent to the study area along the eastern boundary.
- The peak discharges for the pre-development hydrological catchments range between 0.01-0.05m^3/s, 0.04-0.22m^3/s and 0.09-0.55m^3/s for the critical 1, 5 and 100 year ARI storm events.
- The AAMGL ranges between 14.5mAHD and 11.0mAHD with the depth to the AAMGL less than 1.2m across the majority of the study area.
- The generally 'Poor' vegetation condition of the study area is consistent with the historical agricultural and grazing land uses.

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 Water Conservation

It is widely thought that South West of WA 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:

- Minimise water requirements for establishment of surface water quality treatment areas and landscaping.
- Minimise water requirements for surface water quality treatment areas and landscaping maintenance.

4.2 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*. The *Stormwater Management Manual for Western Australia* also provides guidance on the broad principles of Water Sensitive Urban Design (WSUD).

The stormwater criteria have been determined in light of the guidance provided in the above documents and in consideration discussions with the Department of Water (Krish Seewraj 30 June 2010).

4.2.1 Stormwater Quantity

The stormwater management design criteria proposed for the study area include:

- Retain the 10 year ARI storm event on site for each lot.
- The post-development peak flows for the critical 1, 5 and 100 year ARI storm events from the overall development 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 to cater for runoff from the road reserve based on the 5 year ARI rainfall 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.
- A clearance of 500mm from the obvert of the flood storage area will be provided to the 100 year flood level in the adjacent river.
- A clearance of 300mm from the 100 year flood levels in road reserves will be provided to the adjacent lot floor levels.

4.2.2 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 groundwater and surface water annual monitoring reports (Cardno BSD, 2007; Cardno BSD, 2008).

The design criteria that will be adopted to ensure that the above objectives are met will include:

- Provide vegetated treatment areas for connected impervious areas. These are to be a minimum of 2% of the connected impervious areas (and likely to result in retention of ~3 month ARI event) and will either be within road reserves or within dedicated drainage reserves, whichever is most practical or realistically achievable.
- Apply appropriate structural and non-structural measures to reduce applied nutrient loads.

4.3 Groundwater Management

Any proposed manipulation of groundwater levels during construction should be approached in a manner that adequately considers nearby wetland water dependant ecosystems, elevated nutrient concentrations within superficial aquifers and ASS potential across the site, and should be fully rationalised within the future UWMP documents

The WSUD principles for best practice management of groundwater levels and quality that have been adopted for this DWMS include:

- Minimise changes to the underlying groundwater levels as a results of development.
- Minimise the risk of nutrient enrichment of downstream receiving surface water bodies from groundwater sources.
- The groundwater leaving the study area should be at least the same, or better, than the water entering the study area.

In consideration of discussions with the Department of Water (Krish Seewraj 30 June 2010), the design criteria for groundwater management that will be adopted for this LWMS in order to achieve the principles stated above are as follows:

- 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.
    - If subsoil drainage is not used the separation distance of 1.2m from the long term annual average maximum groundwater level (AAMGL) must be achieved.
    - If subsoil drainage is to be used then the separation distance of 1.2m from the controlled groundwater level (CGL) is to be achieved. Subsoil drainage should not be placed lower than the AAMGL; however, where it is shown that there is negligible impact on the surrounding environment; subsoil drainage may be placed lower than the AAMGL but no lower than the CGL.

- The bio-retention system, FSA and drainage inverts are set with a clearance of 300mm to the AAMGL although existing inverts below the AAMGL may remain.
- The clean fill imported onto the development 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 City of Bunbury.

5 Water Conservation Strategy

5.1 Fit for Purpose

The objective for fit for purpose water is to achieve the highest order use of each water source. Due to the industrial style of development proposed for Lot 15, scheme water will be required to meet the requirements of the development. An existing 100mm main that serves the Bunbury Regional Prison is located along the western side of South Western Highway. The mains pipe is under capacity and will not be available for supply to Lot 15. The proposed connection to the scheme water supply is to extend a water main along South West Highway from Endeavour Road Halifax, approximately 1500m to the proposed northern access road to the study area (Cardno, 2010). Services to each lot will be deferred until the specific demand for each lot is known.

In determining an estimate of the total scheme water required for the study area, a water balance was created based on the Water Corporation spreadsheet *AltSupply_Water_Use_Model.xls*. A total of 428.5ML/yr will be required assuming a light industrial land-use. The total amount of wastewater produced will be approximately equal to 391.5ML/yr. A total of 44.2ML/yr of water will be required for the irrigation of verges (assuming the verge area is equal to 30% of the road reserve), the floodway reserve POS in the south eastern corner of the development and the FSAs. It is expected that the water required for irrigation will be sourced from groundwater.

Rainwater harvesting may be a potential scenario that would be able to then be used for irrigation purposes on the entry statements or plumbed into the lots for non-potable drinking sources. This would decrease the requirement for scheme water within the subdivision.

Rainwater tanks may be used to help retain the 10 year storm event on site. In order for this to be achieved however a dedicated air space would be required within the rainwater tanks. The use of rainwater tanks for irrigation and non-potable uses is also dependant on what the lots are used for, as land-use may vary significantly under the industrial development.

5.2 Wastewater Management

Due to the type of development and the sensitive downstream environment of Preston River, it is not appropriate for wastewater to be disposed of onsite. It is proposed that the entire Lot 15 development will be connected to deep sewer. A sewer pump station will be required to be located in the north eastern corner of Lot 15. The effluent from the pump station will be pumped along South Western Highway north to a receiving point in Gibbons Road Halifax (Cardno, 2010).

6 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 4.2**.

6.1 Development Drainage System

The storm water runoff from the development will be detained in order to ensure peak flows from the critical 1, 5 and 100 year ARI storm events are maintained at pre-development conditions. The combinational use of vegetated treatment areas, flood storage areas (FSAs) and roadside swales will provide storage in a treatment train effect. All discharge from the FSA will be directed to the Preston River as per the pre-development hydrology. The stormwater drainage system for the development (including nominal locations for swales, vegetated treatment areas and FSAs) is provided within **Figure 11**.

6.1.1 Vegetated Treatment Areas

Vegetated treatment areas will be sized at a minimum of 2% of the connected impervious area which will retain the approximately volume generated in a 3 month ARI storm event. The VRAs will be planted with native drought tolerant plant species. 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. Larger rainfall events will be conveyed by overland flow or pipe network to a network of interconnected FSAs which will detain flows to match the pre-development discharge rate. A concept diagram of how the vegetated treatment areas will be linked with the FSAs is shown in **Figure 12**.

6.1.2 Swales

Swales provide both conveyance of stormwater and retention/detention storage. It is proposed to utilise swales alongside select road reserves to capture 50% of flows from the road pavement (crown road) and road verge. Stormwater will be directed into the swale via flush kerbing. The swales were assumed to be approximately 0.3m deep and 2m wide (detailed designs to be finalised at UWMP stage). 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). The swales will be used to detain flows to match post-development peak floss to pre-development conditions.

6.1.3 Flood Storage Areas

FSAs are utilised to detain major event flows in order to maintain post-development peak flows at 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, orifice or similar). 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). A concept design of how the FSAs may be designed is shown in **Figure 13**. The FSAs higher in the catchment will retain the 5 year ARI storm event, conveyed to the FSAs via the pipe network system. The FSA at the lowest catchment will ensure the 100 year storm event, conveyed to the FSA via a pipe network and overland flow in the road reserves, is contained within the FSA. The critical 1, 5 and 100 year ARI

peak flows will be discharged at peak flow rates consistent to the pre-development environment via the pipe system that connects the FSAs.

As the VRAs and FSAs are located within lots, an easement will be required to be placed on each of the areas identified for drainage purposes. The side slopes of the VRAs and FSAs are both at 1:6 and therefore no fencing will be required to be installed for safety reasons. The FSAs will be planted with native turf species such as *Cynodon dactylon* (Couch grass) which will minimise the water requirements for the development.

6.2 Lot Drainage System

The 10 year ARI storm event will be retained on site within rainwater tanks and/or soakwells. A nominally sized rainwater tank of 3kL per 250m^2 of roof area is assumed for each lot. If rainwater tanks are used, they need to have a low flow discharge outlet that will ensure a dedicated air space is maintained within the rainwater tank. The assumed storage for each lot is equal to 1,500L per 250m^2. The remainder of the runoff in the 10 year event will be retained in soakwells, though it is noted that individual landowners may choose more storage in rainwater tanks and less in soakwells or an onsite sump or subsurface storage area, depending on their needs.

6.3 Post-Development Surface Runoff Modelling

As described in **Section 6.1**, this LWMS proposes to utilise rainwater tanks, soakwells, FSAs and roadside 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 C**).

The retention of the 10 year ARI storm event from lots will be achieved through the use of soakwells and rainwater tanks. The total storage required is shown in **Table 6.3.a** with the full description of storages for each sub-catchment shown in **Appendix C**.

Table 6.3.a Development Lot Storage Requirements

Rainwater Tanks (ML)	Soakwells (ML)
1,315	10,076

Note that the above volumes are nominally allocated, and in the ultimate development the ratios of storage in rainwater tanks, soakwells or onsite storage may vary.

Runoff from half the road reserve (crown road) adjacent to the eastern site boundary and the western boundary adjacent to the CCW will be detained within roadside swales. The proposed dimensions of the road side swales are shown in **Appendix C**.

The FSAs are proposed at different heights to cater for the different flow regimes. The 5 year ARI storm event from road reserves will be conveyed within the pipe network system. Basins higher up in the catchments have a depth of 0.5m in order to ensure the 5 year ARI storm event is contained within the FSA. A 300mm pipe diameter with a 100mm diameter choke (or similar) will be installed to ensure peak flows are maintained at pre-development conditions while ensuring that blockages within the pipe network and flooding do not occur. The 100 year ARI storm event will be conveyed within the road reserve and directed to FSAs at the lowest point within the catchment. The FSAs at the bottom of the catchment have proposed depths of either 0.75m or 1.0m in order to contain the 100 year ARI storm event within the FSAs thereby ensuring flooding of adjacent lots does not occur. Differing discharge pipe sizes from the FSAs were used in order to ensure peak flows are maintained

at pre-development conditions. Full descriptions of the proposed dimensions of the FSAs are shown in **Appendix C**. These can be varied at detailed design stage, provided the overall result is that the pre-development peak flows are not exceeded in the post-development environment.

Minor roads will remain passable in the 5 year ARI storm event as all FSAs are sized in order for the 5 year event to be contained within the FSA. As there are no major roads within the development, and flows will be directly away from the major roads adjacent to the development (i.e. South Western Highway and the proposed Bunbury Outer Ring Road), conveyance of flows within the road reserve will achieve the criterion of ensuring all major roads remain passable in the 100 year storm event.

A comparison between the equivalent pre-development and post-development peak flows are shown in **Table 6.3.b**.

Table 6.3.b Comparison of Equivalent Pre-Development and Post Development Peak Flows

Discharge Catchment	Corresponding Area (ha)	Pre-Development (m^3/s)			Post-Development (m^3/s)		
		1 year	5 year	100 year	1 year	5 year	100 year
1	14.395	0.015	0.074	0.186	0.052	0.096	0.208
4	9.769	0.010	0.050	0.126	0.021	0.037	0.122
7	9.800	0.011	0.050	0.127	0.019	0.031	0.122
8	16.376	0.026	0.118	0.278	0.014	0.024	0.264
14	15.501	0.033	0.145	0.327	0.007	0.021	0.341
17	6.515	0.021	0.091	0.212	0.014	0.061	0.159

The peak flow rates from the post-development environment are generally consistent with the pre-development environment, ensuring erosion within Preston River will be minimised while providing the flows required for ecological preservation. The inundated areas for the 1, 5 and 100 year ARI events are shown in **Figure 14**, **Figure 15** and **Figure 16** respectively.

A clearance of 300mm from the 100 year flood levels in road reserves to the adjacent lot floor levels is to be achieved to ensure flooding of lots is avoided. As the 5 year storm event will be conveyed in the pipe network system and the 100 year event is retained within each FSA at the bottom of the catchments, a clearance of 300mm from the obvert of the FSAs will achieve this criterion. The FSA must also achieve a clearance of 500mm from the 100 year flood level within Preston River. **Table 6.3.c** below shows the 100 year flood levels in Preston River, FSA obverts, minimum lot levels and the clearances obtained in order to achieve the above criteria.

Table 6.3.c FSA Obverts, 100 year Flood Levels, Lot Levels and Clearance Levels

Catchments	FSA obvert (mAHD)	100 year flood level (mAHD)	Minimum lot level (mAHD)	Lot level clearance to FSA obvert (m)	FSA obvert clearance to flood level (m)
1	12.30	10.50	12.60	0.30	1.80
2	14.05	-	14.45	0.40	-
3	13.05	-	13.45	0.40	-
4	13.05	10.50	13.35	0.30	2.55
5	14.55	-	14.95	0.40	-
6	13.05	-	13.45	0.40	-
7	12.40	10.50	12.70	0.30	1.90
8/9	15.10	-	15.50	0.40	-
10	15.60	-	16.00	0.40	-
11	14.05	-	14.45	0.40	-
12	13.30	-	13.70	0.40	-
13	12.55	-	12.95	0.40	-
14	12.80	12.00	13.10	0.30	0.80
15	14.60	-	15.00	0.40	-
16	13.80	-	14.20	0.40	-
17	13.00	12.00	13.30	0.30	1.00
18	14.95	-	15.35	0.40	-
19	13.80	-	14.20	0.40	-

Table 6.3.c shows a clearance of 0.4m from the lot level to the FSA obvert which is greater than the requirement of providing 0.3m separation. This is due to the clearance required to achieve separation from the AAMGL as discussed in **Section 7**. These levels should be seen as minimum requirements to achieve the criteria stipulated in this LWMS. Final designs will be provided at UWMP stage which will confirm the levels require to achieve the separation clearances.

Each FSA will incorporate a vegetated treatment area that will be sized at 2% of the connected impervious area which is separated from the larger detention area. This criterion aims to treat frequent low intensity events equivalent to the 3 month storm event. As the 10 year storm event is being retained within lots, the connected impervious area corresponds with the impervious area of the road reserve. The impervious area was assumed to be equal to 70% of the road reserve. **Table 6.3.d** shows the catchment, road reserve and connected impervious areas and the vegetated treatment area required for stormwater quality treatment.

Table 6.3.d FSA Obverts, 100 year Flood Levels, Lot Levels and Clearance Levels

Catchments	Catchment Area (ha)	Road Reserve (ha)	Connected Impervious Area (ha)	Vegetated Treatment Area (m^2)
1	11.772	2.102	1.471	294
2	2.042	0.446	0.312	62
3	3.842	0.517	0.362	72
4	3.572	0.699	0.489	98
5	2.087	0.453	0.317	63
6	3.632	0.405	0.284	57
7	3.875	0.596	0.417	83
8/9	2.203	0.491	0.344	69
10	3.093	0.748	0.524	105
11	3.042	0.654	0.457	91
12	2.946	0.575	0.402	80
13	3.105	0.605	0.424	85
14	1.758	0.403	0.282	56
15	3.558	0.703	0.492	98
16	1.883	0.419	0.293	59
17	3.707	1.165	0.815	163
18	2.864	0.726	0.508	102
19	2.618	1.053	0.737	147
Total	*61.597*	*12.759*	*8.931*	*1,786*

7 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**.

7.1 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. These treatment areas will improve the quality of the water prior to it infiltrating into the underlying groundwater.
- Garden beds should not be immediately adjacent to the infiltration treatment areas or FSA to reduce nutrient transportation into these infiltration areas.

7.2 Groundwater Level Management

The primary objective for groundwater level management is to ensure that a suitable clearance from final lot levels to the groundwater is achieved (see **Section 4.3**). As shown in **Figure 10**, the clearance to the AAMGL is less than 1.2m across the majority of study area. Fill will be imported into the study area to ensure a separation distance of 1.2m from the AAMGL is achieved. Subsoil drainage will be positioned at the AAMGL to ensure groundwater does not rise up into the clean fill. The subsoil drainage will not be used lower groundwater levels as it will be positioned at the AAMGL which we assumed to be the level of the CGL. This approach is considered appropriate as there is no groundwater dependant ecosystems onsite that would be impacted by limiting rise of groundwater to the AAMGL.

7.3 Implications for Fill

The study area is located in and adjacent to the 100 year floodway of Preston River, as shown in **Figure 8**. The depth to the AAMGL is also less than 1.2mBGS as shown in **Figure 10**. As indicated above, fill will be required to be imported onto the site in order to ensure the criteria outlined in **Section 4** are achieved. **Figure 17** shows the area that will likely required fill. The fill required area was created from multi criteria GIS analysis following the criteria listed below:

- Separation of 0.5m above the floodway.
- Separation of 1.2m above the AAMGL.
- Levels required to achieve a minimum grade of 1:200 for surface flow paths.

Figure 17 was prepared in order to identify the need for imported fill and will be utilised in generating the bulk earthworks levels which will be presented in the future UWMP.

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 15, 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
- Use of rainwater tanks and/or soakwells based on geotechnical investigations
- Status of groundwater abstraction licence
- Non-structural water quality improvement measures
- Wetland management categories and boundaries
- Management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program

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 retention/detention storage areas will still need to be specified and presented within the future UWMPs.

In order to review the final retention/detention storage areas 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 peak flows are able to meet the performance requirements detailed within this LWMS.

8.3 Use of Rainwater Tanks and/or Soakwells based on Geotechnical Investigations

As discuss in **Section 6**, the 10 year ARI storm event is to be retained onsite. This LWMS proposes to use a combination of rainwater tanks and soakwells. However, as indicated in **Section 3.3.2**, shrink swell clay soils have the potential to exist within the development. A geotechnical investigation will therefore need to be conducted to identify suitable locations for the use of soakwells and/or subsurface storage. Should shrink swell clay soils exist within the development, a greater amount of storage will need to be provided for within rainwater tanks, which will be finalised at UWMP stage.

8.4 Status of Groundwater Abstraction Licence

As discuss in **Section 5.1**, verges and POS/landscaped areas are expected to be irrigated with groundwater. The study area is located in the Bunbury Groundwater Area and the Bunbury East Subarea. The two aquifers in the regions, superficial and Leederville, are both over-allocated as of the 21st October 2010 (DOW, pers. comm.). In order to gain a licence for abstraction purposes, trading of water entitlements will be required to be undertaken. The status of the trading and approval of the groundwater abstraction licence will need to be addressed at the UWMP stage.

8.5 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).

8.6 Wetland Management Categories and Boundaries

As identified in **Section 3.5.1** there are a number of Conservation Category/Resource Enhancement wetlands within the study area that could potentially be required to be conserved along with a proposed buffer zone. The LSP currently intrudes into the wetland mapped areas. The quality of the wetland vegetation in these locations however is questionable. A wetland reclassification assessment is expected to be undertaken to verify and/or alter the wetland categories and boundaries. The results of the assessment will be reported on at the UWMP stage.

8.7 Management and Maintenance Requirements

The management measures to be implemented to address surface water quality, such as the use of vegetation within roadside swales and vegetated retention areas 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 CoB 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.

8.8 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 15, 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.
- 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).

8.9 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 CoB. 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.

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 generally 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 CoB. These monitoring programs will be further detailed at the UWMP stage.

9.1 Recommended Program for UWMP

9.1.1 Pre-Development Monitoring

Pre-development groundwater monitoring will need to be undertaken to determine the groundwater quality entering and exiting the study area. Six bores will provide a suitable bore density for the size of the development as shown in **Figure 18**. Either existing bores located within an appropriate distance from the proposed bore locations in **Figure 18** or new bores will be installed to monitoring the groundwater quality.

A single snapshot sample will be taken and analysed at a NATA accredited laboratory for nutrients, nutrient species, heavy metals and hydrocarbons as well as sampling *in situ* physio-chemical parameters. With the proposed use of industrial for the study area and the lack of development to the east on Preston River, nutrient concentrations are not expected to exceed ANZEEC default trigger (2000).

9.1.2 Post-Development Monitoring

Post-development groundwater monitoring should be conducted at or as close as possible to the pre-development monitoring bore locations. Where this is not possible, bores should be re-installed, post-development, at locations that can provide comparable results.

As there are no defined streamlines or surface water channels within the study area, surface water monitoring is not proposed to be conducted. The proposed monitoring program frequency and analytes to be sampled is shown in **Table 9.1**. The post-development monitoring should be conducted for two years and include at least one year of monitoring when 80% of the development is complete.

Table 9.1 Monitoring Program Summary

Monitoring Period	Monitoring Type	Locations	Frequency	Parameters
Pre-Development	Groundwater	Six bores located upstream and downstream of the groundwater flow	Single snapshot sampling	*In situ* pH, EC, dissolved oxygen, temperature. Sample pH, TSS, TN, TKN, NH_4, NO_X, TP, FRP. Sample heavy metals and hydrocarbons.
Post-Development		Network of monitoring bores providing a suitable spatial representation of the study area	Quarterly (typically Jan, April, July, Oct)	

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

Trigger criteria for groundwater management will be based upon the groundwater sampling data and the default trigger criteria for surface water quality from the *National Water Quality Management Strategy* (ANZECC, 2000) as groundwater quality default trigger criteria have not been developed. The ANZECC default trigger criteria are shown in **Table 9.2.1**.

Table 9.2.1 Post-Development Surface Water Trigger Values

TN (µg/L)	TP (µg/L)	ORP (µg/L)	NH_4 (µg/L)	NO_X (µg/L)	DO (%)	pH	Conductivity (mS/cm)
1,200	65	40	80	150	80-120	6.5-8.0	0.12-0.30

9.2.2 Contingency Measures

If the results from the post-development monitoring indicate that action is required to address the issue, a number of contingency measures may be employed by the developer. In relation to nutrients, these include:

- Identify source if possible.
- Remove source if possible (e.g. fertiliser input, etc.).
- Remove sediment-bound nutrients by removing basin sediments.
- Review implementation of vegetated landscape management practices.

9.3 Reporting

Reporting of the pre-development results will occur on completion of the monitoring program and a summary included in future UWMPs. Post-development monitoring reports are expected to be published on an annual basis and provided to the CoB 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 Government and CoB policies. The responsibility for working within the framework established within the LWMS rests with the proponent, although it is anticipated that future UWMP documents will be developed in consultation with the CoB and DoW and in consideration of other relevant policies and documents.

Due to the size of the Lot 15 development, 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 the Lot 15 study area constitutes a single landholding, the cost of implementing management strategies outlined in this LWMS will be borne solely by the proponent. The CoB 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 CoB to reach a mutually agreeable outcome where required.

10.3 Review

This LWMS is not expected to be reviewed unless significant change to the LSP is undertaken. 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 7**, 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.
- Water supply for landscaping irrigation.
- 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 CoB 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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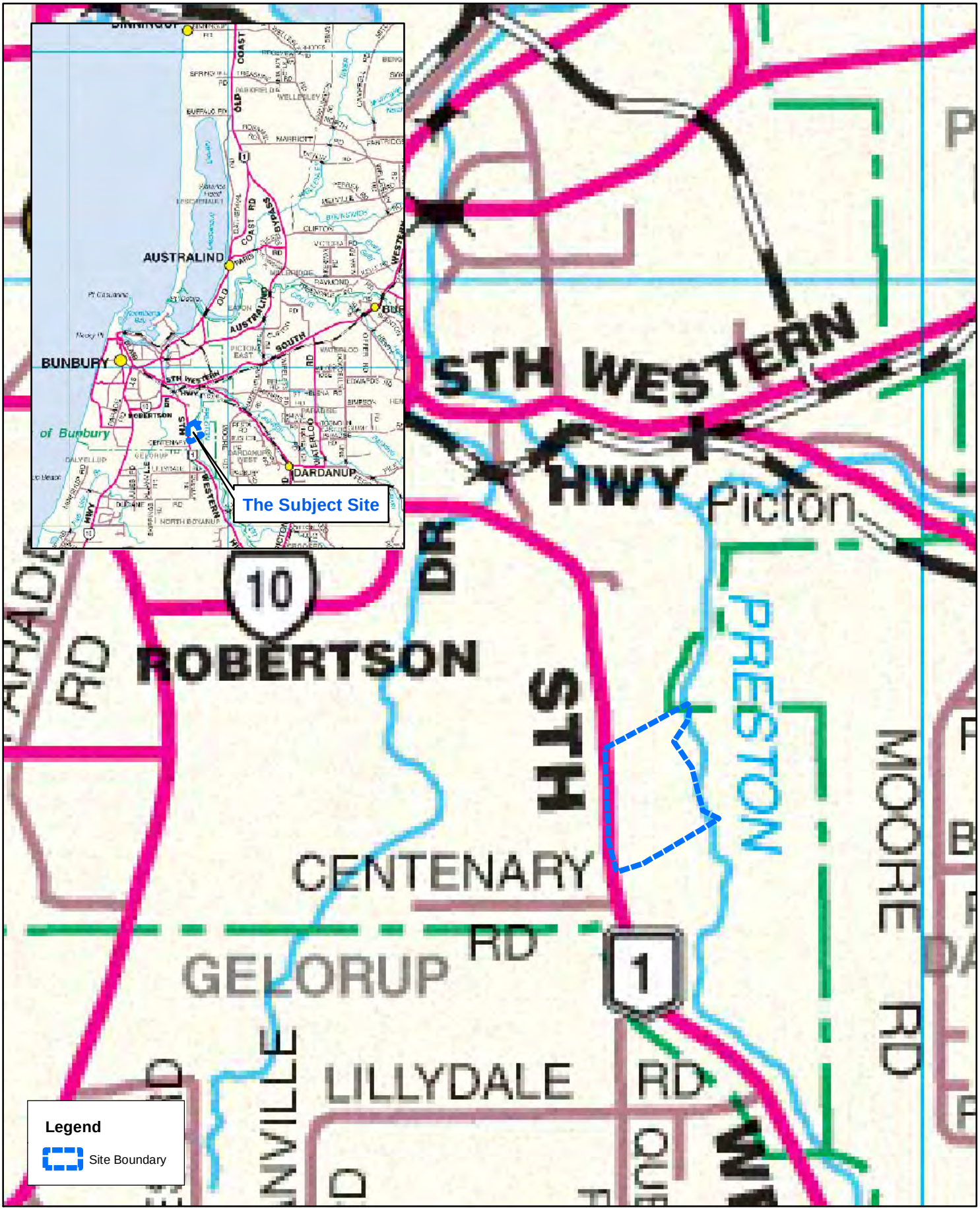
Figures



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PROJECT **Lot 15 South West Highway, Devonport LWMS**

DRAWING TITLE **FIGURE 1 : Site Location**

PRINCIPAL **NBR Investments Pty Ltd**

Project Number **B10007**

Original **A4**

Drawing Number **SK01**

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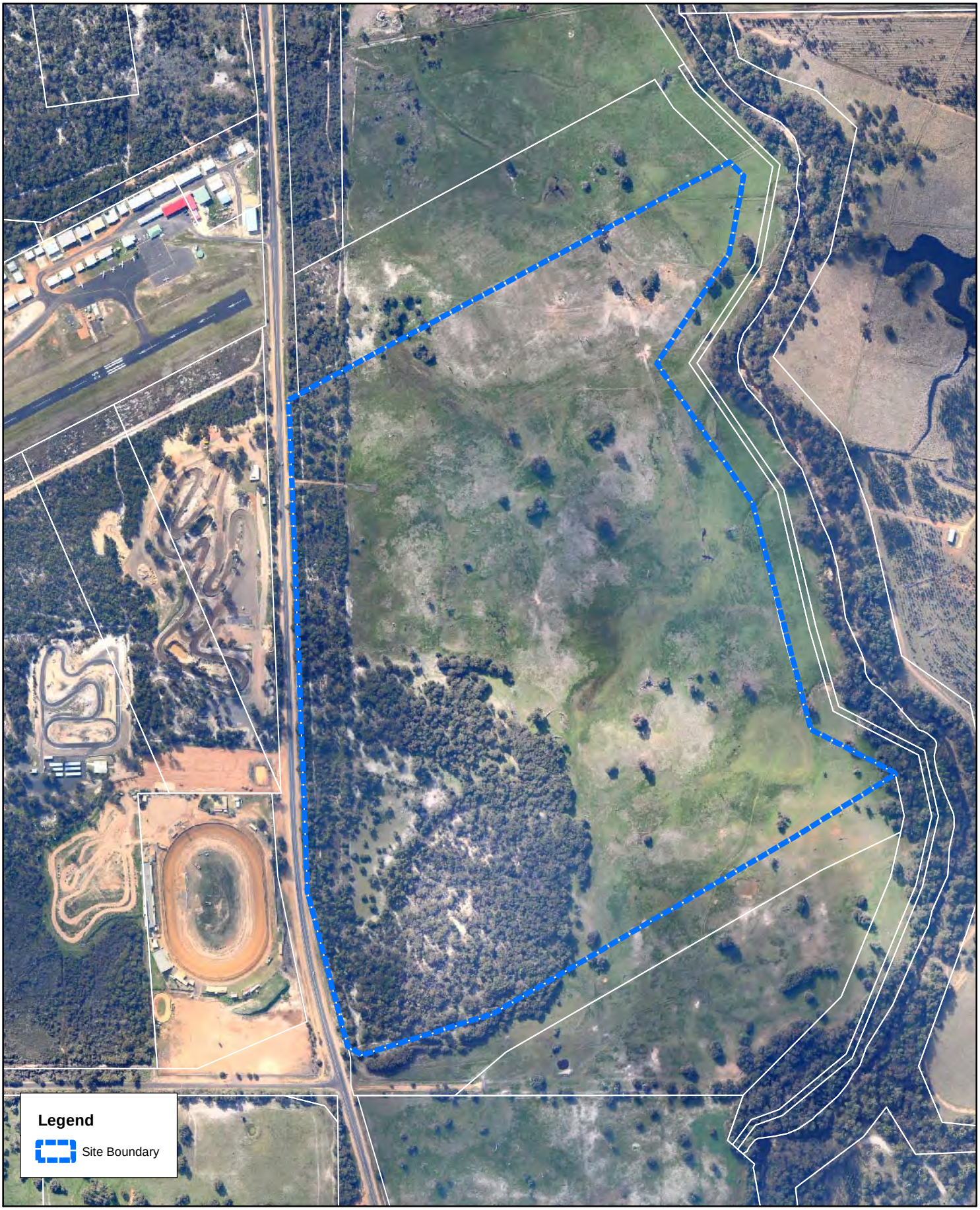

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PROJECT **Lot 15 South West Highway, Devonport LWMS**

DRAWING TITLE **FIGURE 2 : Site Boundary & Aerial Image**

PRINCIPAL **NBR Investments Pty Ltd**

Project Number **B10007**

Original **A4**

Drawing Number **SK02**

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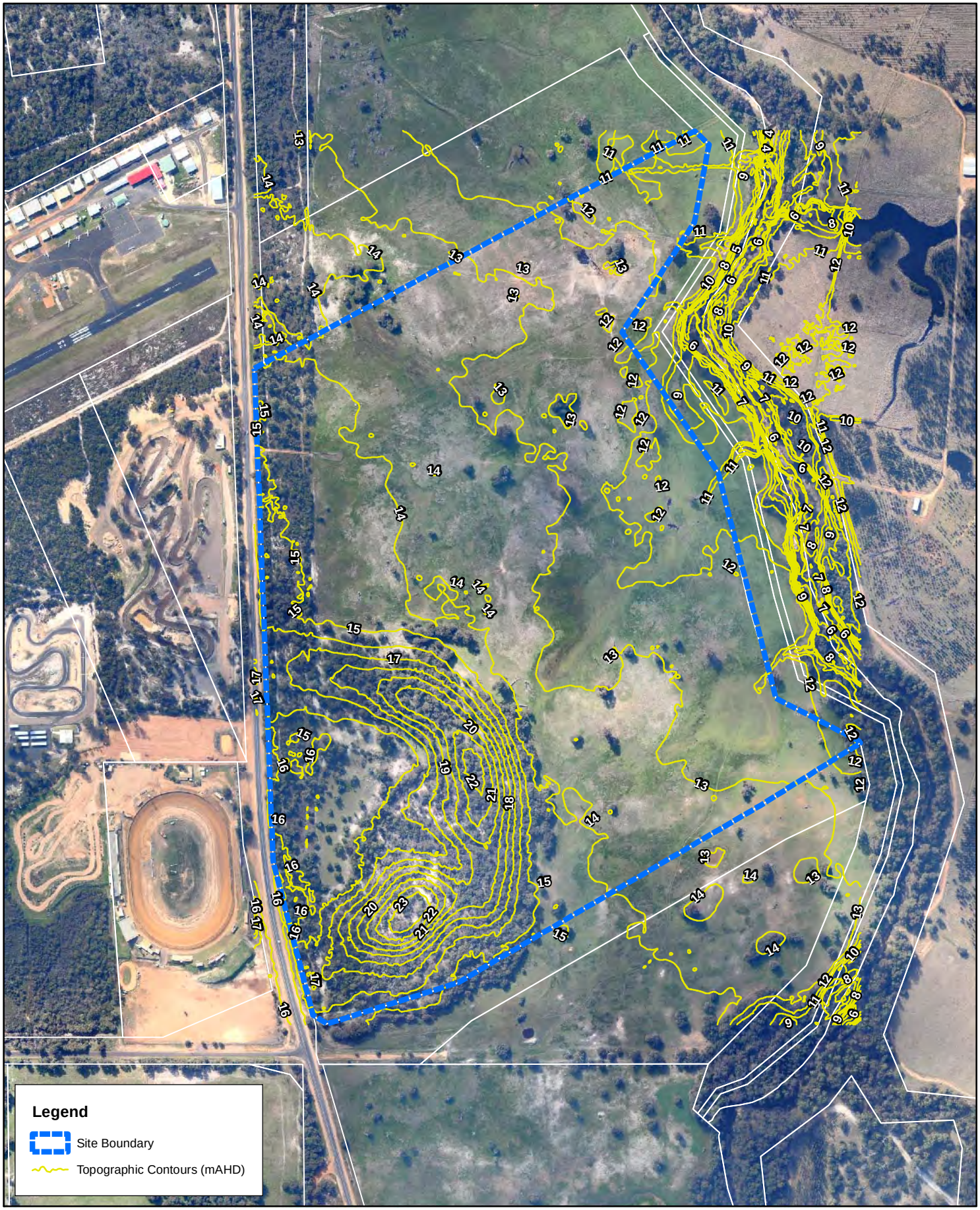

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PROJECT Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE FIGURE 3 : Topographic Contours

PRINCIPAL NBR Investments Pty Ltd

Project Number B10007

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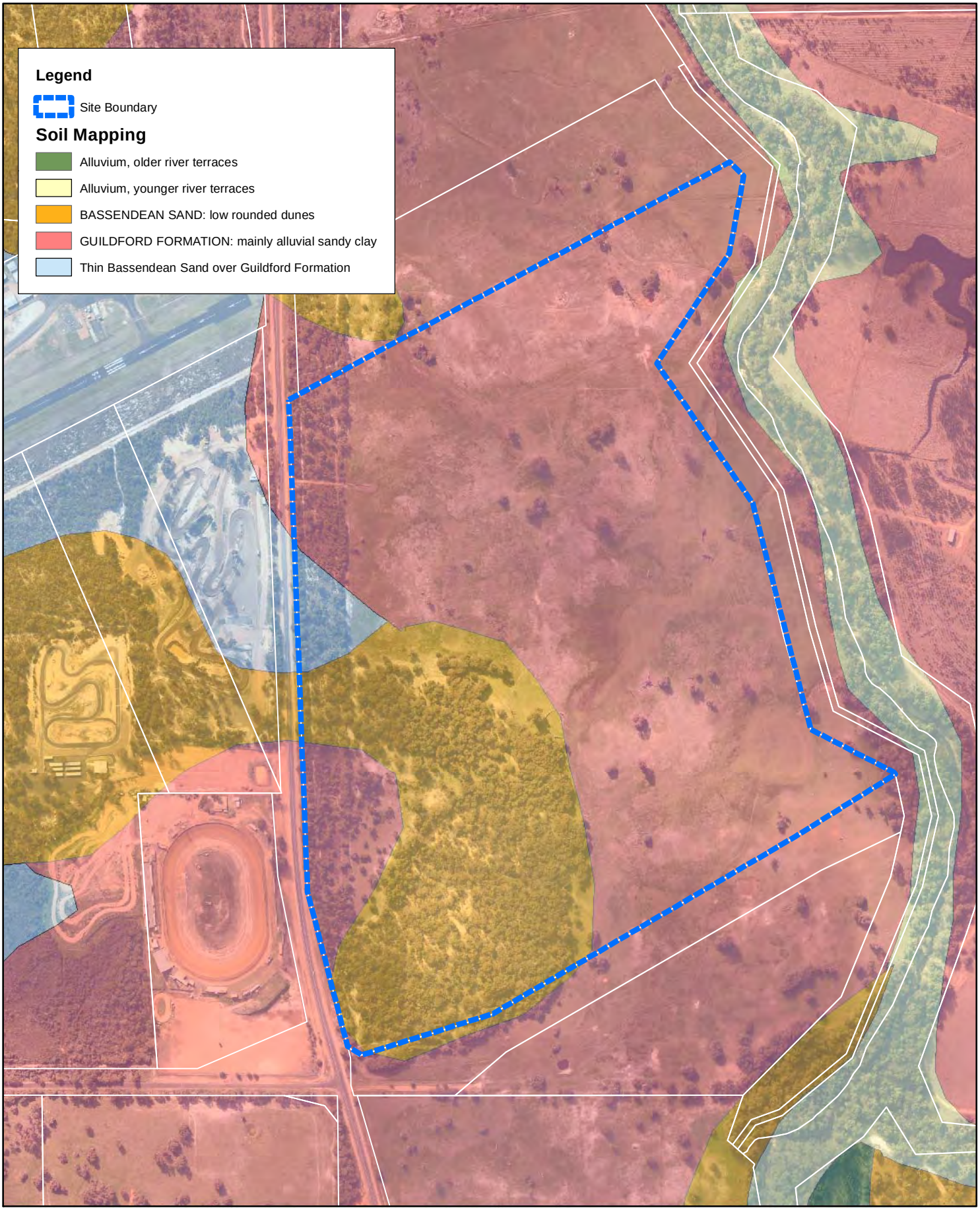

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PROJECT **Lot 15 South West Highway, Devonport LWMS**

DRAWING TITLE **FIGURE 4 : Soil Mapping**

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Project Number **B10007**

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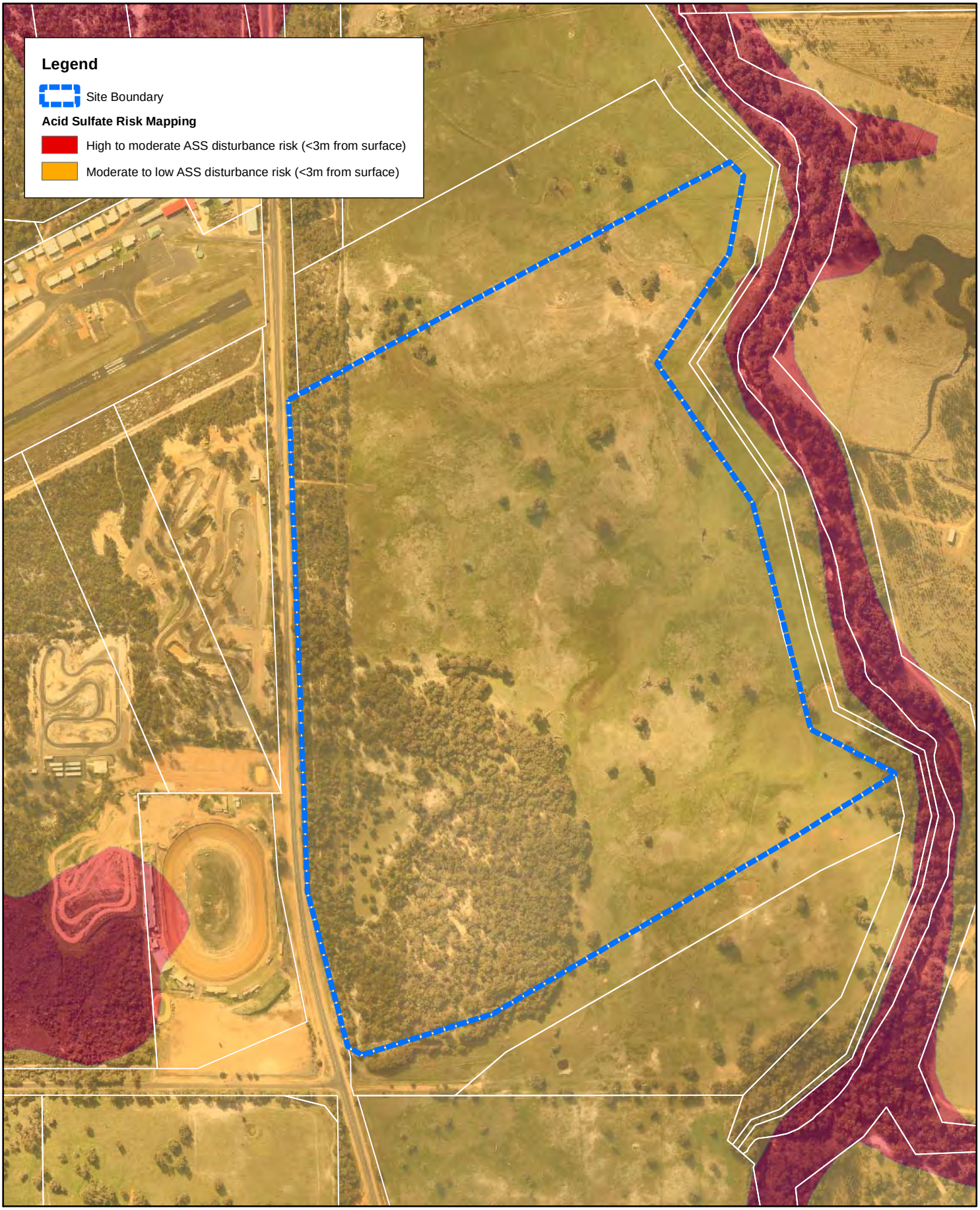

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PROJECT **Lot 15 South West Highway, Devonport LWMS**

DRAWING TITLE **FIGURE 5 : Acid Sulfate Soil Mapping**

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Project Number **B10007**

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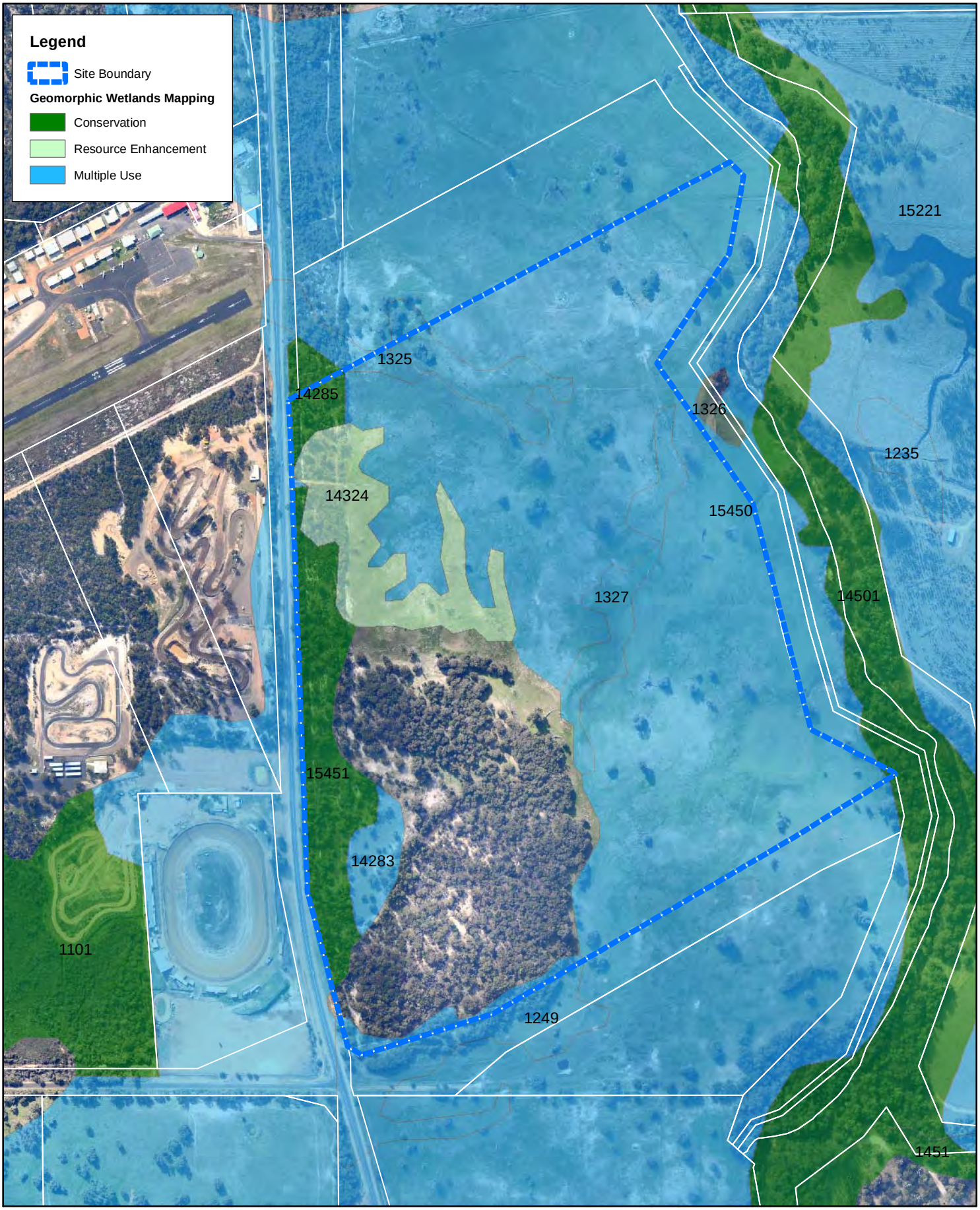

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DRAWING TITLE **FIGURE 6 : Geomorphic Wetlands**

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Project Number **B10007**

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DRAWING TITLE FIGURE 7 : Environmentaly Sensitive Areas

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Project Number B10007

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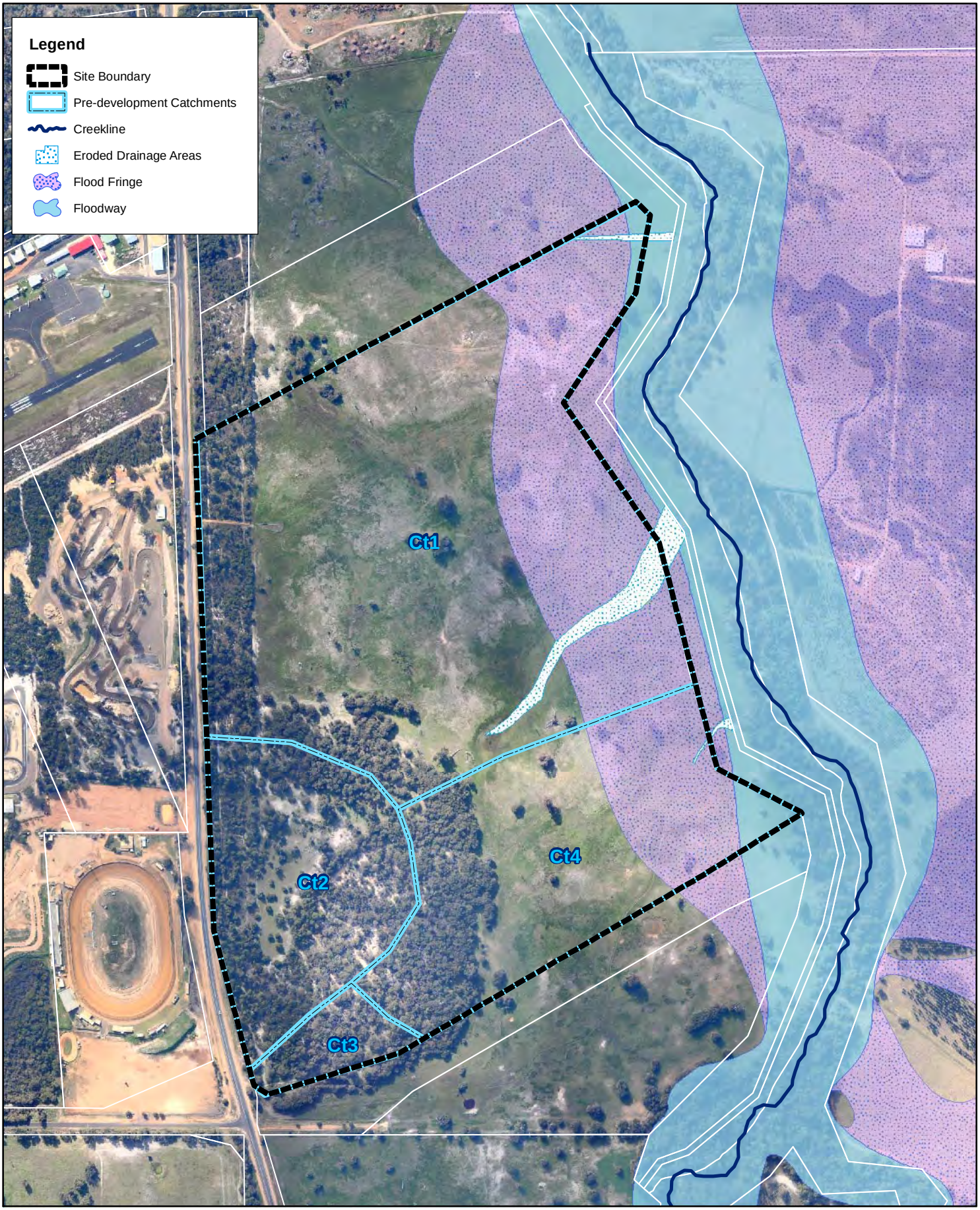

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PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 8 : Hydrological Features & Pre-development Sub-Catchments

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Project Number: B10007

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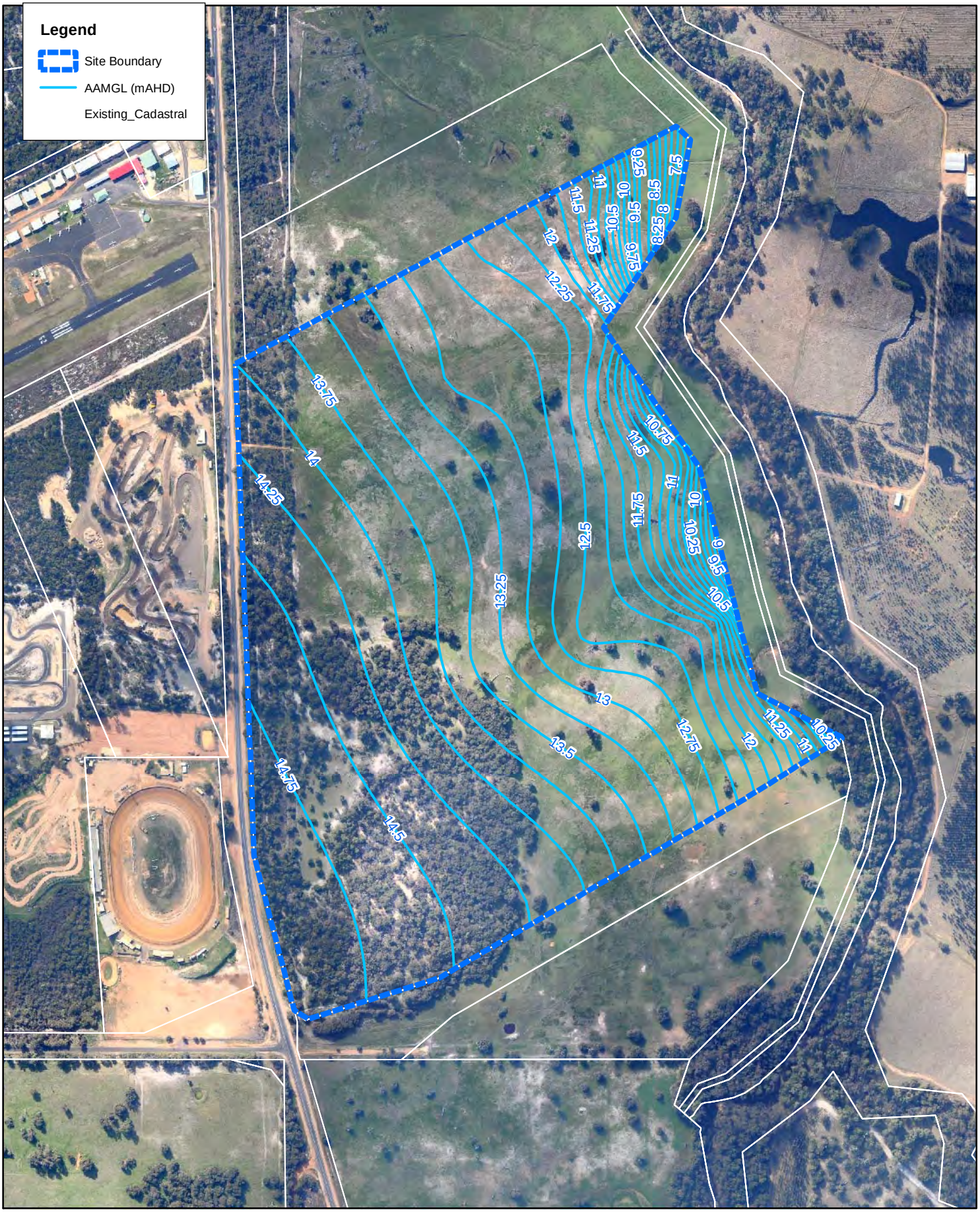

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DRAWING TITLE **FIGURE 9 : Average Annual Maximum Groundwater Level Contours**

PRINCIPAL **NBR Investments Pty Ltd**

Project Number **B10007**

Original **A4**

Drawing Number **SK09**

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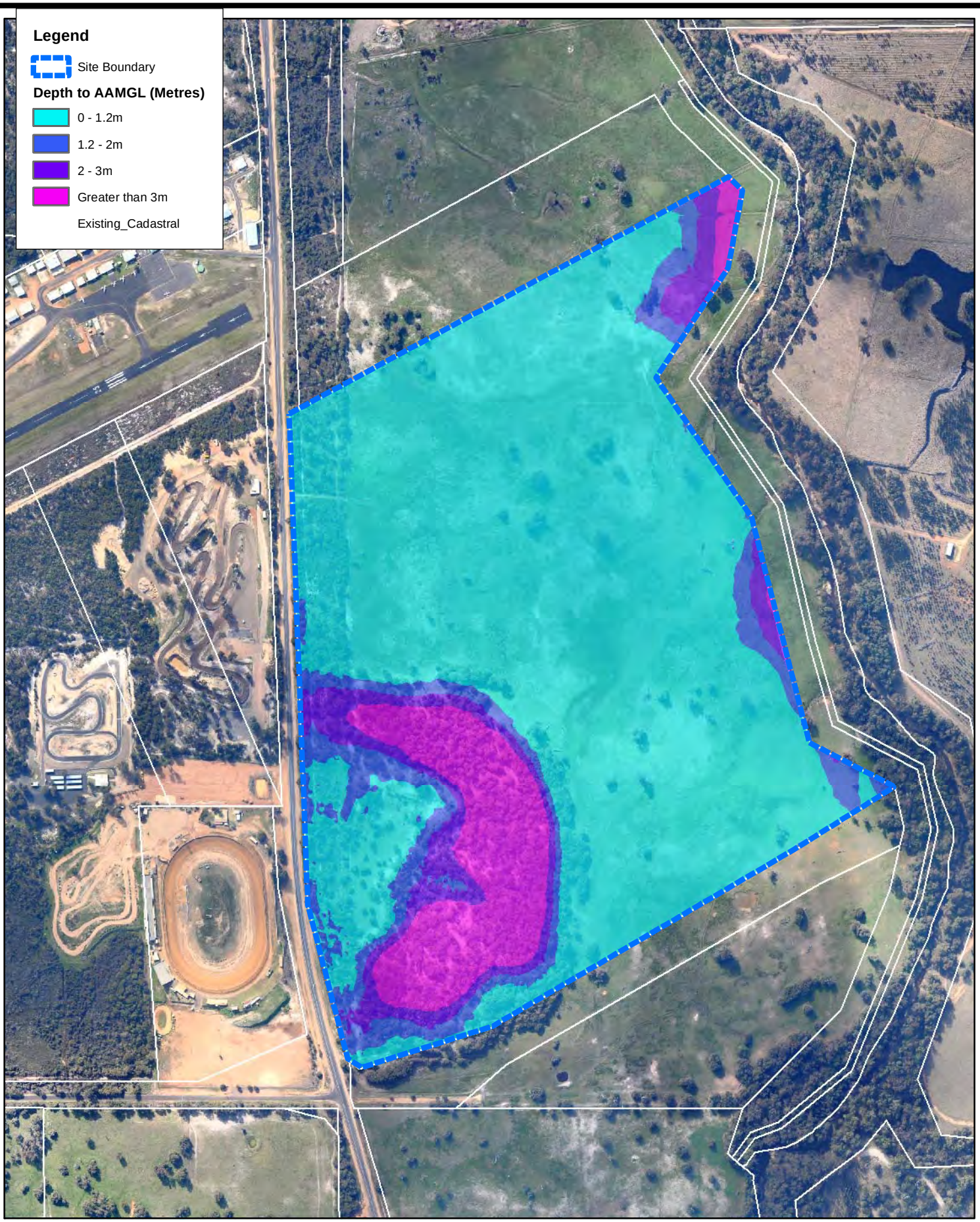

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PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 10 : Depth to AAMGL

PRINCIPAL: NBR Investments Pty Ltd

Project Number: B10007

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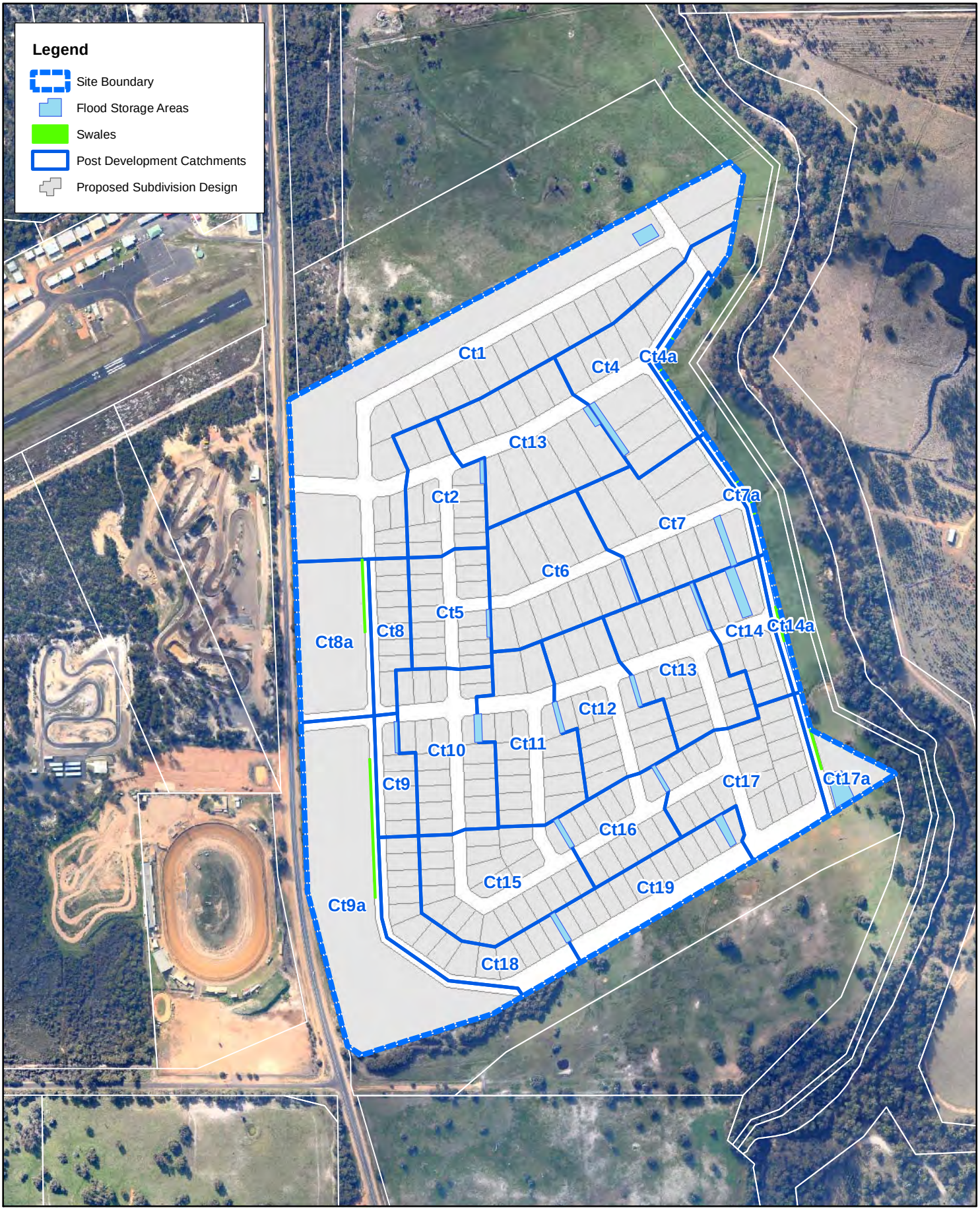

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PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 11 : Stormwater Drainage System

PRINCIPAL: NBR Investments Pty Ltd

Project Number: B10007

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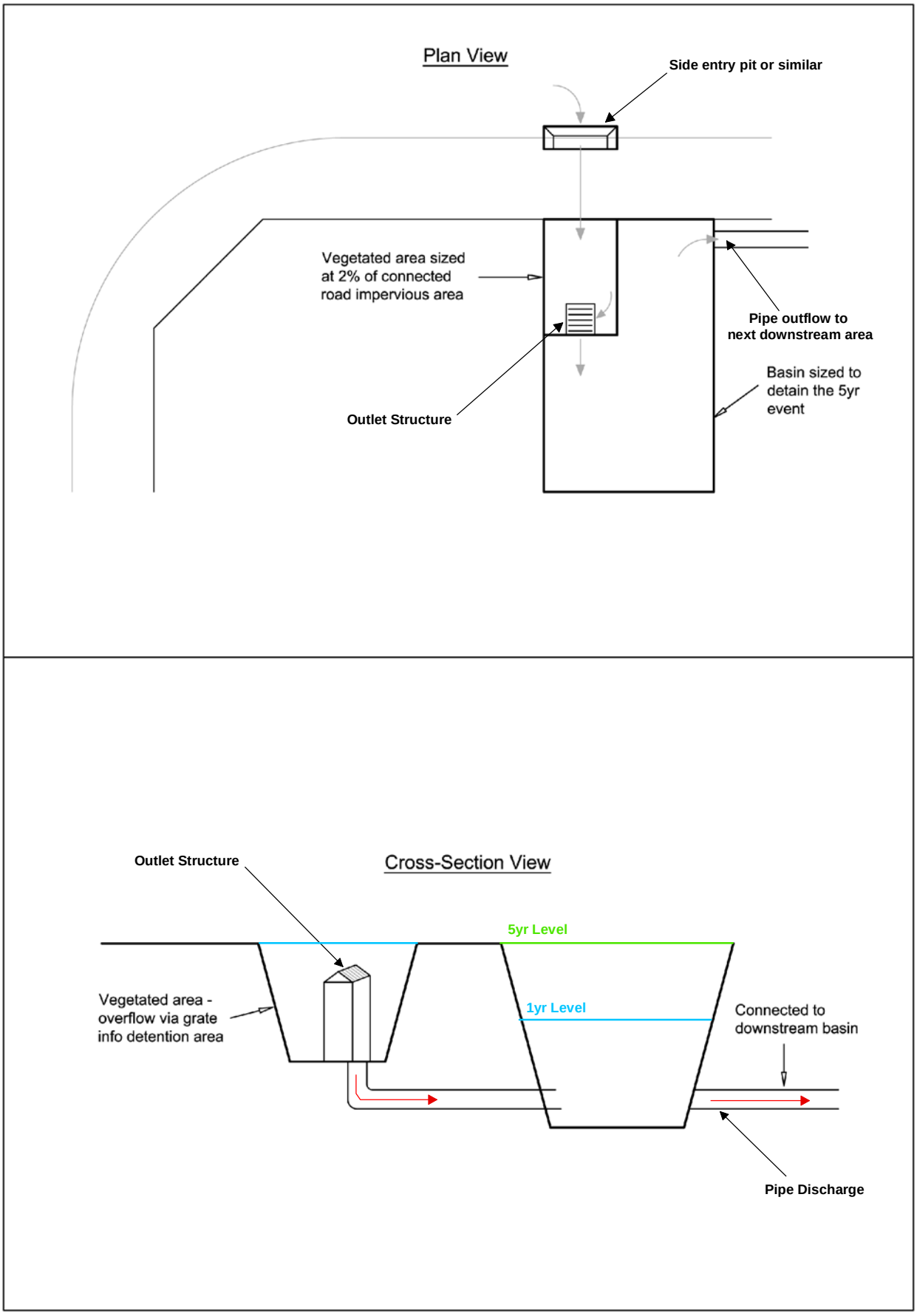

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PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 12 : Concept Design Vegetated Treatment Area

PRINCIPAL: NBR Investments Pty Ltd

Project Number: B10007

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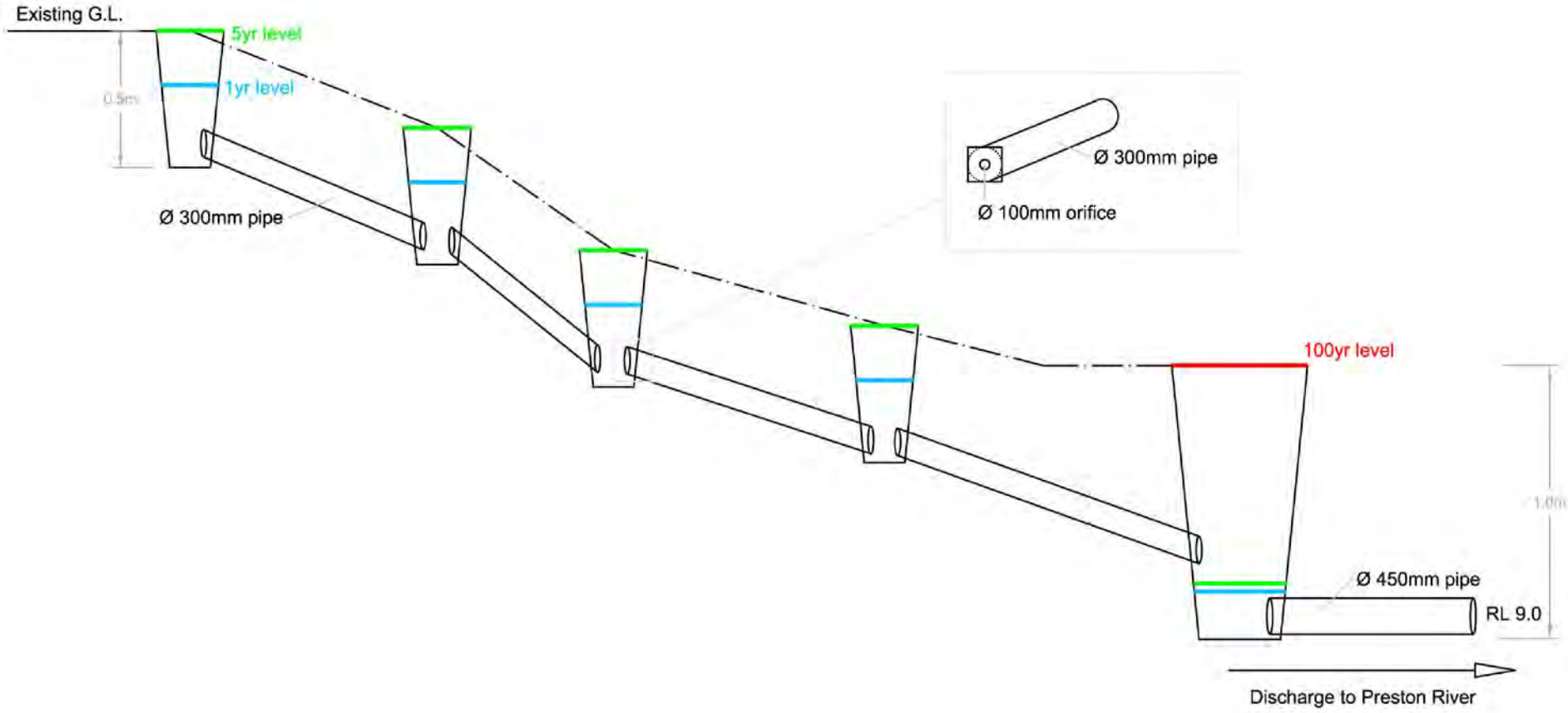

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DATE	No.	ACTIVITY - REVISION DESCRIPTION	DES	DRN	CHK'D	APPD

PROJECT **Lot 15 South West Highway, Devonport LWMS**

DRAWING TITLE **FIGURE 13 : Concept Drainage Plan & Flood Storage Area Connections**

PRINCIPAL **NBR Investments Pty Ltd**

Scale:

Cardno

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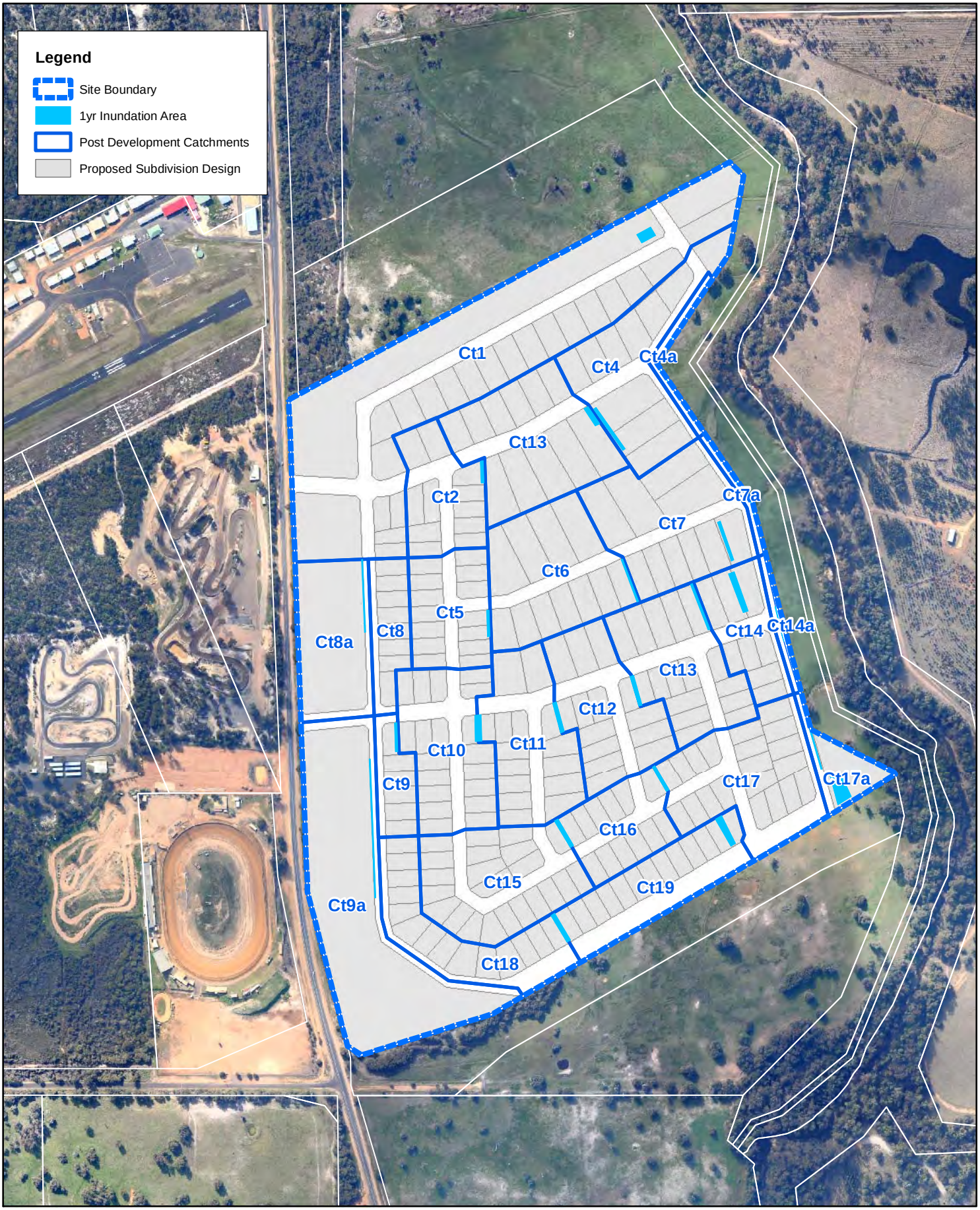
Project Number	Drawing Number	Revision	Original
B10007	SK13	00	A4

Designed	SLC	Checked	SLC	Date: 5/11/2010
Drawn	SB	Approved	DC	
Local Authority	City of Bunbury			Sheet 1 of 1



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Scale: 1:7,500

0 50 100 200 300 400 500 600 700 800 Metres

PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 14 : 1 Year Innundation Area

PRINCIPAL: NBR Investments Pty Ltd

Project Number: B10007

Original: A4

Drawing Number: SK14

Revision:

Designed SLC | Checked SLC

Drawn SB | Approved DC

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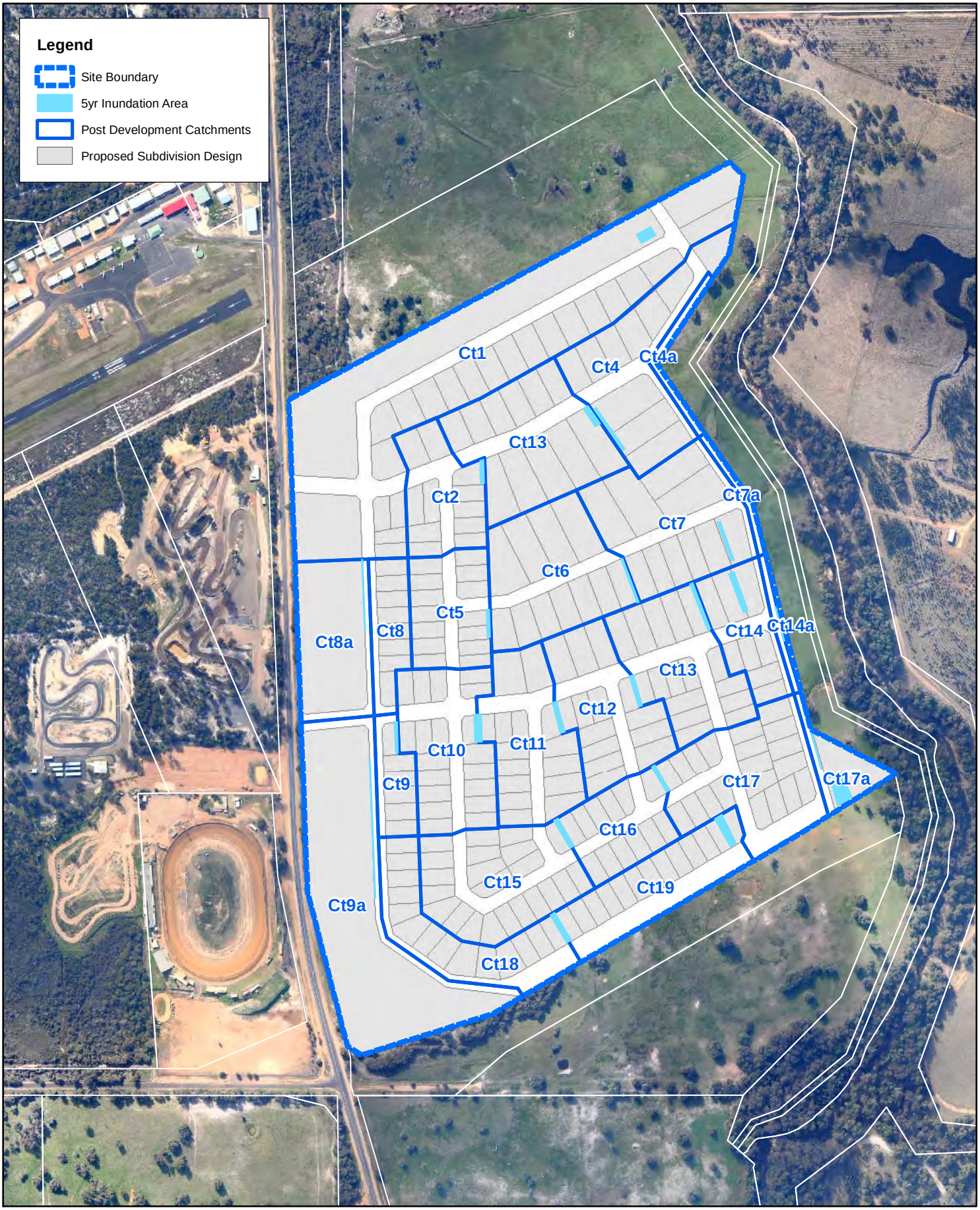
Sheet 1 of 1

Date 26/10/10



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Scale: 1:7,500

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PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 15 : 5 Year Innundation Area

PRINCIPAL: NBR Investments Pty Ltd

Project Number: B10007

Original: A4

Drawing Number: SK15

Revision:

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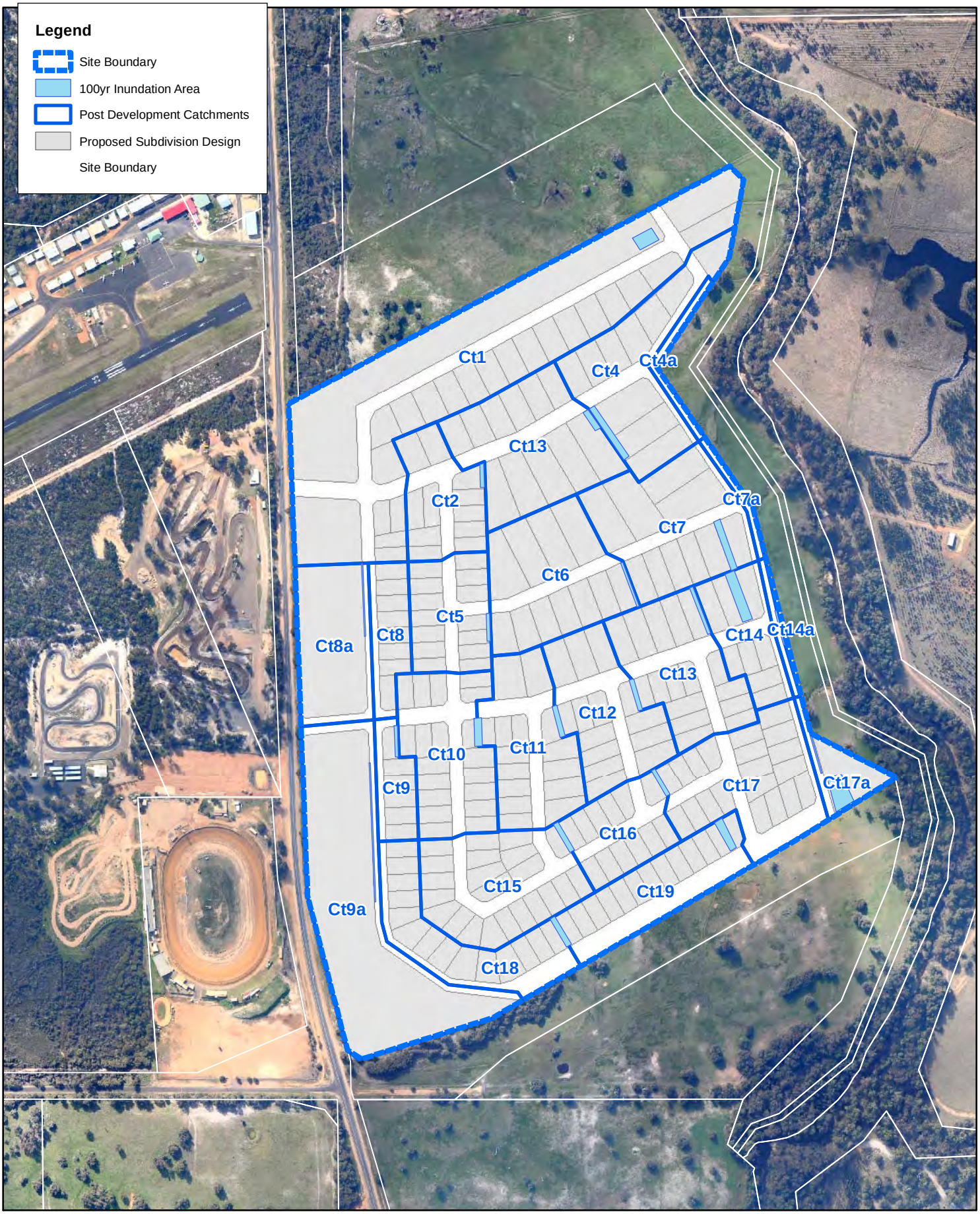

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PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 16 : 100 Year Innundation Area

PRINCIPAL: NBR Investments Pty Ltd

Project Number: B10007

Original: A4

Drawing Number: SK16

Revision:

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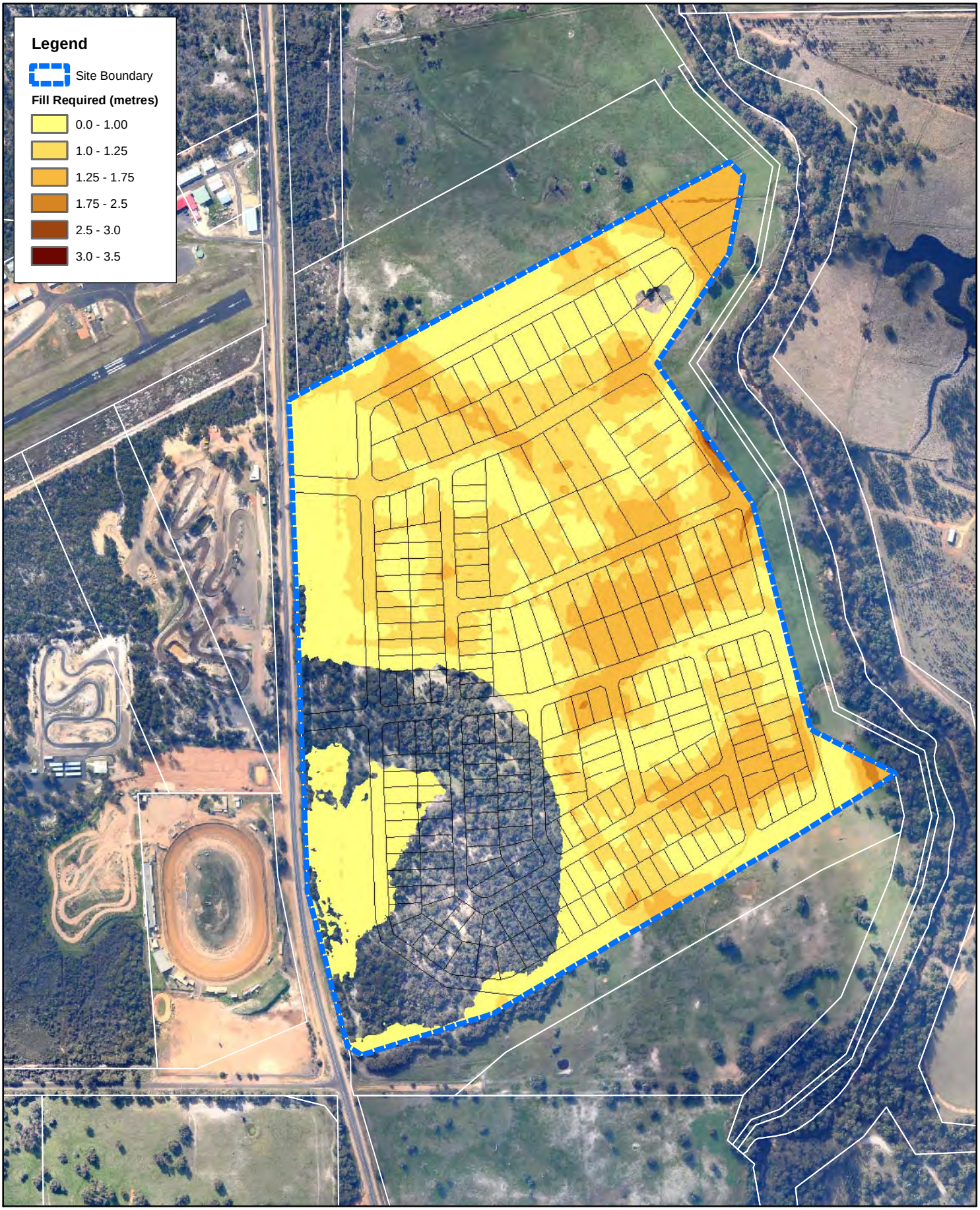
Date 26/10/10



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PROJECT: **Lot 15 South West Highway, Devonport LWMS**

DRAWING TITLE: **FIGURE 17 : Area Requiring Imported Fill and Minimum Earthworks Levels**

PRINCIPAL: **NBR Investments Pty Ltd**

Project Number **B10007**

Original **A4**

Drawing Number **SK18**

Revision

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

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Scale: 1:7,500

0 50 100 200 300 400 500 600 700 800 Metres

PROJECT: Lot 15 South West Highway, Devonport LWMS

DRAWING TITLE: FIGURE 18 : Groundwater Monitoring Bore Locations

PRINCIPAL: NBR Investments Pty Ltd

Project Number: B10007

Original: A4

Drawing Number: SK17

Revision:

Designed SLC | Checked SLC

Drawn SB | Approved DC

Local Authority: City of Bunbury

Sheet 1 of 1

Date 26/10/10

Appendix A

Local Structure Plan

LEGEND

- LIGHT GENERAL INDUSTRY (2000m² - 5,000m²)
- SERVICE INDUSTRY / COMMERCIAL (1000m² - 2000m²)
- CONSERVATION / REVEGETATION AREA
- CONSERVATION CATEGORY WETLAND
- CONSERVATION CATEGORY WETLAND 50m BUFFER AREA
- PROPOSED BUNBURY OUTER RING ROAD (APPROX. AREA)
- FLOOD STORAGE AREA
- DRAINAGE SWALE
- CS — POTENTIAL CONVENIENCE STORE / LUNCH BAR LOCATION

11
549
14
455
BUNBURY AIRPORT
REVEGETATION AREA
PROPOSED 100m WIDE ECOLOGICAL LINK OVER LOTS 15 & 14 SUBJECT TO REVEGETATION
20m ROAD RESERVE
PROPOSED FORESHORE REVEGETATION AREA
5133
7
5814
REVEGETATION AREA
INTERSECTION TREATMENT AS PER MRWA REQUIREMENTS
BUNBURY MOTORCYCLE CLUB
CS
15
72.210ha
25m ROAD RESERVE
RETAINED VEGETATION
20m ROAD RESERVE
Preston River
FLOODWAY RESERVE
SOUTH WESTERN HIGHWAY
641
BUNBURY GO-KART CLUB
INTERSECTION TREATMENT AS PER MRWA REQUIREMENTS
532
BUNBURY SPEEDWAY
FUTURE ROAD WIDENING
FUTURE BUNBURY OUTER RING ROAD
ANY LAND REQUIRED FOR ROAD WIDENING PURPOSES SHALL BE PURCHASED BY MRWA
9
5133
FUTURE RING ROAD DIAMOND INTERCHANGE SUBJECT TO MRWA DESIGN
17
FUTURE INDUSTRIAL LAND
0

STRUCTURE PLAN CONDITIONS

GENERAL

1. This Structure Plan provides a framework for the assessment of future subdivision and development of Lot 15 South Western Highway, Davenport pursuant to the City of Bunbury Town Planning Scheme No 7.
2. Subdivision shall be generally in accordance with the approved Structure Plan adopted by Council and endorsed by the WAPC. Variations to the Structure Plan may include adjustments to road and lot configuration provided the variation does not alter the intent of the approved Structure Plan and subject to approval by the City of Bunbury and WAPC.
3. This Structure Plan shall be read in conjunction with the City of Bunbury Town Planning Scheme No 7 and should any discrepancy arise, the provisions of this Structure Plan shall prevail.
4. All lots shall be connected to reticulated services i.e. reticulated water and sewer unless otherwise agreed by the relevant authorities.
5. Planning consent for earthworks will not be required if detailed engineering plans have been approved by the City of Bunbury in accordance with a WAPC subdivision approval for the site.
6. Design Guidelines (including landscaping requirements) for staged industrial development within the Structure Plan area shall be approved by the City of Bunbury as a condition of subdivision.
7. A condition of subdivision will require a notification on certificate of titles that Design Guidelines exist for the Structure Plan area.
8. Any portion of Lot 15 which may be required for the purpose of road widening is subject to purchase by MRWA.

ENVIRONMENTAL

9. A condition of subdivision approval will require the subdivider to prepare and submit an Urban Water Management Plan (UWMP), to the City of Bunbury and the Department of Water for approval.
10. Provision of drainage basins within Regional Open Space or in floodway areas may require approval from the DEC or DoW.
11. Prior to the commencement of any site works:
    - A preliminary site investigation shall be undertaken to determine whether Acid Sulphate Soils (ASS) are present on the land and if present, their extent and severity;
    - If the site is found to contain ASS, a ASS management plan shall be submitted and approved by the WAPC and Department of Water;
    - All site works shall be carried out in accordance with the provisions of the approved ASS management plan.
12. A condition of subdivision will require an Environmental Management Plan to be prepared, approved by the Department of Environment and Conservation and implemented to address the following:
    - Rehabilitation and re-vegetation of identified ecological linkages on the Structure Plan;
    - Landscaping and vegetation protection provisions for the identified drainage reserves and vegetated areas;
    - Measures to ensure appropriate management of weeds and the spread of dieback;
    - Noise and dust during the construction phase;
    - Protection of water quality; and
    - Any Fauna (including Western Ringtail Possum) and Flora protection measures.

0 10 20 30 40 50 100 150 200m

STRUCTURE PLAN

Revision	Date	Item
F	25/10/2010	Initial Issue

NOTES

Base data supplied by Landgate
Aerial Photography dated November 2002, accuracy +/- 4m, Projection MGA50

Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

NBR INVESTMENTS	:	CLIENT
1:2,500@A1; 1:5,000@A3	:	SCALE
25 October 2010	:	DATE
11434-1-001	:	PLAN No
f	:	REVISION
SL	:	PLANNER
BL	:	DRAWN

Property Description:

LOT 15
SOUTH WESTERN HIGHWAY,
DAVENPORT

RPS

RPS Environment and Planning Pty Ltd
ACN 108 680 977
ABN 45 108 680 977

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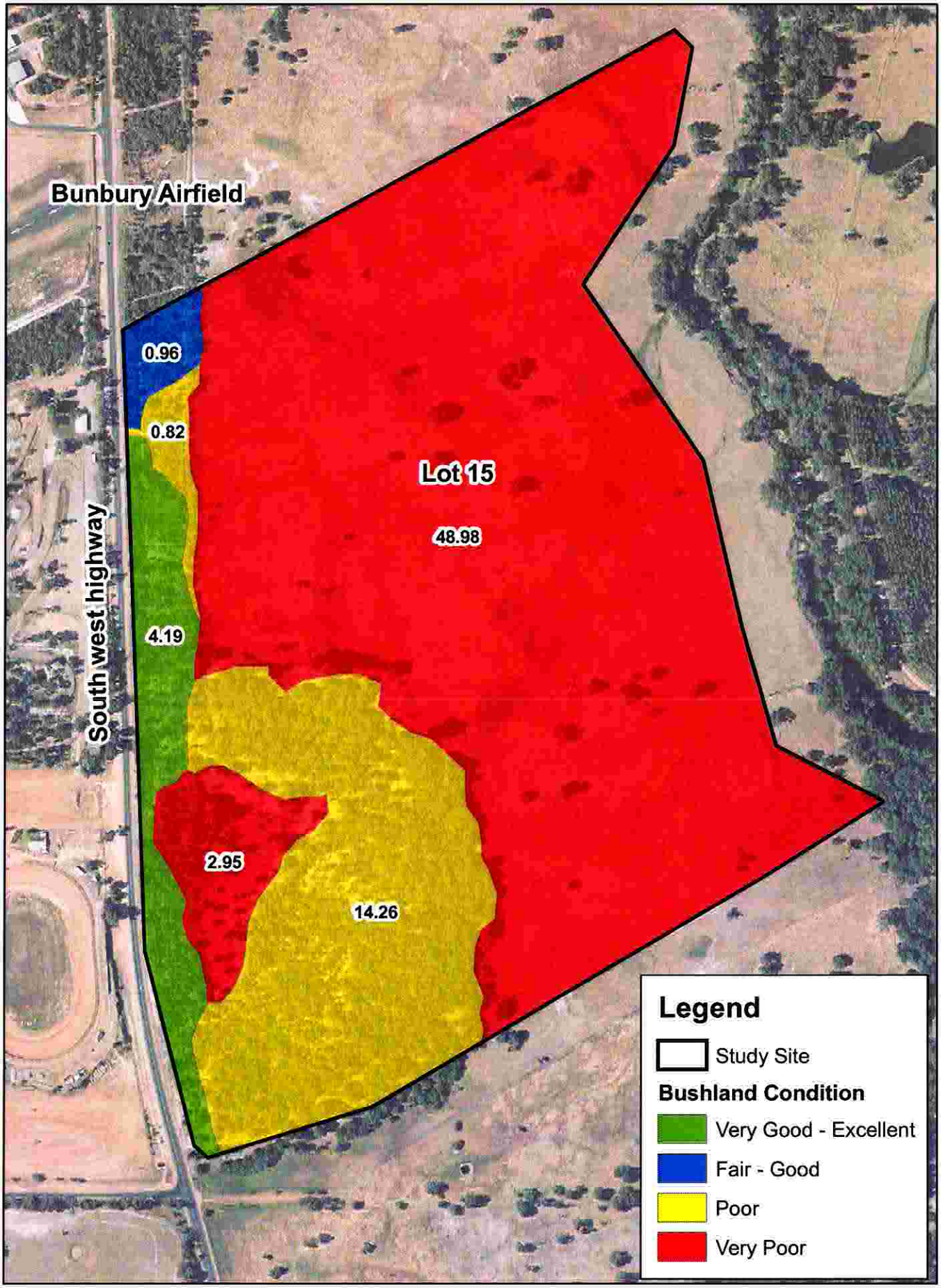
Appendix B

Vegetation Condition Mapping



ecoscape

0 50 100 200 Meters

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Bushland Condition Mapping | **Map 3**

Lot 15 South West Highway, Davenport | March 2008

Appendix C

Modelling Parameters, Assumption and Results

Modelling Parameters, Assumptions 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 the study area, 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 - continuing 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 the study area (**Sections 3.3**, **3.4** and **3.5**). The Infiltration Land Types (ILT) used in the XPSWMM modelling are summarised in **Table C.1**.

Table C.1 Infiltration Loss Parameters for XPSWMM Hydrological Modelling

Infiltration Land Type		Initial Loss (mm)	Continuing Loss (mm/hr)	Catchment Roughness
Pre-development	Sand - Sparse Vegetation	17.5	2.5	0.15
	Sand - Medium Vegetation	21.5	2.5	0.20
Post-development	Road	1	0.1	0.02
	Verge	9	1.5	0.10
	Lot Impervious	1	0.1	0.02
	Garden	20	2.5	0.20
	Roof	7	0.1	0.02
	POS	12.5	2.5	0.10

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 10 year ARI storm event.
- Soakwells were assumed to be incorporated within the development and accounted for with storage and infiltration within the model. The soakwells were sized to capture and retain overflow from the rainwater tanks for the 10 year ARI event.
- Garden areas will have high infiltration rates as it is likely that sand or mulch will be used. 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.
- Landscaped/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 less than the pre-development Sand-Sparse Infiltration Land Type.
- The verge area is similar to landscaped/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 landscaped/POS rates.
- Infiltration was assumed from the bio-retention system of vegetated retention areas, roadside swales and FSAs. A hydraulic conductivity of 5×10^{-5}m/s was assumed for the infiltration of soakwells with a 50% clogging factor for the vegetated retention areas, roadside swales and FSAs.

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 industrial developments and have 50% as roof area, 45% as impervious paved area and 5% as pervious garden. The road reserve was assumed to contain 60% verge and 40% bitumen, which, given the infiltration rates described above, provides a corresponding 85% impervious area and 15% pervious area from the road reserve.

Modelling Results

The rainwater tanks and soakwell storages required for each catchment are shown in **Table C.2**. The dimensions of the bio-retention swales are shown in **Table C.3** while the dimensions and associated lot levels and clearances from the FSAs are shown in **Table C.4**. The bio-retention swale areas were sized at 2% of the connected impervious area of their associated catchments.

Table C.2 Storage in Rainwater Tanks and Soakwells per Catchment

Catchment	Rainwater Tanks (ML)	Soakwells (ML)
1	140	1,071
2	48	366
3	100	761
4	86	660
5	49	376
6	97	740
7	98	750
8	29	225
9	22	172
10	70	541
11	72	551
12	71	546
13	75	575
14	41	310
15	86	657
16	44	339
17	76	586
18	64	490
19	47	360
Total	*1,315*	*10,076*

Table C.3 Bio-retention Swale Dimensions

Catchment	Depth (m)	Side Slope	Surface Area (m^2)	Volume (m^3)
4a	0.3	1:6	200	30.00
7a	0.3	1:6	130	19.50
8a	0.3	1:6	240	36.00
9a	0.3	1:6	430	64.50
14a	0.3	1:6	145	21.75
17a	0.3	1:6	125	18.75
Total	-	-	*1,270*	*190.50*

Table C.4 Flood Storage Area Dimensions and Clearance Levels

Catchment	Bottom Area (m^2)	Top Area (m^2)	Side Slope	Depth (m)	FSA Volume (m^3)	FSA Invert (mAHD)	FSA Obvert (mAHD)	Pipe Diameter (m)	Orifice Diameter (m)	Weir Height (mAHD)	Weir Depth (m)	AAMGL (mAHD)	Lot Level Clearance to FSA Obvert (m)	Minimum Lot Level (mAHD)	Lot Separation from AAMGL (m)	100 year Flood Level (mAHD)	Basin Obvert Clearance to Flood Level (m)	Determining Factor
1	295	685	0.167	0.75	355	11.95	12.70	0.45	-	-	-	11.25	0.30	13.00	1.75	12.2	0.50	SW
2	80	220	0.167	0.50	70	13.55	14.05	0.30	0.10	-	-	13.25	0.40	14.45	1.20	-	-	GW
3	125	300	0.167	0.50	105	12.55	13.05	0.30	0.10	-	-	12.25	0.40	13.45	1.20	-	-	GW
4	290	845	0.167	1.00	545	12.30	13.30	0.30	-	-	-	12.00	0.30	13.60	1.60	12.3	1.00	GW
5	80	220	0.167	0.50	70	14.05	14.55	0.30	0.10	-	-	13.75	0.40	14.95	1.20	-	-	GW
6	100	255	0.167	0.50	85	12.55	13.05	0.30	0.10	-	-	12.25	0.40	13.45	1.20	-	-	GW
7	255	780	0.167	1.00	495	11.95	12.95	0.30	-	-	-	11.25	0.30	13.25	2.00	12.45	0.50	SW
8	-	-	-	-	-	-	-	-	-	-	-	14.00	-	15.20	1.20	-	-	GW
9	85	235	0.167	0.50	75	14.60	15.10	0.30	0.10	-	-	14.30	0.40	15.50	1.20	-	-	GW
10	260	490	0.167	0.50	185	14.10	14.60	0.30	0.10	-	-	13.80	0.40	15.00	1.20	-	-	GW
11	185	380	0.167	0.50	140	13.55	14.05	0.30	0.10	-	-	13.25	0.40	14.45	1.20	-	-	GW
12	160	350	0.167	0.50	125	12.80	13.30	0.30	0.10	-	-	12.50	0.40	13.70	1.20	-	-	GW
13	170	360	0.167	0.50	130	12.05	12.55	0.30	0.10	-	-	11.75	0.40	12.95	1.20	-	-	GW
14	485	1160	0.167	1.00	800	12.10	13.10	0.45	-	-	-	11.50	0.30	13.40	1.90	12.6	0.50	SW
15	170	365	0.167	0.50	130	14.10	14.60	0.30	0.10	-	-	13.80	0.40	15.00	1.20	-	-	GW
16	115	285	0.167	0.50	95	13.30	13.80	0.30	0.10	-	-	13.00	0.40	14.20	1.20	-	-	GW
17	570	1285	0.167	1.00	905	12.60	13.60	-	-	13.40	0.20	11.70	0.30	13.90	2.20	12.9	0.50	SW
18	205	410	0.167	0.50	150	14.45	14.95	0.30	0.10	-	-	14.15	0.40	15.35	1.20	-	-	GW
19	330	585	0.167	0.50	225	13.30	13.80	0.30	0.10	-	-	13.00	0.40	14.20	1.20	-	-	GW

Appendix D

Groundwater Levels Monitoring Report

Thompson McRobert Edgeloe
Group

Groundwater Levels Monitoring Report
Lot 15 South Western Highway, Davenport

Research, Design & Delivery of
Sustainable Development

07420
December 2009

Project Management Planning Geotechnical Environmental Engineering

DOCUMENT QUALITY CONTROL

AUTHOR
Peter Jones

DATE
09.12.2009

CHECKED BY
Brendan Oversby

DATE
09.12.2009

REVISION TABLE

No.	PURPOSE	DATE
1	Issued for Client Review	09.12.2009

THOMPSON McROBERT EDGELOE GROUP PTY. LTD.

PO BOX 733, BUNBURY

PH: (08) 9791 4411

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EXECUTIVE SUMMARY

Thompson McRobert Edgeloe Group (TME) has prepared this report on behalf of NBR Investments for a proposed industrial subdivision development. The subject land consists of Lot 15 on Diagram 64665 South Western Highway, Davenport.

The subject land is located in an area that exhibits high groundwater levels. This necessitated the requirement for monitoring of the superficial groundwater level across the site as per advice provided by the Department of Water.

TME monitored groundwater levels at 15 monitoring bore sites across the subject land with regular measurements between December 2007 and November 2009.

In both years the maximum groundwater level was record at less than 1000 mm (1m) below the surface at all monitoring bores, except one. The highest maximum groundwater level was 10 mm below the surface. Water was also seen ponding at the surface on land near the bores.

Comparative nearby long-term groundwater monitoring sites from the Department of Water suggest that the maximum and lowest groundwater levels are close to static for the past 30 years however a slight lowering trend has occurred in the past 10 years. The data suggested that the monitoring period of 2008 and 2009 for the subject land was a relatively good representation of the long-term levels and fluctuations.

The overall shallow maximum groundwater levels (less then 1 metre below the surface level) means that there will be a need to generate plans and strategies to manage the groundwater before any development proceeds.

INTRODUCTION

Thompson McRobert Edgeloe Group (TME) has prepared this report on behalf of NBR Investments for a proposed industrial subdivision development. The subject land consists of Lot 15 on Diagram 64665 South Western Highway, Davenport. See *Figure* 1 for the location of the subject land at a broad scale context.

The subject land is located in an area that exhibits high groundwater levels. This necessitated the requirement for monitoring of the superficial groundwater level across the site as per advice provided by the Department of Water (DoW). The data gathered will also be used for the engineering design of any potential development.

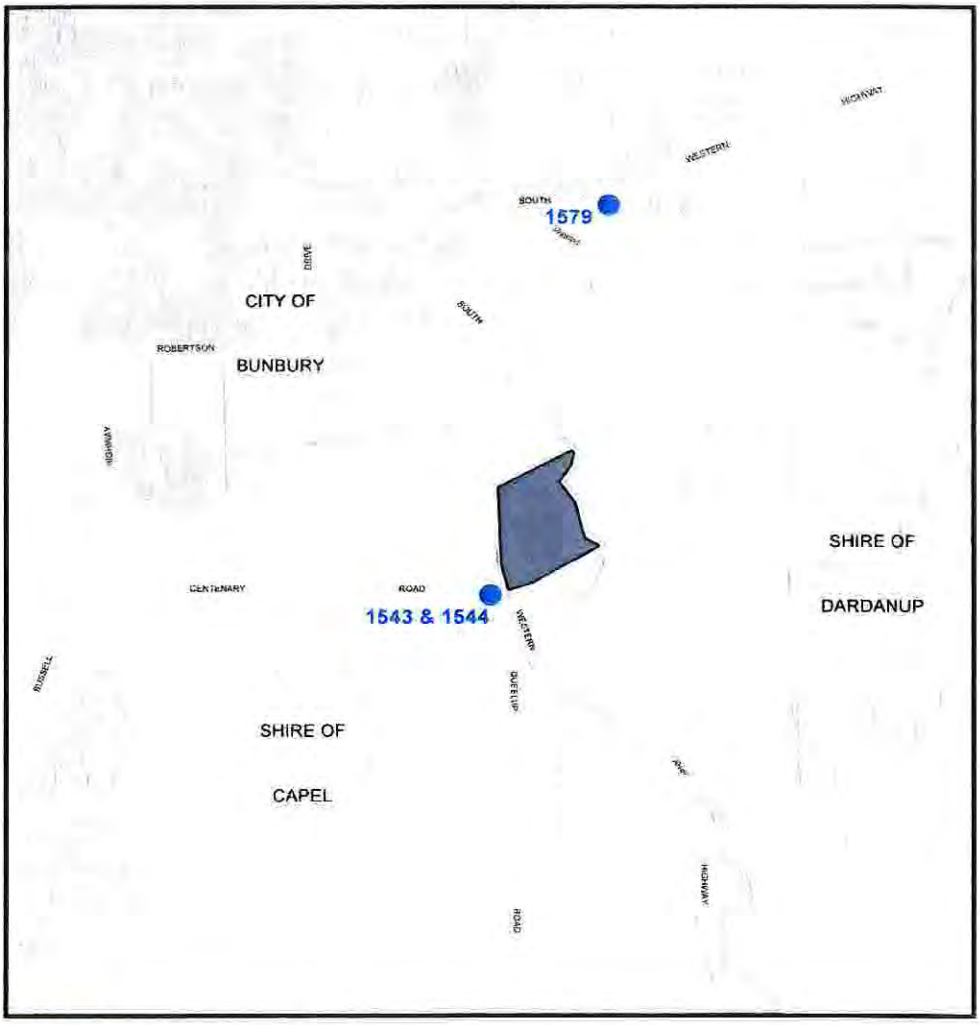


Figure 1 *– Location Plan*

METHODOLOGY

In November 2007, Australind Water Boring installed 15 water table monitoring bores on the subject land and TME verified their installation (see *Figure 3* for locations). Monitoring bores were constructed to a depth of 2.1m below the natural surface level. PVC casing pipes with slots were placed within the holes and the bottom of the pipe was capped. The monitoring bores were finished with free draining sand backfill and a bentonite plug. The standard monitoring bores installed are illustrated in *Figure 2*.

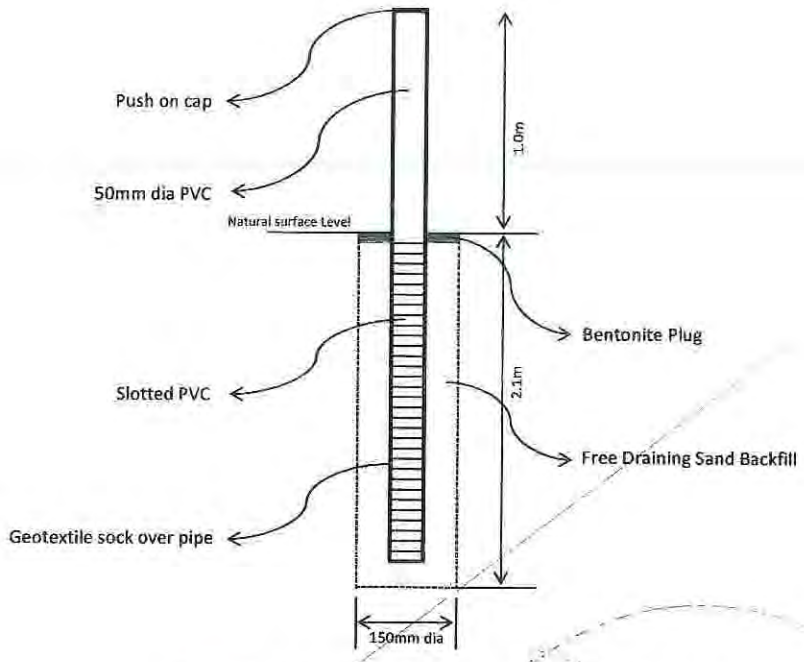


***Figure 2** – Standard water table monitoring bore.*

TME monitored groundwater levels from December 2007 to November 2009, which encompassed the minimum 2 winter periods for DoW requirements. A total of 14 measurements were taken for each monitoring bore site during this period of time. All measurements were undertaken on the same day for every monitoring bore.

To obtain the measurement of the groundwater's level, an electrical sounder groundwater probe was lowered into the pipe until it signalled that it had reached the water table. The depth was recorded, and in the office the pipe height above the surface level was subtracted from the recorded measurement to ascertain the depth to the groundwater from the ground's surface.

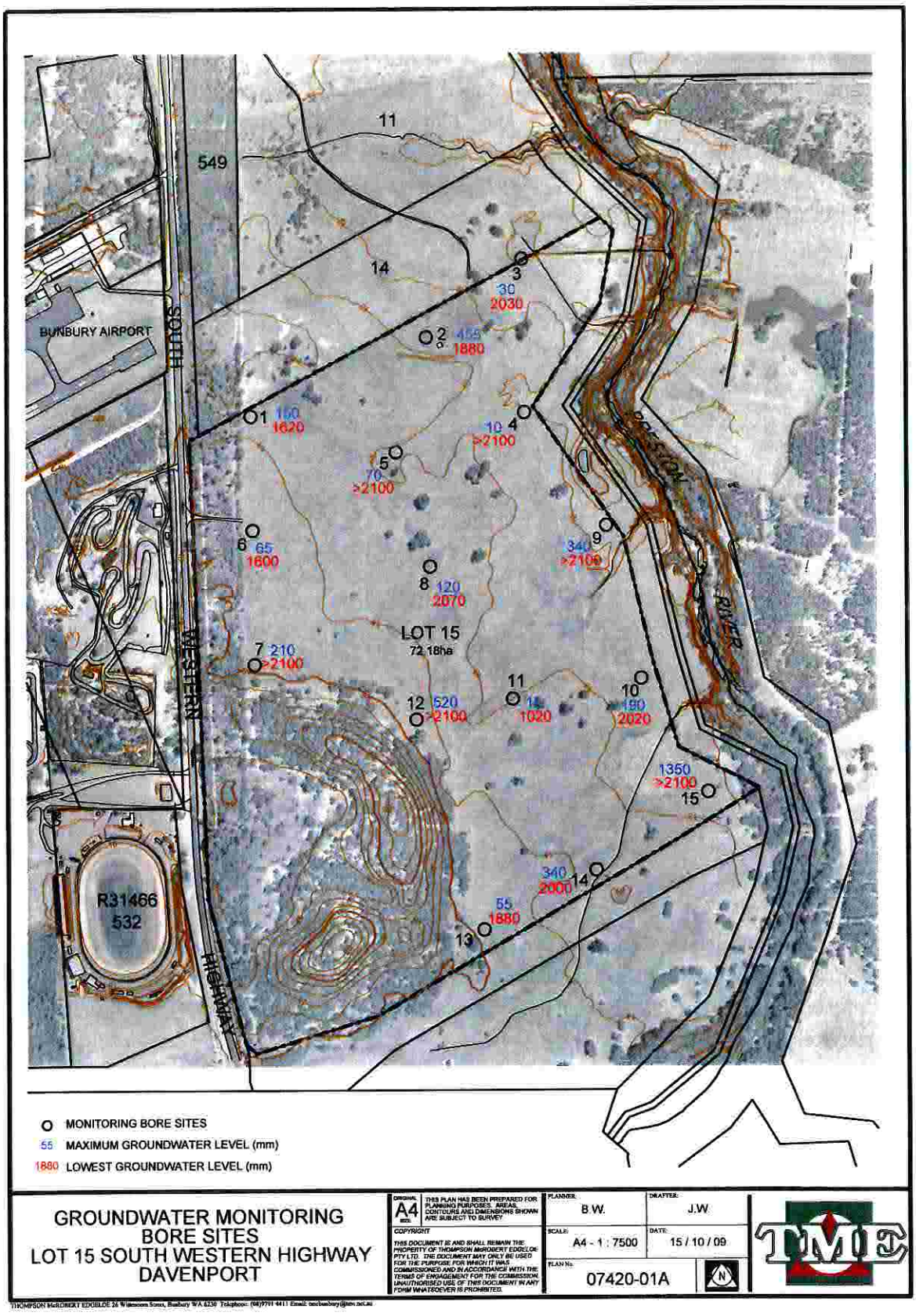


Figure 3 – *Groundwater Bore Monitoring Sites*

RESULTS

The following table summarises the maximum and lowest groundwater levels, along with the dates these were measured. Also the groundwater levels range for each monitoring bore site. These values are relative to the distance of the water below ground surface level found at each monitoring bore.

Monitoring Bore No.	Maximum Groundwater Level (mm)	Date(s) Recorded	Lowest Groundwater Level (mm)	Date(s) Recorded	Range (mm)
1	150	Sept 2009	1620	April 2009	1470
2	455	July 2008	1880	April 2009	1425
3	30	July 2008	2030	April 2009	2000
4	10	July 2008	DRY	April 2009	>2090
5	70	July 2008	DRY	March 2008	>2030
6	65	July 2008	1600	April 2009	1535
7	210	Sept 2009	DRY	April 2009	>1890
8	120	July 2008	2070	April 2009	1950
9	340	July 2008	DRY	Jan, March & May 2008 Feb & April 2009	>1760
10	190	July 2008	2020	April 2009	1830
11	15	July 2008	1020	April 2009	1005
12	520	July 2008	DRY	April 2009	>1580
13	55	July 2008	1880	April 2009	1825
14	340	July 2008	2000	April 2009	1660
15	1350	Sept 2009	DRY	Jan, March & May 2008 Feb & April 2009	>750

***Table 1** – Summary of groundwater monitoring results*

The 'dry' recording for the monitoring bores was made when no water was present within the bore's pipe when monitored. This meant that at the time of measurement, the groundwater level was lower then 2.1 metres below the surface level, as 2.1 m was the standard depth of the installed bore pipes. Levels deeper then 2.1 m were not measured.

Maximum Groundwater Level (MGL)

The MGL for all monitoring bores during the study period was predominantly in July 2008, with three sites in September 2009. *Table 2* shows that the MGL observed in 2009 was generally approximately 100mm deeper then 2008 records, however the MGL was higher at three sites in 2009. The MGL from the surface ranged approximately from 10 to 1515 mm in 2008 and from 90 to 1350 mm in 2009. All sites had records of the groundwater within 1 metre of the surface level in 2008 and 2009, except for monitoring bore 15 where the groundwater level rose to within approximately 1500 and 1350 mm of the surface in 2008 and 2009 respectively.

Monitoring Bore No.	Maximum Groundwater Level (mm) 2008	Maximum Groundwater Level (mm) 2009	Variation between years (mm)
1	320	150	170
2	455	490	35
3	30	140	110
4	10	310	300
5	70	100	30
6	65	90	25
7	385	210	175
8	120	370	250
9	340	470	130
10	190	380	190
11	15	140	125
12	520	610	90
13	55	200	145
14	340	410	70
15	1515	1350	165

***Table 2** – The maximum groundwater levels (MGL) from the surface in 2008 and 2009 on the subject land, and the variation between the years. Black text signifies that 2008 had a higher MGL and red text signifies that 2009 had a higher MGL.*

Lowest Groundwater Level (LGL)

The LGL ranged from 940 mm to deeper then 2100 mm in 2008, and from 1020 mm to deeper then 2100mm in 2009 (see *Table 3*). The table shows that 2009 levels were lower at all sites compared to the 2008 LGL, except for monitoring bore 5. The frequency of measurements are reduced in drier months, so the actually LGL may have been lower then those recorded.

Monitoring Bore No.	Lowest Groundwater Level (mm) 2008	Lowest Groundwater Level (mm) 2009	Variation between years (mm)
1	1430	1620	190
2	1750	1880	130
3	2000	2030	30
4	2050	DRY	>50
5	DRY	1100	>1000
6	1360	1600	240
7	1330	DRY	>770
8	1960	2070	110
9	DRY	DRY	N/A
10	1660	2020	360
11	940	1020	80
12	1600	DRY	>500
13	1700	1880	180
14	1910	2000	90
15	DRY	DRY	N/A

***Table 3** – The lowest groundwater levels (LGL) from the surface in 2008 and 2009 on the subject land, and the variation between the years. Black text signifies that 2008 had a higher LGL, and red text signifies that 2009 had a higher LGL.*

Annual Seasonal Variation

The annual seasonal variation during the monitoring period between MGL and LGL was recorded as greater than 1000 mm for all sites, except three (see *Table 3* for annual LGL recordings). Monitoring site 11 was the only bore to have less then 1000 mm annual seasonal variation in both years.

Difference between Monitoring Years

The maximum and lowest groundwater levels were recorded lower in 2009 than 2008 at the majority of the monitoring bores. The difference between the 2009 and 2008 MGL was between 25 mm deeper to 175 mm shallower to the surface level. The difference between the monitored years LGL ranged from over 770 mm deeper to over 1000 mm shallower to the surface level. Rainfall data shows that the autumn months in 2008 had over 200 mm more rainfall than the autumn months of 2009, and this may have contributed to the higher groundwater levels observed in 2008.

Monitoring bore site 7 had one of the greatest variations between 2008 and 2009. The annual variation was 945 mm in 2008 and in excess of 1890 mm in 2009. Monitoring bore site 5 had over 1000 mm difference between the two years also. The remainder of the sites had less then 500 mm difference between years.

Monitoring bore site 15's results were very different to those observed in the remainder of the monitoring bores across the site. The groundwater was not recorded higher than 1350 mm from the surface level during the monitoring period. The similar location of other sites along the Preston River fringe did not show similar results. This may suggest that the monitoring bore lies above a different groundwater system than the majority of the subject land.

Due to the number of bore sites on the subject land the groundwater level data for all bores is shown in three separate graphs (*Figures 4, 5 and 6*). The bores displayed within each graph were selected according to their proximity to Preston River, using the assumption that those selected bores should display the most similar levels on the subject land.

For full details of recordings for each monitoring bore site please refer to *Appendix 1*.

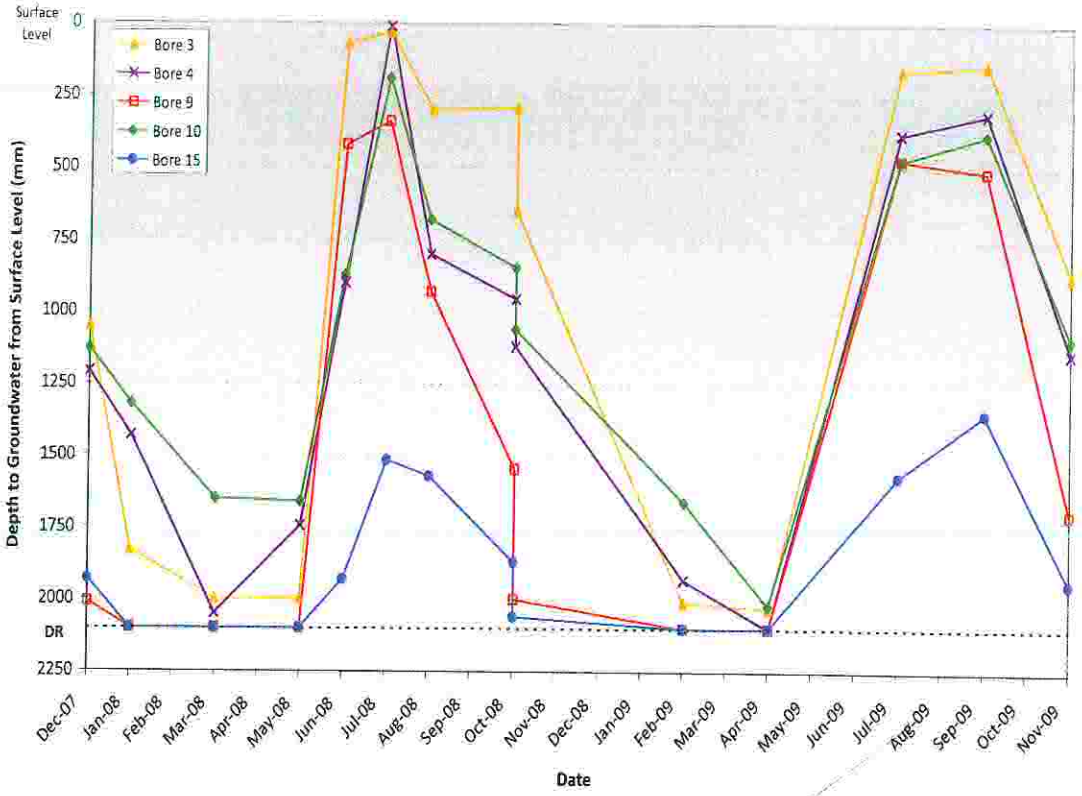


Figure 4 *– Groundwater Levels for all monitoring bores closest to Preston River*

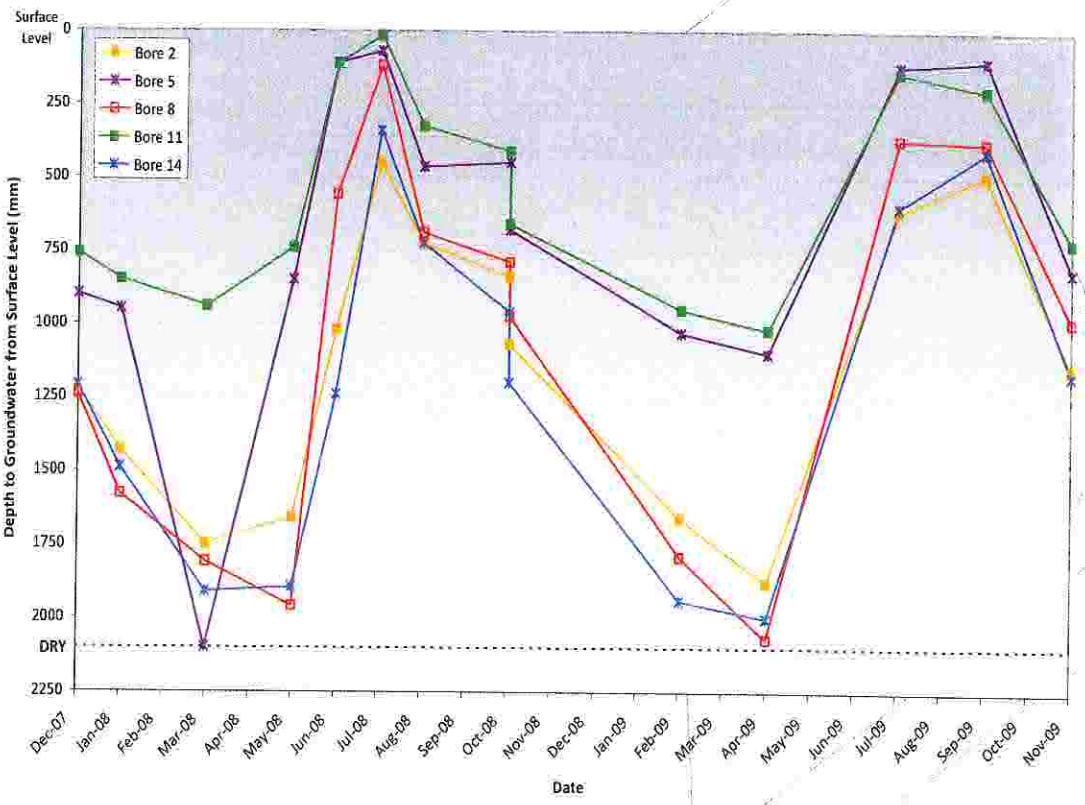


Figure 5 *– Groundwater Levels for all monitoring bores along centre of subject land*

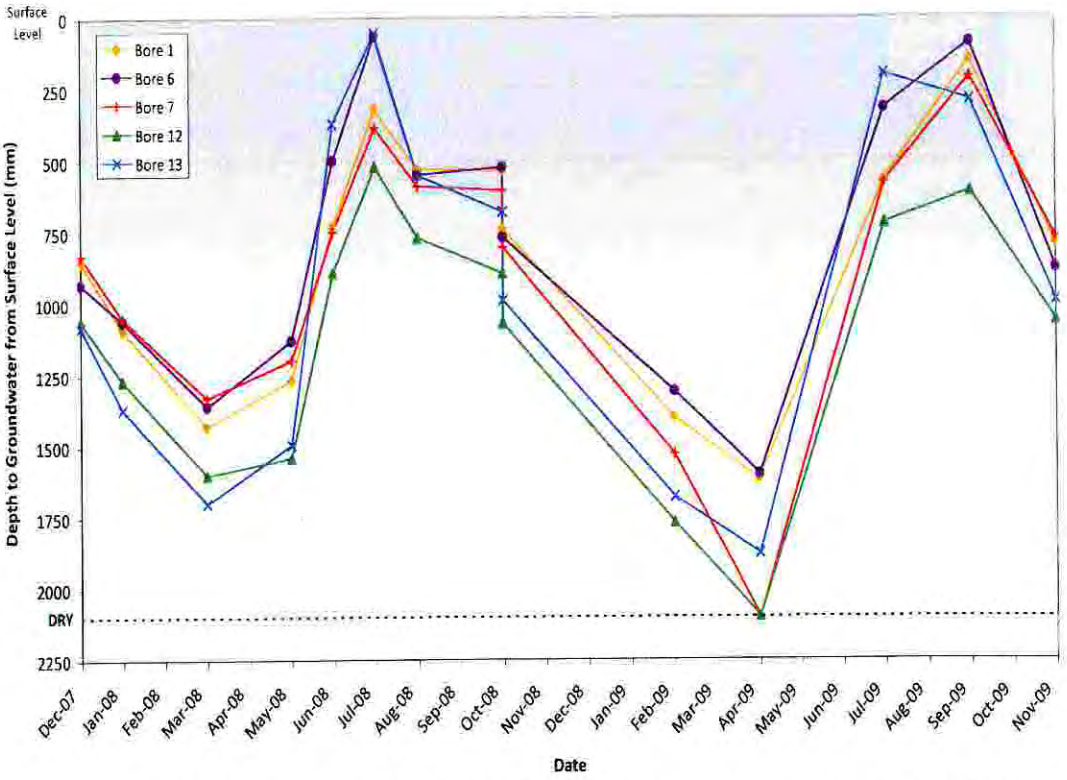


Figure 6 *– Groundwater Levels for all monitoring bores furthest from Preston River*

COMPARISON TO DEPARTMENT OF WATER MONITORING BORES

To ascertain the long-term water table patterns for the subject land a query of all the Department of Water (DoW) groundwater monitoring bores within a 3 km radius of the subject land was undertaken by DoW on TME's behalf. Five monitoring bores were found within this radius but only three had long-term recordings, established in 1977 or 1978. The other two sites had only been established in 2007 and could not provide any historical data of groundwater levels, which were relevant to the comparison undertaken for the purpose of this report.

The furthest away, long-term monitoring site investigated from the subject land was monitoring site 1579. The bore site was located approximately 3 km north east of the subject land, along the Boyanup-Picton Road in Picton (see *Figure 2*). The groundwater levels were slightly deeper at this site than observed on the subject land and this may have been because of difference in soil profile and types (see *Figure 7*).

Monitoring site 1594 was another of the three long-term sites investigated, however the data was inappropriate for comparison with the subject land because it was measuring groundwater levels from a deeper confined aquifer (approximately 10 m below the surface level). Monitoring site 1593 was located at the same spot as 1594, approximately 1 km south west of the subject land, and site 1543 was measuring groundwater levels within a shallow unconfined aquifer, similar to the subject land (see *Figure* 8). This site provided the strongest comparison to the subject land.

Four measurements per year are widely considered as seasonal, and a minimum requirement to consider a site as monitored. However due to the limited number of bores available for comparison and that these bores had less then four measurements between 1994 and 2006, a minimum of two measurements were considered adequate for this report. Undertaking two measurements in a year may have resulted in the monitoring not capturing the actual MGL and LGL each year for the bore sites, as these levels may have been reached pre or post measurement. There were no records for the MGL at bore site 1543 for 2009, but the LGL was available for 2009.

Site 1543's groundwater levels were close to static for the duration of the monitoring period, which was in contrast to the declining trend observed at the other site. The MGL trend over the past 20 years at site 1543 has been static, however over the last 10 years the MGL has lowered on average by 68 mm per year. Site 1579 has had a very different MGL trend, with a lowering on average of 110 mm and 69 mm per year over the last 10 and 20 years respectively.

The extent of the lowering trend of the MGL at site 1579 has resulted in the 2008 MGL not reflecting the annual average maximum groundwater level (AAMGL). The 2008 MGL was actually lower then the annual average lowest groundwater level (AALGL) by approximately 250 mm and approximately 880 mm lower than the AAMGL. The MGL in a year at this site has not exceeded the AAMGL since 1996. The AAMGL also has had a lowering trend on average of 35 mm and 31 mm per year over the last 10 and 20 years respectively (see *Figure 7*).

However, site 1543's static trend resulted in the MGL for 2008 being only approximately 280 mm lower then the AAMGL, and the MGL in a year exceeded the AAMGL in 2005 and 2007. The lowest groundwater level (LGL) for 2009 was the lowest on record for the site, and approximately 300 mm lower than the AALGL. The AAMGL has had a slight lowering trend on average of 7 mm and 5 mm per year over the last 10 and 20 years respectively (see *Figure 8*).

The proximity and similar unconfined aquifer depths observed at site 1543 suggests that 2008 and 2009 were relatively good representative years for groundwater levels in the vicinity of the subject land. The similar results and patterns observed on the subject land to site 1543 over the monitoring period further supports the suggestion that the groundwater levels recorded on the subject land are a good representation of groundwater levels for the subject land.

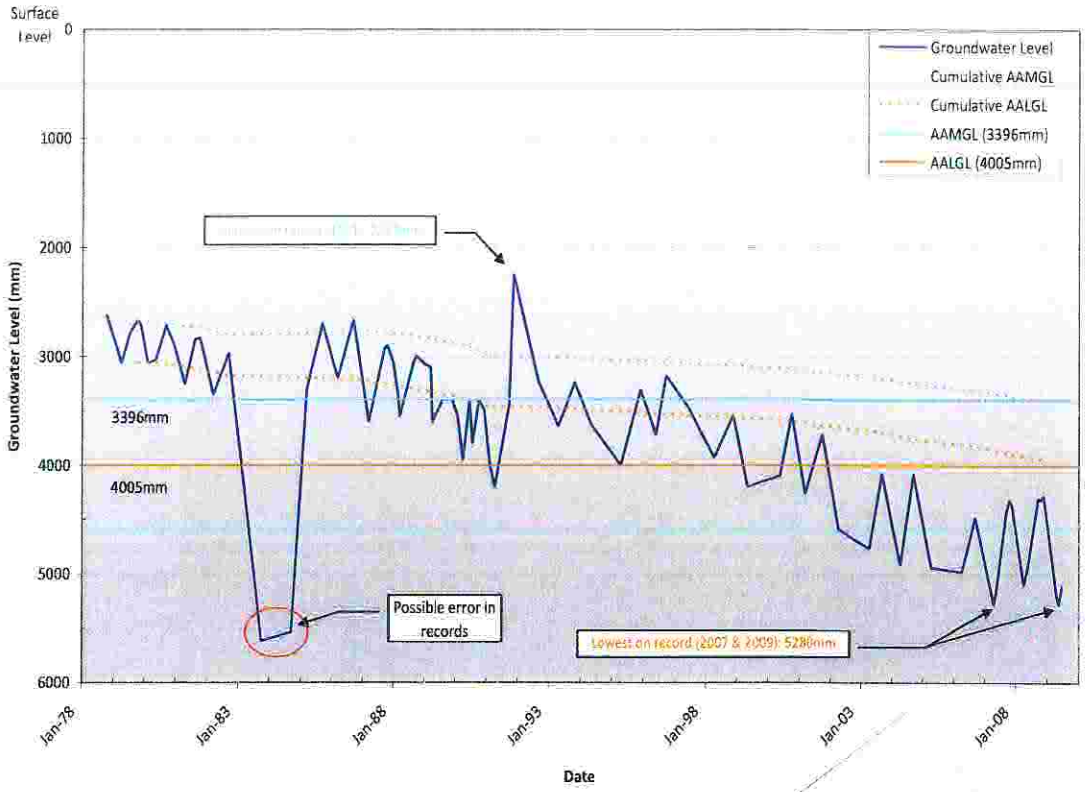


Figure 7 *– Department of Water monitoring bore ID 1579*

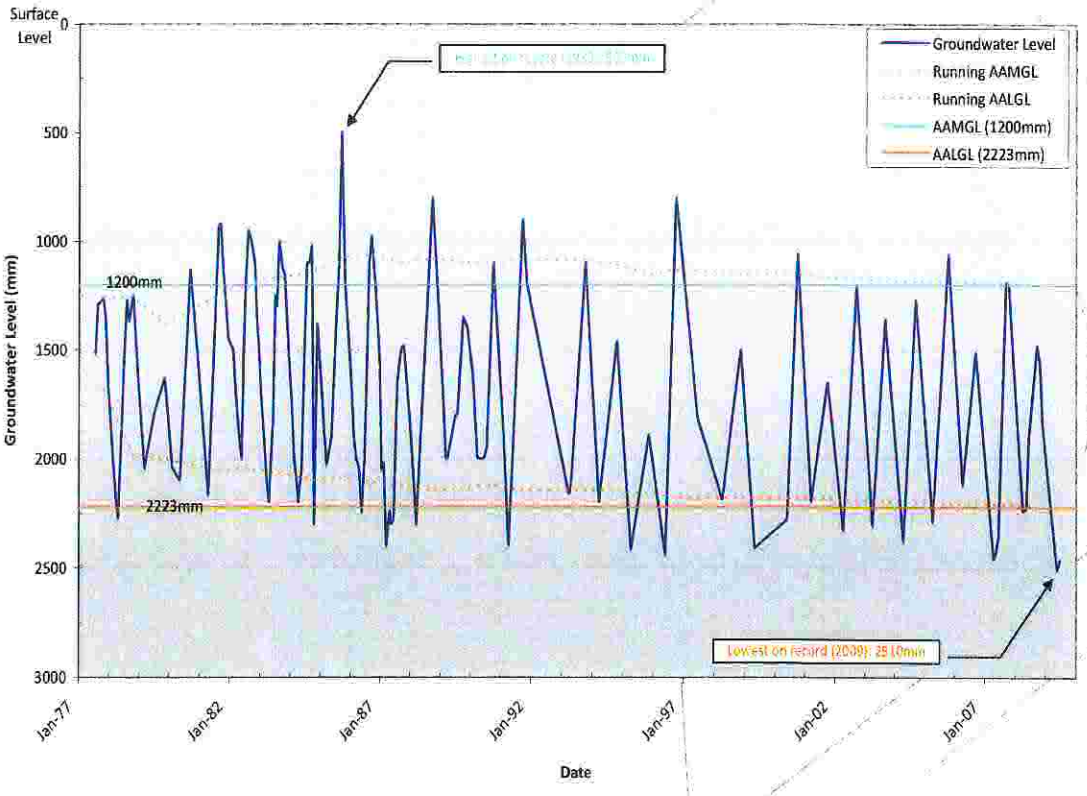


Figure 8 *– Department of Water monitoring bore ID 1543*

COMPARISON TO RAINFALL PATTERNS

The graph in *Figure 9* visually depicts a direct relationship between rainfall events and the water table level. This implies that rainfall may directly recharge the shallow groundwater table at the site, and that there is little influence on the shallow water table from flows outside of the site.

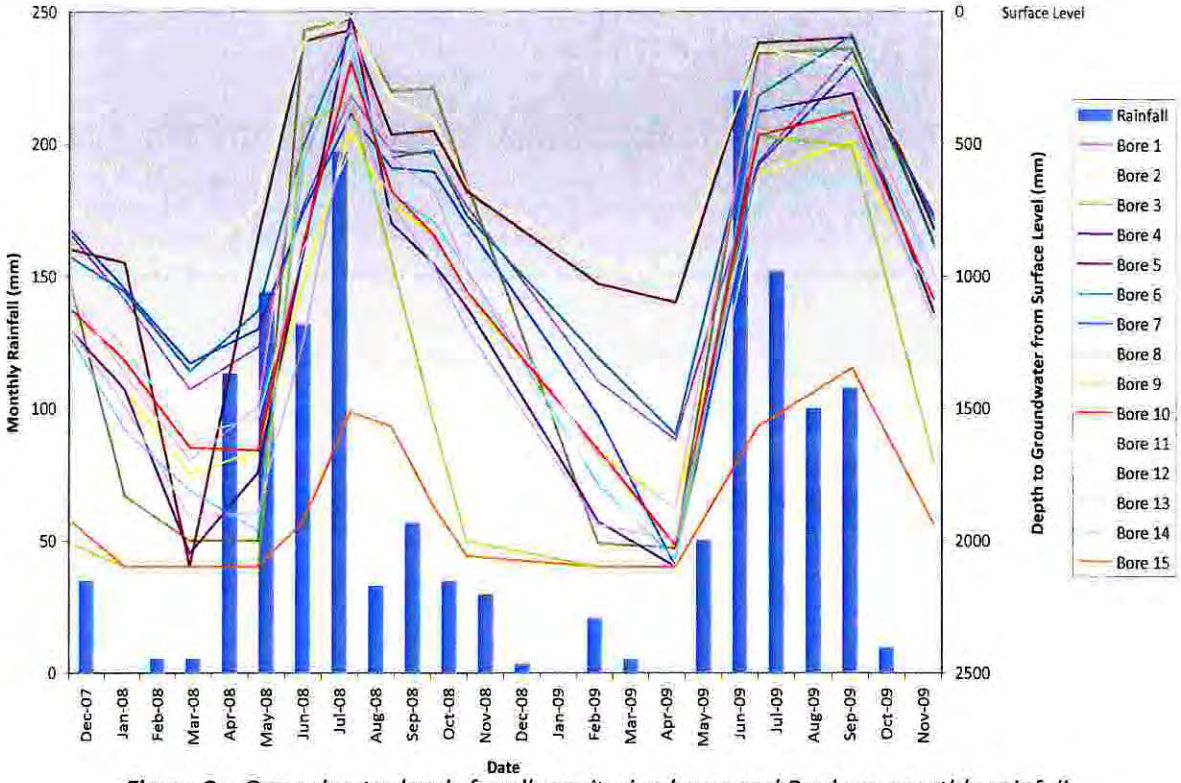


Figure 9 *– Groundwater levels for all monitoring bores and Bunbury monthly rainfall*

RECOMMENDATIONS

Due to the shallowness of the groundwater levels (less than 1 metre below the surface level) there will be a need to generate plans and strategies to manage the groundwater before any development proceeds. Groundwater management issues for this site may include:

- sewage effluent disposal;
- subsurface drains;
- fill requirements;
- groundwater quantity and quality; and
- other engineering designs.

These should be addressed primarily through any water management plans that are developed for the subject land proposal.

Groundwater contours for the site can be developed once a detailed feature survey of the area is undertaken. This will assist with determining the general direction of groundwater movement.

APPENDIX 1

FIELD MONITORING RECORDS

Appendix - Field Monitoring Records

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **1**
Eastings: 377754.91 *Northings:* 6306175.00
Height of Pipe Above Surface Level (mm): 930

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	1780	850	
17/01/2008	2020	1090	
13/03/2008	2360	1430	
09/05/2008	2200	1270	
16/06/2008	1660	730	
25/07/2008	1250	320	
28/08/2008	1460	530	
02/10/2008	1465	535	
30/10/2008	1670	740	
17/02/2009	2330	1400	
23/04/2009	2550	1620	
01/07/2009	1500	570	
17/09/2009	1080	150	
24/11/2009	1720	790	

Bore Number: **2**
Eastings: 378035.00 *Northings:* 6306320.48
Height of Pipe Above Surface Level (mm): 920

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2140	1220	
17/01/2008	2350	1430	
13/03/2008	2670	1750	
09/05/2008	2580	1660	
16/06/2008	1940	1020	
25/07/2008	1375	455	
28/08/2008	1645	725	
02/10/2008	1760	840	
30/10/2008	1990	1070	
17/02/2009	2580	1660	
23/04/2009	2800	1880	
01/07/2009	1540	620	
17/09/2009	1410	490	
24/11/2009	2070	1150	

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **3**
Eastings: 378203.04 *Northings:* 6306423.51
Height of Pipe Above Surface Level (mm): 900

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	1950	1050	
17/01/2008	2730	1830	
13/03/2008	2900	2000	
09/05/2008	2900	2000	
16/06/2008	970	70	
25/07/2008	930	30	
28/08/2008	1200	300	
02/10/2008	1190	290	
30/10/2008	1550	650	
17/02/2009	2910	2010	
23/04/2009	2930	2030	
01/07/2009	1060	160	
17/09/2009	1040	140	
24/11/2009	1770	870	

Bore Number: **4**
Eastings: 378260.68 *Northings:* 6306204.66
Height of Pipe Above Surface Level (mm): 870

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2080	1210	
17/01/2008	2300	1430	
13/03/2008	2920	2050	
09/05/2008	2615	1745	
16/06/2008	1770	900	
25/07/2008	880	10	
28/08/2008	1670	800	
02/10/2008	1825	955	
30/10/2008	1990	1120	
17/02/2009	2800	1930	
23/04/2009	3000	DRY	Monitoring bore dry
01/07/2009	1250	380	
17/09/2009	1180	310	
24/11/2009	2010	1140	

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **5**
Eastings: 377990.05 *Northings:* 6306121.41
Height of Pipe Above Surface Level (mm): 980

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	1880	900	
17/01/2008	1930	950	
13/03/2008	2030	DRY	Monitoring bore dry
09/05/2008	1830	850	
16/06/2008	1090	110	
25/07/2008	1050	70	
28/08/2008	1445	465	
02/10/2008	1430	450	
30/10/2008	1660	680	
17/02/2009	2010	1030	
23/04/2009	2080	1100	
01/07/2009	1100	120	
17/09/2009	1080	100	
24/11/2009	1800	820	

Bore Number: **6**
Eastings: 377759.10 *Northings:* 6305990.97
Height of Pipe Above Surface Level (mm): 910

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	1840	930	
17/01/2008	1970	1060	
13/03/2008	2270	1360	
09/05/2008	2040	1130	
16/06/2008	1410	500	
25/07/2008	975	65	
28/08/2008	1460	550	
02/10/2008	1435	525	
30/10/2008	1680	770	
17/02/2009	2220	1310	
23/04/2009	2510	1600	
01/07/2009	1230	320	
17/09/2009	1000	90	
24/11/2009	1790	880	

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **7**
Eastings: 377772.83 *Northings:* 6305787.09
Height of Pipe Above Surface Level (mm): 870

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	1700	830	
17/01/2008	1920	1050	
13/03/2008	2200	1330	
09/05/2008	2070	1200	
16/06/2008	1620	750	
25/07/2008	1255	385	
28/08/2008	1460	590	
02/10/2008	1475	605	
30/10/2008	1675	805	
17/02/2009	2400	1530	
23/04/2009	2970	DRY	Monitoring bore dry
01/07/2009	1450	580	
17/09/2009	1080	210	
24/11/2009	1640	770	

Bore Number: **8**
Eastings: 377989.12 *Northings:* 6305826.42
Height of Pipe Above Surface Level (mm): 850

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2090	1240	
17/01/2008	2430	1580	
13/03/2008	2660	1810	
09/05/2008	2810	1960	
16/06/2008	1410	560	
25/07/2008	970	120	
28/08/2008	1540	690	
02/10/2008	1640	790	
30/10/2008	1825	975	
17/02/2009	2640	1790	
23/04/2009	2920	2070	
01/07/2009	1220	370	
17/09/2009	1230	380	
24/11/2009	1840	990	

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **9**
Eastings: 378327.38 *Northings:* 6306005.89
Height of Pipe Above Surface Level (mm): 870

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2880	2010	
17/01/2008	3030	DRY	Monitoring bore dry
13/03/2008	3030	DRY	Monitoring bore dry
09/05/2008	3030	DRY	Monitoring bore dry
16/06/2008	1290	420	
25/07/2008	1210	340	
28/08/2008	1800	930	
02/10/2008	2415	1545	
30/10/2008	2870	2000	
17/02/2009	3040	DRY	Monitoring bore dry
23/04/2009	3040	DRY	Monitoring bore dry
01/07/2009	1340	470	
17/09/2009	1380	510	
24/11/2009	2570	1700	

Bore Number: **10**
Eastings: 378379.87 *Northings:* 6305752.60
Height of Pipe Above Surface Level (mm): 910

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2040	1130	
17/01/2008	2230	1320	
13/03/2008	2560	1650	
09/05/2008	2570	1660	
16/06/2008	1780	870	
25/07/2008	1100	190	
28/08/2008	1590	680	
02/10/2008	1755	845	
30/10/2008	1970	1060	
17/02/2009	2570	1660	
23/04/2009	2930	2020	
01/07/2009	1380	470	
17/09/2009	1290	380	
24/11/2009	2000	1090	

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **11**
Eastings: 378183.73 *Northings:* 6305739.04
Height of Pipe Above Surface Level (mm): 940

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	1700	760	
17/01/2008	1790	850	
13/03/2008	1880	940	
09/05/2008	1680	740	
16/06/2008	1050	110	
25/07/2008	955	15	
28/08/2008	1265	325	
02/10/2008	1350	410	
30/10/2008	1600	660	
17/02/2009	1890	950	
23/04/2009	1960	1020	
01/07/2009	1080	140	
17/09/2009	1140	200	
24/11/2009	1660	720	

Bore Number: **12**
Eastings: 378025.25 *Northings:* 6305690.47
Height of Pipe Above Surface Level (mm): 920

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	1980	1060	
17/01/2008	2190	1270	
13/03/2008	2520	1600	
09/05/2008	2460	1540	
16/06/2008	1810	890	
25/07/2008	1440	520	
28/08/2008	1690	770	
02/10/2008	1815	895	
30/10/2008	1990	1070	
17/02/2009	2690	1770	
23/04/2009	3020	2100	
01/07/2009	1640	720	
17/09/2009	1530	610	
24/11/2009	1980	1060	

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **13**
Eastings: 378158.85 *Northings:* 6305350.59
Height of Pipe Above Surface Level (mm): 970

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2050	1080	
17/01/2008	2340	1370	
13/03/2008	2670	1700	
09/05/2008	2465	1495	
16/06/2008	1340	370	
25/07/2008	1025	55	
28/08/2008	1520	550	
02/10/2008	1650	680	
30/10/2008	1960	990	
17/02/2009	2650	1680	
23/04/2009	2850	1880	
01/07/2009	1170	200	
17/09/2009	1260	290	
24/11/2009	1960	990	

Bore Number: **14**
Eastings: 378302.61 *Northings:* 6305459.97
Height of Pipe Above Surface Level (mm): 920

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2130	1210	
17/01/2008	2410	1490	
13/03/2008	2830	1910	
09/05/2008	2815	1895	
16/06/2008	2160	1240	
25/07/2008	1260	340	
28/08/2008	1645	725	
02/10/2008	1880	960	
30/10/2008	2120	1200	
17/02/2009	2860	1940	
23/04/2009	2920	2000	
01/07/2009	1520	600	
17/09/2009	1330	410	
24/11/2009	2090	1170	

Project Name: **Lot 15 South Western Highway, Davenport**
Client: **John Waters & City of Bunbury**
Job No: **07420**

Bore Number: **15**
Eastings: 378481.74 *Northings:* 6305567.57
Height of Pipe Above Surface Level (mm): 890

Date	Depth to Water (mm)	Groundwater Level (mm)	Comments
03/12/2007	2820	1930	
17/01/2008	3000	DRY	Monitoring bore dry
13/03/2008	3000	DRY	Monitoring bore dry
09/05/2008	3000	DRY	Monitoring bore dry
16/06/2008	2820	1930	
25/07/2008	2405	1515	
28/08/2008	2460	1570	
02/10/2008	2760	1870	
30/10/2008	2950	2060	
17/02/2009	2990	DRY	Monitoring bore dry
23/04/2009	3000	DRY	Monitoring bore dry
01/07/2009	2460	1570	
17/09/2009	2240	1350	
24/11/2009	2830	1940	

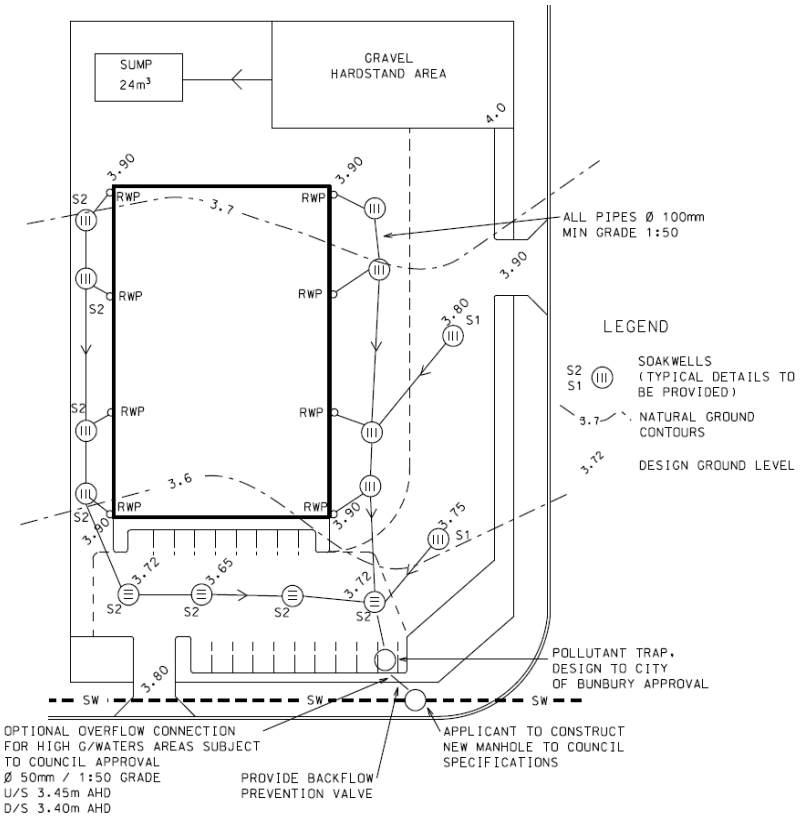
Information Guide – Stormwater Drainage Plan

When a "Stormwater Drainage Plan" is required as a condition of a planning approval, it should comply with the Information Guide - *Stormwater Disposal from Private, Commercial and Industrial Properties'* and contain the following information:

- North arrow and scale (all plans are to be provided at 1:200).
- Location of existing buildings to be retained and any existing building to be removed.
- Existing ground levels and contours, levels are to be in Australian Height Datum (AHD).
- Details of roads, accessways, crossovers, car parking and manoeuvring, fencing and verge treatments (including extent of sealed areas and stormwater drainage)
- Site levels, floor levels, location and details of cut/fill, and method of retaining - levels are to be in Australian Height Datum (AHD).
- Method of stormwater treatment (see diagram MISC-02-01 for an example of drainage plan using soakwells, over page)
- Groundwater impact assessment
- Others services located on site (e.g. Western Power/ Alinta / Telstra).
- Volume retention calculations

Typical volumes and areas served by standard sized soakwells is summarised in the following table for designers reference:

Soakwell size Diameter (m) x depth (m)	**Storage Volume**	**Area served - 2m² per 65m²**	**Area served – sandy areas 1m³ per 65m²**
Ø 1.8m x 1.2m	3.0m³	100 m ²	200 m²
Ø 1.5m x 1.2m	2.1 m³	70 m²	140 m²
Ø 1.2m x 1.2m	1.4 m³	45 m²	90 m²
Ø 1.2m x 0.9m	1.0 m³	35 m²	70 m²
Ø 0.2m x 0.6m	0.4 m³	12 m²	25 m²



STORMWATER DRAINAGE

Soakwell sizes: S1 = 1800 dia x 1800 deep = 4.6 m2
S2 = 1500 dia x 1200 deep = 2.1 m3

Sump size: 10m x 5m x 0.48 av.ht. = 24.0 m3
invert level 3.10m AHD

Storage in carpark: crossover level (overflow level) = 3.80 m AHD
average height of storage area = 0.066 m
area at crossover level = 500 m2
volume = 33.0 m3

Impervious Areas	Area (m2)	Design Vol. (m3) 2m3 per 65m2	Storage volume in Soakwells / Sumps (minimum 1m3/65m2)	Additional 1m3 / 65 m2 Storage above ground	Total Volume retained within the property
Roof Area	1000	30.8 m3	16.8 m3 (08 nos S2)	33.0 m3 (carpark)	67.2 m3
Car Park Area	500	15.4 m3	8.2 m3 (04 nos S2)		
Paved Area	600	18.4 m3	9.2 m3 (02 nos S1)		
Gravel hardstand	750	23.0 m3	24.0 m3 (sump)		24.0 m3
TOTAL	2850	87.6 m3			91.2 m3

BUNBURY CITY COUNCIL				
STORMWATER DRAINAGE PLAN (SAMPLE ONLY)				
SCALE N.T.S	DESIGN A.T.	DRAWN D.S. 01/2002		CHECKED A.T. 01/2002
APPROVED CITY ENGINEER DATE	REVISED	MISC - 02 - 01 SHEET 1 OF 1		

City of Bunbury Standard Drawing MISC-02-01

Project: Lot 81 South Western Highway, Davenport
Client: NBR Investments

Bore Number 1

Easting: 377756.17 **Northing:** 6306176.05 (MGA94)
Height Of Pipe Above Ground Level (mm) 0 **Elevation:** 13.934 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	763	763	13.171		13.934	Bore Damaged - cut at GL
4/08/2016	290	290	13.644	473	13.934	
5/09/2016	150	150	13.784	140	13.934	
4/10/2016	260	260	13.674	-0.11	13.934	

Bore Number 2

Easting: 378033.24 **Northing:** 6306319.99 (MGA94)
Height Of Pipe Above Ground Level (mm) 60 **Elevation:** 12.848 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	978	918	11.87		12.788	Bore Damaged - cut near GL
4/08/2016	360	300	12.488	618	12.788	
5/09/2016	490	430	12.358	-130	12.788	
4/10/2016	590	530	12.258	-0.1	12.788	

Bore Number 3

Easting: 378201.99 **Northing:** 6306424.66 (MGA94)
Height Of Pipe Above Ground Level (mm) 0 **Elevation:** 11.228 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	347	347	10.881		11.228	Bore Damaged - cut at GL
4/08/2016	140	140	11.088	207	11.228	
5/09/2016	115	115	11.113	25	11.228	
4/10/2016	100	100	11.128	0.015	11.228	

Bore Number 5

Easting: 377989.76 **Northing:** 6306123.39 (MGA94)
Height Of Pipe Above Ground Level (mm) 40 **Elevation:** 13.115 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	243	203	12.872		13.075	Bore Damaged - cut near GL
4/08/2016	100	60	13.015	143	13.075	
5/09/2016	100	60	13.015	0	13.075	
4/10/2016	110	70	13.005	-0.01	13.075	

Bore Number 10

Easting: 378375.98 **Northing:** 6305756.49 (MGA94)
Height Of Pipe Above Ground Level (mm) 0 **Elevation:** 12.488 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	880	880	11.608		12.488	Bore Damaged - cut at GL
4/08/2016	260	260	12.228	620	12.488	
5/09/2016	400	400	12.088	-140	12.488	
4/10/2016	480	480	12.008	-0.08	12.488	

Bore Number 11

Easting: 378184.32 **Northing:** 6305736.89 (MGA94)
Height Of Pipe Above Ground Level (mm) 170 **Elevation:** 12.717 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	365	195	12.352		12.547	Bore Damaged - cut near GL

4/08/2016	250	80	12.467	115	12.547	
5/09/2016	260	90	12.457	-10	12.547	
4/10/2016	300	130	12.417	-0.04	12.547	

Bore Number **13A**

Easting: 378158.67 **Northing:** 6305352.11 (MGA94)
Height Of Pipe Above Ground Level (mm) -100 **Elevation:** 14.171 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	385	485	13.786		14.271	Bore 13 not found. This bore found
4/08/2016	Bore under water					close by, named 13A. Bore damaged/
5/09/2016	60	160	14.111	325	14.271	cut 100 below GL.
4/10/2016	210	310	13.961	-0.15	14.271	

Bore Number **14**

Easting: 378306.05 **Northing:** 6305461.92 (MGA94)
Height Of Pipe Above Ground Level (mm) 0 **Elevation:** 13.693 (AHD)

Date	Depth To Water (mm)	Ground Water Level (mm)	Ground Water AHD Level	Difference(mm)	Ground Surface AHD Level	Comments
5/07/2016	782	782	12.911		13.693	Bore Damaged - cut at GL
4/08/2016	145	145	13.548	637	13.693	
5/09/2016	310	310	13.383	-165	13.693	
4/10/2016	400	400	13.293	-0.09	13.693	

Government of Western Australia
Department of Health

Approved secondary treatment systems and aerated wastewater treatment systems

Secondary treatment systems (STS) are wastewater treatment systems which produce treated effluent of secondary standard, i.e. 20 mg/L of Biochemical Oxygen Demand (BOD), 30 mg/L of Total suspended solids (TSS) and 10 cfu/100 mL of Escherichia (E) coli. Due to the treatment and disinfection process, the treated wastewater from STS systems may be used for garden irrigation.

The STSs systems listed below have been certified to the latest Australian Standard **AS 1546.3:2017- On-site domestic wastewater treatment units.Secondary treatment systems** and approved by the Chief Health Officer for installations in Western Australia. AS 1546.3:2017 sets out requirements for the design, commissioning, performance and conformity testing of **secondary treatment systems**.

Aerated Wastewater Treatment System (AWTS) is a system which uses the processes of aeration followed by clarification to achieve biological treatment of wastewater.The AWTS systems listed below have been certified to the previous Australian Standard **AS 1546.3:2008 - On-site domestic wastewater treatment units. Aerated wastewater treatment systems** and approved by the Chief Health Officer for installations in Western Australia. AS 1546.3:2008 sets out requirements for the design, commissioning, performance and conformity testing of **aerated wastewater treatment systems**.

In some instances the Government Sewerage Policy 2019 (external site) requires installation of STS and not AWTS. For more details please refer to the Government Sewerage Policy 2019 (external site).

STSs and AWTSs are to be installed and operated in accordance with the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974*, the *Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units Serving Single Dwellings* and *AS 1547: 2012 On-site domestic wastewater management.*

As the conditions of approval can vary between designs, persons interested in installing a particular STS or AWTS should confirm it meets their needs and discuss site requirements with the local government. For more information on STS and AWTS refer to Secondary Treatment and Aerated Wastewater Treatment Systems.

STSs and AWTSs have regular service requirements (usually quarterly) and maintenance must be through an authorised person or their staff/subcontractors.

Where nutrient retention is required, the local government should be consulted to determine if the nutrient removal capacity of the system will meet their requirements.

Please note that all systems require to be certified to AS1546.3:2017:

- **any new STSs without current certification; and**
- **existing AWTS with current certification to AS 1546.3:2008 (as per table below) by the current certification expiry date.**

Table 1: Approved STS (certified to AS1546.3:2017)

Manufacturer / Distributor	Model	Capacity	Comment / Restrictions	Approval Expiry Date
BioSeptic Pty Ltd (external site) Phone: (02) 4629 6666 or 1300 658 111 Email: sales@bioseptic.com.au	Performa 2020	1500L/day 10EP	Advanced Secondary Treatment System with Chlorine disinfection, 3 Monthly Service and 4.3 yearly sedimentation pump out or as required. Approved for above ground spray irrigation, sub-surface, sub-strata drip irrigation, leach drains and soakwells. The system achieved the following results over testing period to AS 1546.3:2017: • TSS 5.8mg/l • BOD 1.9mg/l • Turbidity 14.5NTU • **E coli <1 CFU/100ml**	Global Certification Number 576 30/06/2025
Everhard Industries Pty Ltd (external site) Phone: (08) 94178222 Email: waorders@everhard.com.au	Aqua Advanced Poly and Concrete	1200L/day 8EP	Advanced Secondary Treatment System with Chlorine disinfection, 3 Monthly Service and 3.3 yearly sedimentation pump out or as required. Approved for above ground spray irrigation, sub-surface, sub-strata drip irrigation, leach drains and soakwells. The system achieved the following results over testing period to AS 1546.3:2017: • TSS 5.4mg/l • BOD 1.25mg/l • Turbidity 7.6NTU • E coli 0.2 CFU/100ml	Global Certification Number 632 28/092025

Biomax Pty Ltd	BioMax-C10 and P10-M		This system is currently undergoing testing to AS1546.3:2017	Preliminary certification number SMK40530
Fuji Clean Australia PTY LTD Phone: 1300 733 619 Email: dwain@fujiclean.com.au WA Distributor: ECOWATER WA Phone: 08 9561 2927 Email: ecowaterwa@bigpond.com Mob: 0417 098 281	FujiClean ACE 1200	1200L/day 8EP	Advanced Secondary Treatment System with Chlorine disinfection, 3 Monthly Service and 5 yearly sedimentation pump out or as required. Approved for above ground spray irrigation, sub-surface, sub-strata drip irrigation, leach drains and soakwells. The system achieved the following results over testing period to AS 1546.3:2017: • TSS 2.9mg/l • BOD <2mg/l • Turbidity 3.63NTU • E coli <1CFU/100ml • Total Nitrogen 14.79mg/l • Phosphorus 10.33mg/l	Global Certification Number 476 15/03/2024
Kingspan Water & Energy Pty Ltd(external site) Phone:1300 736 562 Email:gerry.quinn@kingspan.com	BioFicient Series 1	1500L/day 10EP	Aerated Secondary treatment system certified to AS 1546.3:2017	SMK40710 22/11/2023
	Advanced BioFicient	1200L/day 8EP	Advanced Secondary Treatment System with Chlorine disinfection, 3 Monthly Service and 2 yearly sedimentation pump out or as required. Approved for above ground spray irrigation, sub-surface, sub-strata drip irrigation, leach drains and soakwells.The system achieved the following results over testing period to AS 1546.3:2017: • TSS 4.1mg/l • BOD 1.07mg/l • Turbidity 6.9NTU • E coli <1CFU/100ml	Global Certification Number 581 10/06/2025

Taylex Australia Pty Ltd (external site) Phone: 1300 TAYLEX (1300 829539) Email: info@taylex.com.au	Taylex ABS 1500 (Concrete and plastic)	1500L/day 10EP	Advanced Secondary Treatment System with Chlorine disinfection, 3 Monthly Service and 3.2 yearly sedimentation pump out or as required. Approved for above ground spray irrigation, sub-surface, sub-strata drip irrigation, leach drains and soakwells.The system achieved the following results over testing period to AS 1546.3:2017: • TSS 7.6mg/l • BOD 1.5mg/l • Turbidity 31.1NTU • E coli 1.4 CFU/100ml	Global Certification 40/22 19/08/2025
	Taylex ABS 5000 Concrete	5000L/day 33EP	Advanced Secondary Treatment System with Chlorine disinfection, 3 Monthly Service and 3.2 yearly sedimentation pump out or as required. Approved for above ground spray irrigation, sub-surface, sub-strata drip irrigation, leach drains and soakwells.The system achieved the following results over testing period to AS 1546.3:2017: • TSS 6.12mg/l • BOD 1.07mg/l • Turbidity 8.51NTU • E coli 0.41 CFU/100ml • Nitrogen 45.68mg/l • Phosphorus 9.21mg/l	Global Certification 40/24 16/12/2025

Toowomba Tanks Pty Ltd (external site) Phone: (07) 4634 3860 Email: sales@tanks.com.au WA Distributor: TMC Australasia: 0418 267 959 Email: tony@tmcwaterrecycling.com	TurboJet Single	1500L/day 10 EP	Advanced Secondary Treatment System with Chlorine disinfection, 3 Monthly Service and 3.5 yearly sedimentation pump out or as required.Approved for above ground spray irrigation, sub-surface, sub-strata drip irrigation, leach drains and soakwells. The system achieved the following results over testing period to AS 1546.3:2017: • TSS 9.2mg/l • BOD5 <2mg/l • Total Nitrogen 51.1mg/l • Phosphorus 11.6mg/l • Turbidity 8.8NTU • E coli <1CFU/100ml	Global Certification 567 22/05/2025

Table 2: Approved AWTS (certified to AS1546.3:2008)

Manufacturer / Distributor	Model	Capacity	Comment / Restrictions	Approval Expiry Date
Allied Pumps (external site) Phone: 9350 1000 / 1800 447 777 Email: sales@alliedpumps.com.au	Everhard Aqua-Nova 2000 Model 80100	1800L/day	Aerated Wastewater Treatment System certified to AS1546.3:2008	Global Certification No. 077 16/02/2022
Aquarius Wastewater Systems Pty Ltd (external site) Phone: 9240 8545 Email:admin@aquariuswastewater.com.au	Aquarius O–3	1800L/day	Aerated Wastewater Treatment System with Ozone disinfection and Alum dosing. Nutrient reduction capability: N reduced to <10mg/L. & P reduced to < 1mg/L as per certification SMKH21519 to AS1546.3:2008	SMKH21519 25/03/2026
	Aquarius O–2	1800L/day	Aerated Wastewater Treatment System without disinfection and Alum dosing certified to AS1546.3:2008.	

Manufacturer / Distributor	Model	Capacity	Comment / Restrictions	Approval Expiry Date
	Aquarius O–2 NR	1800L/day	Aerated Wastewater Treatment System without disinfection, with Alum dosing. Nutrient reduction capability: N reduced to <10mg/L. & P reduced to < 1mg/L as per certification SMKH21519 to AS1546.3:2008	
Biolytix Ltd (external site) WA Distributor: Water installations: 9295 6263	BF6 - Mark 2	1600L/day	Aerated Wastewater Treatment System without disinfection,certified to AS1546.3:2008	SMK40499 31/12/2025
Jowa Group Pty Ltd (external site) Phone: 8381 9100 Email: admin@biocycle.com.au WA Distributors: Greg Browden: 0401 967 330	Biocycle BIO-7000	1500L/day 10EP	Aerated Wastewater Treatment System with Chlorine disinfection, certified to AS1546.3:2008	SMKH20266 22/11/2025
Fuji Clean Australia Pty Ltd (external site) WA Distributor: Ecowater WA: 0417 098 281 Email: ecowaterwa@bigpond.com	CE1500EX	1500L/day 10EP	Aerated Wastewater Treatment System with some Nitrogen reduction and 3 monthly service achieving the following average results tested to AS1546.3:2008: • TSS 4.27 mg/L • BOD 2.29 mg/L • E.coli 1.2 cfu /100mL • D.O. 5.07 mg/L • Nitrogen 53% reduction	Global Certification Number 249/6 09/05/2025

Manufacturer / Distributor	Model	Capacity	Comment / Restrictions	Approval Expiry Date
Global Roto-Moulding Pty Ltd (external site) Phone: (07) 4697 7099 Email: info@globalwater.com.au	UBI Aqua 6000L	1500L/day	Aerated Wastewater Treatment System with Chlorine disinfection, certified to AS1546.3:2008	SMK40298 10/05/2022
Graf Australia Pty Ltd (external site) Phone: 1300 131 971 Email: info@grafaustralia.com.au WA Distributor: Aquarius Wastewater Systems PL (external site) Phone: 9240 8545 Email: mel@aquariuswastewater.com.au	Graf E-Pro 15-1 Graf E-Pro 15-1C Graf E-Pro 15-1 PAC	1500L/day	Aerated Wastewater Treatment System with some Nitrogen and Phosphorus reduction and 4 monthly service achieving the following average results tested to AS1546.3:2008: TP (% removal): 3 mg/L (54%) TN (% removal): 24 mg/L (50%)	Global certification No. 329, 329/1 & 188 &188/2 26/10/2024
	Graf E-Pro 15-2 Graf E-Pro 15-2C Graf E-Pro 15-2 PAC	1500L/day	Aerated Wastewater Treatment System with some Nitrogen and Phosphorus reduction and 6 monthly service achieving the following average results tested to AS1546.3:2008: TP (% removal): 3 mg/L (54%) TN (% removal): 24 mg/L (50%)	
	Graf E-Pro 15-3 Graf E-Pro 15-3+O Graf E-Pro 15-3 PAC	1500L/day	Aerated Wastewater Treatment System with some Nitrogen and Phosphorus reduction and 6 monthly service achieving the following average results tested to AS1546.3:2008: TP (% removal): 3 mg/L (54%) TN (% removal): 24 mg/L (50%)	
Suncoast Waste Water Management (external site)	Ozzi Kleen RP-10	2000L/day	Aerated Wastewater Treatment System with Chlorine disinfection, certified to AS1546.3:2008	SMK02608 14/08/2021

Manufacturer / Distributor	Model	Capacity	Comment / Restrictions	Approval Expiry Date
Phone: 1800 450 767 Email: info@ozzikleen.com	Ozzi Kleen RP-10A+	2000L/day	Aerated Wastewater Treatment System with Chlorine disinfection and Alum dosing, certified to AS1546.3:2008	
Taylex Australia Pty Ltd (external site) Phone: 1300 TAYLEX (1300 829539) Email: info@taylex.com.au	Taylex ABS 10EP (Concrete and plastic)	2000L/day	Aerated Wastewater Treatment System with some Nitrogen and Phosphorus reduction and 3 monthly service achieving the following average results tested to AS1546.3:2008: TP (% removal): 2.5 mg/L (84.67%) TN (% removal): 24.9 mg/L (53.71)	Global Certification 040/8 & 040/10 11/07/2025
	Taylex ABS 8EP (Concrete and plastic)	1200L/day	Aerated Wastewater Treatment System with some Nitrogen and Phosphorus reduction and 3 monthly service achieving the following average results tested to AS1546.3:2008: TP (% removal): 2.5 mg/L (84.67%) TN (% removal): 24.9 mg/L (53.71)	

Table 3: Systems assessed and not approved or approval withdrawn

Manufacturer	Model	Reason not approved / Further information
BioSystems 2000 Pty Ltd	Biosystem 2000	Certification is not provided as of 1 July 2015.
Earthsafe Environmental Pty Ltd	Earthsafe Environmental	Certification SMKH20612 is not available online

Manufacturer	Model	Reason not approved / Further information
Fuji Clean Australia Pty Ltd	CE1200	Certification is not provided as of 1 July 2015.
Galvin Concrete & Sheetmetal Pty Ltd	Clearwater 90 Compact	Certification is not provided as of 1 July 2015.
Icon-Septech Pty Ltd	Septech Turbojet 2000	Company liquidated. For further information, visit: Australian Securities and Investments Commission (external site). Systems that have been purchased on or before 27 June 2016 may still be installed.
Jowa Group Pty Ltd	Biocycle 5800	Certification not provided as of 1 July 2015.
Water Gurus Pty Ltd	Novaclear	Company liquidated. For further information, visit: Australian Securities and Investments Commission (external site)

More information

Environmental Health Directorate
Department of Health
Telephone: 9222 2000
Email: ehinfo@health.wa.gov.au

Appendix B

Bushfire Assessment Report

Prepared by Ecosystem Solutions

Bushfire Management Plan Coversheet

This Coversheet and accompanying Bushfire Management Plan has been prepared and issued by a person accredited by Fire Protection Association Australia under the Bushfire Planning and Design (BPAD) Accreditation Scheme.

Bushfire Management Plan and Site Details

Site Address / Plan Reference: Lot 81 South Western Highway		
Suburb: Davenport	**State:** WA	**P/code:** 6230
Local government area: City of Bunbury		
Description of the planning proposal: Subdivision of current agricultural lot into 6 industrial lots		
BMP Plan / Reference Number: 18640	**Version:** Rev F	**Date of Issue:** 2/12/2021
Client / Business Name: NBR Investments, C/- LB Planning		

Reason for referral to DFES	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?	☐	☑
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the BPC elements)?	☑	☐

Is the proposal any of the following special development types (see SPP 3.7 for definitions)?

Unavoidable development (in BAL-40 or BAL-FZ)	☐	☑
Strategic planning proposal (including rezoning applications)	☐	☑
Minor development (in BAL-40 or BAL-FZ)	☐	☑
High risk land-use	☐	☑
Vulnerable land-use	☐	☑

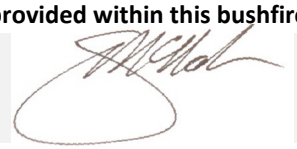
If the development is a special development type as listed above, explain why the proposal is considered to be one of the above listed classifications (E.g. considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

Note: The decision maker (e.g. local government or the WAPC) should only refer the proposal to DFES for comment if one (or more) of the above answers are ticked "Yes".

BPAD Accredited Practitioner Details and Declaration

Name	Accreditation Level	Accreditation No.	Accreditation Expiry
Gary McMahon	Level 3	35078	11/2022
Company Ecosystem Solutions		**Contact No.** (08) 9759 1960	

I declare that the information provided within this bushfire management plan is to the best of my knowledge true and correct

Signature of Practitioner  **Date** 2/12/2021

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Bushfire Management Plan

Lot 81 South Western Highway, Davenport

2 December 2021

Prepared for:
NBR Investments
C/- LB Planning
Att: Stan Lawrence-Brown

Limitations Statement

This report has been prepared for NBR Investments (C/- LB Planning, Att: Stan Lawrence-Brown) and remains the property of Ecosystem Solutions. No express or implied warranties are made by Ecosystem Solutions Pty Ltd regarding the findings and data contained in this report. No new research or field studies were conducted other than those specifically outlined in this report. All of the information details included in this report are based upon the research provided and obtained at the time Ecosystem Solutions Pty Ltd conducted its analysis.

In undertaking this work the authors have made every effort to ensure the accuracy of the information used. Any conclusions drawn or recommendations made in the report are done in good faith and the consultants take no responsibility for how this information and the report are used subsequently by others.

Please note that the contents in this report may not be directly applicable towards another organisation's needs. Ecosystem Solutions Pty Ltd accepts no liability whatsoever for a third party's use of, or reliance upon, this specific report.

Document Control

Client - NBR Investments
C/- LB Planning
Att: Stan Lawrence-Brown

Site – Lot 81 South Western Highway, Davenport

Version	Revision	Purpose	Author	Reviewer	Submitted	
					Form	Date
Report	Rev A	Initial Report	DP	GM	Electronic (email)	5/12/2018
Report	Rev B	Comments from WAPC	DP	GM	Electronic (email)	24/01/2019
Report	Rev C	Comments from DFES	DP	GM	Electronic (email)	15/04/2019
Report	Rev D	Comments from DPLH	KP	GM	Electronic (email)	5/11/2019
Report	Rev E	FSAR	KP	GM	Electronic (email)	26/05/2020
Report	Rev F	Update Veg Map	DC	GM	Electronic (email)	2/12/2021

Filename: Z:\PROJECTS\18640 Lot 81 South Western Highway, Davenport BMP Update\Reports\Lot 81 South Western Highway, Davenport BMP Rev F.docx

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Table 6	Local Government Authority Responsibilities	32

1 Proposal

This Bushfire Management Plan (BMP) has been prepared for Lot 81 South Western Highway, Davenport (hereafter referred to as the 'Site') by Ecosystem Solutions Pty Ltd, Danae Plowman (B.Sc. PG Dip Engy & Env) and Gary McMahon (B.Sc. M. Env Mgmt. PG Dip Bushfire Protection).

The Lot is 41.832 ha in size with a proposal is to subdivide the lot into six industrial lots. Details are provided in Figure 1.

The Site is located within a bushfire prone area, as declared by *State Planning Policy 3.7: Planning in Bushfire Prone Areas* (Figure 2).

The purpose of this BMP is to detail the fire management methods and requirements that will be implemented within and around the Site to reduce the threat to residents and fire fighters in the event of a fire.

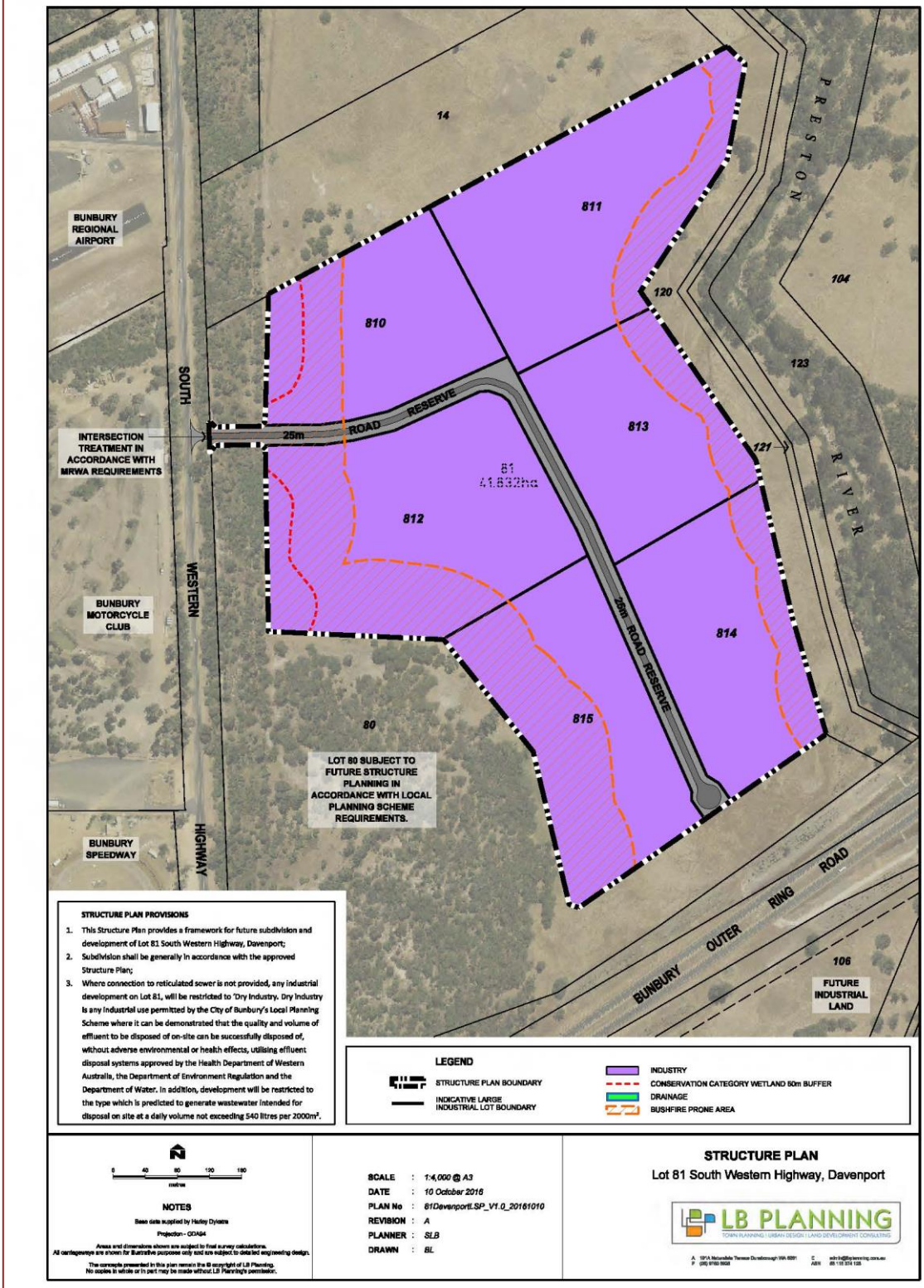


Figure 1 The Development Application for the Site

Figure 2 Map of Bushfire Prone Areas for the Site shown in blue (Map of Bushfire Prone Areas)

2 Bushfire Assessment Results

2.1 Assessment Inputs

The assessment of the Site was undertaken on 23 August 2016 with follow up assessment conducted on 24 October 2019, for the purpose of determining the Bushfire Attack Level in accordance with AS 3959 - 2018 Simplified Procedure (Method 1).

Plot	1	**Vegetation Classification or Exclusion Clause**	Class B – Woodland upslope / flat

Photo ID: 1

Photo ID: 2

Description / Justification for Classification:	*Agonis flexuosa* (Peppermint), *Banksia ilicifolia, B. littoralis* and *Corymbia calophylla* (Marri) with a canopy cover of 10-30% over an understorey of bare ground or introduced grasses. This plot includes the area within the Environmentally Sensitive Area buffer, located within proposed lot 810 and 812 that is currently grassland however, there may be a requirement to revegetate this area in the future and therefore a maximum classification of Class B Woodland has been included based on the expected mature growth of any future revegetation.

Plot	2	Vegetation Classification or Exclusion Clause	Class A – Forest upslope / flat

Photo ID: 3

Photo ID: 4

Description / Justification for Classification:	*Kunzea glabrescens*, *Melaleuca* sp. and *Corymbia calophylla* (Marri) with canopy cover 30 – 70% over a well developed understorey including *Dasypogon bromeliifolius*. .

Plot	3	Vegetation Classification or Exclusion Clause	Class A – Forest downslope >5 to 10 degrees

Photo ID: 5

Photo ID: 6

Description / Justification for Classification:	*Eucalyptus rudis* (Flooded Gum), *Corymbia calophylla* (Marri) and *Agonis flexuosa* (Peppermint) trees with canopy of 30 – 70% and an understorey of introduced grasses. Areas that are currently Class G – Grassland that are to be revegetated as per Appendix A – Foreshore Management Plan, have been included in this plot.

Plot	4	Vegetation Classification or Exclusion Clause	Class A – Forest downslope >0 to 5 degrees

Photo ID: 7

Description / Justification for Classification:	Small patch of juvenile *Eucalyptus* sp. Although currently less than 4 m in height, the potential height and canopy structure of these trees when in their mature state will be 10 m to 30 m high, resulting in a forest classification.

Plot	5	Vegetation Classification or Exclusion Clause	Class A – Forest upslope / flat

Photo ID: 8

Photo ID: 9

Description / Justification for Classification:	Strip of revegetation along the Bunbury Outer Ring Road, to the south of the site and an area to the north west of the Site. This plot includes a mix of native species including *Acacia* sp., *Eucalyptus* sp., *Hakea* sp. and *Melaleuca* sp. with canopy cover 30 – 70%. Also included in this plot are the upland areas adjacent to the Preston River that are currently Class G – Grassland but are to be revegetated as per Appendix A – Foreshore Management Plan

Plot	6	Vegetation Classification or Exclusion Clause	Class G Grassland upslope / flat

Photo ID: 10

Photo ID: 11

Description / Justification for Classification:	Introduced grass species within areas neighbouring the Site.

Plot	7	Vegetation Classification or Exclusion Clause	Excluded Clause 2.2.3.2 (e) & (f)

Photo ID: 12

Photo ID: 13

Photo ID: 14

Description / Justification for Classification:	Areas greater than 100m from the Site are excluded under S 2.2.3.2 (a). Non vegetated areas including roads, the proposed access road (Photo 13) and any building or hardstands eventuating within the Site are excluded under S 2.2.3.2 (e). Low threat vegetation including nature strip along the west of the South Western Highway and the grass within the Site, are excluded under clause 2.2.3.2 (f). Grass will be maintained below 10 cm as a condition of this Bushfire Management Plan by the developer and subsequent landowners (Photos 12 and 14). Photo 13 includes classified vegetation to the left and right (Plots 1 & 2).

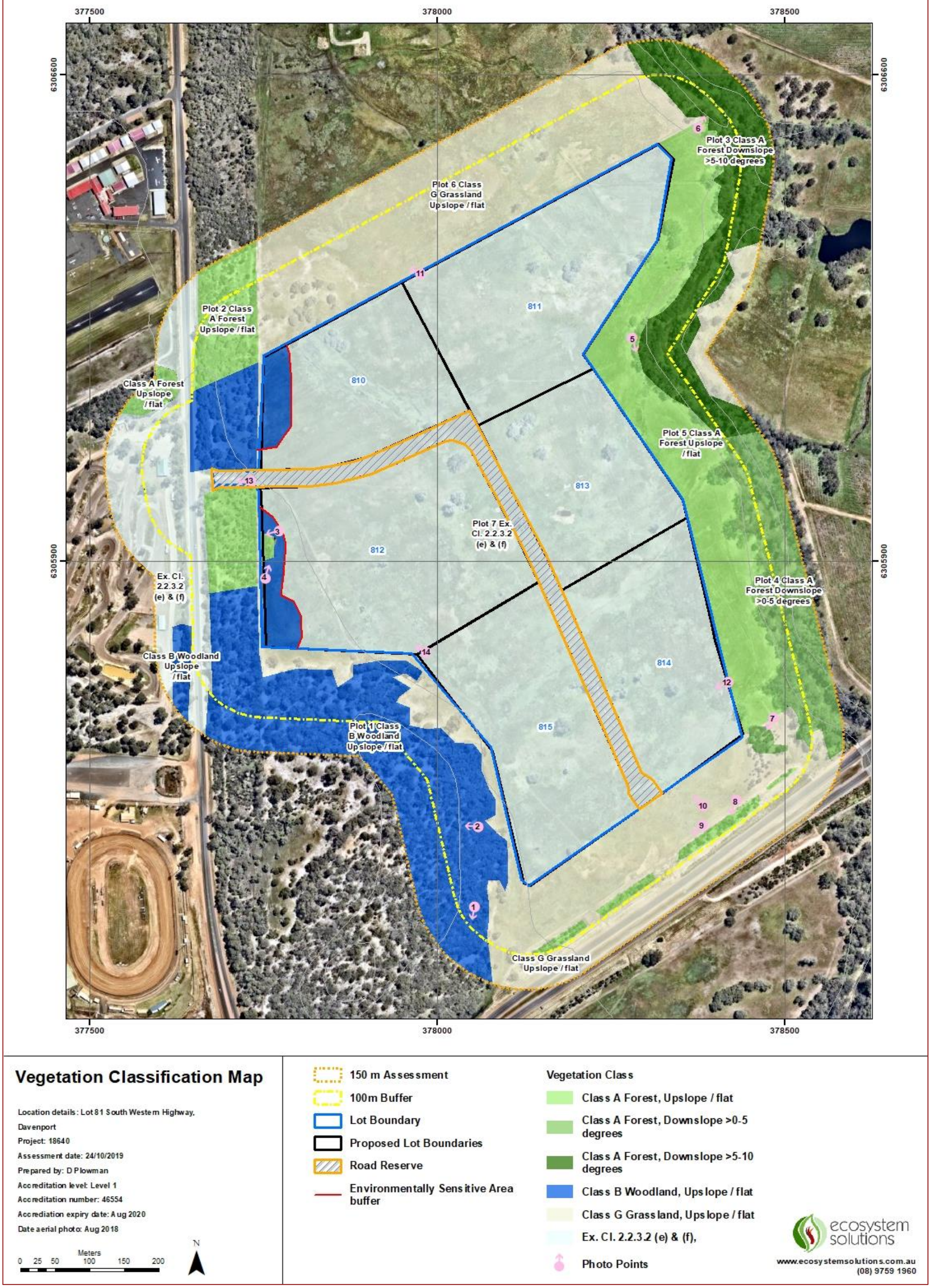


Figure 3 Map of Vegetation Class and Effective Slope

2.2 Assessment Outputs

The results from the Site assessment are provided in Table 1. The Determined Bushfire Attack Level (highest BAL) for the Site has been determined in accordance with clause 2.2.6 of AS 3959-2018 with map provided in Figure 4.

Table 1 Site Assessment Results

Method 1 BAL Determination				
Fire Danger Index - 80 (AS3959-2018 Table 2.1)				
Plot	**Vegetation Classification**	**Effective Slope Under the Classified Vegetation (degrees)**	**Separation Distance to the Classification Vegetation (metres)**	**Bushfire Attack Level**
1	Class B Woodland	Upslope / Flat	Min 14 m*	BAL-29*
2	Class A Forest	Upslope / Flat	Min 21 m*	BAL-29*
3	Class A Forest	Downslope >5-10 degrees	Min 33 m*	BAL-29*
4	Class A Forest	Downslope >0-5 degrees	Min 27 m*	BAL-29*
5	Class A Forest	Upslope / Flat	Min 21 m*	BAL-29*
6	Class G Grassland	Upslope / Flat	Min 8 m*	BAL-29*
7	Excluded Clause 2.2.3.2 (e) & (f)	NA	NA	BAL-LOW
Determined Bushfire Attack Level				**BAL-29***

* A lower BAL rating can be achieved based on an increased separation distance from the classified vegetation, depending on the location of any building within the Lots. A detailed BAL assessment may be required prior to the construction of any building.

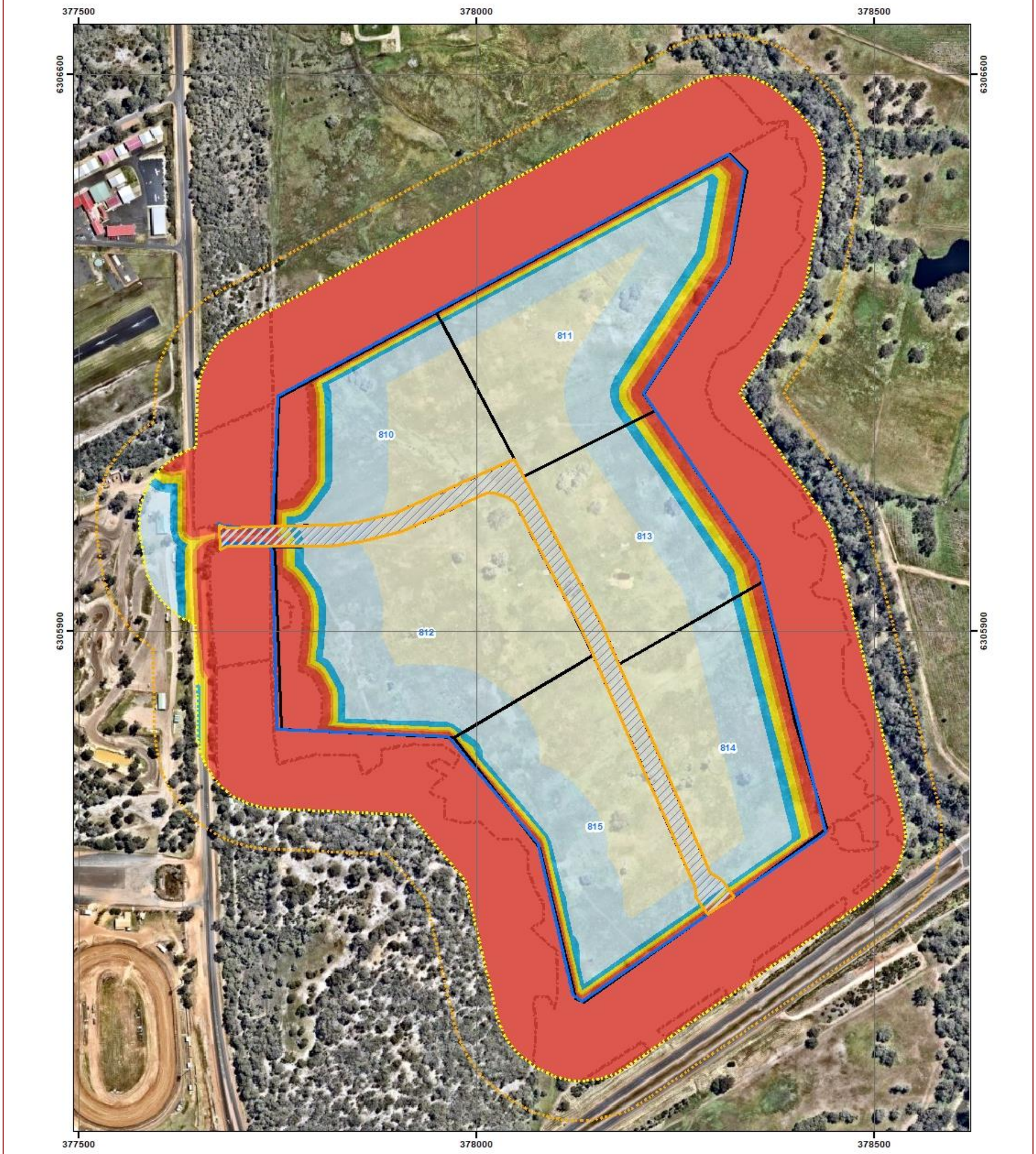


Figure 4 Map of Bushfire Attack Level Assessment

3 Environmental Considerations

3.1 Native Vegetation – modification and clearing

The Site contains predominately previously cleared areas with scattered trees.

The area has been assessed for environmental values using a simple desktop review. There are Environmentally Sensitive Areas in proximity to the Site, being the Preston River to the east and a Conservation Category Wetland to the west, with the buffers of these ESAs crossing into the Site. Banksia Woodlands of the Swan Coastal Plain, Clay Pans of the Swan Coastal Plain and the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological communities are likely to occur within the area (PMST, accessed 31/10/2019). Declared rare flora (DRF) species or species habitat is likely to occur within the area (Table 2). There is no proposed clearing of remnant native vegetation as a result of this proposal and therefore no proposed impact to these environmental values.

The Site will be maintained in a low fuel state, as a condition of this BMP, with the exclusion of the Environmentally Sensitive Area buffer within lots 810 and 812.

Table 2 Environmental values within or adjacent to the Site

Environmental Value	Yes or No	If Yes - describe
Conservation Covenants	No	Not applicable
Bushfire Forever Sites	No	Not applicable
Conservation Category Wetlands and Buffer	Yes	The Preston River to the east of the Site is an Environmentally Sensitive Area, with a Conservation Category Wetland that is also an Environmentally Sensitive Area to the west of the Site (SLIP DWER-accessed 31/10/2019).
Threatened Ecological Communities (TECs)	Yes	Threatened Ecological Communities, Banksia Woodland of the Swan Coastal Plain , Clay Pans of the Swan Coastal Plain and Tuart Woodlands and Forests of the Swan Coastal Plain are likely to occur within the area.
Declared Rare Flora (DRF)	Yes	Species or species habitat are likely to occur within the area.
Significant through Local Planning or Biodiversity Strategy	No	Not applicable

3.2 Re-vegetation / Landscape Plans

The area to the west of the Site contains an Environmentally Sensitive Area with the buffer extending into proposed lot 810 and 812. This buffer area in lot 810 and 812 is predominately grassland with no current requirement for revegetation. However, there may be a requirement to revegetate this area in the future

and therefore a maximum classification of Class B Woodland has been included based on the expected mature growth of any future revegetation.

To the east of the Site, revegetation works are required along the Preston River. The Foreshore Management Plan is included in Appendix A. Vegetation classification of this area has used the worst-case-scenario of Class A – Forest for the entire area that is proposed for revegetation.

4 Assessment Against the Bushfire Protection Criteria

4.1 Compliance with the Acceptable Solutions for each Element

Bushfire Protection Criteria - Element 1 - Location		
Intent: To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.		
Performance Principle P1: The intent may be achieved where the strategic planning proposal, subdivision or development application is located in an area where the bushfire hazard assessment is or will, on completion, be moderate or low OR a BAL-29 or below applies AND the risk can be managed. For unavoidable development in areas where BAL-40 or BAL-FZ applies, demonstrating that the risk can be managed to the satisfaction of DFES and the decision-maker.		
Acceptable Solution	**Compliance**	**Assessment Statements**
A1.1 Development location The strategic planning proposal, subdivision and development application is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL–29 or below.	Compliance with this element is achieved.	The edges of the proposed industrial Lots exceed BAL-29, however Figure 4 shows there is sufficient area within the Site for any structure to be within an area of BAL-29 or below. It is a condition of this BMP that no building will be constructed in an area above BAL-29 rating. Figure 6 depicts the BAL-29 setback line, highlighting the area available for development. The minimum separation distance to the classified vegetation of any building to achieve BAL-29 is: • Class B Woodland upslope/ flat – 14 m • Class A Forest upslope / flat – 21 m • Class A Forest downslope >0-5 degrees – 27 m • Class A Forest downslope >65-10 degrees – 33 m • Class G Grassland upslope / flat – 8 m The Site will be maintained by the developer with grassland under 10 cm as a requirement of this BMP until the Lots are sold, when management of grasses at

	under 10 cm will become the responsibility of the individual landowner. This condition excludes the Environmentally Sensitive Area buffer within lots 810 and 812, which is classified as Class B Woodland based on possible future requirements for revegetation.

Bushfire Protection Criteria - Element 2 - Siting and Design		
Intent: To ensure that the siting and design of development minimises the level of bushfire impact.		
Performance Principle P2: The siting and design of the strategic planning proposal, subdivision or development application, including roads, paths and landscaping, is appropriate to the level of bushfire threat that applies to the site. That it incorporates a defendable space and significantly reduces the heat intensities at the building surface thereby minimising the bushfire risk to people, property and infrastructure, including compliance with AS 3959 if appropriate.		
Acceptable Solution	**Compliance**	**Assessment Statements**
A2.1 Asset Protection Zone (APZ) Every habitable building is surrounded by, and every proposed lot can achieve, an APZ depicted on submitted plans, which meets the following requirements: • Width: Measured from any external wall or supporting post or column of the proposed building, and of sufficient size to ensure the potential radiant heat impact of a bushfire does not exceed 29kW/m^2 (BAL-29) in all circumstances. • Location: the APZ should be contained solely within the boundaries of the lot on which the building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity (see explanatory notes). • Management: the APZ is managed in accordance with the requirements of 'Standards for Asset Protection Zones'. (see Schedule 1).	Compliance with this element is achieved.	As illustrated in the BAL Contour (Figure 4) there is sufficient area within the Lots for any building to be within a BAL-29 or lower rating. Asset Protection Zones will be achieved with all proposed lots being established and maintained in perpetuity as a low fuel zone as part of the development process, ensuring that any areas of an APZ that extend into a neighbouring lot will also be maintained in a low fuel state in perpetuity. The proposed lots will be maintained in accordance to the requirements of the Guidelines for Asset Protection Zones (Appendix B). **This condition excludes the Environmentally Sensitive Area buffer extending into lots 810 and 812, which is classified as Class B Woodland based on possible future requirements for revegetation.**

Bushfire Protection Criteria - Element 3 - Vehicular Access		
Intent: To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.		
Performance Principle P3: The internal layout, design and construction of public and private vehicular access and egress in the subdivision/ development allow emergency and other vehicles to move through it easily and safely at all times.		
Acceptable Solution	**Compliance**	**Assessment Statements**
A3.1 Two Access Routes Two different vehicular access routes are provided, both of which connect to the public road network, provide safe access and egress to two different destinations and are available to all residents/the public at all times and under all weather conditions.	Performance Principle	The Site is accessed via the public road system from South Western Highway which allows access north to Bunbury town centre and south, to Boyanup town centre. The proposed road within the Site is a non-compliant cul-de-sac (A3.3 below), which is required due to the inability for access to occur out onto the Bunbury Outer Ring Road or an EAW to be established through the Conservation Category Wetland, which is contained within an Environmentally Sensitive Area. The cul-de-sac is approximately 1km long, 800m longer than what is required for a road with no EAW under the Guidelines. The intent of the Performance Principle for this element, states '*the internal layout, design and construction of public and private vehicular access and egress in the subdivision/development allow emergency and other vehicles to move through it easily and safely at all times*', is met, with the road within the Site being 20 metres wide to facilitate easy and safe movement of emergency and other vehicles through the development at all times. As a worst-case scenario, a vehicle at the end of the cul-de-sac would have 1 km to travel to reach South Western Highway, which if travelling at 20km/hr would take 3 minutes. Additional access is provided for Emergency Services through the Fire Services Access Route (A3.7). In addition, areas within the development that are subject to a BAL rating of less than BAL-2 (with a flame temperature of

		1,200 K, see Appendix D) have been mapped (Figure 6). These areas provide an area that can be used as a Refuge Open Space, in the unlikely circumstance that evacuation from the development is impossible, any people within the Site can move into these areas to seek refuge in a bushfire emergency. It is recommended that a sign be placed along the road within this area to alert anyone within the Site of a safe place to seek refuge in a bushfire situation, **where evacuation is not possible**. It is recommended that the sign instructs people to remain within their vehicles if possible, as that will provide a further level of protection.
A3.2 Public Road A public road is to meet the requirements in Table 6, Column 1 (Figure 5).	Compliance with this element is achieved.	The proposal includes the construction of a public road from the South Western Highway into the Site. Construction will meet the technical requirements of the Guidelines (Figure 5).
A3.3 Cul-de-sac (including a dead-end road) Where no alternative exists (i.e. the lot layout already exists, demonstration required): • Requirements in Table 6, Column 2 (Figure 5); • Maximum length: 200 m (if public emergency access is provided between cul-de-sac heads maximum length can be increased to 600 m provided no more than eight lots are serviced and the emergency access way is no more than 600 m); and • Turn-around area requirements, including a minimum 17.5 metre diameter head	Performance Principle	The proposed public road access into the Site results in a cul-de-sac, which are to be avoided in bushfire prone areas. The length of the cul-de-sac is greater than 200 m with no proposed Emergency Access Way at the cul-de-sac head, due to the restricted access allowed onto the Bunbury Outer Ring Road and the inability to construct an EAW through the Conservation Category Wetland. The cul-de-sac is approximately 1 km in length and will be constructed to meet the technical requirements of the Guidelines (A3.3), with a 17.5 m diameter head, 20 metre wide road and less than eight lots being serviced. The intent of the Performance Principle for this element is met if '*the internal layout, design and construction of public and private vehicular access and egress in the subdivision /*

development allow emergency and other vehicles to move through it easily and safely at all times' (WAPC, V1.3 Dec 2017).

The road will be 20 m wide, well exceeding the minimum width of 6 m and allowing two vehicles to exit at a time in an emergency. The Site is for industrial development, with no habitable buildings to be constructed within the Site. There is only minimal classified vegetation within the Site, with the majority of the area being low threat vegetation with grasses managed at under 10 cm in height and only scattered trees and as such the bushfire hazards within the area of the development is minimal.

As a worst-case scenario, a vehicle at the end of the cul-de-sac would have 1 km to travel to reach South Western Highway, which if travelling at 20km/hr would take 3 minutes.

The access road is servicing six industrial lots in total through a low threat bushfire landscape.

A Fire Service Access Route (A3.7) will be provided to allow a secondary route through the Site for emergency vehicles.

In addition, areas within the development that are subject to a BAL rating of less than BAL-2 (with a flame temperature of 1,200 K, see Appendix D) have been mapped (Figure 6). These areas provide an area that can be used as a Refuge Open Space, in the unlikely circumstance that evacuation from the development is impossible, any people within the Site can move into these areas to seek refuge in a bushfire emergency. It is recommended that a sign be placed along the road within this area to alert anyone within the Site of a safe place to seek refuge in a bushfire situation **if evacuation is not possible.** It is

Bushfire Protection Criteria - Element 3 - Vehicular Access		
		recommended that the sign instructions people to remain within their vehicles if possible, as that will provide a further level of protection.
A3.4 Battle-axe	Not applicable to this Site.	
A3.5 Private driveway >50m • Requirements in Table 6, Column 3 (Figure 5); • Required where a house site is more than 50 m from a public road; • Passing bays: every 200 m with a minimum length of 20 m and a minimum width of 2 m; • Turn-around areas designed to accommodate type 3.4 fire appliances and to enable them to turn around safely every 500 m (i.e. kerb to kerb 17.5 m) and within 50 m of a house; • Any bridges or culverts are able to support a minimum weight capacity of 15 t; and • All-weather surface (i.e. compacted gravel, limestone or sealed).	Compliance with this element is achieved.	The location of buildings within the Lots may result in a private driveway greater than 50 m. Any driveway over 50 m will comply with the requirements in the Guidelines (A3.5).
A3.6 Emergency Access Way	Not applicable to this Site.	

Bushfire Protection Criteria - Element 3 - Vehicular Access		
A3.7 Fire Service Access Routes (perimeter roads) To provide access within and around the edge of the subdivision and related development to provide direct access to bushfire prone areas for fire fighters and link between public road networks for firefighting purposes: • Requirements Table 6, Column 5 (Figure 5); • Provided as right of ways or public access easements in gross to ensure accessibility to the public and fire services during an emergency; • Surface: all-weather (i.e. compacted gravel, limestone or sealed); • Dead end roads are not permitted; • Turn-around areas designed to accommodate type 3.4 appliances and to enable them to turn around safely every 500 m (i.e. kerb to kerb 17.5 m); • No further than 600 m from a public road; • Allow for two-way traffic; and • Must be signposted.	Performance Principle	A Fire Service Access Route will be provided around the perimeter of the Site to allow a secondary access for emergency vehicles. Access to the Fire Service Access Route will be provided via an easement in gross, with ongoing maintenance of the FSAR to the standards in the Guidelines the responsibility of each individual land owner. While the length is greater than 600 m for lots 814 and 815 to access South West Highway, it is due to the restricted access allowed onto the Bunbury Outer Ring Road and inability to construct additional access through the Conservation Category Wetland. The lots within the Site are industrial lots with six in total with a low threat surrounding, with substantial areas within the Site available for Refuge Open Space in an emergency situation. The indicative route is provided in Figure 7. The Fire Service Access Route shall not be constructed within the Environmentally Sensitive Area Buffer.

Bushfire Protection Criteria - Element 3 - Vehicular Access		
A3.8 Firebreak Width Lots greater than 0.5 ha must have an internal perimeter firebreak of a minimum width of 3 m or to the level as prescribed in the local firebreak notice issued by the local government.	Compliance with this element is achieved.	The proposed Lots exceed 2,024 m^2 and therefore require 3 m wide firebreaks free of flammable material, immediately inside the boundaries and surrounding all buildings and haystacks, as per the City of Bunbury Fire Notice (Appendix C). Where the boundary has a Fire Service Access Route, this can be used as the fire break for that lot boundary as it provides adequate break in fuel loads, exceeds the minimal width (6 m wide) and allows two-way traffic. Indicative fire breaks are provided in Figure 7. Firebreaks shall not be constructed within the Environmentally Sensitive Area Buffer.

TECHNICAL REQUIREMENTS	1 Public road	2 Cul-de-sac	3 Private driveway	4 Emergency access way	5 Fire service access routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal clearance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 metres	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius (m)	8.5	8.5	8.5	8.5	8.5
*Refer to E3.2 Public roads: Trafficable surface					

Figure 5 Vehicular access technical requirements (Guidelines for Planning in Bushfire Prone Areas Table 6)

Figure 6 Areas within the Site available for Refuge Open Space

Bushfire Protection Criteria - Element 4 - Water		
Intent: To ensure that water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.		
Performance Principle P4: The subdivision, development or land use is provided with a permanent and secure water supply that is sufficient for fire fighting purposes.		
Acceptable Solution	**Compliance**	**Assessment Statements**
A4.1 Reticulated Areas The subdivision, development or land use is provided with a reticulated water supply in accordance with the specifications of the relevant water supply authority and Department of Fire and Emergency Services.	Compliance with this element is achieved.	The Site will be provided with reticulated water in accordance with the Water Corporation's No. 63 Water Reticulation Standard. Fire hydrants will be supplied in accordance with the Water Corporation requirements.
A4.2 Non-reticulated Areas	Not applicable to this Site.	
A4.3 Individual lots within non-reticulated areas (only for 1 additional lot)	Not applicable to this Site.	

4.2 Performance Based Solutions

The Site assessment was conducted in accordance with AS 3959-2018 Simplified Procedure (Method 1). Due to the nature of the Site, a Performance Based Solution has been appropriate.

Sections A 3.1, A3.3 and A3.7 above outline a Performance Principle-Based Solution, necessary due to the restricted access allowed onto the Bunbury Outer Ring Road. The proposed road within the development exceeds the compliant length of 200m by approximately 800m, as no Emergency Access Way is possible due to restricted access onto the Bunbury Outer Ring Road and inability for additional access to be constructed through the Conservation Category Wetland. The intent of the Performance Principle is met with the road being 20 metres wide and only servicing 6 industrial lots with no habitable buildings allowed within the development and the vast majority of the Site being managed as low threat or non-vegetated and presenting a Low bushfire hazard (BAL-Low rating), with a maximum of 1 km to travel to access South Western Highway (which for a vehicle travelling 20km/hr would take approximately 3 minutes). In addition, an area of BAL-2 or lower has been mapped that can provide Refuge Open Space for anyone within the development in the unlikely event that evacuation from the Site is impossible in a bushfire emergency event.

The Proposal meets the remainder of the compliance requirements for the four Bushfire Protection Criteria Elements.

4.3 Summary of the Assessment Outcomes

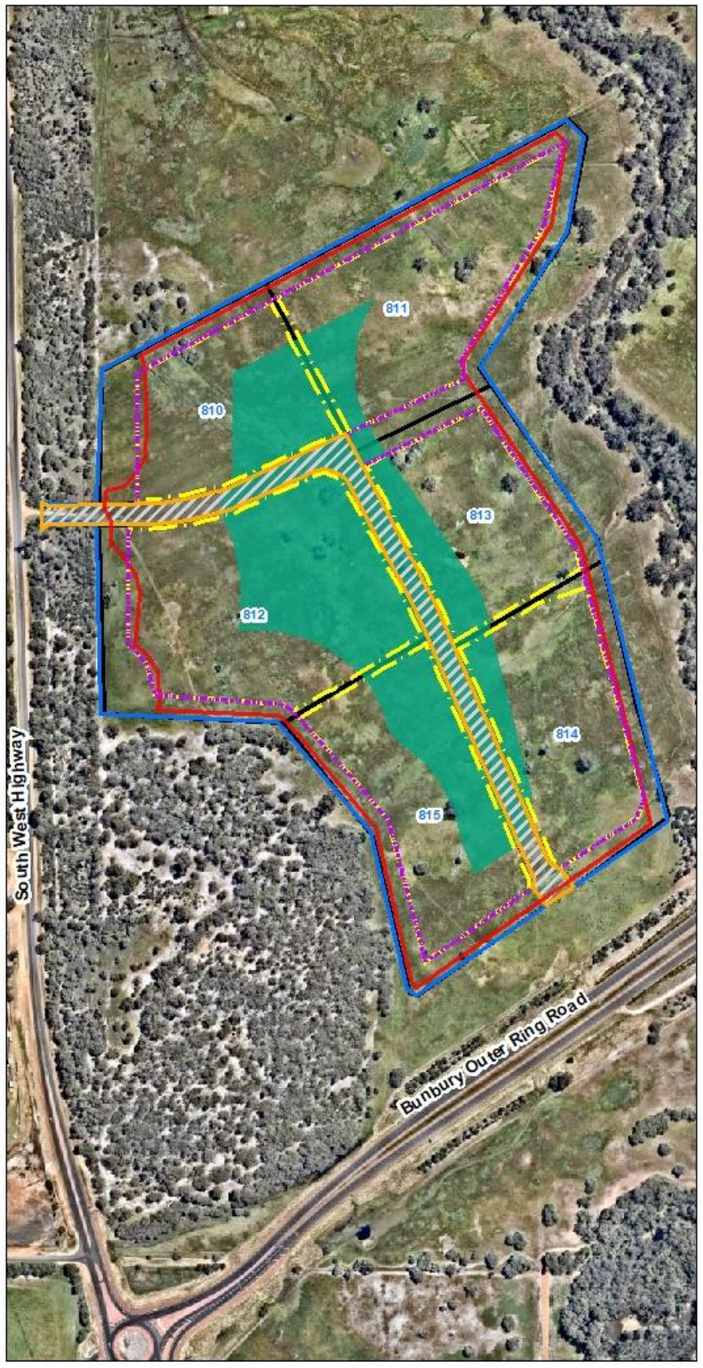
This plan provides Acceptable Solutions or achieves the intent of the Performance Principle for the criteria outlined in the Guidelines for Planning in Bushfire Prone Areas (WAPC, Dec 2017).

The layout and design of the development is such that no structure will be required to be exposed to a radiant heat flux in excess of 29kW/m^2 (BAL-29) provided the management as outlined in the plan is adopted.

This proposal is for the development of industrial lots with associated facilities to be developed within the Site. There are no habitable buildings to be constructed within the Site.

A summary of the Bushfire Management Strategies to be implemented is provided in Figure 7.

Spatial representation of the proposed risk management measures



NOTES

The minimum separation distance from classified vegetation for any future builidngs within the Site is the distance required to meet the BAL-29 setback. The BAL-29 setback line illustrates the edges of the Site that are >BAL-29 and not available for the construction of buildings.

The Proposed Lots will be maintained as an Asset Protection Zone (APZ) by the Developer with responsiblity handed over to the Landowner once sold. Vegetation within the APZ is to comply with Schedule 1 Element 2 of the Guidelines noting that:
- Trees >5m in height are to be setback a minimum distance of 6m from the building with no branches overhanging the roof.
- Shrubs <5m in height are to be setback a minimum distance of 3m from the building, and not planted in clumps greater than 5 sqm
- Grass is to be maintained at less than 100mm in height.

Reticulated water supply and fire hydrants will be provided by the Developer in accordance with the Water Corporation's No. 63 Water Reticulation Standard.

The Proposed Road will be constructed to meet the minimal technical requirements detailed in the Guidelines for cul-de-sacs (Element 3) by the Developer, within minimum width of 20 metres to allow safe and easy access and egress.

A Fire Service Access Route around the perimeter of the Site will be constructed to meet the Guidelines (A3.7) with a easement in gross for each lot to allow access to emergency services in the event of a bushfire. The FSAR must go around the Environmentally Sensitive Area Buffer. The FSAR will be constructed by the Developer, with ongoing maintenance to the standard of the Guidelines the responsibility of the individual land owner.

All private driveway access will be suitable for a fire truck with a minimal 4 m trafficable surface. Any private driveway that exceeds 50 m will be constructed to mee the Guidelines (A3.5). Any gates along the driveway will have a minimum width of 3.6 m.

Firebreaks within the Proposed Lot boundary will be 3 m wide, and constructed by the Landowner to the requirements of the City of Bunbury Fire Notice. Where the lot boundary has a Fire Service Access Route, the Fire Service Access Route can be used as the fire break for that lot boundary as it provides adequate break in fuel loads, exceeds the minimal width (6 m wide) and allows two-way traffic. As with the FSAR, firebreaks must go around the Environmentally Sensitive Area Buffer.

Ongoing maintenance of the APZ, firebreaks and the driveway are the responsibility of the Landowner. The measures listed above shall be implemented prior to subdivision approval and shall continue to be maintained in perpetuity.

LEGEND

- Proposed Lot Boundaries
- Lot Boundary
- Road Reserve
- BAL-29 Setback Line
- Indicative Fire Service Access Route
- Indicative Firebreak
- Refuge Open Space area (<BAL-2)

N

0 25 50 100 150 200
Meters

PROPERTY / ASSESSMENT

Developer: NBR Investments
Property Address: Lot 81 South Western Highway, Davenport
Project No: 18640
Prepared by: D Plowman
Accreditation Level: Level 1
Accreditation Number: 46554

ecosystem solutions
www.ecosystemsolutions.com.au
(08) 9759 1960

Figure 7 Map of Bushfire Management Strategies

5 Responsibilities for Implementation and Management of the Required Bushfire Measures

The responsibilities for the Developer, Builder, Landowner/Occupier and Local Government are outlined in Table 3, Table 4, Table 5 and Table 6 respectively.

Table 3 Developer Responsibilities

Number	Action	Due	Completed
1	Install the cul-de-sac to the standards stated in the BMP (Section 4.1, A3.3).	Prior to occupancy	☐
2	Install a reticulated water supply and fire hydrants in accordance with Water Corporation's No. 63 Water Reticulation Standard and services to the relevant authority.	Prior to occupancy	☐
3	Establish the Lots in a low fuel state, in compliance with the Asset Protection Zone requirements (Appendix B) to the dimensions and standard stated in the BMP, excluding the areas of ESA buffer extending into the Site.	Prior to occupancy	☐
4	Install a Fire Service Access Route around the perimeter of the Site to the standard in the Guidelines (A3.7) with an easement in gross on each lot to ensure access to emergency services during an emergency.	Prior to occupancy	☐
5	Install appropriate signage within the Refuge Open Space area.	Prior to occupancy	☐
6	Place a notification on each lot title of the existence of this Bushfire Management Plan and responsibilities that must be maintained within it.	Prior to occupancy	☐

Table 4 Builder Responsibilities

Action	Action	Due	Completed
1	Be aware of the existence of any BMP that refers to the Site.	Prior to any building work.	☐
2	Ensure any building or incidental structure to which a building permit applies is compliant on completion with the bushfire provisions of the Building Code of Australia (BCA) as it applies in WA.	Prior to any building work.	☐

Table 5 Landowner / Occupier Responsibilities

Number	Action	Due
1	Maintain the Lot to Asset Protection Zone (APZ) standard (Appendix B), as stated in the BMP.	Ongoing
2	Construct and maintain 3 m wide firebreaks within the Lot boundary, in compliance with the City of Bunbury Fire Notice, issued under s33 of the *Bush Fires Act 1954* (Refer to Element 3).	Ongoing
3	Construct private driveways suitable for a fire truck with a minimal 4 m trafficable surface. Any private driveway that exceeds 50 m will be constructed to meet the Guidelines (Element 3). Any gates along the driveway will have a minimum width of 3.6 m. Vehicular access within the lot will be maintained to the required surface condition and clearances.	Ongoing
4	Maintain the portion of the Fire Service Access Route within their lot boundary to the standards in the Guidelines, as described in the BMP.	Ongoing
5	Ensure that any builders (of future structures on the Lot) are aware of the existence of this Bushfire Management Plan and the responsibilities it contains regarding the application of construction standards corresponding to the determined BAL rating.	Ongoing
6	Ensure all future buildings the landowner has responsibility for, are designed and constructed in full compliance with: (a) the requirements of the *WA Building Act 2011* and the bushfire provisions of the Building Code of Australia (BCA) as applicable to WA; and (b) with any identified additional requirements established by this BMP or the relevant local government.	Ongoing
7	Updating the Bushfire Management Plan may be required to ensure that the bushfire risk management measures remain effective. Bushfire plans do not expire and are a 'living document'. Updating is required in certain circumstances, including (but not limited to) if site conditions change, if further details are required at subsequent development stages or to reflect new technologies or methodologies in best practice bushfire risk management ('Guidelines' s4.6.4).	Ongoing

Table 6 Local Government Authority Responsibilities

Number	Action	Due
1	Monitor landowner compliance with the annual Firebreak Order.	Ongoing
2	Develop and maintain district bushfire fighting services and facilities.	Ongoing
3	Administer the *Bushfire Act 1954* and monitor landowner compliance.	Ongoing
4	Promote education and awareness of bushfire prevention and preparation measures though the community.	Ongoing
5	Administer the requirements of the *Planning and Development Act 2005* and the *Building Act 2011*.	Ongoing

Appendix A Foreshore Management Plan

Lot 81 South Western Highway, Davenport
Foreshore Management Plan

NBR Investments Pty Ltd

ecoscape

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Rev0	Bruce Turner	Andrew Fry		27/10/2017
Final Rev 0	Bruce Turner	Marc Wohling		16/05/2018
Final Rev 1	Bruce Turner	Marc Wohling		14/06/208

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1 INTRODUCTION

1.1 BACKGROUND

Ecoscape was engaged by NBR Investments to undertake the preparation of a Foreshore Management Plan (FMP) for the proposed Lot 81 South Western Highway, Davenport (the study area) (**Figure 1**). The FMP is a requirement to support a Scheme Amendment Application for rezoning from Development Zone (Industrial) to Industry.

The implementation of the FMP will be the responsibility of the relevant land owner/s and land manager/s, not the proponent of Lot 81. The foreshore area consists of a number of Lots running parallel with the river course outside of the proposed structure plan, which are not owned by the proponents of the structure plan application (**Map 1**). The FMP is being prepared to support structure planning for Lot 81 and is necessary to ensure that potential impacts on the adjacent foreshore associated with the planning and development of Lot 81 have been adequately considered. The FMP is indicative only as no timeframes or budgets for implementation have been established.

The FMP addresses the conditions from The City of Bunbury (The City); Department of Water and Environmental Regulation (DWER) and the Department of Biodiversity, Conservation and Attractions (DBCA) as listed below. The conditions addressed in this Management Plan are listed as the following:

- A Foreshore Management Plan for the Preston River adjacent to the development site to be prepared to the satisfaction of the City, DWER and DBCA

Conditions not addressed in this FMP are listed as follows:

- The Bushfire Management Plan submitted with the structure plan for Lot 81 should be revisited concurrently with the development of this Foreshore Management Plan. Fire management measures should not impact the wetland's vegetation, threatened fauna habitat, the Preston River riparian zone or the agreed CCW proposed structurally vegetated buffer area. This is to ensure the buffer will have vegetation that will require consideration in the Bushfire Management Plan and its setback requirements. Given this DBCA recommends that the provision for a Fire MP to be prepared and implemented includes a requirement for consultation with Parks and Wildlife
- DBCA recommends that the structure plan include a provision requiring a Wetlands Buffer Rehabilitation Plan (WBRP) to be prepared and implemented to the satisfaction of the Department.
- DBCA recommends that the structure plan include a provision requiring a Black Cockatoo Habitat Tree Management Plan (BCHMP) to be prepared and implemented, which outlines how the fauna habitat trees will be protected from potential impacts associated with fill requirements and subsequent development

Figure 1: Study Area Location.

1.2 STUDY AREA

The foreshore study area is bounded by Lot 81 to the west and the Preston River to the east, the north and south boundaries are in line with those of Lot 81. The foreshore study area is approximately 9 ha in extent.

The foreshore is comprised of a number of cadastral boundaries outside of the proposed Lot 81 eastern boundary (**Map 1**).

1.2.1 WETLANDS

The foreshore area is covered by a conservation category (CC) wetland as classified by DBCA (**Map 1**). Assessment of the Geomorphic Wetlands of the Swan Coastal Plain dataset ((Department of Parks and Wildlife 2014) indicates a CC wetland along the eastern boundary (UFI 14501).

The Environmental Protection Authority (EPA) urges that all areas covered by CC wetlands and the associated buffers are fully protected (Environmental Protection Authority 2008). The EPA uses the recommendations of Hill (Hill *et al.* 1996) to provide guidelines for the protection of CC wetlands by applying a buffer zone of at least 50 m from the wetland boundary.

Consultation with Peter Hanly (DBCA Senior Regional Planning Officer, South West Region) resulted in the extension of the western boundary of the CC wetland of the Preston River. This extended boundary was realigned with one of the cadastral boundaries to the east of the Lot 81 structure plan boundary and is shown on **Map 1** as CCW additional area. The applied 50 m buffer area crosses into Lot 81 by approximately 10 m along the entire eastern boundary.

1.2.2 WATERWAYS

The Preston River runs adjacent to the eastern boundary of the study area and has been identified as a key component of the ecological linkages for the area by the EPA (Molloy *et al.* 2009). The study area boundary is set back from the river by approximately 70 m.

1.3 PURPOSE AND APPROACH

The purpose of the FMP is to provide management measures for the protection and enhancement of the foreshore area and surrounds. The approach is to use best practice management to reduce weed invasion, manage erosion and ensure rehabilitation efforts are successful (Water and Rivers Commission 2003).

1.3.1 CONTEXT

The foreshore forms part of a Regional Open Space reserve under the Greater Bunbury Regional Scheme (GBRS) and is identified as part of the 'Preston River Link' under the Leschenault Regional Park Establishment Plan.

The foreshore, which includes both the riverbank and upland areas, are currently in a degraded to completely degraded state of Bushland Condition (Keighery 1994) (**Image 1; Image 2**) and will benefit from efforts to remove weeds and promote native vegetation regeneration. The cover of introduced weed species does provide stability to the steep riverbanks and with the presence of the large native trees, mostly *Eucalyptus rudis*, *Corymbia calophylla* and *Agonis flexuosa*, also provides critical fauna habitat and connectivity to adjacent areas of bushland.

Image 1: Upland area looking south to the Bunbury Outer Ring Road (Image Point 833; see Map 2).

Image 2: Riverbank of the Preston River (Image Point 803).

The vegetation structure of the foreshore is comprised of scattered emergent shrubs (*Kunzea* and *Melaleuca* species) over dense patches of *Watsonia* and weedy herb species e.g. Sour Sob (*Oxalis pes-caprae*) and African lovegrass (*Eragrostis curvula*) Image 3.

Image 3: Typical Riverbank vegetation structure (Image Point 802).

2 PLAN FOR MANAGEMENT

2.1 VISION

To ensure the foreshore environmental values, attributes and functions are protected.

2.2 OBJECTIVES

To manage and maintain revegetation works within the foreshore of the Preston River.

2.3 MANAGEMENT STRATEGIES

The foreshore will be managed through the implementation of a number of management measures that will protect the environmental values of the Preston River.

2.3.1 EROSION MANAGEMENT STRATEGY

A Local Water Management Strategy will be developed to provide details of the level of protection at the stormwater outlets on the foreshore. This will also take into account the requirement for larger post flows and subsequent soft and hard modifications for stormwater discharge on the Preston River foreshore. These discharge point(s) on the foreshore will require three years of maintenance.

Protection from scouring and erosion of the Preston River foreshore will be achieved by retaining and infiltrating stormwater within the Lot 81 footprint. Removal of excess nutrients and contaminants from stormwater collected within the footprint of Lot 81 will be achieved in a series of bioretention/filtration swales that will initially nutrient strip the stormwater before infiltration.

Erosion within the foreshore will be controlled by the use of rock spalls and mass planting of sedge species at the existing channels. The installation of biofiltration swales within Lot 81 could potentially reduce and manage the outfall of stormwater via the existing channels that have scoured the river banks in various places.

2.3.2 WEED MANAGEMENT STRATEGY

A weed management strategy will be implemented to control priority weed species and prevent re-invasion prior to and post revegetation implementation. Monitoring and maintenance will be scheduled to ensure the success of weed control efforts will be achieved.

2.3.3 REVEGETATION STRATEGY

Revegetation works will be implemented after earthworks have been completed as outlined in this plan, to further protect the foreshore values. Revegetation efforts will be monitored for success with recommendations made for follow up infill planting should this be required.

Both the weed and revegetation management measures will be subject to the achievement of success criteria agreed with the City prior to commencement of weed control and planting.

2.3.4 IMPLEMENTATION STRATEGY

The implementation of this FMP will be enhanced by using the option of scalping/scouring the upland areas of pasture grasses to enhance the establishment of direct seeding of native vegetation for revegetation. This option could be undertaken by excavator machinery with the resultant spoil being stockpiled on the proposed Lot 81 development site.

Implementation of revegetation measures for the river banks is recommended to use a method of planting after initial weed control spraying has been completed.

2.4 MANAGEMENT ZONES

Management zones have been categorised for the foreshore rehabilitation area to allow for clearer understanding of the differing requirements for management of each zone type. The management zones are displayed on **Map 2** and fall into two broad types labelled Riverbank and Upland.

Each management zone has a specific list of native vegetation species nominated for revegetation works to better reflect the values and ecosystem function of the zone. The River Bank zone should contain more shrub species at high density to maintain bank stability and provide fauna habitat resources. The Upland zone should contain the larger shrub and tree species reflecting the already existing structure of the native vegetation of the foreshore. These two zones will therefore require differing management actions in the implementation of the FMP.

The Riverbank Management Zone comprises steep banks of approximately 90-100% cover of grass and herb weed species under an overstorey of mature Eucalypt and Peppermint trees and is approximately 2.2 ha in extent (**Image 4**).

Image 4: Typical structure and composition of the Riverbank Management Zone (Image Point 809).

The Upland Management Zone comprises completely degraded paddocks of pasture grass and herb weed species and is approximately 6.6 ha in extent. The land surface has been historically modified to maximise the area available for grazing activity (**Image 5**).

Image 5: Typical structure and landscape of the Upland Management Zone (Image Point 820).

2.5 RECOMMENDATIONS

Recommendations are made to highlight management measures required to be undertaken to ensure a successful and efficient implementation of the FMP. Recommendations are given time frames and allocate actions to a responsible entity.

3 EROSION MANAGEMENT

The foreshore area will be protected from erosion and sedimentation impacts, potentially caused by construction and earthwork activity, through the implementation of the following controls:

- battered slopes to have jute matting installed post earthworks and prior to revegetation works
- stormwater outfalls will be inoperable during construction with stormwater to be held and infiltrated within the development footprint

A contingency measure is proposed in the form of straw bales placed along the development edge should greater than expected overland stormwater events be encountered. The straw bales will temporarily hold sediment from entering the foreshore and can also be used to minimise scouring around outfall pipe heads.

3.1.1 WATER QUALITY MONITORING

A monitoring program will need to be determined in conjunction with broader monitoring being undertaken for the development area, as per a Local Water Management Strategy (LWMS). It is proposed that monitoring could be undertaken and that the parameters be determined with the City, DWER and DBCA.

Water quality monitoring will follow the requirements stated within the LWMS, including parameters and frequency.

3.1.2 CONTINGENCY MEASURES

Monitoring results will be compared between each monitoring event, should any of the indicators from the sampling exceed the initial measurements by 10%, for two consecutive samples, the City and DWER will be notified and the matter will be investigated. The possible contingency measures are as follows:

- soil amendment in high nutrient areas
- increased planting of water and nutrient thirsty plants in groundwater recharge areas.

The measures employed and the timing will be resolved at the time with the DWER and the City.

3.1.3 RECOMMENDATIONS

Actions		Priority	Responsibility
3	**Stormwater Treatment Zone**		
3.1	Monitor and maintain stormwater outfall channels	Moderate	Land Owner/Manager
3.2	Monitor for erosion, rectify with additional rock armour if/when required	Moderate	Land Owner/Manager

4 WEED MANAGEMENT

4.1 OBJECTIVES

The objectives of weed control are to:

- reduce the extent and/or density of targeted weeds
- reduce the extent and/or density to assist revegetation
- prevent introduction of additional weed species
- prevent increases in weed density and distribution for non-targeted weeds
- minimise detrimental impacts of the weed control program such as off target impacts on the native biota
- improve the visual amenity of the wetland buffer
- reduce potential fire risk.

Weed control and revegetation work will be undertaken simultaneously as the process of landform re-construction takes place. This will allow for the minimisation of re-invasion. Efforts should be conducted in a staged approach to focus resources efficiently and ensure a good coverage and density of plantings.

4.2 MANAGEMENT STRATEGIES

4.2.1 OPTIONAL SCALPING

Due to the majority of the Foreshore area being covered by pasture grasses and introduced weed species it is proposed to mechanically scalp/scour the topsoil layer by excavator, stockpiling the removed layer on Lot 81 as a potential landfill source. This method will allow for minimal weed control efforts initially and facilitate in the revegetation of the Upland zone.

Once scalping/scouring has been completed temporary wing fences at the north and south boundaries of Lot 81 should be installed to deter incursions by Kangaroos that may destroy newly planted tube stock. The fences should be 1.8 m high as a minimum and of sufficiently small mesh size to exclude Kangaroos, it will be necessary to ensure the bottom edge of the fence is adequately secured to the ground to stop animals "pushing" under the fence. This will be important at the ends closest to the Preston River banks.

If practical, mulching to a depth of 100 mm should be considered to be spread across the site prior to planting taking place to deter weed species germination.

4.2.2 PRIORITISATION

Prioritisation of weed control is critical to the success of both the control of weeds and the use of limited resources. Along the foreshore edge, prioritisation aims to:

- maintain vegetation and habitats along the foreshore that are in the best condition. These areas are more resilient and sustainable provided that disturbance is minimised and invasive weed populations are quickly removed
- eradicate new weeds introduced into the site which pose a significant threat to environmental and social values
- co-ordinate weeding programs to ensure an integrated approach to works
- control degradation processes that increase ecosystem vulnerability.

4.2.3 METHODS OF WEED CONTROL

Chemical and manual weed control should be undertaken post topsoil scouring and again before revegetation commences. **Table 1** describes the control methods suitable for likely present priority weed species. Methods are as follows:

1. Hand weeding, pulling, digging
2. Herbicide wipe, stem injection, cut stump
3. Spot spraying
4. Blanket spraying

Table 1: Priority Weed Species and Recommended Control Methods

SPECIES		HERBICIDE CONTROL			OPTIMAL HERBICIDE TIME												MANUAL CONTROL	GENERAL COMMENT	REFERENCE
Scientific Name	Common Name	Wicker Wipe (per 1 L water)	Targeted Herbicide Control (10L Spraypack)	General Herbicide Control (10L Spraypack)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Grass																			
Avena barbata	Bearded Oat	500 mL glyphosate (450 g/L)	160 mL fluazifop-p (128 g/L)	50 mL glyphosate (450 g/L) 10 mL Spray-seed ®													Hand remove individual plants and small populations	Occurs mainly in highly disturbed areas. Easy to control.	1, 2, 3
Briza maxima	Blowfly Grass	Not recommended	4 g Achieve® 16 mL Fusilade® Forte 200 g Propon®	10-100 mL glyphosate (450 g/L)													Hand remove individual plants and small populations	Occurs in disturbed bushland.	1, 2, 3
Cynodon dactylon	Couch	Not recommended	50 mL fluazifop-p (212 g/L) 125 mL fluazifop-p (128 g/L) 16 mL haloxyfop (520 g/L) 80 mL quizalofop-p-ethyl (100g/L)	100 mL glyphosate (450 g/L)													Manually dig up soil around plant, taking care to remove and dispose all rhizome and stolon materials to prevent resprouting.	widely planted as a lawn grass it invades wetlands and river edges in southern Western Australia. It is native to the Kimberley and the tropics worldwide.	1, 2, 3
Eragrostis curvula	African Lovegrass	Not recommended	100 mL clopyralid (300 g/L) 2 mL haloxyfop (520 g/L)	100-200 mL glyphosate (450 g/L)													Hand remove seedlings and small plants. Roots of mature plants tend to break off and regrow.	A serious weed of roadsides sometimes invading bushland. Flowers much of the year. Relatively resistant to glyphosate. Requires repeated spraying.	1, 2, 3, 5
Ehrharta calycina	Perennial Veldt Grass	500 mL glyphosate (450 g/L)	130 mL fluazifop-p (128 g/L)	50 mL glyphosate (450 g/L) 10 mL Spray-seedO													Plants are easy to hand remove as roots are shallow and do not tend to break off.	Serious environmental weed	1, 2, 3, 5
Bulbous																			
Gladiolus caryophyllaceus	Wild Gladiolus	100-500 mL glyphosate (450 g/L)	No specific information	100 mL glyphosate (450 g/L)													Small populations can be dug out, ensuring to remove all plant material to prevent resprouting.	Highly invasive and common in Perth's bushlands. Spray when flowering.	2, 3, 5
Watsonia meriana var. bulbillifera	Watsonia	The plants can be wicker wiped using a mixture of 1:2 glyphosate (450g/L) using a wiping glove in areas where overspray is needed to be avoided	100 g 2,2-DPA (740g/kg) plus 25 mL wetting agent in 10 L water. Apply from flower stem emergence to mid flowering for the most effective results.	100 g 2,2-DPA (740g/kg) plus 25 mL wetting agent in 10 L water. Apply from flower stem emergence to mid flowering for the most effective results.													Due to this species producing many corms and bulbils removal by hand can often be ineffective. Mowing and slashing have been shown to be ineffective unless repeated very frequently	Tends to grow in sites where the soil dries out in summer, for example, around granite rocks, and in wandoo woodlands. A serious environmental weed, it is found between Perth and Albany. Spray when flower spikes emerge.	1, 2, 3
Zantedeschia aethiopica	Aurm Lily	500 mL glyphosate (450 g/L)	0.3 g metsulfuron (600 g/kg) + 100 ml glyphosate (450 g/L) 0.3 g chlorsulfuron (750 g/kg) + 10 mL 2,4-D amine (500 g/L)	No specific information													Only effective with younger plants and if all plant material is removed to prevent resprouting. Cut flowers to prevent birds spreading seeds.	Normally found mostly in or near wetlands and waterways, but now being found in much drier areas. This species has been identified as being difficult to control with herbicides. Glyphosate alone is relatively ineffective.	1, 2, 3, 4, 5
Other																			
Asparagus asparagoides	Bridal Creeper	500 mL glyphosate (450 g/L)	0.1-0.2 g metsulfuron (600 g/kg) 0.04g metsulfuron (600 g/kg) + surfactant in sensitive areas	100 mL glyphosate (450 g/L)													Small populations can be removed proved the root mat is carefully dug up, ensuring the removal of all rhizomes and tubers to prevent resprouting.	One of the State's most urgent environmental weed problems. It is extremely invasive, spreading rapidly over and smothering other vegetation. Spray when flowering.	1, 2, 3, 5
Pelargonium capitatum	Rose Pelargonium	Not recommended	20 mL 2,4-D amine (500g/L) 100 mL Tordon® 75-D Try 0.1 g metsulfuron (600g/kg)	No specific information, try: 50-100 mL glyphosate (450 g/L)													Ensure to dispose of all cut material, as new plants may resprout from fragments.	Naturalised in Perth's coastal areas. Smothers small native plants. Colonises natural bare sandy areas. Glyphosate is relatively ineffective.	1, 2, 3

Herbicide Timing

Optimal

Sub-optimal

References

1 Moore and Wheeler (2008)

2 Brown and Brooks (2002)

3 Department of Parks and Wildlife (2015)

4 Brown and Brooks (2001)

5 Shire of Mundaring (2013)

4.2.4 HERBICIDES

It is necessary that the application of herbicides be in accordance to labelling requirements or the manufacturers Materials Safety Data Sheet (MSDS) and must be undertaken by qualified personnel trained in the application of herbicide chemicals. The application of any herbicide for purposes not specified on the labelling requires an Off-Label Permit from the National Registration Authority in Canberra. Care must be taken herbicides are not applied on adjacent native vegetation.,

Surfactants should not be used with the herbicide treatments near or in the foreshore. Many common herbicides such as Roundup® contain NPE surfactants which are known to affect the development of amphibian species, which can lead to a decline or even loss of such fauna species (Mann & Biggs 1999). Herbicides not containing NPE surfactants, such as Roundup Biactive®, are strongly recommended.

The application of herbicides must also be in accordance with water catchment restrictions. Chemical based weed control strategies, in particular, must recognise potential adverse impacts on water resources such as lakes, wetlands, streams, rivers and dams. The herbicide's label should also contain a section outlining appropriate measures for the "Protection of Wildlife, Fish, Crustaceans and Environment"

4.2.5 MONITORING AND MAINTENANCE

Monitoring and evaluation are key actions that need to be undertaken during weed management to measure the success of control strategies. Performance indicators will be developed to objectively assess the success of weed control strategies. This will not only contribute to accountability where public funds are involved, but also provide a mechanism for modifying the strategy and maintaining its flexibility.

The use of photographs from set points also enhances this process and will be carried out on a biannual basis as part of the monitoring which will also involve documenting the location and relative abundance of weed species.

Following this initial period, it is recommended that the site continue to be monitored yearly and appropriate weed treatment be implemented to target identified weed species.

4.2.6 COMPLETION CRITERIA

Table 2 shows recommended success criteria for the weed control efforts.

Table 2: Suggested Completion Criteria for Weed Management

Assessment Parameter	Method	Completion Criteria
Priority weed species presence	Quadrats	30% decrease in the number of priority weeds recorded in the baseline survey. No new high priority weed species become established in the study area
Total weed species presence	Quadrats	30% decrease in the number of total weeds recorded in the baseline survey.
Weed cover	Weed mapping	No more than 5% weed cover and a maximum of 5 weeds/ m2

4.2.7 RECOMMENDATIONS

Actions		Priority	Responsibility
4	**Weed Management**		
4.1	Weed control works of the revegetated sites should occur during optimal control times	High	Land Owner/Manager
4.2	Formal monitoring with annual reports of progress being submitted to the City. The results, problems encountered and how they were rectified should be described in the annual report.	High	Land Owner/Manager

5 REVEGETATION

5.1 OBJECTIVES

The objectives for the revegetation of the foreshore are to:

- minimise the impact of activities that could result in degradation to vegetation communities through the use of appropriate management strategies
- improve the overall condition of vegetation communities of the riparian interface

5.2 MANAGEMENT STRATEGIES

The main issues that need to be addressed in improving the condition of the foreshore area are:

- assisted natural regeneration in the form of weed control
- reconstruction in the form of strategic revegetation.

It is assumed that natural regeneration will occur after the revegetation planting and weed management that will be applied to the foreshore.

Revegetation will follow the planting design as shown in **Map 3**. Timing of revegetation works will be as follows:

- general earthworks to attain correct slope and scour topsoil layer of Upland Zone
- initial weed control spraying to control establishment of off-site weed species
- install fencing
- complete direct seeding
- initial tubestock planting in first winter post site earthworks being completed
- second weed control event 3 months post initial planting
- first monitoring event to establish achievement of success criteria 6 months post initial planting
- second monitoring event 12 months post initial planting, recommendations made for infill planting if necessary to maintain desired density
- third monitoring event 18 months post initial planting.

5.2.1 PROVENANCE

It is recognised that the required revegetation works will need a large amount of propagules (e.g. seed, tubestock). It is important that propagules are first attempted to be sourced from regional vegetation to preserve the provenance where practicable. If not enough propagules can be obtained, propagules are to be sourced from nearby areas with similar climate and geology.

5.2.2 METHODS FOR PLANTING

The optimum tubestock planting time for foreshore vegetation is during their active growing period which is the warmer months of late spring, summer and early autumn. This needs to be taken into account when programming works.

If the scalping/scouring option for the Upland Zone is chosen tubestock planting will be replaced with direct seeding for this zone. It is recommended that a rate of 8-10 kg/ha will be required to achieve the desired revegetation densities.

Table 3 below describes the methods suitable to planting tubestock for revegetation. Strict supervision of planting stock will be required to avoid undesirable rates and clumping of species distribution.

Table 3: Methods used for planting tubestock

Methods for Planting
Prior to planting, chemical and manual weed control will be undertaken to ensure seedlings are planted into weed free areas.
The installation of tubestock will ensure a general density of at least 2 plants per square meter and an overstorey, middle storey and understorey ratio of 20:30:50. The installation of tubestock will ensure a general density of at least 4 plants per square meter.
Only tubestock that are healthy, disease free and actively growing with well-developed root system should be planted.
Tubestock will be planted only when the soil is sufficiently wet to plant without the need for additional watering.
Species planting list provided and to be adhered to (**Appendix Two**).
Tubestock to be sourced from accredited nurseries to ensure stock is disease and weed free.
Plastic guards (4050 mm x 400 mm x 100 mm) will be placed around seedlings for protection with three bamboo stakes. The guards should be removed when seedling growth starts to become restricted.

Revegetation will not be irrigated; therefore it is essential that seedlings be planted as soon as practical after soil has become sufficiently wet. Revegetation will be undertaken over a five year period to ensure sufficient coverage is achieved.

An integral part of the planting program is supplementary planting in subsequent winters to address plant deaths. Typically non irrigated planting accepts a mortality of approximately 30%, however the City may specify a higher success rate, should monitoring determine that more than 20% mortality of seedlings has occurred, infill planting will be conducted to reach the final density targets.

5.2.3 FENCING AND FIREBREAKS

Fencing of the Lot 81 boundary will be necessary to provide protection against kangaroo damage to foreshore revegetation. The proponents of the Lot 81 development will be responsible for the installation of a chain-link fence at 1.8 meters in height to the entire Lot boundary. The Land Owner(s)/Manager(s) will be responsible for the installation of "wing" fences at the north and south boundaries of Lot 81 terminating at the Preston River edge.

Three meter wide firebreaks will be installed on either side of the Lot 81 boundary fence which will also have two six meter wide gates for the entry/exit of fire protection vehicles at the north east and south east corners of Lot 81.

The existing stock fence will be required to be removed as it currently does not align with the Lot 81 boundary and will restrict any rehabilitation works.

5.2.4 PLANTING LAYOUT

The proposed planting layout is shown on **Map 3.** The species chosen are all readily available through commercial wholesale nurseries and these will be sourced locally where possible. A species list is provided in **Appendix Two**.

5.2.5 MONITORING AND MAINTENANCE

The revegetation program should be monitored to detect any poor success rates or unsatisfactory revegetation of an area following a three year period. An acceptable revegetation success rate is typically in the order of 80% of plants from 90% of species.

Maintenance of tree guards should occur at least quarterly including hand weeding inside tree guards to ensure tubestock are establishing well and are not being out competed by weeds. However, maintenance may need to occur more frequently depending on rate of weed growth or acts of vandalism. Therefore additional maintenance may be required.

Formal monitoring is to occur bi-annually at the beginning of winter and the end of summer, with in-fill planting to be programmed in for the following winter (or late spring if wetland species), to address

tubestock mortality. Monitoring should be undertaken by a qualified environmental scientist and include assessing:

- seedling survival
- foliage % cover
- species representation
- presence of weeds and % cover
- overall success of plant establishment
- photographic records of revegetation.

5.2.6 COMPLETION CRITERIA

Suggested completion criteria are listed in **Table 4**.

Table 4: Suggested Completion Criteria for Revegetation Projects

Assessment Parameter	Method	Completion Criteria
Soil and landform	Visual inspection	Site must be safe, stable & suitable for agreed use without inputs
Seedling survival	Quadrats, photo monitoring	4 plants/m^2 installed for dryland species at the end of the monitoring period. Sedge density will be determined by % cover. Ground covers and Sedges should be installed at 5 plants/m^2. Seeding application rate to be 8-10 kg/ha.
% Foliage cover	Quadrats	≥85% for all sites
Species representation	Quadrats, transects	75% of wetland species and 50% dryland of species used in the revegetation program should be represented as they would in the natural environment at the end of the monitoring period.
% Weed cover and presence	Quadrats	Weed control target to be a maximum of 5% cover with a maximum of 5 weeds per m2; no weeds to exceed 15cm in height.
Weed presence	Weed mapping	No Weeds of National Significance (WONS) or Declared Pest plants to be within the buffer zones or adjacent landscape zones at the end of the monitoring period.
Structure and function	Transects, photo monitoring	The structure must be representative of a natural vegetation type, based on FCT.
Monitoring and maintenance	Quadrats, transects, photo monitoring	Maintenance of the revegetated sites should occur quarterly. Formal monitoring with annual reports of progress being submitted to the City. The results, problems encountered and how they were rectified should be described in the annual report.

5.2.7 RECOMMENDATIONS

	Actions	Priority	Responsibility
5	**Revegetation**		
5.1	undertake revegetation works	High	Land Owner/Manager
5.2	Confirm planting species lists, tubestock availability and planting densities with DBCA	Medium	Land Owner/Manager
5.3	Undertake monitoring and maintenance of the rehabilitation areas for 2 years after development on an bi-annual basis	High	Land Owner/Manager
5.4	Identify areas of rehabilitation that require supplemental planting from the winter monitoring events	Medium	Land Owner/Manager

6 IMPLEMENTATION PLAN

Table 5 shows a provisional schedule of the previous mentioned actions and monitoring responsibilities. All reporting to the City of Bunbury will be on an annual basis, unless not applicable to the Action.

It will be the responsibility of the Land Owners/Managers to implement the FMP with no conditions on the proponent of Lot 81 other than the installation of firebreaks and fencing to the eastern boundary of Lot 81.

Table 5: Implementation Plan

Actions	Frequency	Timeframe	Responsibility
Water Quality Management			
Continue to monitor water quality pre construction, during construction and post construction in line with the LWMS for the site.	Quarterly	Pre-construction, during construction and post-construction	Land Owner/Manager
Weed Control			
Undertake/Complete scalping/scouring of Upland Zone	Once	Prior to revegetation works	Land Owner/Manager
Undertake weed control in conjunction with revegetation activities.	As required in two year maintenance period	Prior to revegetation works and on completion of works until completion criteria are met.	Land Owner/Manager
Ensure application of any herbicides is in accordance with the material safety data sheets and Department of Health (2007) restrictions	As required	Ongoing for the two year management period, or until handover to the City.	Land Owner/Manager
Implement monitoring program to assess changes in weed species and distribution in the study area and adapt weed strategies accordingly	Bi-annually	Two years maintenance period or until completion criteria are met.	Land Owner/Manager
Maintenance of the revegetation areas, particularly tree guards, for 2 years after development	As required in two year maintenance period	Ongoing for the two year management period, or until handover to the City.	Land Owner/Manager
Revegetation			
Remove existing stock fence on eastern boundary of Lot 81	Once	Prior to revegetation works	Developer
Install Fences to revegetation works boundary	Once	Prior to seeding/planting	Land Owner/Manager
Undertake revegetation works	Once prior to subdivision and then as required until handover to the City	Post subdivision earthworks, and including the second winters in-fill plantings until completion criteria are met.	Land Owner/Manager
Confirm revegetation species lists and planting densities are specified and agreed by the City and DBCA	Once	Prior to subdivision earthworks as part of the approved Management Plan	Land Owner/Manager
Undertake monitoring of the revegetation areas for two years after development	Bi-annually	Ongoing for the two year management period, or until handover to the City.	Land Owner/Manager
Identify areas of revegetation that require supplemental planting, and conduct infill planting	Initially at the end of summer, then bi-annually	Two years maintenance period or until completion criteria are met.	Land Owner/Manager

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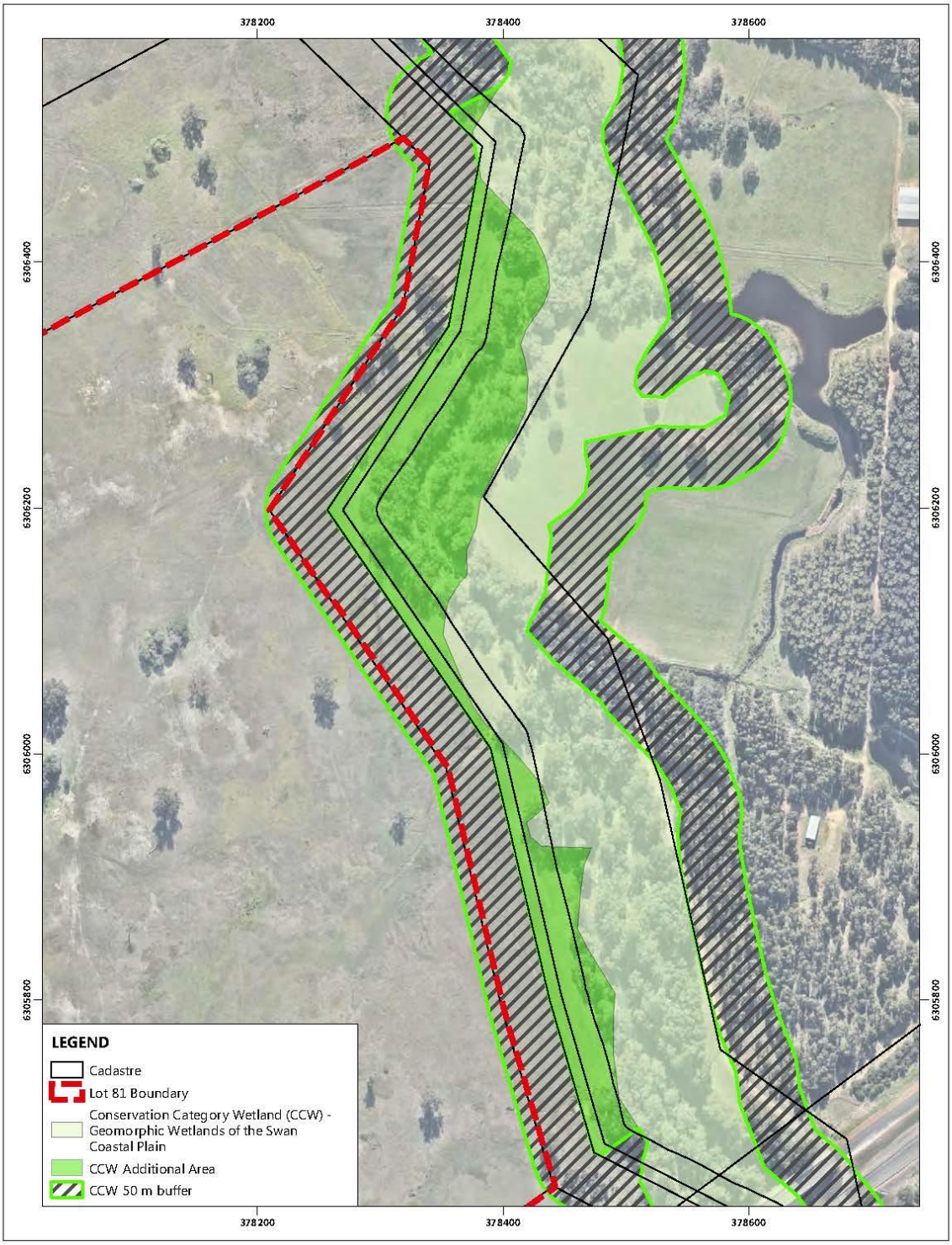
APPENDIX ONE: MAPS



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DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
CADASTRE: LANDGATE WETLAND MAPPING: DBCA
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

N

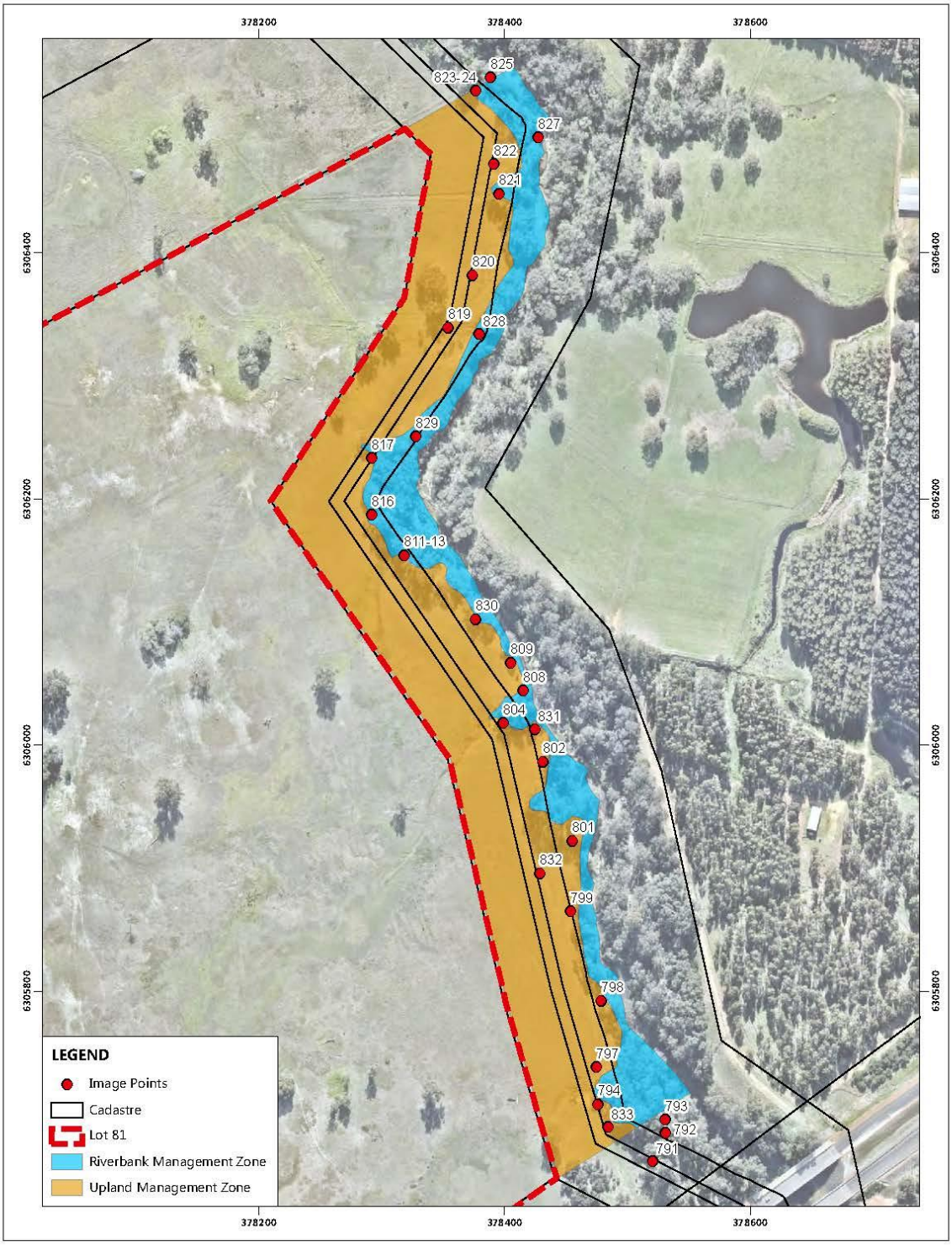
0 50 100 m

GEOMORPHIC WETLANDS

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 01



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PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
CADASTRE: LANDGATE
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

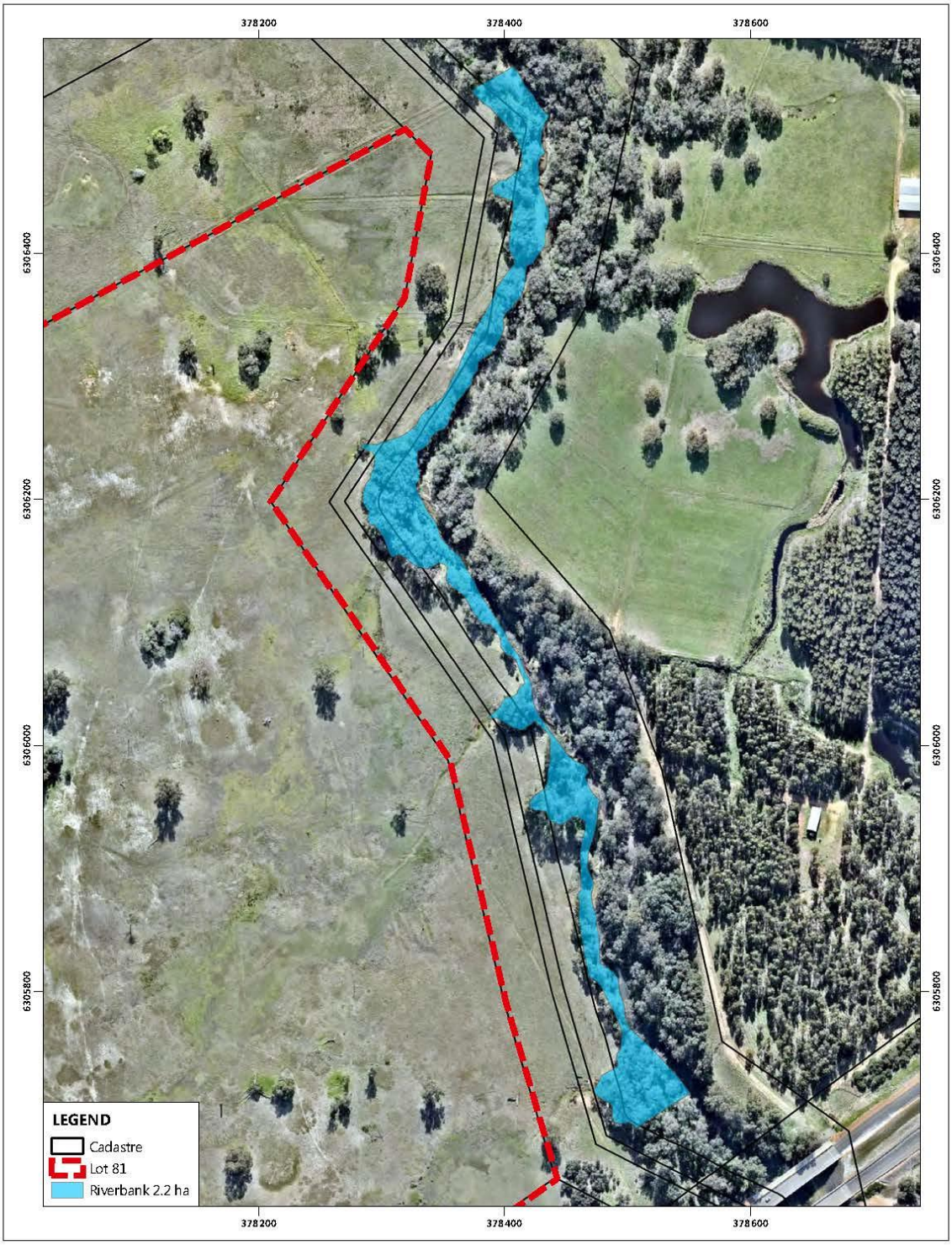
0 50 100 m

PROPOSED MANAGEMENT ZONES

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 02



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PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES :
CADASTRE: LANDGATE
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

N

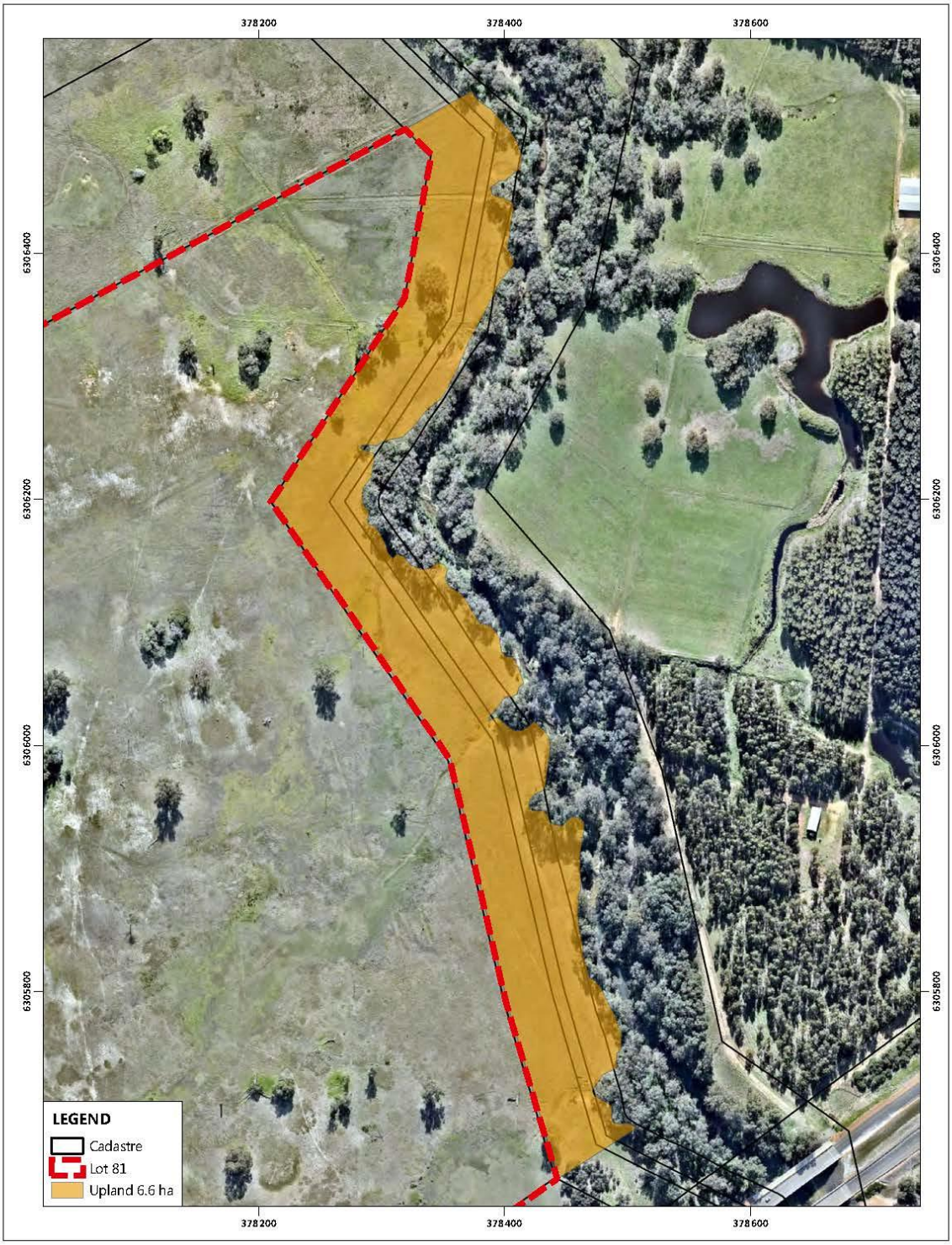
0 50 100 m

PLANTING LAYOUT CONCEPT PLAN RIVERBANK

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 03



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DATUM: GDA 1994
UNITS: METER

DATA SOURCES :
CADASTRE: LANDGATE
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

N

0 50 100 m

PLANTING LAYOUT CONCEPT PLAN UPLAND

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 04

APPENDIX TWO: SUGGESTED PLANTING SPECIES LIST

Riverbank Planting Zone

Stratum and Density (plants/m^2)	Species
OVERSTORY (0.3/m^2)	*Agonis flexuosa*
	Eucalyptus rudis
	Melaleuca rhaphiophylla
	Melaleuca preissiana
SHRUB (4/m^2)	*Acacia pulchella*
	Astartea fascicularis
	Bossiaea eriocarpa
	Hypocalymma angustifolium
	Melaleuca viminea
	Pericalymma ellipticum
	Taxandria linearifolia
	Viminea juncea
GROUNDCOVER (5/m^2)	*Baumea juncea*
	Bolboschoenus caldwellii
	Carex fascicularis
	Ficinia isolepis
	Ficinia nodosa
	Gahnia trifida
	Juncus kraussii
	Juncus subsecundus
	Juncus pallidus
	Lepidosperma longitudinale
	Leptospermum effusum

Upland Planting Zone

Stratum	Species
OVERSTORY (0.3/m^2)	*Agonis flexuosa*
	Banksia grandis
	Banksia littoralis
	Corymbia calophylla
	Eucalyptus marginata
	Eucalyptus rudis
	Melaleuca preissiana
SHRUB (4/m^2)	*Acacia pulchella*
	Bossiaea eriocarpa
	Gompholobium capitatum
	Hakea lissocarpha
	Hakea prostrata
	Hakea varia
	Hibbertia cuneiformis
	Hibbertia subvaginata
	Hypocalymma angustifolium
	Hypocalymma robustum
	Jacksonia furcellata
	Jacksonia horrida
	Kunzea glabrescens
	Kunzea micrantha
	Melaleuca viminea
	Pultenaea skinneri
	Pericalymma ellipticum
	Xanthorrhoea brunonis
GROUNDCOVER (5/m^2)	*Anigozanthos viridis*
	Conostylis aculeata
	Dasypogon bromeliifolius
	Dianella revoluta var. revoluta
	Ficinia nodosa
	Gahnia trifida
	Hemiandra pungens
	Juncus pallidus
	Kennedia coccinea
	Lepidosperma effusum
	Patersonia occidentalis
	Philotheca spicata
	Scaevola calliptera
	Thysanotus multiflorus

Appendix B Asset Protection Zone Requirements

The Site (excluding areas of the ESA buffer extending into the Site) will meet the following requirements (*Guidelines for Planning in Bushfire Prone Areas Version 1.3, Dec 2017*):

a. Width: measured from any external wall or supporting post or column of the proposed building, (developable area/building envelope for a subdivision) and of sufficient size to ensure the potential radiant heat impact of a bushfire does not exceed 29kW/m^2 (BAL-29) in all circumstances;

b. Location: the APZ should be contained solely within the boundaries of the lot on which the building is situated, except in situations where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, into perpetuity;

c. Fences: within the APZ are constructed from non-combustible materials (eg. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used.

d. Objects: within 10 metres of a building combustible object must not be located close to vulnerable parts of the building i.e. windows and doors.

e. Fine Fuel load: combustible dead vegetation matter less then 6mm in thickness reduced to and maintained at an average of two tonnes per hectare.

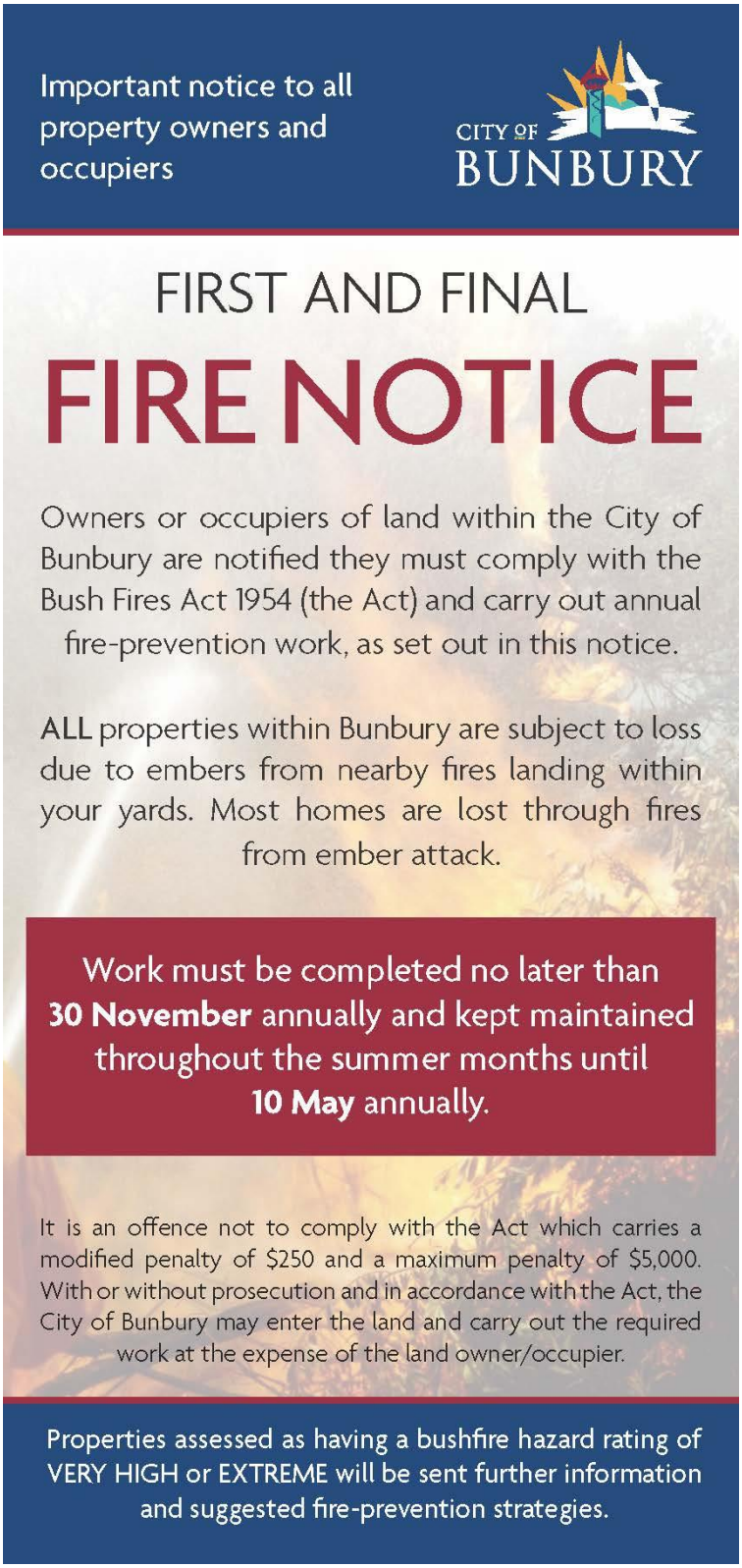
f. Trees (>5m in height): trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and/or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy.

g. Shrubs (0.5m – 5m in height): should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m^2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated at trees.

h. Ground covers (<0.5m in height): can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 meters of a structure, but 3 metres from windows or doors if greater than 100 millimetres in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs.

i. Grass: should be managed to maintain a height of 100 millimetres or less.

Appendix C City of Bunbury Fire Notice


Important notice to all property owners and occupiers
CITY OF BUNBURY
FIRST AND FINAL
FIRE NOTICE
Owners or occupiers of land within the City of Bunbury are notified they must comply with the Bush Fires Act 1954 (the Act) and carry out annual fire-prevention work, as set out in this notice.
ALL properties within Bunbury are subject to loss due to embers from nearby fires landing within your yards. Most homes are lost through fires from ember attack.
Work must be completed no later than 30 November annually and kept maintained throughout the summer months until 10 May annually.
It is an offence not to comply with the Act which carries a modified penalty of $250 and a maximum penalty of $5,000. With or without prosecution and in accordance with the Act, the City of Bunbury may enter the land and carry out the required work at the expense of the land owner/occupier.
Properties assessed as having a bushfire hazard rating of VERY HIGH or EXTREME will be sent further information and suggested fire-prevention strategies.

REQUIREMENTS

Private property
(including residential, commercial and industrial)

- Where the area of land is 2024m^2 or less, all flammable material on the land is to be removed except living trees.
- Where the land area exceeds 2024m^2 provide a 3 metre firebreak free of all flammable material, immediately inside all boundaries and surrounding all buildings and haystacks. Where adjoining lots are held or used by the owner/occupier, firebreaks may be provided immediately inside the external boundaries of the group or lots. Total removal of flammable material from the property would be considered an acceptable alternative.

Fuel and gas depots
All flammable material must be cleared from land where there are containers used for liquid or gas-fuel storage including clearing all flammable material from any liquid or gas-fuel storage ramps or supports.

Plantations
Firebreaks 15 metres wide must be provided immediately adjoining all external boundaries of the planted area. The outer 10 metres must be cleared of all flammable material. The inner 5 metres, closest to the trees may be kept in a reduced fuel state by slashing or used for grazing provided the height of grass does not exceed 8cm.

Plantations must be subdivided into areas not exceeding 30 hectares by firebreaks 6 metres wide. Firebreaks must be cleared of all flammable material and in the vertical plane a minimum height clearance of 5 metres from the ground level will be maintained above the firebreak.

For more information call 9792 7106 or visit www.bunbury.wa.gov.au

PROHIBITED AND RESTRICTED BURNING

The prohibited burning period in the City of Bunbury district is from **30 December to 28 March** annually.

The restricted burning periods in the City of Bunbury district are from **15 November to 29 December, and from 29 March to 10 May** annually.

These dates may be varied according to seasonal conditions, but any changes will be publicly advertised.

Burning permits - bush, grass and garden refuse
Permits are required for any burning including garden refuse during the restricted burning period as above.

Burning of anything including bush, grass and garden refuse is totally prohibited from **30 December to 28 March** annually.

Burning permits will only be issued to owner/occupiers of land for hazard reduction burning until 30 November annually.

Campfires
Campfires are completely banned in the City of Bunbury from 15 November to 10 May annually.

Exemptions
If it is impractical to clear firebreaks as required by this notice or if natural features make firebreaks unnecessary, you may apply to the Council or its authorised officer until 15 November for permission to provide firebreaks in alternative positions or take other action to abate fire hazards. If permission is not granted the requirements of the notice must be complied with.

Andrew Brien
Chief Executive Officer

Appendix D Refuge Open Space Calculations

Calculated October 29, 2019, 5:00 pm (BALc v.4.8)

Forest Down 0 to 5 BAL2

Bushfire Attack Level calculator - AS3959-2009 (Method 2)			
Inputs		Outputs	
Fire Danger Index	80	Rate of spread	3.38 km/h
Vegetation classification	Forest	Flame length	26.22 m
Surface fuel load	25 t/ha	Flame angle	82 °
Overall fuel load	35 t/ha	Panel height	25.97 m
Vegetation height	n/a	Elevation of receiver	12.98 m
Effective slope	5 °	Fire intensity	61,280 kW/m
Site slope	0 °	Transmissivity	0.6879999999999999
Distance to vegetation	176 m	Viewfactor	0.0257
Flame width	100 m	Radiant heat flux	1.98 kW/m²
Windspeed	n/a	Bushfire Attack Level	BAL-12.5
Heat of combustion	18,600 kJ/kg		
Flame temperature	1,200 K		

Rate of Spread - Mcarthur, 1973 & Noble et al., 1980

Flame length - NSW Rural Fire Service, 2001 & Noble et al., 1980

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005

Calculated October 29, 2019, 4:57 pm (BALc v.4.8)

Forest Down 5 to 10 BAL2

Bushfire Attack Level calculator - AS3959-2009 (Method 2)			
Inputs		Outputs	
Fire Danger Index	80	Rate of spread	4.78 km/h
Vegetation classification	Forest	Flame length	35.3 m
Surface fuel load	25 t/ha	Flame angle	81 °
Overall fuel load	35 t/ha	Panel height	34.86 m
Vegetation height	n/a	Elevation of receiver	17.43 m
Effective slope	10 °	Fire intensity	86,527 kW/m
Site slope	0 °	Transmissivity	0.681
Distance to vegetation	205 m	Viewfactor	0.0259
Flame width	100 m	Radiant heat flux	1.97 kW/m²
Windspeed	n/a	Bushfire Attack Level	BAL-12.5
Heat of combustion	18,600 kJ/kg		
Flame temperature	1,200 K		

Rate of Spread - Mcarthur, 1973 & Noble et al., 1980

Flame length - NSW Rural Fire Service, 2001 & Noble et al., 1980

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005

Calculated October 29, 2019, 4:53 pm (BALc v.4.8)

Forest Up Flat BAL2

Bushfire Attack Level calculator - AS3959-2009 (Method 2)			
Inputs		Outputs	
Fire Danger Index	80	Rate of spread	2.4 km/h
Vegetation classification	Forest	Flame length	19.8 m
Surface fuel load	25 t/ha	Flame angle	83 °
Overall fuel load	35 t/ha	Panel height	19.65 m
Vegetation height	n/a	Elevation of receiver	9.82 m
Effective slope	0 °	Fire intensity	43,400 kW/m
Site slope	0 °	Transmissivity	0.701
Distance to vegetation	153 m	Viewfactor	0.0252
Flame width	100 m	Radiant heat flux	1.98 kW/m²
Windspeed	n/a	Bushfire Attack Level	BAL-12.5
Heat of combustion	18,600 kJ/kg		
Flame temperature	1,200 K		

Rate of Spread - Mcarthur, 1973 & Noble et al., 1980

Flame length - NSW Rural Fire Service, 2001 & Noble et al., 1980

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005

Calculated October 29, 2019, 5:03 pm (BALc v.4.8)

Grass Up Flat BAL2

Bushfire Attack Level calculator - AS3959-2009 (Method 2)			
Inputs		Outputs	
Grassland Fire Danger Index	80	Rate of spread	10.4 km/h
Vegetation classification	Grassland	Flame length	5.86 m
Surface fuel load	4.5 t/ha	Flame angle	87 °
Overall fuel load	4.5 t/ha	Panel height	5.85 m
Vegetation height	n/a	Elevation of receiver	2.92 m
Effective slope	0 °	Fire intensity	24,180 kW/m
Site slope	0 °	Transmissivity	0.747
Distance to vegetation	80 m	Viewfactor	0.0235
Flame width	100 m	Radiant heat flux	1.96 kW/m²
Windspeed	n/a	Bushfire Attack Level	BAL-12.5
Heat of combustion	18,600 kJ/kg		
Flame temperature	1,200 K		

Rate of Spread - Noble et al. 1980

Flame length - Purton, 1982

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005

Calculated October 29, 2019, 4:52 pm (BALc v.4.8)

Woodland Up Flat BAL2

Bushfire Attack Level calculator - AS3959-2009 (Method 2)			
Inputs		Outputs	
Fire Danger Index	80	Rate of spread	1.43 km/h
Vegetation classification	Woodland	Flame length	12.35 m
Surface fuel load	15 t/ha	Flame angle	85 °
Overall fuel load	25 t/ha	Panel height	12.31 m
Vegetation height	n/a	Elevation of receiver	6.15 m
Effective slope	0 °	Fire intensity	18,599 kW/m
Site slope	0 °	Transmissivity	0.722
Distance to vegetation	120 m	Viewfactor	0.0246
Flame width	100 m	Radiant heat flux	1.98 kW/m²
Windspeed	n/a	Bushfire Attack Level	BAL-12.5
Heat of combustion	18,600 kJ/kg		
Flame temperature	1,200 K		

Rate of Spread - Mcarthur, 1973 & Noble et al., 1980

Flame length - NSW Rural Fire Service, 2001 & Noble et al., 1980

Elevation of receiver - Douglas & Tan, 2005

Flame angle - Douglas & Tan, 2005

Radiant heat flux - Drysdale, 1999, Sullivan et al., 2003, Douglas & Tan, 2005

Appendix C

Environmental Assessment

Prepared by Ecoscape

Lot 81 South West Highway Davenport
Environmental Assessment

NBR Investments

ecoscape

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Draft Rev 0	Andrew Fry			15/08/2016
Draft Rev 1	Andrew Fry			21/10/2016

Direct all inquiries to:
Ecoscape (Australia) Pty Ltd
9 Stirling Highway • PO Box 50 NORTH FREMANTLE WA 6159
Ph: (08) 9430 8955 Fax: (08) 9430 8977

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SUMMARY

Ecoscape undertook a desktop investigation and field assessment of the Lot 81 South West Highway Davenport (the study area) in order to provide environmental information to support a re-zoning application. The investigation used previous information gathered and reported on in 2010 to form the basis of the investigation and supported this with a field assessment completed in August 2016.

The key relevant environmental factors investigated included:

- Wetland values
- Soils and landform
- Land capability
- Flora and fauna values.

There is a Resource Enhancement (RE) wetland recorded within the study area, which was recorded as Multiple Use (MU) in 2010 and has therefore been modified by DPaW post 2010. This wetland occurs in the North West corner of the study area and may potentially constrain the sites development potential. Ecoscape recommends that a request for modification be lodged with the Department of Parks and Wildlife (DPaW) to alter the classification of the portions of this RE wetland that lie within the study area. The presence of a Conservation Category Wetland (CCW) along the road reserve of the South West Highway has been avoided and an appropriate buffer has been applied removing any impact to this wetland.

The majority of the soil types present on the study area were identified as the Pinjarra Phases common to the Swan Coastal Plain and are generally regarded as being poorly drained and unable to retain nutrients. The landform is flat alluvial plain and exhibits low depth to groundwater and is seasonally inundated by surface water run-off. These factors are generally solved through engineering drainage solutions and filling of the land to achieve separation from groundwater levels.

A land capability assessment indicated that the land capability factors of the study area, based on soil mapping, indicated the land has a capability of Class 4 Low. The most limiting factor was in relation to high waterlogging risk ratings. The high risk of waterlogging was generally as a result of soils with low abilities to absorb water and shallow depth to groundwater.

Land capability and the risk of flooding from high groundwater have indicated impacts to the ability to treat waste water. Recommendations are made to address waste water treatment through the installation of anaerobic treatment units or contained waste water systems depending on the level of human occupancy on the Lots.

The results indicated that there were no impacts to flora values from the proposed re-zoning and therefore no constraints to the proposal. There were a number of potential Black Cockatoo habitat trees recorded and should these be retained no impacts are expected from the re-zoning.

1 INTRODUCTION

1.1 CONTEXT

Ecoscape was engaged by NBR Investments Pty Ltd to provide an environmental, heritage and land capability assessment for Lot 81 Southwest Highway, Davenport (the study area). The study area bounded by the South West Highway to the west, the Bunbury Outer Ring Road to the south and the Preston River to the east, see Figure 1. The study area is approximately 42 ha in extent. The information gathered will be used to support a Scheme Amendment Application for rezoning from Development Zone (Industrial) to Industry.

The environmental assessment was undertaken to Environmental Protection Authority (EPA) guidelines and standards and constitutes a desktop investigation with a field visit to confirm the desktop results. A desktop investigation was undertaken for Matters of National Environmental Significance as administered by the Commonwealth Department of the Environment and Energy (DotEE).

The objectives of the investigation are to review available data on the following aspects:

- Presence of classified wetlands of both the State and Commonwealth listings
- Presence of known environmentally sensitive areas; threatened flora; threatened fauna
- Soil subsystem types present
- Land capability assessment (LCA) category
- Depth to groundwater and surface water flow
- Presence of Acid Sulphate Soil (ASS) risk category
- Presence of Registered Aboriginal Heritage Sites.

Figure 1 Study Area

2 METHODOLOGY

2.1 DESKTOP ASSESSMENT

The desktop investigation used datasets available through government sources and Ecoscape databases to map environmental information onto the study area. Information sourced included the following:

- DPaW NatureMap Threatened and Priority Fauna, Flora and Communities database and wetland mapping
- DotEE Environment Protection and Biodiversity Conservation (EPBC) Protected Matters Search Tool
- Department of Agriculture and Food WA (DAFWA) Soil Subsystem mapping
- Department of Environment Regulation (DER) ASS risk mapping
- Department of Aboriginal Affairs Heritage Site Enquiry System

Environmental aspects included in this investigation are as follows:

- Environmentally Sensitive Areas as mapped by DPaW
- Categorised wetlands as classified by DPaW being either Conservation, Resource Enhancement or Multiple Use
- Presence of potential Acid Sulphate Soils
- Land capability assessment factors including soil type and ability to export nutrients
- Presence of conservation significant flora and fauna species including potential presence of Black Cockatoo habitat
- Aboriginal heritage.

Maps were produced of each of the relevant aspects above in relation to the study area and are displayed in **Appendix One**.

Information included in this report has been taken from previous environmental investigations undertaken on the study area including:

- Environmental Assessment – Ecoscape 2008
- Environmental Offset Proposal – Ecoscape 2009
- Environmental Assessment – Ecoscape 2010
- Fauna Survey – Ecosystems Solutions 2010
- Fauna Habitat Assessment - Ecoscape 2015

2.2 COCKATOO SURVEY

A Black Cockatoo habitat field survey was conducted following relevant Commonwealth Black Cockatoo survey guidelines (Department of Sustainability Environment Water Population and Communities 2012). The following actions were undertaken:

- Demarcating, photographing and recording the GPS locations of potential and existing breeding trees as defined by DotEE guidance and relevant environmental regulators (i.e. trees of suitable species having DBH over 500 mm)
- recording evidence of each tree hollow use
- identifying and recording tree hollow size and height, including evidence of use by Black Cockatoo
- recording the location and height of all trees with hollows within the study area

A survey of the study area was conducted by an Ecoscape Environmental Scientist on 19 July 2016. The entire study area was traversed on foot and all trees with DBH of 500 mm or greater were recorded and described following the stated methodology.

Mapping was produced of identified potential breeding trees. The breeding trees identified were further classified dependent on whether or not hollows of a suitable size to provide nesting opportunities for Cockatoo species were identified.

3 RESULTS

3.1 ENVIRONMENTALLY SENSITIVE AREAS

A search of the Department of Environment Regulation (DER) Environmentally Sensitive Areas (ESA) database indicates an ESA is mapped as being present along the western boundary of the study area (Department of Environment Regulation & Government of Western Australia 2014). This ESA is associated with the 50 meter buffer zone applied to a conservation class wetland located to the west of the study area which is displayed on **Map 2**.

3.2 ASSESSMENT OF WETLANDS

The study area is covered by a number of wetlands of several classes as classified by DPaW, see **Map 2**. Assessment of the Geomorphic Wetlands of the Swan Coastal Plain dataset (Department of Parks and Wildlife 2014) indicates these consist of a small section of Conservation Category wetland (CC) along the western boundary (id- 14285,15451), an area of Resource Enhancement (RE) wetland also along the western boundary (id-14324) and the remainder of the study area being covered by Multiple Use (MU) wetland areas (id-1249, 1325,1327,14283, 15450).

The EPA urges that all areas covered by CC wetlands and the associated buffers are fully protected (Environmental Protection Authority 2008). The EPA uses the recommendations of Hill (Hill *et al.* 1996) to provide guidelines for the protection of CC wetlands by applying a buffer zone of at least 50 m from the wetland boundary This small area of CC wetland and the associated 50 meter buffer zone will likely constrain the amount of developable area along the western boundary of the study area. The EPA also urges that measures are taken to minimise the impacts on areas of RE wetlands. Therefore the area currently mapped as RE may also represent a constraint to development.

It is Ecoscape's opinion that a wetland classification boundary modification request could potentially be lodged with DPaW with the intention of reclassifying the area mapped as RE within the study area to MU. This is considered appropriate due to the cleared nature of the RE area. It would be proposed that the RE wetland boundary be modified to only include the vegetated areas along the road reserve outside of the study area. The EPA suggests that development in areas classified as MU wetland is appropriate as along as reasonable measures are taken to retain the wetlands hydrological functions (Environmental Protection Authority 2008).

3.3 POTENTIAL ACID SULPHATE SOILS

Assessment of mapping of potential acid sulphate soils (ASS) via Department of Environment Regulation datasets indicates that the entirety of the study area is mapped as having a moderate to low risk of containing ASS.

3.4 LANDFORM AND SOILS

The vast majority of the study area (98.3%) consists of soils mapped as phases of the Pinjarra group. The soils can generally be described as consisting of moderately well drained loams and mottled duplex soils over imperfectly drained clays. The remaining small area (1.7%) is associated with the Bassendean group which is characterised by deep well drained bleached grey sands (**Table 1**). The soil subsystems present are displayed on **Map 3**.

Table 1: Soil Sub-systems (DAFWA 2012)

Unit Name	Description	Area (Ha)	% of total area
Bassendean B2 Phase	Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.	0.72	1.7
Pinjarra, B1 Phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.	0.15	0.4
Pinjarra P1b Phase	Flat to very gently undulating plain with deep acidic mottled yellow duplex (or ¿effective duplex) soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas.	34.47	82
Pinjarra P3 Phase	Flat to very gently undulating plain with deep, imperfect to poorly drained acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surface horizons.	1.06	2.5
Pinjarra P6a Phase	Very gently undulating alluvial terraces and low rises contiguous with the plain, with deep moderately well to well drained soils associated with major current river systems and larger streams. Acidic red and yellow duplex soils, less common	3.72	8.9
Pinjarra P6c Phase	Very gently undulating alluvial terraces and fans. Moderate to moderately well drained uniform friable brown loams, or well structured gradational brown earths.	1.74	4.2
Totals		**41.87**	**100%**

3.5 HYDROLOGY

The study area is located in the Middle Preston surface water management sub area DOW 2008. Drainage at the site is generally from the south west to the east. There are no defined streamlines within the study area with flows consisting of broad surface movements. The Preston River flows in close proximity to the eastern boundary of the site. A groundwater level monitoring report produced by the Thompson, McRobert and Edgelow (TME) Group in 2009 reported that the minimum depth to groundwater for the area encompassing the study area ranged between 0.01 m and 2.10 m below existing ground surface with the average being less than 0.5 m at peak groundwater levels.

Detailed descriptions of the hydrology of the study area can be found by referring to the Local Water Management Strategy document for Lot 81 South West Highway prepared by Development Engineering Consultants, 2016.

3.6 LAND CAPABILITY ASSESSMENT

Land capability refers to the ability of land to support a type of land use without causing damage (Austin & Cocks 1990) . It considers both the specific requirements of the land use plus the risks of degradation associated with the land use, e.g. phosphorus export hazard or wind erosion. The procedure to conduct this assessment is described in the Land Evaluation Standards for Land Resource Mapping Technical Report produced by DAFWA in 2005. Five land capability classes are used as shown in **Table 2**

Table 2: Land Capability Classes for Given Land Use Types, adapted from (Wells & King 1989)

Capability Class	General Description
1 Very High	Very few physical limitations present and easily overcome. Risk of land degradation is negligible
2 High	Minor physical limitations affecting either productive land use and/or risk of degradation. Limitations overcome by careful planning.
3 Fair	Moderate physical limitations significantly affecting productive land use and/or risk of degradation. Careful planning and conservation measures required.
4 Low	High degree of physical limitation not easily overcome by standard development techniques and/or resulting in high risk of degradation. Extensive conservation measures and careful ongoing management required.
5 Very low	Severe limitations. Use is usually prohibitive in terms of development costs or the associated risk of degradation

The land capability class is determined by applying the site characteristics (e.g. soil permeability, texture, depth to groundwater etc.) to a series of land quality tables which determine the capability of the land to sustain a particular land use. The proposed land use determines the set of land qualities that are used for the assessment.

In this case the guidelines do not specifically state requirements for effluent disposal from sewage systems for industrial developments. The most appropriate comparative proposed land use category available is for the installation of septic tanks associated with the development of rural residential developments. The rural residential guidelines for assessing the requirements for the installation of effluent disposal units were used in this assessment in order to consider the potential of onsite effluent disposal.

The land qualities to be considered in this assessment are:

- ease of excavation
- flood hazard
- land instability
- microbial purification ability
- soil absorption ability
- waterlogging / inundation risk.

Soil data from (Department of Agriculture and Food Western Australia 2012) was used to determine the characteristics of the soil mapped as being present within the study area. The general description of soils covering the vast majority of the site was determined to be soils consisting of moderately to moderately well drained loams and mottled duplex soils over imperfectly drained clays. This categorisation was used to assess the soils at a desktop level.

Shown below in **Table 3** are the resultant ratings associated with the assessed land qualities, with the characteristic which was most limiting (i.e. the biggest impediment to developing on site effluent disposal systems) being stated for each. As all soil information is based on desktop mapping, assessment based on more detailed soil assessments may produce differing results. This assessment was intended to provide a general description of the study area only.

Table 3: Land Quality Ratings

Land Quality for Assessment	Rating	Lowest Rated Characteristic (limiting factor)
Ease of Excavation	Moderate	Waterlogging Risk- High
Flood Hazard Risk	Low	Areas associated with high terraces of river
Land Instability Hazard	Very Low	Waterlogging Risk High to Very High
Microbial Purification Ability	Low	Infiltration Rate Moderate, <1.5 m to water table
Soil Absorption Ability	Low	Waterlogging Risk- High
Waterlogging Risk	High	Infiltration Rate-Moderate to Moderate Slow

These risks/ratings were then converted into a land capability class according to the matrix for septic tanks for rural and residential developments presented in **Table 4**. Explanation of each land capability class is provided in **Table 2.**

Table 4: Land Capability calculation matrix for septic tanks for rural and residential developments (DAFWA 2005)

Land quality and capability	Land capability class				
	1	2	3	4	5
Ease of excavation *(x)*	H	M	L	VL	
Flood hazard *(f)*	N		L	M	H
Land instability *(c)*	N	VL	L	M	H
Microbial purification ability *(p)*	H	M	L	VL	
Soil absorption *(zj)*	H	M	L	VL	
Waterlogging *(i)*	N, VL	L	M	H	VH

H=High, M=Moderate, L=Low, VL=Very Low, N=Nil

Based on the assessed characteristics the calculated land capability class for the study area for the disposal of effluent via onsite septic drains is class 4 Low.

3.7 CONSERVATION SIGNIFICANT ASPECTS

3.7.1 FAUNA

The study area is devoid of any remnant native vegetation with sufficient structure to provide fauna habitat value, other than large hollow bearing trees. These scattered and isolated trees where assessed for value as potential Black Cockatoo breeding trees, as per the guidelines form DotEE, and are displayed on **Map 1.**

Results from database searches for conservation significant fauna species likely to be present in the locality of the study area are provided in **Table 5**. It is highly unlikely that any of these species will be present as resident within the study area and may only rarely use the study area as a corridor between the Peppermint Forest, in the south west corner of Lot 80, and the Preston River to the east.

Table 5: Potential Conservation Significant Fauna

Scientific name	Common name	*EPBC ACT 1999*	*WC ACT 1950*
Bird			
Botaurus poiciloptilus	Australasian Bittern	Endangered	T
Calyptorhynchus banksii subsp. naso	Forest Red-tailed Black-Cockatoo	Vulnerable	T
Calyptorhynchus baudinii	Baudin's Cockatoo (long-billed black-cockatoo)	Vulnerable	T
Calyptorhynchus latirostris	Carnaby's Cockatoo (short-billed black-cockatoo)	Endangered	T
Ixobrychus flavicollis subsp. australis	Australian Black Bittern	-	P1
Oxyura australis	Blue-billed Duck	-	P4
Mammal			
Dasyurus geoffroii	Chuditch, Western Quoll	Vulnerable	T
Isoodon obesulus subsp. fusciventer	Quenda	-	P5
Macropus irma	Western Brush Wallaby	-	P4
Phascogale tapoatafa subsp. tapoatafa	Wambenger	-	T
Pseudocheirus occidentalis	Western Ringtail Possum	Vulnerable	T
Setonix brachyurus	Quokka	Vulnerable	T
Reptiles			
Ctenotus ora	Coastal Plains Skink	-	P3

3.7.2 FLORA

Due to the completely degraded bushland condition (Keighery 1994) of the entire study area, the lack of any native vegetation understory, and the history of grazing, it is considered highly unlikely that any conservation significant flora, as listed in **Table 6** , would be present within the study area.

Table 6: Potential Conservation Significant Flora

Scientific name	Common names	*EPBC 1999*	DPaW
Acacia flagelliformis	-	-	P4
Acacia semitrullata	-	-	P4
Andersonia gracilis	Slender Andersonia	Endangered	T
Angianthus drummondii	-	-	P3
Aponogeton hexatepalus	Stalked Water Ribbons	-	P4
Austrostipa bronwenae	-	-	T
Austrostipa jacobsiana	-	-	T
Boronia tetragona	-	-	P3
Caladenia huegelii	Grand Spider Orchid	Endangered	T
Caladenia speciosa	-	-	P4
Diuris drummondii	Tall Donkey Orchid	Vulnerable	T
Diuris purdiei	Purdie's Donkey-orchid	Endangered	T
Drakaea elastica	Glossy-leafed Hammer-orchid	Endangered	T
Drakaea micrantha	Dwarf Hammer-orchid	Vulnerable	T

Scientific name	Common names	*EPBC 1999*	DPaW
Eucalyptus rudis subsp. cratyantha	-	-	P4
Gastrolobium whicherense	-	-	P2
Lasiopetalum membranaceum	-	-	P3
Leucopogon sp. Busselton	-	-	P2
Platysace ramosissima	-	-	P3
Pultenaea skinneri	Skinner's Pea	-	P4
Schoenus benthamii	-	-	P3
Schoenus loliaceus	-	-	P2
Stylidium longitubum	Jumping Jacks	-	P4
Thelymitra variegata	Queen of Sheba	-	P2
Verticordia attenuata	-	-	P3

3.7.3 COMMUNITIES

Interrogation of the DPaW Threatened Ecological Communities Database indicates that no priority or threatened ecological communities occur within the study area. It was identified that a threatened ecological community occurs in close proximity to the study are to the southwest, there is no impact expected to this community from the re-zoning proposal.

3.8 COCKATOO SURVEY

The majority of trees observed on the site were Peppermints (*Agonis flexuosa*), Flooded Gums (*Eucalyptus rudis*) and Swamp Paperbarks (*Melaleuca preissii*). A small number of Jarrahs (*Eucalyptus marginata*) were recorded on the edges of areas of higher elevation.

According to the Commonwealth guidelines on tree assessment (Department of Sustainability Environment Water Population and Communities 2012) of the tree species present only Flooded Gums and Jarrah trees are able to be considered as nesting habitat. The locations of these species, their DBH and a description of the hollows present are provided in **Table 7**.

Of the 15 trees mapped as potential nesting trees due to their DBH and species eight were observed to have hollows of a medium size (10-20cm diameter) or greater. Hollows of this size are known to be suitable for breeding hollows for Cockatoo species (Johnstone *et al.* 2011). Additionally two of these trees (tree numbers three and six) were observed to have hollows which were occupied by Pink and Grey Galahs indicating their suitability for nesting. Potential nesting tree and potential nesting trees identified to have suitable hollows are displayed on **Map 1.**

Table 7: Identified Potential Cockatoo Nesting Trees

Tree Number	Species	Height (m)	DBH (cm)	Number of Hollows	Usage Notes	Easting MGA 50	Northing MGA 50
1	*Eucalyptus marginata*	6	71	none	-	377746.232	6306147.725
2	Unknown eucalypt (dead)	8	89	none	-	377754.682	6306193.299
3	*Eucalyptus rudis*	16	133	1 medium hollow, 2 small hollows	Galahs observed nesting	378138.068	6306322
4	*Eucalyptus rudis*	16	159	none	-	378281.943	6306326.914
5	*Eucalyptus rudis*	16	255,86,109	2 large hollows low on trunk, 2 small hollows	-	378298.701	6306340.876
6	*Eucalyptus rudis*	26	210	1 medium hollow, 4 small hollows	Galahs observed nesting	378254.292	6306069.178
7	*Eucalyptus rudis*	7	198	none	-	378315.353	6305963.374
8	*Eucalyptus rudis*	22	256	1 large hollow, 3 small hollows	-	378126.117	6305962.991
9	*Eucalyptus rudis*	10	185,54	none	-	378157.832	6306067.41
10	*Eucalyptus rudis*	14	102	1 small hollow	-	377989.114	6306092.456
11	*Eucalyptus rudis*	23	261	1 large hollow, 4 small hollows	-	378024.503	6306067.617
12	*Eucalyptus rudis*	12	220	none	-	378431.041	6305678.494
13	*Eucalyptus rudis*	26	162	1 large hollow, 1 small hollow	-	378347.78	6305722.472
14	*Eucalyptus rudis*	15	258,102	1 medium , 3 small hollows	-	378184.803	6305683.606
15	*Eucalyptus marginata*	6	115	1 medium hollow	-	378152.829	6305496.344

3.9 ABORIGINAL HERITAGE

A search of the Department of Aboriginal Affairs online database (Department of Aboriginal Affairs 2015) was undertaken for the study area. The search indicates that the north western corner of the study area intersects with registered Aboriginal site (19795 Preston River Mythological Site). The extent of the registered site within the study area is shown on **Map 4**.

4 CONCLUSIONS

4.1 WETLAND ASSESSMENT

The presence of the RE wetland may constrain the amount of developable land if not requested for modification. This wetland was not classified as RE in 2010 and was instead classed as Multiple Use at the time of the previous environmental assessment. Ecoscape recommends that a request to modify the area of RE wetland within Lot 81 from RE to Multiple Use be considered.

As no impact to the Conservation category wetland along the South West Highway interface is proposed and a suitable buffer of 50 m has been applied there is no constraint expected from this rezoning proposal.

4.2 LAND CAPABILITY ASSESSMENT

The investigation of the land capability factors of the study area, based on soil mapping, indicates the land has a capability of Class 4 Low. The most limiting factor was in relation to high waterlogging risk ratings. The high risk of waterlogging was generally as a result of soils with low abilities to absorb water and shallow depth to groundwater.

This result is for the state of the land as it is currently, which does not appear able to sustain the installation of traditional septic systems without causing potential health hazards, due to the inability of waste water to be absorbed by the local soil conditions during periods of high groundwater level. The effect that land fill may play when Lot envelopes are to be raised above the groundwater maximum, or the annual average maximum of groundwater level (AAMGL) has not been taken into account. The use of aerobic treatment units (ATUs) is therefore proposed to treat waste water on site.

In the relevant Department of Agriculture and Food WA technical report (Department of Agriculture and Food Western Australia 2005) the preferred management options for situations where developments are proposed in areas with a high risk of waterlogging are described, they include:

- Consider alternative methods such as ATUs
- Consider technology such as Ecomax which utilises leach drains with amended soil around them
- Building the areas surrounding up to two meters above the highest season water tables using sand fill (less preferred).

ATU means Aerobic Treatment Unit, an apparatus for treating sewage either wholly or partially by aerobic means and includes any associated effluent disposal system. ATUs require a minimum 250 m^2 of land. This area is additional to any space required for the residence, sheds, carports, driveways, access paving and setback distances.

Guidance from the Department of Health Code of Practice for the Design Manufacture Installation and Operation of ATUs (Department of Health 2001) indicates the following with respect to depth to groundwater:

- The minimum depth from the upper surface of the irrigation area to the highest known water table shall be 500 mm. In the case of a surface irrigation system, the 500 mm distance being from the upper surface of the irrigation area to the highest known water table level.
- For subsoil systems, the 500 mm is taken from the invert of the discharge pipe to the highest known water level. This is necessary to ensure a safety factor exists should there be a malfunction in the chlorination unit.

Given that irrigation is above ground, a 500 mm zone of unsaturated soil is seen as the minimum acceptable depth to permit microbiological attenuation. For Lot 81 irrigation areas will need to be comprised of pads of attenuating soil 500 mm deep, with a 2 m separation distance above maximum groundwater level and located at least 100 m from the Preston River buffer.

It is recommended that ATUs are installed to treat waste water that may be generated on the site. These units should be installed as per the guidelines as supplied by the Department of Health (Department of Health 2001).

Alternatively if the level of human occupancy is low, the use of contained waste water systems could be used at a Lot level. These systems are similar to the "Port-A-Loo' method of containing waste water and are pumped out and removed from the site on a regular basis. These units have the advantage of being wholly contained and therefore provide NO impact to environmental health. The use of this type of waste water treatment can be managed for spills by installing bunding and minimal separation from groundwater.

Methods used for "on-site" effluent solutions will need to be installed by each property / business owner, in accordance with their specific business / operational needs and to the satisfaction of the City of Bunbury.

4.3 REMAINING ENVIRONMENTAL FACTORS

The remaining environmental factors of Flora; Fauna; Soils; and Hydrology have been assessed as not constraining the development of the study area as Industry. Engineering solutions are common and well developed to address drainage and nutrient export impacts posing no constraint.

There are no impacts to flora or vegetation as the study area is completely degraded. There are Black Cockatoo potential habitat breeding trees within the study area, Ecoscape does not see these as a constraint if they can be left in situ. If these trees cannot be retained we would then argue that a sufficiently large number of similar trees can be found in the nearby natural areas already protected and on Lot 80.

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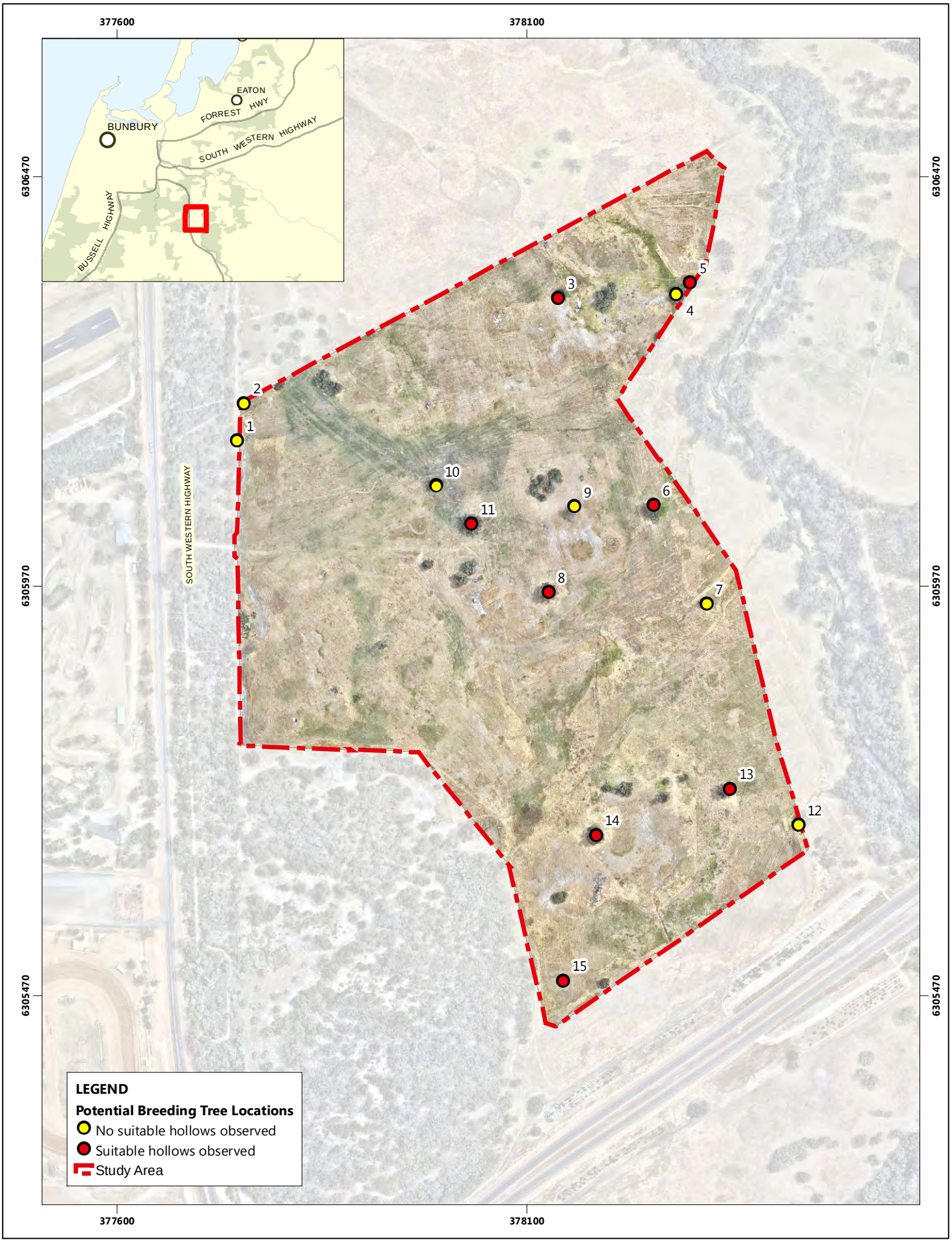
APPENDIX ONE: MAPS



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DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
SERVICE LAYERS: STREETS- STREET PRO 2009
IMAGERY: NEARMAP 2016

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
00	AF	BT	22/07/2016

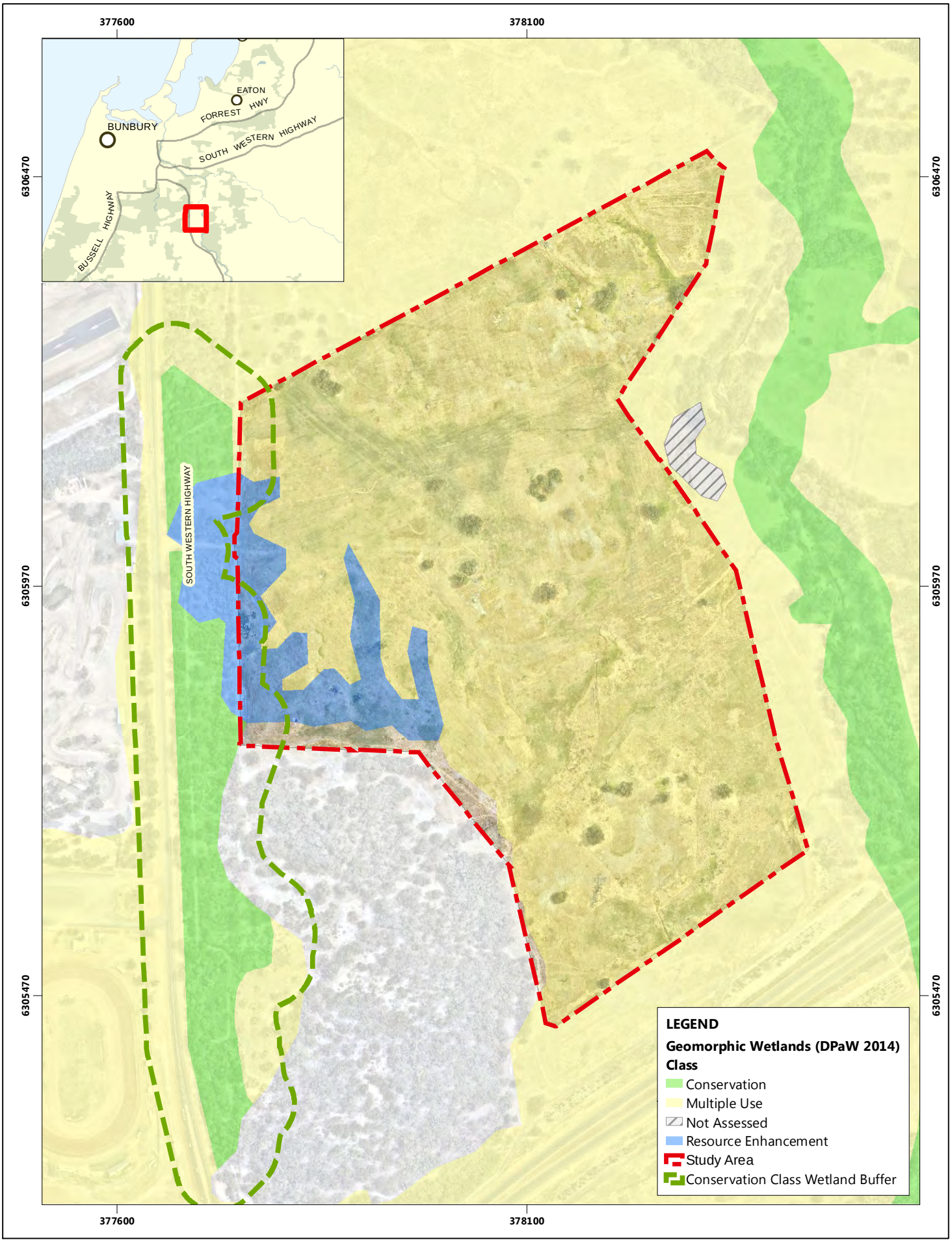
0 50 100 Meters

N

POTENTIAL COCKATOO BREEDING TREE LOCATIONS

NBR INVESTMENTS

MAP 01



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UNITS: METER

DATA SOURCES:
SERVICE LAYERS: STREETS- STREET PRO 2009
IMAGERY: NEARMAP 2016
DATA: GEOMORPHIC WETLANDS DPAW 2014

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REV	AUTHOR	APPROVED	DATE
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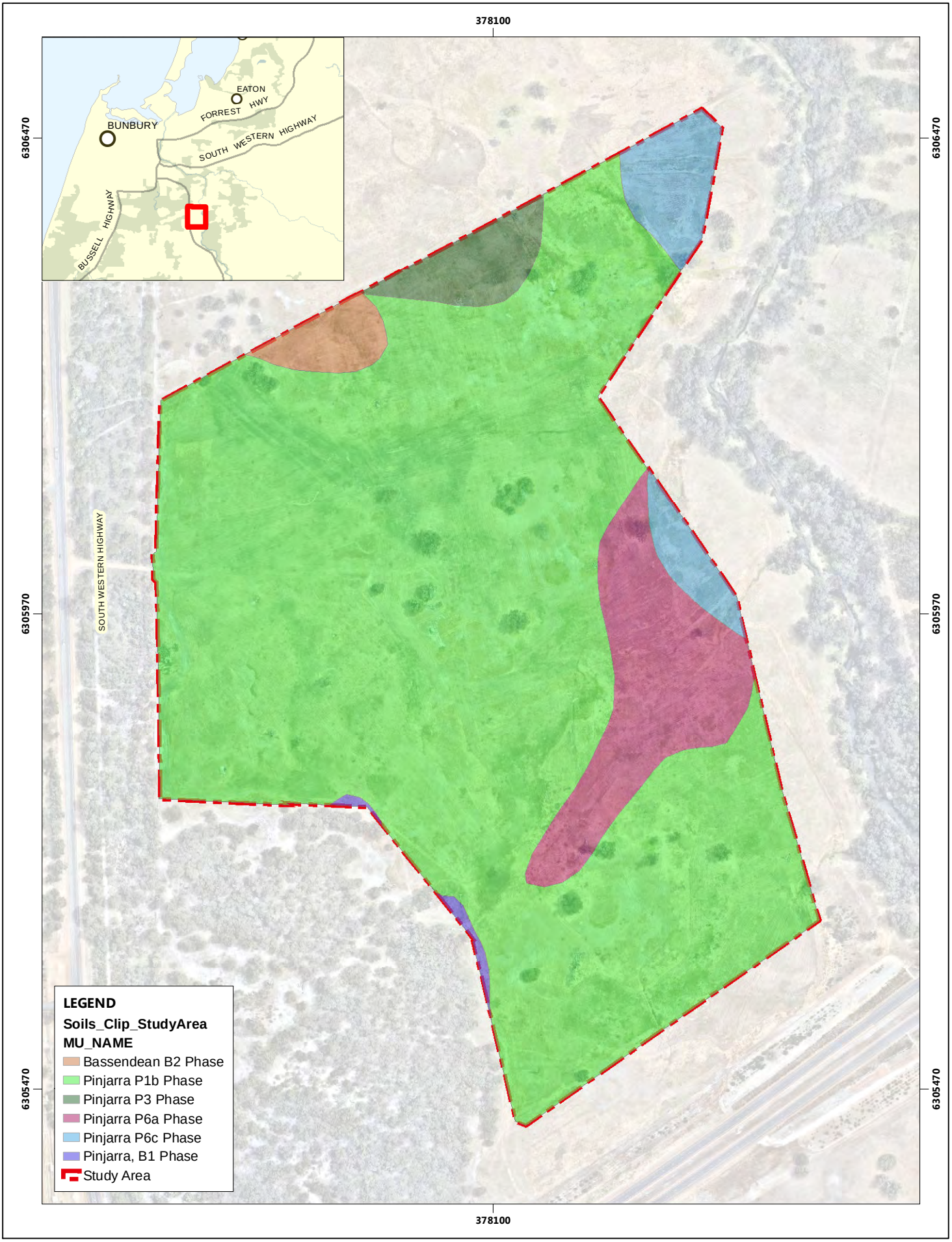
GEOMORPHIC WETLAND AND ENVIRONMENTALLY SENSITIVE AREAS MAPPING

NBR INVESTMENTS

MAP 02



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DATA: GEOMORPHIC WETLANDS DPAW 2014

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PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
00	AF	BT	22/07/2016

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SOIL SUBSYSTEM MAPPING

NBR INVESTMENTS

MAP 03

Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Legend

Selected Heritage Sites

- Registered Sites
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area

APPENDIX TWO: POTENTIAL COCKATOO BREEDING TREES

Plate 1: Tree 1

Plate 2: Tree 2

Plate 3: Tree 3

Plate 4: Tree 4

Plate 5: Tree 5

Plate 6: Tree 6

Plate 7: Tree 7

Plate 8: Tree 8

Plate 9: Tree 9

Plate 10: Tree 10

Plate 11: Tree 11

Plate 12: Tree 12

Plate 13: Tree 13

Plate 14: Tree 14

Plate 15: Tree 15

APPENDIX THREE: PROTECTED MATTERS SEARCH TOOL

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: 20/07/16 18:31:47

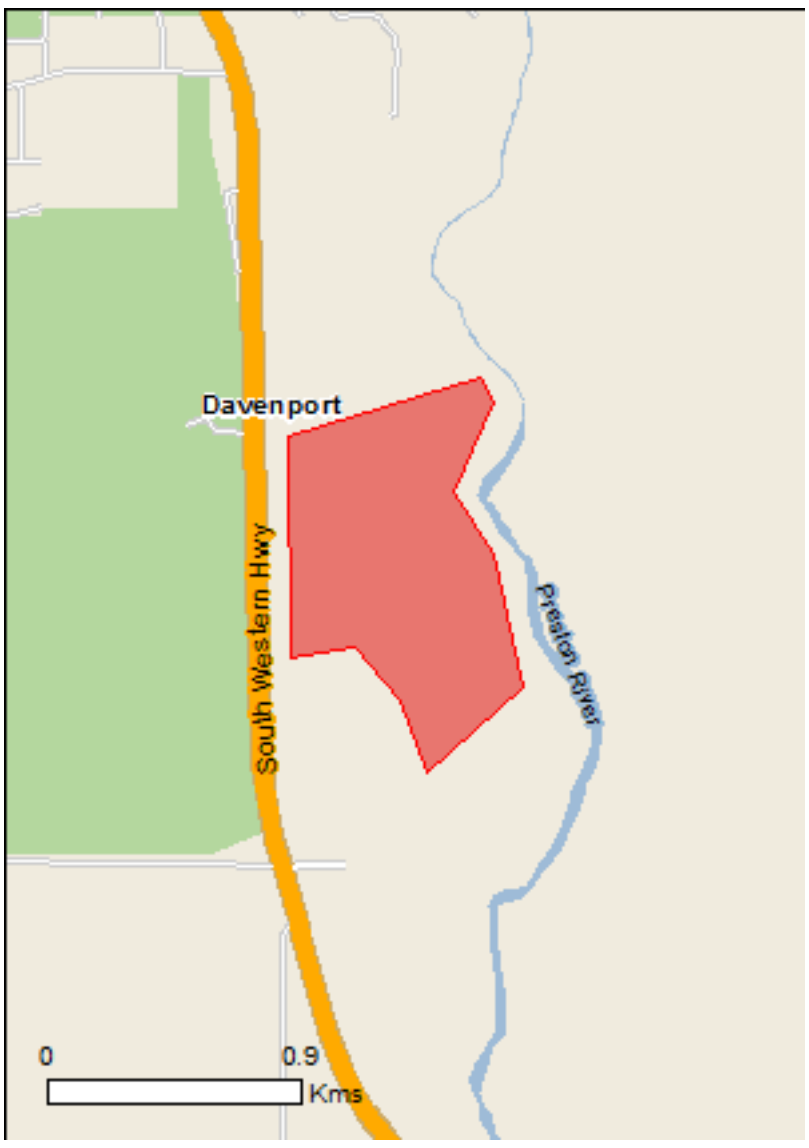
Summary

Details

- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat

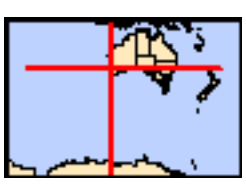
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 2.0Km



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:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	14
Listed Migratory Species:	4

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. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

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:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	9
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.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	30
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Breeding known to occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to 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, Womp, Woder, Ngoor, Ngoolangit [25911]	Vulnerable	Species or species habitat known to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat may occur within 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 may occur within area
Diuris drummondii Tall Donkey Orchid [4365]	Vulnerable	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat may occur within area
Drakaea elastica Glossy-leafed Hammer-orchid, Praying Virgin	Endangered	Species or species

Name	Status	Type of Presence
[16753]		habitat likely to occur within area
Drakaea micrantha		
Dwarf Hammer-orchid [56755]	Vulnerable	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		
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Pandion haliaetus		
Osprey [952]		Species or species habitat may occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

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]		Breeding known to occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to 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		
Anas platyrhynchos Mallard [974]		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
Mammals		
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
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
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 rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		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		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus declinatus Bridal Veil, Bridal Veil Creeper, Pale Berry Asparagus Fern, Asparagus Fern, South African Creeper [66908]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur 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
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
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
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Protasparagus plumosus Climbing Asparagus-fern, Ferny Asparagus [11747]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
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
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area

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 and National Heritage properties, Wetlands of International and National 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.

Coordinates

-33.383864 115.690076,-33.383864 115.690076,-33.381929 115.689261,-33.380496 115.687759,-33.380783 115.685785,-33.374941 115.685656,-33.373364 115.691793,-33.374045 115.692179,-33.376446 115.690935,-33.378059 115.692179,-33.381607 115.693123,-33.383864 115.690076

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:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Parks and Wildlife Commission NT, Northern Territory Government
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian 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
Forestry Corporation, 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.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

APPENDIX FOUR: REGISTERED ABORIGINAL SITES SEARCH RESULTS

Search Criteria

1 Registered Aboriginal Sites in Custom search area (5); 377632.85mE, 6305117.85mN z50 (MGA94) : 378547.85mE, 6306333.50mN z50 (MGA94)

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Aboriginal Affairs by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at heritageenquiries@daa.wa.gov.au and we will make every effort to rectify it as soon as possible.

South West Settlement ILUA Disclaimer

Your heritage enquiry is on land within the following Indigenous Land Use Agreement(s): Gnaala Karla Booja People ILUA

On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will ‘impact’ (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines and Petroleum (DMP) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMP, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.dpc.wa.gov.au/lantu/Claims/Pages/SouthWestSettlement.aspx.

Further advice can also be sought from the Department of Aboriginal Affairs (DAA) at heritageenquiries@daa.wa.gov.au.

Coordinate Accuracy
Accuracy is shown as a code in brackets following the coordinates. Map coordinates (Latitude/Longitude and Easting/Northing) are based on the GDA 94 Datum. The Easting/Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '500000mE:Z50' means Easting=500000, Zone=50.

Terminology (NB that some terminology has varied over the life of the legislation)
Place ID/Site ID: This a unique ID assigned by the Department of Aboriginal Affairs to the place
Status:
- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972*
- **Other Heritage Place which includes:**
  - **Stored Data / Not a Site:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this stage to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972*

Status Reason: e.g. Exclusion - Relates to a portion of an Aboriginal site or heritage place as assessed by the Aboriginal Cultural Material Committee (ACMC). e.g. such as the land subject to a section 18 notice.
Origin Place ID: Used in conjuction with Status Reason to indicate which Registered Site this Place originates from.
Access and Restrictions:
- **File Restricted = No:** Availability of information (other than boundary) that the Department of Aboriginal Affairs holds in relation to the place is not restricted in any way.
- **File Restricted = Yes:** Some of the information that the Department of Aboriginal Affairs holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Aboriginal Affairs receives written approval from the informants who provided the information. Download the Request to Access Restricted Information letter and form.
- **Boundary Restricted = No:** place location is shown as accurately as the information lodged with the Registrar allows.
- **Boundary Restricted = Yes:** To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km²) provides a general indication of where the place is located. If you are a landowner and wish to find out more about the exact location of the place, please contact DAA.
- **Restrictions:**
  - **No Restrictions:** Anyone can view the information.
  - **Male Access Only:** Only males can view restricted information.
  - **Female Access Only:** Only females can view restricted information

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

List of Registered Aboriginal Sites with Map

Site ID	Site Name	File Restricted	Boundary Restricted	Restrictions	Status	Status Reason	Origin Place ID	Site Type	Knowledge Holders	Coordinates	Legacy ID
19795	Preston River	No	No	No Gender Restrictions	Registered Site			Mythological	*Registered Knowledge Holder names available from DAA	400159mE 6290621mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Legend

Selected Heritage Sites

- Registered Sites
- Aboriginal Community Occupied
- Aboriginal Community Unoccupied
- Town
- Search Area

Appendix D

Wetland Buffer Rehabilitation Plan

Prepared by Ecoscape

Lot 81 South Western Highway, Davenport - Wetlands Buffer Rehabilitation Plan

NBR Investments

ecoscape

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Draft rev 0	Bruce Turner	Jared Nelson		11/12/2017
Final rev 0	Bruce Turner	Marc Wohling		16/05/2018
Final Rev 1	Bruce Turner	Marc Wohling		14/06/2018

Direct all inquiries to:
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Ph: (08) 9430 8955 Fax: (08) 9430 8977

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2.2 Objectives 4
2.3 Management Strategy 4
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2.4 Recommendations 4

3 Wetland Buffer Rehabilitation Strategy 5
3.1 Revegetation 5
3.1.1 Objective 5
3.1.2 Management Strategies 5
3.1.3 Provenance 5
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1 INTRODUCTION

1.1 BACKGROUND

Ecoscape was engaged by NBR Investments to undertake the preparation of a Wetlands Buffer Rehabilitation Plan (WBRP) for the proposed Lot 81 South Western Highway, Davenport (the study area) (**Figure 1**). The WBRP is a requirement to support a Scheme Amendment Application for rezoning from Development Zone (Industrial) to Industry.

The WBRP addresses the conditions from The City of Bunbury (The City); Department of Water and Environmental Regulation (DWER) and the Department of Biodiversity, Conservation and Attractions (DBCA) as listed below. The conditions addressed in this Management Plan are listed as the following:

- DBCA recommends that the structure plan include a provision requiring a Wetlands Buffer Rehabilitation Plan (WBRP) to be prepared and implemented to the satisfaction of the Department.

Conditions not addressed in this Management Plan are listed as follows:

- A Foreshore Management Plan (FMP) for the Preston River adjacent to the development site to be prepared to the satisfaction of the City, DWER and DBCA.
- The Bushfire Management Plan (BMP) submitted with the structure plan for Lot 81 should be revisited concurrently with the development of this FMP. Fire management measures should not impact the wetland's vegetation, threatened fauna habitat, the Preston River riparian zone or the agreed Conservation Category (CC) Wetland buffer area. Given this DBCA recommends that the provision for a BMP to be prepared and implemented includes a requirement for consultation with the Department.
- DBCA recommends that the structure plan include a provision requiring a Black Cockatoo Habitat Tree Management Plan (BCHMP) to be prepared and implemented, which outlines how the fauna habitat trees will be protected from potential impacts associated with fill requirements and subsequent development.

Figure 1: Study Area Location.

1.2 STUDY AREA

The study area is bounded by the South Western Highway to the west, the Preston River to the east, the Bunbury Outer Ring Road to the south and cleared pasture land to the north. The study area is approximately 42 ha in extent with the proposed wetland buffers being approximately two hectares.

1.2.1 WETLAND

The study area is covered by a number of wetlands of three classes as classified by DBCA. Review of the Geomorphic Wetlands of the Swan Coastal Plain dataset (Department of Biodiversity Conservation and Attractions 2017) indicates a CC Wetland adjacent to the eastern boundary (UFI 14501), a small section of CC Wetland adjacent to the western boundary (UFI 14285, 15451), and an area of Resource Enhancement (RE) Wetland, also along the western boundary and within Lot 81 (UFI 14324). The remainder of the study area is covered by Multiple Use (MU) Wetlands (UFI 1325, 1327, 15450) (**Map 1**).

The EPA urges that all areas covered by CC Wetlands and the associated buffers are fully protected (EPA 2008). The EPA uses the recommendations in *Guidance Statement No. 33* to provide guidance for the protection of CC Wetlands by applying a buffer zone of at least 50 m from the wetland boundary (EPA 2008).

Consultation with Peter Hanly (DBCA Senior Regional Planning Officer, South West Region) resulted in modifications to the mapped wetlands as follows:

- The extension of the western boundary of the CC wetland of the Preston River. This extended boundary was realigned with one of the cadastral boundaries to the east of the Lot 81 structure plan boundary and is shown on **Map 2** as Conservation. The applied 50 m buffer area crosses into Lot 81 by approximately 10 m along the entire eastern boundary.
- Wetland UFI 14324 has been modified to part CC wetland, the area outside the western boundary of Lot 81, and part Multiple Use wetland, the area inside Lot 81 (**Map 2**).

The buffer area along the western boundary of Lot 81 is the subject area of this WBRP (**Map 3**).

1.3 PURPOSE AND APPROACH

The purpose of the WBRP is to provide management measures for the protection and enhancement of the wetland areas and applied buffers. The approach is to use best practice management to:

- provide rehabilitation of cleared areas of the applied buffer through revegetation and weed management
- manage stormwater flows to protect wetland values from pollutants, litter and future potential storage.

Wetland buffers are applied according to *Guidance Statement No. 33* and DBCA advice to ensure these values are sustainable.

1.3.1 CONTEXT

The study area is comprised of cleared pasture land with scattered and isolated trees and was assessed as being in a completely degraded bushland condition in 2016 (**Image 1**) (Ecoscape 2016). The land is seasonally inundated indicating a maximum groundwater level at the surface. Historical land use is documented as grazing. Lot 81 excludes the remnant Peppermint woodland adjacent to the south west (**Map 1**).

Image 1: Lot 81 buffer area looking south from the North West corner of Lot 81.

2 PLAN FOR MANAGEMENT

2.1 VISION

To ensure the CC Wetland environmental values, attributes and functions are protected.

2.2 OBJECTIVES

To enhance and protect CC Wetland areas and applied buffer zones within, and where they extend outside of, Lot 81.

2.3 MANAGEMENT STRATEGY

The CC Wetland buffers will be managed through the implementation of a management strategy to protect their environmental values. The area of land within Lot 81 and within the applied buffer forms the basis of this WBRP and is the subject of proposed management measures and recommendations (**Map 3**).

2.3.1 WETLAND BUFFER REHABILITATION STRATEGY

The area of land within Lot 81 and within the applied buffer will be rehabilitated through revegetation planting, weed control and maintenance to agreed completion criteria. Revegetation efforts will be monitored for success with recommendations made for follow up infill planting should this be required.

Both the revegetation and weed management measures will be subject to the achievement of completion criteria that will be agreed with DBCA and the City prior to commencement of works. Reporting on an annual basis is recommended to provide feedback to the City on the achievement of weed control and revegetation efforts.

2.4 RECOMMENDATIONS

Recommendations are made to highlight management measures required to be undertaken to ensure a successful and efficient implementation of the WBRP. Recommendations are given time frames and allocated actions to a responsible entity.

3 WETLAND BUFFER REHABILITATION STRATEGY

The current DBCA wetland mapping shows CC Wetlands (UFI 14285, 15451) and an RE Wetland (UFI 14324) located along the western boundary of Lot 81 (**Map 1**). The DBCA provided advice as to the treatment of these wetland boundaries in a Schedule of Submissions from the City of Bunbury, received 10 February 2017.

The DBCA (then the Department of Parks and Wildlife) advice was stated as follows:
"Parks and Wildlife considers that the vegetated portions of the REW should be treated as forming part of the CCW. Therefore Parks and Wildlife considers the proposed CCW buffer line should be depicted as a regular linear buffer line from north to south, which would include a portion of the REW."

Ecoscape has applied this advice and produced a wetland map depicting the proposed changes to the wetland categories, their boundaries and the associated buffers to the CC Wetlands (**Map 2**).

Further advice from DBCA relating to the protection and management of the buffer is stated as follows:
"The agreed CCW buffer area should be protected from development, pollutants, litter, future potential storage and accidental vehicle impacts. The SP refers to the Bunbury-Wellington Region Plan policies and guidelines within the "Planning Unit P8: Davenport" area including requirements for landscape buffers, conservation and tree planting areas. Given this Parks and Wildlife recommends that the WBRP include a requirement for rehabilitation within the agreed CCW buffer area to enhance and protect the CCW areas."

This Management Plan is in response to the recommendations made by DBCA.

3.1 REVEGETATION

3.1.1 OBJECTIVE

The objective for the revegetation of the applied buffer is to enhance and protect CC wetlands and minimise the impact of activities that could result in degradation to wetland communities.

3.1.2 MANAGEMENT STRATEGIES

The main issues that need to be addressed in improving the condition of the buffer area are:
- reconstruction in the form of revegetation
- assisted natural regeneration in the form of weed control and grazing exclusion.

Timing of revegetation works will be as follows:
- general earthworks to attain correct slope and scalp turf from topsoil layer
- construction of rabbit and kangaroo exclusion fencing
- initial weed control spraying
- initial tubestock planting in first winter post site earthworks being completed
- second weed control event 3 months post initial planting
- first monitoring event to establish achievement of success criteria 6 months post initial planting
- third weed control event 10-12 months following initial planting
- second monitoring event 12 months post initial planting, recommendations made for infill planting and further weed control if necessary to maintain desired density
- third monitoring event 18 months post initial planting.
- removal of fencing once vegetation established (approximately five years).

3.1.3 PROVENANCE

A proposed revegetation species planting list is provided in **Appendix One**. It is important that propagules are first attempted to be sourced from regional vegetation to preserve the provenance where practicable. If not enough propagules can be obtained, propagules are to be sourced from nearby areas with similar climate and geology.

3.1.4 METHODS FOR PLANTING

The optimum tubestock planting time for wetland vegetation is during their active growing period in spring and when soil conditions are not waterlogged. This needs to be taken into account when programming works.

Table 1 describes the methods suitable to planting tubestock for revegetation. Strict supervision of planting stock will be required to avoid undesirable rates and clumping of species distribution.

Table 1: Methods used for planting tubestock

Methods for Planting
Prior to planting, chemical and manual weed control will be undertaken to ensure seedlings are planted into weed free areas.
Construction of rabbit and kangaroo exclusion fencing will be undertaken to reduce grazing of tubestock
The installation of tubestock will ensure a general density of at least 3 plants per square meter.
Only tubestock that are healthy, disease free and actively growing with well-developed root system should be planted.
Tubestock will be planted only when the soil is sufficiently wet to plant without the need for additional watering and when there is minimal risk of waterlogging.
Species planting list provided and to be adhered to (Appendix Two).
Tubestock to be sourced from accredited nurseries to ensure stock is disease and weed free.

Revegetation will not be irrigated; it is therefore essential that seedlings be planted as soon as practical after soil has become sufficiently wet and when there is minimal risk of waterlogging. Revegetation will be undertaken over a two year period to ensure sufficient coverage is achieved.

An integral part of the planting program is supplementary planting in subsequent winters to address plant deaths. Typically non irrigated planting accepts a survival of approximately 70%. DBCA and the City may specify a higher success rate. Should monitoring determine that mortality of seedlings in excess of the completion criteria has occurred, infill planting will be conducted to reach the final density targets.

3.1.5 MONITORING AND MAINTENANCE

The revegetation program should be monitored to detect any poor success rates or unsatisfactory revegetation of an area following a two year period.

Formal monitoring is to occur bi-annually at the beginning of winter (primarily for weed monitoring) and the end of summer (primarily for survival and in-fill planting) with in-fill planting to be programmed for the following winter (or late spring if wetland species), to address tubestock mortality. Monitoring should be undertaken by a qualified environmental scientist and include assessing:

- seedling survival
- foliage % cover
- species representation
- presence of weeds and % cover
- overall success of plant establishment
- photographic records of revegetation
- condition of fencing.

3.1.6 COMPLETION CRITERIA

Suggested completion criteria are listed in **Table 2**.

Table 2: Suggested Completion Criteria for Revegetation Projects

Assessment Parameter	Method	Completion Criteria
Soil and landform	Visual inspection	Site must be safe, stable & suitable for agreed use without inputs
Seedling survival	Quadrats, photo monitoring	3 plants/m^2 installed with 70% survival recorded
% Foliage cover	Quadrats	100% cover of native species targeted for final density. Monitoring should comment on if plant growth appears to be on a trajectory to achieve this target
Species representation	Quadrats, transects	75% of species used in the revegetation program should be represented
Monitoring and maintenance	Quadrats, transects, photo monitoring	Maintenance of the revegetated sites should occur biannually. Formal monitoring with annual reports of progress being submitted to the City. The results, problems encountered and how they were rectified should be described in the annual report.

3.1.7 RECOMMENDATIONS

	Actions	Priority	Responsibility
3	**Revegetation**		
3.1	Engage a qualified environmental consultant to undertake revegetation works	High	Developer
3.2	Confirm planting species lists, tubestock availability and planting densities with DBCA	Medium	Developer
3.3	Undertake monitoring and maintenance of the rehabilitation areas for 2 years after development on an bi-annual basis	High	Developer
3.4	Identify areas of rehabilitation that require supplemental planting from the winter monitoring events	Medium	Developer
3.5	Undertake infill planting	High	Developer

3.2 WEED CONTROL

Weeds are all plants that are not endemic to the site. Some are declared pest weeds under the Agriculture and Related resources Protection Act.

3.2.1 OBJECTIVES

The objectives of weed control are to:

- remove competition to rehabilitation species
- reduce the extent and/or density of targeted competition weeds
- prevent introduction of additional weed species
- minimise detrimental impacts of the weed control program such as off target impacts on the native biota
- improve the visual amenity of the wetland buffer
- reduce potential fire risk.

Weed control and revegetation work will be undertaken simultaneously as the process of landform re-construction takes place. This will allow for the minimisation of re-invasion. Efforts should be conducted in a staged approach to focus resources efficiently and ensure a good coverage and density of plantings.

3.2.2 MANAGEMENT STRATEGIES

3.2.2.1 Scalping

Due to the entire area of the buffer being covered by pasture grasses and introduced weed species it is proposed to mechanically scalp/scour the topsoil layer by loader, stockpiling the removed layer on Lot 81 as a potential landfill source. This method will allow for minimal weed control efforts initially and facilitate revegetation efforts.

If practical, mulching to a depth of 100 mm should be considered to be spread across the site prior to planting taking place to deter weed species germination.

3.2.2.2 Prioritisation

Prioritisation of weed control is critical to the success of achieving viable native wetland species cover. Good quality early control of weeds will achieve the most efficient use of limited resources. Prioritisation aims to:

- maintain native wetland vegetation in the best condition
- eradicate new weeds introduced into the site which pose a significant threat to environmental and social values
- co-ordinate weeding programs to ensure an integrated approach to works
- control degradation processes that increase ecosystem vulnerability.

3.2.2.3 Methods of Weed Control

Chemical and manual weed control should be undertaken after topsoil scouring and again following initial planting. Control methods suitable for likely present priority weed species are as follows:

1. Spot spraying
2. Herbicide wipe, stem injection, cut stump
3. Hand weeding, pulling, digging
4. Achieve dense canopy cover as early as possible to shade and block out potential weed re-establishment.

3.2.2.4 Herbicides

It is necessary that the application of herbicides be in accordance with labelling requirements or the manufacturers Materials Safety Data Sheet (MSDS) and must be undertaken by qualified personnel trained in the application of herbicide chemicals. The application of any herbicide for purposes not specified on the labelling requires an Off-Label Permit from the National Registration Authority in Canberra. Care must be taken herbicides are not applied on adjacent native vegetation.

Surfactants should not be used with the herbicide treatments near or in the buffer. Many common herbicides such as Roundup® contain NPE surfactants which are known to affect the development of amphibian species, which can lead to a decline or even loss of such fauna species (Mann & Biggs 1999). Herbicides not containing NPE surfactants, such as Roundup Biactive®, are strongly recommended.

The application of herbicides must also be in accordance with water catchment restrictions. Chemical based weed control strategies, in particular, must recognise potential adverse impacts on water resources such as lakes, wetlands, streams, rivers and dams. Significant control measures must be implemented in Public Drinking Water Sources Areas. The Department of Health (2007) PSC-88 *Use of Herbicides in Water Catchment Areas* provides further advice on this matter. The herbicide's label should also contain a section outlining appropriate measures for the *"Protection of Wildlife, Fish, Crustaceans and Environment".*

3.2.3 MONITORING AND MAINTENANCE

Monitoring and evaluation are key actions that need to be undertaken during weed management to measure the success of control strategies. Performance indicators will be developed to objectively assess the success of weed control strategies. This will provide a mechanism for modifying the strategy and maintaining its effectiveness.

When monitoring, the following strategies should be employed:

- establish monitoring quadrats in areas subject to weed control programmes to record the effectiveness of control methods
- monitoring quadrats are selected by random number along a transect e.g. 10 x 1 m2 quadrats at 10 random sites along a transect through the site, sites are selected by random number generator
- for species-led control – monitor effectiveness of control of discrete weed populations or patches, including presence or absence, and if present, the degree of new infestation
- for site-led control – establish monitoring quadrats and survey and record on a biannual basis
- for both control methods – monitor the effectiveness of different control methods used (manual vs. chemical control; spot spray vs. blanket spray; contractor vs. community control).

The use of photographs from set points also enhances this process and will be carried out on a biannual basis as part of the monitoring which will also involve documenting the location and relative abundance of weed species. Quarterly maintenance/management inspections, including inspection of tree guards, will be undertaken for a period of two years to monitor the success of the rehabilitation process.

Following this initial period, it is recommended that the site continue to be monitored yearly and appropriate weed treatment be implemented to target identified weed species.

3.2.4 COMPLETION CRITERIA

Table 3 shows recommended success criteria for the weed control efforts.

Table 3: Suggested Completion Criteria for Weed Management

Assessment Parameter	Method	Completion Criteria
Weed presence	Weed mapping	No Weeds of National Significance (WONS) or Declared Pest plants to be within the buffer zones or adjacent landscape zones at the end of the monitoring period.
Weed cover	Weed mapping	No more than 10% weed cover and a maximum of 5 weeds/ m2

3.2.5 RECOMMENDATIONS

Actions		Priority	Responsibility
4	**Weed Control**		
4.1	Weed control works of the revegetated sites should occur during optimal control times, up to 3 times a year.	High	Developer
4.2	Formal monitoring with annual reports of progress being submitted to the City. The results, problems encountered and how they were rectified should be described in the annual report.	High	Developer

4 IMPLEMENTATION PLAN

Table 4 shows a provisional schedule of the previous mentioned actions and monitoring responsibilities. All reporting to the City of Bunbury will be on an annual basis, unless not applicable to the Action.

Table 4: Implementation Plan

Actions	Frequency	Timeframe	Responsibility	Reporting
Weed Control				
Undertake/Complete scalping/scouring of Buffer areas within Lot 81	Once	Prior to revegetation works	Developer	N/A
Undertake weed control in conjunction with revegetation activities.	As required in two year maintenance period	Prior to revegetation works and on completion of works until completion criteria are met.	Developer	N/A
Ensure application of any herbicides is in accordance with the material safety data sheets and Department of Health (2007) restrictions	As required	Ongoing for the two year management period, or until handover to the City.	Developer	N/A
Implement monitoring program to assess changes in weed species and distribution in the study area and adapt weed strategies accordingly	Bi-annually	Two years maintenance period or until completion criteria are met.	Developer	Annual Report
Revegetation				
Engage a qualified environmental contractor to undertake revegetation works	Once prior to subdivision and then as required until handover to City of Busselton	Post subdivision earthworks, and including the second winters in-fill plantings until completion criteria are met.	Developer	N/A
Confirm revegetation species lists and planting densities are specified and agreed by the City and DBCA	Once	Prior to subdivision earthworks as part of the approved Management Plan	Developer	N/A
Construct rabbit and kangaroo exclusion fencing	Once	Prior to revegetation works	Developer	N/A
Undertake revegetation planting	Initial	Initial planting	Developer	Annual Report
Undertake monitoring of the revegetation areas for two years after development	Biannually	Ongoing for the two year management period, or until handover to the City.	Developer	Annual Report
Identify areas of revegetation that require supplemental planting, and conduct infill planting	Initially at the end of summer, then bi-annually	Two years maintenance period or until completion criteria are met.	Developer	Annual report should also identify if this is required and where it will occur.

Table 5: Event Timeline.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Weed Control																								
Undertake/Complete scalping/scouring of Buffer areas within Lot 81																								
Undertake weed control in conjunction with revegetation activities																								
Implement monitoring program to assess changes in weed species and distribution																								
Revegetation																								
Construct rabbit and kangaroo exclusion fencing																								
Undertake revegetation planting																								
Undertake monitoring of the revegetation areas for two years after development																								
Identify areas of revegetation that require supplemental planting, and conduct infill planting																								

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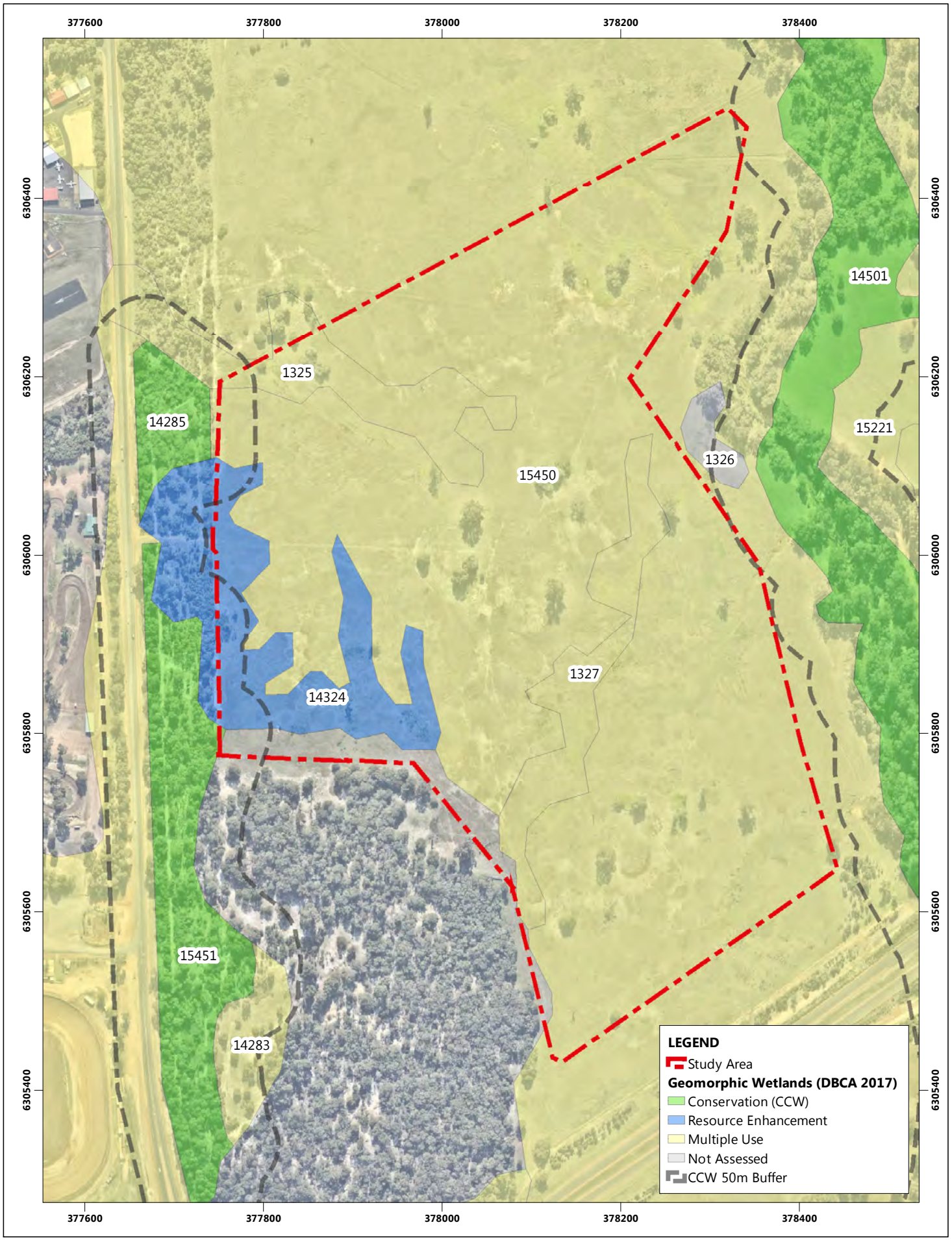
MAPS



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DATUM: GDA 1994
UNITS: METER

DATASOURCES :
IMAGERY: NEARMAP 2016
DATA: GEOMORPHIC WETLANDS DBCA 2017

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
01	AF	BT	14/11/2017

N

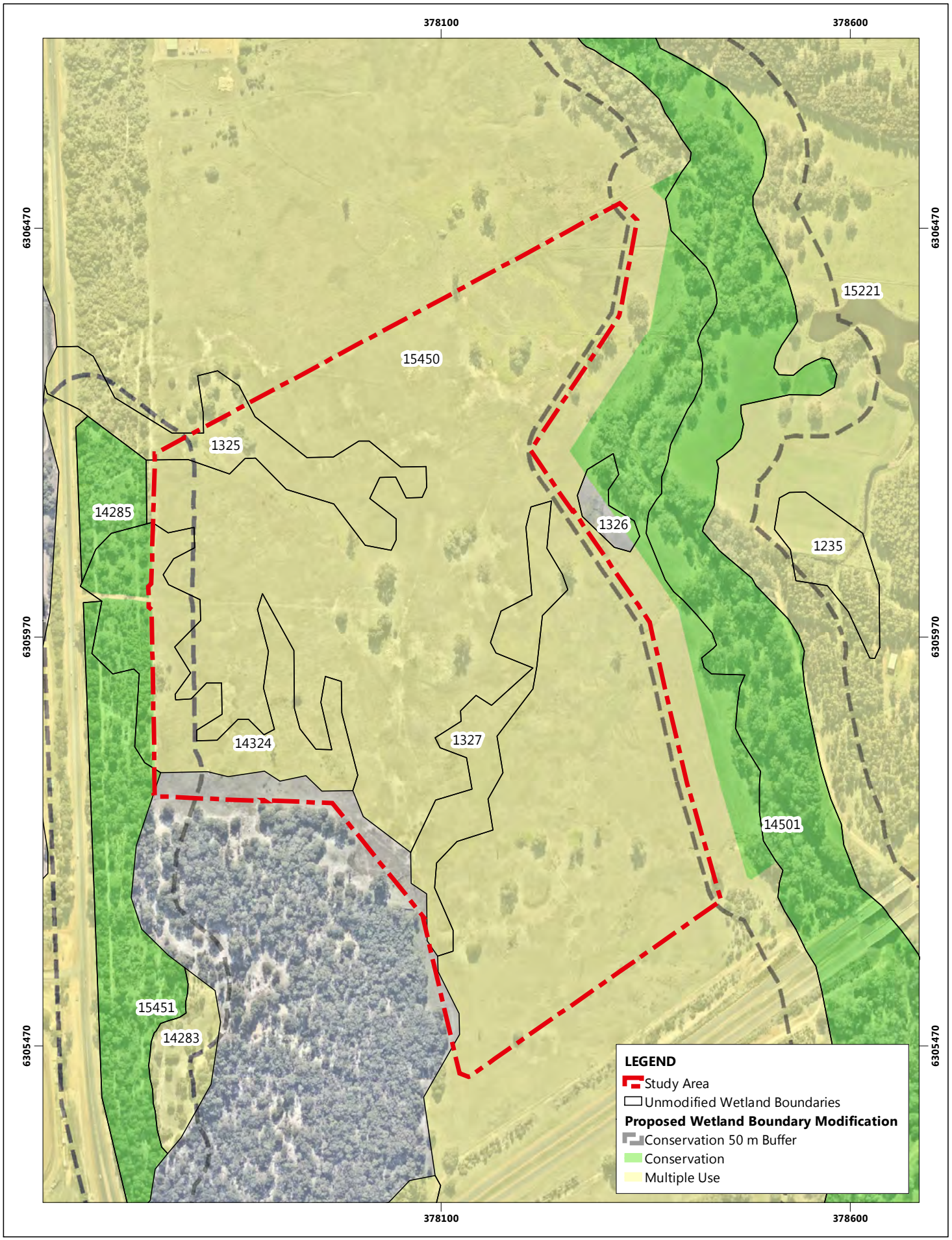
0 50 100 150 m

CURRENT GEOMORPHIC WETLANDS MAPPING

LOT 81 SOUTH WESTERN HIGHWAY WETLANDS BUFFER REHAB. PLAN

CLIENT: NBR INVESTMENTS

MAP 01



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DATUM: GDA 1994
UNITS: METER

DATASOURCES :
IMAGERY: NEARMAP 2016
DATA: GEOMORPHIC WETLANDS DBCA 2017

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
01	AF	BT	14/11/2017

N

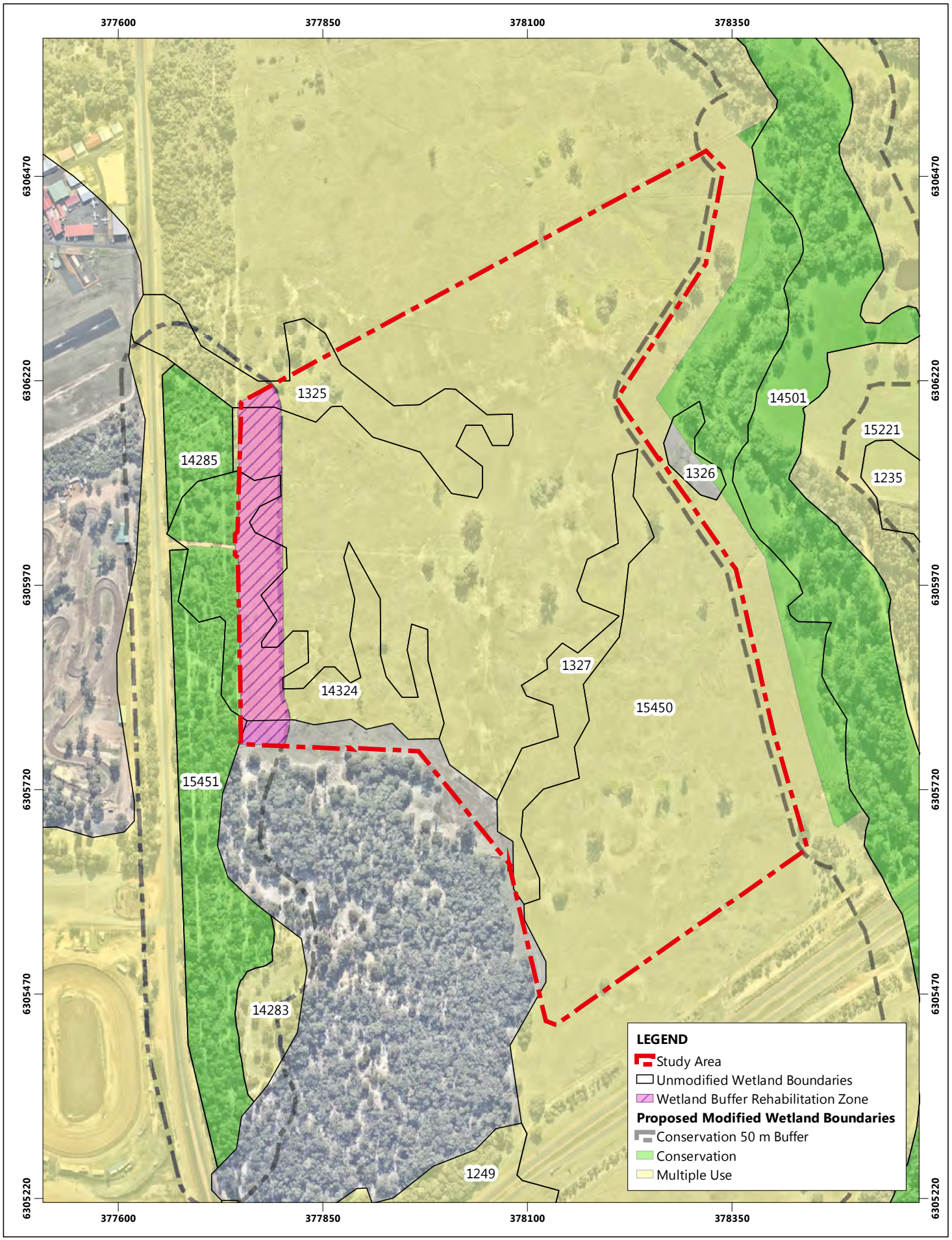
0 50 100 150 m

PROPOSED WETLAND BOUNDARY MODIFICATION

LOT 81 SOUTH WESTERN HIGHWAY WETLANDS BUFFER REHAB. PLAN

CLIENT: NBR INVESTMENTS

MAP 02



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DATUM: GDA 1994
UNITS: METER

DATASOURCES :
SERVICE LAYERS: STREETS- STREET PRO 2009
IMAGERY: NEARMAP 2016
DATA: GEOMORPHIC WETLANDS DBCA 2017

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
02	DR	BT	09/04/2018

N

0 275 550 825 m

WETLAND BUFFER REHABILITATION PLAN

LOT 81 SOUTH WESTERN HIGHWAY WETLANDS BUFFER REHAB. PLAN

CLIENT: NBR INVESTMENTS

MAP 03

APPENDIX ONE Revegetation Species Planting List

Wetland Buffer Revegetation Zone

Stratum and Density (plants/m^2)	Species
OVERSTORY (0.5/m^2)	*Agonis flexuosa*
	Eucalyptus rudis
	Melaleuca rhaphiophylla
	Melaleuca preissiana
	Corymbia calophylla
SHRUB (1/m^2)	*Acacia lasiocarpa var. lasiocarpa*
	Acacia pulchella
	Bossiaea eriocarpa
	Bossiaea linophylla
	Grevillea diversifolia
	Hakea lissocarpha
	Hakea prostata
	Hakea varia
	Hypocalymma angustifolium
	Hypocalymma robustum
	Jacksonia furcellata
	Kunzea glabrescens
	Melaleuca lateritia
	Melaleuca viminea
GROUNDCOVER (1.5/m^2)	*Aotus gracillima*
	Astartea fascicularis
	Baumea juncea
	Conostylis aculeata
	Dasypogon bromeliifolius
	Dianella revoluta var. revoluta
	Ficinia nodosa
	Juncus pallidus
	Kennedia prostrata
	Lepidosperma longitudinale
	Lomandra sericea
	Patersonia occidentalis

Bio Retention Swale Sedge Species

Species
Anigozanthos flavidus
Ficinia nodosa
Gahnia trifida
Juncus kraussii
Juncus subsecundus
Juncus pallidus
Melaleuca incana
Melaleuca lateritia
Poa poiformis

* combined species density of 4/m^2

Appendix E

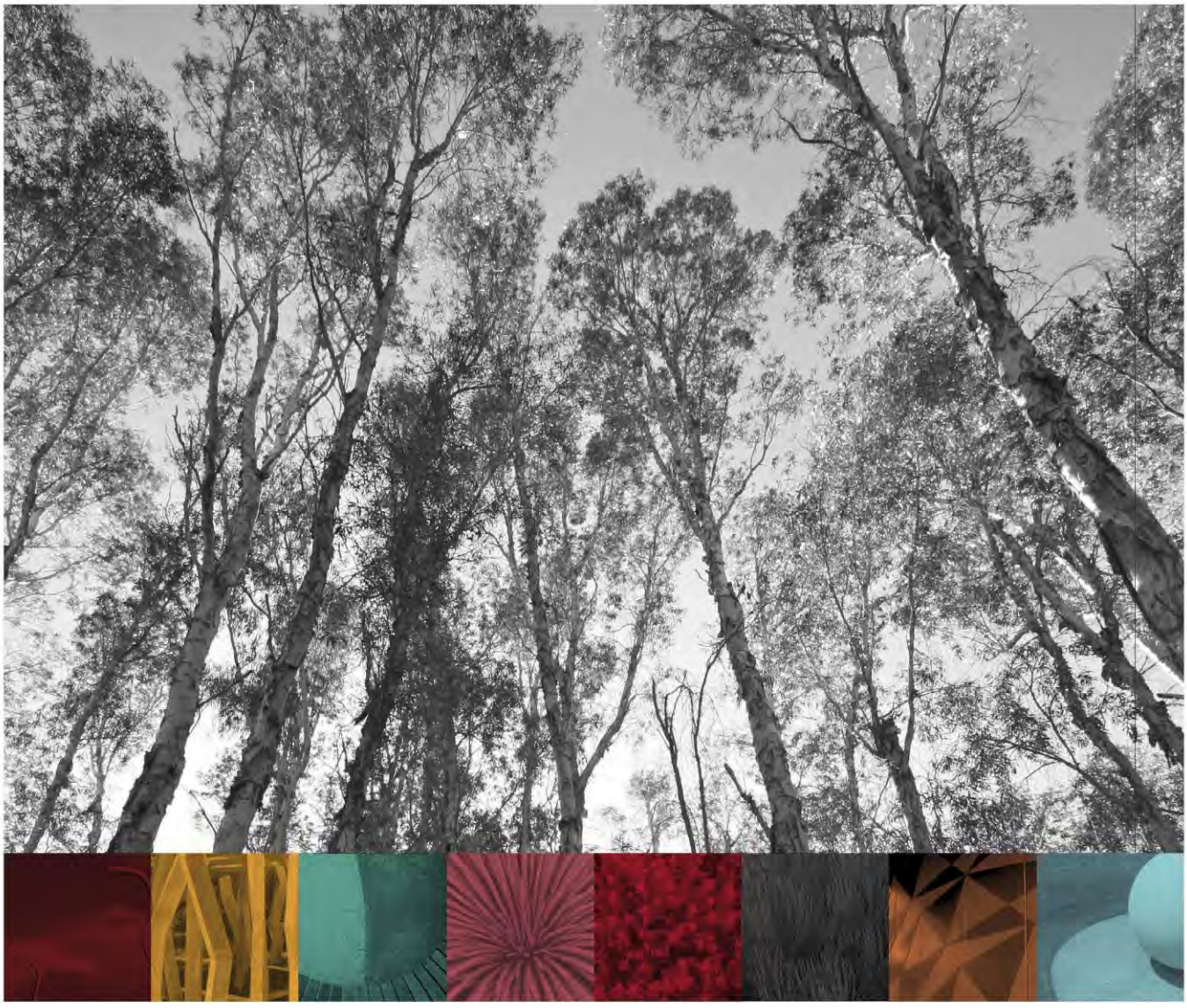
Black Cockatoo Habitat Tree Management Plan

Prepared by Ecoscape

Lot 81 South Western Highway, Davenport - Black Cockatoo Habitat Tree Management Plan

NBR Investments

ecoscape



VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Draft Rev 0	Bruce Turner	 Damien Cancilla Environment Group Leader	 Damien Cancilla Environment Group Leader	22/11/2017
Final Rev 0	Bruce Turner	 Damien Cancilla Environment Group Leader	 Damien Cancilla Environment Group Leader	09/04/2018

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1 INTRODUCTION

1.1 BACKGROUND

Ecoscape was engaged by NBR Investments to undertake the preparation of a Black Cockatoo Habitat Tree Management Plan (BCHTMP) for the proposed Lot 81 South Western Highway, Davenport (the study area) (**Figure 1**). The BCHTMP is a requirement to support a Scheme Amendment Application for rezoning from Development Zone (Industrial) to Industry.

The BCHTMP addresses the conditions from The City of Bunbury (The City) and the Department of Biodiversity, Conservation and Attractions (DBCA) as listed below. The conditions addressed in this BCHTMP are listed as the following:

- DBCA recommends that the structure plan include a provision requiring a Black Cockatoo Habitat Tree Management Plan (BCHTMP) to be prepared and implemented, which outlines how the fauna habitat trees will be protected from potential impacts associated with fill requirements and subsequent development

Conditions not addressed in this Management Plan are listed as follows:

- A Foreshore Management Plan for the Preston River adjacent to the development site to be prepared to the satisfaction of the City, DWER and DBCA
- The Bushfire Management Plan submitted with the structure plan for Lot 81 should be revisited concurrently with the development of this Foreshore Management Plan. Fire management measures should not impact the wetland's vegetation, threatened fauna habitat, the Preston River riparian zone or the agreed CCW buffer area. Given this DBCA recommends that the provision for a Fire MP to be prepared and implemented includes a requirement for consultation with Parks and Wildlife
- DBCA recommends that the structure plan include a provision requiring a Wetlands Buffer Rehabilitation Plan (WBRP) to be prepared and implemented to the satisfaction of the Department.

Figure 1 Study Area

1.2 STUDY AREA

The study area is bounded by the South Western Highway to the west, the Preston River to the east, the Bunbury Outer Ring Road to the south and cleared pasture land to the north. The study area is approximately 42 ha in extent.

1.3 BLACK COCKATOO HABITAT SURVEY

1.3.1 REGIONAL CONTEXT

All three of the conservation significant Black Cockatoo species are likely to occur in the locality of the study area as identified by the Commonwealth guidelines mapping of breeding and non-breeding ranges (Commonwealth of Australia 2012).

Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)

EPBC Act – Vulnerable; WC Act – Schedule 3

This subspecies occurs in the humid and subhumid south-west; mainly in hilly interior, north to Gingin (formerly to Dandaragan) and east to Mt Helena (formerly to Toodyay), Christmas Tree Well, near Brookton, North Bannister (formerly to Wandering), Mt Saddleback, Kojonup, Rocky Gully, upper King River and east to the Green Range. It is endemic to Western Australia (Department of Conservation and Environment & Australian Government 2008; Johnstone & Storr 1998).

Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)

EPBC Act – Vulnerable; WC Act – Schedule 3

The Western Australian Museum lists describes the distribution of this species as occurring in south-western humid and subhumid zones, north to Gidgegannup, east to Clackline, Wandering, Quindanning, the Perup River, Lake Muir and King River, and west to eastern strip of Swan Coastal Plain including West Midland, Gosnells, Byford, North Dandalup, Yarloop, Wokalup and Bunbury also the Stirling and Porongurup Ranges and along the south coast to Waychinicup National Park. It is endemic to Western Australia (Johnstone & Storr 1998). The Commonwealth guidelines have mapped the Bunbury region as a known breeding area.

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

EPBC Act – Endangered; WC Act – Schedule 2

Carnaby's cockatoo is endemic to the south-west of Western Australia, with a widespread distribution. The species is highly mobile and displays a seasonal migratory pattern that is linked to breeding (Berry 2008; Saunders 1980; Saunders 1990). Breeding takes place between late July and December and most breeding occurs in the inland parts of its distribution, in areas receiving between 300 and 750 mm of annual average rainfall (Saunders 1974). During the non-breeding season (January to July) the majority of the birds move to the higher rainfall coastal regions of their range including the Midwest coast, Swan Coastal Plain and south coast (Department of Parks and Wildlife 2013).

There are a number of resident populations throughout the species range that do not show breeding migration but remain close to their breeding sites year round (e.g. Jarrah forests from Mundaring to Nannup, Hopetoun, Perth and Peel region (Johnstone *et al.* 2011; Johnstone & Storr 1998)). There has been an apparent expansion in the breeding range to include areas further west and south since the middle of last century with a more rapid increase in the past 10-30 years into the Jarrah-Marri forests and the coastal tuart forests south of Perth (Johnstone *et al.* 2011; Johnstone & Storr 1998).

1.3.2 FIELD ASSESSMENT METHODS

A Black Cockatoo habitat assessment was conducted following relevant Commonwealth Black Cockatoo referral guidelines (Commonwealth of Australia 2012) and the recent draft referral guidelines (CoA, DotEE 2017). The following actions were undertaken:

- Demarcate, photograph and record the GPS locations of potential and existing breeding habitat as defined by Commonwealth guidance (i.e. trees of suitable species having DBH over 500 mm; including

Eucalyptus rudis and *E. marginata*). All three Black Cockatoo species utilise both *E. rudis* and *E. marginata* for foraging and breeding.
- record the location and height of all trees with hollows within the study area
- identify and record tree hollow size and height, including evidence of use by Black Cockatoo
- assessment of foraging habitat quality using the draft scoring tool.

A survey of the study area was conducted by an Ecoscape Environmental Scientist on 19 July 2016. The entire study area was traversed on foot and all trees with DBH of 500 mm or greater were recorded and described following the Commonwealth draft referral guidelines. The data from the 2016 survey was then assessed using the recent draft referral guidelines of 2017 for foraging habitat quality (CoA, DotEE 2017).

Mapping was produced of identified potential breeding habitat. The Breeding habitat trees identified were further classified dependent on whether or not hollows of a suitable size were present to provide nesting opportunities for Black Cockatoo species.

1.3.2.1 Breeding Habitat

The fauna survey for Black Cockatoo habitat followed the *Black Cockatoo referral guidelines* (Commonwealth of Australia 2012). In addition to following the guidelines each tree was scored for breeding habitat value using a scoring system developed by Dr Mike Bamford (2016), the score reflects the existing value of the tree characteristics with respect to its potential to as breeding habitat and therefore assists in more accurately assessing the real impact of disturbance (**Table 1**).

Table 1: Grading system for the assessment of potential breeding habitat for Black Cockatoos

Class	Description of Tree and Hollows/Activity
1	Active nest observed; adult (or immature) bird seen entering or emerging from hollow.
2	Hollow of suitable size and angle (i.e. near-vertical) visible with chew marks around entrance.
3	Potentially suitable hollow visible but no chew marks present; or potentially suitable hollow present (as suggested by structure of tree, such as large, vertical trunk broken off at a height of >10m).
4	Tree with large hollows or broken branches that might contain large hollows but hollows or potential hollows are not vertical or near-vertical; thus a tree with or likely to have hollows of sufficient size but not to have hollows of the angle preferred by Black-Cockatoos.
5	Tree lacking large hollows or broken branches that might have large hollows; a tree with more or less intact branches and a spreading crown.

1.3.3 FORAGING HABITAT QUALITY

A scoring tool has been developed by the Commonwealth to determine if the impact area contains quality foraging habitat (**Table 2**)(Commonwealth of Australia 2017). Habitat surveys must be sufficient to complete the scoring tool and provide a score and justification for foraging habitat quality.

The elements of the scoring tool require surveys to provide information on the following:
- the presence of all plant species that provide foraging, including non-native food sources used by black cockatoos
- the presence of tree species used for breeding
- use as a roosting site
- the vegetation present in the surrounding area i.e. at least 12 km from the impact area, including proximity to any breeding habitat, roosting sites or watering points
- breeding habitat, such as an estimate of the number of trees with a diameter at breast height (1.3 metres from the ground) of 500 mm, or 300 mm if salmon gum or wandoo
- numbers of any known nesting trees
- presence of disease, such as *Phytophthora cinnamomi* or marri canker (*Quambalaria coyrecup*).

Table 2: Commonwealth Foraging Quality Scoring Tool (Commonwealth of Australia & DotEE 2017)

Starting Score	Foraging habitat for Carnaby's Cockatoo	Foraging habitat for Baudin's Cockatoo	Foraging habitat for Forest Red-tailed Black cockatoo
10 (Very high quality)	Foraging habitat that is being managed for black cockatoos such as habitat that is the focus of successful rehabilitation, and/or has some level of protection from clearing, and/or is quality habitat described below with attributes contributing to meet a score of ≥10	Foraging habitat that is being managed for black cockatoos such as habitat that is the focus of successful rehabilitation, and/or has some level of protection from clearing, and/or is quality habitat described below with attributes contributing to meet a score of ≥10	Foraging habitat that is being managed for black cockatoos such as habitat that is the focus of successful rehabilitation, and/or has some level of protection from clearing, and/or is quality habitat described below with attributes contributing to meet a score of ≥10
7 (High quality)	Native shrubland, kwongan heathland and woodland dominated by proteaceous plant species such as *Banksia* spp. (including *Dryandra* spp.), *Hakea* spp. and *Grevillea* spp., as well as native eucalypt woodland and forest that contains foraging species, including along roadsides. Does not include orchards, canola, or areas under a RFA	Native eucalypt woodlands and forest, and proteaceous woodland and heath, particularly marri, including along roadsides. Does not include orchards or areas under a RFA	Jarrah and marri woodlands and forest, and edges of karri forests, including wandoo and blackbutt, within the range of the subspecies, including along roadsides. Does not include areas under a RFA
5 (Quality)	Pine plantation or introduced eucalypts	Pine plantation or introduced eucalypts	Pine plantation or introduced eucalypts
1 (Low quality)	Individual foraging plants or small stand of foraging plants	Individual foraging plants or small stand of foraging plants	Individual foraging plants or small stand of foraging plants
Additions	**Context adjustor - attributes improving functionality of foraging habitat**	**Context adjustor - attributes improving functionality of foraging habitat**	**Context adjustor - attributes improving functionality of foraging habitat**
+3	Is within the Swan Coastal Plain (important foraging area).	Is within the known foraging area (see map).	Jarrah and/or marri show good recruitment (i.e. evidence of young trees).
+3	Contains trees with suitable nesting hollows	Contains trees with suitable nesting hollows	Contains trees with suitable nesting hollows
+2	Primarily contains marri	Primarily contains marri	Primarily contains marri and/or jarrah
+2	Contains trees with potential to be used for breeding (dbh ≥ 500 mm or ≥ 300 mm dbh for salmon gum and wandoo)	Contains trees with potential to be used for breeding (dbh ≥ 500 mm or ≥ 300 mm dbh for salmon gum and wandoo)	Contains trees with potential to be used for breeding (dbh ≥ 500 mm or ≥ 300 mm dbh for salmon gum and wandoo)
+1	Is known to be a roosting site	Is known to be a roosting site	Is known to be a roosting site
Subtractions	**Context adjustor - attributes reducing functionality of foraging habitat**	**Context adjustor - attributes reducing functionality of foraging habitat**	**Context adjustor - attributes reducing functionality of foraging habitat**
-2	No clear evidence of feeding debris.	No clear evidence of feeding debris.	No clear evidence of feeding debris.
-2	No other foraging habitat within 6 km.	No other foraging habitat within 6 km.	No other foraging habitat within 6 km.
-1	Is > 12 km from a known breeding location	Is > 12 km from a known breeding location	Is > 12 km from a known breeding location
-1	Is > 12 km from a known roosting site	Is > 12 km from a known roosting site	Is >12 km from a known roosting site
-1	Is > 2 km from a watering point	Is > 2 km from a watering point	Is > 2 km from a watering point
-1	Disease present (e.g. Jarrah Dieback, *Phytophthora cinnamomi* or Marri Canker, *Quambalaria coyrecup*)..	Disease present (e.g. Jarrah Dieback, *Phytophthora cinnamomi* or Marri Canker, *Quambalaria coyrecup*)..	Disease present (e.g. Jarrah Dieback, *Phytophthora cinnamomi* or Marri Canker, *Quambalaria coyrecup*).

1.3.4 BLACK COCKATOO HABITAT SURVEY RESULTS

The majority of trees observed on the site were Peppermints (*Agonis flexuosa*), Flooded Gums (*Eucalyptus rudis*) and Swamp Paperbarks (*Melaleuca preissii*). A small number of Jarrah (*Eucalyptus marginata*) were recorded on the edges of areas of higher elevation.

According to the Commonwealth Black Cockatoo referral guidelines, of the tree species present, Flooded Gums and Jarrah trees are considered as breeding habitat (Commonwealth of Australia 2012). The locations of these species, their DBH and a description of the hollows present are provided in **Table 3** with images displayed of each nesting habitat tree in **Appendix Two**.

1.3.4.1 Black Cockatoo Habitat Trees

Of the 15 trees mapped as Black Cockatoo habitat trees, eight were observed to have hollows of a medium size (10-20cm diameter) or greater (highlighted in **Table 3**). Hollows of this size are known to be suitable for breeding hollows for Cockatoo species (Johnstone *et al.* 2011). Additionally two of these trees (tree numbers BCHT 03 and BCHT 06) were observed to have hollows which were occupied by Pink and Grey Galahs indicating their suitability for nesting. Black Cockatoo habitat trees and habitat trees identified to have suitable hollows are displayed on **Map 1.**

Black Cockatoo habitat trees were scored using the scale (**Table 1**) developed by Dr Mike Bamford (2016), to further refine nesting value to Black Cockatoo. No trees were recorded as either Class 1 or Class 2. There were three trees scored as Class 3, which have high value as nesting habitat and should be retained if possible. Class 3 trees possess the necessary characteristics preferred by the Black Cockatoos but no evidence of use was recorded. Six trees were scored as Class 4 and six trees scored as Class 5. Class 4 trees have hollows large enough for nesting but do not exhibit the characteristics preferred by the birds. Class 5 trees do not currently exhibit the characteristics necessary for Black Cockatoo to use for nesting.

None of the trees showed signs of nesting activity (e.g. hollows with chew marks at entrance) at the time of the survey, however the trunks were of suitable size (DBH >500 mm) and have a high potential to form suitable hollows in the future.

1.3.4.2 Foraging and Roosting Habitat

Based on the guidelines for the three Black Cockatoo species (Commonwealth of Australia 2012), the trees present within Lot 81 were assessed as suitable foraging habitat (Ecoscape 2016).

The *Draft Referral Guideline* (Commonwealth of Autralia & DotEE 2017) now has a scoring tool for the assessment of foraging habitat quality and was scored as follows:

- Starting score – Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo combined
  - **+1** (Low Quality) being individual foraging plants or small stand of foraging plants
- Additions –
  - **+3** within the Swan Coastal Plain
  - **+3** Contains trees with suitable nesting hollows
  - **+2** Contains trees with potential to be used for breeding (dbh ≥ 500 mm)
- Subtractions
  - **-2** No clear evidence of feeding debris.

The final score is **7** (of a maximum score of 21), according to the guidelines this indicates high quality habitat which has the assigned scores between **6** and **8**. Impacts on high quality foraging habitat are likely to have a significant impact, with a lower acceptability of loss in hectares; the action should be referred for assessment (Commonwealth of Autralia & DotEE 2017).

Table 3: Identified Potential Nesting Habitat Trees (high value trees highlighted).

ID	Species	Height (m)	DBH (mm)	Number of Hollows	Class	Easting MGA 50	Northing MGA 50
BCHT 01	*Eucalyptus marginata*	6	710	none	5	377746.232	6306147.725
BCHT 02	Unknown eucalypt (dead)	8	890	none	5	377754.682	6306193.299
BCHT 03	*Eucalyptus rudis*	16	1330	1 medium hollow, 2 small hollows	4	378138.068	6306322
BCHT 04	*Eucalyptus rudis*	16	1590	none	5	378281.943	6306326.914
BCHT 05	*Eucalyptus rudis*	16	2550,860,1090	2 large hollows low on trunk, 2 small hollows	3	378298.701	6306340.876
BCHT 06	*Eucalyptus rudis*	26	2100	1 medium hollow, 4 small hollows	4	378254.292	6306069.178
BCHT 07	*Eucalyptus rudis*	7	1980	none	5	378315.353	6305963.374
BCHT 08	*Eucalyptus rudis*	22	2560	1 large hollow, 3 small hollows	3	378126.117	6305962.991
BCHT 09	*Eucalyptus rudis*	10	1850,540	none	5	378157.832	6306067.41
BCHT 10	*Eucalyptus rudis*	14	1020	1 small hollow	4	377989.114	6306092.456
BCHT 11	*Eucalyptus rudis*	23	2610	1 large hollow, 4 small hollows	4	378024.503	6306067.617
BCHT 12	*Eucalyptus rudis*	12	2200	none	5	378431.041	6305678.494
BCHT 13	*Eucalyptus rudis*	26	1620	1 large hollow, 1 small hollow	3	378347.78	6305722.472
BCHT 14	*Eucalyptus rudis*	15	2580,1020	1 medium , 3 small hollows	4	378184.803	6305683.606
BCHT 15	*Eucalyptus marginata*	6	1150	1 medium hollow	4	378152.829	6305496.344

1.4 PURPOSE AND APPROACH

The purpose of the BCHTMP is to provide management measures for the protection of the existing Black Cockatoo habitat trees. The approach is to use best practice management to:

- avoid the identified Black Cockatoo Habitat trees where possible
- mitigate impacts through the instalment of nesting boxes on existing trees outside of Lot 81
- manage impact from landfill through management and engineering
- promote rehabilitation by planting new Black Cockatoo habitat tree species in protected areas within Lot 81.

The Environmental Assessment Report from 2016 detailed the surveyed and identified potential breeding habitat trees within Lot 81 (Ecoscape 2016).

1.5 RECOMMENDATIONS

Recommendations are made to highlight management measures required to be undertaken to ensure a successful and efficient implementation of the BCHTMP. Recommendations are given time frames and allocate actions to a responsible entity.

2 PLAN FOR MANAGEMENT

2.1 VISION

To ensure the Black Cockatoo habitat environmental values, attributes and functions within Lot 81 are protected.

2.2 OBJECTIVES

To manage and implement measures to protect existing Black Cockatoo habitat trees within Lot 81.

2.3 MANAGEMENT STRATEGIES

The Black Cockatoo habitat trees will be managed through the implementation of a number of management strategies.

2.3.1 AVOIDANCE

Avoidance of existing Black Cockatoo habitat trees, where possible, is recommended to avoid impact on Black Cockatoo habitat. High value trees have been identified as tree numbers BCHT 05, BCHT 08 and BCHT 13 (**Table 3**).

Eight of the 15 identified Black Cockatoo habitat trees were recorded as having suitable sized hollows for Black Cockatoo species (**Map 1**). Where possible these trees should be avoided when clearing and landfill is applied to Lot 81. Appropriate tree protection zones will be applied to exclude landfill compaction of the root zone around each tree depending on the calculated canopy "drip" zone.

Where avoidance is not possible and practical, mitigation and rehabilitation measures will be employed to maintain and exceed the existing level of Black Cockatoo nesting habitat within Lot 81.

Recommendations:

No.	Recommendation	Priority	Responsible party
1			
1.1	Avoid high value habitat trees when clearing and applying landfill	High	Developer
1.2	Apply tree protection zones for the exclusion of landfill to high value habitat trees	High	Developer
1.3	Tree protection zones to be demarcated and calculated by canopy drip zone extent	Moderate	Developer

2.3.2 MITIGATION

Mitigation of impacts from removal of Black Cockatoo habitat trees will be implemented by installing new nesting boxes to existing trees adjacent to Lot 81, either in the Preston River Foreshore to the east or the Peppermint woodland to the west. Two nest boxes are proposed for installation for each identified nesting habitat tree removed. DBCA approved nesting boxes will be installed on selected and agreed trees.

Maintenance of nest boxes will be undertaken on an annual basis for a two year and will require an experienced environmental scientist with knowledge on Black Cockatoo behaviour to determine nest box status. It recommended that monitoring is coincident with Black Cockatoo breeding periods (Department of Parks and Wildlife 2015a; Department of Parks and Wildlife 2015b).

Recommendations:

No.	Recommendation	Priority	Responsible party
2			
2.1	Two approved nesting boxes to be installed on selected and agreed trees for each identified nesting habitat tree removed	Moderate	Developer/ DBCA
2.2	Nest box monitoring and maintenance to be undertaken in the breeding season for two years	Moderate	Developer

2.3.3 REHABILITATION

Promote rehabilitation of Black Cockatoo habitat trees through the planting of habitat tree species within Lot 81. Tree species and planting densities will be agreed and approved by DBCA prior to revegetation implementation. A two year monitoring period with bi-annual inspections for revegetation success is recommended for implementation.

Ecoscape recommends the use of local provenance tubestock of known Black Cockatoo foraging and nesting preference tree species, such as *Eucalyptus rudis*; *E. marginata* and *Corymbia calophylla*. Tubestock to be planted at a density of 1 stem per 10 m^2 (10 trees planted for each Black Cockatoo habitat tree removed). Tubestock will be protected by rabbit mesh guards until of sufficient size, or where Kangaroo grazing is an issue, Kangaroo guards >2 m high and 1.5 m diameter, or within Kangaroo exclusion area.

2.3.3.1 Completion Criteria

Suggested completion criteria are listed in **Table 4**.

Table 4: Suggested Completion Criteria for Revegetation Projects

Assessment Parameter	Method	Completion Criteria
Soil and landform	Visual inspection	Site must be safe, stable & suitable for agreed use without inputs
Tubestock survival	Visual inspection	75% of tubestock planted should be represented at the end of a two year monitoring period.
Monitoring and maintenance	Stem count of survival / photo monitoring	Bi-annual monitoring with annual reports of progress being submitted to DBCA. The results, problems encountered and how they were rectified should be described in the annual report.

Recommendations:

No.	Recommendation	Priority	Responsible party
3			
3.01	10 tubestock plants per Black Cockatoo habitat tree removed to be installed at 1 plant per sq m	High	Developer
3.02	Plant species to be approved by DBCA	Moderate	Developer/ DBCA
3.03	Tubestock survival to monitored bi-annually for two years to agreed completion criteria	Moderate	Developer

3 IMPLEMENTATION

Table 5 shows a provisional schedule of the previous mentioned actions and monitoring responsibilities. All reporting to DBCA will be on an annual basis, unless not applicable to the Action.

Table 5: Implementation Plan

Actions	Frequency	Timeframe	Responsibility	Reporting
Land Clearing and Earthworks				
Avoid tagged high value Black Cockatoo habitat trees	Once	Prior to earthworks and during landfill operations	Developer	N/A
Demarcate Black Cockatoo habitat tree protection zones	Once	Prior to earthworks and during landfill operations	Developer	N/A
Mitigation				
Identify number of Black Cockatoo habitat trees unable to be avoided and to be removed	Once	Prior to earthworks and landfill operations	Developer / Environmental Consultant	DBCA
Identify agreed Black Cockatoo habitat trees adjacent to Lot 81 for installation of nesting boxes	Once	Post earthworks operations	Developer / Environmental Consultant	DBCA
Install nesting boxes	Once	Post earthworks operations	Developer / Environmental Consultant	DBCA
Nest box monitoring and maintenance to be undertaken in the breeding season for two years	Annually	12 months post installation	Developer / Environmental Consultant	DBCA
Rehabilitation				
Confirm revegetation species lists and planting densities as specified and agreed by DBCA	Once	Prior to subdivision earthworks as part of the approved Management Plan	Developer	n/a
Undertake monitoring and maintenance of the revegetation areas for two years after development	Bi-annually	Ongoing for a two year management period	Developer	DBCA

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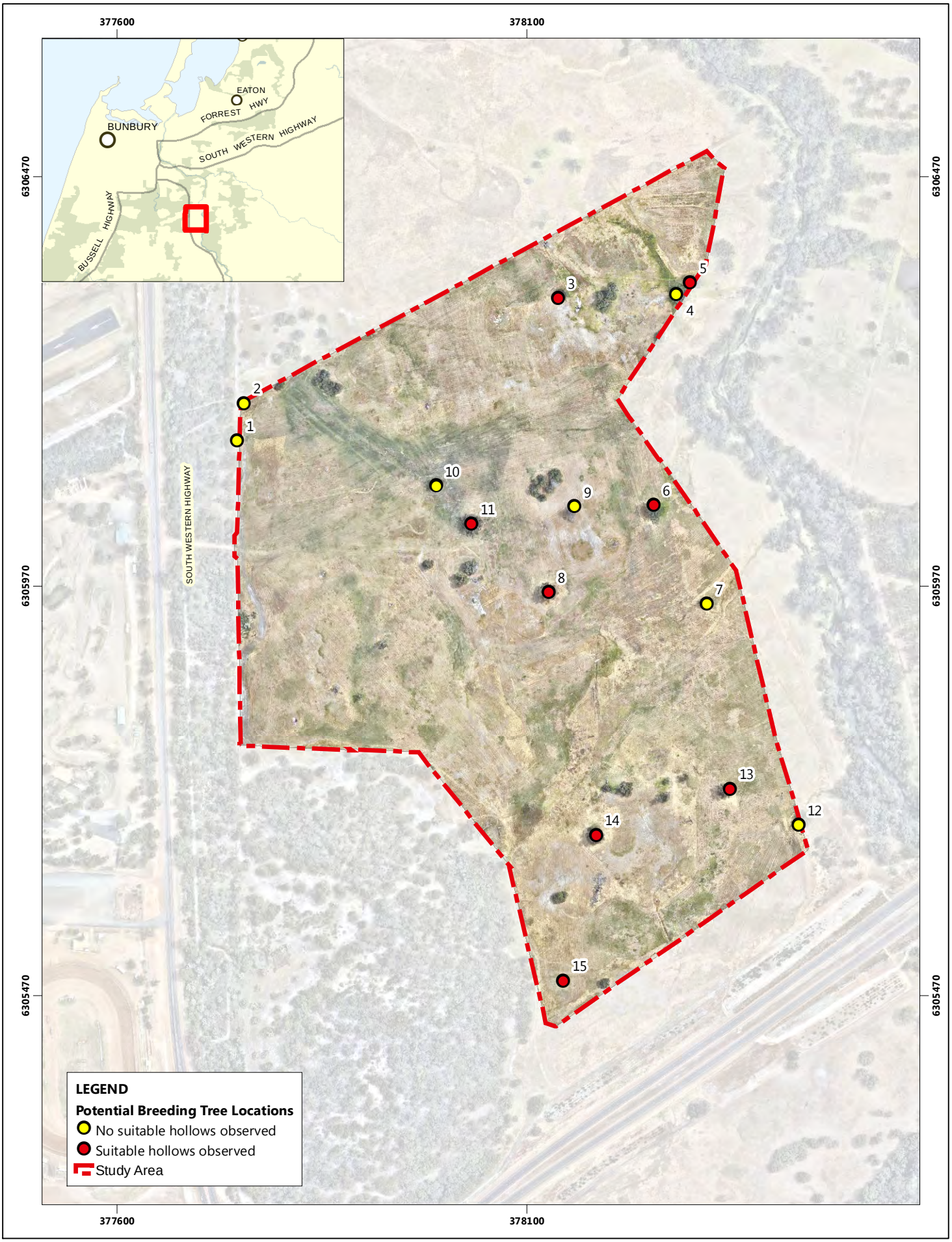
APPENDIX ONE MAPS



SCALE: 1:6,000 @ A4

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES:
SERVICE LAYERS: STREETS- STREET PRO 2009
IMAGERY: NEARMAP 2016

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
00	AF	BT	22/07/2016

0 50 100 Meters

N

POTENTIAL COCKATOO BREEDING TREE LOCATIONS

NBR INVESTMENTS

MAP 01

APPENDIX TWO BLACK COCKATOO HABITAT TREES

Plate 1: BCHT 01

Plate 2: BCHT 02

Plate 3: BCHT 03

Plate 4: BCHT 04

Plate 5: BCHT 05

Plate 6: BCHT 06

Plate 7: BCHT 07

Plate 8: BCHT 08

Plate 9: BCHT 09

Plate 10: BCHT 10

Plate 11: BCHT 11

Plate 12: BCHT 12

Plate 13: BCHT 13

Plate 14: BCHT 14

Plate 15: BCHT 15

Appendix F

Foreshore Management Plan

Prepared by Ecoscape

Lot 81 South Western Highway, Davenport
Foreshore Management Plan

NBR Investments Pty Ltd

ecoscape

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Rev0	Bruce Turner	Andrew Fry		27/10/2017
Final Rev 0	Bruce Turner	Marc Wohling		16/05/2018
Final Rev 1	Bruce Turner	Marc Wohling		14/06/208

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1 INTRODUCTION

1.1 BACKGROUND

Ecoscape was engaged by NBR Investments to undertake the preparation of a Foreshore Management Plan (FMP) for the proposed Lot 81 South Western Highway, Davenport (the study area) (**Figure 1**). The FMP is a requirement to support a Scheme Amendment Application for rezoning from Development Zone (Industrial) to Industry.

The implementation of the FMP will be the responsibility of the relevant land owner/s and land manager/s, not the proponent of Lot 81. The foreshore area consists of a number of Lots running parallel with the river course outside of the proposed structure plan, which are not owned by the proponents of the structure plan application (**Map 1**). The FMP is being prepared to support structure planning for Lot 81 and is necessary to ensure that potential impacts on the adjacent foreshore associated with the planning and development of Lot 81 have been adequately considered. The FMP is indicative only as no timeframes or budgets for implementation have been established.

The FMP addresses the conditions from The City of Bunbury (The City); Department of Water and Environmental Regulation (DWER) and the Department of Biodiversity, Conservation and Attractions (DBCA) as listed below. The conditions addressed in this Management Plan are listed as the following:

- A Foreshore Management Plan for the Preston River adjacent to the development site to be prepared to the satisfaction of the City, DWER and DBCA

Conditions not addressed in this FMP are listed as follows:

- The Bushfire Management Plan submitted with the structure plan for Lot 81 should be revisited concurrently with the development of this Foreshore Management Plan. Fire management measures should not impact the wetland's vegetation, threatened fauna habitat, the Preston River riparian zone or the agreed CCW proposed structurally vegetated buffer area. This is to ensure the buffer will have vegetation that will require consideration in the Bushfire Management Plan and its setback requirements. Given this DBCA recommends that the provision for a Fire MP to be prepared and implemented includes a requirement for consultation with Parks and Wildlife
- DBCA recommends that the structure plan include a provision requiring a Wetlands Buffer Rehabilitation Plan (WBRP) to be prepared and implemented to the satisfaction of the Department.
- DBCA recommends that the structure plan include a provision requiring a Black Cockatoo Habitat Tree Management Plan (BCHMP) to be prepared and implemented, which outlines how the fauna habitat trees will be protected from potential impacts associated with fill requirements and subsequent development

Figure 1: Study Area Location.

1.2 STUDY AREA

The foreshore study area is bounded by Lot 81 to the west and the Preston River to the east, the north and south boundaries are in line with those of Lot 81. The foreshore study area is approximately 9 ha in extent.

The foreshore is comprised of a number of cadastral boundaries outside of the proposed Lot 81 eastern boundary (**Map 1**).

1.2.1 WETLANDS

The foreshore area is covered by a conservation category (CC) wetland as classified by DBCA (**Map 1**). Assessment of the Geomorphic Wetlands of the Swan Coastal Plain dataset ((Department of Parks and Wildlife 2014) indicates a CC wetland along the eastern boundary (UFI 14501).

The Environmental Protection Authority (EPA) urges that all areas covered by CC wetlands and the associated buffers are fully protected (Environmental Protection Authority 2008). The EPA uses the recommendations of Hill (Hill *et al*. 1996) to provide guidelines for the protection of CC wetlands by applying a buffer zone of at least 50 m from the wetland boundary.

Consultation with Peter Hanly (DBCA Senior Regional Planning Officer, South West Region) resulted in the extension of the western boundary of the CC wetland of the Preston River. This extended boundary was realigned with one of the cadastral boundaries to the east of the Lot 81 structure plan boundary and is shown on **Map 1** as CCW additional area. The applied 50 m buffer area crosses into Lot 81 by approximately 10 m along the entire eastern boundary.

1.2.2 WATERWAYS

The Preston River runs adjacent to the eastern boundary of the study area and has been identified as a key component of the ecological linkages for the area by the EPA (Molloy *et al*. 2009). The study area boundary is set back from the river by approximately 70 m.

1.3 PURPOSE AND APPROACH

The purpose of the FMP is to provide management measures for the protection and enhancement of the foreshore area and surrounds. The approach is to use best practice management to reduce weed invasion, manage erosion and ensure rehabilitation efforts are successful (Water and Rivers Commission 2003).

1.3.1 CONTEXT

The foreshore forms part of a Regional Open Space reserve under the Greater Bunbury Regional Scheme (GBRS) and is identified as part of the 'Preston River Link' under the Leschenault Regional Park Establishment Plan.

The foreshore, which includes both the riverbank and upland areas, are currently in a degraded to completely degraded state of Bushland Condition (Keighery 1994) (**Image 1; Image 2**) and will benefit from efforts to remove weeds and promote native vegetation regeneration. The cover of introduced weed species does provide stability to the steep riverbanks and with the presence of the large native trees, mostly *Eucalyptus rudis*, *Corymbia calophylla* and *Agonis flexuosa*, also provides critical fauna habitat and connectivity to adjacent areas of bushland.

Image 1: Upland area looking south to the Bunbury Outer Ring Road (Image Point 833; see Map 2).

Image 2: Riverbank of the Preston River (Image Point 803).

The vegetation structure of the foreshore is comprised of scattered emergent shrubs (*Kunzea* and *Melaleuca* species) over dense patches of *Watsonia* and weedy herb species e.g. Sour Sob (*Oxalis pes-caprae*) and African lovegrass (*Eragrostis curvula*) Image 3.

Image 3: Typical Riverbank vegetation structure (Image Point 802).

2 PLAN FOR MANAGEMENT

2.1 VISION

To ensure the foreshore environmental values, attributes and functions are protected.

2.2 OBJECTIVES

To manage and maintain revegetation works within the foreshore of the Preston River.

2.3 MANAGEMENT STRATEGIES

The foreshore will be managed through the implementation of a number of management measures that will protect the environmental values of the Preston River.

2.3.1 EROSION MANAGEMENT STRATEGY

A Local Water Management Strategy will be developed to provide details of the level of protection at the stormwater outlets on the foreshore. This will also take into account the requirement for larger post flows and subsequent soft and hard modifications for stormwater discharge on the Preston River foreshore. These discharge point(s) on the foreshore will require three years of maintenance.

Protection from scouring and erosion of the Preston River foreshore will be achieved by retaining and infiltrating stormwater within the Lot 81 footprint. Removal of excess nutrients and contaminants from stormwater collected within the footprint of Lot 81 will be achieved in a series of bioretention/filtration swales that will initially nutrient strip the stormwater before infiltration.

Erosion within the foreshore will be controlled by the use of rock spalls and mass planting of sedge species at the existing channels. The installation of biofiltration swales within Lot 81 could potentially reduce and manage the outfall of stormwater via the existing channels that have scoured the river banks in various places.

2.3.2 WEED MANAGEMENT STRATEGY

A weed management strategy will be implemented to control priority weed species and prevent re-invasion prior to and post revegetation implementation. Monitoring and maintenance will be scheduled to ensure the success of weed control efforts will be achieved.

2.3.3 REVEGETATION STRATEGY

Revegetation works will be implemented after earthworks have been completed as outlined in this plan, to further protect the foreshore values. Revegetation efforts will be monitored for success with recommendations made for follow up infill planting should this be required.

Both the weed and revegetation management measures will be subject to the achievement of success criteria agreed with the City prior to commencement of weed control and planting.

2.3.4 IMPLEMENTATION STRATEGY

The implementation of this FMP will be enhanced by using the option of scalping/scouring the upland areas of pasture grasses to enhance the establishment of direct seeding of native vegetation for revegetation. This option could be undertaken by excavator machinery with the resultant spoil being stockpiled on the proposed Lot 81 development site.

Implementation of revegetation measures for the river banks is recommended to use a method of planting after initial weed control spraying has been completed.

2.4 MANAGEMENT ZONES

Management zones have been categorised for the foreshore rehabilitation area to allow for clearer understanding of the differing requirements for management of each zone type. The management zones are displayed on **Map 2** and fall into two broad types labelled Riverbank and Upland.

Each management zone has a specific list of native vegetation species nominated for revegetation works to better reflect the values and ecosystem function of the zone. The River Bank zone should contain more shrub species at high density to maintain bank stability and provide fauna habitat resources. The Upland zone should contain the larger shrub and tree species reflecting the already existing structure of the native vegetation of the foreshore. These two zones will therefore require differing management actions in the implementation of the FMP.

The Riverbank Management Zone comprises steep banks of approximately 90-100% cover of grass and herb weed species under an overstorey of mature Eucalypt and Peppermint trees and is approximately 2.2 ha in extent (**Image 4**).

Image 4: Typical structure and composition of the Riverbank Management Zone (Image Point 809).

The Upland Management Zone comprises completely degraded paddocks of pasture grass and herb weed species and is approximately 6.6 ha in extent. The land surface has been historically modified to maximise the area available for grazing activity (**Image 5**).

Image 5: Typical structure and landscape of the Upland Management Zone (Image Point 820).

2.5 RECOMMENDATIONS

Recommendations are made to highlight management measures required to be undertaken to ensure a successful and efficient implementation of the FMP. Recommendations are given time frames and allocate actions to a responsible entity.

3 EROSION MANAGEMENT

The foreshore area will be protected from erosion and sedimentation impacts, potentially caused by construction and earthwork activity, through the implementation of the following controls:

- battered slopes to have jute matting installed post earthworks and prior to revegetation works
- stormwater outfalls will be inoperable during construction with stormwater to be held and infiltrated within the development footprint

A contingency measure is proposed in the form of straw bales placed along the development edge should greater than expected overland stormwater events be encountered. The straw bales will temporarily hold sediment from entering the foreshore and can also be used to minimise scouring around outfall pipe heads.

3.1.1 WATER QUALITY MONITORING

A monitoring program will need to be determined in conjunction with broader monitoring being undertaken for the development area, as per a Local Water Management Strategy (LWMS). It is proposed that monitoring could be undertaken and that the parameters be determined with the City, DWER and DBCA.

Water quality monitoring will follow the requirements stated within the LWMS, including parameters and frequency.

3.1.2 CONTINGENCY MEASURES

Monitoring results will be compared between each monitoring event, should any of the indicators from the sampling exceed the initial measurements by 10%, for two consecutive samples, the City and DWER will be notified and the matter will be investigated. The possible contingency measures are as follows:

- soil amendment in high nutrient areas
- increased planting of water and nutrient thirsty plants in groundwater recharge areas.

The measures employed and the timing will be resolved at the time with the DWER and the City.

3.1.3 RECOMMENDATIONS

Actions		Priority	Responsibility
3	**Stormwater Treatment Zone**		
3.1	Monitor and maintain stormwater outfall channels	Moderate	Land Owner/Manager
3.2	Monitor for erosion, rectify with additional rock armour if/when required	Moderate	Land Owner/Manager

4 WEED MANAGEMENT

4.1 OBJECTIVES

The objectives of weed control are to:

- reduce the extent and/or density of targeted weeds
- reduce the extent and/or density to assist revegetation
- prevent introduction of additional weed species
- prevent increases in weed density and distribution for non-targeted weeds
- minimise detrimental impacts of the weed control program such as off target impacts on the native biota
- improve the visual amenity of the wetland buffer
- reduce potential fire risk.

Weed control and revegetation work will be undertaken simultaneously as the process of landform re-construction takes place. This will allow for the minimisation of re-invasion. Efforts should be conducted in a staged approach to focus resources efficiently and ensure a good coverage and density of plantings.

4.2 MANAGEMENT STRATEGIES

4.2.1 OPTIONAL SCALPING

Due to the majority of the Foreshore area being covered by pasture grasses and introduced weed species it is proposed to mechanically scalp/scour the topsoil layer by excavator, stockpiling the removed layer on Lot 81 as a potential landfill source. This method will allow for minimal weed control efforts initially and facilitate in the revegetation of the Upland zone.

Once scalping/scouring has been completed temporary wing fences at the north and south boundaries of Lot 81 should be installed to deter incursions by Kangaroos that may destroy newly planted tube stock. The fences should be 1.8 m high as a minimum and of sufficiently small mesh size to exclude Kangaroos, it will be necessary to ensure the bottom edge of the fence is adequately secured to the ground to stop animals "pushing" under the fence. This will be important at the ends closest to the Preston River banks.

If practical, mulching to a depth of 100 mm should be considered to be spread across the site prior to planting taking place to deter weed species germination.

4.2.2 PRIORITISATION

Prioritisation of weed control is critical to the success of both the control of weeds and the use of limited resources. Along the foreshore edge, prioritisation aims to:

- maintain vegetation and habitats along the foreshore that are in the best condition. These areas are more resilient and sustainable provided that disturbance is minimised and invasive weed populations are quickly removed
- eradicate new weeds introduced into the site which pose a significant threat to environmental and social values
- co-ordinate weeding programs to ensure an integrated approach to works
- control degradation processes that increase ecosystem vulnerability.

4.2.3 METHODS OF WEED CONTROL

Chemical and manual weed control should be undertaken post topsoil scouring and again before revegetation commences. **Table 1** describes the control methods suitable for likely present priority weed species. Methods are as follows:

1. Hand weeding, pulling, digging
2. Herbicide wipe, stem injection, cut stump
3. Spot spraying
4. Blanket spraying

Table 1: Priority Weed Species and Recommended Control Methods

SPECIES		HERBICIDE CONTROL			OPTIMAL HERBICIDE TIME												MANUAL CONTROL	GENERAL COMMENT	REFERENCE
Scientific Name	Common Name	Wicker Wipe (per 1 L water)	Targeted Herbicide Control (10L Spraypack)	General Herbicide Control (10L Spraypack)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Grass																			
Avena barbata	Bearded Oat	500 mL glyphosate (450 g/L)	160 mL fluazifop-p (128 g/L)	50 mL glyphosate (450 g/L) 10 mL Spray-seed ®													Hand remove individual plants and small populations	Occurs mainly in highly disturbed areas. Easy to control.	1, 2, 3
Briza maxima	Blowfly Grass	Not recommended	4 g Achieve® 16 mL Fusilade® Forte 200 g Propon®	10-100 mL glyphosate (450 g/L)													Hand remove individual plants and small populations	Occurs in disturbed bushland.	1, 2, 3
Cynodon dactylon	Couch	Not recommended	50 mL fluazifop-p (212 g/L) 125 mL fluazifop-p (128 g/L) 16 mL haloxyfop (520 g/L) 80 mL quizalofop-p-ethyl (100g/L)	100 mL glyphosate (450 g/L)													Manually dig up soil around plant, taking care to remove and dispose all rhizome and stolon materials to prevent resprouting.	widely planted as a lawn grass it invades wetlands and river edges in southern Western Australia. It is native to the Kimberley and the tropics worldwide.	1, 2, 3
Eragrostis curvula	African Lovegrass	Not recommended	100 mL clopyralid (300 g/L) 2 mL haloxyfop (520 g/L)	100-200 mL glyphosate (450 g/L)													Hand remove seedlings and small plants. Roots of mature plants tend to break off and regrow.	A serious weed of roadsides sometimes invading bushland. Flowers much of the year. Relatively resistant to glyphosate. Requires repeated spraying.	1, 2, 3, 5
Ehrharta calycina	Perennial Veldt Grass	500 mL glyphosate (450 g/L)	130 mL fluazifop-p (128 g/L)	50 mL glyphosate (450 g/L) 10 mL Spray-seedÒ													Plants are easy to hand remove as roots are shallow and do not tend to break off.	Serious environmental weed	1, 2, 3, 5
Bulbous																			
Gladiolus caryophyllaceus	Wild Gladiolus	100-500 mL glyphosate (450 g/L)	No specific information	100 mL glyphosate (450 g/L)													Small populations can be dug out, ensuring to remove all plant material to prevent resprouting.	Highly invasive and common in Perth's bushlands. Spray when flowering.	2, 3, 5
Watsonia meriana var. bulbillifera	Watsonia	The plants can be wicker wiped using a mixture of 1:2 glyphosate (450g/L) using a wiping glove in areas where overspray is needed to be avoided	100 g 2,2-DPA (740g/kg} plus 25 mL wetting agent in 10 L water. Apply from flower stem emergence to mid flowering for the most effective results.	100 g 2,2-DPA (740g/kg} plus 25 mL wetting agent in 10 L water. Apply from flower stem emergence to mid flowering for the most effective results.													Due to this species producing many corms and bulbils removal by hand can often be ineffective. Mowing and slashing have been shown to be ineffective unless repeated very frequently	Tends to grow in sites where the soil dries out in summer, for example, around granite rocks, and in wandoo woodlands. A serious environmental weed, it is found between Perth and Albany. Spray when flower spikes emerge.	1, 2, 3
Zantedeschia aethiopica	Aurm Lily	500 mL glyphosate (450 g/L)	0.3 g metsulfuron (600 g/kg) + 100 ml glyphosate (450 g/L) 0.3 g chlorsulfuron (750 g/kg) + 10 mL 2,4-D amine (500 g/L)	No specific information													Only effective with younger plants and if all plant material is removed to prevent resprouting. Cut flowers to prevent birds spreading seeds.	Normally found mostly in or near wetlands and waterways, but now being found in much drier areas. This species has been identified as being difficult to control with herbicides. Glyphosate alone is relatively ineffective.	1, 2, 3, 4, 5
Other																			
Asparagus asparagoides	Bridal Creeper	500 mL glyphosate (450 g/L)	0.1-0.2 g metsulfuron (600 g/kg) 0.04g metsulfuron (600 g/kg) + surfactant in sensitive areas	100 mL glyphosate (450 g/L)													Small populations can be removed proved the root mat is carefully dug up, ensuring the removal of all rhizomes and tubers to prevent resprouting.	One of the State's most urgent environmental weed problems. It is extremely invasive, spreading rapidly over and smothering other vegetation. Spray when flowering.	1, 2, 3, 5
Pelargonium capitatum	Rose Pelargonium	Not recommended	20 mL 2,4-D amine (500g/L) 100 mL Tordon® 75-D Try 0.1 g metsulfuron (600g/kg)	No specific information, try: 50-100 mL glyphosate (450 g/L)													Ensure to dispose of all cut material, as new plants may resprout from fragments.	Naturalised in Perth's coastal areas. Smothers small native plants. Colonises natural bare sandy areas. Glyphosate is relatively ineffective.	1, 2, 3

Herbicide Timing

- Optimal
- Sub-optimal

References

1 Moore and Wheeler (2008)
2 Brown and Brooks (2002)
3 Department of Parks and Wildlife (2015)
4 Brown and Brooks (2001)
5 Shire of Mundaring (2013)

4.2.4 HERBICIDES

It is necessary that the application of herbicides be in accordance to labelling requirements or the manufacturers Materials Safety Data Sheet (MSDS) and must be undertaken by qualified personnel trained in the application of herbicide chemicals. The application of any herbicide for purposes not specified on the labelling requires an Off-Label Permit from the National Registration Authority in Canberra. Care must be taken herbicides are not applied on adjacent native vegetation.,

Surfactants should not be used with the herbicide treatments near or in the foreshore. Many common herbicides such as Roundup® contain NPE surfactants which are known to affect the development of amphibian species, which can lead to a decline or even loss of such fauna species (Mann & Biggs 1999). Herbicides not containing NPE surfactants, such as Roundup Biactive®, are strongly recommended.

The application of herbicides must also be in accordance with water catchment restrictions. Chemical based weed control strategies, in particular, must recognise potential adverse impacts on water resources such as lakes, wetlands, streams, rivers and dams. The herbicide's label should also contain a section outlining appropriate measures for the "Protection of Wildlife, Fish, Crustaceans and Environment"

4.2.5 MONITORING AND MAINTENANCE

Monitoring and evaluation are key actions that need to be undertaken during weed management to measure the success of control strategies. Performance indicators will be developed to objectively assess the success of weed control strategies. This will not only contribute to accountability where public funds are involved, but also provide a mechanism for modifying the strategy and maintaining its flexibility.

The use of photographs from set points also enhances this process and will be carried out on a biannual basis as part of the monitoring which will also involve documenting the location and relative abundance of weed species.

Following this initial period, it is recommended that the site continue to be monitored yearly and appropriate weed treatment be implemented to target identified weed species.

4.2.6 COMPLETION CRITERIA

Table 2 shows recommended success criteria for the weed control efforts.

Table 2: Suggested Completion Criteria for Weed Management

Assessment Parameter	Method	Completion Criteria
Priority weed species presence	Quadrats	30% decrease in the number of priority weeds recorded in the baseline survey. No new high priority weed species become established in the study area
Total weed species presence	Quadrats	30% decrease in the number of total weeds recorded in the baseline survey.
Weed cover	Weed mapping	No more than 5% weed cover and a maximum of 5 weeds/ m2

4.2.7 RECOMMENDATIONS

Actions		Priority	Responsibility
4	**Weed Management**		
4.1	Weed control works of the revegetated sites should occur during optimal control times	High	Land Owner/Manager
4.2	Formal monitoring with annual reports of progress being submitted to the City. The results, problems encountered and how they were rectified should be described in the annual report.	High	Land Owner/Manager

5 REVEGETATION

5.1 OBJECTIVES

The objectives for the revegetation of the foreshore are to:

- minimise the impact of activities that could result in degradation to vegetation communities through the use of appropriate management strategies
- improve the overall condition of vegetation communities of the riparian interface

5.2 MANAGEMENT STRATEGIES

The main issues that need to be addressed in improving the condition of the foreshore area are:

- assisted natural regeneration in the form of weed control
- reconstruction in the form of strategic revegetation.

It is assumed that natural regeneration will occur after the revegetation planting and weed management that will be applied to the foreshore.

Revegetation will follow the planting design as shown in **Map 3**. Timing of revegetation works will be as follows:

- general earthworks to attain correct slope and scour topsoil layer of Upland Zone
- initial weed control spraying to control establishment of off-site weed species
- install fencing
- complete direct seeding
- initial tubestock planting in first winter post site earthworks being completed
- second weed control event 3 months post initial planting
- first monitoring event to establish achievement of success criteria 6 months post initial planting
- second monitoring event 12 months post initial planting, recommendations made for infill planting if necessary to maintain desired density
- third monitoring event 18 months post initial planting.

5.2.1 PROVENANCE

It is recognised that the required revegetation works will need a large amount of propagules (e.g. seed, tubestock). It is important that propagules are first attempted to be sourced from regional vegetation to preserve the provenance where practicable. If not enough propagules can be obtained, propagules are to be sourced from nearby areas with similar climate and geology.

5.2.2 METHODS FOR PLANTING

The optimum tubestock planting time for foreshore vegetation is during their active growing period which is the warmer months of late spring, summer and early autumn. This needs to be taken into account when programming works.

If the scalping/scouring option for the Upland Zone is chosen tubestock planting will be replaced with direct seeding for this zone. It is recommended that a rate of 8-10 kg/ha will be required to achieve the desired revegetation densities.

Table 3 below describes the methods suitable to planting tubestock for revegetation. Strict supervision of planting stock will be required to avoid undesirable rates and clumping of species distribution.

Table 3: Methods used for planting tubestock

Methods for Planting
Prior to planting, chemical and manual weed control will be undertaken to ensure seedlings are planted into weed free areas.
The installation of tubestock will ensure a general density of at least 2 plants per square meter and an overstorey, middle storey and understorey ratio of 20:30:50. The installation of tubestock will ensure a general density of at least 4 plants per square meter.
Only tubestock that are healthy, disease free and actively growing with well-developed root system should be planted.
Tubestock will be planted only when the soil is sufficiently wet to plant without the need for additional watering.
Species planting list provided and to be adhered to (**Appendix Two**).
Tubestock to be sourced from accredited nurseries to ensure stock is disease and weed free.
Plastic guards (4050 mm x 400 mm x 100 mm) will be placed around seedlings for protection with three bamboo stakes. The guards should be removed when seedling growth starts to become restricted.

Revegetation will not be irrigated; therefore it is essential that seedlings be planted as soon as practical after soil has become sufficiently wet. Revegetation will be undertaken over a five year period to ensure sufficient coverage is achieved.

An integral part of the planting program is supplementary planting in subsequent winters to address plant deaths. Typically non irrigated planting accepts a mortality of approximately 30%, however the City may specify a higher success rate, should monitoring determine that more than 20% mortality of seedlings has occurred, infill planting will be conducted to reach the final density targets.

5.2.3 FENCING AND FIREBREAKS

Fencing of the Lot 81 boundary will be necessary to provide protection against kangaroo damage to foreshore revegetation. The proponents of the Lot 81 development will be responsible for the installation of a chain-link fence at 1.8 meters in height to the entire Lot boundary. The Land Owner(s)/Manager(s) will be responsible for the installation of "wing" fences at the north and south boundaries of Lot 81 terminating at the Preston River edge.

Three meter wide firebreaks will be installed on either side of the Lot 81 boundary fence which will also have two six meter wide gates for the entry/exit of fire protection vehicles at the north east and south east corners of Lot 81.

The existing stock fence will be required to be removed as it currently does not align with the Lot 81 boundary and will restrict any rehabilitation works.

5.2.4 PLANTING LAYOUT

The proposed planting layout is shown on **Map 3.** The species chosen are all readily available through commercial wholesale nurseries and these will be sourced locally where possible. A species list is provided in **Appendix Two**.

5.2.5 MONITORING AND MAINTENANCE

The revegetation program should be monitored to detect any poor success rates or unsatisfactory revegetation of an area following a three year period. An acceptable revegetation success rate is typically in the order of 80% of plants from 90% of species.

Maintenance of tree guards should occur at least quarterly including hand weeding inside tree guards to ensure tubestock are establishing well and are not being out competed by weeds. However, maintenance may need to occur more frequently depending on rate of weed growth or acts of vandalism. Therefore additional maintenance may be required.

Formal monitoring is to occur bi-annually at the beginning of winter and the end of summer, with in-fill planting to be programmed in for the following winter (or late spring if wetland species), to address

tubestock mortality. Monitoring should be undertaken by a qualified environmental scientist and include assessing:

- seedling survival
- foliage % cover
- species representation
- presence of weeds and % cover
- overall success of plant establishment
- photographic records of revegetation.

5.2.6 COMPLETION CRITERIA

Suggested completion criteria are listed in **Table 4**.

Table 4: Suggested Completion Criteria for Revegetation Projects

Assessment Parameter	Method	Completion Criteria
Soil and landform	Visual inspection	Site must be safe, stable & suitable for agreed use without inputs
Seedling survival	Quadrats, photo monitoring	4 plants/m^2 installed for dryland species at the end of the monitoring period. Sedge density will be determined by % cover. Ground covers and Sedges should be installed at 5 plants/m^2. Seeding application rate to be 8-10 kg/ha.
% Foliage cover	Quadrats	≥85% for all sites
Species representation	Quadrats, transects	75% of wetland species and 50% dryland of species used in the revegetation program should be represented as they would in the natural environment at the end of the monitoring period.
% Weed cover and presence	Quadrats	Weed control target to be a maximum of 5% cover with a maximum of 5 weeds per m2; no weeds to exceed 15cm in height.
Weed presence	Weed mapping	No Weeds of National Significance (WONS) or Declared Pest plants to be within the buffer zones or adjacent landscape zones at the end of the monitoring period.
Structure and function	Transects, photo monitoring	The structure must be representative of a natural vegetation type, based on FCT.
Monitoring and maintenance	Quadrats, transects, photo monitoring	Maintenance of the revegetated sites should occur quarterly. Formal monitoring with annual reports of progress being submitted to the City. The results, problems encountered and how they were rectified should be described in the annual report.

5.2.7 RECOMMENDATIONS

	Actions	Priority	Responsibility
5	**Revegetation**		
5.1	undertake revegetation works	High	Land Owner/Manager
5.2	Confirm planting species lists, tubestock availability and planting densities with DBCA	Medium	Land Owner/Manager
5.3	Undertake monitoring and maintenance of the rehabilitation areas for 2 years after development on an bi-annual basis	High	Land Owner/Manager
5.4	Identify areas of rehabilitation that require supplemental planting from the winter monitoring events	Medium	Land Owner/Manager

6 IMPLEMENTATION PLAN

Table 5 shows a provisional schedule of the previous mentioned actions and monitoring responsibilities. All reporting to the City of Bunbury will be on an annual basis, unless not applicable to the Action.

It will be the responsibility of the Land Owners/Managers to implement the FMP with no conditions on the proponent of Lot 81 other than the installation of firebreaks and fencing to the eastern boundary of Lot 81.

Table 5: Implementation Plan

Actions	Frequency	Timeframe	Responsibility
Water Quality Management			
Continue to monitor water quality pre construction, during construction and post construction in line with the LWMS for the site.	Quarterly	Pre-construction, during construction and post-construction	Land Owner/Manager
Weed Control			
Undertake/Complete scalping/scouring of Upland Zone	Once	Prior to revegetation works	Land Owner/Manager
Undertake weed control in conjunction with revegetation activities.	As required in two year maintenance period	Prior to revegetation works and on completion of works until completion criteria are met.	Land Owner/Manager
Ensure application of any herbicides is in accordance with the material safety data sheets and Department of Health (2007) restrictions	As required	Ongoing for the two year management period, or until handover to the City.	Land Owner/Manager
Implement monitoring program to assess changes in weed species and distribution in the study area and adapt weed strategies accordingly	Bi-annually	Two years maintenance period or until completion criteria are met.	Land Owner/Manager
Maintenance of the revegetation areas, particularly tree guards, for 2 years after development	As required in two year maintenance period	Ongoing for the two year management period, or until handover to the City.	Land Owner/Manager
Revegetation			
Remove existing stock fence on eastern boundary of Lot 81	Once	Prior to revegetation works	Developer
Install Fences to revegetation works boundary	Once	Prior to seeding/planting	Land Owner/Manager
Undertake revegetation works	Once prior to subdivision and then as required until handover to the City	Post subdivision earthworks, and including the second winters in-fill plantings until completion criteria are met.	Land Owner/Manager
Confirm revegetation species lists and planting densities are specified and agreed by the City and DBCA	Once	Prior to subdivision earthworks as part of the approved Management Plan	Land Owner/Manager
Undertake monitoring of the revegetation areas for two years after development	Bi-annually	Ongoing for the two year management period, or until handover to the City.	Land Owner/Manager
Identify areas of revegetation that require supplemental planting, and conduct infill planting	Initially at the end of summer, then bi-annually	Two years maintenance period or until completion criteria are met.	Land Owner/Manager

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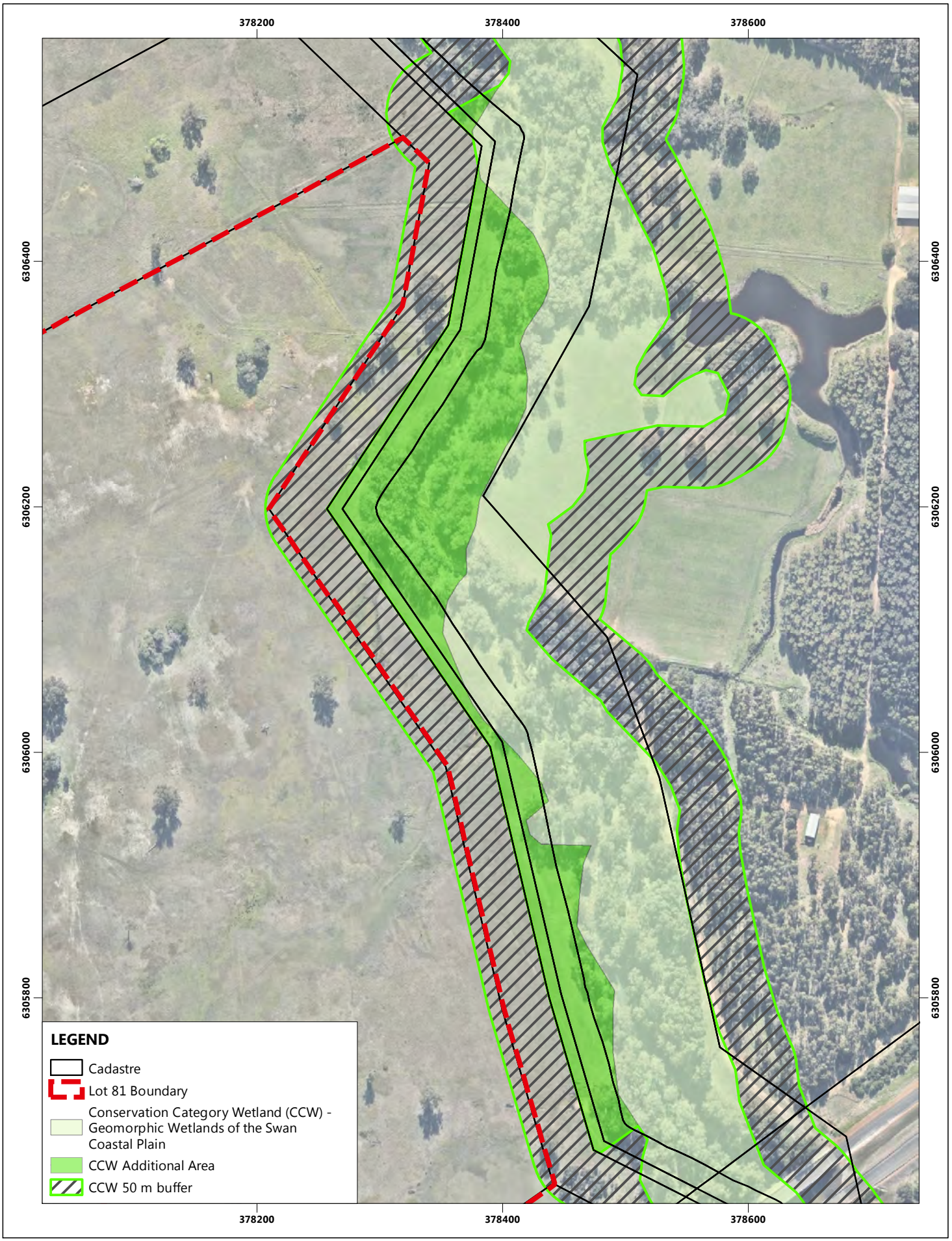
APPENDIX ONE: MAPS



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DATUM: GDA 1994
UNITS: METER

DATA SOURCES :
CADASTRE: LANDGATE; WETLAND MAPPING: DBCA
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

N

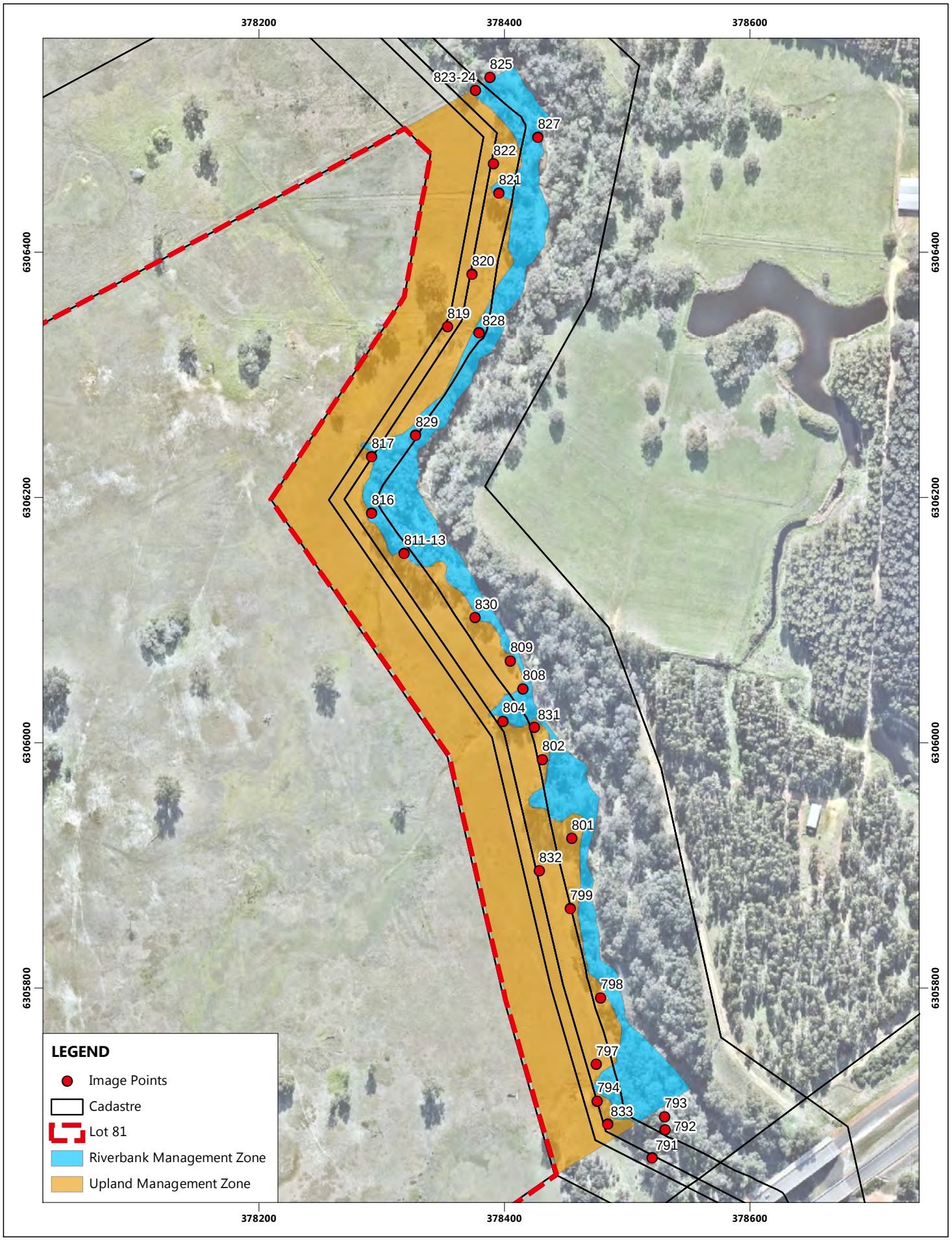
0 50 100 m

GEOMORPHIC WETLANDS

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 01



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PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES :
CADASTRE: LANDGATE
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

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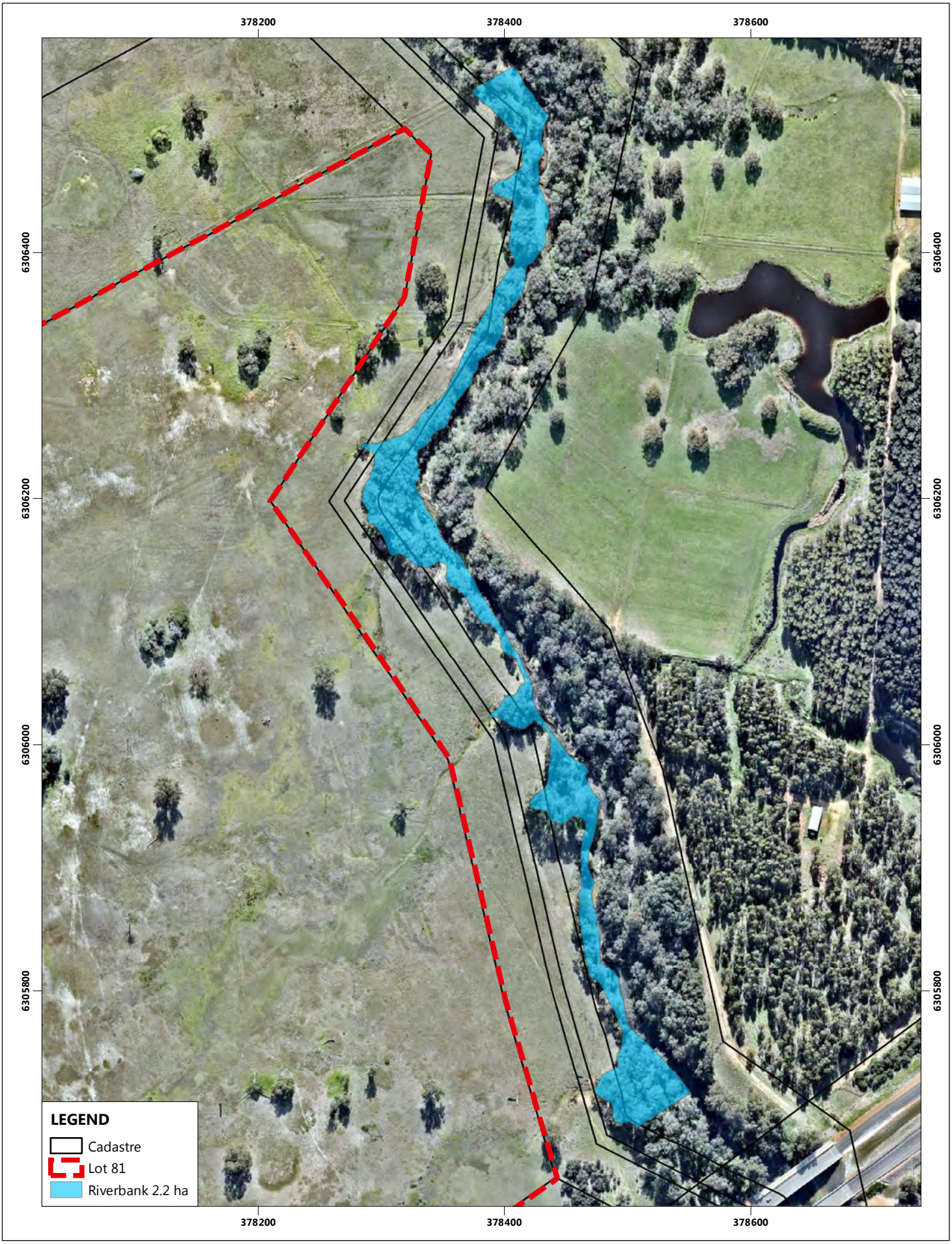
PROPOSED MANAGEMENT ZONES

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 02



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PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES :
CADASTRE: LANDGATE
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

N

0 50 100 m

PLANTING LAYOUT CONCEPT PLAN RIVERBANK

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 03

SCALE: 1:4,000 @ A4

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

DATA SOURCES :
CADASTRE: LANDGATE
AERIAL: NEARMAP

ecoscape

PROJECT NO: 3740-16

REV	AUTHOR	APPROVED	DATE
0	DR	JN	27/04/2018

N

0 50 100 m

PLANTING LAYOUT CONCEPT PLAN UPLAND

LOT 81 SOUTH WESTERN HIGHWAY FORESHORE MANAGEMENT PLAN

CLIENT: NBR INVESTMENTS

MAP 04

APPENDIX TWO: SUGGESTED PLANTING SPECIES LIST

Riverbank Planting Zone

Stratum and Density (plants/m^2)	Species
OVERSTORY (0.3/m^2)	*Agonis flexuosa*
	Eucalyptus rudis
	Melaleuca rhaphiophylla
	Melaleuca preissiana
SHRUB (4/m^2)	*Acacia pulchella*
	Astartea fascicularis
	Bossiaea eriocarpa
	Hypocalymma angustifolium
	Melaleuca viminea
	Pericalymma ellipticum
	Taxandria linearifolia
	Viminea juncea
GROUNDCOVER (5/m^2)	*Baumea juncea*
	Bolboschoenus caldwellii
	Carex fascicularis
	Ficinia isolepis
	Ficinia nodosa
	Gahnia trifida
	Juncus kraussii
	Juncus subsecundus
	Juncus pallidus
	Lepidosperma longitudinale
	Leptospermum effusum

Upland Planting Zone

Stratum	Species
OVERSTORY (0.3/m^2)	*Agonis flexuosa*
	Banksia grandis
	Banksia littoralis
	Corymbia calophylla
	Eucalyptus marginata
	Eucalyptus rudis
	Melaleuca preissiana
SHRUB (4/m^2)	*Acacia pulchella*
	Bossiaea eriocarpa
	Gompholobium capitatum
	Hakea lissocarpha
	Hakea prostrata
	Hakea varia
	Hibbertia cuneiformis
	Hibbertia subvaginata
	Hypocalymma angustifolium
	Hypocalymma robustum
	Jacksonia furcellata
	Jacksonia horrida
	Kunzea glabrescens
	Kunzea micrantha
	Melaleuca viminea
	Pultenaea skinneri
	Pericalymma ellipticum
	Xanthorrhoea brunonis
GROUNDCOVER (5/m^2)	*Anigozanthos viridis*
	Conostylis aculeata
	Dasypogon bromeliifolius
	Dianella revoluta var. revoluta
	Ficinia nodosa
	Gahnia trifida
	Hemiandra pungens
	Juncus pallidus
	Kennedia coccinea
	Lepidosperma effusum
	Patersonia occidentalis
	Philotheca spicata
	Scaevola calliptera
	Thysanotus multiflorus

Appendix G

Transport Assessment

Prepared by Shawmac

CONSULTING CIVIL & TRAFFIC ENGINEERS, RISK MANAGERS.

Project:	Lot 81 South Western Highway, Davenport Transport Assessment
Client:	NBR Investments
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1. Introduction and Background

1.1. General

This Transport Assessment has been prepared by Shawmac Pty Ltd, on behalf of NBR Investments to support a proposed structure plan for Lot 81 South Western Highway, Davenport, in the City of Bunbury.

1.2. Transport Statement Objective

This Transport Assessment outlines the likely impact of the proposed structure plan on network traffic flows, safe access, pedestrian and cycle facilities and local amenity. As part of the assessment, Shawmac considered the likely traffic demand that would be generated through the proposed development.

The assessment considers aspects associated with:

- Generation of traffic including impacts on roads;
- Integration with the surrounding land uses;
- Use of public and other transport modes such as walking and cycling; and
- Safety and access issues.

1.3. Site Location

The subject site is located approximately 180 kilometres south of the Perth CBD and 7.5km south-east of the Bunbury Town Centre. **Figure 1** below shows the broad the location of the site.

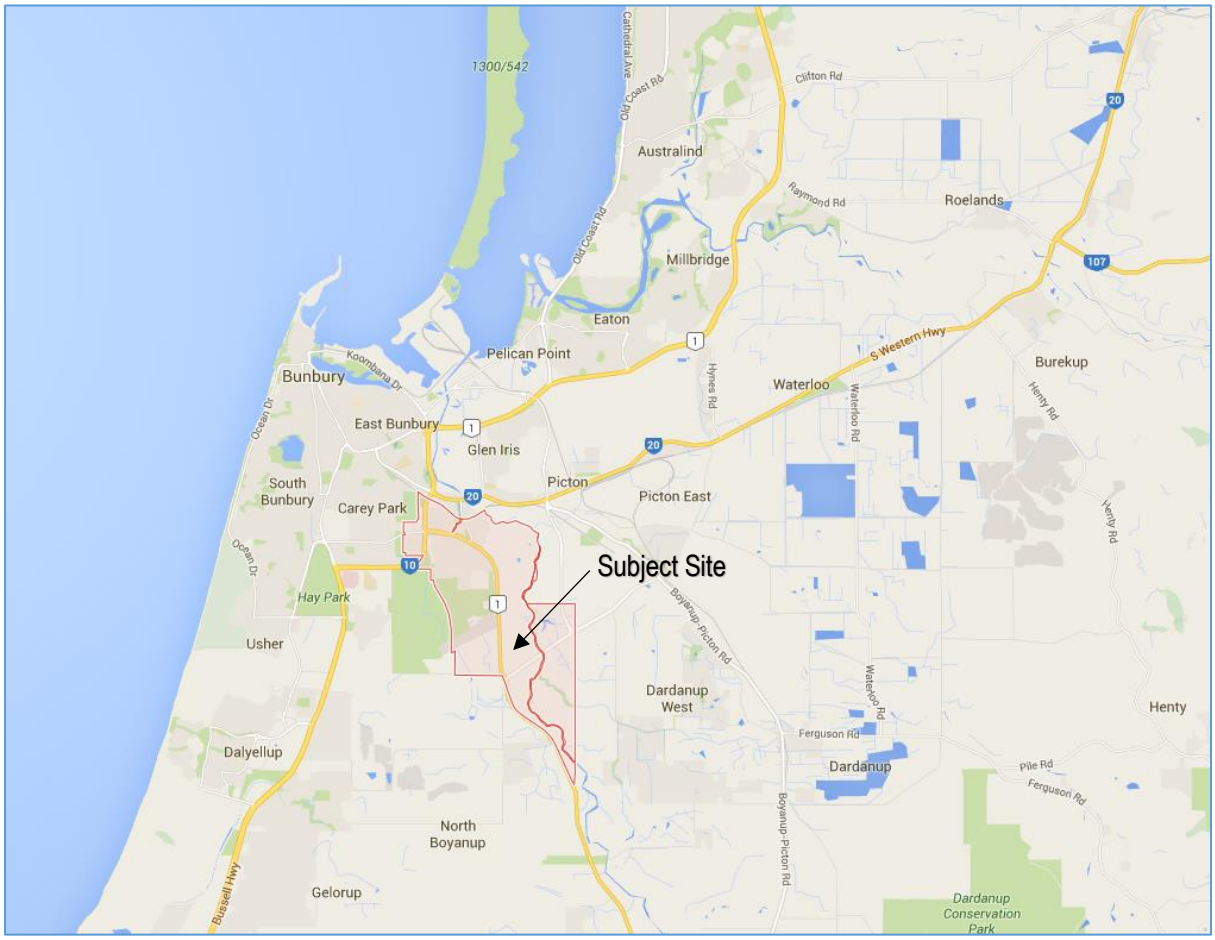


Figure 1 - Regional Context

The subject site is located on the eastern side of South Western Highway with the southern border of the site at the Bunbury Outer Ring Road.

The site is predominantly cleared with some light vegetation. The Preston River forms the eastern boundary of the site and there is undeveloped land to the north and southwest of the site. On the western side of South Western Highway is the Bunbury Speedway and Car Club and to the north is the Bunbury Airport.

Figure 2 shows the location of the site in the context of the local area.

Figure 2 - Local Context

1.4. Surrounding Major Attractors and Generators

The Bunbury Airport is located on the western side of South West Highway, approximately 2km north of the site. The Bunbury Speedway is located to the south-west of the site.

The Bunbury Town Centre, Port and residential areas are located to the north and west of the site, between 4km and 10km. To the south are the townsites of Busselton, Dunsborough, Margaret River and other residential suburbs.

2. Existing Situation

2.1. Land Use

The subject site is predominantly cleared with some vegetation. There is cleared and bush land to the south and east of the subject site. The Bunbury Airport and Bunbury Car Club and Speedway are located to the west of site.

2.2. Zoning

The subject site is currently zoned "Development zone - industrial" under the City of Bunbury *Town Planning Scheme No 7 (TPS 7)*. An extract from the planning scheme is shown below in **Figure 3.**

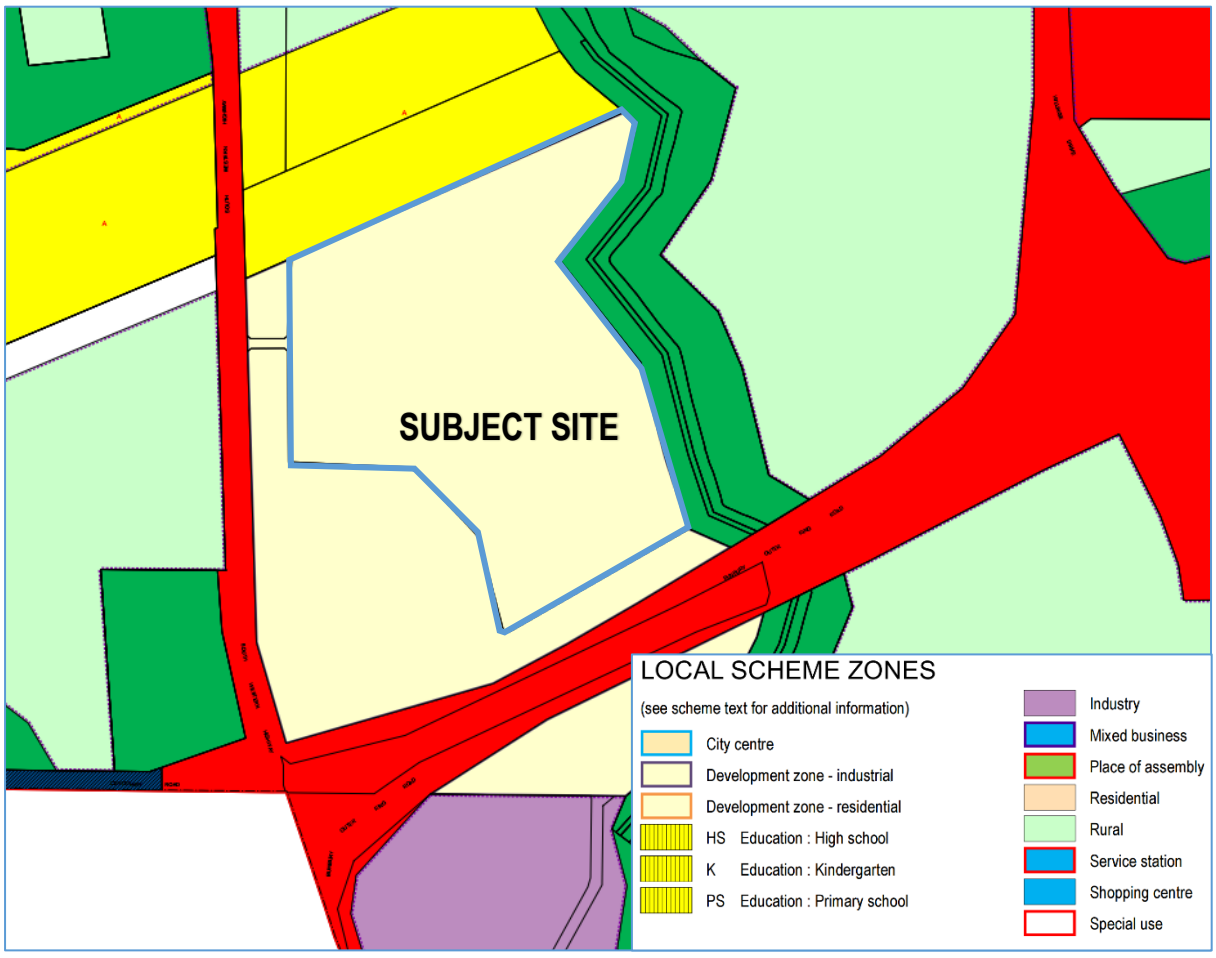


Figure 3 - Extract of City of Bunbury TPS 7

2.3. Existing Road Network

South Western Highway forms the western border of the site. South Western Highway is classified as a *Primary Distributor* under the MRWA Functional Road Hierarchy and provides an in-land connection between Armadale, on the south-eastern fringes of the Perth Metropolitan Area, to Bunbury and then continuing in-land to South Coast Highway, west of Albany. In the vicinity of the site, South Western Highway has been constructed as a single

carriageway with a 10.6m seal with two 3.8m wide lanes and 1.5m wide sealed shoulders. There is approximately 3.5m on unsealed shoulder on both sides of the road. There is a painted and raised paved median for approximately 300m north of the roundabout intersection with Bunbury Outer Ring Road, and a right turning lane into Centenary Road.

Bunbury Outer Ring Road forms part of the southern border of the site and provides a connection between South Western Highway to Boyanup Picton Road in Picton East. Bunbury Outer Ring Road is classified as a *Primary Distributor* under the MRWA Functional Road Hierarchy and has been constructed as a dual divided carriageway with an 11-16m wide natural central median and two 10.5m wide seals including sealed shoulders and two traffic lanes in each direction.

The road classification for each road surrounding the proposed development site is shown on **Figure 4** as an extract from Main Roads Western Australia (MRWA) *Road Information Mapping System*.

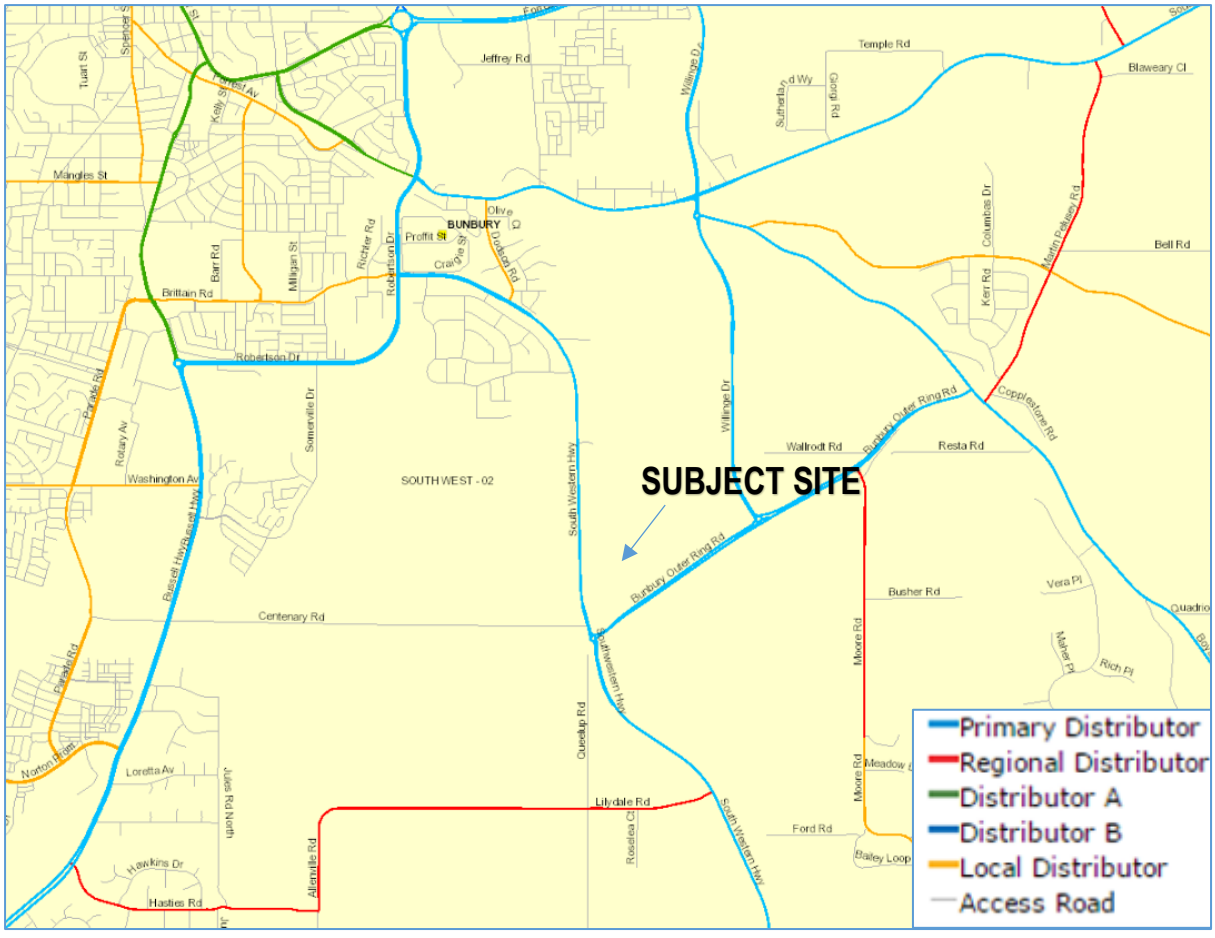


Figure 4 - Road Hierarchy

2.4. Road Hierarchy vs Actual Flows

Traffic counts for South Western Highway and Bunbury Outer Ring Road were obtained from Main Roads Western Australia's *Reporting Centre* and indicated average weekday traffic volumes of 6,207 vpd for South Western Highway and 2,817 vpd for Bunbury Outer Ring Road, east of South Western Highway.

Table 1 details the comparison of actual flows against the recommended maximum flows under the *Liveable Neighbourhood* guidelines. The table indicates that all roads in the vicinity of the subject site are currently operating within their classification.

Table 1 - Road Classification and Current Traffic Volumes

MRWA Road Classification	Road Name.	Desirable Max. Traffic Volume. (vpd)	Current Traffic Volumes (vpd)	% Heavy Vehicles (M-F)	Date
Primary Distributor	South Western Highway	50,000	6,207	11.5%	16 September 2013
Primary Distributor	Bunbury Outer Ring Road	50,000	2,817	29%	14 September 2014

2.5. Public Transport Facilities

There are currently no public transport facilities within a 400m walkable catchment of the subject site.

2.6. Existing Pedestrian and Cycling Network

There are no formal pedestrian or cycling facilities adjacent to the site and no projects identified along South Western Highway and Bunbury Outer Ring Road in the City of Bunbury Bicycle Plan.

The sealed shoulders on these roads can accommodate cyclists and pedestrians and shared paths available at the roundabout intersection of South Western Highway and Bunbury Outer Ring Road for crossing this intersection.

3. Development Proposal

3.1. Structure Plan Proposal

The proposed structure plan is attached in **Appendix A** and shown in **Figure 5.** The subject site is cleared rural land with some minor vegetation. The structure plan proposal is for 6 large industrial lots, with a single road connecting to South Western Highway.

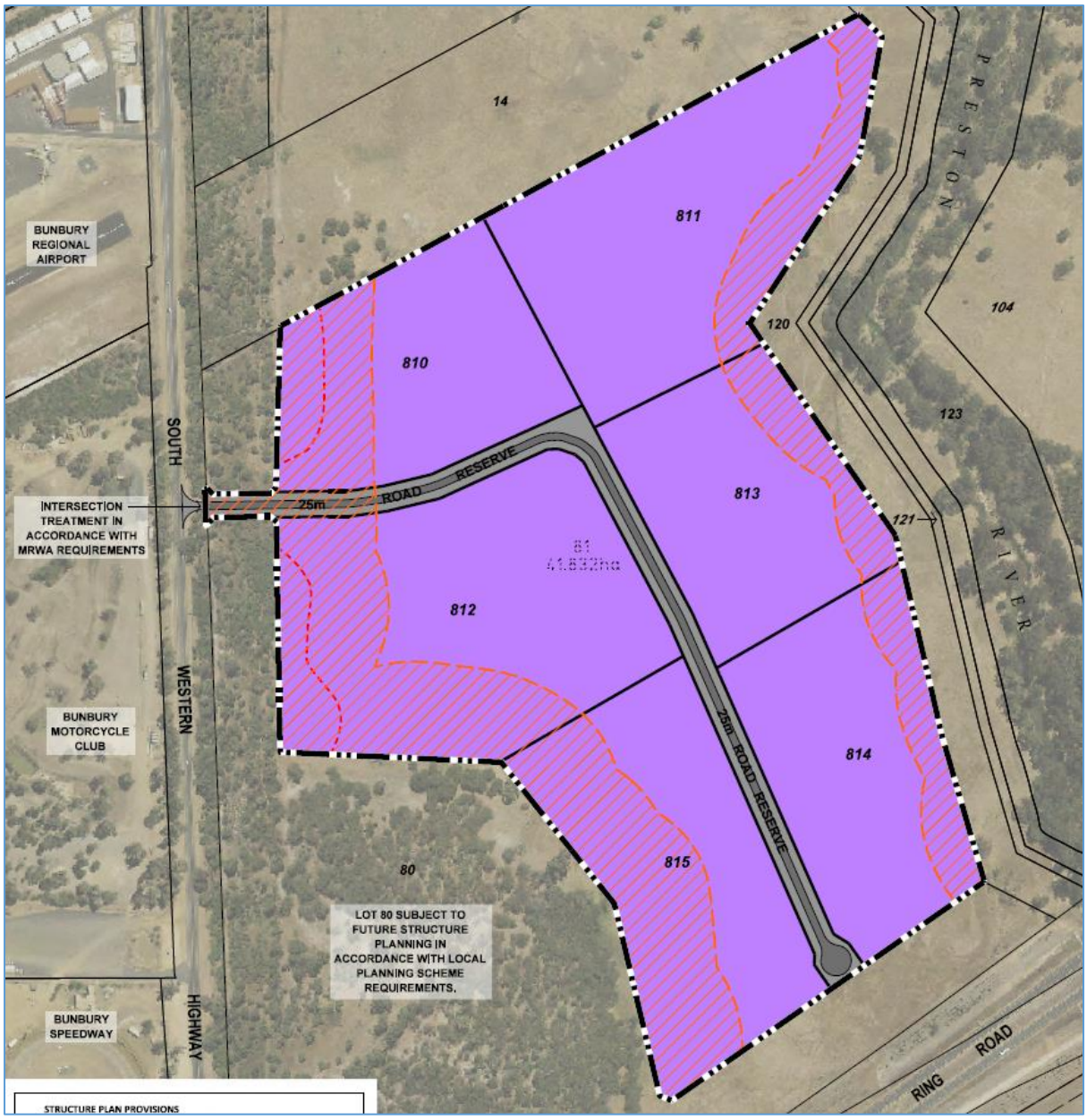


Figure 5 - Proposed Structure Plan

3.2. Proposed Land Use

The proposed structure plan as shown in **Figure 5** consists of 6 industrial lots and a 25m wide road reservation. The proposed land use and areas is shown in **Table 2** below

Table 2 - Proposed Land Use

Land Use	Lot Number	Area (ha)
Industrial	810	5.23
Industrial	811	7.75
Industrial	812	8.89
Industrial	813	5.17
Industrial	814	5.71
Industrial	815	6.56
Road Reservation	N/A	2.522
	TOTAL	**41.832**

3.3. Changes to External Transport Networks

A new intersection at South Western Highway will be constructed to connect with the proposed structure plan road. The intersection treatment will be in accordance with Main Roads WA (MRWA) requirements.

The Bunbury Outer Ring Road will be completed by 2021, with up to an estimated 15,000 vehicles per day using various sections of the new road (MRWA, 2016). **Figure 6** shows the ultimate route of the Bunbury Outer Ring Road and other planned Primary Regional Roads for the Greater Bunbury Area. The majority of heavy vehicle traffic destined for the proposed structure plan is predicted to use this route to access the Bunbury Port, or as a bypass north towards Perth or south towards Busselton.

Figure 6 - Greater Bunbury Region - Planned Primary Regional Roads (MRWA, 2016)

4. Transport Assessment

4.1. Assessment Period

The time periods for assessment were chosen based on the full development of the proposed structure plan, taken as 2018, and a 10-year forecast (2028) based on a 3% p.a. annual growth rate for South Western Highway.

4.2. Traffic Generation

Trip Generation rates were applied using the Institute of Transportation Engineers (ITE) *Trip Generation Manual 8th Edition.*

Assessed generation is shown on **Table 3** and **Table 4** and is based on Lot Numbers assigned in Table 2.

Table 3 - Trip Generation

Lot No.	Land Use	Generation Rate			Unit	Area	Estimated Generation		
		ADT	AM Peak	PM Peak			ADT	AM Peak	PM Peak
810	Industrial	128	18.56	17.94	Ha	5.23	669	97	94
811	Industrial	128	18.56	17.94	Ha	7.75	992	144	139
812	Industrial	128	18.56	17.94	Ha	8.89	1138	165	159
813	Industrial	128	18.56	17.94	Ha	5.17	662	96	93
814	Industrial	128	18.56	17.94	Ha	5.71	731	106	102
815	Industrial	128	18.56	17.94	Ha	6.56	840	122	118
TOTAL						**39.31**	**5032**	**730**	**705**

Table 4 - Peak Hour Directional Distribution

Lot No.	AM Peak		PM Peak	
	IN	OUT	IN	OUT
810	81	17	21	73
811	119	24	31	108
812	137	28	35	124
813	80	16	20	72
814	88	18	23	80
815	101	21	26	92
TOTAL	**606**	**124**	**155**	**550**

4.3. Traffic Distribution

Based on the location and connectivity of the surrounding network and the major attractors / generators discussed in Section 2.4, the following assumptions have been made for the distribution of the site-generated traffic:

- 60 % will enter and exit from the north towards the Bunbury Townsite and South Western Highway north
- 40% will enter and exit from the south towards South Western Highway and Bunbury Outer Ring Road
    - 20% to and from the south via South Western Highway
    - 20% to and from the east via Bunbury Outer Ring Road

For the 10-year development scenario, including the completion of the MRWA Bunbury Outer Ring Road and Bunbury Port Access Road, it is estimated that a larger proportion of vehicles will access the site from the south as indicated below:

- 30 % will enter and exit from the north towards the Bunbury Townsite and South Western Highway north
- 70% will enter and exit from the south towards South Western Highway and Bunbury Outer Ring Road
    - 20% to and from the south via South Western Highway
    - 50% to and from the east via Bunbury Outer Ring Road

4.4. Design Traffic Flows

The traffic flows of the network were assigned to the road network using the volumes generated in Section 5.2 as shown in **Figure 7.** The maximum traffic flows for the structure plan will occur near the South Western Highway intersection with an estimated 5,032 vehicles per day and 730 vehicles per hour during the AM Peak and 705 vehicles per hour during the PM Peak. It is estimated that 10% of the traffic flows will be heavy vehicles.

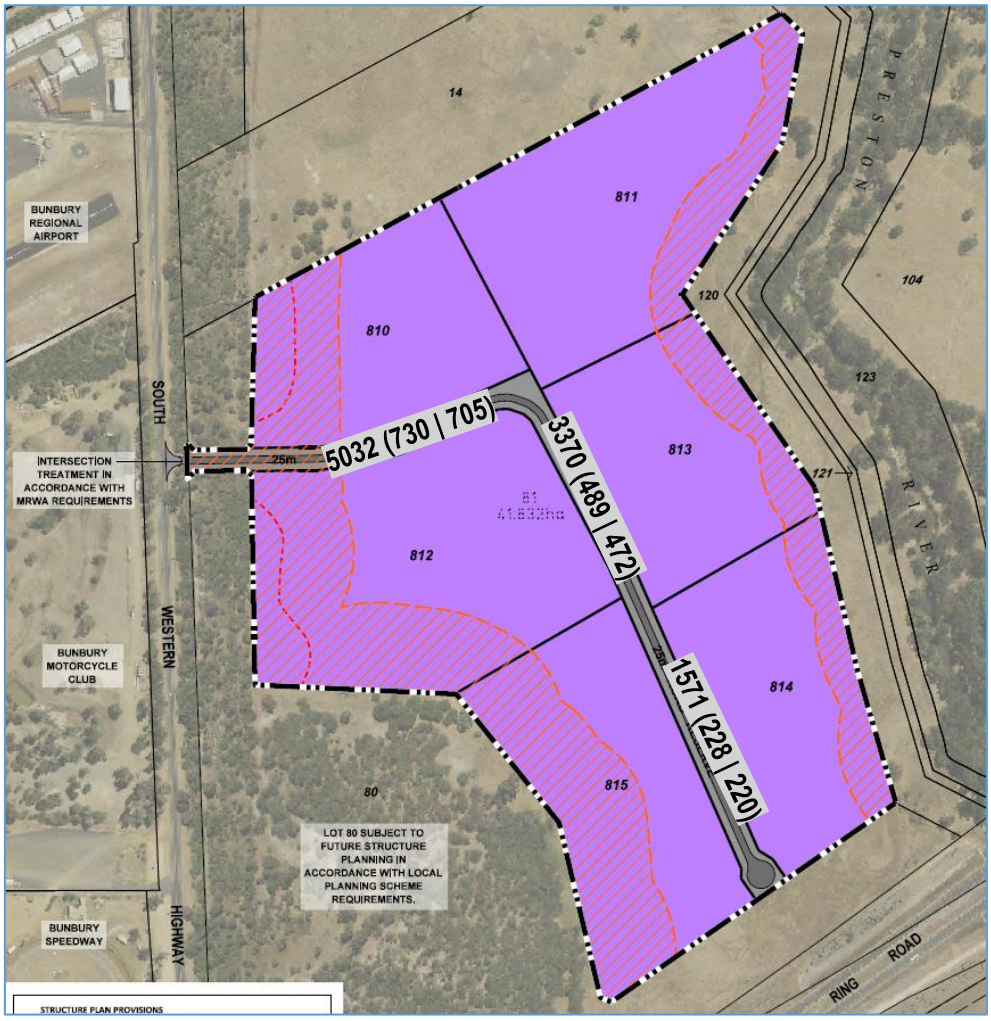


Figure 7 - Future Daily Traffic Volumes

4.5. External Traffic Flows

The predicted volumes for 2018 for South Western Highway and Bunbury Outer Ring Road were calculated using a 3% p.a. compound growth rate from the most recent available data. This method was also applied for 2028 South Western Highway volumes, however the 2028 traffic volume on Bunbury Outer Ring Road was predicted as 15,000vpd assuming the ultimate completion volumes noted by MRWA. The predicted flows were added to these 2018 and 2028 volumes as shown in **Table 5** below.

The traffic increases on South Western Highway and Bunbury Outer Ring Road are not expected to impact the operation of the roads.

Table 5 - Existing Road Network - Predicted Flows

Location	Desirable Max. Traffic Volume. (vpd)	Existing Traffic Volumes (vpd) / Year	2018 Development Year (vpd)			2028 Forecast Year (vpd)		
			Base Traffic Volumes	Predicted Volumes	Site-generated increase	Base Traffic Volumes	Predicted Volumes	Site-generated increase
South Western Highway - north of site	35,000	6,207 September 2013	7,196	10,215	+3019	9,670	11,180	+1510
South Western Highway - south of site	35,000	6,207 September 2013	7,196	9,209	+2013	9,670	13,192	+3522
Bunbury Outer Ring Road - east of South Western Highway	35,000	2,817 August 2014	3,170	4,176	+1006	15,000	17,516	+2516

5. Roads and Intersections

5.1. Proposed Internal Transport Networks

The structure plan proposal has one internal road connecting with South Western Highway. As this road is predicted to carry approximately 5,000 vehicles per day, with a high proportion of heavy vehicle traffic, the road should be constructed to an industrial standard, with the intersection, bend and cul-de-sac designed for the maximum vehicle intended for use within the development.

5.2. Road Hierarchy and Reserves

Due to the low connectivity (cul-de-sac) and primary purpose as the provision of property access, the road will function as an *Access Road (Industrial),* however the road will operate with greater than the maximum desirable volume of 3,000vpd.

As stated in the Western Australian Planning Commission (WAPC) *Policy DC 4.1- Industrial Subdivision,* heavily trafficked routes require a 25m road reservation, with a 10m carriageway width preferred. The corner of the road between Lots 810 and 811 should be designed with a minimum truncation of 8.5m.

5.2.1. Intersection Analysis

Internal peak hour traffic volumes within the development are generally small and as such negligible impacts are predicted. Warrants for analysis for each intersection as shown in Table 6.1 of Austroads Guide to Traffic Management Part 3, Traffic Studies and Analysis, shown below as **Table 6**, were applied and determined that no intersections required capacity analysis. Peak hour traffic volumes were assumed to be approximately 10% of predicted daily traffic.

Table 6 - Intersection Analysis Warrants

Intersection	Hourly volume major road	Hourly volume minor road	Comment.
Warrants as per Table 6.1 of Austroads Guide to Traffic Management Part 3, Traffic Studies and Analysis - Two Lane Major Road Cross Road	400 vph 500 vph 650 vph	250 vph 200 vph 100 vph	Table details flows that initiate intersection analysis. As major flows increase, there is reduced capacity to accept minor flows.
South Western Highway - Structure Plan Access Road	620	500	3 way intersection – Analysis required.

The proposed intersection of South Western Highway and the Structure Plan Access Road was assessed using SIDRA Intersection 7.0. Traffic volumes for South Western Highway for the development year, 2018, and the ten-year forecast year, 2028, were estimated by applying a 3% p.a. compound rate to existing traffic volumes. The Heavy Vehicle percentage for South Western Highway was obtained from MRWA Classification Counts from 2014 and is taken as the average Monday to Friday, 11.5%. The site-generated heavy vehicle traffic was estimated as

10% of the peak hour volumes. The movement summaries for the assessment are attached in Appendix C and shows that the proposed intersection will operate at a satisfactory level of service, with minimal delays for the proposed development year, and for the year 2028.

5.3. Pedestrian/ Cyclist Access

Footpaths should be provided on at least one side the Structure Plan Access Road to accommodate any future connections to the established pedestrian and cycling network external to the area. It is recommended that the footpath is constructed with a minimum width of 1.5 metres.

5.4. Public Transport Access

As discussed in Section 3.5, there are limited public transport services in the area. It is recommended that the Public Transport Authority review the requirements for this area as urban development progresses.

5.5. Safety issues

A review of the overall transport proposal for the site did not identify any specific issues that present unacceptable risks to the road user or that cannot be managed through appropriate design protocols.

Road hazards are typically present at intersections and may occur due inadequate sight distance, inappropriate geometry or substandard capacity that promotes undesirable and potentially hazardous movements.

For the new roads, the allocation of adequate road reservation width and truncation of corners will generally allow sight distance requirements to be accommodated in the detailed design phase of the project. Geometric standards prescribed by Austroads and Main Roads WA guidelines will ensure that no unacceptable risk is introduced into the road environment. Assessment of the operational performance of intersections undertaken in this study prescribes appropriate geometry and lane allocation to minimise delay and optimise performance.

Detailed design undertaken as part of the Development Application process would need to define at least the following elements:

- Road cross sections including lane widths, on-road cycle lanes, path widths and provisions for people with disabilities;
- Intersection geometries; and
- Pedestrian and cycle facilities (cross sections, crossing requirements and ramps).

5.6. Noise

Due to the location adjacent to two major roads, a regional airport and a motorway, the proposed development is not likely to generate any traffic noise or result in any vibration issues that would adversely impact the community.

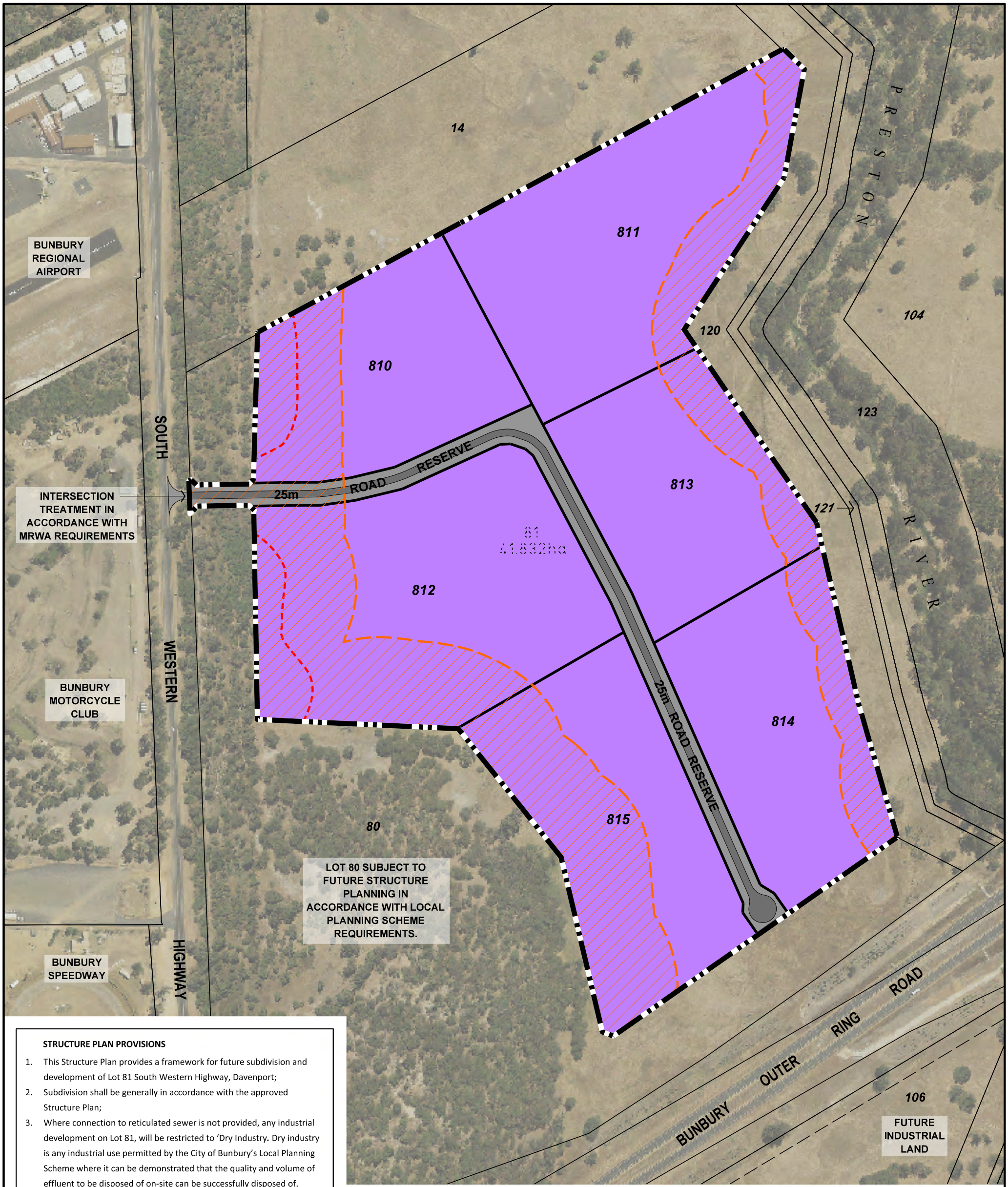
6. Conclusions

Based on the assessment of traffic generation exercise it is predicted that the traffic on South Western Highway and Bunbury Outer Ring Road is within the desirable capacity of these roads.

With respect to the proposed structure plan area, the following is concluded;

- Under the ultimate development of the structure plan, the site will yield 6 industrial lots with a single access road.
- The predicted traffic flows are approximately 5,032 vehicles per day.
- The new intersection with South Western Highway is predicted to operate at acceptable levels of service for the predicted development year, 2018 and for 10 years beyond the development year.
- The new road within the structure plan area will be constructed as *Access Road* to an industrial standard, with a 10m wide carriageway and all 8.5m truncated corners. All other cross section details, line marking, intersection control and local area traffic management measures are to be addressed during the detailed subdivision design stages.
- Pedestrian and cyclist facilities should be provided within the development to allow for future connections on South Western Highway.
- Public Transport services are not currently available however given the nature of the development this is unlikely to affect the future development operations.

Appendix A – Structure Plan



STRUCTURE PLAN PROVISIONS

1. This Structure Plan provides a framework for future subdivision and development of Lot 81 South Western Highway, Davenport;
2. Subdivision shall be generally in accordance with the approved Structure Plan;
3. Where connection to reticulated sewer is not provided, any industrial development on Lot 81, will be restricted to 'Dry Industry. Dry industry is any industrial use permitted by the City of Bunbury's Local Planning Scheme where it can be demonstrated that the quality and volume of effluent to be disposed of on-site can be successfully disposed of, without adverse environmental or health effects, utilising effluent disposal systems approved by the Health Department of Western Australia, the Department of Environment Regulation and the Department of Water. In addition, development will be restricted to the type which is predicted to generate wastewater intended for disposal on site at a daily volume not exceeding 540 litres per 2000m².

LEGEND

- STRUCTURE PLAN BOUNDARY
- INDICATIVE LARGE INDUSTRIAL LOT BOUNDARY
- INDUSTRY
- CONSERVATION CATEGORY WETLAND 50m BUFFER
- DRAINAGE
- BUSHFIRE PRONE AREA

0 40 80 120 160
metres

NOTES

Base data supplied by Harley Dykstra

Projection - GDA94

Areas and dimensions shown are subject to final survey calculations.
All carriageways are shown for illustrative purposes only and are subject to detailed engineering design.

SCALE	:	*1:4,000 @ A3*
DATE	:	*10 October 2016*
PLAN No	:	*81DavenportLSP_V1.0_20161010*
REVISION	:	*A*
PLANNER	:	*SLB*
DRAWN	:	*BL*

STRUCTURE PLAN

Lot 81 South Western Highway, Davenport

LB PLANNING
TOWN PLANNING | URBAN DESIGN | LAND DEVELOPMENT CONSULTING

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P (08) 9750 5925
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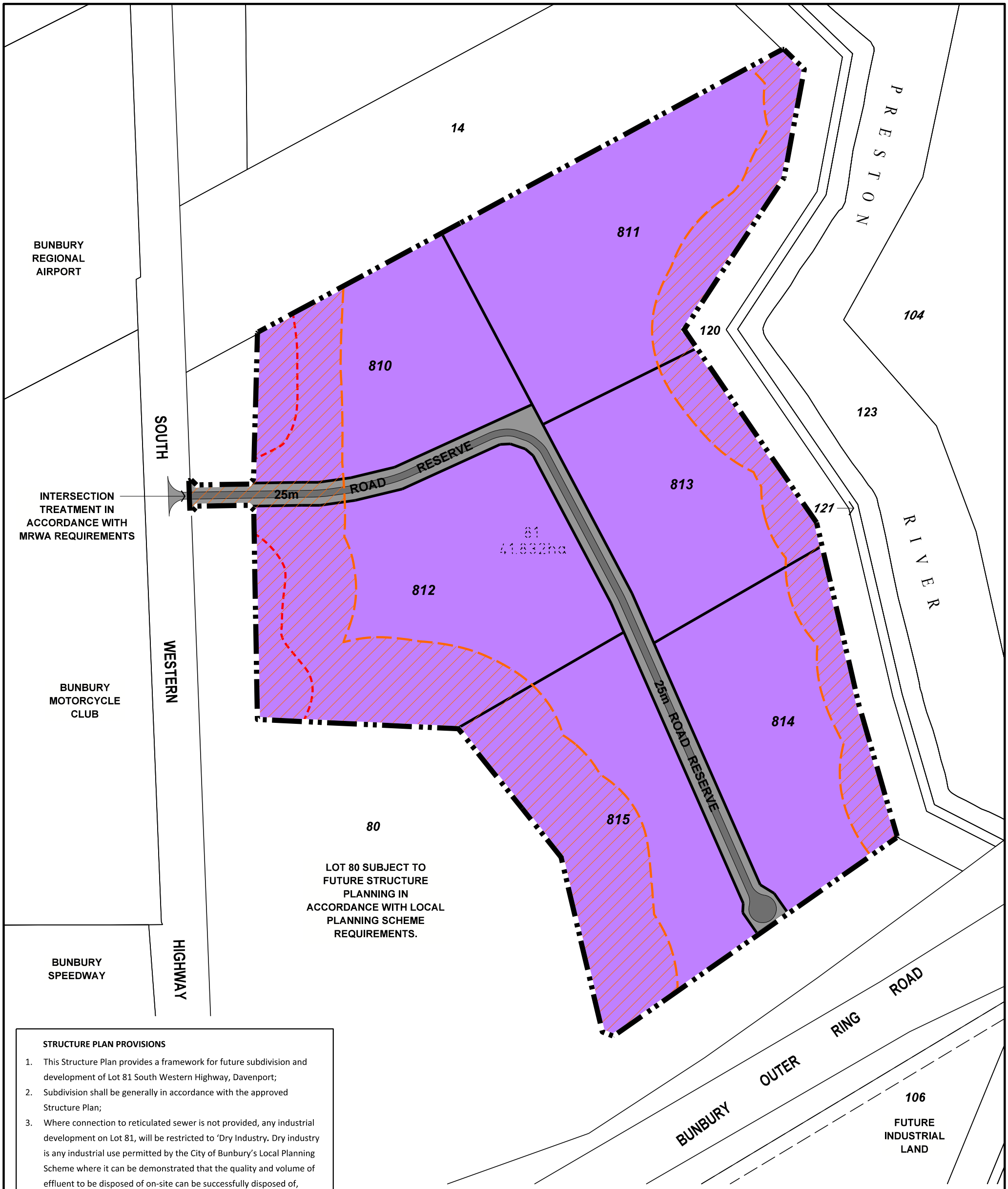
ABN 55 115 374 128



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0 40 80 120 160
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SCALE	:	*1:4,000 @ A3*
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STRUCTURE PLAN

Lot 81 South Western Highway, Davenport

LB PLANNING
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Appendix B - Traffic Data

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**Bunbury Outer Ring Rd (H058)**
Site No:	**51566**	Location Description:	**East of Moore Rd (SLK 0.40)**
Date Range:	**12 Nov 2013 to 20 Nov 2013**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000	1	2	3	3	4	5	3	3	3
0100	1	4	5	1	1	1	4	2	2
0200	7	11	7	6	11	0	0	8	6
0300	15	12	15	13	6	2	3	12	9
0400	17	27	17	26	16	6	3	21	16
0500	92	88	93	97	91	32	25	92	74
0600	103	126	129	116	98	40	20	114	90
0700	96	111	105	91	100	37	21	101	80
0800	84	91	96	98	92	42	28	92	76
0900	73	82	76	65	73	36	40	74	64
1000	68	70	59	75	69	48	37	68	61
1100	83	60	56	66	74	41	52	68	62
1200	59	54	67	55	78	48	69	63	61
1300	68	69	77	64	66	34	34	69	59
1400	76	74	82	70	110	43	51	82	72
1500	94	109	108	102	127	31	45	108	88
1600	131	137	146	138	99	50	50	130	107
1700	124	127	121	118	91	73	57	116	102
1800	59	64	62	74	51	57	43	62	59
1900	30	24	30	22	22	30	13	26	24
2000	14	18	16	18	16	16	13	16	16
2100	4	8	15	10	12	47	5	10	14
2200	10	6	6	4	6	25	4	6	9
2300	2	2	3	2	4	9	4	3	4
Total	1311	1376	1394	1334	1317	753	624	1346	1158

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour	0645	0600	0600	0645	0545	0530	1130	0600	0645
	1/4 Hr Vol	38	42	45	39	33	16	16	37	31
	1/2 Hour	0530	0545	0545	0545	0530	1000	1130	0545	0545
	1/2 Hr Vol	66	72	75	69	65	27	30	69	56
	1 Hour	0515	0600	0530	0530	0530	1130	1145	0530	0530
	1 Hr Vol	111	126	130	123	115	50	71	121	102
	1 Hr Fact	.8409	.75	.7303	.8786	.8712	.7813	.8068	.8082	.8285
	2 Hour	0530	0530	0530	0515	0530	1115	1045	0530	0530
	2 Hr Vol	212	241	238	230	207	92	122	229	192
PM	1/4 Hour	1700	1730	1600	1700	1430	1800	1800	1600	1600
	1/4 Hr Vol	45	40	46	41	40	27	26	38	32
	1/2 Hour	1600	1600	1600	1645	1515	1745	1745	1600	1600
	1/2 Hr Vol	74	72	82	78	70	43	44	71	61
	1 Hour	1615	1615	1600	1615	1500	1730	1730	1600	1600
	1 Hr Vol	138	138	146	145	127	79	71	133	115
	1 Hr Fact	.7667	.8961	.7935	.8841	.7938	.7315	.6827	.885	.8953
	2 Hour	1530	1545	1545	1615	1430	1645	1615	1545	1545
	2 Hr Vol	255	269	267	258	241	142	119	254	222
Peak	12 Hour	0530	0545	0545	0545	0530	0645	0715	0545	0545
	12 Hr Vol	1072	1113	1123	1073	1094	547	531	1100	967

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**Bunbury Outer Ring Rd (H058)**
Site No:	**51566**	Location Description:	**East of Moore Rd (SLK 0.40)**
Date Range:	**12 Nov 2013 to 20 Nov 2013**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
0000	1	0	1	1	1	2	2	1	2	2	4	1	1	2	1	1	2	1
0100	0	1	3	1	3	2	0	1	1	0	0	1	2	2	1	1	1	1
0200	3	4	5	6	3	4	2	4	4	7	0	0	0	0	3	5	2	4
0300	6	9	4	8	7	8	7	6	1	5	0	2	2	1	5	7	4	6
0400	6	11	13	14	8	9	12	14	8	8	5	1	2	1	9	11	8	8
0500	26	66	23	65	28	65	24	73	20	71	8	24	10	15	24	68	20	54
0600	48	55	61	65	54	75	47	69	44	54	29	11	15	5	51	64	43	48
0700	36	60	38	73	43	62	32	59	47	53	14	23	12	9	39	61	32	48
0800	37	47	46	45	41	55	43	55	34	58	28	14	18	10	40	52	35	41
0900	39	34	38	44	34	42	31	34	34	39	20	16	21	19	35	39	31	33
1000	35	33	40	30	36	23	41	34	35	34	25	23	21	16	37	31	33	28
1100	52	31	27	33	30	26	41	25	33	41	25	16	27	25	37	31	34	28
1200	33	26	25	29	33	34	31	24	41	37	26	22	42	27	33	30	33	28
1300	33	35	38	31	37	40	32	32	28	38	18	16	20	14	34	35	29	29
1400	44	32	42	32	40	42	43	27	64	46	19	24	28	23	47	36	40	32
1500	51	43	67	42	70	38	54	48	79	48	15	16	19	26	64	44	51	37
1600	85	46	89	48	101	45	90	48	58	41	22	28	21	29	85	46	67	41
1700	68	56	68	59	65	56	67	51	54	37	22	51	20	37	64	52	52	50
1800	42	17	41	23	41	21	48	26	31	20	30	27	31	12	41	21	38	21
1900	10	20	13	11	16	14	13	9	10	12	10	20	8	5	12	13	11	13
2000	10	4	8	10	7	9	5	13	7	9	11	5	7	6	7	9	8	8
2100	3	1	3	5	9	6	5	5	8	4	42	5	2	3	6	4	10	4
2200	7	3	4	2	3	3	4	0	4	2	22	3	1	3	4	2	6	2
2300	2	0	1	1	2	1	2	0	2	2	4	5	3	1	2	1	2	1
Total	677	634	698	678	712	682	676	658	649	668	399	354	333	291	681	664	592	566

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
AM	1/4 Hour	1100	0530	0600	0745	0600	0645	0600	0530	0600	0530	1130	0530	1145	0530	0600	0530	0600	0530
	1/4 Hr Vol	22	27	31	27	28	28	18	27	21	27	11	14	10	11	25	26	21	23
	1/2 Hour	1100	0530	0545	0530	0545	0530	0545	0530	0600	0530	1130	0515	1145	1115	0600	0530	0600	0530
	1/2 Hr Vol	34	53	38	48	37	46	27	53	29	53	16	19	20	15	33	50	28	42
	1 Hour	1100	0515	0600	0630	0530	0515	0600	0515	0700	0530	1130	0500	1145	1130	0600	0515	0600	0515
	1 Hr Vol	52	74	61	77	54	77	47	85	47	74	30	24	45	28	53	76	46	64
	1 Hr Fact	.5909	.6852	.5	.8021	.4909	.7549	.6528	.787	.8393	.6852	.6818	.4286	.8036	.7	.5392	.7268	.5565	.6923
	2 Hour	0930	0515	0600	0515	0600	0515	0545	0515	0600	0515	1015	1115	1045	1100	0600	0515	0600	0515
	2 Hr Vol	91	137	99	146	97	147	85	155	91	129	52	43	71	52	92	144	80	119
PM	1/4 Hour	1700	1730	1700	1730	1600	1730	1800	1630	1430	1430	2145	1730	1800	1730	1600	1730	1600	1730
	1/4 Hr Vol	37	22	30	22	35	20	28	18	22	18	20	21	22	15	28	20	23	19
	1/2 Hour	1600	1730	1600	1715	1600	1730	1600	1630	1515	1515	2130	1730	1745	1730	1600	1730	1600	1730
	1/2 Hr Vol	54	36	50	37	58	35	51	30	42	28	33	31	29	26	50	33	42	32
	1 Hour	1615	1700	1615	1645	1600	1700	1600	1615	1500	1345	2115	1645	1200	1700	1530	1700	1530	1700
	1 Hr Vol	95	56	91	59	101	56	90	56	79	48	52	53	42	37	88	53	73	51
	1 Hr Fact	.6419	.6364	.7712	.6705	.7319	.7179	.8333	.7778	.8977	.6667	.65	.631	.75	.6167	.7897	.6673	.7859	.6557
	2 Hour	1530	1600	1515	1600	1530	1600	1530	1615	1430	1345	2045	1645	1215	1545	1530	1600	1530	1600
	2 Hr Vol	169	102	171	107	179	101	166	100	150	94	67	88	65	66	166	99	139	93
Peak	12 Hour	0615	0515	0600	0515	0545	0515	0615	0515	0600	0500	1015	0645	0715	0715	0600	0515	0630	0515
	12 Hr Vol	568	515	576	543	583	547	562	539	551	560	274	277	282	249	568	541	501	473

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**Bunbury Outer Ring Rd (H058)**
Site No:	**51565**	Location Description:	**West of Moore Rd (SLK 1.85)**
Date Range:	**29 May 2015 to 10 Jun 2015**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon ✈	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000	0	3	2	8	6	9	7	4	5
0100	5	11	11	6	11	9	5	9	8
0200	16	26	26	18	26	7	4	22	18
0300	26	43	49	55	53	6	6	45	34
0400	27	47	48	50	54	13	7	45	35
0500	100	167	179	189	173	40	32	162	126
0600	119	207	224	197	194	61	42	188	149
0700	112	191	219	197	182	46	37	180	141
0800	122	196	204	190	179	88	49	178	147
0900	95	145	133	141	138	101	59	130	116
1000	109	135	153	127	127	106	71	130	118
1100	117	142	150	118	140	116	99	133	126
1200	130	138	148	136	180	105	81	146	131
1300	133	141	153	132	188	93	68	149	130
1400	140	190	163	185	228	85	76	181	152
1500	152	228	227	204	236	80	87	209	173
1600	197	327	310	285	224	79	78	269	214
1700	164	250	257	246	229	102	85	229	190
1800	76	109	114	112	101	61	59	102	90
1900	32	50	36	63	43	30	29	45	40
2000	23	26	28	28	18	21	17	25	23
2100	19	26	30	19	31	20	14	25	23
2200	13	8	14	6	15	8	8	11	10
2300	3	5	3	6	8	7	4	5	5
Total	1930	2811	2881	2718	2784	1293	1024	2622	2204

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour	0530	0645	0645	0545	0530	1115	1130	0645	0530
	1/4 Hr Vol	41	67	73	67	63	32	30	56	43
	1/2 Hour	0530	0530	0630	0530	0530	1115	1130	0530	0530
	1/2 Hr Vol	76	118	128	121	120	62	57	110	84
	1 Hour	0530	0530	0630	0745	0530	1115	1100	0530	0530
	1 Hr Vol	132	211	236	217	210	119	98	194	152
	1 Hr Fact	.8148	.8508	.8082	.8097	.84	.9297	.8305	.8765	.8853
	2 Hour	1145	0530	0530	0530	0530	1030	1100	0530	0530
	2 Hr Vol	264	417	452	411	398	224	179	382	294
PM	1/4 Hour	1600	1630	1645	1600	1530	1730	1730	1600	1600
	1/4 Hr Vol	59	98	84	89	71	33	27	73	58
	1/2 Hour	1600	1630	1600	1700	1530	1715	1715	1645	1645
	1/2 Hr Vol	106	184	161	152	133	57	46	136	107
	1 Hour	1600	1600	1600	1630	1515	1200	1530	1600	1600
	1 Hr Vol	196	327	310	288	251	104	88	266	208
	1 Hr Fact	.8376	.8342	.9226	.878	.8838	.9286	.9362	.9123	.8918
	2 Hour	1545	1530	1545	1545	1530	1200	1545	1545	1545
	2 Hr Vol	371	584	572	548	481	197	168	503	402
Peak	12 Hour	0545	0545	0545	0545	0530	0645	0715	0545	0545
	12 Hr Vol	1592	2296	2350	2187	2253	1063	845	2129	1761

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**Bunbury Outer Ring Rd (H058)**
Site No:	**51565**	Location Description:	**West of Moore Rd (SLK 1.85)**
Date Range:	**29 May 2015 to 10 Jun 2015**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon ✈		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
0000	0	0	2	1	0	2	6	2	3	3	5	4	2	5	2	2	3	2
0100	3	2	8	3	6	5	4	2	4	7	6	3	2	3	5	4	5	4
0200	8	8	11	15	13	13	7	11	13	13	3	4	2	2	10	12	8	9
0300	17	9	26	17	28	21	34	21	30	23	3	3	2	4	27	18	20	14
0400	19	8	32	15	25	23	33	17	34	20	11	2	5	2	29	17	23	12
0500	78	22	120	47	132	47	138	51	113	60	31	9	28	4	116	45	91	34
0600	54	65	115	92	126	98	114	83	102	92	26	35	13	29	102	86	79	71
0700	48	64	84	107	103	116	88	109	85	97	22	24	13	24	82	99	63	77
0800	65	57	98	98	107	97	90	100	89	90	40	48	31	18	90	88	74	73
0900	51	44	78	67	76	57	62	79	70	68	40	61	32	27	67	63	58	58
1000	58	51	69	66	80	73	60	67	66	61	44	62	34	37	67	64	59	60
1100	66	51	80	62	87	63	64	54	77	63	68	48	52	47	75	59	71	55
1200	76	54	76	62	71	77	63	73	84	96	51	54	48	33	74	72	67	64
1300	77	56	79	62	81	72	66	66	92	96	52	41	31	37	79	70	68	61
1400	76	64	107	83	92	71	118	67	117	111	48	37	38	38	102	79	85	67
1500	87	65	122	106	119	108	87	117	123	113	41	39	44	43	108	102	89	84
1600	98	99	171	156	158	152	135	150	123	101	41	38	46	32	137	132	110	104
1700	92	72	146	104	133	124	139	107	126	103	57	45	49	36	127	102	106	84
1800	31	45	41	68	47	67	37	75	35	66	23	38	24	35	38	64	34	56
1900	18	14	31	19	19	17	40	23	19	24	18	12	13	16	25	19	23	18
2000	12	11	14	12	20	8	14	14	11	7	12	9	9	8	14	10	13	10
2100	9	10	9	17	12	18	12	7	21	10	13	7	5	9	13	12	12	11
2200	7	6	6	2	9	5	4	2	12	3	4	4	3	5	8	4	6	4
2300	1	2	4	1	2	1	4	2	4	4	3	4	2	2	3	2	3	2
Total	1051	879	1529	1282	1546	1335	1419	1299	1453	1331	662	631	528	496	1400	1225	1170	1034

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
AM	1/4 Hour	0530	0745	0545	0745	0545	0745	0545	0745	0545	0745	1115	1000	1145	1130	0545	0745	0545	0745
	1/4 Hr Vol	31	23	51	40	52	42	57	45	46	33	20	20	18	18	46	35	34	26
	1/2 Hour	0530	0730	0530	0730	0530	0730	0530	0745	0530	0730	1115	0945	1145	1115	0530	0730	0530	0730
	1/2 Hr Vol	61	37	93	65	99	71	100	71	89	58	37	37	31	27	87	59	67	45
	1 Hour	0530	0600	0530	0730	0530	0730	0515	0745	0530	0730	1100	0915	1115	1100	0530	0730	0530	0730
	1 Hr Vol	84	65	143	118	148	128	160	126	133	105	68	69	54	47	130	106	99	82
	1 Hr Fact	.6774	.7738	.701	.7468	.7115	.7619	.7018	.7	.7228	.8077	.85	.8625	.75	.6714	.7065	.7476	.723	.7815
	2 Hour	1145	0600	0530	0630	0530	0645	0515	0645	0530	1145	1045	0900	1100	1000	0530	0645	0530	0645
	2 Hr Vol	152	129	258	209	288	226	268	221	237	196	120	122	99	83	235	189	178	147
PM	1/4 Hour	1730	1600	1630	1600	1645	1600	1730	1600	1530	1300	1730	1800	1730	1800	1645	1600	1645	1600
	1/4 Hr Vol	34	35	57	55	56	55	42	53	37	44	24	20	18	18	42	44	32	34
	1/2 Hour	1715	1600	1630	1600	1645	1600	1715	1600	1515	1245	1715	1745	1715	1800	1645	1600	1645	1600
	1/2 Hr Vol	56	59	113	85	95	88	83	83	69	68	36	32	28	26	76	71	59	55
	1 Hour	1645	1600	1630	1600	1645	1600	1645	1545	1515	1215	1645	1200	1645	1515	1645	1600	1645	1600
	1 Hr Vol	105	99	193	156	172	152	158	155	137	121	57	54	50	44	147	129	118	100
	1 Hr Fact	.7836	.7174	.8465	.7091	.7679	.6972	.9405	.7311	.9257	.6954	.5938	.871	.6944	.88	.8704	.733	.9197	.7287
	2 Hour	1545	1545	1545	1515	1545	1600	1545	1530	1530	1415	1200	1200	1545	1415	1545	1515	1545	1515
	2 Hr Vol	196	176	318	269	305	276	282	281	258	226	103	94	95	83	270	238	217	188
Peak	12 Hour	0545	0630	0530	0615	0530	0615	0530	0630	0530	0615	0645	0615	0645	0715	0530	0615	0530	0615
	12 Hr Vol	858	744	1249	1070	1275	1108	1126	1086	1180	1092	530	533	441	406	1138	1012	932	845

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**Bunbury Outer Ring Rd (H058)**
Site No:	**51564**	Location Description:	**East of South Western Hwy (SLK 3.19)**
Date Range:	**28 Aug 2014 to 14 Sep 2014**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000	8	5	4	6	5	8	7	6	6
0100	6	3	3	3	5	3	7	4	4
0200	20	23	18	17	19	4	8	19	16
0300	22	25	19	19	19	6	4	21	16
0400	40	41	41	43	36	10	8	40	31
0500	109	119	118	118	104	34	29	114	90
0600	208	223	234	223	197	52	26	217	166
0700	234	226	222	218	216	67	35	223	174
0800	237	242	249	234	244	91	53	241	193
0900	147	166	123	162	165	108	91	153	137
1000	162	139	149	147	157	119	104	151	140
1100	152	145	154	155	164	114	118	154	143
1200	156	152	155	162	148	126	128	155	147
1300	159	163	159	163	166	112	101	162	146
1400	193	168	183	182	210	83	115	187	162
1500	235	249	247	246	237	95	124	243	205
1600	242	267	289	263	245	97	108	261	216
1700	237	229	250	229	217	98	102	232	195
1800	107	115	119	117	111	64	70	114	100
1900	50	58	50	49	45	35	33	50	46
2000	25	33	37	32	24	19	26	30	28
2100	15	17	19	19	29	24	15	20	20
2200	12	8	18	10	18	16	7	13	13
2300	4	11	7	5	10	9	6	7	7
Total	2780	2827	2867	2822	2791	1394	1325	2817	2401

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour	0645	0645	0645	0645	0745	0915	1130	0645	0645
	1/4 Hr Vol	73	82	73	72	68	32	33	71	51
	1/2 Hour	0630	0630	0630	0630	0815	1000	1115	0630	0630
	1/2 Hr Vol	137	144	137	141	128	62	65	135	98
	1 Hour	0630	0730	0730	0745	0745	1145	1130	0745	0745
	1 Hr Vol	246	253	253	250	249	122	127	248	188
	1 Hr Fact	.8425	.9036	.9234	.9282	.9154	.8883	.9525	.9106	.9317
	2 Hour	0630	0630	0630	0630	0700	1130	1115	0630	0645
	2 Hr Vol	482	491	488	480	460	242	247	478	354
PM	1/4 Hour	1700	1645	1700	1700	1700	1215	1530	1700	1700
	1/4 Hr Vol	87	77	89	86	81	34	35	84	65
	1/2 Hour	1645	1645	1645	1645	1645	1215	1530	1645	1645
	1/2 Hr Vol	145	152	168	148	142	68	66	150	118
	1 Hour	1630	1630	1615	1615	1615	1215	1200	1615	1615
	1 Hr Vol	262	293	306	274	262	127	128	276	218
	1 Hr Fact	.7572	.9575	.8596	.7965	.8053	.9248	.96	.8255	.8356
	2 Hour	1530	1530	1530	1515	1515	1200	1430	1530	1515
	2 Hr Vol	506	550	573	545	508	238	243	531	426
Peak	12 Hour	0615	0615	0600	0615	0615	0630	0715	0615	0615
	12 Hr Vol	2364	2383	2407	2389	2368	1185	1151	2381	1969

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**Bunbury Outer Ring Rd (H058)**
Site No:	**51564**	Location Description:	**East of South Western Hwy (SLK 3.19)**
Date Range:	**28 Aug 2014 to 14 Sep 2014**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
0000	7	1	2	3	2	2	3	3	2	3	4	4	3	4	3	2	3	3
0100	2	4	1	2	2	1	2	1	3	2	2	1	5	2	2	2	2	2
0200	14	6	16	7	12	6	12	5	11	8	2	2	6	2	13	6	10	5
0300	15	7	16	9	13	6	11	8	12	7	5	1	2	2	13	7	11	6
0400	25	15	26	15	26	15	29	14	23	13	8	2	6	2	26	14	20	11
0500	74	35	79	40	78	40	79	39	73	31	23	11	20	9	77	37	61	29
0600	120	88	121	102	133	101	127	96	111	86	27	25	9	17	122	95	93	74
0700	130	104	108	118	120	102	111	107	109	107	34	33	17	18	116	108	90	84
0800	128	109	128	114	135	114	128	106	137	107	43	48	30	23	131	110	104	89
0900	69	78	89	77	68	55	76	86	83	82	53	55	44	47	77	76	69	69
1000	86	76	71	68	78	71	73	74	77	80	60	59	53	51	77	74	71	68
1100	89	63	75	70	75	79	87	68	89	75	65	49	67	51	83	71	78	65
1200	74	82	81	71	82	73	84	78	79	69	63	63	63	65	80	75	75	72
1300	74	85	89	74	83	76	82	81	86	80	64	48	59	42	83	79	77	69
1400	102	91	93	75	104	79	94	88	101	109	46	37	69	46	99	88	87	75
1500	127	108	130	119	129	118	136	110	117	120	47	48	67	57	128	115	108	97
1600	120	122	142	125	154	135	133	130	123	122	51	46	59	49	134	127	112	104
1700	113	124	101	128	114	136	105	124	100	117	59	39	54	48	107	126	92	102
1800	41	66	41	74	46	73	45	72	41	70	25	39	32	38	43	71	39	62
1900	30	20	29	29	26	24	26	23	24	21	16	19	19	14	27	23	24	21
2000	16	9	21	12	19	18	18	14	11	13	11	8	13	13	17	13	16	12
2100	11	4	14	3	12	7	12	7	18	11	12	12	8	7	13	6	12	7
2200	8	4	4	4	6	12	5	5	11	7	8	8	4	3	7	6	7	6
2300	2	2	4	7	4	3	3	2	7	3	3	6	3	3	4	3	4	4
Total	1477	1303	1481	1346	1521	1346	1481	1341	1448	1343	731	663	712	613	1482	1334	1265	1136

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
AM	1/4 Hour	0645	0645	0645	0745	0645	0845	0630	0745	0630	0745	0915	0930	1130	1015	0645	0745	0645	0745
	1/4 Hr Vol	41	32	43	40	44	37	43	36	39	39	18	17	23	16	41	36	29	27
	1/2 Hour	0630	0830	0630	0730	0630	0830	0630	0730	0630	0730	1115	0915	1115	1145	0630	0730	0630	0730
	1/2 Hr Vol	82	59	80	73	85	61	85	63	75	63	35	32	40	30	81	63	58	47
	1 Hour	0630	0800	0630	0730	0730	0800	0630	0745	0800	0745	1115	1000	1115	1145	0630	0730	0745	0745
	1 Hr Vol	144	109	130	129	141	114	137	117	137	117	65	59	70	61	134	115	100	88
	1 Hr Fact	.878	.8651	.7558	.8063	.8704	.7703	.7904	.8125	.9341	.75	.9198	.9031	.75	.8798	.8187	.8023	.9761	.8302
	2 Hour	0630	0645	0630	0645	0630	0700	0630	0645	0630	0730	1115	0915	1130	1100	0630	0700	0630	0730
	2 Hr Vol	273	214	254	239	282	216	266	217	251	218	131	115	135	116	264	217	194	167
PM	1/4 Hour	1700	1700	1645	1700	1645	1700	1545	1700	1600	1700	1300	1230	1445	1245	1530	1700	1530	1700
	1/4 Hr Vol	40	47	42	51	41	54	41	52	34	48	19	17	21	18	36	50	29	38
	1/2 Hour	1645	1700	1630	1645	1630	1645	1545	1700	1600	1645	1300	1215	1430	1200	1530	1645	1530	1645
	1/2 Hr Vol	69	85	83	85	81	92	80	80	67	79	35	34	38	34	70	82	56	64
	1 Hour	1515	1630	1600	1630	1600	1630	1515	1615	1530	1615	1215	1200	1445	1200	1530	1630	1530	1615
	1 Hr Vol	132	143	142	153	154	156	145	145	131	139	65	63	71	65	136	144	109	112
	1 Hr Fact	.9041	.7688	.8452	.7574	.9506	.729	.8914	.7016	.9632	.724	.8705	.9265	.8589	.9198	.951	.72	.9433	.7315
	2 Hour	1515	1530	1530	1530	1530	1530	1515	1515	1515	1515	1200	1200	1400	1515	1515	1530	1515	1530
	2 Hr Vol	259	259	273	277	291	283	273	272	247	262	127	111	136	111	266	267	214	212
Peak	12 Hour	0545	0630	0530	0630	0545	0615	0530	0615	0530	0630	0615	0645	0715	0700	0530	0615	0530	0630
	12 Hr Vol	1234	1145	1238	1160	1280	1140	1249	1159	1225	1162	618	568	616	535	1243	1153	1024	950

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**South Western Hwy (H009)**
Site No:	**15872**	Location Description:	**East of Robertson Dr (SLK 154.06)**
Date Range:	**21 Oct 2013 to 02 Nov 2013**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000	17	47	39	32	37	52	28	34	36
0100	20	21	20	18	29	24	20	22	22
0200	32	49	42	38	37	28	24	40	36
0300	38	51	58	48	61	23	14	51	42
0400	132	145	144	154	165	69	22	148	119
0500	516	565	574	555	558	209	75	554	436
0600	806	847	833	833	814	221	84	827	634
0700	1144	1163	1125	1127	1083	316	175	1128	876
0800	1236	1272	1213	1237	1202	509	293	1232	995
0900	1078	1082	1053	1054	1155	706	450	1084	940
1000	1073	1006	1043	1005	1143	712	543	1054	932
1100	1099	1063	1056	1090	1162	846	563	1094	983
1200	1103	1098	1120	1114	1203	741	557	1128	991
1300	1059	1047	1008	1136	1195	582	528	1089	936
1400	1084	1137	1144	1222	1313	499	555	1180	993
1500	1430	1386	1418	1462	1521	493	496	1443	1172
1600	1440	1493	1528	1517	1389	424	383	1473	1168
1700	971	1040	1041	1038	1004	325	315	1019	819
1800	407	495	495	503	552	244	212	490	415
1900	265	288	289	313	304	157	121	292	248
2000	124	189	191	183	187	110	81	175	152
2100	107	139	109	134	136	74	44	125	106
2200	57	61	57	76	102	48	21	71	60
2300	53	45	45	40	53	51	23	47	44
Total	15291	15729	15645	15929	16405	7463	5627	15800	13155

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour	0745	0745	0745	0745	0745	1145	1130	0745	0745
	1/4 Hr Vol	352	358	355	361	333	251	157	352	291
	1/2 Hour	0745	0745	0745	0745	0745	1145	1130	0745	0745
	1/2 Hr Vol	646	678	644	666	623	484	303	651	542
	1 Hour	0745	0745	0745	0745	1145	1115	1130	0745	0745
	1 Hr Vol	1289	1317	1282	1302	1225	887	601	1282	1080
	1 Hr Fact	.9168	.921	.9028	.9017	.9784	.8852	.957	.9118	.9269
	2 Hour	0715	0730	0730	0730	1130	1030	1130	0730	0745
	2 Hr Vol	2427	2504	2385	2423	2425	1609	1135	2420	2070
PM	1/4 Hour	1530	1600	1600	1600	1530	1200	1430	1600	1600
	1/4 Hr Vol	421	415	428	423	413	233	157	411	343
	1/2 Hour	1530	1545	1600	1545	1530	1200	1200	1545	1545
	1/2 Hr Vol	765	780	804	798	813	413	298	781	654
	1 Hour	1515	1545	1545	1545	1515	1200	1415	1530	1530
	1 Hr Vol	1491	1522	1576	1541	1549	741	565	1525	1281
	1 Hr Fact	.8854	.918	.9206	.9108	.9388	.7951	.8997	.9269	.9347
	2 Hour	1515	1515	1515	1515	1445	1200	1315	1515	1515
	2 Hr Vol	2880	2914	2992	2980	2948	1322	1087	2930	2454
Peak	12 Hour	0545	0545	0545	0615	0615	0630	0730	0545	0615
	12 Hr Vol	13538	13671	13606	13863	14216	6406	5084	13774	11959

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**South Western Hwy (H009)**
Site No:	**15872**	Location Description:	**East of Robertson Dr (SLK 154.06)**
Date Range:	**21 Oct 2013 to 02 Nov 2013**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
0000	10	7	20	27	17	22	10	22	17	20	24	28	15	13	15	20	16	20
0100	8	12	9	12	11	9	12	6	14	15	12	12	11	9	11	11	11	11
0200	20	12	25	24	24	18	20	18	19	18	13	15	9	15	22	18	19	17
0300	21	17	26	25	29	29	27	21	37	24	10	13	8	6	28	23	23	19
0400	98	34	108	37	114	30	122	32	128	37	51	18	12	10	114	34	90	28
0500	420	96	457	108	462	112	454	101	458	100	165	44	50	25	450	103	352	84
0600	576	230	585	262	578	255	570	263	555	259	139	82	39	45	573	254	435	199
0700	634	510	642	521	618	507	626	501	605	478	159	157	108	67	625	503	485	392
0800	581	655	592	680	599	614	591	646	565	637	223	286	155	138	586	646	472	522
0900	496	582	492	590	479	574	491	563	507	648	326	380	192	258	493	591	426	514
1000	480	593	470	536	490	553	454	551	529	614	314	398	224	319	485	569	423	509
1100	506	593	485	578	499	557	518	572	549	613	395	451	203	360	511	583	451	532
1200	527	576	523	575	541	579	529	585	586	617	355	386	222	335	541	586	469	522
1300	544	515	525	522	507	501	560	576	598	597	300	282	215	313	547	542	464	472
1400	520	564	557	580	544	600	571	651	621	692	245	254	224	331	563	617	469	525
1500	572	858	569	817	579	839	594	868	648	873	239	254	211	285	592	851	487	685
1600	546	894	559	934	541	987	548	969	556	833	201	223	159	224	550	923	444	723
1700	374	597	418	622	421	620	391	647	418	586	169	156	139	176	404	614	333	486
1800	195	212	214	281	229	266	222	281	245	307	94	150	71	141	221	269	181	234
1900	113	152	147	141	137	152	157	156	131	173	69	88	59	62	137	155	116	132
2000	52	72	88	101	70	121	105	78	93	94	50	60	48	33	82	93	72	80
2100	54	53	53	86	55	54	68	66	79	57	38	36	22	22	62	63	53	53
2200	27	30	27	34	27	30	40	36	57	45	22	26	8	13	36	35	30	31
2300	22	31	20	25	18	27	20	20	30	23	21	30	14	9	22	25	21	24
Total	7396	7895	7611	8118	7589	8056	7700	8229	8045	8360	3634	3829	2418	3209	7670	8128	6342	6814

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
AM	1/4 Hour	0645	0815	0645	0815	0645	0815	0645	0815	0645	0815	1145	1145	1015	1130	0645	0815	0645	0815
	1/4 Hr Vol	222	183	240	184	233	175	235	183	226	171	122	129	67	102	231	179	184	151
	1/2 Hour	0630	0800	0645	0800	0630	0800	0630	0800	0645	0845	1145	1145	1000	1130	0630	0800	0630	1145
	1/2 Hr Vol	383	343	387	358	382	323	377	347	353	332	221	263	124	203	373	339	301	294
	1 Hour	0630	0745	0645	0800	0630	0745	0645	0745	0645	0815	1115	1115	0945	1130	0645	0745	0645	1115
	1 Hr Vol	684	659	688	680	668	635	670	661	643	656	400	487	230	392	667	650	541	569
	1 Hr Fact	.772	.9003	.7182	.9264	.7167	.9097	.7143	.9055	.7129	.9591	.823	.9086	.8582	.9608	.7225	.9083	.7335	.9572
	2 Hour	0630	0745	0645	0730	0645	0745	0645	0745	0645	0815	1100	1015	1130	1030	0645	0745	0645	1045
	2 Hr Vol	1303	1252	1330	1298	1314	1217	1311	1240	1246	1291	749	874	436	722	1299	1252	1073	1090
PM	1/4 Hour	1530	1630	1600	1600	1515	1600	1515	1600	1530	1600	1200	1200	1430	1215	1530	1600	1530	1600
	1/4 Hr Vol	165	262	158	257	158	291	162	277	179	242	99	134	69	95	157	260	134	214
	1/2 Hour	1515	1530	1545	1600	1515	1600	1515	1545	1530	1545	1200	1200	1430	1200	1515	1545	1515	1545
	1/2 Hr Vol	313	471	309	478	305	519	306	501	351	471	185	229	124	189	309	479	264	397
	1 Hour	1515	1545	1515	1545	1515	1545	1515	1600	1515	1545	1200	1200	1430	1200	1515	1545	1515	1545
	1 Hr Vol	600	915	600	944	596	998	603	969	662	904	355	386	241	335	612	945	522	781
	1 Hr Fact	.9119	.8731	.9494	.9201	.943	.8589	.9334	.8745	.9246	.9358	.8965	.7201	.8732	.8816	.9764	.9087	.9733	.9124
	2 Hour	1500	1515	1430	1515	1430	1515	1430	1515	1400	1445	1200	1200	1345	1315	1415	1515	1415	1515
	2 Hr Vol	1118	1778	1159	1799	1142	1875	1179	1863	1269	1734	655	668	443	649	1169	1801	1005	1493
Peak	12 Hour	0530	0630	0530	0630	0530	0630	0530	0630	0530	0630	0530	0715	0700	0745	0530	0630	0530	0630
	12 Hr Vol	6499	7205	6551	7270	6525	7253	6584	7471	6898	7516	3110	3388	2123	2965	6611	7343	5723	6388

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**South Western Hwy (H009)**
Site No:	**15874**	Location Description:	**East of Dodson Rd (SLK 155.11)**
Date Range:	**23 Sep 2004 to 29 Sep 2004**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000	6	8	24	11	22	31	26	14	18
0100	6	13	17	8	10	20	10	11	12
0200	11	14	15	12	21	10	7	15	13
0300	27	23	25	21	25	9	4	24	19
0400	76	70	60	68	70	16	10	69	53
0500	176	205	215	192	176	44	21	193	147
0600	313	345	354	320	323	98	30	331	255
0700	368	423	373	396	404	169	83	393	317
0800	470	483	491	481	405	279	149	466	394
0900	392	367	381	406	430	392	192	395	366
1000	361	353	381	391	454	438	248	388	375
1100	377	388	298	385	435	448	322	377	379
1200	373	353	359	428	416	390	331	386	379
1300	397	352	397	383	445	317	318	395	373
1400	438	480	479	500	483	252	320	476	422
1500	552	562	601	574	602	250	342	578	498
1600	562	555	563	562	590	239	310	566	483
1700	450	477	512	497	520	220	276	491	422
1800	262	258	258	323	349	169	195	290	259
1900	115	150	146	220	214	102	117	169	152
2000	96	101	108	195	127	69	69	125	109
2100	74	88	82	94	97	73	44	87	79
2200	43	65	51	51	76	64	37	57	55
2300	24	35	50	25	53	55	18	37	37
Total	5969	6168	6240	6543	6747	4154	3479	6333	5616

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour	0800	0815	0815	0815	1030	1130	1145	0815	0815
	1/4 Hr Vol	135	141	146	142	132	128	86	135	111
	1/2 Hour	0800	0800	0815	0815	1015	1030	1100	0800	0815
	1/2 Hr Vol	264	265	274	261	242	242	168	247	208
	1 Hour	0745	0730	0800	0745	1015	1115	1145	0745	0815
	1 Hr Vol	486	510	491	485	460	468	344	477	396
	1 Hr Fact	.9	.9043	.8408	.8539	.8712	.9141	.7818	.882	.893
	2 Hour	0745	0730	0730	0730	0915	1030	1145	0730	0745
	2 Hr Vol	878	933	902	908	893	909	659	897	770
PM	1/4 Hour	1530	1545	1530	1530	1630	1200	1230	1530	1530
	1/4 Hr Vol	171	152	161	154	169	125	110	158	132
	1/2 Hour	1530	1545	1515	1645	1530	1200	1445	1530	1530
	1/2 Hr Vol	328	302	317	299	322	219	193	304	260
	1 Hour	1530	1515	1445	1445	1545	1200	1445	1530	1530
	1 Hr Vol	616	572	608	590	623	390	356	584	500
	1 Hr Fact	.9006	.9408	.9441	.9578	.9216	.78	.8812	.9217	.9439
	2 Hour	1530	1445	1445	1500	1530	1200	1445	1445	1445
	2 Hr Vol	1151	1125	1170	1136	1198	707	682	1145	985
Peak	12 Hour	0630	0600	0630	0645	0630	0700	0745	0630	0630
	12 Hr Vol	5077	5138	5199	5365	5563	3563	3120	5264	4697

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**South Western Hwy (H009)**
Site No:	**15874**	Location Description:	**East of Dodson Rd (SLK 155.11)**
Date Range:	**23 Sep 2004 to 29 Sep 2004**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
0000	2	4	4	4	9	15	5	6	7	15	18	13	13	13	5	9	8	10
0100	4	2	10	3	13	4	8	0	7	3	5	15	7	3	8	2	8	4
0200	6	5	8	6	10	5	8	4	15	6	3	7	4	3	9	5	8	5
0300	17	10	9	14	13	12	10	11	16	9	7	2	4	0	13	11	11	8
0400	50	26	50	20	38	22	52	16	52	18	11	5	6	4	48	20	37	16
0500	130	46	148	57	174	41	147	45	133	43	23	21	9	12	146	46	109	38
0600	191	122	200	145	188	166	186	134	186	137	61	37	10	20	190	141	146	109
0700	171	197	199	224	180	193	186	210	172	232	84	85	42	41	182	211	148	169
0800	165	305	173	310	181	310	158	323	133	272	104	175	70	79	162	304	141	253
0900	153	239	158	209	147	234	141	265	167	263	157	235	86	106	153	242	144	222
1000	132	229	145	208	158	223	129	262	175	279	173	265	120	128	148	240	147	228
1100	174	203	176	212	130	168	191	194	204	231	231	217	161	161	175	202	181	198
1200	203	170	179	174	192	167	229	199	240	176	241	149	162	169	209	177	207	172
1300	216	181	175	177	203	194	206	177	239	206	190	127	147	171	208	187	197	176
1400	210	228	211	269	234	245	225	275	244	239	144	108	124	196	225	251	199	223
1500	272	280	272	290	272	329	278	296	325	277	157	93	123	219	284	294	243	255
1600	308	254	311	244	287	276	289	273	323	267	129	110	133	177	304	263	254	229
1700	276	174	283	194	288	224	276	221	304	216	116	104	117	159	285	206	237	185
1800	120	142	127	131	116	142	167	156	188	161	85	84	96	99	144	146	128	131
1900	48	67	65	85	69	77	124	96	117	97	34	68	55	62	85	84	73	79
2000	43	53	52	49	57	51	112	83	65	62	37	32	39	30	66	60	58	51
2100	48	26	51	37	44	38	64	30	59	38	42	31	22	22	53	34	47	32
2200	29	14	43	22	34	17	36	15	36	40	38	26	24	13	36	22	34	21
2300	11	13	19	16	42	8	11	14	33	20	33	22	14	4	23	14	23	14
Total	2979	2990	3068	3100	3079	3161	3238	3305	3440	3307	2123	2031	1588	1891	3161	3171	2788	2828

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
AM	1/4 Hour	0645	0800	0730	0815	0545	0815	1130	0815	1100	0745	1130	1030	1100	1145	0600	0815	1130	0815
	1/4 Hr Vol	63	93	60	88	55	100	64	100	57	78	65	81	42	47	55	90	48	72
	1/2 Hour	0545	0800	0545	0800	0530	0815	0715	0815	1145	1015	1145	1030	1100	1045	0545	0800	1145	0800
	1/2 Hr Vol	104	181	114	174	108	175	114	174	107	149	140	152	84	84	107	168	97	133
	1 Hour	0645	0745	0545	0745	0630	0800	1130	0745	1145	0730	1115	1000	1145	1145	1145	0745	1145	0800
	1 Hr Vol	194	321	210	315	200	310	228	332	227	284	263	265	166	178	198	311	200	253
	1 Hr Fact	.7698	.8629	.9211	.8949	.9434	.775	.8906	.83	.9458	.9103	.8018	.8179	.8137	.7542	.8808	.8601	.9115	.8802
	2 Hour	1145	0745	0545	0730	0530	0730	1130	0745	1145	0745	1100	0900	1100	1145	1145	0745	1145	0745
	2 Hr Vol	403	558	406	570	390	555	430	601	470	558	472	500	323	346	406	565	398	483
PM	1/4 Hour	1700	1530	1600	1445	1715	1500	1730	1530	1630	1545	1200	1215	1230	1445	1715	1530	1715	1530
	1/4 Hr Vol	92	97	91	86	94	96	77	85	93	77	82	44	51	62	83	83	68	70
	1/2 Hour	1700	1530	1545	1430	1700	1500	1630	1445	1615	1530	1200	1200	1215	1445	1700	1530	1700	1445
	1/2 Hr Vol	173	174	162	161	167	184	147	166	174	149	132	87	88	124	163	153	135	134
	1 Hour	1630	1530	1630	1430	1630	1445	1645	1445	1545	1545	1200	1200	1200	1445	1630	1445	1630	1445
	1 Hr Vol	327	308	315	296	316	341	293	324	337	286	241	149	162	222	316	301	263	261
	1 Hr Fact	.8886	.7938	.9375	.8605	.8404	.888	.9513	.9529	.9059	.9286	.7348	.8466	.7941	.8952	.9541	.9066	.9629	.934
	2 Hour	1530	1445	1530	1415	1530	1445	1545	1430	1530	1445	1200	1200	1200	1445	1530	1445	1530	1445
	2 Hr Vol	635	567	617	567	597	612	581	579	667	547	431	276	309	417	618	571	517	497
Peak	12 Hour	0545	0630	0545	0630	0600	0630	0615	0645	0630	0630	0645	0730	0745	0730	0600	0630	0600	0645
	12 Hr Vol	2472	2630	2491	2678	2460	2749	2497	2880	2719	2844	1811	1765	1396	1726	2524	2753	2243	2455

Weekly Volume by Hour

Traffic Flow:	**Both Directions**	Road Name:	**South Western Hwy (H009)**
Site No:	**50907**	Location Description:	**South of Bunbury Airport Access Rd (SLK 157.17)**
Date Range:	**06 Sep 2013 to 16 Sep 2013**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
0000	6	11	13	4	16	24	24	10	14
0100	7	15	8	11	8	15	15	10	11
0200	12	12	6	9	13	12	6	10	10
0300	21	22	22	12	18	9	5	19	16
0400	30	30	26	29	31	18	9	29	25
0500	133	134	111	125	108	38	26	122	96
0600	256	270	256	252	264	83	47	260	204
0700	431	417	450	449	422	156	69	434	342
0800	531	524	511	545	533	271	150	529	438
0900	433	420	415	442	470	389	312	436	412
1000	403	396	394	388	467	480	338	410	409
1100	385	373	395	393	462	477	399	402	412
1200	392	405	360	376	488	449	393	404	409
1300	397	382	358	433	480	404	366	410	403
1400	437	431	440	456	527	364	394	458	436
1500	505	511	529	543	615	333	387	541	489
1600	544	547	529	600	599	277	328	564	489
1700	476	495	468	558	535	278	281	506	442
1800	236	257	245	301	298	180	192	267	244
1900	114	156	110	191	162	108	114	147	136
2000	83	109	88	126	105	77	59	102	92
2100	59	77	74	95	95	71	42	80	73
2200	31	28	35	36	49	58	21	36	37
2300	15	12	25	20	34	40	12	21	23
Total	5937	6034	5868	6394	6799	4611	3989	6207	5662

Peak Statistics

		Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon - Fri	Mon - Sun
AM	1/4 Hour	0745	0845	0745	0815	0745	1030	1115	0745	0745
	1/4 Hr Vol	168	145	161	151	145	131	107	152	109
	1/2 Hour	0745	0800	0745	0800	0745	1030	1115	0745	1115
	1/2 Hr Vol	310	265	302	300	276	251	214	289	214
	1 Hour	0745	0800	0730	0745	0745	1030	1115	0745	1115
	1 Hr Vol	570	524	569	567	540	493	404	552	426
	1 Hr Fact	.8482	.9034	.8835	.9387	.931	.9408	.9439	.9105	.973
	2 Hour	0745	0745	0715	0730	0745	0945	1115	0745	0930
	2 Hr Vol	1023	982	1012	1022	1038	963	792	1013	837
PM	1/4 Hour	1530	1700	1630	1630	1530	1200	1415	1630	1530
	1/4 Hr Vol	151	154	160	163	169	129	109	150	129
	1/2 Hour	1700	1645	1630	1615	1530	1200	1415	1615	1530
	1/2 Hr Vol	282	289	283	324	329	229	206	293	250
	1 Hour	1530	1615	1630	1545	1530	1200	1400	1545	1530
	1 Hr Vol	554	559	555	618	631	449	394	575	490
	1 Hr Fact	.9203	.9075	.8672	.9479	.9362	.8702	.9037	.9592	.9489
	2 Hour	1530	1515	1515	1545	1515	1200	1400	1530	1530
	2 Hr Vol	1104	1080	1077	1193	1229	853	781	1141	957
Peak	12 Hour	0630	0630	0630	0630	0630	0715	0800	0630	0645
	12 Hr Vol	5238	5214	5174	5527	5919	4057	3650	5461	4853

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**South Western Hwy (H009)**
Site No:	**50907**	Location Description:	**South of Bunbury Airport Access Rd (SLK 157.17)**
Date Range:	**06 Sep 2013 to 16 Sep 2013**	Count Type:	**Classification Counts**

Average Vehicle Volume

Hour	Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
0000	2	4	3	8	4	9	1	3	5	11	7	17	6	18	3	7	4	10
0100	2	5	5	10	2	6	4	7	3	5	5	10	6	9	3	7	4	7
0200	6	6	4	8	2	4	5	4	5	8	6	6	2	4	4	6	4	6
0300	10	11	11	11	9	13	3	9	6	12	6	3	2	3	8	11	7	9
0400	17	13	18	12	16	10	12	17	15	16	10	8	4	5	16	14	13	12
0500	70	63	65	69	61	50	64	61	63	45	13	25	8	18	65	58	49	47
0600	170	86	183	87	175	81	160	92	173	91	49	34	25	22	172	87	134	70
0700	298	133	294	123	321	129	324	125	288	134	89	67	28	41	305	129	235	107
0800	368	163	370	154	361	150	371	174	373	160	178	93	81	69	369	160	300	138
0900	266	167	252	168	263	152	299	143	293	177	221	168	188	124	275	161	255	157
1000	246	157	232	164	228	166	226	162	296	171	267	213	197	141	246	164	242	168
1100	193	192	202	171	195	200	210	183	255	207	250	227	223	176	211	191	218	194
1200	180	212	177	228	170	190	193	183	228	260	197	252	206	187	190	215	193	216
1300	201	196	173	209	154	204	205	228	217	263	167	237	198	168	190	220	188	215
1400	209	228	212	219	207	233	215	241	227	300	159	205	229	165	214	244	208	227
1500	221	284	207	304	219	310	246	297	239	376	141	192	215	172	226	314	213	276
1600	173	371	187	360	166	363	207	393	188	411	110	167	147	181	184	380	168	321
1700	136	340	130	365	148	320	201	357	172	363	115	163	132	149	157	349	148	294
1800	106	130	128	129	108	137	121	180	117	181	93	87	96	96	116	151	110	134
1900	48	66	60	96	38	72	61	130	81	81	55	53	59	55	58	89	57	79
2000	25	58	35	74	33	55	30	96	34	71	28	49	23	36	31	71	30	63
2100	15	44	15	62	17	57	11	84	23	72	31	40	13	29	16	64	18	55
2200	12	19	10	18	11	24	13	23	13	36	23	35	9	12	12	24	13	24
2300	3	12	4	8	5	20	6	14	11	23	14	26	5	7	6	15	7	16
Total	2977	2960	2977	3057	2913	2955	3188	3206	3325	3474	2234	2377	2102	1887	3077	3131	2818	2845

Peak Statistics

		Mon		Tue		Wed		Thu		Fri		Sat		Sun		Mon - Fri		Mon - Sun	
		N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S
AM	1/4 Hour	0745	1115	0745	1115	0745	1145	0800	1145	0745	0900	1030	1130	0945	1115	0745	1115	0745	1115
	1/4 Hr Vol	122	51	101	58	115	71	108	52	108	58	74	59	62	48	111	53	79	52
	1/2 Hour	0745	1145	0745	1100	0745	1145	0800	1145	0745	1145	1030	1145	1115	1115	0745	1145	0745	1145
	1/2 Hr Vol	225	107	200	100	226	120	214	102	201	121	140	123	121	94	213	111	151	109
	1 Hour	0745	1145	0745	1145	0730	1130	0730	1145	0745	1145	1030	1145	1100	1145	0745	1145	0745	1145
	1 Hr Vol	404	203	376	206	426	210	414	198	392	246	271	247	223	184	395	215	292	215
	1 Hr Fact	.8279	.875	.9307	.9035	.9261	.7394	.9583	.9519	.9074	.8913	.9218	.9015	.9065	.9109	.8862	.9244	.9251	.9253
	2 Hour	0745	1145	0715	1145	0715	1130	0730	1130	0745	1145	0945	1130	0945	1115	0715	1145	0745	1145
	2 Hr Vol	692	408	675	437	724	417	722	404	707	508	531	490	433	364	695	440	546	434
PM	1/4 Hour	1530	1715	1445	1700	1500	1630	1345	1715	1330	1630	1200	1315	1545	1615	1530	1630	1530	1630
	1/4 Hr Vol	63	107	70	112	65	117	70	109	66	115	64	69	63	51	59	106	56	82
	1/2 Hour	1530	1700	1445	1700	1445	1615	1345	1700	1530	1615	1200	1230	1415	1600	1515	1700	1530	1700
	1/2 Hr Vol	119	205	135	210	126	202	129	214	127	220	108	131	119	99	116	202	108	161
	1 Hour	1500	1630	1430	1645	1430	1630	1500	1630	1330	1615	1200	1230	1400	1200	1445	1630	1445	1630
	1 Hr Vol	221	393	235	385	243	387	246	397	240	423	197	253	229	187	228	395	211	312
	1 Hr Fact	.884	.9225	.8393	.8594	.9346	.8269	.9318	.9106	.9091	.9196	.7756	.9167	.9542	.9257	.9638	.9329	.9497	.9481
	2 Hour	1400	1530	1345	1545	1415	1545	1445	1545	1400	1530	1200	1200	1400	1200	1400	1530	1400	1530
	2 Hr Vol	429	735	429	730	434	732	469	770	466	810	364	489	444	355	442	757	417	610
Peak	12 Hour	0615	0645	0615	0700	0615	0645	0630	0730	0615	0700	0715	0700	0745	0800	0615	0645	0630	0700
	12 Hr Vol	2673	2580	2638	2594	2621	2563	2868	2689	2950	3000	1990	2070	1972	1680	2767	2712	2462	2403

Appendix C - SIDRA Movement Summaries

MOVEMENT SUMMARY

Site: 101 [2018 AM Peak Predicted]

Lot 81 South Western Highway Davenport
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
2	T1	449	11.5	0.391	0.1	LOS A	0.0	0.0	0.00	0.24	75.7
3	R2	255	10.0	0.391	7.1	LOS A	0.0	0.0	0.00	0.24	66.8
Approach		704	11.0	0.391	2.6	NA	0.0	0.0	0.00	0.24	72.2
East: Structure Plan Access Road											
4	L2	52	10.0	0.121	6.4	LOS A	0.4	2.8	0.31	0.66	52.0
6	R2	79	10.0	0.121	7.8	LOS A	0.4	2.8	0.31	0.66	51.8
Approach		131	10.0	0.121	7.2	LOS A	0.4	2.8	0.31	0.66	51.9
North: South Western Highway North											
7	L2	383	10.0	0.325	7.2	LOS A	0.0	0.0	0.00	0.43	64.6
8	T1	195	11.5	0.325	0.0	LOS A	0.0	0.0	0.00	0.43	72.5
Approach		578	10.5	0.325	4.8	NA	0.0	0.0	0.00	0.43	67.0
All Vehicles		1413	10.7	0.391	3.9	NA	0.4	2.8	0.03	0.35	67.6

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101 [2018 PM Peak Predicted]

Lot 81 South Western Highway Davenport
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
2	T1	224	11.5	0.160	0.0	LOS A	0.0	0.0	0.00	0.15	77.3
3	R2	65	10.0	0.160	7.0	LOS A	0.0	0.0	0.00	0.15	68.1
Approach		289	11.2	0.160	1.6	NA	0.0	0.0	0.00	0.15	75.0
East: Structure plan Access Road											
4	L2	232	10.0	0.531	9.7	LOS A	3.1	23.2	0.57	0.92	50.8
6	R2	347	10.0	0.531	8.3	LOS A	3.1	23.2	0.57	0.92	50.6
Approach		579	10.0	0.531	8.8	LOS A	3.1	23.2	0.57	0.92	50.7
North: South Western Highway North											
7	L2	98	10.0	0.309	7.2	LOS A	0.0	0.0	0.00	0.11	68.7
8	T1	463	11.5	0.309	0.0	LOS A	0.0	0.0	0.00	0.11	77.8
Approach		561	11.2	0.309	1.3	NA	0.0	0.0	0.00	0.11	76.0
All Vehicles		1429	10.7	0.531	4.4	NA	3.1	23.2	0.23	0.45	63.1

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101 [2028 AM Peak Predicted]

Lot 81 South Western Highway Davenport
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
2	T1	605	11.5	0.585	0.1	LOS A	0.0	0.0	0.00	0.28	74.8
3	R2	446	10.0	0.585	7.1	LOS A	0.0	0.0	0.00	0.28	66.1
Approach		1052	10.9	0.585	3.1	NA	0.0	0.0	0.00	0.28	70.9
East: Structure plan Access Road											
4	L2	92	10.0	0.133	6.7	LOS A	0.5	3.5	0.35	0.65	51.8
6	R2	39	10.0	0.133	9.4	LOS A	0.5	3.5	0.35	0.65	51.6
Approach		131	10.0	0.133	7.5	LOS A	0.5	3.5	0.35	0.65	51.7
North: South Western Highway North											
7	L2	192	10.0	0.252	7.2	LOS A	0.0	0.0	0.00	0.27	66.6
8	T1	262	11.5	0.252	0.0	LOS A	0.0	0.0	0.00	0.27	75.0
Approach		454	10.9	0.252	3.0	NA	0.0	0.0	0.00	0.27	71.2
All Vehicles		1636	10.8	0.585	3.4	NA	0.5	3.5	0.03	0.31	68.9

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

Site: 101 [2028 PM Peak Predicted]

Lot 81 South Western Highway Davenport
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
2	T1	302	11.5	0.230	0.0	LOS A	0.0	0.0	0.00	0.18	76.7
3	R2	114	10.0	0.230	7.0	LOS A	0.0	0.0	0.00	0.18	67.6
Approach		416	11.1	0.230	1.9	NA	0.0	0.0	0.00	0.18	74.0
East: Structure plan Access Road											
4	L2	405	10.0	0.720	14.1	LOS B	5.7	43.4	0.79	1.19	47.9
6	R2	174	10.0	0.720	11.6	LOS B	5.7	43.4	0.79	1.19	47.7
Approach		579	10.0	0.720	13.3	LOS B	5.7	43.4	0.79	1.19	47.8
North: South Western Highway North											
7	L2	49	10.0	0.368	7.2	LOS A	0.0	0.0	0.00	0.05	69.6
8	T1	623	11.5	0.368	0.1	LOS A	0.0	0.0	0.00	0.05	78.9
Approach		673	11.4	0.368	0.6	NA	0.0	0.0	0.00	0.05	78.2
All Vehicles		1667	10.8	0.720	5.3	NA	5.7	43.4	0.28	0.48	63.3

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).

Vehicle movement LOS values are based on average delay per movement.

Minor Road Approach LOS values are based on average delay for all vehicle movements.

NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road movements.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Appendix H

Servicing Report

Prepared by Development Engineering Consultants

DEVELOPMENT
ENGTNEERTNG
CONSULTANTS

Telephone: (08) 9481 1900
Facsimile: (08) 9481 1700
Suite 3, Ground Floor
The Atrium 123A Colin Street
West Perth WA 6005

Our Ref: PRO 1069 - Servicing Report September 2016

ERCEG DEVELOPMENTS

LOT 81 SOUTHWESTERN HIGHWAY, DAVENPORT
ENGINEERING SERVICING REPORT

General

The above land is proposed to be developed into 6 general industrial lots. This report covers existing and proposed services plus proposals for roads, drainage, water supply, power and telecommunications.

Executive Summary

The land the subject of this report is located on the north western corner of the Southwestern Highway and the Bunbury Outer Ring road, in the Davenport industrial area of the City of Bunbury. The land is bounded by the Preston River on the north, and by land owned by the city of Bunbury on the west, which lies under the airport flight path. The land area to be developed is approximately 42 hectares.

Access to the site is from the Southwestern Highway, which is a sealed road of good standard.

The Preston River located along the northern boundary of the land will have some influence on drainage and the minimum level of fill for the development because of the 1 in 100 year flood levels.

The existing land ranges in height from RL 15 metres AHD along the southern boundary falling uniformly to RL 12 metres AHD along the Preston River frontage, with a small section of the north western corner falling to RL 11 metres AHD. The land has previously been used for grazing purposes, and is generally cleared, fenced, and vacant. The land is not connected to any services, but three phase high voltage overhead power lines do traverse the property.

The soil type, according to the Environmental Geology Series plans of the Geological Survey of WA is Guildford Formation comprising sandy clays and silt. A preliminary geotechnical site investigation has shown approximately 1 metre of Bassendean sand and / or silty sand over clay across the land, with a greater depth of sand along the southern boundary.

The required services are either of very limited capacity or currently not available adjacent to the site, and will need to be extended / upgraded at the developer's cost from west of the site via Southwestern Highway.

Storm water discharging from the 1 in 100 year Design Storm from the development road will be detained in on site in drainage swales. Each developed site will be responsible for detaining its own stormwater for each design storm.

A LWMS report has been prepared for the proposed development by DEC.

Site

The site, located on the north side of the Southwestern Highway at the junction with the Bunbury Outer ring Road, opposite the Bunbury airport and some 3.2 km east of the South West Highway bypass Road.

The site is proposed to be subdivided into 6 large industrial lots of various sizes. These lots will be fully serviced as required by the WAPC and as specified by the City of Bunbury and the relevant servicing authorities.

The site is vacant semi-cleared land used for rural purposes.

The geology of the land is described by the Environmental Geology Map of the Geological Survey of WA, as being "Guildford Formation" of sandy clays and silts. A preliminary site investigation has found that the soil is sand and silty sand over clay, with an average depth of sandy material of one metre.

Groundwater investigations indicate that the depth to groundwater range between 0.01m & 2.10m as measured from several bores installed over the site. It is therefore assumed that the groundwater is perched on top of the clay interface, requiring some sand fill over this level to comply with WAPC and City of Bunbury development and building approval.

The Southwestern Highway along the southern boundary of the site is a single sealed carriageway of 7.2m with 1.2m wide sealed shoulders in good condition with informal drainage. Drainage is contained in the roadside verges. The only service located within the road reserve alongside the development is a water main servicing the Bunbury Regional prison, and Telstra underground telephone cables.

Development Proposal

It is proposed to develop the land as an industrial subdivision, with all normal services, with drainage to be detained on site for the design storm, using best management practices, as set out in the LWMS report to reduce nutrients and maintain pre-development flow conditions. Controlled stormwater discharge from the development will enter the Preston River via existing minor watercourses.

The initial development will entail roadworks and associated drainage and services. It is envisaged that each lot owner will develop his lot with buildings, parking, on-site wastewater disposal system and drainage detention. Some fill will be required to provide suitable foundation conditions for buildings, allow installation of site wastewater disposal and general drainage.

A preliminary site geotechnical investigation has shown the land to be typical Guildford formation soils with generally one metre of sand/ silty sand over the clay base. Further Geotechnical work will be required to determine building foundation requirements.

Fill will be required along the majority of the eastern portion of the site if building development is desired along this eastern boundary, as this area is affected by the 1 in 100 year Preston River floodway.

Drainage of stormwater will be managed using roadside drainage swales and minimum piped drainage. Three designated drainage basin sites will be required to detain extreme event from the proposed road reserve. Overflow from these detention basins will be directed into designated overflow channels within easements from the road eastwards to meet up with three existing minor drainage channels entering the Preston River.

These basins will cater for design storms up to the 1 in 100 year event, being attenuated on site to pre-development flows.

All subdivision roads and required services will be designed and constructed to current Council and other service authority standards. There is no intention to upgrade the Southwestern Highway, other than the entry into the development.

Earthworks

The site slopes west away from the Southwestern Highway towards the Preston River. Initially earthworks will only be required for the construction of the subdivsional road and drainage swales.

Ground level varies generally from RL 14m AHD along Southwestern Highway falling to RL 12m AHD along the river boundary along the northern boundary.

Earthworks on site will entail removal of topsoil, stockpiling of the sandy layer, and where required, cut and fill of the underlying clay material to facilitate drainage, and replacement of all suitable sandy material under the proposed road pavement.

Fill for buildings and wastewater disposal areas will be the responsibility of the individual lot owner(s).

Roads

The subdivisional road will be designed and constructed to City of Bunbury industrial standards, and will be a substantial pavement in width and depth. It is expected that this road will be fully kerbed, with stormwater being collected in roadside swales using suitably designed / constructed "kerb breaks".

No works are envisaged to Southwestern Highway.

Drainage

The eastern boundary of the site is adjacent to the Preston River. The 1 in 100 year flood level of the Preston River will have an impact on the development drainage and minimum fill levels, as a minimum of 500mm height above the estimated 1 in 100 year floodway is required for all areas within developed lots that are to contain significant or critical infrastructure.

The development site will essentially be divided into three stormwater catchments, each directing extreme flow events towards three overflow channels as described in greater detail in the LWMS report.

Typically fill will need to be placed approximately 1.2 metres above the clay layer, with on-site detention & site soakage required for each industrial lot. Each industrial lot will be provided with an outlet overflow connection pipe which will similarly directed all appropriately detained extreme event overflows into the three "east-west" overflow channels that meet up with three existing natural channels that currently directs all flows into the Preston River.

All stormwater drainage design and construction will be done to the City of Bunbury specification and approval.

Three basin sites will detain the design storm runoff from the proposed road reserve and all lots within the estate will be required to detained flows within their lots to pre-development conditions as outlined in the LWMS report - by way of soak wells, rainwater tanks, underground storage devices &/or detention basins.

Groundwater & Flood Levels

According to the plans supplied by the Department of Water (DoW), site levels fall from RL 14m AHD along the southern boundary of the site to generally RL 12m AHD along the Preston River frontage.

The previous LWMS report has derived AAMGL's over the site which falls from RL 14.5 on the western boundary to RL 10.0 along a major part of the eastern boundary, adjacent to the Preston River.

The DoW plan also shows the 1 in 100 year flood level for the Preston River adjacent to the development falls from approximately RL12.85 at the north-eastern (upstream) corner of the site to RL 12.18 at the north-western (downstream) corner of the site. At this point the floodway impinges some 25 to 30 metres into the north eastern corner of the site. No filling is allowed within the floodway area which only impacts upon a very small area on the far north-eastern corner of the site.

There is a requirement for any buildings to be sited at least 500mm above the 1 in 100 year flood level. Fill over and above this stipulation will be placed, where required, for this development to provide the required site building classification and allow site soak wells to function. The fill will need to consist of clean free draining sand.

Power

A north-south high voltage (HV) aerial line runs within the eastern portion of the site adjacent to the Preston River and has two spur lines near the central-eastern part of lot 81. One of the spur lines heads east over the Preston River and one that heads west to service the existing "dirt bike" track on the west side of Southwestern Highway. Underground HV cables run along the western portion of Bunbury Outer Ring Rd (where it abuts lot 80) and another short length runs along the west side of SW Hwy heading towards the airport. These underground cables are feed from two HV switchgear units on the north side of the Outer Ring Rd - one close to the NE corner of the SW Hwy/Outer Ring Rd intersection & another roughly mid-way between this intersection & the Preston River.

All internal power reticulation lines and transformer installations (& under-grounding / relocation of any existing infrastructure) will be completed at the cost of the developer – including the upgrading (as necessary) of any existing HV switchgear units and the maintenance of supply to all existing / surrounding properties.

The subdivision would best be serviced by a transformer at each lot - servicing to at least a WP minimum servicing requirement of 200kVA/ha. The location of each transformer site will be determined at the detailed subdivision design stage.

Water Supply

At present there is a 100mm water main along Southwestern Highway which appears to be a dedicated main serving the Bunbury Regional prison. This main is located on the southern verge of Southwestern Highway according to the plan supplied by Aqwest.

It is therefore proposed that a new 150mm water main be extended along Southwestern Highway to the development from Halifax Drive, some 1.5Km west of the site.

Water services are controlled by the Aqwest (Bunbury Water Board), and all design and construction will be to their approval. It is anticipated that a hydraulic study will be required at the cost of the developer to determine the specific requirements of supply of potable and fire- fighting water, street hydrants etc.

Sewer

The site is not currently connected to sewer. Water Corporation sewer infrastructure exists some 2 km west of the site at Dodson Road. Water Corporation sewer planning for this area shows a future main Type 90 Waste Water Pumping Station (WWPS Bunbury "G") to be located north of the Preston River. No planning or funding has been planned at this stage.

It is also advised that a temporary WWPS will not be approved, and that it would not be workable due to the 2km pumping distance in a small main, leading to problems with stale or septic discharge, paucity of flow needing topping up with scheme water for hydraulic reasons.

Therefore it is obvious that site disposal of wastewater should be effected by the use of ATU's for each site sized to suit.

Discharge from ATU's should be as per Health Department regulations, at least 100 metres from the Preston River, and at least 2 metres above the groundwater/ clay level.

This may require filling with suitable granular material (sand with a PRI greater than 10) for lots north of the subdivision road, and locations along the southern boundaries of the lots south of the subdivisional road where the land is higher and depth to clay is suitable.

Telephone & NBN

Telstra services exist in the area along Southwester Highway adjacent to the site. Some upgrading/ augmentation will be involved. If Telstra is to be the servicing authority, Telstra normally requires twelve months' notice of the commencement of the development starting in order to ascertain any upgrading requirements.

NBN services are not available.

Gas

ATCO has advised that a 160mm diameter high pressure gas main is located along the southern verge of Southwestern Highway.

DEVELOPMENT ENGINEERING CONSULTANTS PTY LTD

THIS REPORT IS DATED 30TH SEPTEMBER 2016.

Appendix I

Certificate of Title

WESTERN AUSTRALIA

REGISTER NUMBER	
81/DP404278	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	29/9/2015

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 2884 FOLIO 998

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 81 ON DEPOSITED PLAN 404278

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

NBR INVESTMENTS PTY LTD OF 320 LORD STREET PERTH
(AF N126146) REGISTERED 18 SEPTEMBER 2015

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

1. J605951 MORTGAGE TO BANK OF WESTERN AUSTRALIA LTD REGISTERED 31.1.2006.

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:	DP404278.
PREVIOUS TITLE:	2784-502.
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA:	CITY OF BUNBURY.