Shire of Serpentine Jarrahdale

West Mundijong Industrial Area Local Structure Plan

Contents Page

Situational Analysis

Rezoning for this development has been gazetted and the Shire is proceeding with the development of a structure plan. Land for crucial supporting infrastructure (such as the Tonkin Highway extension and the Mundijong freight rail realignment) has been set aside.

In 2018 Premier Mark McGowan stated: "Long-term the West Mundijong site is intended to become a significant economic gateway and a link to the inner harbour and future outer harbour."

The Federal and State governments have also committed joint funding to deliver the $505 million extension of Tonkin highway from Thomas Road to South Western Highway.

Appendixes

Executive Summary

Executive Summary

The West Mundijong area was identified as a future industrial area in the following key documents prepared by the State Government:

- Directions 2031 and Beyond;
- Southern Metropolitan Sub-Regional Structure Plan 2009;
- Economic and Employment Lands Strategy: non-heavy industrial: Perth metropolitan and Peel regions;
- Perth and Peel @3.5m;
- Southern Perth and Peel Subregional Frameworks Document.

The status of West Mundijong as a future industrial area is also supported by the Council and Western Australian Planning Commission (WAPC) through:

- The approved, Mundijong Whitby District Structure Plan 2011;
- Amendment 187 (PL403) which gazetted the West Mundijong Development Contribution Scheme on 30 January 2018.
- Town Planning Scheme No.2

Council also supported the development through:

- The Local Planning Strategy;
- Local Planning Scheme No. 3;
- The West Mundijong District Structure Plan, an addendum to the gazetted Development Contribution Scheme;
- Council resolutions to progress the West Mundijong planning framework, the latest being a decision in August 2020 to progress the current documents to enable a first stage of development of dry industries up to a minimum size of 1.5-2ha.

PART ONE

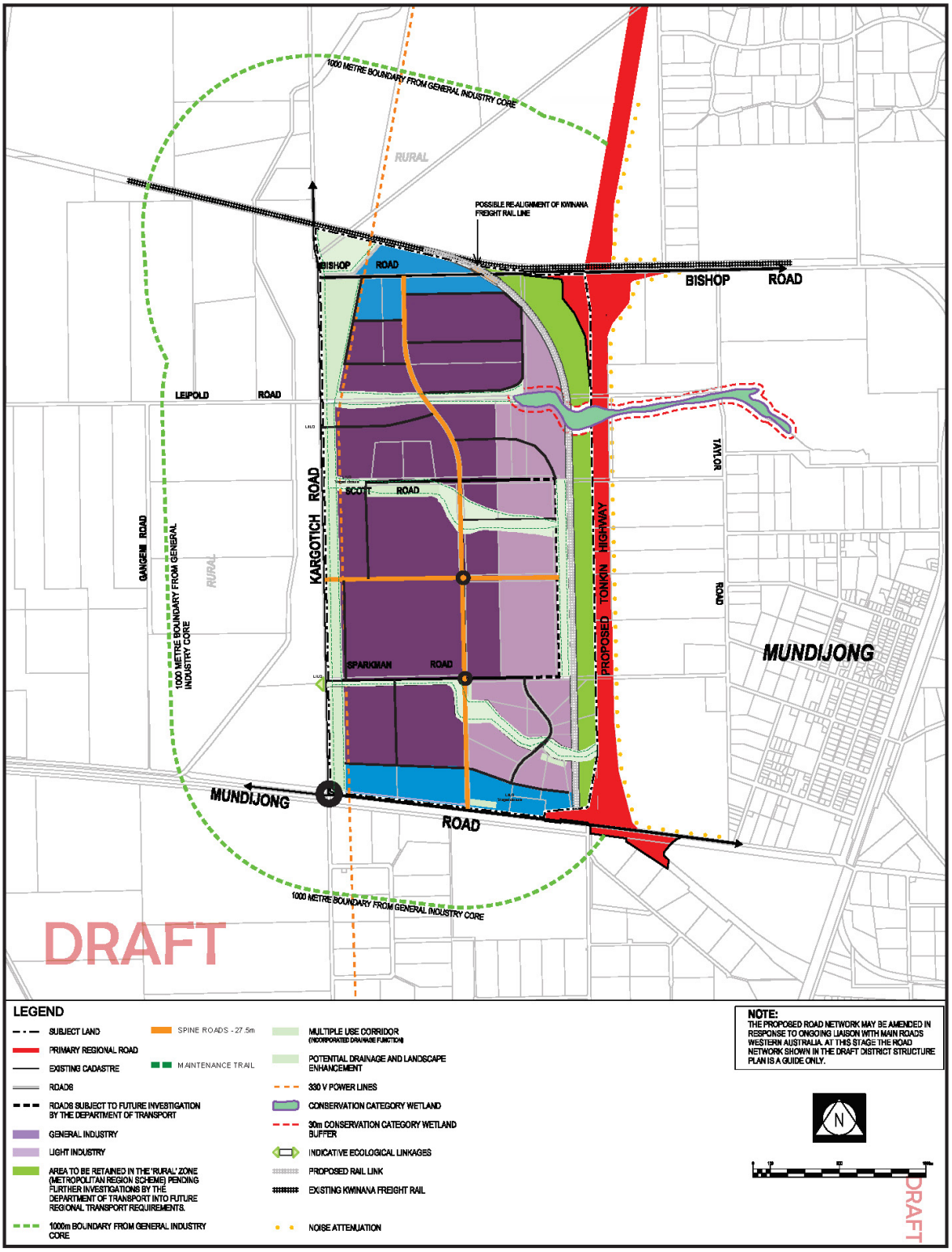
1. Policy Section

Structure Plan Area

The structure plan area is approximately 474.34 hectares and is located west of the Mundijong town site. The area is located approximately 45 kilometres southeast of the Perth Central Business District.

The area is framed by Mundijong Road (south), Tonkin Highway Road reserve (east), Kwinana freight rail (north) and Kargotich Road (west). An ultimate deviation to the existing freight rail will see its current route through the middle of Mundijong townsite, shifted to run parallel to the western boundary of Tonkin Highway.

Figure 1: West Mundijong Structure Plan



2. Structure Plan Content

The structure plan has been formulated as a document to guide future subdivision, land use and development under the auspices of Clause 27 of the Deemed Provisions of Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (the Scheme). Further, the structure plan seeks to assist landowners in the orderly transition of land use to achieve industrial development outcomes for the precinct.

The structure plan has been prepared generally in accordance with the WAPC's guidelines for statutory plans.

Accordingly the structure plan comprises of two parts:

Part 1 – Policy section

Part 2 – Non statutory (explanatory) section

Part 1 only includes the structure plan map and policy requirements.

Part 2 is intended to provide an outline and explanation of the structure plan, and the policy requirements contained in Part 1.

3. Metropolitan Region Scheme and Local Planning Scheme

The West Mundijong Structure Plan now responds to the land being zoned 'Urban' under the Scheme. The land is already zoned 'Industry' under the Metropolitan Region Scheme.

Inclusion in the 'Urban Development' zone enables structure planning to facilitate development of the land for light and general industry.

4. Interpretation and Scheme Relationship

The terms used in the structure plan have the respective meanings given to them in the Scheme or where not defined in the Scheme, as set out in this structure plan

The structure plan shall guide the local government and the Western Australian Planning Commission (WAPC) in considering subdivision proposals submitted to the WAPC.

5. Compliance with the Structure Plan

Development and subdivision within the structure plan area, may not be permitted unless in accordance with the requirements of Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 and the associated Deemed Provisions under the Planning and Development (Local Planning Schemes) Regulations 2015.

Development shall comply with the cumulative noise emission limits set out in the Noise Assessment Report (Appendix A).

Subdivision shall be generally consistent with the structure plan, including the following supporting documents:

- Environmental Assessment Report – including Noise Assessment Report (Appendix A)
- Local Water Management Strategy (Appendix C)
- Traffic Impact Statement (Appendix D)

6. Modifications to the Structure Plan

In considering modifications to the structure plan, decision makers shall have due regard to the District Structure Plan, relevant State and Local Planning Policies, the objectives of the zone and relevant planning matters.

7. Subdivision Phases

This structure plan provides for a phased approach to subdivision. The first phase is termed a dry lot industrial subdivision, which is subject to a minimum lot size of 1.5 - 2ha;

This first phase is not reliant on reticulated water or sewer infrastructure being provided;

The 1.5 - 2ha minimum lot size requirement is to provide sufficient flexibility for onsite potable water catchment (via water tanks) and onsite effluent disposal;

Intensity of development is also compatible with current road infrastructure limits, and the planned upgrades reflective of the Development Contribution Scheme for the area.

8. Subdivision Beyond the Dry Lots Industrial Phase

For subdivision at greater intensities than the 1.5 - 2ha dry lot industrial phase, the following will be required to be adequately addressed:

Engineering and Servicing

- Servicing response that demonstrates the subdivider being capable of providing all services to proposed lots;
- Geotechnical Investigation to determine fill requirements.

Traffic Design and Management

- A road network that reflects a well ordered and connected industrial area, and which provides for necessary road widths and space capacity to carry industrial vehicles;
- Traffic Impact Assessment.

Water Management

- An amendment to the adopted Local Water Management Strategy, which is precinct specific to the area of the structure plan being proposed for subdivision beyond the 1.5 - 2ha dry lot phase. This must demonstrate an acceptable transition of the precinct to be able to deal with drainage and depth to groundwater requirements in a manner that responds to the design criteria set through the Local Water Management Strategy.

Minimum lot sizes, beyond the dry lot phase, shall not be below 4000sqm.

9. Preferred and Non Preferred Land Use

The following are the list of preferred land uses for the DRY LOT GENERAL INDUSTRY PRECINCT

Land Use	Explanation
Abattoir	Core general industry use that may have offsite impacts.
Fuel depot	Core general industry use that may have offsite impacts.
Industry	Core general industry use that may have offsite impacts.
Trade Supplies	Industry use appropriate to general industry precinct.
Transport Depot	Industry use appropriate to general industry precinct.
Ware	Industry use appropriate to general industry precinct.
Waste Storage Facility	Core general industry use that may have offsite impacts.

The following are the list of preferred land uses for the DRY LOT LIGHT AND SERVICE INDUSTRY PRECINCT

Land Use	Explanation
Bulky goods showroom	Service commercial use, requiring sufficient space and access. Offsite impacts can be managed.
Industry – light	Core light industry use. Offsite impacts can be managed.
Industry – service	Core light industry use. Offsite impacts can be managed.
Motor vehicle, boat or caravan sales	Service commercial use, requiring sufficient space and access. Offsite impacts can be managed.
Motor vehicle repair	Light industry use. Offsite impacts can be managed.
Motor vehicle wash	Light industry use. Offsite impacts can be managed.
Trade display	Light industry use. Offsite impacts can be managed.
Trade supplies	Light industry use. Offsite impacts can be managed.
Warehouse/storage	Light industry use. Offsite impacts can be managed.

The following are non preferred land uses under the INITIAL DRY LOT PHASE IN EITHER PRECINCT

Land Use	Explanation
Amusement parlour	Not an industry use, services a number of people given lack of water and waste services.
Fast food outlet	Not an industry use, services a number of people given lack of water and waste services.
Place of worship	Not an industry use, services a number of people given lack of water and waste services.
Service station	Not an industry use, services a number of people given lack of water and waste services.

10. Transition of Sensitive Land Use

The presence of sensitive land uses within the area means any new industrial development must comply with the Environmental Protection (Noise) Regulations 1997, and must respond to the separation distances as defined under the EPAs Separation Distances between Industrial and Sensitive Land Uses. Sensitive land uses provide a limiting factor while they remain.

Appendix A contains a Noise Assessment Report, and provides further guidance in respect of the contributing factor of each development to cumulative noise impacts. Compliance with Appendix A is also required.

PART TWO

Explanatory Section

The structure plan has been prepared in accordance with the WAPC's guidelines for statutory plans.

Accordingly the structure plan comprises of two parts:

a) Part 1 – Policy section

b) Part 2 – Non statutory (explanatory) section

Part 1 only includes the structure plan map and policy requirements.

Part 2 is intended to provide an outline and explanation of the structure plan.

1. Planning and Background

1.1 Introduction and Purpose

The structure plan also seeks to provide:

- An outline of intended industrial land use for the area;
- A road framework including integration with existing and planned future transport infrastructure;
- A response to the context of the land;
- Proposed interface measures with existing and planned sensitive uses;
- An outline of servicing issues and transitional arrangements;
- A local water management strategy (drainage framework); and
- Guidance in the preparation of subdivision.

The structure plan is a document that will guide future subdivision and development in accordance with Clause 27 of the Deemed Provisions of the Scheme.

1.2 Land Description and Location

The structure plan area is located within the locality of Mundijong within the Shire of Serpentine Jarrahdale.

The area is located directly 20 kilometres east of the Kwinana industrial area via Mundijong Road. Mundijong Road will provide direct linkage to Kwinana and associated infrastructure, including complementary industries and services. This includes the proposed Westport Outer Harbour development that has recently been approved by government.

The extension of the Tonkin Highway along the eastern boundary of the site will provide direct access to a considerable range of destinations within the Perth metropolitan area via the highway and freeway transport system. Such destinations include complementary industrial estates, ports, strategic suppliers or input sources,

Figure 2. Location Plan

1.3 Area and Land Use

The structure plan area is approximately 474 hectares. The area is framed by Mundijong Road (south), Tonkin Highway Road reserve (east), Kwinana freight rail (north) and Kargotich Road (west). The area has been derived from the Economic and Employment Lands Strategy.

The land is predominantly used for the grazing of cattle. The area has been substantially cleared of remnant vegetation to enable grazing. There is also a concentration of rural lifestyle development in the south eastern margins of the area around Pure Steel Lane.

Figure 3. Location Map

Figure 4. Aerial Site Plan

Land Ownership Table

Address Line	Owner Name
25 PURE STEEL LANE MUNDIJONG	L, Fletcher B & G Wibberley
48 PURE STEEL LANE MUNDIJONG	S, Downs F, Trichet
174 PURE STEEL LANE MUNDIJONG	Shire of Serpentine Jarrahdale
1149 KARGOTICH ROAD MUNDIJONG	Mundijong Nominees Pty Ltd
181 SCOTT ROAD MUNDIJONG	Water Corporation
525 BISHOP ROAD MUNDIJONG	Wellstrand Pty Ltd
900 HOPKINSON ROAD MUNDIJONG	T, Mustica
1081 KARGOTICH ROAD MUNDIJONG	Busquest Investments Pty Ltd

Land Ownership Table

Address Line	Owner Name
1087 KARGOTICH ROAD MUNDIJONG	CTJ (WA) Pty Ltd
184 SCOTT ROAD MUNDIJONG	Civilpit Pty Ltd
46 PURE STEEL LAND MUNDIJONG	M, Saywell
73 PURE STEEL LANE MUNDIJONG	A & I Walpole
72 PURE STEEL LANE MUNDIJONG	D & T Walters
64 PURE STEEL LANE MUNDIJONG	L, Edwards I, Snell
31 PURE STEEL LANE MUNDIJONG	Goldbase Investments Pty Ltd
1255 KARGOTICH ROAD MUNDIJONG	K, Bailey
59 PURE STEEL LANE MUNDIJONG	C, Burton S, Guy
24 PURE STEEL LANE MUNDIJONG	D, Tucker
402 SCOTT ROAD MUNDIJONG	L, Atwell P, Harbison D, Sparkman
13 KARGOTICH ROAD MUNDIJONG	Crossley Asspcoates {ty :td
525 BiSHOP ROAD MUNDIJONG	Wellstrand Pty Ltd
11 PURE STEEL LANE MUNDIJONG	A & S, Fitzi
58 PURE STEEL LANE MUNDIJONG	J & T, Atkins
122 SCOTT ROAD MUNDIJONG	A & H, Anderson
114 SCOTT ROAD MUNDIJONG	B & L, McCarthy
1305 MUNDIJONG ROAD MUNDIJONG	Western Australian Planning Commission
99 GOSSAGE ROAD MUNDIJONG	T, Mustica

1. Planning and Background

1.3 Planning Framework

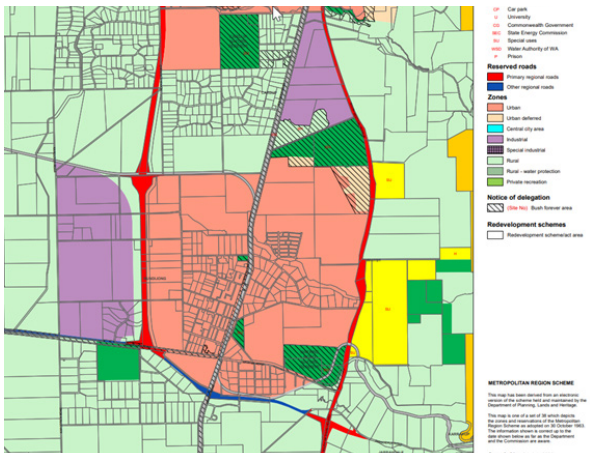
ZONING AND RESERVATIONS

The land is zoned 'Industrial' in the MRS. A small portion of the land in the north eastern margins is reserved as 'primary regional road' in lieu of the Tonkin Highway extension and future intersection upgrades with Bishop Road. A strip of land between the 'primary regional road' reservation and 'Industrial' zone is zoned 'Rural' and provides for the expected deviation of the freight rail in this corridor.

With respect to adjoining and nearby land the following should be noted:

- Mundijong Road, adjoining the southern boundary, is a designated 'other regional road';
- The portion of Mundijong Road is also a designated 'bush forever area';
- Land adjoining the eastern boundary is designated 'primary regional road' in lieu of the southern extension of the Tonkin Highway; and
- The primary regional road reserve allows for future intersection treatment to Mundijong Road and grade separation of the freight rail line.

Figure 5. Metropolitan Region Scheme



The Minister for Planning approved the Shire of Serpentine Jarrahdale Local Planning Scheme amendment on 30 January 2018 for the purpose of—

Reclassifying the following land parcels to the 'Urban Development' zone in West Mundijong—

(a) Part Lot 99 Kargotich Road (near intersection Kargotich Road)

(b) Lot 38 Bishop Road (Cnr Kargotich Road)

(c) Lots 1680, 525 and 405 Bishop Road

(d) Lots 2, 6, 9 8, 7 and 402 Scott Road

(e) Lot 4 Sparkman Road

(f) Lot 2 Kargotich Road

(g) Lots 11 and 1255 Mundijong Road

(h) Lots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 Pure Steel Lane

The majority of the parcels are included within the 'Urban Development' zone as delineated on the Scheme amendment map.

A portion of Lot 7 and Lot 402 Scott Road and Portion of Lot 405 Bishop Road are in the 'Public Open Space' reserve for the purposes of the Mandejal Brook.

1.4 Regional and sub-regional Structure Plans

DIRECTIONS 2031 AND BEYOND

In August 2010, the WAPC released Directions 2031 and Beyond. The purpose of the document is to guide future development for the Perth and Peel regions. In terms of metropolitan planning Directions 2031 represents the primary planning document for the metropolitan region including Peel.

The following key points arise from Directions 2031 which directly relate to West Mundijong:

- Identification of West Mundijong as an industrial area;
- Planned intermodal freight terminal at West Mundijong;
- Potential additional dwelling yield of 12,500 for Mundijong townsite; and
- Designation of Mundijong town site as a 'District Centre'.

The following key points arise from Directions 2031 which indirectly relate to West Mundijong:

- A projected further growth in population of 30,000 for Serpentine Jarrahdale by 2030;
- Employment self sufficiency target of 55%; and
- Identification of Tonkin Highway and Mundijong Road as 'strategic' roads.

A significant recommendation of Directions 2031 relates to the possible intermodal facility at West Mundijong. It states:

"An investigation of the suitability of an intermodal freight terminal at West Mundijong, as a strategically important industrial site, will be required. The potential realignment of the Kwinana–South West freight rail line that runs along the eastern boundary of the proposed West Mundijong strategic industrial area presents the opportunity to develop an intermodal terminal in this area. The West Mundijong site has the potential to become a strategically important intermodal node given its proximity to the intersection point of the rail system and the primary road network".

PERTH AND PEEL @ 3.5 MILLION

The Perth and Peel@3.5million strategic documents "… clearly spells out what SJ could look like in the future, how we can maintain our valued lifestyle and how we can realistically accommodate a substantially increased population." It specifically mandates the creation of areas for employment in the areas where there is a lack of employment.

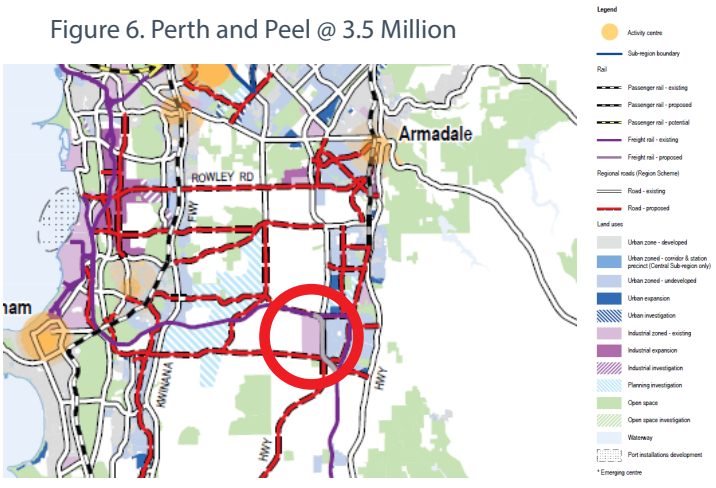
The following paragraphs quoted from the document shows how critically important economic development and specifically manufacturing is to provide the employment. The recently announced state infrastructure projects confirm the importance of development of the West Mundijong industrial area.

4.3 Key planning framework principles - Identify ultimate land uses for industrial and public purposes sites, while promoting access to finite basic raw materials, through the strategic staging and sequencing of development.

4.5 Delivering a connected city - planning for the development and growth of both the Inner Harbour at Fremantle and the future Outer Harbour at Kwinana by the Westport Taskforce.

Overall overarching objectives - Economy and employment - To promote employment opportunities and increase the number of people who live and work within the sub-regions, with a focus on attracting strategic economic and employment land uses within the strategic metropolitan centres and key industrial centres, while maximising use of existing and proposed infrastructure.

Figure 6. Perth and Peel @ 3.5 Million



1. Planning and Background

PERTH AND PEEL @ 3.5 MILLION

Economy - For sub-regions with lower employment self-sufficiency, such as the North-West and the South Metropolitan Peel's south-eastern sector, it is critical that employment opportunities focus on key industries that encourage people to live and work within the same sub-region.

South Metropolitan Peel sub-region: In 2011, the sub-region generated a total of 143,970 jobs, estimated to rise to 437,730 by 2050. Employment opportunities are expected to focus on manufacturing, construction, retail, healthcare and social assistance. Jobs in the south west sector are projected to reach 195,115; 137,030 in the south east sector and 105,580 in the Peel sector by 2050.

South Metropolitan Peel sub-region: This sub-region is expected to require 5,900 hectares of industrial land to 2050 with the Kwinana Industrial Area, the Rockingham Industrial Zone, the Australian Marine Complex and the Latitude 32 industrial area accounting for the majority of this demand. The establishment of the Outer Harbour will also provide opportunities, as do the alumina refineries in Pinjarra and Wagerup. Other industrial areas for expansion or establishment will include sites at Nambeelup, Maddington/Kenwick, Pinjarra, Forrestdale and Mundijong. Staged delivery of infrastructure and public and private sector investment to maximise economic development and employment potential will be critical to the successful development of priority employment lands. This will require a coordinated and collaborative approach to delivery across government and private stakeholders.

Local government has an important role in facilitating economic development within the sub-region through the preparation of local development strategies that:

- encourage and facilitate of growth for activity and industrial centres for the purpose of delivering employment opportunities;
- protect of employment generating land from the encroachment of competing and/or incompatible land uses;
- create employment opportunities which utilise local labour force skills to increase employment self-sufficiency;
- maximise and encourage further growth of the area's key economic sectors and/or clusters;
- cultivate and strengthen relationships with key stakeholders; and
- provide targeted services and support to businesses to facilitate economic growth.

Figure 7. Employment and Economic Network 2050

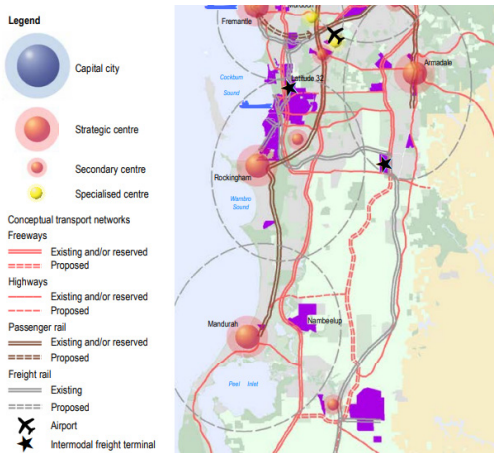
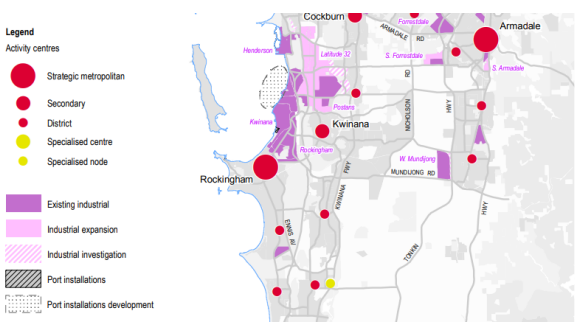


Figure 8. Employment Opportunities

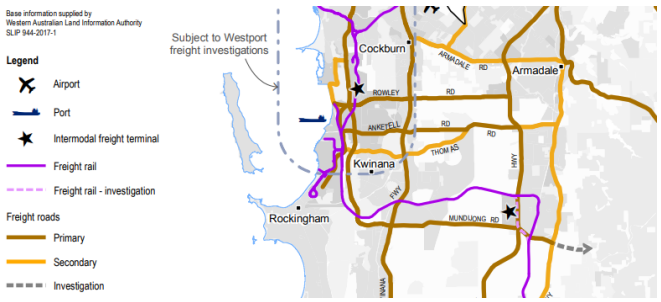


Mundijong (west) - Mundijong is a future industrial area that is expected to mainly cater for increased agriculture-related industries, including transport and logistics. Comprehensive district planning for the area will need to respond to the proposed intermodal facility and long-term realignment of the freight rail out of the developing Mundijong town centre.

Figure 9. Industrial Investigation Areas

TABLE 7: Industrial Investigation areas – key considerations

Site	Key considerations
Cardup	Arrangements being made for the long-term protection of Bush Forever site 361.
West Mundijong – freight rail realignment	Determine land requirements for future realignment of the freight railway that currently passes through Mundijong.



The West Mundijong Area responds to Table 8: Implementation actions and shows the intent of the local government to improve the economic and employment situation within the Shire.

Figure 10. Economy and Employment

Economy and employment

Sub-regional planning framework objective	Strategic direction/priority	Actions	By whom
To promote employment opportunities and increase the number of people who live and work within the sub-region, with a focus on attracting strategic economic and employment land uses within the strategic metropolitan centres and key industrial centres, while maximising use of existing and proposed infrastructure.	Promote employment nodes including activity centres, specialised centres, Industrial areas, Industrial Expansion areas and Industrial Investigation areas	Structure planning	WAPC Local government
		Relevant investigations (for investigation areas)	WAPC Various
		Region scheme amendments	WAPC
		Local Economic Development Strategy	Local government
		Local planning strategy/ scheme amendments	WAPC Local government
	Protect employment land from uses inconsistent with the employment objective by planning for ultimate development with limited interim uses	Region scheme amendments	WAPC Local government
		Local planning strategy/ scheme amendments	
		Structure planning	
	Protect strategic industries and land classified for this purpose, together with their buffers, from the encroachment of non-strategic and/ or incompatible land uses	Region scheme amendments	WAPC Local government
		Local planning strategy/ scheme amendments	
		Structure planning	
	Improve employment self-sufficiency to reach target	Structure planning	Local government

SOUTHERN METROPOLITAN SUB-REGIONAL STRUCTURE PLAN 2009 (SMSRSP)

In 2009 the WAPC prepared the SMSRSP.

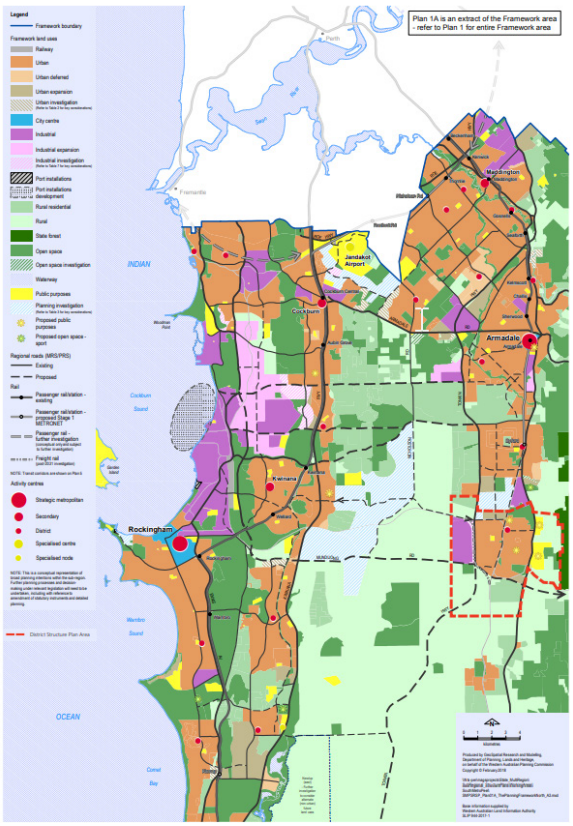
The following key points arise from SMSRSP which directly relate to the investigation area:

- Identification of West Mundijong as an industrial investigation industrial area;
- Possible re-location of the Kwinana South West freight rail line to follow alignment of Tonkin Highway extension;
- Possible extension of Mundijong Road east of Mundijong; and
- Planned dwelling yield of 12,500 for Mundijong townsite

The SMSRSP also established a hierarchy of industrial areas within the sub region which are discussed as follows:

- Kwinana designated as a strategic heavy industry area;
- Latitude 32 established as subsidiary to the Kwinana port;
- Potential future general industry areas at East Baldivis and Forrestdale;
- The Cardup area for light industry.

Figure 11. South Metropolitan Peel - Sub-Regional Planning Framework



1. Planning and Background

1.5 Industrial Land Strategies

ECONOMIC AND EMPLOYMENT LANDS STRATEGY: NON-HEAVY INDUSTRIAL: PERTH METROPOLITAN AND PEEL REGIONS

The Economic and Employment Lands Strategy: non-heavy industrial: Perth metropolitan and Peel regions (EELS) was completed by the WAPC in August 2012. The purpose of the EELS is to determine demand for industrial land in the short to medium term and ensure that sufficient industrial land is identified and made available in the Perth and Peel region. The EELS has identified 37 potential industrial areas. Eleven of the sites have been identified as 'priority industrial sites The EELS states:

West Mundijong … has the potential to become a strategically important intermodal node, given its proximity to the intersection point of the rail system and the primary road network.

DEMAND ANALYSIS FOR EMPLOYMENT GENERATING LAND IN SERPENTINE JARRAHDALE

The study was completed in 2009 for the Shire of Serpentine Jarrahdale. Key findings for West Mundijong:

- An additional 150 hectares of land will be required by 2021 to meet projected demand for industrial land;
- The following sectors offer optimum employment and economic potential:
  - » Manufacture of building construction materials;
  - » Food manufacture; and
  - » Transport and logistics

1.6 Local Planning Strategy

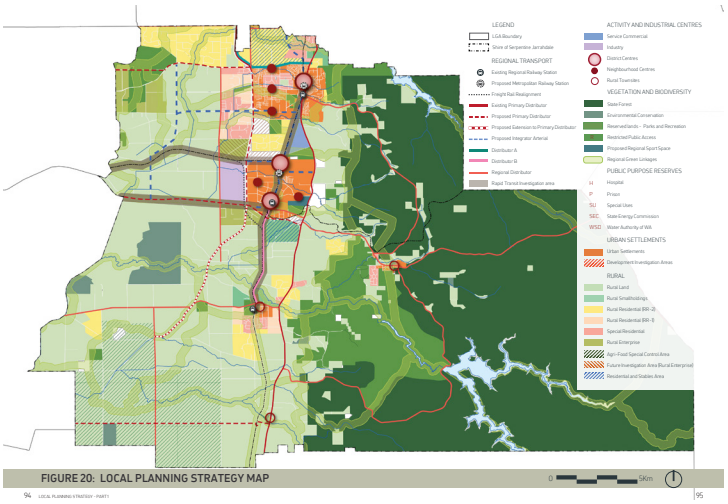
The Local Planning Strategy provides for a variety of industries and businesses ranging from low intensity service industries to intensive general industries which may have offsite impacts. There are two industrial areas identified within the Shire including the West Mundijong Industrial Area and the Cardup Business Park. Both of these industrial and service commercial areas are well connected to regional roads and the freight rail network, with the West Mundijong Industrial Area bound by Mundijong Road, the future Tonkin Highway and the Kwinana Freight Rail and the Cardup Business Park located on South Western Highway.

Industrial development is fundamental to sustaining and strengthening the local economy and creating local employment opportunities. The development of industrial land is important to generate investment within the Shire and attract businesses, creating a need for more services to support such industries. Industrial development generates employment opportunities in both the industries and businesses within industrial areas and the associated support services. Creating local employment opportunities provides the potential for local residents to work within the area in which they live. This may improve employment self-containment within the Shire reducing travel times, traffic congestion and improving resident's access to the workforce, which could result in higher rates of workforce participation, lower unemployment rates and less occurrence of socio-economic disadvantage. Industrial areas can also attract skilled workers to the Shire to patronise local businesses and potentially locate within nearby residential areas, driving both the local economy and housing market. It is crucial for industrial areas to be well located with convenient access to regional transport networks.

Objectives

- Provide for an appropriate and well located supply of industrial land to make the Shire an attractive, well connected location within the region to establish industries and businesses;
- Encourage the growth, development and diversification of the local economic base;
- Facilitate local employment opportunities and improve employment self-containment and self-sufficiency;
- Protect industrial land from the encroachment of sensitive land uses;
- Create sustainable industrial developments which utilise innovative technologies;
- Develop well designed industrial areas with a high level of amenity.

Figure 12. Draft Local Planning Strategy Map



The West Mundijong Industrial Area is optimally located to the west of the Mundijong Whitby urban area, bound by north-south and east-west regional road connections in the form of the future Tonkin Highway and Mundijong Road respectively, and the Kwinana Freight Rail. This location provides efficient connectivity to the freight network, making it ideal for various industrial uses. There are long term plans for the realignment of the Kwinana Freight Rail to be relocated from the Mundijong Whitby urban area to run parallel to the future Tonkin Highway adjacent to the West Mundijong Industrial Area.

The strategic location of the West Mundijong Industrial Area and the future realignment of the Kwinana Freight Rail potentially provides the opportunity for a strategically important intermodal node to be located within the West Mundijong Industrial Area. The proximity of the West Mundijong Industrial Area to agricultural land and food production activities provides the potential to create synergies between existing rural activities such as poultry farming and the new operations within the industrial area. The development of an agri-precinct within the West Mundijong Industrial Area is supported for such purposes.

Strategies

- Ensure industrial development is located in appropriate locations which are highly accessible to road and rail transport connections;
- Investigate the opportunity to develop an intermodal hub within the West Mundijong Industrial Area along the proposed realignment of the Kwinana Freight Rail to support the development of industry;
- Allow for a broad range of industrial uses to be developed within industrial areas;
- Ensure that more intensive industrial uses which are likely to affect the amenity of the surrounding area are located away from existing urban areas;
- Locate less intensive industries, rural industries or large scale commercial uses to act as a buffer between industries of a greater intensity and sensitive land uses;
- Provide for the development of bulky goods retail and other large-scale format retail, services or showrooms within close proximity to activity centres.
- Prevent the development of sensitive land uses within the buffer of industrial land that may prejudice the future development of the industrial land for industrial purposes;
- Encourage industrial developments to utilise best practice management techniques and innovative technology to minimise environmental impacts;
- Require industrial uses that may detract from visual amenity to be screened from view;
- Require landscaping and trees to be provided within industrial areas to enhance amenity and provide shade;
- Identify the land in a 1km buffer north and west of the West Mundijong Industrial Area as 'Rural Enterprise Investigation'.
- 'Support the realignment of the Kwinana Freight Rail out the Mundijong Whitby urban area to the more appropriate location adjacent to the West Mundijong Industrial Area and Tonkin Highway extension, removing a significant constraint to the urban development and amenity of Mundijong Whitby.

1. Planning and Background

Actions

- Review the West Mundijong District Structure Plan and the Cardup Business Park Structure Plan;
- Prepare a development contribution scheme and plan for the West Mundijong Industrial Area and the Cardup Business Park;
- Include a General Industry zone within LPS 3 to allow for a range of industrial uses.
- Include a Light Industry zone within LPS 3 to allow for a limited range of industries which are not likely to have offsite impacts;
- Include an Industrial Development zone in LPS 3 to identify future industrial areas;
- Zone the West Mundijong Industrial Area as Industrial Development under LPS 3;
- Include a Service Commercial zone within LPS 3 to facilitate development of bulky goods retail and other large scale retail and commercial services;
- Facilitate the zoning of the Cardup Business Park to Service Commercial;
- Zone the land between South Western Highway and Soldiers Road, north of Cardup Siding Road as Service Commercial;
- Include provisions to require the screening of industrial uses within LPS 3;
- Include provisions to require landscaping within LPS 3.

1.7 Serpentine Jarrahdale Town Planning Scheme No.2

The Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 refers to the West Mundijong as Development Area 6. A copy of the map and table is below:

Ref. No.	Area	Provisions
DA 6	a) Part Lot 99 Kargotich Road (near intersection Kargotich Road). b) Lot 38 Bishop Road (Cnr Kargotich Road). c) Lots 1680, 525 & 405 Bishop Road. d) Lots 2, 6, 9 8, 7 & 402 Scott Road. e) Lot 4 Sparkman Road. f) Lot 2 Kargotich Road. g) Lots 11 & 1255 Mundijong Road. h) Lots 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 & 12 Pure Steel Lane. *AMD 187 GG 13/02/18*	1. Land use, development, and if necessary, subdivision are to be guided by local structure plan(s) prepared and approved pursuant to Schedule 2 Part 4 of the LPS Regulations. 2. Each Local Structure Plan will require the preparation of a Local Water Management Strategy and appropriate level Bushfire Risk Management Planning. 3. Each Local Water Management Strategy will be required to address the following matters: a) Hydrological assessment to demonstrate no adverse impact on Threatened Ecological Communities and Conservation Category Wetlands within and surrounding the subject land; b) Consideration of Commonwealth referrals for Threatened Ecological Communities within as well as adjoining the subject land; and c) The inclusion of Surveys for habitat of Black Cockatoo. 4. In addition to the considerations outlined in *Schedule 2, Part 4 of the Planning and Development (Local Planning Schemes) Regulations 2015*, the structure plan is to have regard to the following factors: a) Proposed extension of Tonkin Highway. b) Possible realignment of the Kwinana Freight line. c) Provision of a possible intermodal facility if found feasible by the Department of Transport. d) Conservation of Manjedal Brook. e) Preparation and implementation of a noise management strategy to the satisfaction of the Office of Environmental Protection which is cognisant of proposed and existing sensitive uses including those existing uses contained within the structure plan area. f) Provision of ecological corridors reflecting district drainage patterns, vegetation and wetland values within the amendment area. g) Inclusion of a 50 metre buffer around the Conservation Category Wetland unless a specific site study is undertaken and recommends a revision of this buffer distance. 5. Compliance with a Developer Contribution Plan prepared in accordance with clause 9.3. 6. A Wastewater Pump Station is planned in this locality and as a result, odour buffers will apply to sensitive land uses.

1.7 Serpentine Jarrahdale Town Planning Scheme No.2

Figure 13. Town Planning Scheme No.2 Maps

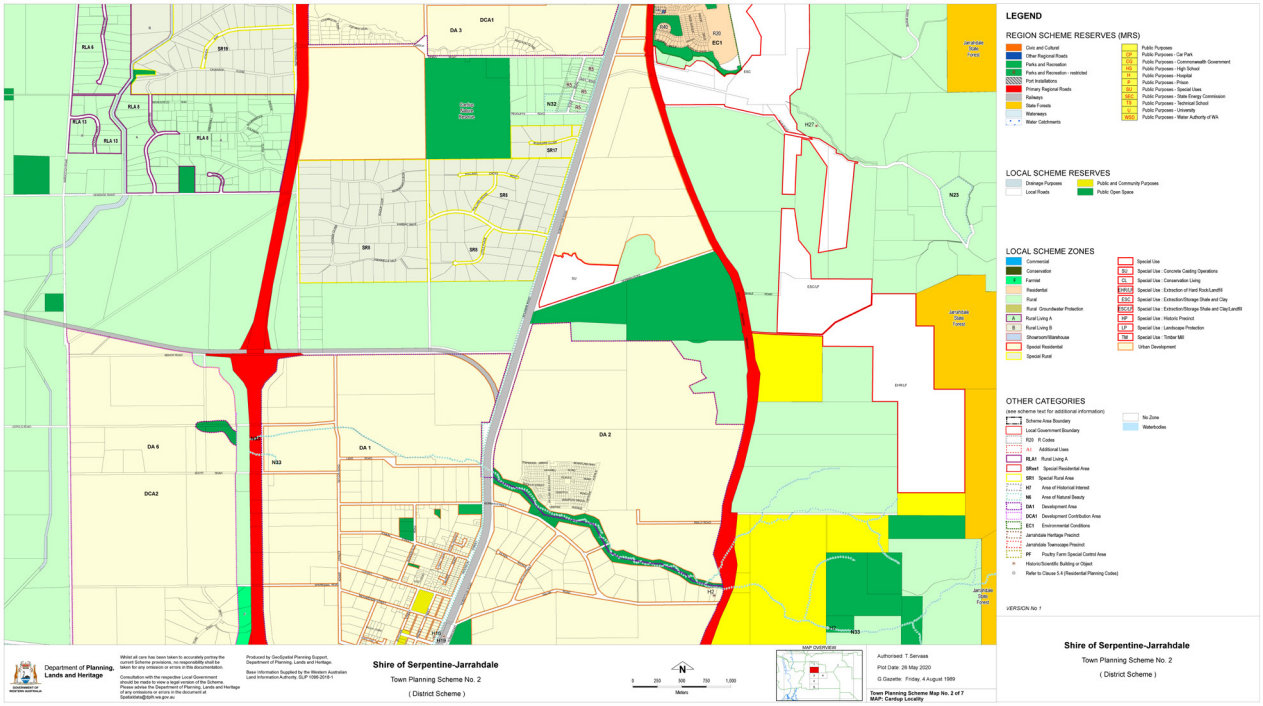
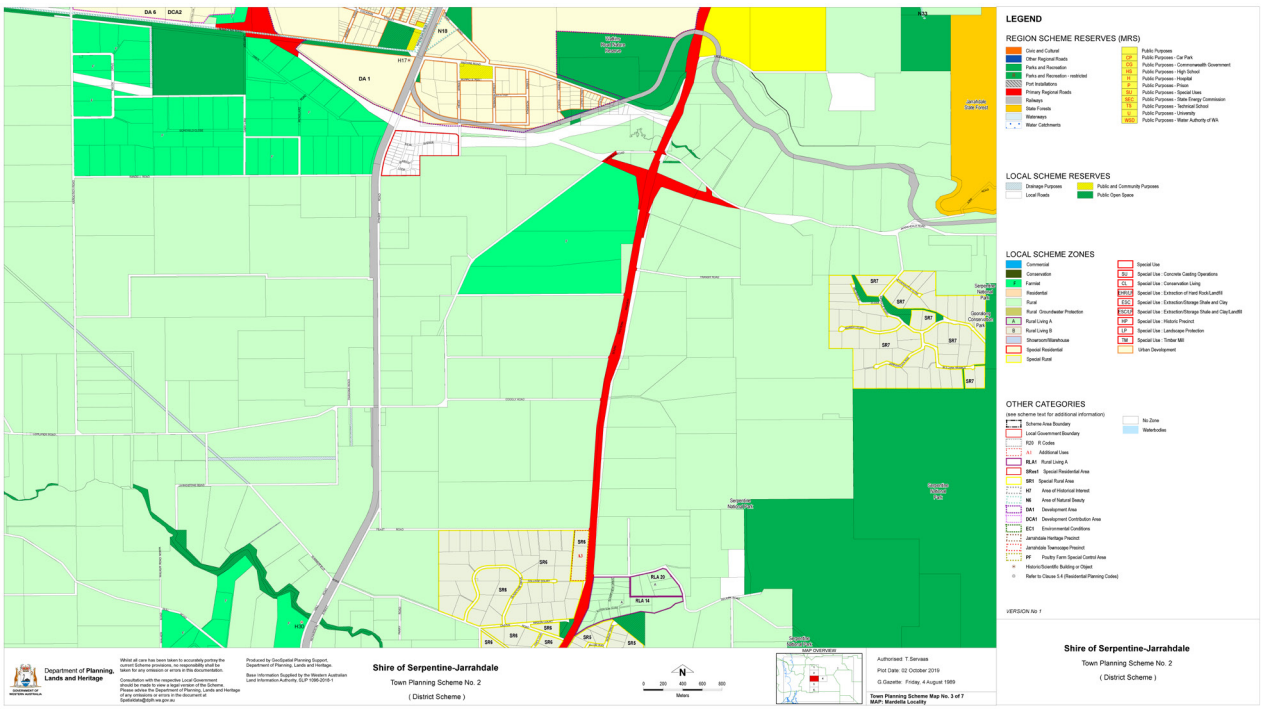


Figure 14. Town Planning Scheme No.2 Maps



1. Planning and Background

1.8 Serpentine Jarrahdale Local Planning Scheme No.3

The Serpentine Jarrahdale Local Planning Scheme No. 3 refers to the West Mundijong Industrial Area as Special Control Area 10.

SCA10	West Mundijong Development Contribution Area	To designate areas where a Development Contribution Plan shall apply. To specify the infrastructure items and contribution methodology contained within the Development Contribution Plan.	1. Items: Mundijong Road: (a) Land required to achieve the proposed 40 metres road reserve; (b) Earthworks for the whole road reserve; (c) The construction and upgrade of one carriageway; (d) Associated drainage works including water sensitive measures; (e) Traffic control devices including two sets of traffic lights, intersection treatments incorporating slip lanes and associated works; (f) Shared paths; (g) Utility removal, relocation and insertion; and (h) Associated costs including design, administration, and management. Kargotich Road: (a) Land required to achieve the proposed 30 metres road reserve; (b) Earthworks for the whole road reserve; (c) Complete road construction based on a single lane split carriageway with central median. (d) Associated drainage works including water sensitive measures; (e) Traffic control devices including intersection treatments incorporating slip lanes and associated works; (f) Shared paths; (g) Utility removal, relocation and insertion; and (h) Associated costs including design, administration, and management. Bishop Road New: (a) Land required to achieve the proposed 30 metres road reserve; (b) Earthworks for the whole road reserve; (c) Complete road construction based on a single lane split carriageway with central median. (d) Associated drainage works including water sensitive measures; (e) Traffic control devices including one set of traffic lights, intersection treatments incorporating slip lanes and associated works; (f) Shared paths; (g) Utility removal, relocation and insertion; and (h) Associated costs including design, administration, and management. North-South Spine Road: (a) Land required over and above a standard 20 metre road reserve to achieve the required road width of 30 metres; (b) Earthworks for the whole road reserve; (c) Complete road construction based on a single lane split carriageway with central median. (d) Associated drainage works including water sensitive measures; (e) Shared paths; (f) Utility removal, relocation and insertion; and (g) Associated costs including design, administration, and management. Land for drainage: • All land required for district drainage purposes. Administrative: All estimated future costs associated with administration planning and development in West Mundijong, including: • Planning studies; • Traffic studies; • Drainage studies; • Road design costs; • Borrowing costs (including interest and principal loan repayments); and • Scheme Management Costs (including administration and management of the DCA). 2. Methodology: Per hectare or square metre basis. 3. Timeframe: Period of operation: 20 years Priority and timing of infrastructure provision: Refer development contribution plan report

1.8 Serpentine Jarrahdale Local Planning Scheme No.3

Figure 15. Local Planning Scheme No.3 Maps

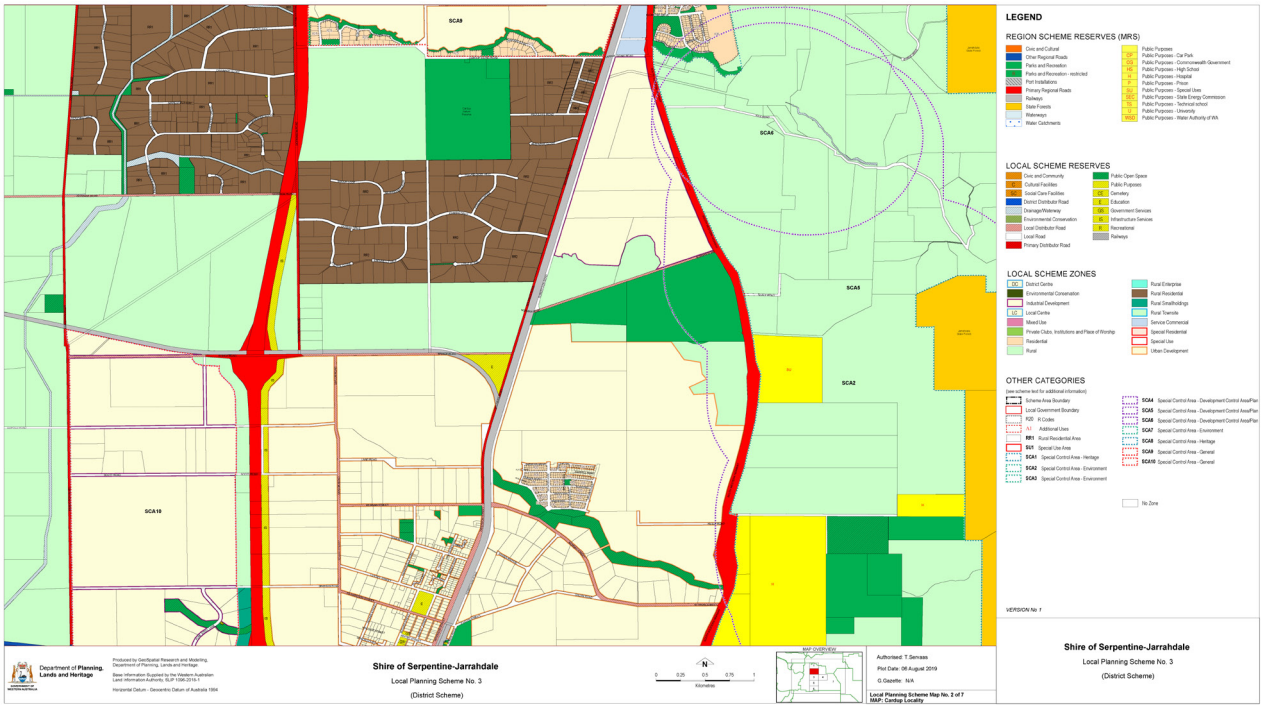
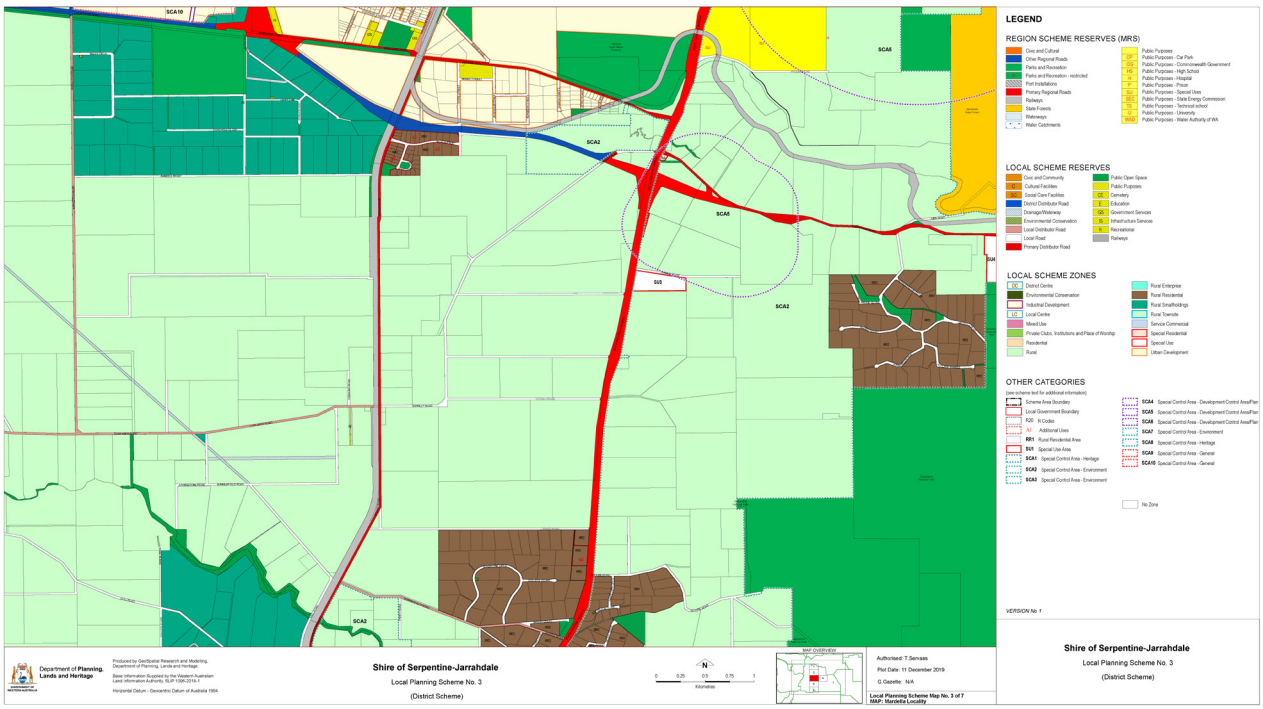


Figure 16. Local Planning Scheme No.3 Maps



1. Planning and Background

1.9 Mundijong Whitby District Structure Plan 2011

The Mundijong Whitby District Structure Plan was endorsed in 2011.

Key implications for West Mundijong:

- Identification of West Mundijong as a 'Strategic Industrial Node';
- Designation of Manjedal Brook as a 'public viewing area';
- Realignment of Kwinana Freight Rail Line to follow alignment of Tonkin Highway extension;
- Long term future population of 40-50,000 residents at Mundijong-Whitby.

Summary

- A high level of strategic support for industrial development at West Mundijong embodied is in both state and local planning strategies;
- Possibility of an intermodal facility at West Mundijong which could be a significant catalyst for industrial development;
- A further projected growth in population of 30,000 for the Shire of Serpentine Jarrahdale by 2030;
- Employment self sufficiency target of 55% and therefore the need to plan for and provide employment generating areas such as West Mundijong;
- Identification of Tonkin Highway and Mundijong Road as 'strategic' roads; and
- Need for the Shire of Serpentine Jarrahdale and the Department of Planning and the Department of Transport to effectively collaborate regarding future planning at West Mundijong

1.10 Mundijong District Structure Plan 2020

Approximately 880 industrial lots are possible in the West Mundijong Industrial Area, providing a significant opportunity to act as a catalyst for change generating a significant amount of jobs and sustained economic growth. The current West Mundijong Structure Plan provides for a general industrial core (279 ha) and supporting light industrial areas (135 ha) for precincts to the east and south. The light industrial areas also provide separation from the core area to adjoining residential areas to the east and south.

Based upon previous work, it is likely that the core may support the following forms of industry, subject to approvals:

- Agribusiness, including abattoirs, food processing, canneries & breweries;
- General industry, including manufacture / prefabrication of building products and materials;
- Storage, warehousing, freight and logistics;
- Heavy machinery servicing and sales; and
- Transport and fuel depot.

To deliver the above, significant investment into transport infrastructure is required - namely the Tonkin Highway extension and freight rail realignment. These transport connections improve the viability of the industries mentioned above and would enable the establishment of an intermodal hub. While the Shire is committed to industrial development at West Mundijong irrespective of an intermodal facility, the following benefits are acknowledged:

- Cost savings on industrial land over other parts of Perth, greatly reducing investment costs;
- Strong transport links via rail and road (offering access to major domestic and international markets with just one traffic light routing by the Tonkin Highway);
- Available industrial land (and surrounding land for associated industrial uses);
- Rapidly growing population in the Shire that will double over the next decade and quadruple by 2050;
- Labour pool of 270,000 potential workers (within a 30 minute drive); and
- Strong inter-regional road linkages (north-south and east-west).

The Mundijong District Structure Plan 2020 recognises the opportunity of a West Mundijong structure plan to provide for a 'first phase of industrial subdivision', based upon a phased approach to subdivision. The first phase is termed a dry lot industrial subdivision, which is subject to a minimum lot size of 1.5- 2ha. This first phase is not reliant on reticulated water or sewer infrastructure being provided. The 1.5 - 2ha minimum lot size requirement is to provide sufficient flexibility for onsite potable water catchment (via water tanks) and onsite effluent disposal. Intensity of development is also compatible with current road infrastructure limits, and the planned upgrades reflective of the Development Contribution Scheme for the area. Refer to the Council Minutes from the 16 November 2020 on the advertised Mundijong District Structure Plan 2020.

More intense subdivision and development will require precinct based planning to occur. These precincts are shown above. For subdivision at greater intensities than the 1.5 - 2ha dry lot industrial phase, the following will be required to be adequately addressed:

Engineering and Servicing

- Servicing response that demonstrates the subdivider being capable of providing all services to proposed lots;
- Geotechnical Investigation to determine fill requirements.

Traffic Design and Management

- A road network that reflects a well ordered and connected industrial area, and which provides for necessary road widths and space capacity to carry industrial vehicles (initially up to RAV4);
- Traffic Impact Assessment.

Water Management

- An amendment to the adopted Local Water Management Strategy, which is precinct specific to the area of the structure plan being proposed for subdivision beyond the 1.5 - 2ha dry lot phase. This must demonstrate an acceptable transition of the precinct to be able to deal with drainage and depth to groundwater requirements in a manner that responds to the design criteria set through the Local Water Management Strategy.

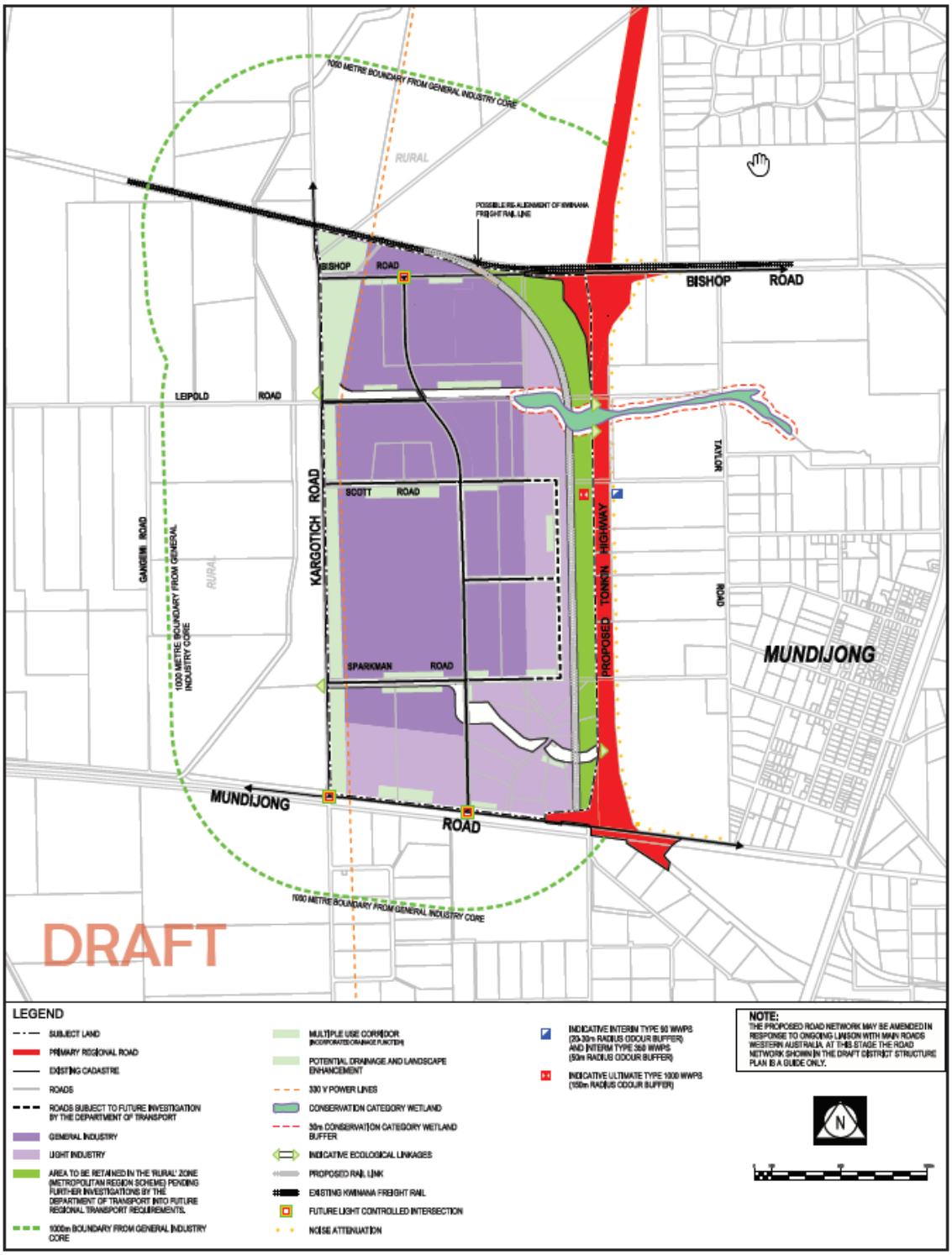
Minimum lot sizes, beyond the dry lot phase, shall not be below 4000sqm.

1.10 West Mundijong District Structure Plan 2017

The structure plan was formulated as a strategic document to support amendments to the Metropolitan Region Scheme (MRS) and the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2. Further, the district structure plan was instrumental in guiding the development of this subsequent structure plan.

1. Planning and Background

Figure 17. West Mundijong District Structure Plan 2017



2. Site Conditions and Constraints

Overall the site has been substantially cleared to enable grazing and related farming activity. There is also evidence of smaller lots being used for rural lifestyle uses, including equestrian activity. Nevertheless, small pockets of remnant vegetation or re-growth are present in isolated parts of the investigation area. It is estimated that such vegetation represents approximately 2% of the total investigation area.

Manjedal Brook traverses the structure plan area east-west. In response to farming activity, the Brook has been substantially cleared of vegetation and altered in order to perform a more efficient drainage function.

PGV Environmental were engaged to prepare a desktop environmental assessment to support the structure plan (refer Appendix A). The results of the desktop assessment conclude that the potential for industrial development to negatively impact on the bio-physical environment are considered to be low.

The primary environmental consideration will be the potential impacts of industrial development on the existing dwellings adjacent to the site and in some cases within the site. DWER has advised that particular regard will need to be given to potential noise impacts. Herring Storer Acoustics were engaged to conduct a noise assessment for potential industry at West Mundijong (refer Appendix B). Their report concluded that certain categories of industry may be developed at West Mundijong and meet the requirements of the relevant noise regulations.

Bidiversity and Natural area assets

Vegetation

The vegetation on the site is 'Completely Degraded' and in small areas 'Degraded' to 'Completely Degraded'. The site does not contain any areas with an intact understorey.

Notwithstanding the significant degradation of vegetation on site the assessment recommends:

Consideration be given to retention of trees in public areas including road reserves, public open space, car parks, entry statement areas and possible ecological corridors; and Salvaging and relocation of some trees including Kingia Australis plants.

It is noted that the Mundijong Road reserve contains threatened ecological communities (TEC) to the south of the road tarmac. To protect these TECs any further construction to provide services or to upgrade this road should be undertaken to the north of the constructed road. Management procedures should be in place to ensure that the vegetation to the south is not disturbed.

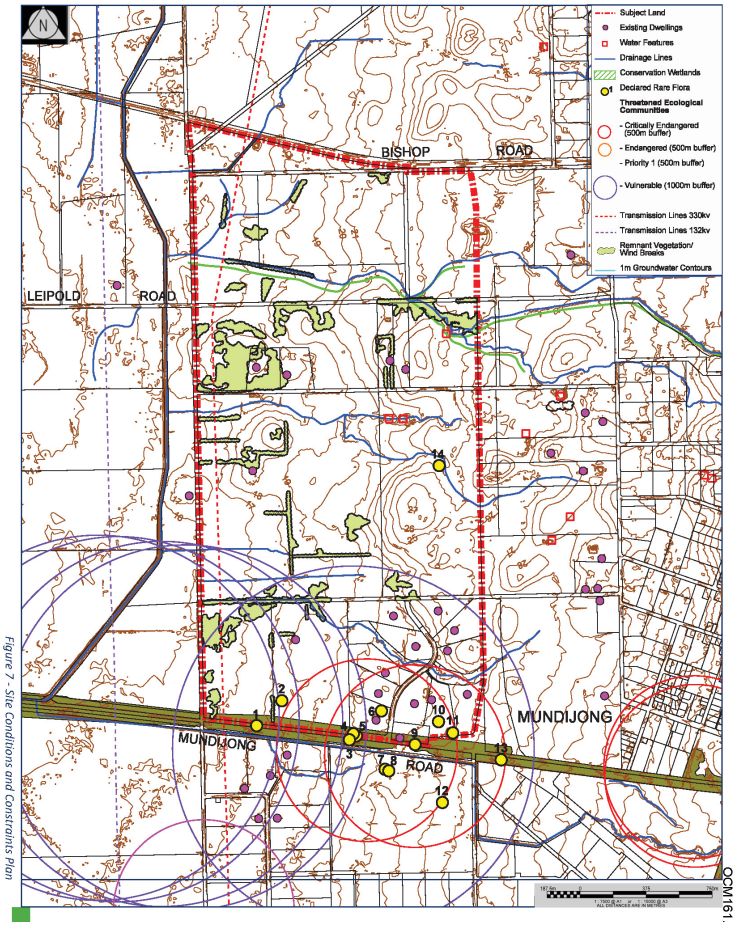


Figure 7 - Site Conditions and Constraints Plan

Figure 18. Site Conditions and Constraints Plan

2. Site Conditions and Constraints

Flora

The report found that there is unlikely to be any declared rare flora and likely to be no priority species present within the structure plan area. It is recommended that no further assessment is required and therefore flora is not an impediment to the development of the structure plan area for industry.

Fauna

The following species listed under Section 18 of the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act may be impacted by development of the site:

- Forest Red-tailed Black-Cockatoo (Calyptorhynchus banksii subsp. naso)
- Baudin's Cockatoo (Calyptorhynchus baudinii)
- Carnaby's Black Cockatoo (Calyptorhynchus latirostris)

Surveys will need to be undertaken at subdivision stage to determine the risk to these species. This will particularly apply to areas that contain Marri trees. Examples include areas to the north of Scott Road on the western end and the lots immediately to the north of Manjedal Brook. Depending upon potential risks to habitat referral may be required to the Commonwealth Department of Sustainability, Environment, Water, Population on and Communities pursuant to the Environmental Protection on and Biodiversity Conservation on Act 1999.

To mitigate potential impact on black cockatoos the report recommends that in subsequent stages of planning consideration be given to the retention of Marri and Flooded Gum trees. It is also noted that there is the potential to improve the black cockatoo habitat by plan ng appropriate species in drainage corridors, open space and road reserves.

Landform and soils

Overall, the area has the appearance of being flat, however the following should be noted:

- The land falls from east to west by up-to 10 metres over a distance of approximately two kilometres;
- A sandy peak is located in the middle of the site near the eastern boundary. The peak is approximately 27 metres AHD;
- The lowest point of the site is approximately 16.5 metres AHD in the south west.

Refer Figure 3 - Aerial Site Plan

Overall, the site does not contain any unique topographical or geological formations and therefore these factors are not an impediment to the development of the site for industrial purposes.

- Some of the soil types on the site are prone to waterlogging and ponding. The assessment recommends that surface water management will be required to manage these soil types. To minimise potential for soil erosion to occur the following management measures are recommended:
- Ground disturbing activities should be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site;
- Landscaping/stabilising/dust suppression of areas where ground disturbance has occurred should be scheduled to occur immediately after clearing/and or infrastructure construction has been completed; and
- Clearing activities have the potential to add clay 'fines' into the drainage channels or the Conservation Category Wetland and the installation of temporary drop-out basins to capture and aid in the settling of clay fines should be considered.

Refer Figure 12 Site Conditions and Constraints Plan

Acid Sulphate Soils (ASS)

The ASS Risk on the site is mapped as being Moderate to Low (<3m from the surface). The WAPC Acid Sulphate Soils Planning Guidelines (WAPC, 2009) indicate that "acid sulphate soils are technically manageable in the majority of cases". ASS Investigation and, if required, Management Plans should be prepared at subdivision stage once the detailed design of the site is finalised. This should be undertaken in accordance with the Acid Sulphate Soils Guideline Series: Identification and Investigation of Acid Sulphate Soils and Acidic Landscapes (DEC, 2009a) and Draft Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes (DEC, 2009b).

Groundwater and surface water

Groundwater management has been outlined in both the District Water Management Strategy and DRY LOT PHASE Local Water Management Strategy. These conclude that potential impacts on groundwater can be mitigated and managed and does not impede development of the site for industrial purposes.

As mentioned in Part 1, an amendment to the adopted Local Water Management Strategy will be required for any precinct that contemplates subdivision beyond the 1.5 - 2ha dry lot phase. This must demonstrate an acceptable transition of the precinct to be able to deal with drainage and depth to groundwater requirements in a manner that responds to the design criteria set through the Local Water Management Strategy.

Surface Water

As for groundwater the management of surface water is outlined in the District Water Management Strategy and Local Water Management Strategy. The structure plan has identified two of the drainage channels (one of which includes Manjedal Brook) as potential 'ecological corridors' that will be revegetated and contain some passive recreation opportunities. The corridors should be designed to create a 'living stream' that is incorporated into the eventual subdivision and development on the site. There is the potential to increase the ecological value of the degraded channels through rehabilitation which may provide additional habitat for some species.

Wetlands

A large proportion of the site is mapped as a palus plain Multiple Use Wetland.

A portion of the Manjedal Brook is also categorised as a Conservation Category Wetland. This structure plan provides for a 30 metre buffer to this section of Manjedal Brook. The buffer distance is consistent with the environmental reporting completed to accompany this structure plan.

The structure plan also includes the Brook within an ecological corridor. A wetland management plan prepared at the time of subdivision, should also detail measures to maintain the hydrology and improve the environmental values of the Brook. It should also include rehabilitation measures and outline the methodology to provide the ecological corridor upon development of the site.

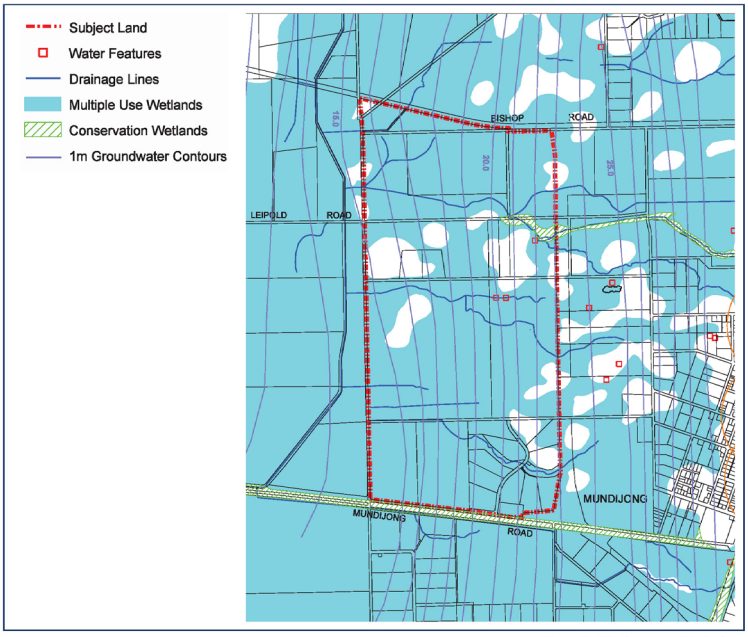


Figure 19. Wetlands and Hydrology Map

2. Site Conditions and Constraints

Wetland Buffers

The part of Manjedal Brook west of the site is in similar condition to the portion of the Brook east of the site. Planning for this part of the Brook is underway and it has been determined that as a riverine wetland the responsible authority for the Brook is the Department of Water. The Water Quality Protection Note 6: Vegetation Buffers to Sensitive Water Resources (DoW, 2006) outlines the manner in which buffer distances are to be measured:

Horizontal buffer distances are measured at right angles to the margins of streams or waterbodies, while buffers are normally circular for water supply wellheads. Where margins to ephemeral waterways are unclear, buffers should be measured outward from grade changes defining run-off channels.

Similar to the portion of the Brook east of the proposed Tonkin Highway extension, the wetland has clearly defined banks. On this basis the wetland buffer should be consistent with that to the east of the site. This will be 30m as measured from the top of the bank. The buffer area is partially vegetated however in areas that are completely degraded drainage infrastructure could be placed in the buffer area, consistent with the eastern part of the Brook.

Heritage

There are possibly two aboriginal heritage sites near or within the structure plan area.

- Site '450' is a registered site and is located near Manjedal Brook near the eastern boundary of the structure plan area.
- A 'heritage place' is also located approximately 500 metres south of site 450, again near the boundary of the proposed southern extension of the Tonkin Highway.

Ethnographic surveys will need to be conducted at subdivision stage to establish their significance and if required what measures should be put in place to ensure their conservation. Subject to survey, the sites may not be located within the development area.

Refer Figure 12 Site Conditions and Constraints.

Sensitive uses / land use compatibility

The structure plan area is adjoined to the east by existing and planned residential uses. Furthermore, there is a preponderance of dispersed dwellings located to the south of the area associated with rural lifestyle or hobby farm subdivisions.

The EPAs Guidance Statement No 3 prescribes standard separation distances between industry and sensitive uses such as residential. Based on the guidance statement, it is unlikely that some categories of industry could locate within 500 metres of existing planned or sensitive uses on account of their emissions which could include noise, dust, odour or public risk. Such uses may include; abattoirs, brickworks, extractive industry, cement manufacturing and heavy fabrication involving steel or other metals. Nevertheless, low emission industries may locate within this area such as warehousing, logistics, service industry and some categories of light industry

Refer to Part 9 - Preferred and Non Preferred Land Uses for all sensitive uses/ land use compatibility for the West Mundijong Industrial site.

Irrespective of the potential for industrial development to the west, the extension of Tonkin Highway will require installation of associated noise attenuation measures in response to planned and existing dwellings to the East near Mundijong town site.

There is an opportunity for low emission uses near the eastern and southern boundaries such as:

- Warehousing
- Logistics
- Heavy machinery servicing, distribution and sales
- Some forms of light industry and service industry use
- Limited showroom development

As explained above, the eastern portion of the site adjoining the extension of the Tonkin Highway has been retained in the 'Rural' zone within the Metropolitan Region Scheme pending further investigations relating to a possible intermodal facility or related transport infrastructure.

Noise emissions

In preparing the structure plan liaison has taken place with the DWER to establish key environmental factors to consider in the development of the plan. While it is likely that future industry will be low emission in nature, the DWER recommended that consideration should be given to potential noise emissions. Odour, dust and light spill were considered to be unlikely emission risks for the types of industry envisaged at West Mundijong.

Acoustic consultants, Herring Storer, were engaged to determine the feasibility of industrial development given the proximity of existing and planned noise sensitive uses. Their report concluded that future industrial development has the potential to comply with the relevant regulations subject to the following critical factors:

- Industrial development being limited to non heavy industry as detailed in the Economic and Employment Lands Strategy prepared by the WAPC;
- Future individual industrial developments being limited to predicted noise levels of (108dB) in the general industry core and (101dB) in the supporting light industry precincts;
- Provision for 'internal buffers' to the eastern and southern margins of the estate to provide sufficient separation from the general industrial core to existing and planned adjoining sensitive uses. The internal buffer should be a minimum width of 500 metres and could be developed for light industry to complement development within the core;
- Construction of the southern extension of the Tonkin Highway to act as a further barrier to sensitive uses to the east. The highway provides for both further separation and a 'wall effect' particularly at the intersection of Bishop Road where future highway levels will exceed the natural ground level of the adjoining estate; and
- Requirement that subsequent local structure plans be accompanied by an emission management plan demonstrating how resultant development will comply with the noise report and the relevant noise regulations.

State Industrial Buffer Policy

The State Industrial Buffer Policy: Statement of Planning Policy No. 4.1 (SPP 4.1) outlines the WAPC's approach to buffers for industrial areas within the state. Section 3.2 prescribes a requirement for off-site buffers for certain categories of industry including general industry. Appendix 2 provides mechanisms for securing off-site buffer areas.

It is proposed to provide a buffer to the industrial area via the Local Planning Strategy. This strategy designates land one (1) kilometre to the west and north to be retained in a 'Rural Enterprise Investigation Area'. The purpose of this is to provide a buffer between the higher intensity activities of the industrial land and the rural areas, which may quite possibly have a lower intensity land use.

Existing dwellings within structure plan area

There are several dwellings or sensitive uses located within the structure plan area. Notably there is a concentration of dwellings off Pure Steel Lane in the south eastern margins of the area. Such uses are incompatible with industrial development.

In the short term, the presence of these dwellings will prevent areas from being developed for industry. Consequently development will need to be staged pending removal or cessation of these uses. Alternatively, proponents may demonstrate control of emissions in a way which allows for interim coexistence of some dwellings and future industry.

330 Kv Power Lines

Adjoining the eastern side of Kargotich Road are 330 kv power lines. Refer Figure 7 Site Conditions and Constraints.

3. Infrastructure Proposals

Possible intermodal facility and realignment of Kwinana freight rail

The West Mundijong area has been identified as a potential intermodal facility site. Associated with this initiative is the proposed realignment of the Kwinana freight rail to adjoin the southern extension of Tonkin Highway .

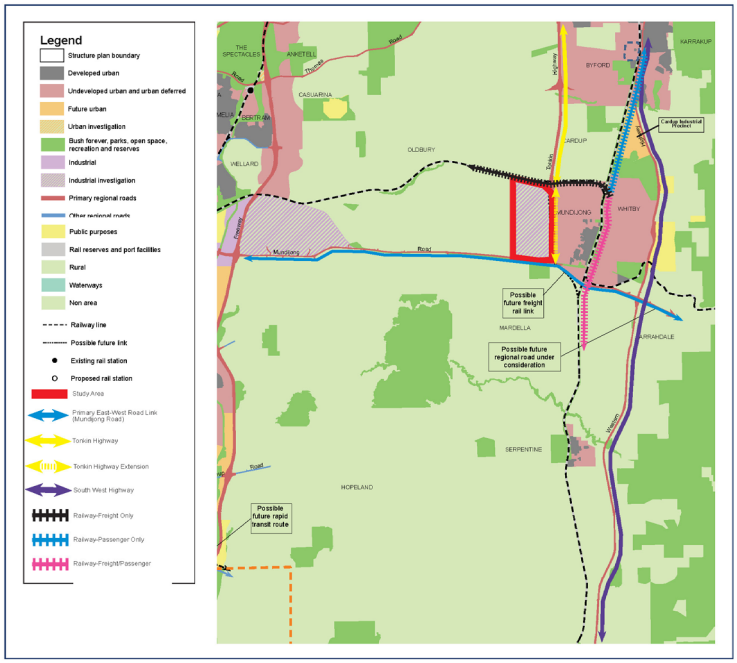


Figure 20. Infrastrictire Initiatives

Southern Extension of Tonkin Highway

The MRS provides for the southern extension of Tonkin Highway.

The extension is vital to connecting the area to key destination points within the metropolitan area and importantly destinations in the north-west via the Great Northern Highway. This is now funded for delivery to begin, with an estimated completion date of 2025.

Mundijong Road

As outlined above Mundijong Road is designated an 'other regional road' in the MRS.

The designation allows for upgrading to the status of a sub regional road. Mundijong directly connects the investigation area to Kwinana Freeway to the west and Kwinana beyond.

The SMRSSP also makes provision for the extension of Mundijong Road east of Mundijong town.

4. Structure Plan

Design Objectives

A structure plan has been prepared for the West Mundijong Industrial Area. The design has been influenced by the following objectives:

Industrial land use

- To provide for a first phase dry lot industrial outcome, with preferred land uses set, and a minimum lot size of 1.5 - 2ha;
- To provide for an ultimate fully surfaced second phase non-heavy industrial outcome, compatible with existing and planned adjoining land use;

Transport

- Provide for a distributor road network designed to enable efficient movement of commercial vehicles within the Estate and to and from the Estate via the existing and planned district and sub–regional road framework;
- To fully optimize the potential of key transport initiatives, including extension of Tonkin Highway, possible realignment of the Kwinana freight rail and a possible intermodal facility;

Environment & Sustainability

- Creation of ecological corridors with the potential to facilitate drainage, environmental rehabilitation, conservation of wetlands and passive recreation where practical;
- Creation of an accessible centre that meets the employment requirements of future neighbouring and district residential areas;
- Provision for future access to sustainable transport modes, such as a possible freight rail line and associated intermodal facility;
- The need for a comprehensive district drainage framework which balances agency requirements with the objective of realizing the optimum development potential of the land;

Land Use

The structure plan provides for a phased approach - Refer to Part 9 - Preferred and Non Preferred Land Uses for all Land uses permitted within each zone within the West Mungijong Industrial site.

In terms of ultimate phase two and beyond, the general industrial core and supporting light industrial areas or precincts are located surrounding to the east and south.

Based upon previous work it is likely that the core may support the following forms of industry, subject to approvals:

- Agribusiness, including abattoirs, food processing, canneries & breweries
- General industry, including manufacture / prefabrication of building products and materials
- Storage and logistics
- Heavy machinery servicing and sales
- Transport and fuel depot

The core area is intended to be zoned 'General Industry'. The range and types of land use appropriate in the area are:

- Fuel Depot
- General Industry
- Light Industry
- Trade Display
- Transport Depot
- Warehouse

The core area will be supported by eastern and southern light industry precincts. The uses envisaged include:

- Automotive repair and servicing;
- Storage and logistics;
- Showrooms; and
- Rural and service industry.

The eastern periphery of the land (adjoining the southern extension of the Tonkin Highway) is now retained in the 'Rural' zone of the MRS and the 'Rural' zone of the local scheme. It is expected that existing rural uses will continue pending completion of the investigations relating to a possible intermodal facility and or related transport infrastructure.

4. Structure Plan

Figure 21. Estimated Development Yield

Component	Area (ha)	Possible Lot Yield
General Industry Core	260ha	72
Light Industry Precincts	120ha	35
Service Commercial Precincts	30ha	20
Ecological Corridors	20ha	N/A
Drainage Corridors	15ha	N/A
Multiple Use Corridor	25ha	N/A
Total	470ha	127

Based on other comparable estates the following average lot sizes have been assumed:

- Phase 1 General industry core: 1.5 - 2ha
- Phase 1 Light industry: 1.5 - 2ha
- 80% of the area is developable
- Phase 2 and beyond ALL precincts: minimum lot size of 4000sqm.

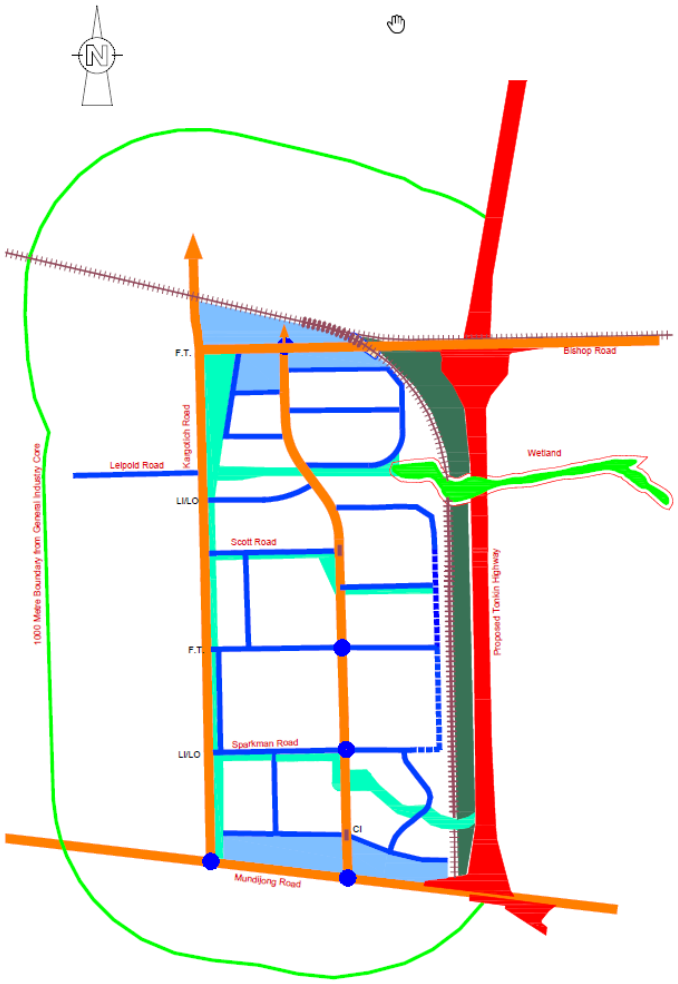
Transport

Road Network

The structure plan provides for two east / west distributor roads and one north / south distributor road. The network is intended to:

- Allow for ease of movement of commercial vehicles within the estate and moving to and from the estate;
- Provide strong connection to adjoining road network, notably Katgotich Road, Mundijong Road and Bishop Road; and
- Assist in defining precincts or local structure plan areas.

Figure 22. Proposed Road Network Plan



A preliminary traffic report has been provided by Cardno. The report recommended upgrades and key intersection treatments as shown in Table 5 - Road Upgrades and Figure 16 - Road upgrades and cross sections.

Figure 23. Road Upgrades

Road	Upgrades Widening (ultimate)	Intersection Treatment (ultimate)
Kargotich Road	29.7m eastern side	Light control at intersection with Mundijong Road and slip lane
Bishop Road	26.2m southern and norhtern sides	Light control intersection to proposed north / south distributor road and sip lane
Mundijong Road	36.7m northern side	Light control at intersection with Kargotich Road and slip lane

The proposed road network may be amended in response to ongoing liaison with Main Roads Western Australia. At this Stage the road network shown in the structure plan is a guide.

Figure 24. Road Upgrade Cross Sections

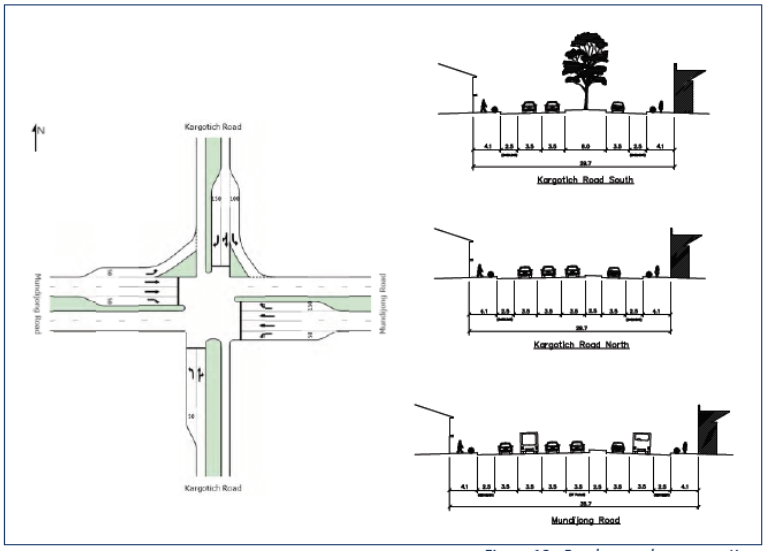


Figure 25. Road Upgrade Cross Sections

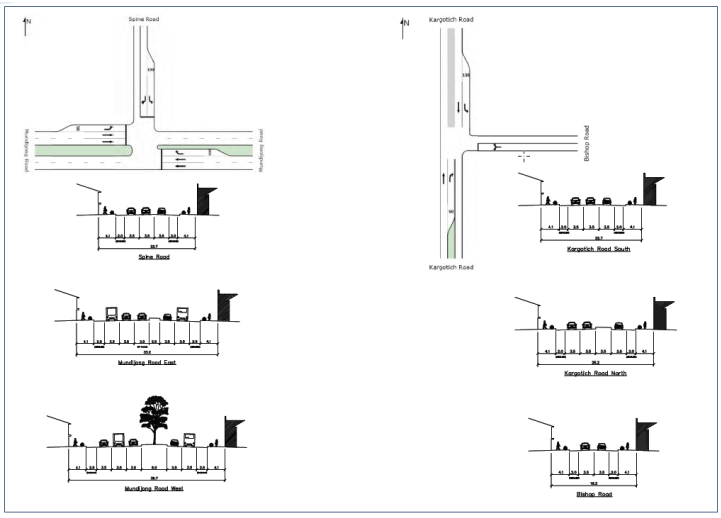
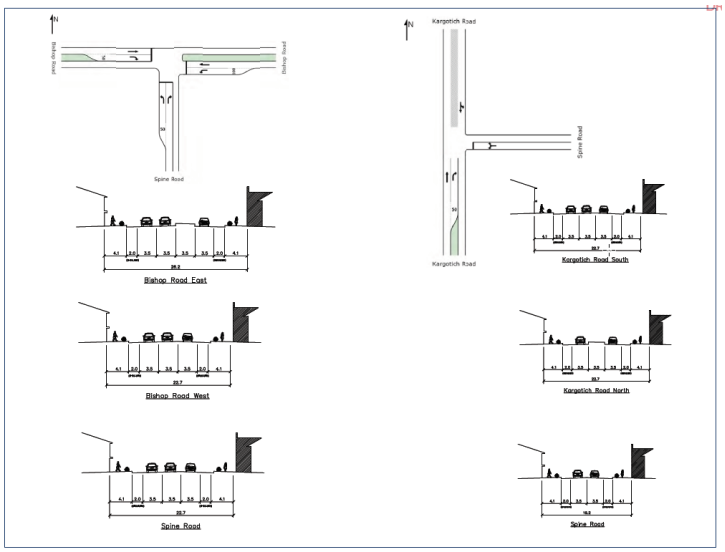


Figure 26. Road Upgrade Cross Sections



4. Structure Plan

State Transport Initiatives

Possible Realignment of Kwinana Freight Rail

The structure plan recognises the possible realignment of the Kwinana Freight Rail parallel with the southern extension of the Tonkin Highway. At the time of preparing this structure plan the realignment shown was the preferred option by both the Department of Transport and the Department of Planning. Nevertheless, the suitability of the route is to be subject to further investigation by the state government in due course.

Possible Intermodal Facility

As outlined above, various state government planning documents envisage a possible intermodal facility at West Mundijong. Accordingly, the structure plan recognises a possible intermodal facility adjoining the southern extension of Tonkin Highway. The location represents the preferred position for such a facility by both the Department of Transport and the Department of Planning. Again, it is understood that the suitability of the location is to be subject to further detailed investigation by the state government in due course.

Ecological Corridors

The structure plan provides for two ecological corridors running east / west through the structure plan area. The corridors generally reflect the location of existing drainage channels. The northern corridor also includes Manjedal Brook. A portion of the Brook is also classified as a conservation category wetland.

The corridors will provide a vital role in providing for the channelling of storm water runoff through the site. The ultimate size and form of the corridors will be further refined as part of the local structure planning process and the associated preparation of a local water management strategy.

Subject to further detailed planning, there is the potential for the corridors to be re-habilitated as 'living streams'. Consideration could also be given to passive recreational opportunities, including bridle paths or tracks.

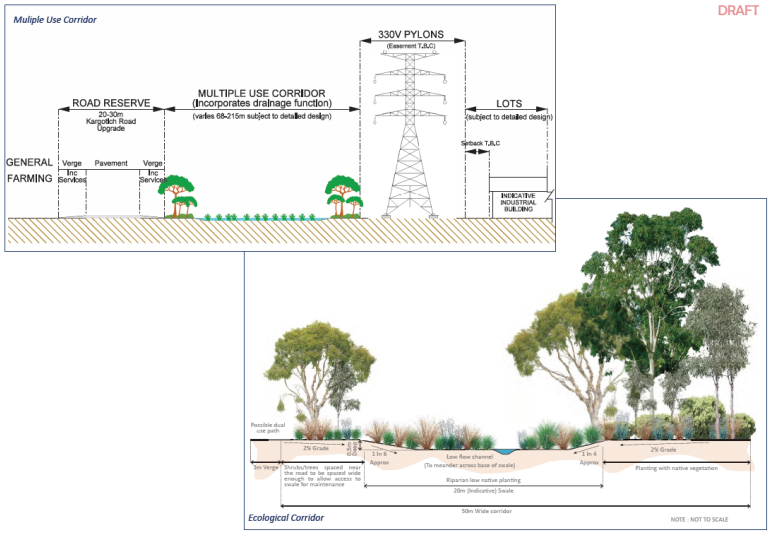
Multiple purpose corridor

The plan makes provision for a multiple purpose corridor which occupies the area between Kargotich Road and the overhead 330 kv power lines. The corridor serves a number of purposes including:

- Principally drainage. Consistent with Western Power requirements retention areas would be located outside the 330 kv corridor;
- Landscape treatment, including possible rehabilitation of remnant vegetation;
- Possible passive recreation opportunities including bridle and dual use paths; and
- Suitable interface to the overhead 330 kv lines.

Details of the corridor will be further refined in subsequent stages of the planning process.

Figure 27. Indicative Ecological & Multiple Use Corridor Cross Sections



5. Servicing

Wastewater

The subject land is located adjacent to the Byford sewer district. The Corporation's long term planning provides for limited capacity to service the area through its future main Byford wastewater pumping station. The Water Corporation acknowledges that the future pump station will need to be integrated with planning for both the industrial area and urban expansion east of the future Tonkin Highway extension.

The Water Corporation will need to review its long term infrastructure plan to accommodate future industrial development of the whole of the industrial estate. Phase one does not rely on sewer servicing, but will be required beyond land use intensity below 2ha dry lot industrial subdivision.

In phase one, it is envisaged that candidate industrial will be large (occupying multiple land parcels) rendering site specific wastewater disposal more feasible than traditional connection to the reticulated wastewater system. This is known to be the case in comparable estates, particularly concerned with logistics, elsewhere in the Perth Metropolitan Area.

Development will need to comply with the Government Sewerage Policy – Department of Health and the Western Australian Planning Commission's development control policy 4.1: Industrial Subdivision.

Water Supply

Subject to further investigations, it might be possible for an initial stage of development to be serviced through extension of existing infrastructure locate east of the Tonkin Highway extension near the intersection with Mundijong Road.

Like wastewater infrastructure, the Water Corporation's long term plans will need to be reviewed in order to service future industrial development at West Mundijong. On site water catchment will be possible under the first phase of subdivision for dry lot.

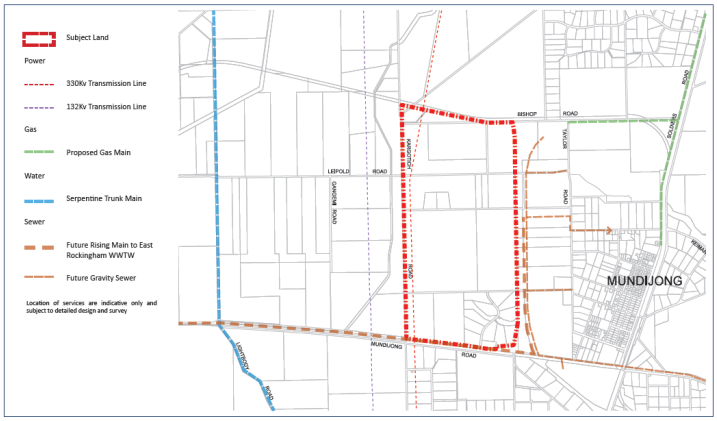
Power

The land is traversed 330 kv lines. Western Power has advised that a 'step down' facility will need to be installed to enable reticulated supply for future industry. There is likely to be sufficient capacity to service industrial development.

Gas

There has recently been gas distribution / reticulation infrastructure installed within the Mundijong area to service future residential development. The existing high pressure gas main located within Soldiers Road to the north at Byford has been extended south to Bishop Road. Lateral gas mains would be required off this trunk to serve the industrial estate.

Figure 28. Servicing Plan



6. Subdivision

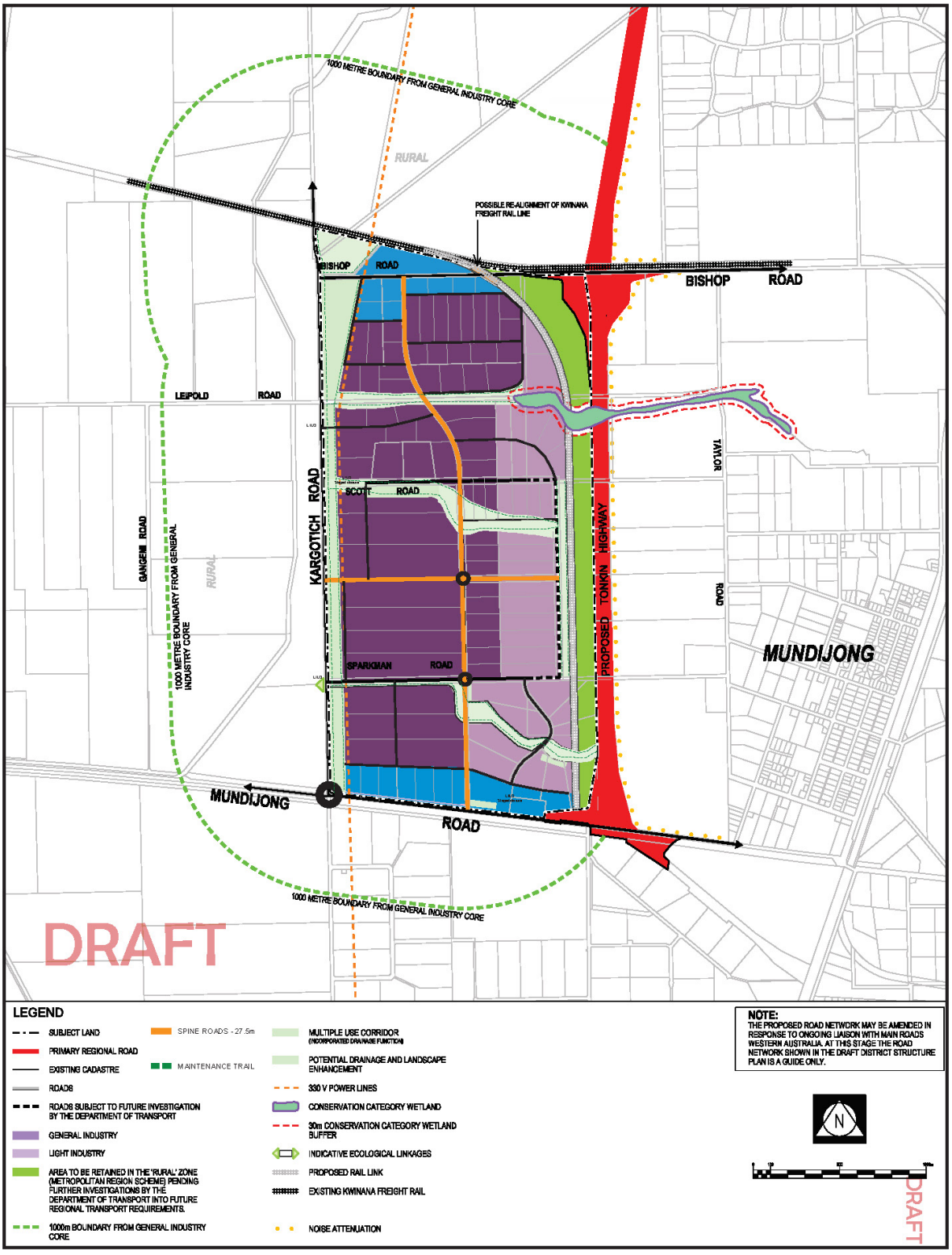
Staging

Stage 1 (20 years) will only allow subdivision to minimum of 1.5 - 2ha for dry industries (large workshops/cold storage etc.) only. Stage 2 will allow further subdivisions but the developer/ landowners will need to arrange for the services to covert to wet industries or smaller lots.

The Western Australian Planning Commission (WAPC) is responsible for approving all subdivision applications and certain classes of strata subdivision applications in our State. Information and comment from the relevant local government, any public authority or utility services provider are also included in this assessment prior to a decision being made on the proposed subdivision.

The Shire will provide comment to the WAPC based on the planning framework and considers the Local Planning Strategy, The Shire of Serpentine Jarrahdale Town Planning Schemes, Structure Plans, State Planning Policies and Local Planning Policies. Officers also consider the environmental, drainage, access, local character and amenity impacts as well as expressing safety concerns and other potential impacts of the subdivision proposal.

Figure 29. Concept Subdivision Plan



Appendixes

Appendix A: Environmental Assessment Report (including the Noise Assessment Report)

- Environmental Assessment Report, pgv Environmental, 23 November 2012 Version 2
- Aboriginal Heritage Enquiry, Department of Indigenous Affairs, 30 October 2012– Appendix 6
- Preliminary Environmental Noise Assessment, Herring Storer Acoustics, Revision 4 to 10 October 2012 – Appendix 7

Appendix B: District Water Management Strategy

- District Water Management Strategy, TME (Town Planning Management Engineering), November 2014, Revision 2
- Drainage Study for West Mundijong Industrial Area, TME (Town Planning Management Engineering), January 2013 – Annexure A
- Area/Sand Fill Analysis, TME (Town Planning Management Engineering), December 2012 – Annexure B

Appendix C: Local Water Management Strategy

- Local Water Management Strategy, Oversby Engineering, completed 2020
- Wetland Study (included in the Local Water Management Strategy), completed 2020

Appendix D: Traffic Impact Statement

- Traffic Impact Statement, Cardno, November 2012, Version 1

Appendix E: Bushfire Assessment

- Bushfire Hazard Assessment, Calibre Consulting, 2015 (DFES approval IN15/20085)
- A Bushfire Management Plan (Hazard Level Assessment), Bushfire Prone Planning, November 2016, (DFES supported subject to BHL ratings modification IN17/4734)

Shire of
Serpentine
Jarrahdale

APPENDIX A

Environmental Assessment Report

- Noise Assessment Report

WEST MUNDIJONG INDUSTRIAL AREA

ENVIRONMENTAL ASSESSMENT

Prepared for:	Serpentine Jarrahdale Shire
Report Date:	23 November 2012
Version:	2
Report No.	2012-63

pgv ENVIRONMENTAL

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1 INTRODUCTION

1.1 Background

Mundijong is located approximately 40km south-south-east of the Perth Central Business District (Figure 1). Mundijong-Whitby has been identified as being a growth area in the future and to meet the growing demand for industrial land the proposed West Mundijong Industrial Area (the site) was identified by the Draft Southern Metropolitan Sub-Regional Structure Plan (WAPC, 2009). The area is defined by Mundijong Road (south), Tonkin Highway Road reserve (east), a railway reserve (north) and Kargotich Road (west) (Figure 2). The area is approximately 470ha. The same area has also been identified in the following documents:

- Industrial Land Capacity Assessment (WAPC, 2009a);
- Industrial Lands Needs Study (WAPC, 2008a); and
- Mundijong Whitby District Structure Plan (Masterplan, 2011).

The Site is zoned 'Rural' under the Metropolitan Region Scheme and 'Farmlet" and 'Rural' zone in the Serpentine Jarrahdale Shire Town Planning Scheme No. 2 (TPS 2). The Serpentine Jarrahdale Shire proposes to change the zoning of the site to 'Industrial'.

During initial discussions with the Office of the Environmental Protect Authority (OEPA) it was determined that the rezoning of the site would need to be accompanied by an Environmental Assessment report which would include:

- Prepare a noise assessment to ensure that an adequate buffer is provided around the proposed industrial area so that noise emissions from various industrial types will be contained within the buffer;
- Consider existing and proposed sensitive land uses within and around the proposed industrial area when determining the location of various industrial types during the preparation of the DSP;
- Include the Manjedal Brook and the Conservation category wetland within an ecological corridor; and
- Defer detailed vegetation surveys and reporting to the local structure planning stage recognising that there are likely to be declared rare flora, priority flora and threatened ecological communities in the vicinity of the subject land and potentially on the subject land.

This was outlined in correspondence between the Serpentine Jarrahdale Shire and the OEPA, in July and September 2012 (Appendix 1).

1.2 Scope of Work

This Environmental Assessment is a desktop assessment of the environmental values of the site. The assessment includes information on the following categories.

Physical characteristics including a description of:

- Landform;
- Drainage and water bodies;
- Geological, hydrogeological and hydrological characteristics; and
- Acid Sulphate Soil Risk Mapping.

Biological characteristics including:

- Declared Rare and Priority Flora and Fauna and Threatened Ecological Community searches of the Department of Environment and Conservation (DEC) Databases;
- Results from the Commonwealth Protected Matters Search Tool which will identify possible matters of National Environmental Significance listed under the *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) that may occur on the sites; and
- A site assessment of the likelihood of conservation significant flora, vegetation and fauna being present on the site.

Recent and present land use including:

- Federal, State and Local Government Environmental Policy areas search;
- Surrounding land uses and potential impacts (such as noise)*;*
- Any records from the Contaminated Sites Database; and
- Assessment of current and historical activities on the site and surrounding areas which have the potential to result in contamination issues.

1.3 Legislation, Policy and Guidelines

The following legislation, policy and guidelines have been considered during this environmental assessment and will guide the required and expected management outcomes from Commonwealth, State and Local government agencies.

- *Environment Protection and Biodiversity Conservation Act 1999*
  - *The Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (SEWPaC, 2012a)
- *Environmental Protection Act 1999*
- *Wildlife Conservation Act 1950*
- *Aboriginal Heritage Act 1972*
- State Policy
  - State Planning Policy No. 2.1 *Peel-Harvey Coastal Plain Catchment* (WAPC, 2003)
  - State Planning Policy No. 2.8 *Bushland Policy for the Perth Metropolitan Region* (WAPC, 2010)
  - State Planning Policy No. 2.9 *Water Resources* (WAPC, 2006)
  - State Planning Policy No. 5.4 *Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (WAPC, 2009b)
  - Environmental Protection Authority Position Statement No. 4 *Environmental Protection of Wetlands* (EPA, 2004)

- Environmental Protection Authority Guidance Statement No 33 *Environmental Guidance for Planning and Development* (EPA, 2008)

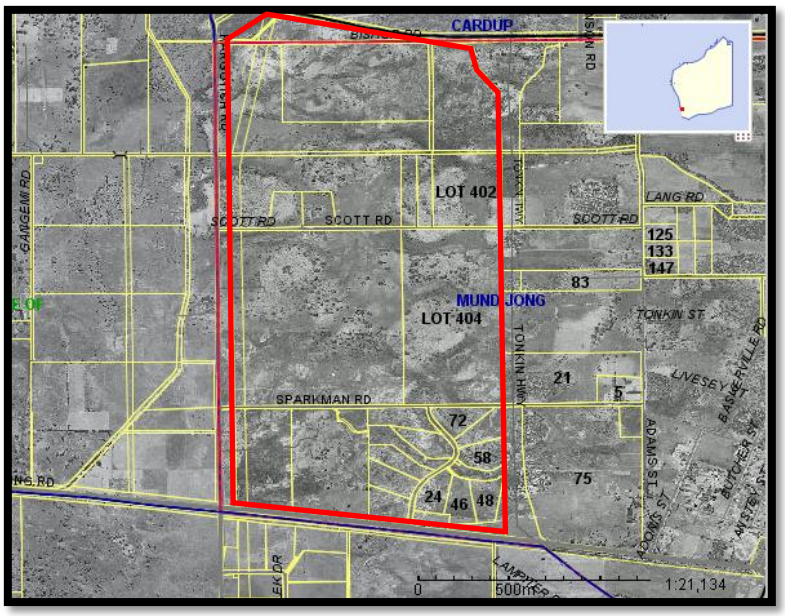
- Serpentine Jarrahdale Shire
  - Local Planning Policy (LPP) 4 *Revegetation Strategy* (SJS, 2010);
  - LPP 6 *Water Sensitive Design* (SJS, 2001);
  - LPP 8 *Landscape Protection* (SJS, 2002);
  - LPP 22 *Water Sensitive Urban Design* (SJS, 2009a); and
  - LPP 26 *Biodiversity Planning* (SJS, 2009b).

2 EXISTING ENVIRONMENT

2.1 Past and Existing Land Use

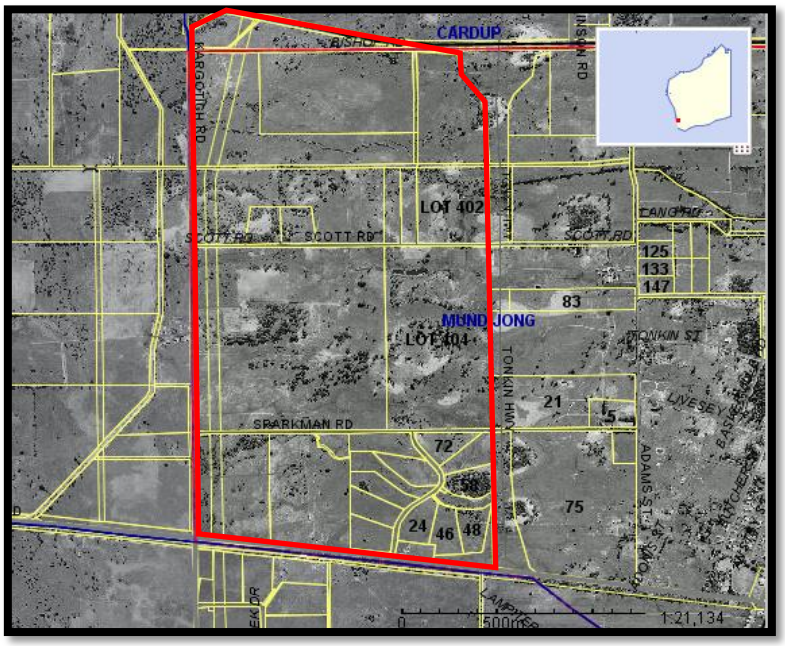
The site has historically been cleared for agricultural purposes. This is shown in the earliest aerial photography available from 1953 (Plate 1).

Plate 1: Aerial Photography from 1953 (Landgate, 2012a)



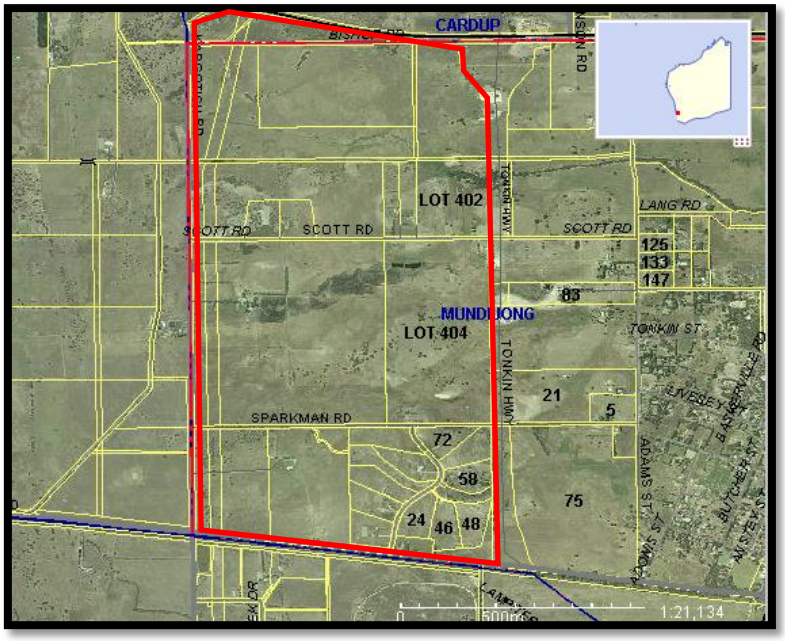
In photography from 1977 the town centre of Mundijong has developed further however there are no significant changes to the site (Plate 2).

Plate 2: Aerial Photography from 1977 (Landgate, 2012a)



In 2003 beginnings of the rural residential area surrounding Steel Blue Road is evident (Plate 3).

Plate 3: Aerial Photography from 2003 (Landgate, 2012a)



2.2 Surrounding Land Use

The site is bounded on the southern side by Mundijong Road. This road reserve also contains a Bush Forever site. To the west is Kargotich Road which adjoins a rural working property. The northern boundary is a railway which in February 2010 carried daily "bulk haul" traffic that was made up of:

- 8 coal trains;
- 18 bauxite trains;
- 4 caustic trains; and
- 4 alumina trains (Masterplan, 2011).

The eastern boundary of the site is the proposed future extension of Tonkin Highway. The Mundijong-Whitby District Structure Plan has been prepared to guide the development of the area to the east of the site. The DSP identifies the area immediately to the east of the proposed Tonkin Highway extension as residential (Masterplan, 2011).

2.3 Topography

The site gently slopes from east to west with elevations ranging from approximately 25m AHD to 15m AHD (Figure 2).

2.4 Geology and Soils

The site is located on the eastern side of the Swan Coastal Plain. The Swan Coastal Plain is generally flat and is approximately 20 to 30 kilometres wide, consisting of a series of geomorphic entities running parallel to the coastline. The youngest and most western of these geomorphic entities is the Quindalup Dunes, followed by the Spearwood Dunes and at the most eastern extent the Bassendean

Dunes. The Pinjarra Plain which is fluvatile in origin extends from the eastern side of the Bassendean Dunes to the western edge of the Darling Scarp, which joins the Ridge Hill Shelf and forms the denuded slope of the Darling Fault (Beard 1990). In areas the aeolian sands from the west may overlay the alluvial soils (NRM, 2008).

The site is situated in a transitional area between the soil systems with the Bassendean Dune System over most of the site. The south-western quarter and a small area in the north-west corner are mapped as part of the Pinjarra Plain System.

The Bassendean Dune and Sandplain System consists of very low relief, leached, grey siliceous Pleistocene sand dunes, intervening sandy and clayey swamps and gently undulating plains. These occur immediately west of, and partly overlie, the Pinjarra Plain. Topography becomes more subdued from west to east.

The Pinjarra Plain System consists of broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. The major soils are naturally poorly drained and many swamps occur.

The description of the soil phases present on the site is provided in Table 1 and soil mapping is shown in Figure 3.

Table 1: Soil Landscape Sub-Systems Found Within the Site

Reference	Description*
212Bs_B1	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 2m; Banksia dominant.
212Bs_B2	Flat to very gently undulating well drained sandplain. Deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
212Bs_B3	Closed depressions and poorly defined stream channels. Poorly to very poorly drained. Moderately deep, bleached sands with an iron-organic pan, or clay subsoil
212Bs_B4	Broad poorly drained sandplain. Deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5m by clay or less frequently a strong iron-organic hardpan.
212Bs_B6	Imperfectly drained sandplain and broad extremely low rises. Deep or very deep grey siliceous sands.
213Pj_P1b	Flat to very undulating plain with deep acidic mottled yellow duplex (or “effective duplex”) soils comprising moderately deep pale sand to sandy loam over clay; imperfectly drained and moderately susceptible to salinity in limited areas.
213Pj_P1d	Pale grey sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity
213Pj_P2a	Flat to very gently undulating plain, Poorly drained. Deep alkaline mottled yellow duplex soils which generally consist of shallow pale sand to sandy loam with a silcrete hardpan at 50-100 cm depth genera
213Pj_P8	Moderately deep to deep sands over mottled clays
213Pj_P11	Poor to imperfectly drained flats over impermeable ironstone pavement. Shallow brown loamy soils or less commonly, very shallow sands over ironstone pavement

* From van Gool, 1990

2.5 Acid Sulphate Soils

Acid sulphate soils (ASS) are wetland soils and unconsolidated sediments that contain iron sulphides which, when exposed to atmospheric oxygen in the presence of water, form sulphuric acid. ASS form in protected low energy environments such as barrier estuaries and coastal lakes and commonly occurs in low-lying coastal lands such as Holocene marine muds and sands. When disturbed, these soils are prone to produce sulphuric acid and mobilise iron, aluminium, manganese and other heavy metals. The release of these reaction products can be detrimental to biota, human health and built infrastructure.

The ASS Risk on the site has been mapped by the DEC (Landgate, 2012b) as being Moderate to Low (<3m from the surface).

2.6 Hydrology

2.6.1 Groundwater

The Superficial Swan overlays the Leederville aquifer which is further described as the sub area Wanneroo member under the site and consists of poorly sorted fine- to medium-grained quartz with feldspar and occasionally trace heavy minerals. This overlays the Cattamara Coal Measures (DoW, 2012a).

Groundwater flows from east to west across the region. The Perth Groundwater Atlas (DoW, 2012b) shows a snapshot of groundwater levels as measured in May 2003 which are an indication of low groundwater levels and range from 23mAHD in the east to 16mAHD in the west of the site. The depth to groundwater from the natural surface ranges from approximately 3 to 5m (DoW, 2012b).

In the Mundijong area the groundwater tends to perch on the underlying clayey soils, causing large fluctuations of up to 3m between high and low groundwater levels (Masterplan, 2011).

2.6.2 Surface water

The site is within the Serpentine River Catchment and lower Serpentine Water allocation sub –area. Surface water in the Shire of Serpentine-Jarrahdale drains to the Serpentine River and ultimately the Peel Harvey Estuary.

Surface runoff from the site is via overland flow from east to west, following the natural topography. There are some very shallow farm drains (approximately 0.2 - 0.5m deep) which help to drain the site (Plate 4 and 5). The surface water also flows to Manjedal Brook.

Plate 4: Drainage line across part of the site off Pure Steel Road

Plate 5: Drainage line near the Leipold T junction with Kargotich Road

2.7 Wetlands

A significant portion of the site is shown in the DEC *Geomorphic Wetlands of the Swan Coastal Plain* dataset as being a Multiple Use Palusplain (Unique Feature Identifier (UFI) 15785) (Landgate, 2012b) (Figure 4). A Palusplain is defined as seasonally waterlogged flats. There is also a small Multiple Use Palusplain mapped on the north western boundary of the site (UFI 14903).

The dataset shows a Conservation Category wetland in the central eastern part of the site (Figure 4). This is classified as a Conservation Category Palusplain (UFI 14945). This wetland is actually part of Manjedal Brook which is a narrow, shallow ephemeral stream. The brook has been parkland cleared

and the vegetation consists of some paperbarks (*Melaleuca rhaphiophylla*) and Flooded Gums (*Eucalyptus rudis*) over a mixture of pasture and weed species (Plate 6).

Plate 6: Degraded vegetation in the Conservation Category Wetland, Manjedal Brook

The DEC Conservation Category wetland boundary has been mapped at a very broad scale and it is most likely that the spatial representation of the wetland is not accurate when considered at the individual lot scale.

2.8 Flora

2.8.1 Database Searches

A search of the DEC Threatened Flora Database (DEFL), the WA Herbarium database (WAHerb), the Declared Rare and Priority Flora Species List (TFPL) (Appendix 2), Naturemap (Appendix 3) and the EPBC Act Protected Matters Search Tool (Appendix 4) indicates a number of species listed as Endangered, Threatened or Priority have been located within a 5km radius of the site. The results from the database searches are shown in Table 2.

Table 2: Conservation Significant Flora known to occur in the Mundijong Area

Species	Common Name	Status Under Wildlife Conservation Act 1950	Status Under EPBC Act 1999
Caladenia huegelii	Grand Spider Orchid	Threatened	Endangered
Darwinia foetida	Muchea Bell	Threatened	Critically Endangered
Diuris purdiei	Purdie's Donkey Orchid	Threatened	Endangered
Drakaea elastica	Glossy-leaved Hammer Orchid	Threatened	Endangered
Eucalyptus balanites	Cadda Road Mallee	Threatened	Endangered

Species	Common Name	Status Under Wildlife Conservation Act 1950	Status Under EPBC Act 1999
Grevillea curviloba subsp. *incurva*	Narrow curved-leaf Grevillea	Threatened	Endangered
Synaphea sp. Fairbridge Farm		Threatened	Critically Endangered
Tetraria australiensis	Southern Tetraria	Threatened	Vulnerable
Verticordia plumosa var. *pleiobotrya*	Narrow-petalled Featherflower	Threatened	Endangered
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)		Priority 1	
Schoenus pennisetis		Priority 1	
Synaphea sp. Pinjarra Plain (A.S. George 17182)		Priority 1	
Johnsonia pubescens subsp. *cygnorum*		Priority 2	
Angianthus drummondii		Priority 3	
Baeckea sp. Perth Region (R.J. Cranfield 444)		Priority 3	
Dillwynia dillwynioides		Priority 3	
Jacksonia gracillima		Priority 3	
Meeboldina decipiens subsp. *decipiens*		Priority 3	
Synaphea sp. Serpentine (G.R. Brand 103)		Priority 3	
Centrolepis caespitosa		Priority 4	Endangered
Drosera occidentalis subsp. *occidentalis*		Priority 4	
Parsonsia diaphanophleba		Priority 4	
Verticordia lindleyi subsp. *lindleyi*		Priority 4	

Table 3 examines the preferred habitat of each species and the likelihood of the species listed in Table 2 to occur on the site.

Table 3: Likelihood of Identified Significant Flora Species occurring on the Site

Scientific Name	Preferred Habitat*	Likelihood of Presence on site
Caladenia huegelii	Grey or brown sand, clay loam	Highly Unlikely
Darwinia foetida	Grey-white sand on swampy, seasonally wet sites	Highly Unlikely
Diuris purdiei	Grey-black sand, moist. Winter-wet swamps	Highly Unlikely
Drakaea elastica	Low-lying situations adjoining winter-wet swamps. Does not survive in disturbed areas	Highly Unlikely

Scientific Name	Preferred Habitat*	Likelihood of Presence on site
Eucalyptus balanites	Sandy soils with lateritic gravel	Highly Unlikely
Grevillea curviloba subsp. *incurva*	Peaty and clay soils	Highly Unlikely
Synaphea sp. Fairbridge Farm	Sandy with lateritic pebbles. Near winter-wet flats, in low woodland with weedy grasses	Highly Unlikely
Tetraria australiensis	Grey sand over clay; sandy or clayey lateritic soils. Winter-wet swampy depressions	Highly Unlikely
Verticordia plumosa var. *pleiobotrya*	Seasonally inundated swamps, road verges	Highly Unlikely
Acacia lasiocarpa var. *bracteolata* long peduncle variant (G.J. Keighery 5026)	Grey or black sand over clay. Swampy areas, winter wet lowlands	Highly Unlikely
Schoenus pennisetis	Grey or peaty sand, sandy clay. Swamps, winter-wet depressions	Highly Unlikely
Synaphea sp. Pinjarra Plain (A.S. George 17182)	Grey sandy loam or clay, grey-brown clayey sand, brown clayey loam, laterite. Flats, seasonally wet	Highly Unlikely
Johnsonia pubescens subsp. *cygnorum*	Grey-white-yellow sand. Flats, seasonally-wet sites	Highly Unlikely
Angianthus drummondii	Grey or brown clay soils, ironstone. Seasonally wet flats	Highly Unlikely
Baeckea sp. Perth Region (R.J. Cranfield 444)	Orange sand, brown loam, white sandy clay. Low flats, winter-wet swamps, railway reserves.	Highly Unlikely
Dillwynia dillwynioides	Sandy soils. Winter-wet depressions	Highly Unlikely
Jacksonia gracillima	Grey and brown well-drained sand	Highly Unlikely
Meeboldina decipiens subsp. *decipiens*	Sand and sandy peat. Swamps	Highly Unlikely
Synaphea sp. Serpentine (G.R. Brand 103)	Brown sandy clay	Highly Unlikely
Centrolepis caespitosa	White sand, clay. Salt flats, wet areas	Highly Unlikely
Drosera occidentalis subsp. *occidentalis*	Sandy and clayey soils. Swamps and wet depressions	Highly Unlikely
Parsonsia diaphanophleba	Alluvial soils. Along rivers	Highly Unlikely
Verticordia lindleyi subsp. *lindleyi*	Grey, black or peaty sand. Winter-wet depressions	Highly Unlikely

* sourced from Florabase (DEC, 2012), SEWPaC SPRAT Database (SEWPaC, 2012a) as well as the DEC database searches.

Many of the species listed can be found in wetland areas of which the site has a large extent. However the site has been extensively cleared and grazed for at least 60 years. Therefore species on the list that may have once occurred on the site are not likely to be present now. Areas that contain

some native tress, including Manjedal Brook, have a completely cleared understorey in which the Conservation Significant species would not occur.

2.9 Vegetation

2.9.1 Vegetation Types

The site is in the Southwest Botanical Province within the Swan Coastal Plain Bioregion and is dominated by vegetation of the Pinjarra Plain and Bassendean System. Most of the native vegetation has been cleared. Large numbers of Swamp Sheoaks (*Casuarina obesa*) occur in paddocks with clay soils. Some Marris (*Corymbia calophylla*) and Spearwood (*Kunzea glabrescens*) and Sheoak (*Allocasuarina fraseriana*) occur in a large patch south of the Leipold Road reserve.

Manjedal Brook mostly contains Flooded Gum (*Eucalyptus rudis*) and Paperbark (*Melaleuca rhaphiophylla* and *M. preissiana*). A small stand of Holly Leafed Banksia (*Banksia ilicifolia*) occurs just to the south of Manjedal Brook.

Several Kingia (*Kingia australis*) trees are scattered in the northern part of the site.

Many exotic Australian native trees and shrubs have been planted in road reserves and paddock fence-lines including Rose Gums (*Eucalyptus grandis*), Broad-leafed Paperbark (*Melaleuca quinquenervia*), Swamp Mahogany (*E. robusta*) and River Red Gum (*E. camaldulensis*).

Therefore the vegetation on the site can be described as:

- Completely cleared containing pasture grasses, which is the predominant vegetation type over the entire site;
- *Casuarina obesa* Woodland over pasture grasses which is dominant in the south western corner of the site (Plate 7);
- *Melaleuca rhaphiophylla* (Paperbark) Woodland over pasture grasses which is associated with the Conservation Category Wetland (Plate 8) and has some *Eucalyptus rudis* (Flooded Gum).
- *Corymbia calophylla* Woodland over pasture grasses which is mainly in the area around Scott Road (Plate 9).
- *Kingia australis* and *Melaleuca rhaphiophylla* over pasture grasses, which occurs in the north of the site (Plate 10) near Bishop Road.

Plate 7: *Casuarina obesa* Woodland over pasture grasses

Plate 8: *Melaleuca rhaphiophylla* Woodland over pasture grasses

Plate 9: *Corymbia calophylla* Woodland over pasture grasses

Plate 10: *Kingia australis* and *Melaleuca rhaphiophylla* over pasture grasses

2.9.2 Vegetation Condition

The vegetation on the site has been historically cleared for rural purposes and is currently used for pasture and grazing. The condition of the vegetation was assessed according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000a). Keighery's condition rating scale ranges from Pristine where the vegetation exhibits no visible signs of disturbance to Completely Degraded where the vegetation structure in no longer intact and without native plant species (Table 5).

Table 5: Vegetation Condition Rating Scale.

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

Source: Government of Western Australia, 2000.

The site has been cleared of native vegetation and used for grazing purposes. A few native trees remain over pasture. The remnant vegetation on site consisted of parkland trees over pasture and weed species. The site is considered Completely Degraded based on the Bush Forever vegetation condition rating scale.

2.9.3 Regionally Significant Vegetation

A search of the DEC's Threatened (TEC) and Priority Ecological Communities (PEC) database was conducted for the site (Appendix 3; 11-0812EC). (Table 4).

Table 4: Threatened and Priority Ecological Communities known to occur in the Mundijong Area

Ecological Community	Description	Status under the Wildlife Conservation Act	Status under the EPBC Act
SCP3a	*Eucalyptus calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	Endangered
SCP3c	*Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	Critically Endangered	Endangered
SCP20b	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	Endangered	
SCP02	Southern wet shrublands, Swan Coastal Plain	Endangered	
SCP3b	*Eucalyptus calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	

Ecological Community	Description	Status under the Wildlife Conservation Act	Status under the EPBC Act
SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered
	Casuarina obesa Association	Priority 1	

Due to the Completely Degraded structure and condition of the vegetation on the site, the TECs and PECs do not occur on the site.

The site does not contain any regionally significant vegetation.

The Bush Forever Site No 360 Mundijong Road and Watkins Road Bushland are in the Mundijong Road reserve adjacent to the southern boundary of the site. Bush Forever Site No. 360 contains plant communities representative of the eastern side of the Swan Coastal Plain that are considered to be regionally significant (WAPC, 2000).

The road alignment within the road reserve is in the northern half of the site. The portion of the road reserve south of Mundijong Road contains the TECs SCP3a, SCP3c and SCP9 in the portion in close proximity to the site. The portion of the road reserve to the north of Mundijong Road does not exhibit any conservation values and the vegetation would not be classified as these TECs. This part of the road reserve contains scattered trees largely over a weedy understorey.

2.10 Conservation Significance of Vegetation and Flora

The site is highly unlikely to contain any conservation significant flora.

The vegetation on the site is too degraded to assign a Floristic Community Type therefore it is highly unlikely that any Threatened or Priority Ecological Communities listed under the State or Commonwealth occur on the site.

2.11 Fauna

2.11.1 DEC Database Search Results

A search of the DEC Threatened Fauna Database (Appendix 5) indicates fourteen species listed as rare or priority have been located in the vicinity of the site. No additional species were identified in the Naturemap database searches (Appendix 3) and seven additional species were identified in the Protected Matters Search Tool (Appendix 4). Table 6 lists the species identified in these database searches.

Table 6: List of Fauna Species Identified from Database Searches.

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Calyptorhynchus banksii subsp. *naso*	Forest Red-tailed Black-Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus baudinii	Baudin's Cockatoo	Schedule 1	Vulnerable
Calyptorhynchus latirostris	Carnaby's Cockatoo	Schedule 1	Endangered

Scientific Name	Common Name	Status under Wildlife Cons. Act	Status under EPBC Act
Dasyurus geoffroii	Chuditch, Western Quoll	Schedule 1	Vulnerable
Leipoa ocellata	Mallee Fowl	Schedule 1	Vulnerable
Phascogale tapoatafa subsp. ssp. (WAM M434)	Brush-tailed Phascogale	Schedule 1	
Rostratula benghalensis	Painted Snipe	Schedule 1	Vulnerable
Setonix brachyurus	Quokka	Schedule 1	
Synomen gratiosa	Graceful Sun-moth	Schedule 1	Endangered
Apus pacificus	Fork-tailed Swift	Schedule 3	Migratory
Ardea alba	Great Egret	Schedule 3	Migratory/ Wetland
Ardea ibis	Cattle Egret	Schedule 3	Migratory/ Wetland
Haliaeetus leucogaster	White-bellied Sea-eagle	Schedule 3	Migratory
Meeorps ornatus	Rainbow Bee-eater	Schedule 3	Migratory
Falco peregrinus	Peregrine Falcon	Schedule 4	
Morelia spilota subsp. *imbricata*	Carpet Python	Schedule 4	
Arbanitis inornatus	Trapdoor Spider	Priority 1	
Acanthophis antarcticus	Southern Death Adder	Priority 3	
Ardeotis australis	Australian Bustard	Priority 4	
Westralunio carteri	Fresh water mussel	Priority 4	
Isoodon obesulus subsp. *fusciventer*	Southern Brown Bandicoot	Priority 5	

The DEC classifies fauna under five different Priority codes and rare and endangered fauna are classified under the *Wildlife Conservation (Specially Protected Fauna) Notice 2008* into four schedules of taxa (DEC, 2011).

2.11.2 Fauna Habitat

The site contains four habitat types (Plates 7 to 9):

- Completely cleared pasture;
- Parkland cleared with scattered *Casuarina obesa* (Swamp Sheoak);
- Parkland cleared wetland area with *Eucalyptus rudis* (Flooded Gum) *Melaleuca rhaphiophylla* (Paperbark); and
- Parkland cleared *Corymbia calophylla*.

The completely cleared pasture dominates the site with the Parkland cleared with scattered *Casuarina obesa* (Swamp Sheoak) occurring mainly in the south west of the site. The wetland area is mainly in the area mapped as the Conservation Category Wetland (Manjedal Brook) with the Parkland cleared *Corymbia calophylla* (Marri) occurring in the north west of the site.

Fauna habitat can be assessed according to the following categories:

High quality fauna habitat *– These areas closely approximate the vegetation mix and quality that would have been in the area prior to any disturbance. The habitat has connectivity with other habitats and is likely to contain the most natural vertebrate fauna assemblage.*

Very good fauna habitat *- These areas show minimal signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) and generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be minimally effected by disturbance.*

Good fauna habitat *– These areas showed signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) but generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be affected by disturbance.*

Disturbed fauna habitat *– These areas showed signs of significant disturbance. Many of the trees, shrubs and undergrowth are cleared. These areas may be in the early succession and regeneration stages. Areas may show signs of significant grazing, contain weeds or have been damaged by vehicle or machinery. Habitats are fragmented or have limited connectivity with other fauna habitats. Fauna assemblages in these areas are likely to differ significantly from what might be expected in the area had the disturbance not occurred.*

Highly degraded fauna habitat *– These areas often have a significant loss of vegetation, an abundance of weeds, and a large number of vehicle tracks or are completely cleared. Limited or no fauna habitat connectivity. Faunal assemblages in these areas are likely to be significantly different to what might have been in the area pre-disturbance.* (Coffey Environments, 2009)

Although these fauna habitat provide different species they all have been mostly cleared for agriculture and fully grazed for a number of years. There is no linkage and all the habitats on site are classified as Highly Degraded Fauna Habitat.

2.11.3 Conservation Significant Species

Outlined below is a short description of each of the species that were identified in the DEC database searches and Protected Matters Search Tool search and their preferred habitat in Table 3. The preferred habitat has been compared to the habitats on the site described above and the likelihood of each species to be present on the site determined.

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus* and *Allocasuarina* spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell). Eggs are laid from July to October, with incubation lasting 29 days (SEWPaC, 2012b).

The site contains some Marri (*Corymbia calophylla*) which are known feeding trees for Carnaby's Black Cockatoo (Higgins 1999). Carnaby's Black-Cockatoos have been recorded during other fauna surveys in the general area and are likely to feed and potentially roost on the site. The likelihood of this species breeding on the site is low as there are no recent records and the potential breeding hollows are not common in the area.

Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)

This species is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species. This species are seasonally present on the Swan Coastal Plain, therefore Baudin's Black Cockatoo are potentially seen in the vicinity of the site (Garnett *et al.* 2011).

Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)

Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (SEWPaC, 2012a). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*) and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri.

Red-Tailed Black Cockatoos have been recorded during other fauna surveys in the general area and were observed on the site during the site visit. Evidence of this species feeding on-site was also observed (Plate 11). They may occasionally roost in the large trees on-site. There is no record to indicate that they breed in the vicinity of the site (Johnstone and Kirkby 2011).

Plate 11: Evidence of Forest Red-tailed Black Cockatoos feeding on the site

Chuditch, Western Quoll (*Dasyurus geoffroii*)

The Chuditch was originally found in over 70% of Australian woodlands; however, since European settlement its range has diminished to a patchy distribution throughout the Jarrah forest and mixed Karri - Marri - Jarrah forest of south-west WA. They have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. The Chuditch creates dens in hollow logs or burrows and have also been recorded in tree hollows and cavities. They are opportunistic feeders, and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles (SEWPaC, 2012b).

The Chuditch is unlikely to occur within the site due to previous agricultural activities which have removed cover for protection, fragmented habitats and the presence of exotic predators.

Malleefowl (*Leipoa ocellata*)

Malleefowl have been found in mallee regions of southern Australia from approximately the 26th parallel of latitude southwards. Malleefowl are now only found throughout these regions in fragmented patches due to clearing of land for agriculture, increased fire frequency, competition with exotic herbivores (sheep, rabbits, goats and cattle) and kangaroos, predation by foxes and cats, inbreeding as a result of fragmentation and possibly hunting for food (SEWPaC, 2012b).

Malleefowl are highly unlikely to be found on the site due the lack of appropriate Mallee habitat.

Southern Brush-tailed Phascogale (*Phascogale tapoatafa*)

Southern Brush-tailed Phascogales are arboreal marsupials which require tree hollows in suitable woodland or forest and rely on abundant invertebrate prey to sustain populations (Pescott, 2012).

This species is highly unlikely to occur on the site as the woodland it too disturbed and due to the presence of predators.

Painted Snipe (*Rostratula benghalensis*)

The Painted Snipe predominately occurs on the eastern coast of Australia and inhabits inland and coastal shallow ephemeral and permanent freshwater wetlands particularly where there is a cover of vegetation, including grasses.

There is no suitable habitat on the site therefore this species is highly unlikely to be present.

Quokka (*Setonix brachyurus*)

Quokkas were originally very common on the Swan Coastal Plain, however, their distribution is now limited to Rottnest Island and a few isolated areas in the south-west of WA. On the mainland, they prefer densely vegetated areas around wetlands and streams, whereas on Rottnest Island they inhabit low scrubby coastal vegetation where water is not readily available year-round. Quokkas breed once a year and produce a single joey. They are herbivorous, and feed on leaves, bark, succulent plants and grasses.

The Quokka is unlikely to occur within the project area due to a lack of suitable habitat and a lack of recent records of this species in the area.

Graceful Sun-moth (*Synemon gratiosa*)

The Graceful Sun-moth is a diurnal moth with dull coloured brown to black forewings and brightly coloured orange hind wings. The larvae burrow into the rhizomes of *Lomandra maritima* and *Lomandra hermaphrodita* exclusively and therefore require the presence of one or both of these species to be present in an area.

Neither of the species of *Lomandra* is likely to be present on the site and therefore the Graceful Sun-moth would not be present.

Fork-tailed Swift (*Apus pacificus*)

The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities (SEWPaC, 2012b).

It is unlikely this species would visit or rely on this site.

Great Egret, White Egret (*Ardea alba* (*modesta*))

The Eastern Great Egret has been reported in a wide range of wetland habitats and usually frequents shallow waters (SEWPaC, 2012b). This species feeds on fish, insects, crustaceans, molluscs, frogs, lizards, snakes and small birds and mammals (SEWPaC, 2012b).

The habitat on the site would not be suitable for this species.

Cattle Egret (*Ardea ibis*)

The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands with breeding in Western Australia recorded in the far north in Wyndham in colonies in wooded swamps such as mangrove forests (SEWPaC, 2012b). This species forages away from water on low lying grasslands, improved pastures and croplands generally in areas that have livestock eating insects, frog, lizards and small mammals (SEWPaC, 2012b).

This species may rarely visit the site but is not likely to rely on the site for survival.

White-bellied Sea-Eagle (*Haliaeetus leucogaster*)

The White-bellied Sea-Eagle is found in coastal habitats with large areas of open water, especially those close to the sea-shore. This species feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal (SEWPaC, 2012b).

The habitat on site is not suitable for this species

Rainbow Bee-eater (*Merops ornatus*)

The Rainbow Bee-eaters that breed in southern Australia are migratory. After breeding, they move north and remain there for the duration of the Australian winter. However, populations that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow

Bee-eater is present throughout the year (SEWPaC, 2012b). The Rainbow Bee-eater nests in a burrow dug in the ground. It is found across the better-watered parts of WA including islands preferring lightly wooded, sandy country near water (SEWPaC, 2012b).

The habitat disturbance on the site means the Rainbow Bee-eater is unlikely to be present on the site.

Peregrine Falcon (*Falco peregrinus*)

The Peregrine Falcon is found in a variety of habitats from woodlands to open grasslands and coastal cliffs. It feeds almost entirely on other birds and sometimes rabbits and other moderate sized mammals, bats and reptiles (DEC, 2012c).

This species is known to be easily frightened and flighty (SEWPaC, 2012b) and therefore is highly unlikely to utilise the site due to the proximity of human activity.

Carpet Python (*Morelia spilota imbricata*)

The South-west Carpet Python is a large snake found across the south-west of Western Australia, north to Geraldton and Yalgoo, and east to Kalgoorlie, Fraser Range and Eyre. They inhabit forest, heath, or wetland areas and shelter in hollow logs or in branches of large trees. Carpet Pythons are often found in colonies, particularly when breeding in spring. This species is widespread within the southwest, but is not in high densities across its distribution.

This species is unlikely to inhabit the site as it is cleared and degraded.

Trapdoor Spider (*Arbanitis inornatus*)

Trapdoor spiders dig burrows down into the ground, which they live in. The burrow is sealed with a lid or 'trapdoor,' which the spiders can emerge from to feed. They are ambush predators, relying on crawling insects such as ants and beetles. Much of these spiders habitat has been modified through land clearing. They are also quite vulnerable to disturbance, as they are sedentary creatures, with poor dispersal ability (Wheatbelt NRM).

This species is not likely to be found on the site as it is highly disturbed.

Southern Death Adder (*Acanthophis antarcticus*)

Southern Death Adders inhabit a range of habitats, including rainforest, scrubland, semi-arid zones and rocky outcrops. Typically during the day they remain mostly buried beneath sand, soil or debris, with just the tail and top of the head exposed. They do not actively hunt their prey but are cryptic snakes which sit motionlessly, sometimes for months on end, constantly watching for any animal which unwittingly comes within striking distance (Pilbara Pythons, 2012).

The habitat on site is not likely to be suitable to this species due to disturbance.

Australian Bustard (*Ardeotis australis*)

The Australian Bustard is a large ground bird of grassland, woodland and open agricultural country across northern Australia and southern New Guinea. It is also commonly referred to in Central Australia as the Bush Turkey, particularly by Aboriginal people.

This species is more common in the north and is unlikely to be present on the site.

Fresh Water Mussel (*Westralunio carteri*)

Westralunio carteri is a freshwater mussel and will not be present on the site as there is no appropriate habitat.

Southern Brown Bandicoot (*Isoodon obesulus* subsp. f*usciventer*)

Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high), often in or near swampy vegetation. Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2002).

This species prefers dense scrub and therefore is not likely to be present on the site.

The likelihood of each species identified in the database searches being present on the site is summarised in Table 7.

Table 7: Likelihood of Conservation Significant species being present on the site

Scientific Name	Common Name	Likelihood to occur on the site
Calyptorhynchus banksii subsp. *naso*	Forest Red-tailed Black-Cockatoo	Recorded
Calyptorhynchus baudinii	Baudin's Cockatoo	Possible
Calyptorhynchus latirostris	Carnaby's Cockatoo	Likely
Dasyurus geoffroii	Chuditch, Western Quoll	No
Leipoa ocellata	Mallee Fowl	No
Phascogale tapoatafa subsp. ssp. (WAM M434)	Brush-tailed Phascogale	Highly Unlikely
Rostratula benghalensis	Painted Snipe	Unlikely
Setonix brachyurus	Quokka	No
Synemon gratiosa	Graceful Sun-moth	No
Apus pacificus	Fork-tailed Swift	Highly Unlikely
Ardea alba	Great Egret	Highly Unlikely
Ardea ibis	Cattle Egret	Possible
Haliaeetus leucogaster	White-bellied Sea-eagle	Highly Unlikely
Meeorps ornatus	Rainbow Bee-eater	Highly Unlikely
Falco peregrinus	Peregrine Falcon	Highly Unlikely
Morelia spilota subsp. *imbricata*	Carpet Python	Highly Unlikely
Arbanitis inornatus	Trapdoor Spider	Highly Unlikely
Acanthophis antarcticus	Southern Death Adder	Highly Unlikely
Ardeotis australis	Australian Bustard	Highly Unlikely

Scientific Name	Common Name	Likelihood to occur on the site
Westralunio carteri	Fresh water mussel	No
Isoodon obesulus subsp. *fusciventer*	Southern Brown Bandicoot	Unlikely

Therefore one Endangered species *Calyptorhynchus banksii* subsp. *naso* (Forest Red-tailed Black-Cockatoo) has been recorded on the site with two species, *Calyptorhynchus baudinii* (Baudin's Cockatoo) and *Calyptorhynchus latirostris* (Carnaby's Black Cockatoo) likely to be present on the site at some times of the year. The Schedule 3 Marine/Migratory listed Cattle Egret may also be an irregular visitor to the site.

2.11.4 Biodiversity Value

The cleared pasture has almost no ecological value from a native fauna perspective. There are a few mature trees in the paddocks.

2.11.5 Ecological Linkages

The site is mostly cleared. There is some ecological linkage to the east of the site through Manjedal Brook which is recognised in the Mundijong-Whitby Structure Plan (Masterplan, 2011). The scattered trees on the site also provide some linkage for avifauna, including Black Cockatoos, flying from the Scarp to the Swan Coastal Plain and back.

2.12 Heritage

2.12.1 Aboriginal heritage

A search of the Aboriginal Heritage Inquiry System indicates that there is one Aboriginal Heritage Site that is located partially within the boundary of the site (DIA, 2012). The site identification number is 450 and is an artefacts scatter (Appendix 6).

There are three other sites in the vicinity of the proposed West Mundijong Industrial Area that are also registered artefacts scatters. Two of these are located to the east of the proposed West Mundijong Industrial Area within and close to the Tonkin Highway alignment. These are sites 18187 and 18188 (Appendix 6). Site 449 is located to the north of the railway line.

There are two listed 'Heritage Places' located close to the proposed West Mundijong Industrial Area. These are listed as sites 17923 and 18189 and are also described as artefact scatters (Appendix 6).

2.12.2 European Heritage

Heritage sites can be listed under the following lists/registers:

- World Heritage Sites;
- National Heritage Sites;
- Commonwealth Heritage Sites;
- Sites on the register of the National Estate; and
- Sites listed in the Shire of Serpentine-Jarrahdale Municipal Heritage Inventory List.

There are no listed Heritage Sites or Interim Heritage Sites on the site (Landgate, 2012b; Heritage Council of Western Australia, 2012; SEWPaC, 2012c, Burgess, 2000).

3 IMPACT OF DEVELOPMENT

3.1 Past and Existing Land Use

The site has been cleared and used for grazing and there are a number of homesteads, sheds and associated farm infrastructure on the site including a private airstrip.

Therefore a Preliminary Site Investigation is recommended prior to development to ensure there are no contaminated areas. The past and existing land use does not impede development as if any contaminated areas such as leaking fuel tanks, pesticide/herbicide dumps or spills, asbestos in existing structures are located then these can be managed under the *Contaminated Sites Act 2003*.

3.2 Noise

The development of the proposed West Mundijong Industrial Area has the potential to create noise emissions from industry. The Preliminary Environmental Noise Assessment by Herring Storer (2012) (Appendix 7) concluded that the placement of industry within the area will be key to the management of noise. This will involve the placement of the potentially noisiest industries in the centre of the site. Noise emissions will need to be managed during the subdivision or development application process pursuant to the *Environmental Protection (Noise) Regulations 1997.*

Environmental noise from the proposed Tonkin Highway and realignment of the railway is likely to impact on the amenity of lots on and around the site. Under State Planning Policy No. 5.4 *Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (SPP 5.4) (WAPC, 2009) transport noise from within major transport corridors, including freight routes, and its impact on noise sensitive land uses must be investigated. The policy aims to:

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

There are a variety of mitigation measures available to mitigate noise from walls to bunds etc. An acoustic assessment at the subdivision stages of planning should be undertaken once the industry to be placed in areas is determined and, if required, mitigation measures put into the design of the industry. The Preliminary Environmental Noise Assessment by Herring Storer (2012) (Appendix 7) concluded that this process must be undertaken by negotiations with the transport providers and developers in a collaborative fashion.

The final civil design for the development and proposed noise amelioration measures are required inputs for acoustic models to determine the level of impact. The final civil design should be completed as part of the future subdivision process with collaboration between the developer and

infrastructure provider. Further acoustic assessments will be required as part of the planning process. Therefore noise can be managed by planning and design and is not an impediment to the potential development of the site for industrial purposes. Section 8 of the Preliminary Environmental Noise Assessment by Herring Storer (2012) (Appendix 7) details recommended mitigation measures that have been considered in consultation with the DEC and Conservation and the office of the EPA

3.3 Industrial Buffers

The land to the north and west of the site have been identified as 'buffer' areas that will be maintained as rural and thereby maintaining setbacks to potentially noisy industry. Additional buffers may need to be imposed during the detailed design process as the development of the site for industrial purposes may impact on noise, air quality, vibration and public health and safety. "Quieter" light industry is to be located at the periphery of the site to the east and south to provide a separation and internalised buffer to residential and rural residential development. General industry is to be located in the core of the site and adjacent to less sensitive rural land uses to the west and north.

The EPA preferred method for determining buffers to sensitive land uses (such as residential development) involves site-specific technical studies however EPA Guidance Statement No. 3 *Separation Distances Between Industrial and Sensitive Land Uses* (EPA, 2005) does provide generic separation distances. Site specific studies are only required if a reduction of the buffer is required.

The generic distance is:

> *Not intended to be absolute separation distances, rather they are a default distance for the purposes of:*
> - *Identifying the need for specific separation distance or buffer definition studies; and*
> - *Providing general guidance on separation distances in the absence of site specific technical studies (EPA, 2005).*

The State Industrial Buffer Policy (WAPC 1997) sets out the regulations as to what is required for the determination of buffers. This policy states:

> *Where an industry, infrastructure or encroaching sensitive use seeks to vary the boundary of a buffer area once defined, the variation shall not be allowed unless justified by the proponent seeking the variation in a scientifically based study. The study should comply with adopted environmental and planning criteria to the satisfaction of the Environmental Protection Authority and the Western Australian Planning Commission State Industrial Buffer Policy.*
>
> *A final decision on the variation of the buffer area would need to take into account the results of that study, the needs of industry and infrastructure (including any arrangements between the proponent seeking the variation, and the industry or infrastructure, to upgrade a facility to reduce the off-site buffer requirement) environmental needs and the rights of adjacent landowners.*

This policy states that the assessment of buffers will be undertaken at the time of assessment of a scheme amendment. However the lack of a specific proposal for the development indicates that buffers should be determined for individual developments.

The *State Industrial Buffer Statement of Planning Policy 4.1* Draft Policy (Amended) (WAPC for Public Comment 2009) does not override the 1997 policy. This policy identifies the environmental criteria specified to determine buffers.

> *The following types of environmental criteria shall be applied on a site or area-specific basis by the developer for the purpose of determining the size of buffer areas and for protecting buffer areas from inappropriate uses. These include—*
>
> - *risk (individual and societal);*
> - *air quality (e.g. dust, sulphur dioxide);*
> - *noise; and*
> - *odour.*

Therefore the surrounding land use and roads will require further consideration and planning, however this does not impede the rezoning of the site and can be managed during the assessment of Development Applications and Subdivisions with buffers determined during subdivision.

3.4 Geomorphology and Soils

The site does not contain any unique topographical or geological formations and therefore these factors are not an impediment to the development of the site for industrial purposes. Some of the soil types on the site are prone to waterlogging and ponding. Surface water management will be required to manage these soil types.

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

- Ground disturbing activities should be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site;
- Landscaping/stabilising/dust suppression of areas where ground disturbance has occurred should be scheduled to occur immediately after clearing/and or infrastructure construction has been completed; and
- Clearing activities have the potential to add clay 'fines' into the drainage channels or the Conservation Category Wetland and the installation of temporary drop-out basins to capture and aid in the settling of clay fines should be considered.

3.5 Acid Sulphate Soils

The ASS Risk on the site is mapped as being Moderate to Low (<3m from the surface). The WAPC *Acid Sulphate Soils Planning Guidelines* (WAPC, 2009c) indicate that "*acid sulphate soils are technically manageable in the majority of cases*". ASS Investigation and, if required, Management Plans should be prepared at subdivision stage once the detailed design of the site is finalised. This should be undertaken in accordance with the *Acid Sulphate Soils Guideline Series: Identification and*

Investigation of Acid Sulphate Soils and Acidic Landscapes (DEC, 2009a) and Draft *Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes* (DEC, 2009b).

3.6 Groundwater

Groundwater management will be outlined in the District Water Management Strategy and will be detailed in the Local Water Management Strategies and Urban Water Management Plans that will be prepared for each stage of development.

Therefore potential impacts on groundwater can be mitigated and managed and does not impede development of the site for industrial purposes.

3.7 Surface Water

As for groundwater the management of surface water will be outlined in the District Water Management Strategy and will be detailed in the Local Water Management Strategies and Urban Water Management Plans that will be prepared for each stage of development

The broad-scale planning for the site has identified two of the drainage channels (one of which links to the Conservation Category Wetland) as ecological corridors that will be revegetated and contain some passive recreation. The corridors should be designed to create a living stream as part of the development on the site.

Development of the site has the potential to increase the ecological value of the degraded channels through rehabilitation.

3.8 Wetlands

3.8.1 Manjedal Brook

The Conservation Category Wetland on the site is part of Manjedal Brook. A large proportion of the site is mapped as a palusplain Multiple Use Wetland.

As per guidance from the EPA the brook has been identified in the planning for West Mundijong as an ecological corridor which will result in the wetland and the drainage line that links to the west of the wetland being rehabilitated as a living stream within the development. A Wetland Management Plan for Manjedal Brook should be developed when planning for the area around the wetland is underway. The plan should be prepared acknowledging the following relevant policies and guidelines:

- Attachment B4-5 in *Environmental Guidance for Planning and Development – Guidance Statement 33* (EPA, 2008);
- *Guidelines Checklist for Preparing a Wetland Management Plan* (DEC, 2008); and
- *Environmental Protection of Wetlands – Position Statement No.4* (EPA 2001).

The Wetland Management Plan should detail measures to maintain the hydrology and improve the environmental values of the creekline. It should also include rehabilitation measures and outline the methodology to provide the ecological corridor in the development.

3.8.2 Wetland Buffers

The part of Manjedal Brook on the site is in similar condition to the brook to the east of the site. Planning for this part of the brook is underway and it has been determined that as a riverine wetland the responsible authority for the brook is the Department of Water. The Water Quality Protection Note 6: *Vegetation buffers to sensitive water resources* (DoW, 2006) outlines the manner in which buffer distances are to be measured:

> *Horizontal buffer distances are measured at right angles to the margins of streams or waterbodies, while buffers are normally circular for water supply wellheads. Where margins to ephemeral waterways are unclear, buffers should be measured outward from grade changes defining run-off channels.*

The section of Manjedal Brook that is classified as Conservation Category on the site has clearly defined banks and it is suggested that the buffer be consistent with that to the east of the site. This will be a 30m buffer measured from the top of the bank. This buffer is partially vegetated however in areas that are completely degraded drainage infrastructure could be placed in the buffer area, consistent with the eastern part of the brook. The eastern part of the brook has wetland tree vegetation present beyond 30m from the bank. This vegetation should be retained and the buffer extended to 50m from the edge of the bank or to the extent of the wetland vegetation, whichever is greater, to ensure the vegetation is protected.

3.9 Vegetation

The vegetation on the site is Completely Degraded and in small areas Degraded to Completely Degraded. The site does not contain any areas with an intact understorey. The development of the site will result in clearing the majority of the vegetation on the site. This vegetation is not significant however during the detailed design process it is recommended that the retention of any trees that can be retained in landscaped area, parking areas and in road/entry areas should be included in the plans for the area. Mature trees to be retained or transplanted must be identified and marked appropriately prior to commencement of any pre-construction activities.

Kingia australis plants should be retained or salvaged and replanted in the development or in Public Open Space nearby wherever possible.

The Mundijong Road reserve contains TECs to the south of the constructed road. To protect these TECs any further construction to provide services or to upgrade this road should be undertaken to the north of the constructed road. Management procedures should be in place to ensure that the vegetation to the south is not disturbed.

3.10 Flora

No Declared Rare Flora are likely to be on the site and no priority species are likely to be present.

It is recommended that no further study on the site be required and therefore flora is not an impediment to the development of the proposed Mundijong West Industrial Area.

3.11 Fauna

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii* subsp. *naso*), and possibly Baudin's Cockatoo (*Calyptorhynchus baudinii*) and Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) could be impacted by the development of the site.

The three species of black cockatoo that do or may occur on the site are listed under Section 18 of the EPBC Act. Under the EPBC Act, a significant impact is determined by the sensitivity, value and quality of the environment which is to be impacted and the intensity, duration, magnitude and geographic extent of the impacts. If a proposed action is deemed to have a significant impact, this action should be referred to the Minister. Therefore development of the site for industrial purposes will need to be examined in the context of the *Matters of National Environmental Significance. Significant Impact Guidelines 1.2 Environment Protection and Biodiversity Conservation Act 1999* (SEWPaC, 2012c). If, according to the Significant Impact Guidelines 1.2, an action is likely to have a significant impact on an endangered and vulnerable species it will need to be referred under the EPBC Act.

The habitat requirements for the Black Cockatoos include foraging (Marris, Flooded Gums, *Banksia* species, Parrot Bush and other Proteaceous shrubs), roosting (tall eucalypts and pines) or breeding habitat (specific Eucalypt trees). There are very few Proteaceous shrubs and only scattered Marri trees on the site therefore it is concluded that the site contains very little suitable habitat for Black Cockatoos. Development of the site is not likely to significantly impact on Black Cockatoo species. However each individual development will need to make its own assessment to determine the implications of the proposed development under the EPBC Act. This will particularly apply to developments that contain Marri trees such as the area to the north of Scott Road on the western end and the lots immediately to the north of Manjedal Brook.

To mitigate potential impact on Black Cockatoos it is suggested that in future planning phases as many Marri and Flooded Gum trees and significant trees (those greater than 500mm in diameter at breast height) be retained. There is also the potential to improve the Black Cockatoo habitat by planting appropriate species in drainage corridors, open space and road reserves.

The Cattle Egret is potentially a brief visitor to the site but would not be impacted by the proposed development. There are no other conservation species identified that are likely to be present on the site.

As stated the development of the site has the potential to increase the ecological value of the degraded channels through rehabilitation which may also increase the ecological linkage over the site.

3.12 Heritage

Aboriginal Heritage Site 450, located partially on the site, is registered with the Department of Indigenous Affairs and as such advice on the implications under the *Aboriginal Heritage Act 1976* of the Heritage Site will need to be investigated.

4 SUMMARY AND CONCLUSIONS

The Environmental Factors that were studied in this environmental assessment were:

- Past and Existing Land Use
- Surrounding Land Use
- Topography
- Geomorphology and Soils
- Surface and Groundwater
- Vegetation
- Flora
- Fauna
- Heritage

The desktop studies resulted in the following conclusions and recommendations:

- Past land uses indicate that rural activities may have some small localised areas that are contaminated. Therefore it is suggested that a Preliminary Site Investigation be undertaken at subdivision stage to identify if there is any potential contamination present that may require further investigation and remediation in order for the site to be suitable for the proposed industrial development.
- The adjacent and future major road and rail alignments will require further acoustic studies to determine the impact of these activities on future industries. Buffers and management should be undertaken in collaboration with the infrastructure provider and developers.
- Some industries that could be considered in the industrial estate have the potential to impact on neighbouring residential development. Appropriate siting of industries requiring buffers will need to be considered at Structure Planning. Impacts can be mitigated with planning and engineering solutions. Therefore it is most appropriate to address these issues at subdivision to ensure the latest information and technology is available.
- Buffers required outside of the industrial site will depend on individual industries, taking into account emissions, noise, odour and public health, and should be determined during development applications or subdivision.
- The topography and geology on the site is not an impediment to development.
- The soils have a Low to Moderate risk of ASS. Therefore this is not considered a constraint to development. Individual industries will need to consider site specific soil types for ASS risk at subdivision or development application stage.
- Surface water and groundwater will be managed under the hierarchy outlined in *Better Urban Water Management* (WAPC, 2008).
- Rehabilitation of the drainage channels has the potential to increase the ecological value of the degraded channels and may also increase the ecological linkage over the site.
- The site has a Conservation Category Wetland (UFI 14945) that is Manjedal Brook. It is recommended that a Wetland Management Plan be prepared for the mapped wetland and adjoining drainage line to be rehabilitated as an ecological corridor in the development. This

should be during subdivision in areas adjacent to the brook and outline measures to maintain the hydrology and improve the environmental values of the wetland.

- A buffer of 30m to the drainage line (top of bank) should be imposed as well as a 50m buffer the outer extent of wetland vegetation, whichever is greater, to the well vegetated eastern part of Manjedal Brook.
- The site is not in a priority surface or groundwater area. Therefore these factors do not constrain development on the site.
- The development of the site will result in clearing small pockets of remnant vegetation and individual trees. The majority of the vegetation has been cleared and is not a constraint to development.
- Wherever possible, trees should be retained in the development particularly in road reserves and carparks. Drainage corridors, open space and road reserves can be enhanced by planting native species.
- No Declared Rare or Priority Flora or TECs are likely to be on the site.
- There are TECs to the south of the constructed Mundijong road and any construction and/or upgrading of this road should be constructed to the north of the existing road.
- Consideration will need to be given to retaining Marri trees to protect habitat for the three species of Black Cockatoo. Development is highly unlikely to have a significant impact according to the Significant Impact Guidelines 1.1 however each individual development should do its own assessment to determine the degree of impact under the EPBC Act. This will particularly apply to developments that contain Marri trees such as the area to the north of Scott Road on the western end and the lots immediately to the north of Manjedal Brook.
- There is a registered Aboriginal heritage site (Site ID 450) in the proposed Mundijong West Industrial Area and therefore advice will need to be sought to determine what approvals, if any, are required under the *Aboriginal Heritage Act, 1976*.

The results of desktop assessment, preliminary field investigations and mitigation measures identified, concludes the potential for deleterious impacts of industrial development on the biophysical environment are considered to be low. Potential impacts of industrial development on the existing residences adjacent to the site will need to be managed through siting industries with emissions away from residences can be managed with a high degree of confidence to minimise environmental harm. The impact of noise from road and rail on the industries will also need to be managed.

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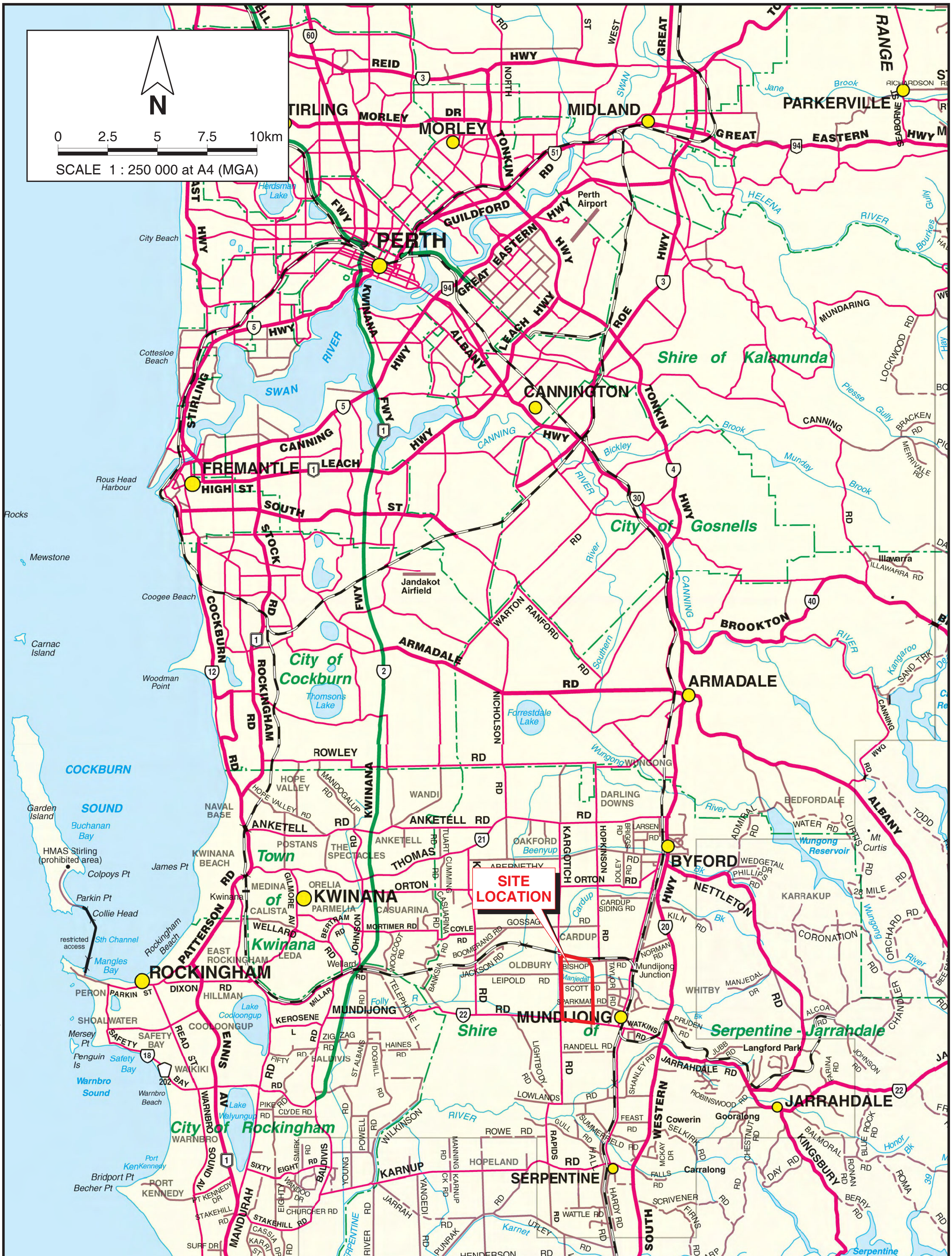
FIGURES



pgv ENVIRONMENTAL

Shire of Serpentine Jarrahdale
ENVIRONMENTAL ASSESSMENT
WEST MUNDIJONG INDUSTRIAL AREA

Drawn: J. Hams	Date: 22 Nov 2012
Job: 10109	Revision: A

SITE LOCATION

Figure 1

PINPOINT CARTOGRAPHICS (08) 9562 7136

2012-063-f01.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-063-f02.dgn

N

0 100 200 300 400 500m

SCALE 1 : 10 000 at A3 (MGA)

401 000mE 402 000mE

6 429 000mN 6 428 000mN 6 427 000mN 6 426 000mN

BISHOP ROAD

SCOTT ROAD

KARGOTICH ROAD

MUNDIJONG ROAD

STEEL LANE

PURE

R 46312 174

R 23793 1724

VCL 47 VCL 46 VCL 179

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Topographic Contour

CADASTRAL SOURCE: Landgate, November 2012.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown October 2012.
CONTOURS SOURCE: Landgate, 1:50,000 Topographic Mapping.

pgv ENVIRONMENTAL

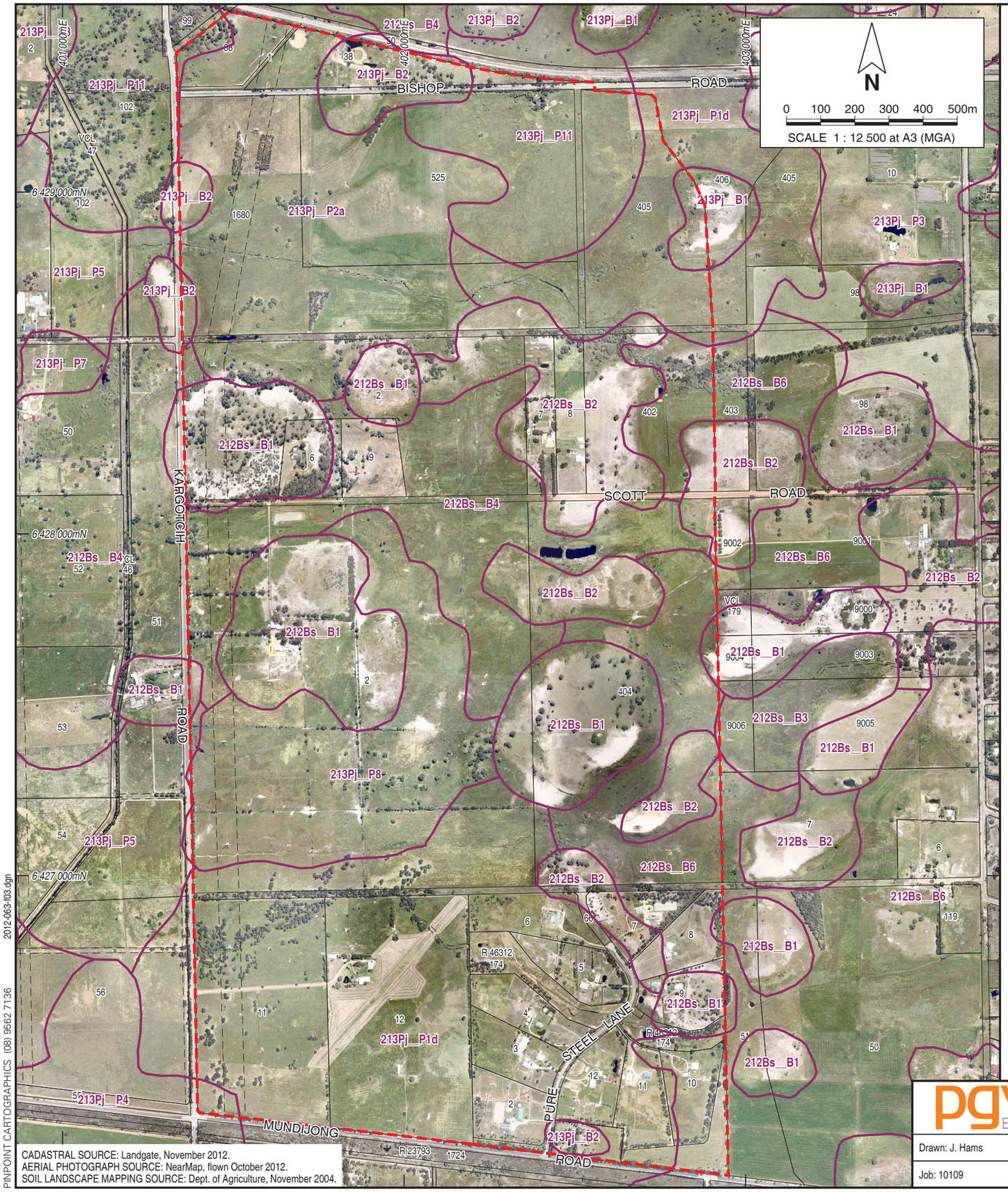
Shire of Serpentine Jarrahdale
ENVIRONMENTAL ASSESSMENT
WEST MUNDIJONG INDUSTRIAL AREA

Drawn: J. Hams | Date: 22 Nov 2012

Job: 10109 | Revision: A

SITE BOUNDARY AND TOPOGRAPHY

Figure 2



CADASTRAL SOURCE: Landgate, November 2012.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown October 2012.
SOIL LANDSCAPE MAPPING SOURCE: Dept. of Agriculture, November 2004.

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary
- Soil Landscape Mapping Boundary
- 213Pj__B1 Soil Landscape Type

Soil Landscape Mapping

212Bs__B1 Bassendean 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.

212Bs__B2 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 1-2m.

212Bs__B3 Bassendean B3 Phase
Closed depressions and poorly defined stream channels with moderately deep, poorly to very poorly drained bleached sands with an iron-organic pan, or clay subsoil. Surfaces are dark grey sand or sandy loam.

212Bs__B4 Bassendean B4 Phase
Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.

212Bs__B6 Bassendean B6 Phase
Sandplain and broad extremely low rises with imperfectly drained deep or very deep grey siliceous sands.

213Pj__B1 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.

213Pj__B2 Pinjarra, 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 1-2m.

213Pj__P11 Pinjarra P11 Phase
Shallow brown loamy soils or less commonly, very shallow sands over ironstone pavement which is a clear barrier to drainage.

213Pj__P1d Pinjarra P1d Phase
Flat to very gently undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and moderately susceptible to salinity.

213Pj__P2a Pinjarra P2a Phase
Flat to very gently undulating plain with deep alkaline mottled yellow duplex soils which generally consist of shallow pale sand to sandy loam with a silcrete hardpan at 50-100 cm depth generally on top of an olive-grey clay.

213Pj__P3 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.

213Pj__P4 Pinjarra P4 Phase
Poorly drained flats, sometimes with gilgai microrelief and with moderately deep to deep black, olive grey and some yellowish brown cracking clays and less commonly non-cracking friable clays with generally acidic subsoils.

213Pj__P5 Pinjarra P5 Phase
Poorly drained flats, commonly with gilgai microrelief and with deep black-grey to olive-brown cracking clays with subsoils becoming alkaline.

213Pj__P7 Pinjarra P7 Phase
Seasonally inundated swamps and depressions with very poorly drained variable acidic mottled yellow and gley sandy duplex and effective duplex soils.

213Pj__P8 Pinjarra P8 Phase
Broad poorly drained flats and poorly defined stream channels with moderately deep to deep sands over mottled clays; acidic or less commonly alkaline gley and yellow duplex soils to uniform bleached or pale brown sands over clay.

PGV ENVIRONMENTAL

Shire of Serpentine Jarrahdale
ENVIRONMENTAL ASSESSMENT
WEST MUNDIJONG INDUSTRIAL AREA

Drawn: J. Hams	Date: 22 Nov 2012
Job: 10109	Revision: A

SOIL LANDSCAPE MAPPING

Figure 3

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-063-I03.dgn

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-063-f04.dgn

N

0 100 200 300 400 500m

SCALE 1 : 10 000 at A3 (MGA)

401 000mE 402 000mE

6 429 000mN 6 428 000mN 6 427 000mN 6 426 000mN

BISHOP ROAD

SCOTT ROAD

KARGOTICH ROAD

MUNDIJONG ROAD

STEEL LANE

PURE LANE

VCL 47 VCL 46 VCL 179

R 46312 174 R 46312 174

14903 14904 14945 15785 14817

1680 1724

Legend

- Site Boundary
- Cadastral Boundary
- Easement Boundary

Geomorphic Wetlands

- Conservation Category
- Multiple Use
- 15785 Wetland UFI

WETLANDS SOURCE: DEC, October 2012.
CADASTRAL SOURCE: Landgate, November 2012.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown October 2012.

pgv ENVIRONMENTAL

Drawn: J. Hams | Date: 22 Nov 2012

Job: 10109 | Revision: A

Shire of Serpentine Jarrahdale
ENVIRONMENTAL ASSESSMENT
WEST MUNDIJONG INDUSTRIAL AREA

GEOMORPHIC WETLANDS

Figure 4

APPENDIX 1

Correspondence between OEPA and Serpentine Jarrahdale Shire

All enquiries to Peter Varelis on 9526 1111
Our ref: A2078 PV:kc
Electronic Ref: OC12/9476

26 July 2012

Attention: Mr. Gary Williams
Chief Executive Officer
Office of the Environmental Protection Authority
Locked Bag 33, Cloisters Square
PERTH WA 6850

Dear Sir

RE: WEST MUNDIJONG INDUSTRIAL AREA: PROPOSED DISTRICT STRUCTURE PLAN AND AMENDMENT TO THE METROPOLITAN REGION SCHEME

We write with regards to our recent meeting held 19 July 2012 in relation to the West Mundijong Industrial Area.

The Shire of Serpentine Jarrahdale (the Shire) would like to confirm the following points:

Background

In February 2012 the Shire completed a Feasibility Assessment for industrial development at West Mundijong. The assessment concluded that the area would be suitable for low to moderate emission general industry.

You are probably aware that future industrial development of the land is foreshadowed in the following key planning documents:

a) *Directions 2031*
b) Draft Southern Metropolitan Sub – Regional Structure Plan 2009
c) Mundijong Whitby District Structure Plan
d) Economics and Employment Lands Strategy: non-heavy industry (2012)

It should be noted that *Directions 2031* also identified a potential intermodal facility within the West Mundijong area. The feasibility of an intermodal facility is currently being progressed by the Department of Transport.

In response to the Feasibility Assessment and the above planning documents, the Shire is preparing a District Structure Plan (DSP) for the West Mundijong area. The purpose of the DSP is to support an amendment to the Metropolitan Region Scheme to include the land within the 'Industrial' zone.

So far, progression of the necessary planning for the site embodies a 'whole of government approach'. Funding for the proposal has been sourced from a number of agencies including the Department of Planning, Department of Agriculture and Food WA and the Department of Transport. The Shire is committed to collaboration with key agencies in order to progress planning and ultimately the development of West Mundijong.

Likely Industrial Development Scenarios

It is important to note that the above documents envisage the development of 'non heavy industry' at West Mundijong. The Feasibility Assessment recommended a range of general industry uses including, but not limited to:

a) Agribusiness, including food distribution;
b) Warehousing and logistics;
c) Transport, heavy machinery sales, servicing and distribution;
d) Service industry, light industry and limited showroom development; and,
e) Manufacture and fabrication of building products: plasterboard, lime production and brickworks.

A Schematic Plan was prepared as part of the Feasibility Assessment and outlines the proposed uses and their potential disposition within the future estate. The plan is attached for your information.

Environmental Factors

The West Mundijong Feasibility Assessment also included a desktop analysis of environmental opportunities and constraints. The following is noteworthy:

a) The vast majority of the site has been cleared of remnant vegetation in order to enable the land to be used for broad acre agriculture;

b) Manjedal Brook bisecting the site East/West. The eastern portion of the Brook is a designated conservation category wetland. The Brook is also identified as a place of environmental beauty in the Shire's Local Town Planning Scheme; and,

c) The proximity of existing and planned sensitive uses. It is noted that the Mundijong Whitby District Structure Plan provides for future residential development to the extension of Tonkin Hwy. The Highway reservation forms the eastern boundary of the site.

Flora and Fauna

It is estimated that less than 3% of the original vegetation remains.

Nevertheless there may be the possibility of rare and endangered flora on the fringes of the site mainly in association with remnant vegetation on the southern side of Mundijong Road. Such vegetation may also support endangered fauna. The subject portion of Mundijong Rd is also a 'Bush Forever' (reference 360).

Given the very limited extent of remnant vegetation, detailed surveys and reporting are not envisaged as required at the DSP and MRS amendment stage. Rather such surveys, if required, can be deferred to the subsequent local structure planning phase. This approach would be consistent with the development of the Mundijong Whitby District Structure Plan immediately to the East.

Similarly it is our view that any Commonwealth referrals can and should be deferred to the Local Structure Planning phase.

Noise

Potential noise emissions are likely to be the most important environmental consideration in the future planning and development of West Mundijong.

Herring Storer Acoustics (HSA) has been engaged to prepare a Noise Assessment to support the preparation of a DSP. The assessment will model noise emissions based upon the industrial land use scenarios identified in the West Mundijong Industrial Feasibility Assessment.

The following points are acknowledged:

a) *The assessment will be completed in accordance with SPP 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning;*

b) *In relation to a), it is acknowledged that the assessment and management of locomotive noise will ultimately be the responsibility of a future proponent of such rail infrastructure. Nevertheless, the Noise Assessment will need to account for all other associated activities / uses that otherwise would be associated with a future intermodal facility;*

c) *The report will model two options for the location of the proposed intermodal facility; and,*

d) *The outcomes of the assessment will primarily determine the buffer distance for the Estate.*

As agreed at our meeting it would be useful if HSA could collaborate with the Department of Environment and Conservation's Noise Branch in the development of the assessment. In particular, a further meeting of the relevant personnel to discuss the draft assessment report prior to finalisation would be beneficial.

Buffer

The location of existing and proposed sensitive uses will be a key consideration in the development of the DSP. As outlined above the outcomes of the noise modeling will be instrumental in determining a suitable buffer distance for the future industrial estate.

The DSP report will make recommendations as how best to implement the buffer in order to meet the requirements of SPP 4.1: *State Industrial Buffer Policy*. Suffice to note:

a) *The Shire is completing a review of its Rural Land Strategy. The review incorporates a buffer for West Mundijong which seeks to prevent further development of sensitive uses within proximity of the area;*

b) *Local Structure Planning for land to the East within the Mundijong Whitby area is cognisant of potential noise impacts that may arise from the future industrial development; and,*

c) *The Feasibility Assessment foreshadowed a need to accommodate low emission industrial uses on the eastern and southern perimeter of the future state in order to reduce the potential for impacts on nearby sensitive uses. It is envisaged that structure planning will need to develop both an 'internal' and 'external' buffer for the estate.*

Wetlands

The majority of the site is designated a 'multiple use' wetland according to Department of Environment and Conservation's geomorphic wetland data base.

As discussed above, the northern portion of the site is traversed by Manjedal Brook. The eastern portion of the Brook is identified as a CCW. The Brook is also identified as an 'area of natural beauty' in the local scheme.

The Shire is not seeking to de-classify the CCW. Subject to further planning and consultation, there might some potential to incorporate the Brook into an ecological corridor incorporating rehabilitation, drainage and passive recreation features. The corridor would also seek to make provision for adequate buffers between the Brook and future industrial development consistent with Department of Environment and Conservation's relevant policy.

The portion of Mundijong Road forming the southern boundary of the site is also identified as a CCW.

Proposed Environmental Reporting

Accompanying the MRS amendment will be an Environment Assessment Report (EAR). The EAR will include:

a) *Desktop review of flora and fauna, including threatened ecological communities. As discussed above it is envisaged that surveys, if required, can deferred to the local structure planning phase;*
b) *An explanation as to how wetland issues will be addressed via structure planning;*
c) *Outcomes of the noise modeling report and in particular how potential noise impacts will be managed; and,*
d) *Recommended buffer distance including mechanisms for implementation via the planning system;*
e) *Transition strategy for existing sensitive uses within the proposed estate and nearby.*

We respectfully seek your agreement to the matters and approach raised in this correspondence.

Again, the Shire expresses its gratitude for your advice and cooperation to date.

Should you have any queries please do not hesitate to contact Mr. Peter Varelis, Senior Strategic Planner, on 9526 1167.

Yours sincerely

Suzette van Aswegen
DIRECTOR STRATEGIC COMMUNITY PLANNING

CC:
Craig Shepherd – Department of Planning
Don Challis – Department of Transport
Lindsay Broardhurst – Main Roads WA

Enclosure: 1. Schematic Plan

Government of **Western Australia**
Office of the **Environmental Protection Authority**

Your Ref: A2078 PV:kc
Our Ref: A527988: OEPA2012/000339
Enquiries: Gary Williams, 6467 5425
Gary.Williams@epa.wa.gov.au

Suzette van Aswegen
Director Strategic Community Planning
Shire of Serpentine - Jarrahdale
6 Paterson Street
MUNDIJONG WA 6123

Attention: Peter Varelis

Dear Ms van Aswegan

WEST MUNIDIJONG INDUSTRIAL AREA PROPOSED DISTRICT STRUCTURE PLAN AND PROPOSED METROPOLITAN REGION SCHEME AMENDMENT

Thank you for your correspondence dated 26 July 2012 seeking confirmation from the Office of the Environmental Protection Authority (OEPA) in relation to the matters described in your letter and discussed with the OEPA at meetings on the 21 June and 19 July 2012, in relation to the West Mundijong Industrial Area District Structure Plan (DSP) and proposed Metropolitan Region Scheme (MRS) amendment.

Your letter accurately reflects the matters discussed at the meetings between the Shire of Serpentine - Jarrahdale and the OEPA. It also satisfactorily outlines the environmental issues and the scope of work the OEPA requires to consider the potential environmental impacts of the proposed DSP and to recommend a level of assessment to the EPA on the MRS amendment.

In particular, the OEPA supports the Shire's intentions to:

(a) prepare a noise assessment to ensure that an adequate buffer is provided around the proposed industrial area so that noise emissions from various industrial types will be contained within the buffer;

(b) consider existing and proposed sensitive land uses within and around the proposed industrial area when determining the location of various industrial types during the preparation of the DSP;

(c) include the Manjedal Brook and the Conservation category wetland within an ecological corridor; and

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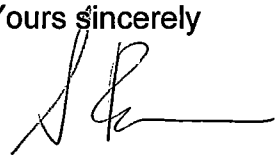
(d) defer detailed vegetation surveys and reporting to the local structure planning stage recognising that there are likely to be declared rare flora, priority flora and threatened ecological communities in the vicinity of the subject land and potentially on the subject land.

I trust this advice is of assistance.

Yours sincerely



Sally Bowman
Manager
Planning and Infrastructure Branch

11 September 2012

APPENDIX 2

DEC Flora Database Searches

DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DECLARED RARE AND PRIORITY FLORA LIST
16 September 2010

SPECIES / TAXON	CONS CODE	DEC REGION	DISTRIBUTION	FLOWER PERIOD
Acacia horridula	3	SW	Helena Valley - Serpentine	May-Aug
Acacia lasiocarpa var. bracteolata long peduncle variant (GJ Keighery 5026)	1	SW	North Dandalup, Mundijong, Gosnells, Jandakot, Serpentine, Mundijong	My,Aug
Acacia oncinophylla subsp. oncinophylla	3	SW,MW,WA	Mogumber, Mundaring, John Forrest NP, Serpentine, Mt Lennard, Dwellingup, Winnejup	
Andersonia audax ms	3	SW	Armadale, Jarrahdale, Monadnocks C.P.	Oct
Andersonia saxatilis ms	1	SW	Jarrahdale, Monadnocks C.P.	
Aponogeton hexatepalus	4	SR,SW	Perth, Pinjarra, Capel, Bunbury, Boyanup, Nannup, Bertram, Mundijong	Aug-Sep
Centrolepis caespitosa	4	SC,SW,WB	South Stirling, Pearce, Meckering, (Byford), Youngs Siding, Narrikup, Orange Grove	Nov
Cyathochaeta teretifolia	3	SW,WA	Whiteman Park, Lake Gnangara, Ellenbrook, Muchea, Denbarker, Yelverton, Wellard, Mundijong	Dec
Dillwynia dillwynioides	3	SW	Harvey, Pinjarrah, Yunderup, Gingin, Perth, Karnup, Mundijong, Serpentine	Aug-Oct
Eryngium pinnatifidum subsp. palustre ms	3	SW	Serpentine, Kenwick, Upper Swan, Gingin, Forrestdale, Bullsbrook, Mandurah, Arrowsmith, Capel	-
Eucalyptus rudis subsp. cratyantha	4	SR,SW	Yallingup, Eagle Bay, Mandurah, Cape Naturaliste, Meelup, Busselton, Serpentine	-
Grevillea crowleyae	2	WB,SW	Dardadine, Dryandra, Jarrahdale	
Grevillea manglesii subsp. ornithopoda	2	SW	Murray River, Pinjarra, York, Jarrahdale, Mundaring, North Bannister	Sep-Oct
Jacksonia gracillima	3	SW,SR	Mundijong, Forrestdale, Capel, Elgin, Modong N.R., Forrestfield, Ambergate	Oct-Nov
Johnsonia pubescens subsp. cygnorum	2	SW	Serpentine, Cardup, Lowlands	Sep-Nov
Lasiopetalum pterocarpum	T	SW	Serpentine Falls	Aug
Meeboldina decipens subsp. decipens ms	3	SW,SR	Cannington, Waroona, Byford, Capel	
Paracaleana gracilicordata	1	SW	Jarrahdale	Oct-Nov
Paracaleana granitica	1	SW	Jarrahdale, Sullivan Rock	Oct-Dec
Parsonsia diaphanophleba	4	SW	Murray River, Coolup, Serpentine	Jan-Feb,May-
Schoenus pennisetis	1	SW,WB	Cannington, Byford, Kenwick, Wongan Hills	Aug-Dec
Stylidium ireneae	4	SW,SR	Waroona, Lane Poole, Serpentine Dam, North Dandalup, Augusta, Kwinana	Oct-Nov
Stylidium longitubum	3	SW,WB,SR	Upper Swan, Bullsbrook, Bunbury, Midland, Busselton, Arthur River, Jandakot, Mundijong, Karnup	Nov
Synaphea odocoileops	1	SW,SR	Serpentine, Elgin, Byford, Wagerup	Aug-Oct
Synaphea sp. Pinjarra plain (AS George 17182)	1	SW	Mundijong, Serpentine	Oct
Synaphea sp. Serpentine (G.R. Brand 103)	3	SW,SR	Serpentine, Mundijong, Byford, Yarloop	Aug-Nov
Tetraria australiensis	T	SW,SR	Mundijong, Busselton, (Cannington, Serpentine River)	Dec

DECLARED RARE AND PRIORITY FLORA LIST

16 September 2010

SPECIES / TAXON	CONS CODE	DEC REGION	DISTRIBUTION	FLOWER PERIOD
Verticordia lindleyi subsp. lindleyi	4	SW,MW	Gillingarra-Forrestdale, Cannington, Guildford, Muchea, Gingin, Murray River, Moore River, Serpentine	Nov-Jan
Verticordia plumosa var. ananeotes	T	SR,SW	Busselton, Serpentine - Blackwood	Dec
Verticordia plumosa var. pleiobotrya	T	SW	Mundijong West Road, Bullsbrook NR	Nov

SHEET_NO	SPECIES	CONSCODE	SITE	VEGETATION	LOCALITY	DATE_
PERTH 00619884	Acacia lasiocarpa var. bracteolata long peduncle variant (G.J. Keighery 5026)	1	Low lying sand over clay. Winter wet, open.		6 km WNW of Mundijong	05 08 1982
PERTH 03377962	Baeckea sp. Perth Region (R.J. Cranfield 444)	3	Dry summer swamp. Sandy white clay soil.	Heath type vegetation.	Abernethy Road, Oakford	23 03 1981
PERTH 04099672	Baeckea sp. Perth Region (R.J. Cranfield 444)	3	Winter wet. Brown clay over ironstone.	Heath of Calothamnus hirsutus, Jacksonia, Melaleuca and Baeckea emergent.	Mundijong road, 4 km W of Mundijong	20 01 1992
PERTH 04497864	Dillwynia dillwynioides	3	Soil: Grey sand. Topography/drainage: Seasonally wet poorly drained flat. Geomorphology: Bassendean sands.	Vegetation: Kunzea ericifolia Scrub over Pericalymma ellipticum Open Low Scrub B over mixed Open Herbs.	Remnant vegetation on Lowlands property (M103) 9 km WNW of Serpentine (plot low09a).	12 09 1992
PERTH 04457811	Dillwynia dillwynioides	3	Soil: Dark brown sand. Topography/drainage: Seasonally wet flat. Geomorphology: Bassendean sands.	Vegetation: Melalueca raphiophylla Open Low Woodland A over Kunzea ericifolia Thicket over Astartea fascicularis Low Scrub A over mixed Herbs.	Remnant vegetation on Lowlands property (M103) 9 km WNW of Serpentine (plot low08).	06 11 1993
PERTH 1096478	Diuris purdiei	T	Sand.		Mundijong.	09 1903
PERTH 05811953	Drosera occidentalis subsp. occidentalis	4	Damp flat. Grey sandy clay. Edge of cleared firebreak.	In regenerating Pericalymma ellipticum heath.	0.9 km SSw of Byford Siding between Soldiers Road and Turner Road, N of small creek,	27 11 1990
PERTH 04916980	Jacksonia gracillima	3	Wetland. Seasonally moist littered black clay.	Dense Heath B (Muir).	Mundijong Road, 200 m E of intersection with Kargotich Road	06 11 1997
PERTH 07127499	Jacksonia gracillima	3	Winter wet flats; brown clay.	Melaleuca uncinata tall shrubland over low shrubland of Calothamnus, Verticordia spp over sedges.	Road verge, 2 km W Mundijong	05 11 2004
PERTH 01969625	Johnsonia pubescens subsp. cygnorum	2			Whitby Falls near Mundijong,	09 10 1923
PERTH 01969528	Johnsonia pubescens subsp. cygnorum	2	Yellow sand.	In open low woodland A with Jarrah and Banksia.	Cardup Nature Reserve	21 09 1988
PERTH 4497686	Johnsonia pubescens subsp. cygnorum	2	Soil: Grey sand. Topography/drainage: Seasonally wet poorly drained flat. Geomorphology: Bassendean sands.	Vegetation: Kunzea ericifolia Scrub over Pericalymma ellipticum Open Low Scrub B over mixed Open Herbs.	Remnant vegetation on Lowlands property (M103) 9 km WNW of Serpentine (adj. to plot low09a).	13 08 1992
PERTH 4497880	Johnsonia pubescens subsp. cygnorum	2	Soil: Grey white sand. Topography/drainage: Well drained flat. Geomorphology: Bassendean sands.	Vegetation: Eucalyptus marginata Forest over Melalueca preissiana Low Forest A over Chaemascilla corymbosa, Dasypogon bromilifolius Open Herbs over Loxocarya fascicularis, Hypolaena exsulca Very Open Low Sedges.	Remnant vegetation on Lowlands property (M103) 9 km WNW of Serpentine (plot low06b).	12 09 1992
PERTH 07130023	Meeboldina decipiens subsp. decipiens	3	Eastern Swan coastal plain - seasonal wetland. Seasonally wet, grey loamy sand.	Low Corymbia calophylla woodland A (Muir, 77). Kingia australis, Xanthorrhoea preissii, Pericalymma spongicaule, Mesomelaena tetragona, Tricostularia neesii.	Brickwood Reserve, Bygord, between Turner and Soldier Roads	14 11 2003
PERTH 07130031	Meeboldina decipiens subsp. decipiens	3	Eastern Swan coastal plain - seasonal wetland. Seasonally wet, grey loamy sand.	Low Corymbia calophylla woodland A (Muir, 77). Kingia australis, Xanthorrhoea preissii, Pericalymma spongicaule, Mesomelaena tetragona, Tricostularia neesii.	Brickwood Reserve, Bygord, between Turner and Soldier Roads	14 11 2003

SHEET_NO	SPECIES	CONSCODE	SITE	VEGETATION	LOCALITY	DATE_
PERTH 04684591	Parsonsia diaphanophleba	4	Riverbank. Dry sand/loam.	With Eucalyptus rudis, Melaleuca rhaphiophylla, Casuarina obesa.	Serpentine River, Lowlands Road	23 04 1997
PERTH 03017656	Parsonsia diaphanophleba	4	Light brown sandy clay, river edge.		Lowlands, Mardella, N side of Serpentine River, NE of old house	31 05 1993
PERTH 02239086	Schoenus pennisetis	1	On cleared track, sandy clay, flat.	With other herbs and grasses.	Between Turner road and Mead Street on track past Aged Peoples Home, 500 m SW of Byford	27 11 1990
PERTH 02239094	Schoenus pennisetis	1	Damp depression, sand and clay.	Cleared break on edge of Pericalymma ellipticum dense low heath C.	Track along E boundary of Geoff Brickwood Reserve, 0.9 km SSW of Byford, adjacent to Soldier's road, just N of small creek	27 11 1990
PERTH 05427452	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Flat. Moist, grey, sandy clay. Pinjarra Plain?	Heath. Characteristic species: Marri, other Synaphea.	Hall Road, Serpentine	01 09 1999
PERTH 07463723	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Brown, moist clay loam. Area between road and rail.	Shrubland with Xanthorrhoea preissii, Kingia australis, Dryandra nivea, Conospermum huegelii, Synaphea petiolaris, Mesomelaena tetragona, Gompholobium marginatum, Conostylis, Laxmannia, Drosera, Restionaceae spp. and weeds - Aira cupaniana, Ursinia anthe	4.65 km S of Abernathy Road rail crossing on Soldiers Road, S of Cardup siding	29 10 2003
PERTH 07463758	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Flora Road reserve. Moist brown clay loam.	Open Hakea and Melaleuca shrubland on edge of Corymbia calophylla remnant woodland. Associated species: Synaphea petiolaris (RB 1075), S. sp. Serpentine (G.R. Brand 103) (RB 1076), 3 x Verticordia spp., Pimelea, Xanthorrhoea preissii, Kingia australis, C	2.1 km W of rail crossing at Mundijong on Mundijong Road; W of Mundijong	18 10 2003
PERTH 07463871	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Brown, moist clay loam. Area between road and rail.	Shrubland with Xanthorrhoea preissii, Kingia australis, Dryandra nivea, Conospermum huegelii, Synaphea petiolaris, Mesomelaena tetragona, Gompholobium marginatum, Conostylis, Laxmannia, Drosera, Restionaceae spp. and weeds - Aira cupaniana, Ursinia anthe	4.65 km S of Abernathy Road rail crossing on Soldiers Road, S of Cardup siding	29 10 2003
PERTH 05140056	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Flat, litter yellow sand. Bassendean sand / Ridgehill shelf.	Woodland, Jarrah, Marri.	Brandale Park, Whitby,	19 08 1997
PERTH 05125820	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	In sandy loam.	In Jarrah - Marri woodland on road verges.	Just N of Mundijong, in Paterson Road,	25 10 1993
PERTH 07463693	Synaphea sp. Pinjarra Plain (A.S. George 17182)	1	Seasonally wet area. Brown loam.	Shrubland. Sedges, grasses, Xanthorrhoea, Allocasuarina, Jacksonia, Calothamnus.	Mundijong Road, 2 km W of South West Highway	26 10 1999
PERTH 04923022	Synaphea sp. Serpentine (G.R. Brand 103)	3	Orange brown clay. Topography/drainage: Seasonally wet poorly drained flat. Geomorphology: Guildford formation (pinjarra plain).	Melalueca uncinata Open Scrub over Verticordia plumosa Dwarf Scrub D over mixed Open Herbs over Leptocarpus canus, Chorizandra enodes Open Low Sedges.	Roadside remnant Mundijong Rd, 2 km W of Mundijong (adj. to plot mud-9)	07 08 1992
PERTH 05297133	Synaphea sp. Serpentine (G.R. Brand 103)	3	Brown sandy clay.		1.3 km W of Mundijong along Watkins Road,	21 09 1998

SHEET_NO	SPECIES	CONSCODE	SITE	VEGETATION	LOCALITY	DATE_
PERTH 04931017	Synaphea sp. Serpentine (G.R. Brand 103)	3	Wetland. Seasonally moist, littered black clay.	Dense Heath B.	Mundijong Road, 200 m E of intersection with Kargotich Road	06 11 1997
PERTH 05427487	Synaphea sp. Serpentine (G.R. Brand 103)	3	Flat. Wet, grey sand clay. Pinjarra Plain?	Heath. Characteristic species: Marri, Synaphea petiolaris?	Hall Road, Serpentine,	01 09 1999
PERTH 07463561	Synaphea sp. Serpentine (G.R. Brand 103)	3	Moist, brown, clay-loam.	Flora road. Open Melaleuca and Hakea shrubland on edge of Corymbia calophylla woodland remnant with Xanthorrhoea preissii, Kingia australis, Synaphea sp. Pinjarra Plain (A.S. George 17182), S. petiolaris, 3 x Verticordia spp., Pimelea, Dillwynia, Calotha	2.1 km W of rail crossing at Mundijong on Mundijong Road	18 10 2003
PERTH 07463588	Synaphea sp. Serpentine (G.R. Brand 103)	3	Rail reserve. Grey-very light brown, sandy loam.	Emergent Corymbia calophylla with understorey of Xanthorrhoea preissii, Kingia australis, Mesomelaena tetragona, Anigozanthos viridis, Synaphea petiolaris, Drosera and weed species Eragrostis curvula, Ehrharta calycina, Briza maxima.	5.25 km S of Abernathy Road rail crossing on Soldiers Road (ca 20 m N of Bishops Road), S of Cardup siding	
PERTH 04164911	Tetraria australiensis	T	Winter wet flats. Grey sand over clay.	Sedgeland and edging Marri woodland.	2 km E of Mundijong	04 01 1993
PERTH 05899133	Tetraria australiensis	T	Low plain. Moist sand-loam. New highway extension.	Marri/Kingias TEC 3a.	Mundijong Road, Mundijong, 150-250 m E of Webb Road on the southern side of Mundijong Road within flora/road reserve, Serpentine/Jarrahdale Shire,	03 12 2001
PERTH 05039274	Tetraria australiensis	T	Gentle slope, winter damp, brown clayey sand.	Eucalyptus calophylla woodland over sedges.	Mundijong townsite, beside Mundijong Road by tennis courts	23 06 1996
PERTH 06427669	Tetraria australiensis	T	Dune Ridge, gentle slope, W aspect, dark brown clayey sand over orange clayey sand, well drained.	Associated species: Eucalyptus marginata.	Private property in Norman Road Bushland (Bush Forever Site 354) South Western Highway, Whitby/Cardup, in System 6 Update quadrat norm02	01 11 1995
PERTH 06513328	Tetraria australiensis	T	Low dune, white and grey sand.	Scattered Eucalyptus calophylla over Banksia menziesii and Banksia attenuata Low Woodland over Tetraria australiensis Tall Sedges.	Watkins Road Reserve on N boundary between fire break and fence line. Watkins Road E of Mundijong (Bush Forever Site 360)	20 02 1996
PERTH 06532888	Tetraria australiensis	T	Low sand dune above a sumpland with exposed ironstone, grey sand.	Scattered Marri over Banksia menziesii and Banksia attenuata Low Woodland.	Private property adjacent to N boundary of Watkins Road Reserve, Mundijong (Bush Forever Site 360)	20 02 1996
PERTH 06532993	Tetraria australiensis	T	Dune flat, grey sand over sandy clay.	Mixed Low Heath D over Open Herbs and Low Sedges.a attenuata Low Woodland.	Watkins Road Reserve (on the low sandy rise to the NW of the original population), Mundijong (Bush Forever Site 360)	26 02 1996

SHEET_NO	SPECIES	CONSCODE	SITE	VEGETATION	LOCALITY	DATE_
PERTH 08124981	Tetraria australiensis	T	Very gentle slope with dry clayey sand.	Corymbia calophylla woodland over Xanthorrhoea preissii and Kingia australis over sedges. Associated vegetation include Corymbia calophylla, Kingia australis, Xanthorrhoea preissii, Hibbertia hypericoides, Tetaria octandra, Haemodorum sp., and grassy wee	Mudijong Townsite Lot 232, Mundijong. Population is scattered throughout the remnant vegetation to the S and W of the old tennis courts	09 12 2008
PERTH 08284628	Tetraria australiensis	T	Plain. Grey sand.	Open sedgeland amongst open Marri woodland. With Corymbia calophylla, Hakea sp., Kingia ausgtralis, Nuytsia floribunda, Stirlingia latifolia, Xanthorrhoea sp.	Watkins [Road] Nature Reserve, ca 250 m ENE of gate on Mundijong Road. Plant growing both sides of shire road	10 03 2010
PERTH 1057251	Verticordia lindleyi subsp. lindleyi	4	Dry summer swamp. Sandy white clay soil.	Heath type.	Abernethy Road, Oakford	23 03 1981
PERTH 1894242	Verticordia plumosa var. pleiobotrya	T	In clay on road verge.		Kargotich Road, S of Randell Road, SW of Mundijong	27 12 1988
PERTH 1883577	Verticordia plumosa var. pleiobotrya	T	Clay flat.	Low heath.	Mundijong road, 0.9 km E of Kargotich road, W of Mundijong	07 11 1986
PERTH 01894382	Verticordia plumosa var. pleiobotrya	T	In sand/clay.	With Marri, Jacksonia, Kingia and Xanthorrhoea.	Rockingham Road, Mundijong (near junction with Kargotich Road)	13 11 1988
PERTH 04521099	Verticordia plumosa var. pleiobotrya	T	Soil: Orange brown clay. Topography/drainage: Seasonally wet poorly drained flat. Geomorphology: Guildford formation (pinjarra plain).	Vegetation: Melalueca uncinata Open Scrub over Verticordia plumosa Dwarf Scrub D over mixed Open Herbs over Leptocarpus canus, Chorizandra enodes Open Low Sedges.	Roadside remnant Mundijong Rd, 2 km W of Mundijong (plot mud-9).	25 10 1992
PERTH 05290384	Verticordia plumosa var. pleiobotrya	T	Flat, damp - winter wet. Yellow sandy clay. Pinjarra Plain.	Shrubland, Verticordia sp., Viminaria juncea.	Between Kargotich (800 m E of) and Webb roads on Mundijong Road,	25 11 1998
PERTH 05580188	Verticordia plumosa var. pleiobotrya	T	Flat, roadside. Litter, brown sandy clay. Pinjarra plain.	Roadside vegetation. Acacia.	kargoyich road, 200 m N of Gossage Road, Mundijong,	30 11 1999
PERTH 07933983	Verticordia plumosa var. pleiobotrya	T	Low lying plain with brown clay / loam.	Low shrubland amongst Melaleuca shrubland to 2 m with Allocasuarina sp., Calothamnus sp., Hakea sp., Melaleuca sp., Verticordia densiflora and Viminaria juncea.	Mundijong Road, 0.7 km E of Kargotich Road	08 01 2008
PERTH 04363698	Verticordia plumosa var. pleiobotrya	T	Brown clay loam over laterite.	Calothamnus hirsutus/Verticordia low heath.	Mundijong Road; W of Mundijong	04 11 1992
PERTH 04931122	Verticordia plumosa var. pleiobotrya	T	Littered, brown clayey sand.	Roadside vegetation.	Kargotich Road, 4.9 km S of Thomas Road	06 11 1997
PERTH 1886851	Verticordia plumosa var. pleiobotrya	T	On sandy loam flat on road verge.	Among scrub.	Kargotich Road, 0.8 km S of Mundijong Road, W of Mundijong	07 11 1986

SHEET	SPNAME	CONSVCODE	POPID1	POPID2	VESTING	PURPOSE1	PURPOSE2	STATUS	OWNERDATE
	Acacia lasiocarpa var. bracteolata long peduncle								
5152	variant(G.J.Keighery 5026)		1	1	SHI				5/08/1982 0:00
7897	Baeckea sp. Perth Region (R.J. Cranfield 444)		3	2	SHI	VER			23/03/1981 0:00
7896	Baeckea sp. Perth Region (R.J. Cranfield 444)		3	4	SHI	VER	DRA		20/01/1992 0:00
7851	Dillwynia dillwynioides		3	3	PRI				15/06/1994 0:00
25828	Dillwynia dillwynioides		3	25	PRI				28/10/1993 0:00
48389	Drakaea elastica	T		22	PRI				31/08/2010 0:00
23667	Johnsonia pubescens subsp. cygnorum		2	1	CC	CFF			21/09/1988 0:00
23670	Johnsonia pubescens subsp. cygnorum		2	4	PRI				13/08/1992 0:00
23671	Johnsonia pubescens subsp. cygnorum		2	5	PRI				12/08/1992 0:00
42590	Tetraria australiensis	T		1 A	CC	CFF			1/12/2009 0:00
42591	Tetraria australiensis	T		1 B	SHI	SNN			27/09/2009 0:00
42592	Tetraria australiensis	T		1 C	RAI	UNK			8/02/2010 0:00
42666	Tetraria australiensis	T		5 A	PRI				8/02/2010 0:00
42667	Tetraria australiensis	T		5 B	PRI				8/02/2010 0:00
42589	Tetraria australiensis	T		8	SHI	REC			9/12/2008 0:00
42689	Tetraria australiensis	T		10	SHI	GVT			28/10/2009 0:00
6161	Verticordia lindleyi subsp. lindleyi		4	2	UNK				23/03/1981 0:00
16286	Verticordia plumosa var. pleiobotrya	T		1	SHI	VER			24/11/1999 0:00
16285	Verticordia plumosa var. pleiobotrya	T		2	SHI	VER			24/11/1999 0:00
16284	Verticordia plumosa var. pleiobotrya	T		3	SHI	VER			24/11/1999 0:00
16287	Verticordia plumosa var. pleiobotrya	T		7 A	SHI	DRA			28/03/2000 0:00
16288	Verticordia plumosa var. pleiobotrya	T		7 B	PRI				28/03/2000 0:00

APPENDIX 3

Naturemap Database Search

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Jackalyn Hams on 29/10/2012

Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115°57' 37" E,32°17' 17" S
Buffer	2km
Group By	Conservation Status

Conservation Status	Species	Records
Rare or likely to become extinct	3	13
Protected under international agreement	1	1
Priority 1	1	2
Priority 3	4	9
Priority 5	1	1
Non-conservation taxon	213	437
TOTAL	**223**	**463**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	1596	*Caladenia huegelii (Grand Spider Orchid)*		T	
2.	1033	*Tetraria australiensis*		T	
3.	12452	*Verticordia plumosa var. pleiobotrya*		T	
Protected under international agreement					
4.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
Priority 1					
5.	30751	*Synaphea sp. Pinjarra Plain (A.S. George 17182)*		P1	
Priority 3					
6.	7829	*Angianthus drummondii*		P3	
7.	20421	*Baeckea sp. Perth Region (R.J. Cranfield 444)*		P3	
8.	20462	*Jacksonia gracillima*		P3	
9.	28354	*Synaphea sp. Serpentine (G.R. Brand 103)*		P3	
Priority 5					
10.	24153	*Isoodon obesulus subsp. fusciventer (Quenda, Southern Brown Bandicoot)*		P5	
Non-conservation taxon					
11.	11519	*Acacia lasiocarpa var. bracteolata*			
12.	3442	*Acacia microbotrya (Manna Wattle)*			
13.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
14.	6205	*Actinotus leucocephalus (Flannel Flower)*			
15.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
16.	1734	*Allocasuarina microstachya*			
17.	197	*Amphipogon debilis*			
18.	200	*Amphipogon turbinatus*			
19.	24316	*Anas superciliosa (Pacific Black Duck)*			
20.	1416	*Anigozanthos viridis (Green Kangaroo Paw)*			
21.	24561	*Anthochaera carunculata (Red Wattlebird)*			
22.	7411	*Anthotium humile (Dwarf Anthotium)*			
23.	12724	*Anthotium junciforme*			
24.	1117	*Aphelia cyperoides*			
25.	20350	*Astartea affinis*			
26.	24319	*Biziura lobata (Musk Duck)*			
27.	1272	*Borya scirpoidea*			
28.	7867	*Brachyscome bellidioides*			
29.	244	*Briza maxima (Blowfly Grass)*	Y		
30.	245	*Briza minor (Shivery Grass)*	Y		
31.	1385	*Burchardia multiflora (Dwarf Burchardia)*			
32.	1276	*Caesia micrantha (Pale Grass-lily)*			
33.	1214	*Calectasia grandiflora (Blue Tinsel Lily)*			
34.	19307	*Calectasia grandiflora subsp. grandiflora*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
35.	36600	*Callitris pyramidalis (Swamp Cypress)*			
36.	5411	*Calothamnus hirsutus*			
37.	5441	*Calytrix aurea*			
38.	2951	*Cassytha flava (Dodder Laurel)*			
39.	2952	*Cassytha glabella (Tangled Dodder Laurel)*			
40.	1121	*Centrolepis aristata (Pointed Centrolepis)*			
41.	1130	*Centrolepis humillima (Dwarf Centrolepis)*			
42.	1132	*Centrolepis mutica*			
43.	1280	*Chamaescilla corymbosa (Blue Squill)*			
44.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
45.	763	*Chorizandra enodis (Black Bristlerush)*			
46.	6543	*Cicendia filiformis (Slender Cicendia)*	Y		
47.	24399	*Columba livia (Domestic Pigeon)*			
48.	25592	*Corvus coronoides (Australian Raven)*			
49.	7946	*Cotula cotuloides (Smooth Cotula)*			
50.	25595	*Cracticus tibicen (Australian Magpie)*			
51.	25596	*Cracticus torquatus (Grey Butcherbird)*			
52.	6663	*Cuscuta epithymum (Lesser Dodder)*	Y		
53.	768	*Cyathochaeta avenacea*			
54.	24322	*Cygnus atratus (Black Swan)*			
55.	283	*Cynodon dactylon (Couch)*	Y		
56.	815	*Cyperus tenellus (Tiny Flatsedge)*	Y		
57.	7454	*Dampiera linearis (Common Dampiera)*			
58.	3832	*Daviesia physodes*			
59.	1259	*Dianella revoluta (Blueberry Lily)*			
60.	306	*Dichelachne crinita (Longhair Plumegrass)*			
61.	7961	*Dittrichia graveolens (Stinkwort)*	Y		
62.	10791	*Diuris carinata (Bee Orchid)*			
63.	1632	*Diuris emarginata (Tall Donkey Orchid)*			
64.	3101	*Drosera heterophylla (Swamp Rainbow)*			
65.	3106	*Drosera macrantha (Bridal Rainbow)*			
66.	11853	*Drosera menziesii subsp. menziesii*			
67.	13216	*Drosera menziesii subsp. penicillaris*			
68.	8911	*Drosera rosulata*			
69.	347	*Ehrharta calycina (Perennial Veldt Grass)*	Y		
70.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
71.	29940	*Euphorbia maculata*	Y		
72.	34757	*Euphorbia prostrata*	Y		
73.	3880	*Eutaxia virgata*			
74.	25622	*Falco cenchroides (Australian Kestrel)*			
75.	25727	*Fulica atra (Eurasian Coot)*			
76.	1518	*Gladiolus angustus (Long Tubed Painted Lady)*	Y		
77.	1520	*Gladiolus caryophyllaceus (Wild Gladiolus)*	Y		
78.	3951	*Gompholobium marginatum*			
79.	12551	*Goodenia micrantha*			
80.	1964	*Grevillea bipinnatifida (Fuchsia Grevillea)*			
81.	2066	*Grevillea pilulifera (Woolly-flowered Grevillea)*			
82.	1464	*Haemodorum brevisepalum*			
83.	1468	*Haemodorum laxum*			
84.	1472	*Haemodorum simplex*			
85.	1475	*Haemodorum spicatum (Mardja)*			
86.	2137	*Hakea ceratophylla (Horned Leaf Hakea)*			
87.	2166	*Hakea incrassata (Marble Hakea)*			
88.	2179	*Hakea marginata*			
89.	2214	*Hakea trifurcata (Two-leaf Hakea)*			
90.	2216	*Hakea varia (Variable-leaved Hakea)*			
91.	24295	*Haliastur sphenurus (Whistling Kite)*			
92.	1068	*Harperia lateriflora*			
93.	5108	*Hibbertia acerosa (Needle Leaved Guinea Flower)*			
94.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
95.	12741	*Hyalosperma cotula*			
96.	6226	*Hydrocotyle callicarpa (Small Pennywort)*			
97.	6229	*Hydrocotyle diantha*			
98.	5817	*Hypocalymma angustifolium (White Myrtle)*			
99.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
100.	1070	*Hypolaena exsulca*			
101.	1503	*Hypoxis occidentalis*			
102.	11	*Isoetes drummondii (Quillwort)*			
103.	912	*Isolepis cyperoides*			
104.	14540	*Isolepis hystrix*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
105.	919	*Isolepis oldfieldiana*			
106.	4029	*Jacksonia sternbergiana (Stinkwood)*			
107.	1178	*Juncus bufonius (Toad Rush)*	Y		
108.	1180	*Juncus capitatus (Capitate Rush)*	Y		
109.	1221	*Kingia australis (Kingia)*			
110.	5835	*Kunzea micrantha*			
111.	17461	*Kunzea micrantha subsp. micrantha*			
112.	5841	*Kunzea recurva*			
113.	1307	*Laxmannia ramosa (Branching Lily)*			
114.	1309	*Laxmannia squarrosa*			
115.	1075	*Lepidobolus preissianus*			
116.	925	*Lepidosperma angustatum*			
117.	1088	*Lepyrodia macra (Large Scale Rush)*			
118.	1090	*Lepyrodia muirii*			
119.	6445	*Leucopogon squarrosus*			
120.	24581	*Lichenostomus virescens (Singing Honeyeater)*			
121.	7408	*Lobelia tenuior (Slender Lobelia)*			
122.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
123.	1232	*Lomandra micrantha (Small-flower Mat-rush)*			
124.	4059	*Lotus angustissimus (Narrowleaf Trefoil)*	Y		
125.	17683	*Meeboldina cana*			
126.	17678	*Meeboldina kraussii*			
127.	37580	*Melaleuca acutifolia*			
128.	36296	*Melaleuca armillaris subsp. armillaris*	Y		
129.	5926	*Melaleuca lateritia (Robin Redbreast Bush)*			
130.	5946	*Melaleuca pauciflora*			
131.	5978	*Melaleuca teretifolia (Banbar)*			
132.	5984	*Melaleuca uncinata (Broom Bush)*			
133.	5987	*Melaleuca viminea (Mohan)*			
134.	957	*Mesomelaena tetragona (Semaphore Sedge)*			
135.	4100	*Mirbelia spinosa*			
136.	7410	*Monopsis debilis*	Y		
137.	492	*Neurachne alopecuroidea (Foxtail Mulga Grass)*			
138.	2401	*Nuytsia floribunda (Christmas Tree)*			
139.	14292	*Oenothera stricta subsp. stricta*	Y		
140.	8133	*Olearia elaeophila*			
141.	4352	*Oxalis glabra*	Y		
142.	7090	*Parentucellia viscosa (Sticky Bartsia)*	Y		
143.	1550	*Patersonia occidentalis (Purple Flag)*			
144.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
145.	6006	*Pericalymma ellipticum (Swamp Teatree)*			
146.	16478	*Pericalymma ellipticum var. floridum*			
147.	20391	*Petrophile juncifolia*			
148.	2308	*Petrophile seminuda*			
149.	2311	*Petrophile squamata*			
150.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
151.	18529	*Philotheca spicata (Pepper and Salt)*			
152.	1172	*Philydrella drummondii*			
153.	1173	*Philydrella pygmaea (Butterfly Flowers)*			
154.	14306	*Philydrella pygmaea subsp. pygmaea*			
155.		*Phytophthora cinnamomi*			
156.	11404	*Pimelea imbricata var. major*			
157.	11402	*Pimelea imbricata var. piligera*			
158.	25704	*Podiceps cristatus (Great Crested Grebe)*			
159.	2419	*Polygonum aviculare (Wireweed)*	Y		
160.	6012	*Regelia ciliata*			
161.	1556	*Romulea rosea (Guildford Grass)*	Y		
162.	7619	*Scaevola lanceolata*			
163.	6263	*Schoenolaena juncea*			
164.	975	*Schoenus bifidus*			
165.	1002	*Schoenus nanus (Tiny Bog Rush)*			
166.	1006	*Schoenus odontocarpus*			
167.	1011	*Schoenus rigens*			
168.	1019	*Schoenus subflavus (Yellow Bog-rush)*			
169.	1026	*Schoenus unispiculatus*			
170.	8225	*Siloxerus humifusus (Procumbent Siloxerus)*			
171.	7022	*Solanum nigrum (Black Berry Nightshade)*	Y		
172.	1558	*Sparaxis bulbifera*	Y		
173.	4733	*Stackhousia monogyna*			
174.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
175.	30278	*Stylidium androsaceum*			
176.	7696	*Stylidium calcaratum (Book Triggerplant)*			
177.	7712	*Stylidium despectum (Dwarf Triggerplant)*			
178.	7713	*Stylidium dichotomum (Pins-and-needles)*			
179.	7717	*Stylidium divaricatum (Daddy-long-legs)*			
180.	7742	*Stylidium inundatum (Hundreds and Thousands)*			
181.	7749	*Stylidium leptophyllum (Needle-leaved Triggerplant)*			
182.	7773	*Stylidium petiolare (Horn Triggerplant)*			
183.	7782	*Stylidium pulchellum (Thumbelina Triggerplant)*			
184.	7790	*Stylidium roseoalatum (Pink-wing Triggerplant)*			
185.	7806	*Stylidium utricularioides (Pink Fan Triggerplant)*			
186.	24331	*Tadorna tadornoides (Australian Shelduck)*			
187.	1034	*Tetraria capillaris (Hair Sedge)*			
188.	1036	*Tetraria octandra*			
189.	1701	*Thelymitra antennifera (Vanilla Orchid)*			
190.	1705	*Thelymitra crinita (Blue Lady Orchid)*			
191.	24844	*Threskiornis molucca (Australian White Ibis)*			
192.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
193.	1328	*Thysanotus dichotomus (Branching Fringe Lily)*			
194.	1338	*Thysanotus manglesianus (Fringed Lily)*			
195.	1339	*Thysanotus multiflorus (Many-flowered Fringe Lily)*			
196.	1351	*Thysanotus sparteus*			
197.	1481	*Tribonanthes australis*			
198.	1482	*Tribonanthes brachypetala*			
199.	1485	*Tribonanthes violacea*			
200.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
201.	1362	*Tricoryne humilis*			
202.	1038	*Tricostularia neesii*			
203.	4292	*Trifolium campestre (Hop Clover)*	Y		
204.	4737	*Tripterococcus brunonis (Winged Stackhousia)*			
205.	1139	*Trithuria bibracteata*			
206.	8255	*Ursinia anthemoides (Ursinia)*	Y		
207.	38388	*Ursinia anthemoides subsp. anthemoides*	Y		
208.	6070	*Verticordia acerosa*			
209.	12388	*Verticordia acerosa var. preissii*			
210.	6076	*Verticordia densiflora (Compacted Featherflower)*			
211.	15432	*Verticordia densiflora var. densiflora*			
212.	6088	*Verticordia huegelii (Variegated Featherflower)*			
213.	15433	*Verticordia huegelii var. huegelii*			
214.	12430	*Verticordia huegelii var. stylosa*			
215.	6107	*Verticordia pennigera*			
216.	6110	*Verticordia plumosa (Plumed Featherflower)*			
217.	4325	*Viminaria juncea (Swishbush)*			
218.	724	*Vulpia myuros (Rat's Tail Fescue)*	Y		
219.	1566	*Watsonia marginata*	Y		
220.	1567	*Watsonia meriana (Bulbil Watsonia)*	Y		
221.	18118	*Watsonia meriana var. meriana*	Y		
222.	1256	*Xanthorrhoea preissii (Grass tree)*			
223.	25765	*Zosterops lateralis (Grey-breasted White-eye)*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX 4

Protected Matters Search Tool Search

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

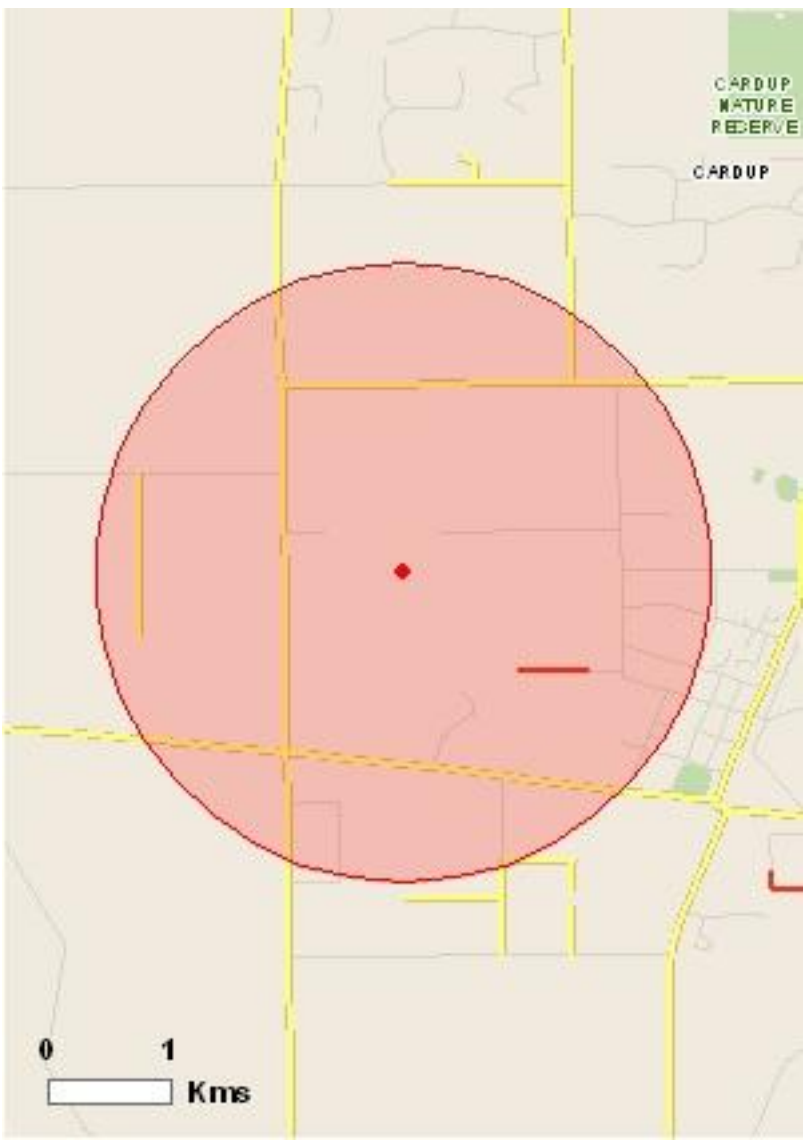
EPBC Act Protected Matters Report

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.

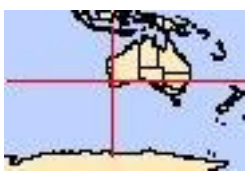
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 29/10/12 17:19:37



Coordinates

Buffer: 2.5Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	18
Listed Migratory Species:	9

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	6
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	16
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (RAMSAR) [Resource Information]

Name	Proximity
Peel-yalgorup system	Upstream from Ramsar

Listed Threatened Ecological Communities [Resource Information]

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.

Name	Status	Type of Presence
Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain	Endangered	Community known to occur within area
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area
Claypans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calyptorhynchus banksii naso		
Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii		
Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Roosting known to occur within area
Calyptorhynchus latirostris		
Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Leipoa ocellata		
Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
Insects		
Synemon gratiosa		
Graceful Sun Moth [66757]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Mammals		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Phascogale calura Red-tailed Phascogale [316]	Endangered	Species or species habitat may 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
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leaved Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus balanites Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area
Synaphea sp. Fairbridge Farm (D.Papenfus 696) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat likely to occur within area
Verticordia plumosa var. pleiobotrya Narrow-petalled Featherflower [55803]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Leipoa ocellata		
Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may 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
Rostratula benghalensis (sensu lato)		
Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Mammals		
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur 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 sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat may 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
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		Species or species

Name	Status	Type of Presence
Sterile Pussy Willow [68497]		habitat likely to occur within area
[Salvinia molesta](#) Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
[Tamarix aphylla](#) Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area

Coordinates

-32.28258 115.96119

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 5

DEC Fauna Database Searches

NAME	SOURCE_CODE	SOURCE_ID	NAME_ID	FAMILY	GENUS	SPECIES	INFRARANK	INFRANAME	AUTHOR	VERNACULAR	KINGDOM	CONSERVATION_CODE	CLASS	DAY	MONTH	YEAR	LOCALITY_NAME	LOCALITY_POSTCODE	SITE_NAME
Calyptorhynchus banksii subsp. naso	TFAUNA	1505	24731	Psittacidae	Calyptorhynchus	banksii	subsp.	naso	Gould	Forest Red-tailed Black-Cockatoo	Animalia	T	BIRD	12	12	1997	CARDUP	6122	Cardup Nature Reserve
Calyptorhynchus baudinii	BIRDATLAS1	79564	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	14	07	1978	OLDBURY	6121	
Calyptorhynchus baudinii	BIRDATLAS2	1026019	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	10	02	2005	MUNDIJONG	6123	Tonkin Street Flora Reserve
Calyptorhynchus baudinii	BIRDATLAS2	328106	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	26	10	1996	MARDELLA	6125	Ti-tree thicket
Calyptorhynchus baudinii	BIRDATLAS2	673816	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	21	09	2002	WHITBY	6123	Manjedal Brook
Calyptorhynchus baudinii	BIRDATLAS2	673826	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	20	11	2002	WHITBY	6123	Manjedal Brook
Calyptorhynchus baudinii	BIRDATLAS2	915385	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	26	10	2006	WHITBY	6123	Whitby
Calyptorhynchus baudinii	TFAUNA	12200	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	22	09	2005	MUNDIJONG	6123	Mundijong
Calyptorhynchus baudinii	WAMSPECIMENS	A36109	24733	Psittacidae	Calyptorhynchus	baudinii			Lear	Baudin's Cockatoo	Animalia	T	BIRD	22	09	2005	MUNDIJONG	6123	
Calyptorhynchus latirostris	BIRDATLAS2	673825	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo	Animalia	T	BIRD	20	10	2002	WHITBY	6123	Manjedal Brook
Calyptorhynchus latirostris	BIRDATLAS2	915384	24734	Psittacidae	Calyptorhynchus	latirostris			Carnaby	Carnaby's Cockatoo	Animalia	T	BIRD	26	10	2006	WHITBY	6123	Whitby
Dasyurus geoffroii	TFAUNA	3090	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Western Quoll	Animalia	T	MAMMAL	05	05	2000	MARDELLA	6125	Lowlands property near Serpentine
Dasyurus geoffroii	TFAUNA	6783	24092	Dasyuridae	Dasyurus	geoffroii			Gould	Western Quoll	Animalia	T	MAMMAL	28	04	2000	MARDELLA	6125	Lowlands property (LL1)
Phascogale tapoatafa subsp. ssp. (WAM M434)	TFAUNA	7688	34045	Dasyuridae	Phascogale	tapoatafa	subsp.	ssp. (WAM M434)	Meyer	Brush-tailed Phascogale	Animalia	T	MAMMAL	27	12	2003	MUNDIJONG	6123	1255 Kargotich Rd, Mundijong. On the NE corner at the intersection with Mundijong Rd
Setonix brachyurus	WAMSPECIMENS	M7684	24145	Macropodidae	Setonix	brachyurus			(Quoy & Gaimard)	Quokka	Animalia	T	MAMMAL	25	08	1967	CARDUP	6122	ALBANY HIGHWAY
Falco peregrinus	BIRDATLAS2	672518	25624	Falconidae	Falco	peregrinus			Tunstall	Peregrine Falcon	Animalia	S	BIRD	13	04	2003	WHITBY	6123	Manjedal Brook
Morelia spilota subsp. imbricata	WAMSPECIMENS	R11812	25240	Boidae	Morelia	spilota	subsp.	imbricata	(Smith)	Carpet Python	Animalia	S	REPTILE				MARDELLA	6125	MUNDIJONG
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96037	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	16	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96038	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	16	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96039	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	16	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96040	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	16	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96042	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	16	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96044	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	17	04	2010	CARDUP	6122	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96046	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	17	04	2010	CARDUP	6122	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96048	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	17	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96052	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	17	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96053	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	17	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96057	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	18	04	2010	CARDUP	6122	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96058	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	18	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96060	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	18	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96062	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	19	04	2010	CARDUP	6122	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96063	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	19	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96064	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	19	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96065	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	19	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96066	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	19	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	FAUNASURVEY	96068	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	19	04	2010	WHITBY	6123	Whitby - Norman Road Bushland
Isoodon obesulus subsp. fusciventer	TFAUNA	10399	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	30	10	2005	CARDUP	6122	South Western Hwy, 100m N of Shale Rd
Isoodon obesulus subsp. fusciventer	TFAUNA	1506	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	12	12	1998	CARDUP	6122	Cardup Nature Reserve
Isoodon obesulus subsp. fusciventer	TFAUNA	7689	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL	09	01	2004	MUNDIJONG	6123	1255 Kargotich Rd, Mundijong. On the NE corner at the intersection with Mundijong Rd
Isoodon obesulus subsp. fusciventer	WAMSPECIMENS	M2896	24153	Peramelidae	Isoodon	obesulus	subsp.	fusciventer	(Gray)	Southern Brown Bandicoot	Animalia	S	MAMMAL				MUNDIJONG	6123	
Ardeotis australis	WAMSPECIMENS	A1020	24610	Otididae	Ardeotis	australis			(J.E. Gray)	Australian Bustard	Animalia	4	BIRD				MUNDIJONG	6123	
Westralunio carteri	FAUNASURVEY	138689	34113	Hyriidae	Westralunio	carteri					Animalia	4	INVERT	15	11	2009	WHITBY	6123	Harvey River
Westralunio carteri	FAUNASURVEY	138696	34113	Hyriidae	Westralunio	carteri					Animalia	4	INVERT	24	06	2010	WHITBY	6123	Mandejal Brook
Acanthophis antarcticus	TFAUNA	16184	25242	Elapidae	Acanthophis	antarcticus			(Shaw & Nodder)	Southern Death Adder	Animalia	3	REPTILE	01	01	1957	BYFORD	6122	Byford
Acanthophis antarcticus	WAMSPECIMENS	R12374	25242	Elapidae	Acanthophis	antarcticus			(Shaw & Nodder)	Southern Death Adder	Animalia	3	REPTILE			1957	BYFORD	6122	BYFORD
Arbanitis inornatus	TFAUNA	13030	33903	Idiopidae	Arbanitis	inornatus				trapdoor spider	Animalia	1	INVERT	01	09	2006	WHITBY	6123	southern creekline on Lots 22,23&29 Norman Rd/Sth Hwy Whitby. Bush Forever Site 354

APPENDIX 6

Aboriginal Heritage Enquiry System Search Results

Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Search Criteria

6 sites in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 50	
Northing	Easting
6426000	401222
6429699	403189

Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

Copyright

Legend

Restriction

N	No restriction
M	Male access only
F	Female access

Access

C	Closed
O	Open
V	Vulnerable

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

[Reliable]	The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.
[Unreliable]	The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information reported.

Status

L - Lodged		ACMC Decision Made
Information lodged, awaiting assessment	→	R - Registered Site I - Insufficient information S - Stored Data

Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of sites, especially for sites with an access code “closed” or “vulnerable”. Map coordinates (Lat/Long) 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. '5000000:Z50' means Easting=5000000, Zone=50.

Sites Shown on Maps

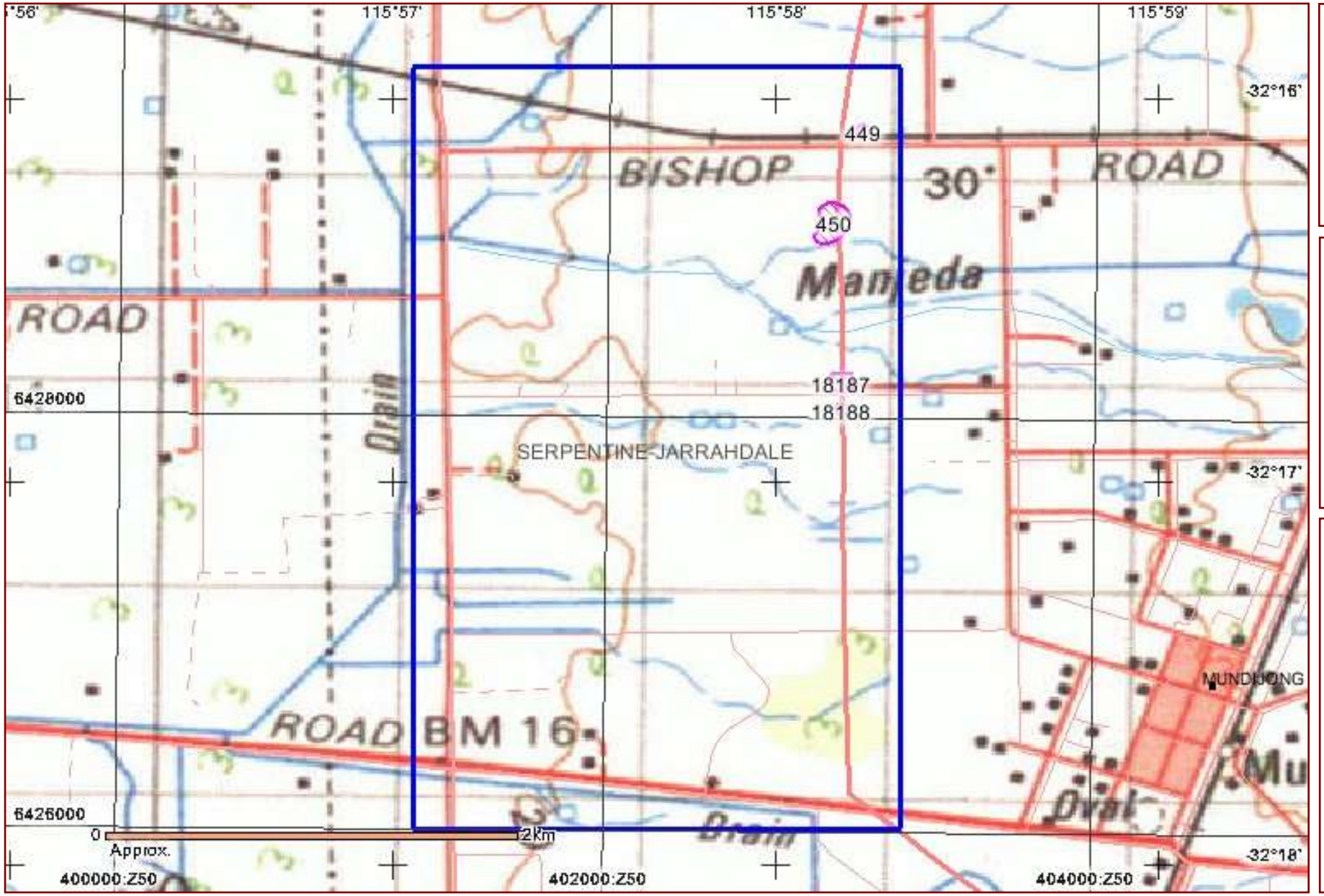
Site boundaries may not appear on maps at low zoom levels

List of 4 Registered Aboriginal Sites with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
449	R	O	N	South-East Corridor 02	Artefacts / Scatter			403039mE 6429389mN Zone 50 [Reliable]	S02954
450	R	O	N	South-East Corridor 03	Artefacts / Scatter			402915mE 6428941mN Zone 50 [Reliable]	S02955
18187	R	O	N	Tonkin Highway - Mundijong Road Scatter # 11	Artefacts / Scatter			402958mE 6428173mN Zone 50 [Reliable]	
18188	R	O	N	Tonkin Highway - Mundijong Road Scatter # 12	Artefacts / Scatter			402961mE 6428042mN Zone 50 [Reliable]	

Aboriginal Heritage Inquiry System

Aboriginal Sites Database



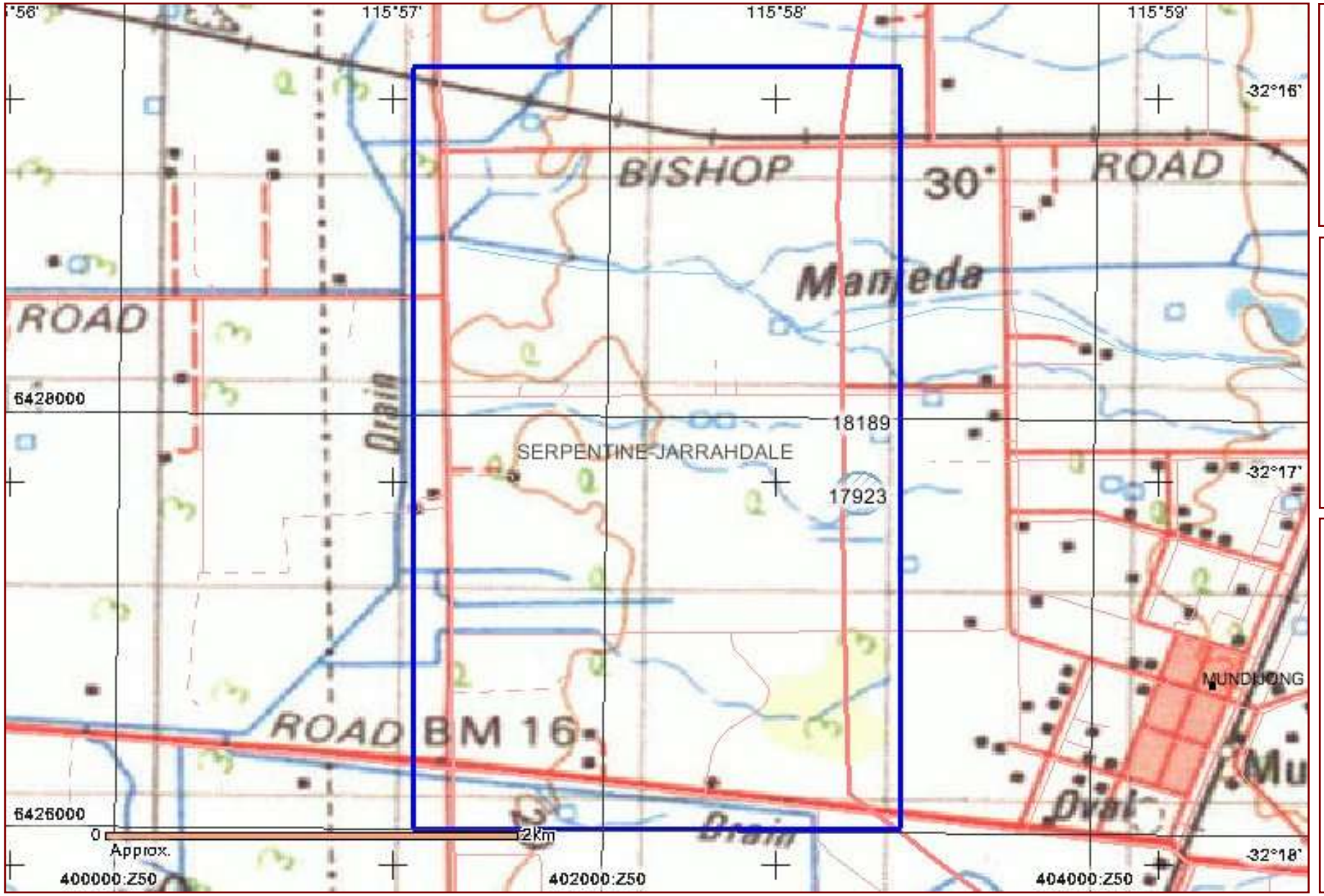
Legend

Selected Heritage Sites

- Registered Sites
- Town
- Map Area
- Search Area

List of 2 Other Heritage Places with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
17923	S	O	N	If #2	Artefacts / Scatter			403038mE 6427638mN Zone 50 [Reliable]	
18189	S	O	N	Tonkin Highway - Mundijong Road Scatter # 13	Artefacts / Scatter			403043mE 6427990mN Zone 50 [Reliable]	



Legend

Selected Heritage Sites

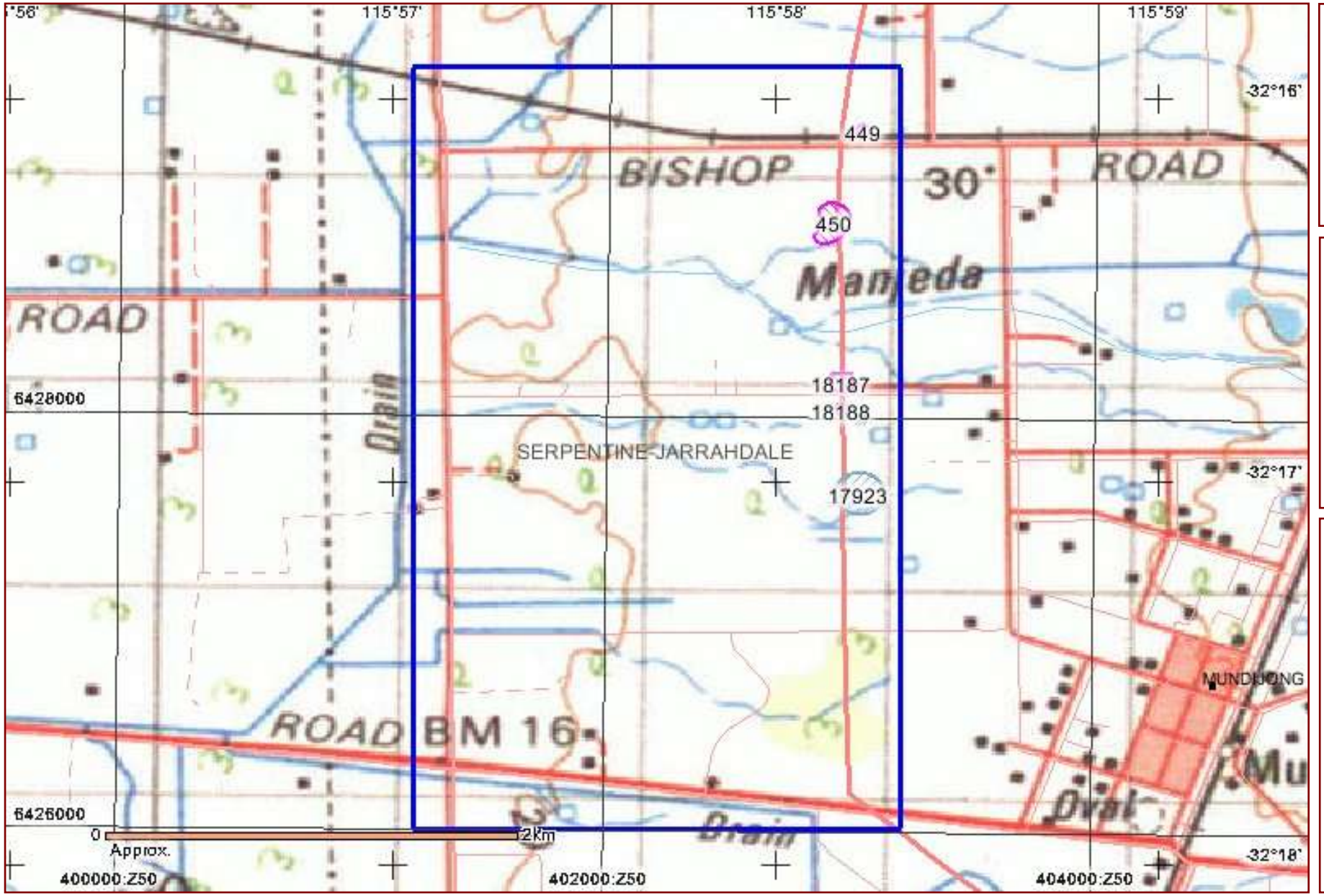
Other Heritage Places

Town

Map Area

Search Area

Map Showing Registered Aboriginal Sites and Other Heritage Places



Legend

Selected Heritage Sites

- Registered Sites
- Other Heritage Places
- Town
- Map Area
- Search Area

Aboriginal Heritage Inquiry System

Heritage Survey Database

Search Criteria

7 surveys in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 50	
Northing	Easting
6425985	401217
6429698	403213

Disclaimer

Heritage Surveys have been mapped using information from the reports and / or other relevant data sources. Heritage Surveys consisting of small discrete areas may not be visible except at large scales. Reports shown may not be held at DIA. Please consult report holder for more information. Refer to www.dia.wa.gov.au/heritage for information on requesting reports held by DIA.

Copyright

Legend

Access

Some reports are restricted. The type of restriction is shown as a code in brackets following the catalogue number. No code indicates an unrestricted report.

[CLOSED]	Closed
[OWE]	Open with exception
[TBD]	To be determined
[RESTRICTED PENDING]	Restricted pending

Survey 2848

Project	Tonkin Highway Extension, Albany Highway to South Western Highway, Mundijong.
Start Date	31 Jul 2001
Proponents	Main Roads Western Australia Western Infrastructure
Consultants	Australian Interaction Consultants
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
105723	HSR MW 2001 PAR	Consultation for a Section 18 Application under the Aboriginal Heritage Act (1972) of the Proposed route of the Tonkin Highway Extension Albany Highway/Mills Road West, Martin, to South Western Highway, Mundijong	Ronald T. Parker	DIA

Survey 2784

Project	Tonkin Highway Extension, Mills Road West, Martin to South Western Highway, Mundijong.
Start Date	28 Jan 1999
Proponents	Main Roads Western Australia
Consultants	BSD Consultants
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
19122	HSR MW 2001 BSD [OWE]	Summary report section 18 notice to disturb Aboriginal Sites : Tonkin Highway extension Mills Road West, Martin to South Western Highway, Mundijong	BSD Consultants	DIA

Survey 2682

Project	Tonkin Highway Extension and Mundijong Road Realignment.
Start Date	03 Dec 1998
Proponents	BSD Consultants Main Roads Western Australia
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
19121	HSR MW 1999 EDW [OWE]	Report of an Aboriginal Heritage Survey : proposed Tonkin Highway extension and Mundijong Road Realignment Project	Adele Millard C. Coomer E. McDonald K. Edwards Andrea Staub E. Pollard Guida Coventry	DIA

Survey 2563

Project	South-East Corridor Structure Plan.
Start Date	21 Jun 1995
Proponents	Ministry for Planning
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Survey 2563 (continued)

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
102051	HSR MW 1996 BLO	Revised Report of an Aboriginal Heritage Survey South-East Corridor Structure Plan. March. 1996.	A. Murphy Clint Hammond E. Blockley E. McDonald K. Edwards Paul Greenfeld	DIA
17927	HSR SW 1995 BLO [CLOSED]	List of Informants (For Report 95/139). Oct. 1995.	McDonald, Hales and Associates Pty Ltd	

Survey 3641

Project	South-East Corridor Structure Plan.
Start Date	21 Jun 1995
Proponents	Minister for Planning and Infrastructure
Consultants	McDonald, Hales and Associates Pty Ltd
Survey Types	Archaeological and Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
101972	HSR SW 1995 BLO [OWE]	Report of an Aboriginal Heritage Survey, South-East Corridor Structure Plan. Oct.1995	Clint Hammond E. Blockley Paul Greenfeld	DIA

Survey 3737

Project	Ballaruk, (Traditional Owners of Whadjuk territory) Site Recording Project
Start Date	01 Jan 1994
Proponents	Heritage Council of Western Australia
Consultants	Tamora Pty Ltd
Survey Types	Ethnographic
Aboriginal People Consulted?	Yes

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
21817	HSR MW 1994 MAC	Ballaruk (traditional owners) Aboriginal site recording project	Barrie Machin	Department of Indigenous Affairs
21818	HSR MW 1995 MAC	Ballaruk (traditional owners of Whadjuk territorial boundaries the lands of the Ballaruk Peoples) Aboriginal site recording project : additional material	Barrie Machin	

Survey 2274

Project	The Perth Area.
Start Date	01 Apr 1970
Proponents	University of Western Australia
Consultants	University of Western Australia
Survey Types	Archaeological and Archaeological and Ethnographic
Aboriginal People Consulted?	No

Related Reports

Report ID	Catalogue Number	Title	Recorders	Held At
103564	HSR MW 1972 UWA	An Archaeological Survey Project: The Perth Area, Western Australia. Apr 1972.	University of Western Australia H. Polach	DIA

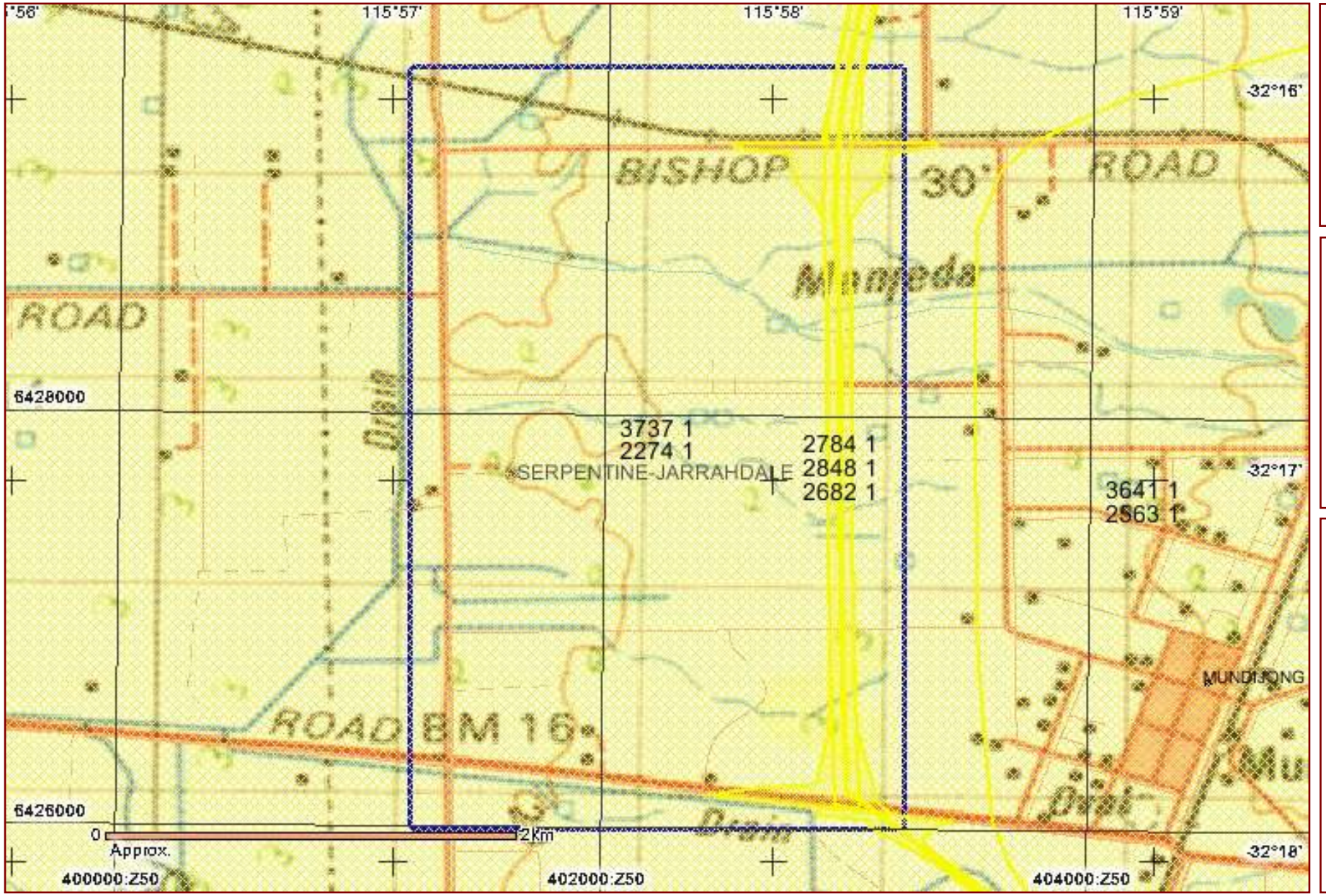
Survey 2274 (continued)

Related Reports (continued)

Report ID	Catalogue Number	Title	Recorders	Held At
104023	Not in Catalogue	An Archaeological Survey Project. The Perth Arch. Area. Western Australia Report no.4 April 1971.	University of Western Australia H. Polach	DIA

Aboriginal Heritage Inquiry System

Heritage Survey Database



Legend

Selected Heritage Surveys

- Heritage Survey
- Town
- Map Area
- Search Area

APPENDIX 7

West Mundijong Preliminary Environmental Noise Assessment

(Herring Storer, 2012)

Rochdale Holdings Pty Ltd A.B.N. 85 009 049 067 trading as:
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SHIRE of SERPENTINE-JARRAHDALE

WEST MUNDIJONG INDUSTRIAL AREA

PRELIMINARY ENVIRONMENTAL NOISE ASSESSMENT

AUGUST 2012

OUR REFERENCE: 15033-4-12113

DOCUMENT CONTROL PAGE

ENVIRONMENTAL NOISE ASSESSMENT
WEST MUNDIJONG

Job No: 12113

Document Reference: 15033-4-12113

FOR

SHIRE of SERPENTINE JARRAHDALE

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Author:	P. Daly / T. Reynolds	**Checked By:**	G. Watts
Date of Issue :	17 August 2012		

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1	Added Appendix C	12/09/2012	PLD	
2	Include comments from Shire of Serp / Jarrah	04/10/2012	TR	
3	Additional comments from Shire of Serp / Jarrah	10/10/2012	PV – SJS	TR

DOCUMENT DISTRIBUTION

Copy No.	Version No.	Destination	Hard Copy	Electronic Copy
1	1	Shire of Serp / Jarrah		✓
2	1	TME		✓
1	2	Shire of Serp / Jarrah		✓
2	2	TME		✓
1	3	Shire of Serp / Jarrah		✓
2	4	TME		✓
1	4	Shire of Serp / Jarrah		✓

CONTENTS

APPENDICIES

1.0 INTRODUCTION

Herring Storer Acoustics have been engaged by TME to develop an acoustic model to predict noise emissions for possible development of the West Mundijong Industrial Area on behalf of the Shire of Serpentine-Jarrahdale.

The objective of this study was to predict noise emissions from possible future industries and determine the maximum noise level for possible industries that will comply with the requirements of the *Environmental Protection (Noise) Regulations 1997*.

The proposed development is based on the use of 'non heavy industry' at West Mundijong. The Feasibility Assessment recommended a range of general industry uses including, but not limited to the following:

a) Agribusiness, including food distribution;
b) Warehousing and logistics;
c) Transport, heavy machinery sales, servicing and distribution;
d) Service industry, light industry and limited showroom development; and,
e) Manufacture and fabrication of building products i.e. plasterboard, lime production and brickworks

The 'representative industry' sound power emissions are based on typical industry spectrum and are considered a conservative indication of the expected noise emissions. Generally, new industrial plants are designed to control noise emissions and minimise internal noise levels for occupational health reasons.

Although outside the scope of this acoustic study, comment is also provided on compliance criteria of the possible freight railway.

2.0 ACOUSTIC CRITERIA

2.1 ENVIRONMENTAL PROTECTION (NOISE) REGULATIONS 1997

The criteria used are in accordance with the *Environmental Protection (Noise) Regulations 1997 (as amended)*. These regulations stipulate maximum allowable external noise levels determined by the calculation of an influencing factor, which is then added to the base levels shown below. The influencing factor is calculated for the usage of land within the two circles, having radii of 100m and 450m from the premises of concern. The baseline assigned noise levels for the different types of receivers and during the different periods of the day are listed in Table 2.1.

TABLE 2.1 - BASELINE ASSIGNED OUTDOOR NOISE LEVEL

Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Within 15m of a noise sensitive premises building	0700 - 1900 hours Monday to Saturday	45	55	65
	0900 - 1900 hours Sunday and Public Holidays	40	50	65
	1900 - 2200 hours all days	40	50	55
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	35	45	55
Further than 15m from a noise sensitive premises building	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and utility premises	All hours	65	80	90

Note: The L_{A10} noise level is the noise that is exceeded for 10% of the time.
The L_{A1} noise level is the noise that is exceeded for 1% of the time.
The L_{Amax} noise level is the maximum noise level recorded.

As this is an initial assessment of noise levels, future zoning is yet to be implemented. Information provided by the shire is that the west and north surrounding areas will be zoned rural for up to 1km from the boundary of the Area. This land area has limited residential properties and it will be protected from high-density residential development by the proposed zoning.

For locations to the east outside the industrial Area (as it is understood that the land would be zoned industrial to the edge of the Area) the influencing factor would range around 8 for those adjacent to the industrial Area to 0 for those residences located at a greater distance of 450 metres from the boundary of the Area. This influencing factor also considers the future development of the Tonkin Highway, which will be located between residents and the industrial Area. It is also understood that the land on the eastern boundary is proposed for high-density residential development, up to the Tonkin Highway, bringing noise sensitive premises to within 100m of the industrial Area. The critical location for compliance, due to how the influencing factor is determined, would be those residence located at just over 100 metres from the edge of the industrial Area. At these residences, the influencing factor would be around 3. The range of assigned noise levels is listed in Table 2.2, with the assigned noise levels for the critical residential locations (i.e. to the east of Tonkin Highway, at 100 metre from the edge of the Area) listed in Table 2.3.

TABLE 2.2 – BASELINE ASSIGNED OUTDOOR NOISE LEVEL

Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Within 15m of a noise sensitive premises building	0700 - 1900 hours Monday to Saturday	45 – 53	55 – 63	55 – 73
	0900 - 1900 hours Sunday and Public Holidays	40 – 48	50 – 58	65 – 73
	1900 - 2200 hours all days	40 – 48	50 – 58	55 – 63
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	35 – 43	45 – 53	55 – 63
Further than 15m of a noise sensitive premises building	All hours	60	75	80
Commercial premises	All hours	60	75	80

Note: The L_{A10} noise level is the noise that is exceeded for 10% of the time.
The L_{A1} noise level is the noise that is exceeded for 1% of the time.
The L_{Amax} noise level is the maximum noise level recorded.

TABLE 2.3 – ASSIGNED OUTDOOR NOISE LEVEL AT CRITICAL LOCATIONS

Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Within 15m of a noise sensitive premises building	0700 - 1900 hours Monday to Saturday	48	58	68
	0900 - 1900 hours Sunday and Public Holidays	43	53	68
	1900 - 2200 hours all days	43	53	58
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	38	48	58

Note: The L_{A10} noise level is the noise that is exceeded for 10% of the time.
The L_{A1} noise level is the noise that is exceeded for 1% of the time.
The L_{Amax} noise level is the maximum noise level recorded.

For other locations, it is understood that it is proposed that there be a 1000-metre buffer zone around the industrial area. Therefore, at any residence at the edge of the buffer zone, being greater than 450 metres from the industrial area, the influencing factor would be 0 and the assigned outdoor noise levels would be as listed in Table 2.4.

TABLE 2.4 - ASSIGNED OUTDOOR NOISE LEVEL AT BUFFER BOUNDARY

Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Within 15m of a noise sensitive premises building	0700 - 1900 hours Monday to Saturday	45	55	65
	0900 - 1900 hours Sunday and Public Holidays	40	50	65
	1900 - 2200 hours all days	40	50	65
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and Public Holidays	35	45	55
Further than 15m of a noise sensitive premises building	All hours	60	75	80

Note: The L_{A10} noise level is the noise that is exceeded for 10% of the time.
The L_{A1} noise level is the noise that is exceeded for 1% of the time.
The L_{Amax} noise level is the maximum noise level recorded.

Under the Regulations it is also a requirement that noise from the site be free of annoying characteristics (tonality, modulation and impulsiveness) at other premises, defined below as per Regulation 9.

"impulsiveness" means a variation in the emission of a noise where the difference between L_{Apeak} and $L_{Amax\ Slow}$ is more than 15 dB when determined for a single representative event;

"modulation" means a variation in the emission of noise that –

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

(b) is present for more at least 10% of the representative assessment period; and

(c) is regular, cyclic and audible;

"tonality" means the presence in the noise emission of tonal characteristics where the difference between –

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

(b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands,

is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels.

Where the above characteristics are present and cannot be practicably removed, the adjustments as listed in Table 2.5 are made to the measured or predicted level at other premises.

TABLE 2.5 - ADJUSTMENTS TO MEASURED LEVELS

Where **tonality** is present	Where **modulation** is present	Where **impulsiveness** is present
+5 dB(A)	+5 dB(A)	+10 dB(A)

Note: These adjustments are cumulative to a maximum of 15 dB

With respect to residential receivers, noise emissions may be tonal in characteristic, particularly under conditions where received noise levels are predicted to be above 35 dB(A). Under strong wind conditions, the generation of local noise from trees and the like will generally mask plant noise emissions and will most likely not have a measurable 'tonal' characteristic. The most significant acoustic parameter is the L_{A10} noise level.

For the case of an industrial estate such as West Mundijong, it is expected that more than one individual industry will contribute to noise levels at noise sensitive premises surrounding the estate. Should the cumulative noise emission approach the 'assigned level' under the regulations, then the requirements of Regulation 7(2) apply. This sub-regulation is:

*7(2) For the purposes of sub-regulation (1)(a), a noise emission is taken to "**significantly contribute to**" a level of noise if the noise emission as determined under sub-regulation (3) exceeds a value which is 5 dB below the assigned level at the point of reception.*

Thus, under the requirements of the *Environmental Protection (Noise) Regulations 1997* there are two criteria that can be used to achieve compliance with the Regulations. The first is the overall noise level received from all industries. In this case, if the overall noise level received at premises complies with the applicable assigned noise level (L_{A10} during the night period of between 35 – 43 dB(A) depending on locations), then noise emissions from all industries would be deemed to comply with the requirements of the Regulations. However, if the overall noise level received at premises exceeds the applicable noise level, compliance will still be achieved, if the noise received at a premises from an individual industry is at least 5 dB(A) below the applicable assigned noise level.

We believe any new industry would need to be considered NOT significantly contributing. Therefore, noise received at any residence (including possible future residence) would need to be 5 dB(A) below the assigned noise level. For this Industrial Area (i.e. east of Tonkin Highway), the critical location for compliance would be residences located at 100 metres from the edge of the Area and the L_{A10} noise level received at these residences needs to be less than 33 dB(A), this being the assigned night period noise level of 38 dB(A) less 5 dB(A). For other locations, the L_{A10} noise level received at a residence needs to be less than 30 dB(A) (i.e. the night period L_{A10} noise level of 35 dB(A) less 5 dB(A)).

2.2 STATE PLANNING POLICY 5.4

The Western Australian Planning Commission (WAPC) released on 22 September 2009 State Planning Policy 5.4 *"Road and Rail Transport Noise and Freight Considerations In Land Use Planning"*. Section 5.3 – Noise Criteria, which outlines the acoustic criteria, states:

"5.3 - NOISE CRITERIA

Table 1 sets out the outdoor noise criteria that apply to proposals for new noise-sensitive development or new major roads and railways assessed under this policy.

These criteria do not apply to—

- *proposals for redevelopment of existing major roads or railways, which are dealt with by a separate approach as described in section 5.4.1; and*
- *proposals for new freight handling facilities, for which a separate approach is described in section 5.4.2.*

The outdoor noise criteria set out in Table 1 apply to the emission of road and rail transport noise as received at a noise-sensitive land use. These noise levels apply at the following locations—

- *for new road or rail infrastructure proposals, at 1m from the most exposed, habitable façade of the building receiving the noise, at ground floor level only; and*
- *for new noise-sensitive development proposals, at 1m from the most exposed, habitable façade of the proposed building, at each floor level, and within at least one outdoor living area on each residential lot.*

Further information is provided in the guidelines.

Table 1: Outdoor Noise Criteria

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

The 5 dB difference between the outdoor noise target and the outdoor noise limit, as prescribed in Table 1, represents an acceptable margin for compliance. In most situations in which either the noise-sensitive land use or the major road or railway already exists, it should be practicable to achieve outdoor noise levels within this acceptable margin. In relation to greenfield sites, however, there is an expectation that the design of the proposal will be consistent with the target ultimately being achieved.

Because the range of noise amelioration measures available for implementation is dependent upon the type of proposal being considered, the application of the noise criteria will vary slightly for each different type. Policy interpretation of the criteria for each type of proposal is outlined in sections 5.3.1 and 5.3.2.

The noise criteria were developed after consideration of road and rail transport noise criteria in Australia and overseas, and after a series of case studies to assess whether the levels were practicable. The noise criteria take into account the considerable body of research into the effects of noise on humans, particularly community annoyance, sleep disturbance, long-term effects on cardiovascular health, effects on children's learning performance, and impacts on vulnerable groups such as children and the elderly. Reference is made to the World Health Organization (WHO) recommendations for noise policies in their publications on community noise and the Night Noise Guidelines for Europe. See the policy guidelines for suggested further reading.

5.3.1 Interpretation and application for noise-sensitive development proposals

In the application of these outdoor noise criteria to new noise-sensitive developments, the objective of this policy is to achieve –

- *acceptable indoor noise levels in noise-sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*
- *a reasonable degree of acoustic amenity in at least one outdoor living area on each residential lot[1].*

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

In areas where the noise target is likely to be exceeded, but noise levels are likely to be within the 5dB margin, mitigation measures should be implemented by the developer with a view to achieving the target levels in at least one outdoor living area on each residential lot[1]. Where indoor spaces are planned to be facing any outdoor area in the margin, noise mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces. In this case, compliance with this policy can be achieved for residential buildings through implementation of the deemed-to-comply measures detailed in the guidelines.

1 For non residential noise-sensitive developments, (e.g. schools and child care centres) consideration should be given to providing a suitable outdoor area that achieves the noise target, where this is appropriate to the type of use.

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

For residential buildings, acceptable indoor noise levels are $L_{Aeq(Day)}$ of 40 dB(A) in living and work areas and $L_{Aeq(Night)}$ of 35 dB(A) in bedrooms[2]. For all other noise-sensitive buildings, acceptable indoor noise levels under this policy comprise noise levels that meet the recommended design sound levels in Table 1 of Australian Standard AS 2107:2000 Acoustics—Recommended design sound levels and reverberation times for building interiors.

These requirements also apply in the case of new noise-sensitive developments in the vicinity of a major transport corridor where there is no existing railway or major road (bearing in mind the policy's 15-20 year planning horizon). In these instances, the developer should engage in dialogue with the relevant infrastructure provider to develop a noise management plan to ascertain individual responsibilities, cost sharing arrangements and construction time frame.

If the policy objectives for noise-sensitive developments are not achievable, best practicable measures should be implemented, having regard to section 5.8 and the guidelines."

5.4 Policy measures for infrastructure redevelopment proposals and freight handling facilities

5.4.1 Redevelopment proposals for existing major road and rail infrastructure

Where policy measures have been triggered by a redevelopment proposal for existing major road or railway infrastructure under section 5.2.2 or 5.2.3, the following policy measures apply.

1) *A screening noise assessment and, if necessary, a detailed assessment should be conducted in accordance with the guidelines.*

2) *Practicable noise management and mitigation measures should be considered in accordance with sections 5.6 and 5.8 of this policy, having regard to –*
   - *the existing transport noise levels;*
   - *the likely changes in noise emissions resulting from the proposal; and*
   - *the nature and scale of the works and the potential for noise amelioration.*

2 For residential buildings, indoor noise levels are not set for utility spaces such as bathrooms. This policy encourages effective "quiet house" design, which positions these non-sensitive spaces to shield the more sensitive spaces from transport noise (see guidelines for further information).

3) The proponent should prepare a noise management plan for the redevelopment works in accordance with the guidelines, and in consultation with the state environmental agency and local government.

5.4.2 Proposed new freight handling facilities

In determining appropriate policy measures for proposed new freight handling facilities, it should be recognised that some noise emissions (for example, from trucks on the premises) are required to meet the Environmental Protection (Noise) Regulations 1997. The noise emissions from the operation of trains at the freight handling facility will depend on the nature of the operations; in the case of a proposed new freight handling facility, appropriate noise criteria must be developed in consultation with the state environmental agency.

If major or minor redevelopments of the railways in a freight handling facility trigger policy measures under section 5.2.3, the procedure in section 5.4.1 should be followed.

5.5 Noise assessment

All noise assessments carried out for the purposes of this policy should be conducted in accordance with the guidelines, and they are the responsibility of the developer and/or infrastructure provider.

The guidelines give detailed information on methods for measuring and predicting transport noise levels for the purpose of undertaking noise assessments.

For new noise-sensitive developments, noise assessments should generally be conducted as early as is practicable in the planning process, typically at the scheme amendment or structure planning stage. The implementation of the outcomes of a noise assessment may become a condition of approval of a subdivision.

In complex cases, it may be appropriate for the detailed assessment report or noise management plan to be referred to the state environmental agency for review.

5.6 Possible noise management and mitigation measures

A range of noise mitigation measures are available to meet the noise criteria. These include –

- *using distance to separate noise-sensitive land uses from noise sources;*
- *construction of noise attenuation barriers such as earth mounds and noise walls;*
- *building design, such as locating outdoor living areas and indoor habitable rooms away from noise sources;*
- *building construction techniques, such as upgraded glazing, ceiling insulation and sealing of air gaps. Note that where upgraded glazing is required, the benefit is only realised when windows are kept closed and, as such, mechanical ventilation should also be considered in these circumstances;*
- *planning and design of the road or rail project such as construction in cut, traffic management or the use of low-noise road surfaces.*

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

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

5.7 Notification on Title

If the measures outlined previously cannot practicably achieve the target noise levels for new noise-sensitive developments, this should be notified on the certificate of title.

Notifications on certificates of title and/or advice to prospective purchasers advising of the potential for noise impacts from major road and rail corridors can be effective in warning people who are sensitive to the potential impacts of transport noise. Such advice can also bring to the attention of prospective developers the need to reduce the impact of noise through sensitive design and construction of buildings and the location of outdoor living areas.

The notification is to ensure that prospective purchasers are advised of –

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

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

An example of a standard form of wording for notifications is presented in the guidelines.

3.0 METHODOLOGY

Predictions of noise level propagation to surrounding areas were achieved utilising the computer program SoundPlan version 7. This program incorporates various parameters including ‘source’ sound power levels, ground topography and atmospheric conditions in determining propagation of noise from the site. Using recognised algorithms (ConCAWE) the program calculates the sound levels at distances from the source resulting in noise levels at receiver locations.

It has been assumed that industries located within the Industrial Area would operate during the night period.

Weather conditions for the modelling were generally in accordance with the Environmental Protection Authority's *"Draft Guidance for Assessment of Environmental Factors No.8 - Environmental Noise"* for the night period and as listed in Table 3.1.

TABLE 3.1 - WEATHER CONDITIONS

Condition	Night Period
Temperature	15 ^{o}C
Relative humidity	50%
Pasquil Stability Class	F
Wind speed	3 m/s

From information received and outlined in the strategic land use plan, the plan allows for:

- Option 1 – Staged industries in the northern section, with the Intermodal area located on the eastern side of the area next to the future development of Tonkin Highway.

- Option 2 – Staged industries in the northern section, with the Intermodal area located on the western side of the area.

From the strategic land use plan provided, we also note residential development would eventually occur up to the boundary of the Area, thus as outlined in Section 2 – Criteria we believe that the critical location for compliance would be those residences at a distance of 100m from the boundary of the Area. However, compliance would still need to be achieved at the residences located at the edge of any buffer.

To determine basic acoustic requirements, preliminary modelling was carried out with:

- Light industry (101 SWL) located within the eastern side of the Area;
- Various industries (104 to 109 SWL) located within the proposed industrial area; and
- The incorporation of an Intermodal Freight area into the above options.

For acoustic modelling purposes, a light industry was taken to be a premises with a maximum overall Sound Power Noise Level of 101 dB(A), with general industries taken to be those with an overall Sound Power Level greater than 104 dB(A).

Note: From previous study, it was determined that the maximum plant Sound Power Noise Level that could be accommodated by the Area was 109 dB(A) based on a 200m x 200m land area. Thus for this study, 109 dB(A) per 40,000m^2 was used as the maximum plant Sound Power Noise Level.

Additional to the above, some general industries were modelled with stacks. These stacks were taken to 40m high and a maximum Sound Power Level of 105 dB(A). This stack noise is in addition to the plant noise level.

Additional to the above, incorporation topography of the future Tonkin Highway and Bishop Road overpass have been taken into account for modelling purposes. From information provided by MRWA, Tonkin Highway has been designed with the inclusion of the rail re-alignment, hence does not account for the rail line crossing Tonkin Highway. Bishop Road, which runs east west, has a future design which allowed the road to be elevated over the rail line as an overpass on Tonkin Highway. As final design levels are not available, preliminary elevations have been used to calculate the potential noise barriers of the roadways from the proposed Mundijong Industrial Area noise emissions. Figure 1 shows the design of Tonkin and Bishop Road, including the re-alignment of the existing rail line.

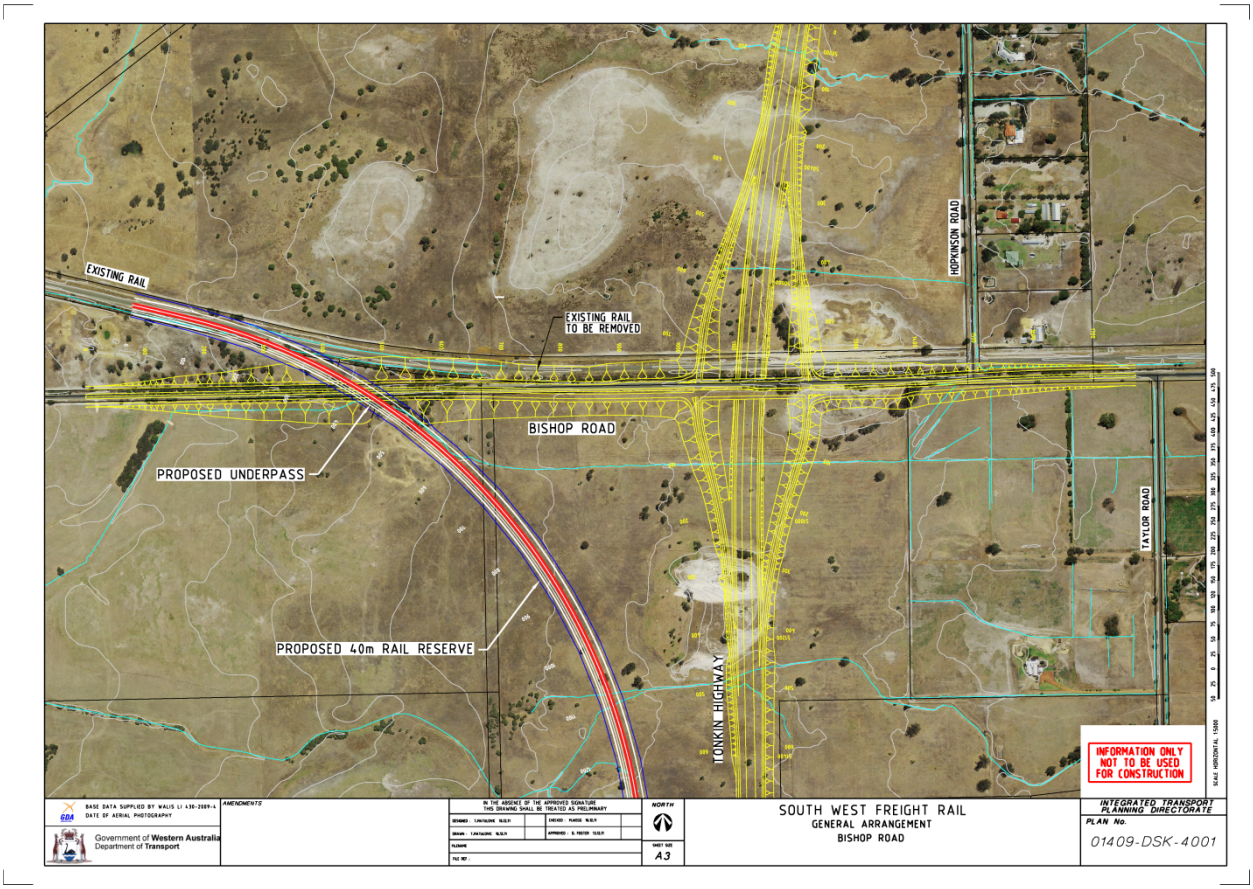


Figure 1 – Proposed Bishop Rd and Tonkin Highway Interchange

4.0 PREDICTED NOISE EMISSIONS

Noise emissions were been calculated for the possible West Mundijong Industrial Area under night conditions of 3m/s wind speed and Pasquil Stability class F as per the Department of Environment Draft 8 guidelines.

The predicted maximum combined noise contour for Option 1 is shown as Figures 1 and 2 in Appendix B.

The predicted maximum combined noise contour for the Option 2 for industries are shown as Figures 3 and 4 in Appendix B

The noise contours shown are the combined noise level contour plots of the noise emissions from each individual industry. The contours shown are the maximum noise level that would be received at a location from the individual industries.

5.0 ASSESSMENT OF PREDICTED NOISE LEVELS

Initial noise modelling indicated that in locations where residence could be developed up to the edge of the industrial Area, that in these locations, the industry would need to be limited to those that emit minimal noise such as:

- Warehouses/showrooms;
- Where any noise is contained within a building; or
- Operations are limited to day period only.

Modelling is based on the inclusion of “light industries” located on the eastern side of the Area. These industries range for approximately 500 metres into the industrial area.

Any larger industries would need to be located within the centre of the Area and south of Bishop Road. However, modelling indicates that the size of the existing buffer zone would limit the Sound Power Level of an industry to between 102 and 109 dB(A) depending on their location in the Area. Achieving these noise levels would not be practicable for some industries and an alternative site would need to be found. Any industries requiring stacks would also need to be located within the centre of the Area.

The sound power level of other industries would vary between 102 dB(A) and 108 dB(A), depending on the location and distance to noise sensitive premises.

For noise emissions from an industry to achieve compliance with the requirements of the Environmental Protection (Noise) Regulations 1997 at residence located outside the area, we believe that the following 2 cases need to be considered :

1 to east of Tonkin Highway; and
2 boundary of any buffer zone.

Given the number of industries that could be located within the area, the criteria for each industry should be to achieve compliance with the “significantly contributing” criteria outlined in the Regulations. To achieve this, even with the above constraints placed on future industry, noise received at a residence from each industry needs to be :

- 33 dB(A) for the residence to the east of Tonkin Highway; and
- 30 dB(A) for other residence located at edge of buffer zone.

6.0 DISCUSSION OF POTENTIAL NOISE IMPACT OF INDUSTRY

Noise modelling indicates that noise emissions from light industries located near the boundary of the Area could result in exceedance of the regulation and a graduation of "quieter" industries such as warehousing or day only operations is recommended around the periphery of the estate where it immediately adjoins residential development. The maximum Sound Power Noise Level for industries located in the “quieter” industries area would be 101 dB(A). Given the potential residence that could be built around the area, new industries located within proximity of existing or potential residence be restricted to sound power levels such that the resultant noise level they generate complies with the following:

1 to the east, at 100 metre from the boundary of the Area does not exceed 33 dB(A).
2 other residence, at edge of any buffer zone does not exceed 30 dB(A).

Larger general industry with Sound Power Levels of around 108 - 110 dB(A) should be limited to the central core of the Area, south of Bishop Road (i.e. away from residence).

The specific location of other industries would be dependent on the Sound Power Level. If the overall Sound Power Level is proposed to be higher, then the proposed industry would be required to locate further away from sensitive receptors such as residential development.

7.0 FUTURE RAILWAY

It is noted that noise emissions from a railway is exempt from the requirements of the Environmental Protection (Noise) Regulations 1997. Noise emissions from any railway line, including as part of a freight handling facility would need comply with the requirements of State Planning Policy 5.4 *"Road and Rail Transport Noise and Freight Considerations In Land Use Planning".*

Under SPP 5.4, noise received at any residence would need to comply with the "Noise Limits", these being:

EXTERNAL
$L_{Aeq(day)}$ of 60 dB(A); and
$L_{Aeq(night)}$ of 55 dB(A).

As this is a new rail infrastructure in the vicinity of a future extension to Tonkin Highway and proposed noise-sensitive land uses, it is noted that under the policy "in these instances, the infrastructure provider and developer are both responsible for ensuring that the objectives of this policy are achieved, and a mutually beneficial noise management plan, including individual responsibilities, should be negotiated between the parties." Thus under SPP 5.4 all parties should enter into discussions / negotiations to obtain the optimum outcome.

Note: In this case, there would actually be two (2) infrastructure providers.

In this case, we believe that there is the potential, if the railway was to be located on the eastern side of the proposed industrial area, for a bund / barrier to be located on the eastern side of the proposed Tonkin Highway extension that would provide the required noise mitigation to the residence from both road and rail noise.

8.0 MITIGATION OF POTENTIAL NOISE IMPACTS

From information received, we understand that, as a result of this modelling exercise and in consultation with senior officers of the Department of Environment and Conservation and Office of the Environmental Protection Authority the following mitigation measures are proposed:

1. "Quieter" light industry is to be located at the periphery of the Area to the east and south to provide a separation and internalised buffer to residential and rural residential development. General industry is to be located in the core of the Area and adjacent to less sensitive rural land uses to the west and north.

2. Consideration be given at further detailed stages of planning to explore the merits and potential of constructing a noise attenuation barrier to mitigate emissions to residential development.

3. Recommend through the Local Structure Plans associated with Precinct E of the Mundijong-Whitby District Structure Plan that Detailed Area Plans be required for those lots adjoining the Water Corporation reservation will need to comply with the requirements of State Planning Policy 5.4. This could include the following building design elements:

    - Noise received at an outdoor area should, where practicable, also achieve an L_{Aeq} of 50 dB(A) during the night period.

    - Where appropriate, locate habitable rooms away from noise sources

- Appropriate use of Quiet House Design to achieve compliance with the following internal criteria :

  INTERNAL
  $L_{Aeq(day)}$ of 40 dB(A) in living and work areas; and
  $L_{Aeq(night)}$ of 35 dB(A) in bedrooms.

4. Concurrently with the preparation of the planning for the Area the Shire is undertaking a review of its strategic land use planning framework. The draft Rural Land Strategy identifies land to the north and west of the Area as a "buffer". The buffer seeks to achieve the following:

   - Identify the land that is the subject of the buffer;
   - Ensure that the land use is maintained as rural;
   - Protect the future subdivision and development of noise sensitive receptors; and
   - Reflect the historic rural use of the land within the buffer.

Additionally, modifications of rail noise should be added to titles of residence located adjacent to possible future railway.

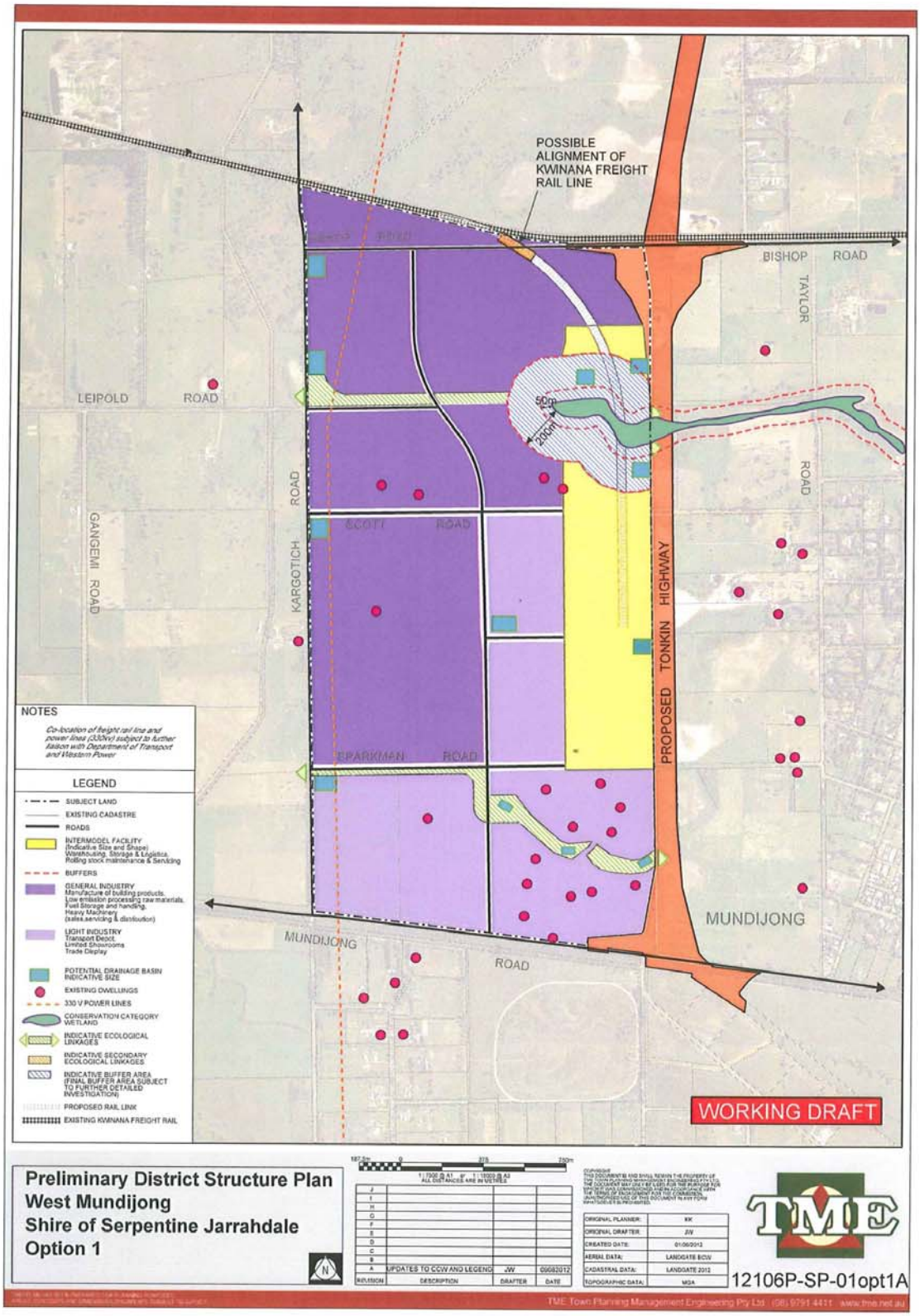
9.0 FUTURE REQUIREMENTS

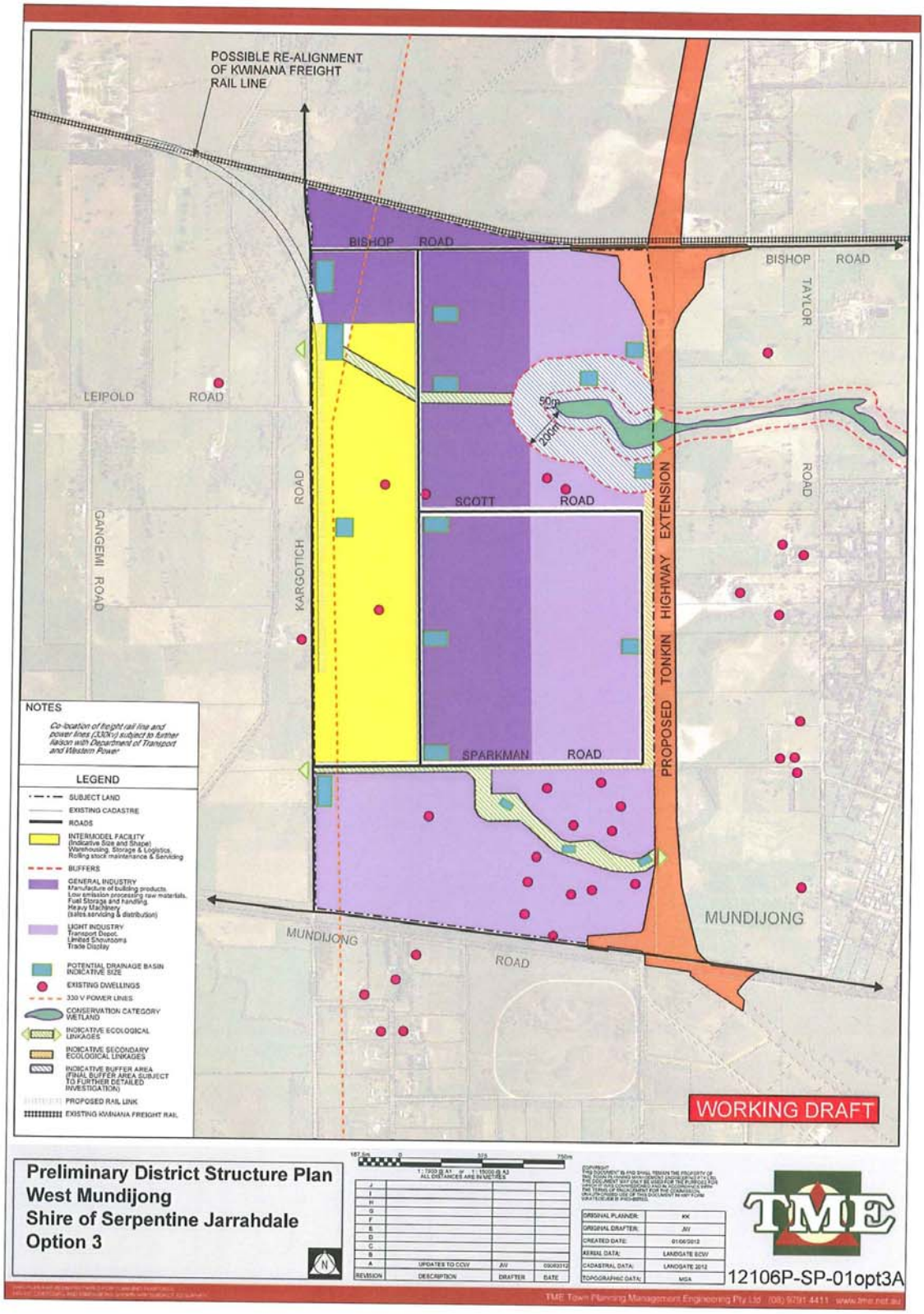
The requirements of the *Environmental Protection (Noise) Regulations 1997* will apply to each industry that locates within the West Mundijong Industrial Area. While there is no obligation to impose a special noise requirement on such industry, to minimise the risk of breaching the *Environmental Protection (Noise) Regulations 1997* it would be prudent to require developments to provide an acoustic assessment by a 'competent' acoustic consultant prior to development approval indicating that the industry would be considered as NOT significantly contributing to the noise received at a residence. This assessment and any associated noise modelling should be provided to the appropriate authorities for approval. Additionally, when each new industry commences operation, verification measurements should be taken of sound power emissions and/or of received noise at the buffer boundary.

Note: To be considered as NOT significantly contributing, the noise received at any residence needs to be at least 5 dB(A) below the assigned noise level.

APPENDIX A

West Mundijong Industrial Park Strategic Land Use Plan


POSSIBLE ALIGNMENT OF KWINANA FREIGHT RAIL LINE
BISHOP ROAD
TAYLOR ROAD
LEIPOLD ROAD
GANGEMI ROAD
KARGOTICH ROAD
SCOTT ROAD
TPARKMAN ROAD
PROPOSED TONKIN HIGHWAY
MUNDIJONG ROAD
MUNDIJONG
50m
200m
NOTES
Co-location of freight rail line and power lines (330kV) subject to further liaison with Department of Transport and Western Power
LEGEND
SUBJECT LAND
EXISTING CADASTRE
ROADS
INTERMODEL FACILITY (Indicative Size and Shape) Warehousing, Storage & Logistics, Rolling stock maintenance & Servicing
BUFFERS
GENERAL INDUSTRY Manufacture of building products. Low emission processing raw materials. Fuel Storage and handling. Heavy Machinery (saliea servicing & distribution)
LIGHT INDUSTRY Transport Depot. Limited Showrooms Trade Display
POTENTIAL DRAINAGE BASIN INDICATIVE SIZE
EXISTING DWELLINGS
330 V POWER LINES
CONSERVATION CATEGORY WETLAND
INDICATIVE ECOLOGICAL LINKAGES
INDICATIVE SECONDARY ECOLOGICAL LINKAGES
INDICATIVE BUFFER AREA (FINAL BUFFER AREA SUBJECT TO FURTHER DETAILED INVESTIGATION)
PROPOSED RAIL LINK
EXISTING KWINANA FREIGHT RAIL
WORKING DRAFT
Preliminary District Structure Plan
West Mundijong
Shire of Serpentine Jarrahdale
Option 1
UPDATES TO CCW AND LEGEND
JW
03/08/2012
DESCRIPTION
DRAFTER
DATE
ORIGINAL PLANNER: KK
ORIGINAL DRAFTER: JW
CREATED DATE: 01/08/2012
AERIAL DATA: LANDGATE BCW
CADASTRAL DATA: LANDGATE 2012
TOPOGRAPHIC DATA: MGA
12106P-SP-01opt1A
TME Town Planning Management Engineering Pty Ltd (08) 9791 4411 www.tme.net.au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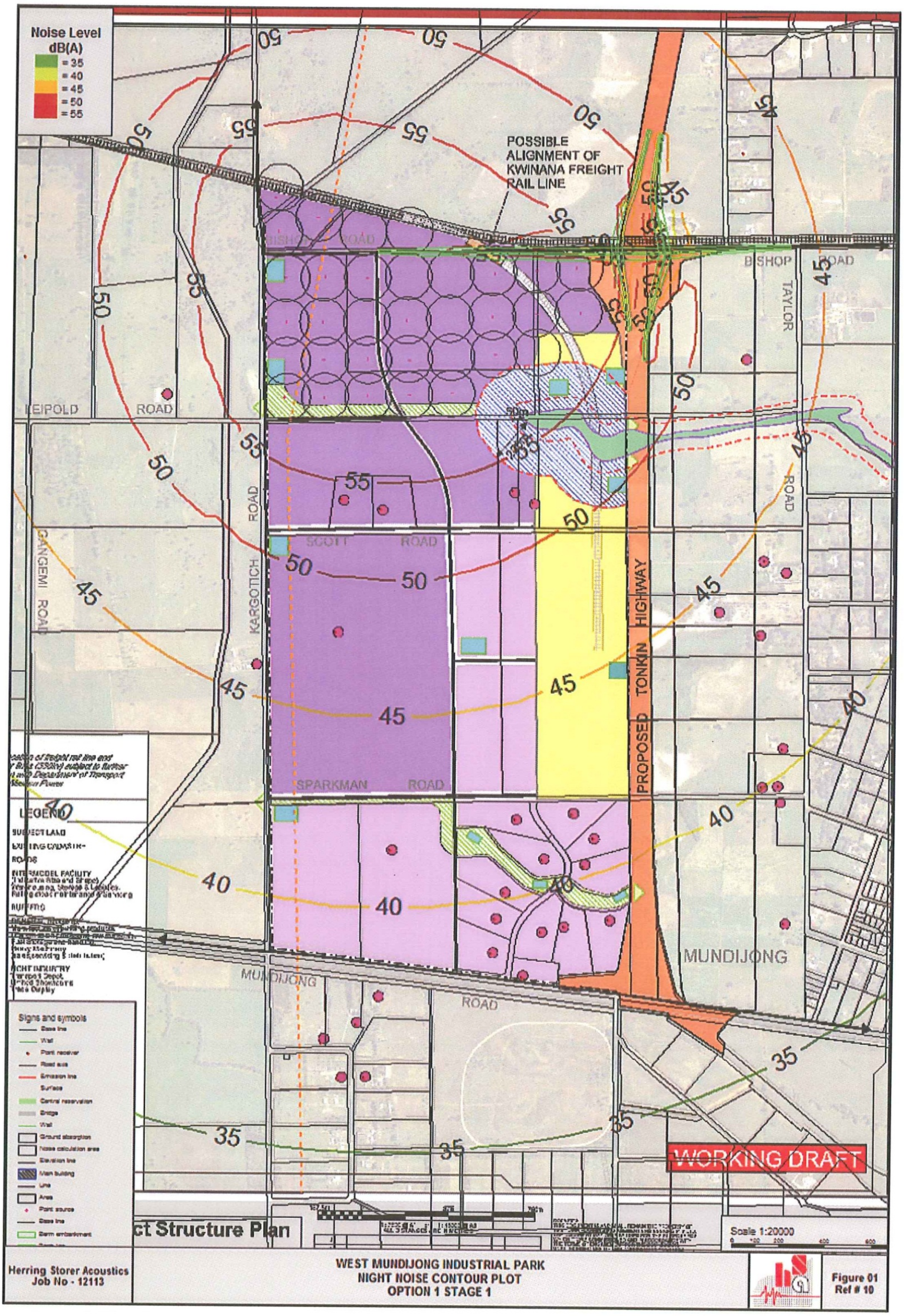
BISHOP ROAD
TAYLOR ROAD
LEIPOLD ROAD
GANGEMI ROAD
KARGOTICH ROAD
SCOTT ROAD
SPARKMAN ROAD
PROPOSED TONKIN HIGHWAY EXTENSION
MUNDIJONG ROAD
MUNDIJONG
50m
200m
NOTES
Co-location of freight rail line and power lines (330kV) subject to further liaison with Department of Transport and Western Power
LEGEND
SUBJECT LAND
EXISTING CADASTRE
ROADS
INTERMODEL FACILITY (Indicative Size and Shape) Warehousing, Storage & Logistics, Rolling stock maintenance & Servicing
BUFFERS
GENERAL INDUSTRY Manufacture of building products, Low emission processing raw materials, Fuel Storage and handling, Heavy Machinery (sales,servicing & distribution)
LIGHT INDUSTRY Transport Depot, Limited Shoursoms Trade Display
POTENTIAL DRAINAGE BASIN INDICATIVE SIZE
EXISTING DWELLINGS
330 V POWER LINES
CONSERVATION CATEGORY WETLAND
INDICATIVE ECOLOGICAL LINKAGES
INDICATIVE SECONDARY ECOLOGICAL LINKAGES
INDICATIVE BUFFER AREA (FINAL BUFFER AREA SUBJECT TO FURTHER DETAILED INVESTIGATION)
PROPOSED RAIL LINK
EXISTING KWINANA FREIGHT RAIL
WORKING DRAFT
Preliminary District Structure Plan
West Mundijong
Shire of Serpentine Jarrahdale
Option 3
REVISION
DESCRIPTION
DRAFTER
DATE
A
UPDATES TO CCW
AV
03/08/2012
ORIGINAL PLANNER: KK
ORIGINAL DRAFTER: AV
CREATED DATE: 01/06/2012
AERIAL DATA: LANDGATE ECW
CADASTRAL DATA: LANDGATE 2012
TOPOGRAPHIC DATA: MGA
TME
12106P-SP-01opt3A
TME Town Planning Management Engineering Pty Ltd (08) 9791 4411 www.tme.net.au

APPENDIX B

Predicted Noise Contours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= 40
= 45
= 50
= 55
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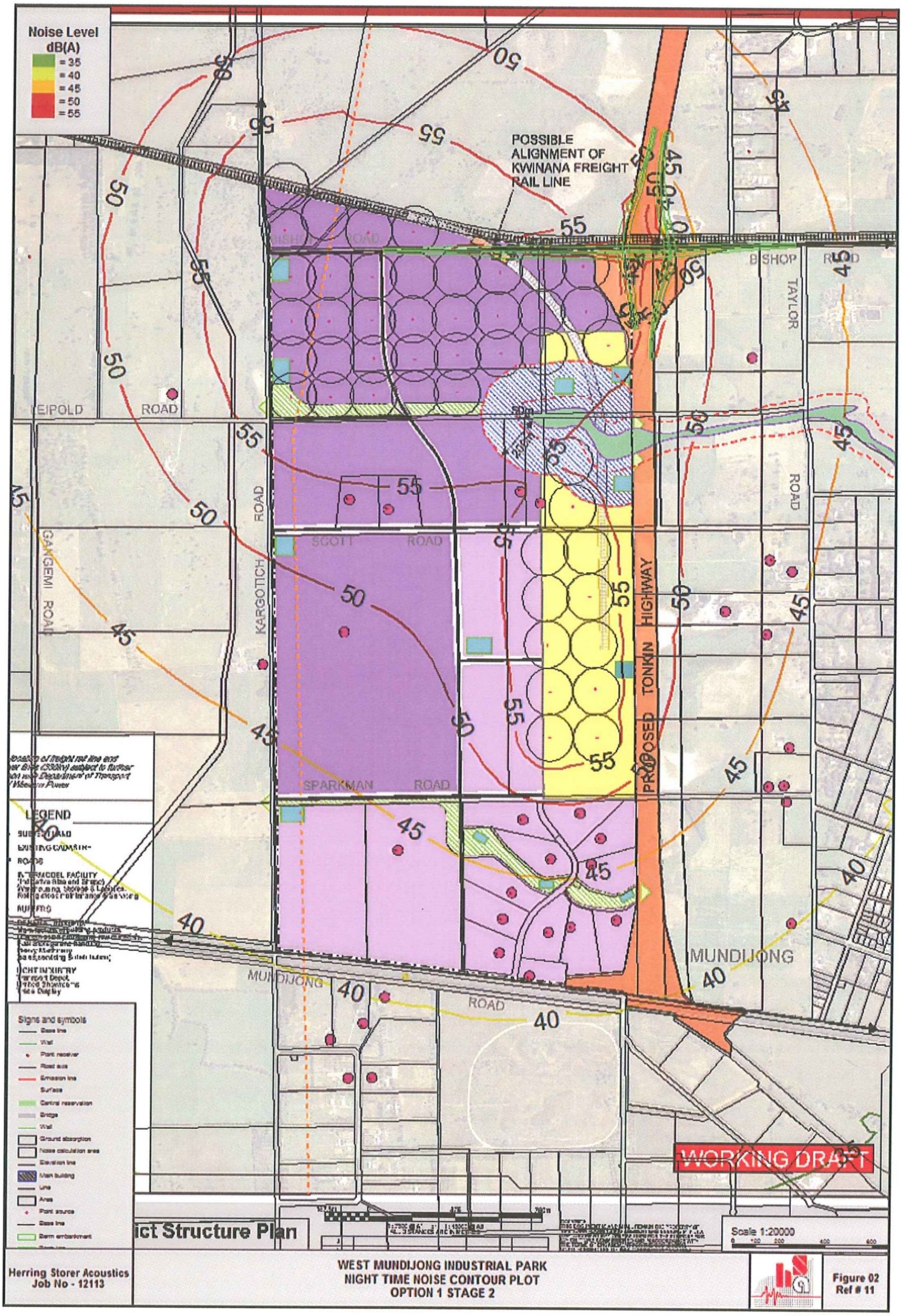
LEIPOLD ROAD
KARGOTICH ROAD
SCOTT ROAD
SPARKMAN ROAD
GANGEMI ROAD
PROPOSED TONKIN HIGHWAY
MUNDIJONG ROAD
MUNDIJONG
50m
LEGEND
Signs and symbols
WORKING DRAFT
Scale 1:20000
Herring Storer Acoustics
Job No - 12113
WEST MUNDIJONG INDUSTRIAL PARK
NIGHT NOISE CONTOUR PLOT
OPTION 1 STAGE 1
Figure 01
Ref # 10


Noise Level dB(A)
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= 45
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= 55
POSSIBLE ALIGNMENT OF KWINANA FREIGHT RAIL LINE
BISHOP ROAD
TAYLOR ROAD
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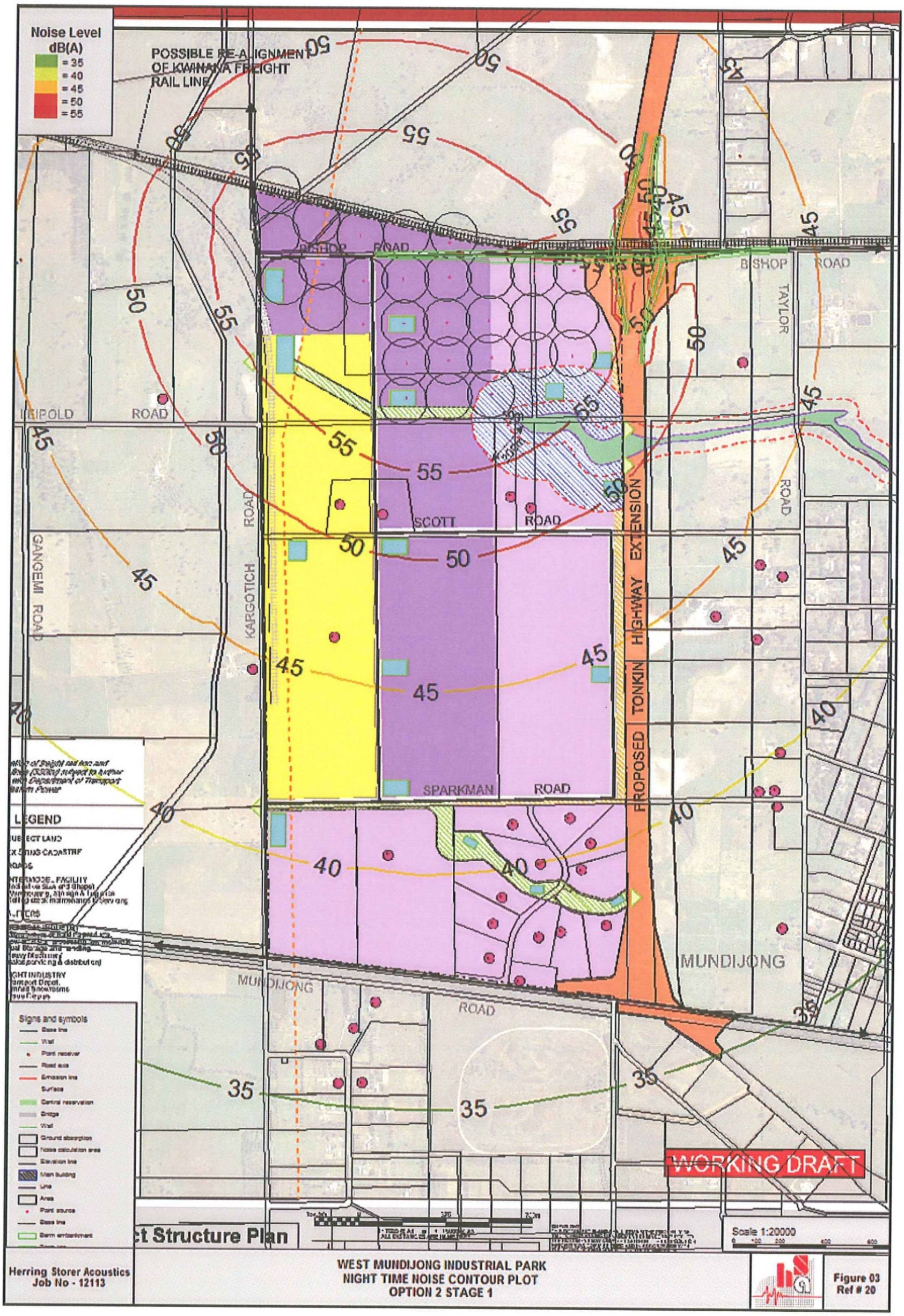
SPARKMAN ROAD
PROPOSED TONKIN HIGHWAY
MUNDIJONG ROAD
MUNDIJONG
LEGEND
Signs and symbols
WORKING DRAFT
Scale 1:20000
ict Structure Plan
Herring Storer Acoustics
Job No - 12113
WEST MUNDIJONG INDUSTRIAL PARK
NIGHT TIME NOISE CONTOUR PLOT
OPTION 1 STAGE 2
Figure 02
Ref # 11


Noise Level dB(A)
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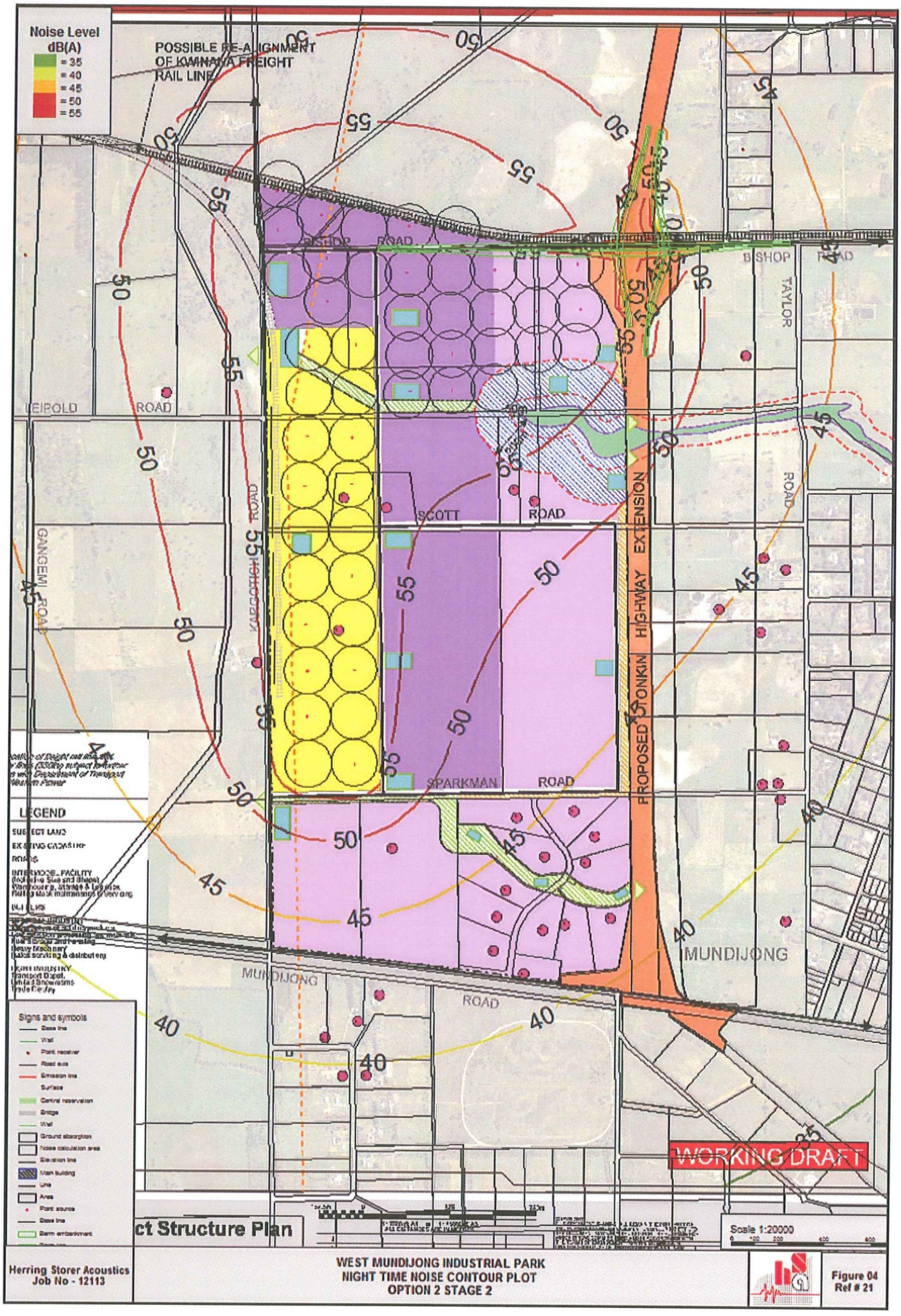
= 40
= 45
= 50
= 55
POSSIBLE RE-ALIGNMENT OF KWINANA FREIGHT RAIL LINE
BISHOP ROAD
TAYLOR
LEIPOLD ROAD
SCOTT ROAD
GANGEMI ROAD
KARGOTICH ROAD
PROPOSED TONKIN HIGHWAY EXTENSION
SPARKMAN ROAD
MUNDIJONG ROAD
MUNDIJONG
WORKING DRAFT
Scale 1:20000
Herring Storer Acoustics
Job No - 12113
WEST MUNDIJONG INDUSTRIAL PARK
NIGHT TIME NOISE CONTOUR PLOT
OPTION 2 STAGE 1
Figure 03
Ref # 20


Noise Level dB(A)
= 35
= 40
= 45
= 50
= 55
POSSIBLE RE-ALIGNMENT OF KWINANA FREIGHT RAIL LINE
BISHOP ROAD
TAYLOR
LEIPOLD ROAD
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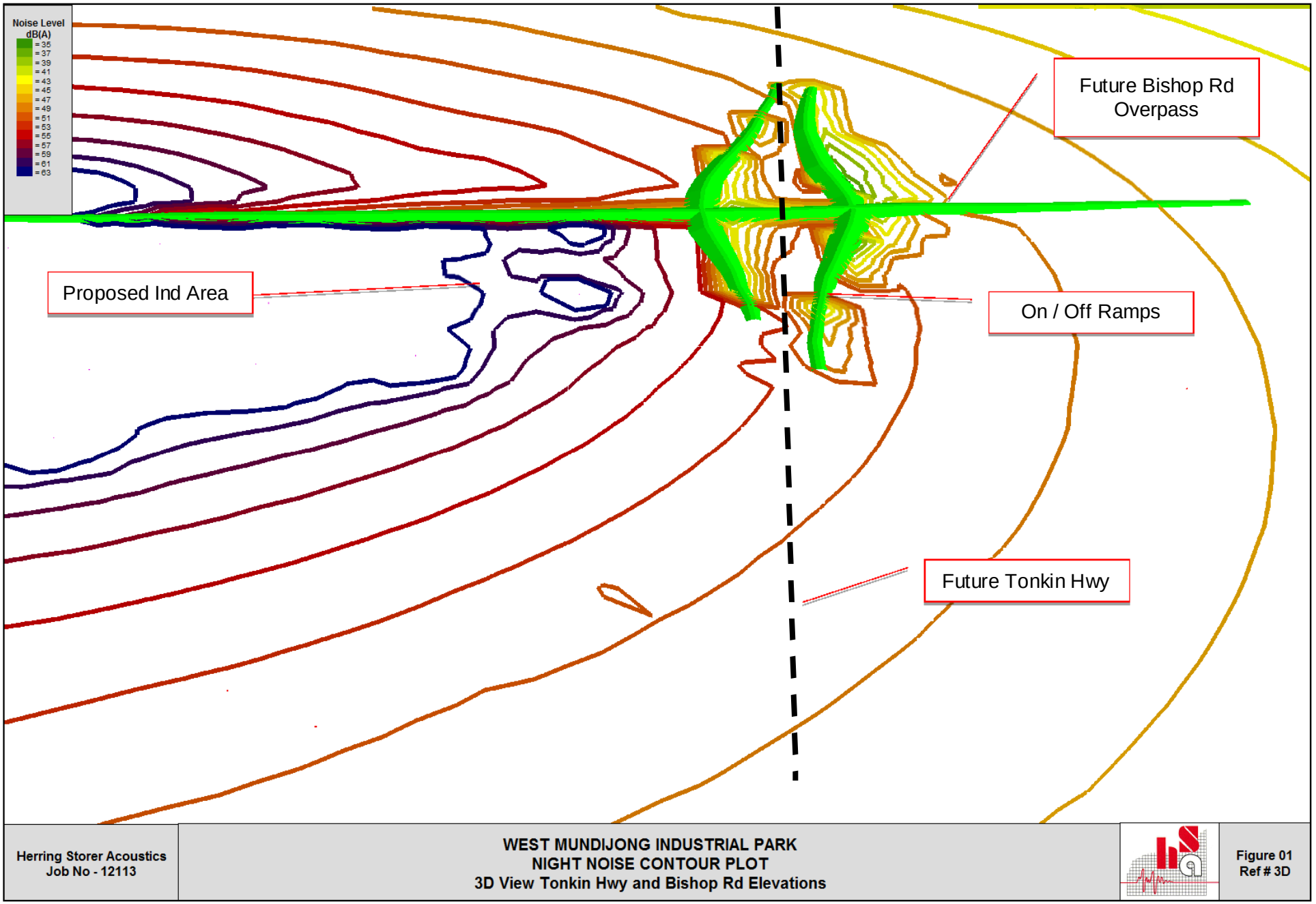
SCOTT ROAD
GANGEMI ROAD
SPARKMAN ROAD
PROPOSED STONKIN HIGHWAY EXTENSION
MUNDIJONG ROAD
MUNDIJONG
LEGEND
Signs and symbols
WORKING DRAFT
Scale 1:20000
ct Structure Plan
Herring Storer Acoustics
Job No - 12113
WEST MUNDIJONG INDUSTRIAL PARK
NIGHT TIME NOISE CONTOUR PLOT
OPTION 2 STAGE 2
Figure 04
Ref # 21

APPENDIX C

3D NOISE CONTOUR PLOT –
BISHOP ROAD and TONKIN HIGHWAY OVERPASS



Herring Storer Acoustics
Job No - 12113

WEST MUNDIJONG INDUSTRIAL PARK
NIGHT NOISE CONTOUR PLOT
3D View Tonkin Hwy and Bishop Rd Elevations

Figure 01
Ref # 3D

APPENDIX B

District Water Management Strategy

Town Planning Management Engineering

12086
November 2014

Serpentine Jarrahdale Shire

WEST MUNDIJONG

District Water Management Strategy





town planning
management
engineering
environmental

Research, Design & Delivery of Sustainable Developments

DOCUMENT QUALITY CONTROL

AUTHOR	DATE
Brendan Oversby	Nov 2014

VERSION TABLE

Rev No.	Purpose	Date
1	Report amended as per council requirements	26.02.2013
2	Final report including DoW requested Changes	28.11.2014

TME Town Planning Management Engineering Pty Ltd

PO BOX 733, BUNBURY

PH: (08) 9791 4411

CONTENTS

ANNEXURES

FIGURES

TABLES

EXECUTIVE SUMMARY

The West Mundijong Industrial Area District Water Management Strategy (DWMS) has been prepared to support the industrial rezoning of the subject land. The subject land is bounded by Mundijong Road (south), Tonkin Highway Road reserve (east), Bishop Road (north) and Kargotich Road (west). It is approximately 474 hectares in area. The land is approximately 1.5km west of the existing Mundijong town site (see Figure 1).

The subject land has a number of minor water courses that either traverse or begin on the site. This includes waterways that begin on the scarp to the east. All water leaving the site via the surface, flows under Kargotich Road and into Oakland's drain, which flows southward. A small section of one of the waterways (Manjedal Brook) is considered a Conservation Category wetland. Around 80% of the remainder of the site is also considered Multiple Use wetland.

The majority of the site has been cleared and is composed of pastures. The remaining native vegetation on the site is degraded. It is usually composed of native overstorey species with none or limited native understorey.

Historically the land has been used for broad acre agricultural purposes, and currently is used for livestock grazing purposes. There are a number of dwellings on the subject land, especially in the rural residential section in the south east corner.

The future Tonkin Highway and rail line are located along the eastern boundary. This area may also include an intermodal area.

The DWMS has been prepared to satisfy the Better Urban Water Management guidelines that require a DWMS to support the rezoning of part of the subject land from 'Rural' to 'Industrial'.

The objective of the DWMS is to demonstrate how a best management practices approach will achieve the principles, objectives and requirements of total water cycle management. The constraints of the site, proposed land use and surrounding environment have all been investigated to determine potential issues and outline potential strategies to manage, protect and conserve the total water cycle of the local environment and the greater catchment. The strategies include:

- Integrate water sensitive urban designs (WSUD) into the development and surrounding landscape;
- Achieve water quality targets entering surrounding waterways and the groundwater resource;
- Manage water quantity and flooding for the industrial development and hydrological regimes;
- Manage the groundwater resource with close to source treatment trains and to minimise the required fill;
- Investigate opportunities for stormwater, superficial groundwater and greywater harvesting and reuse;
- Investigate innovative schemes for Industrial wastewater management;
- Protect associated ecosystems dependent on water resources from the development; and
- Investigate practical methods to reduce potable water demand.

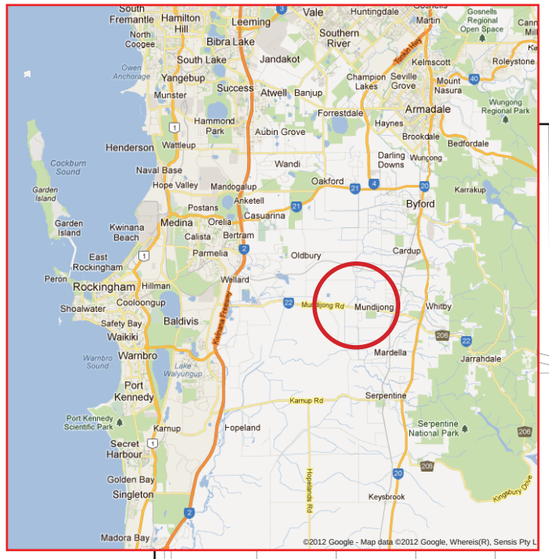
The effectiveness, efficiency and benefits provided by the best management practices will require a collaborative effort between local governments, developers and relevant regulatory authorities.

Cleared rural land with isolated trees typical of the subject land

SUPPORTING DOCUMENTATION

The DWMS was compiled using information contained within the detailed assessments and reports undertaken for the subject land. These reports listed below have been included on the enclosed CD accompanying the DWMS.

- TME. 2012. *West Mundijong Industrial Area Fill Analysis.*
- TME. 2012. *West Mundijong Industrial Area Feasibility Study.*
- PGV Environmental. 2012. *West Mundijong Industrial Area Environmental Assessment.*
- TME. 2012. *Drainage modelling - HECRAS and DRAINS*



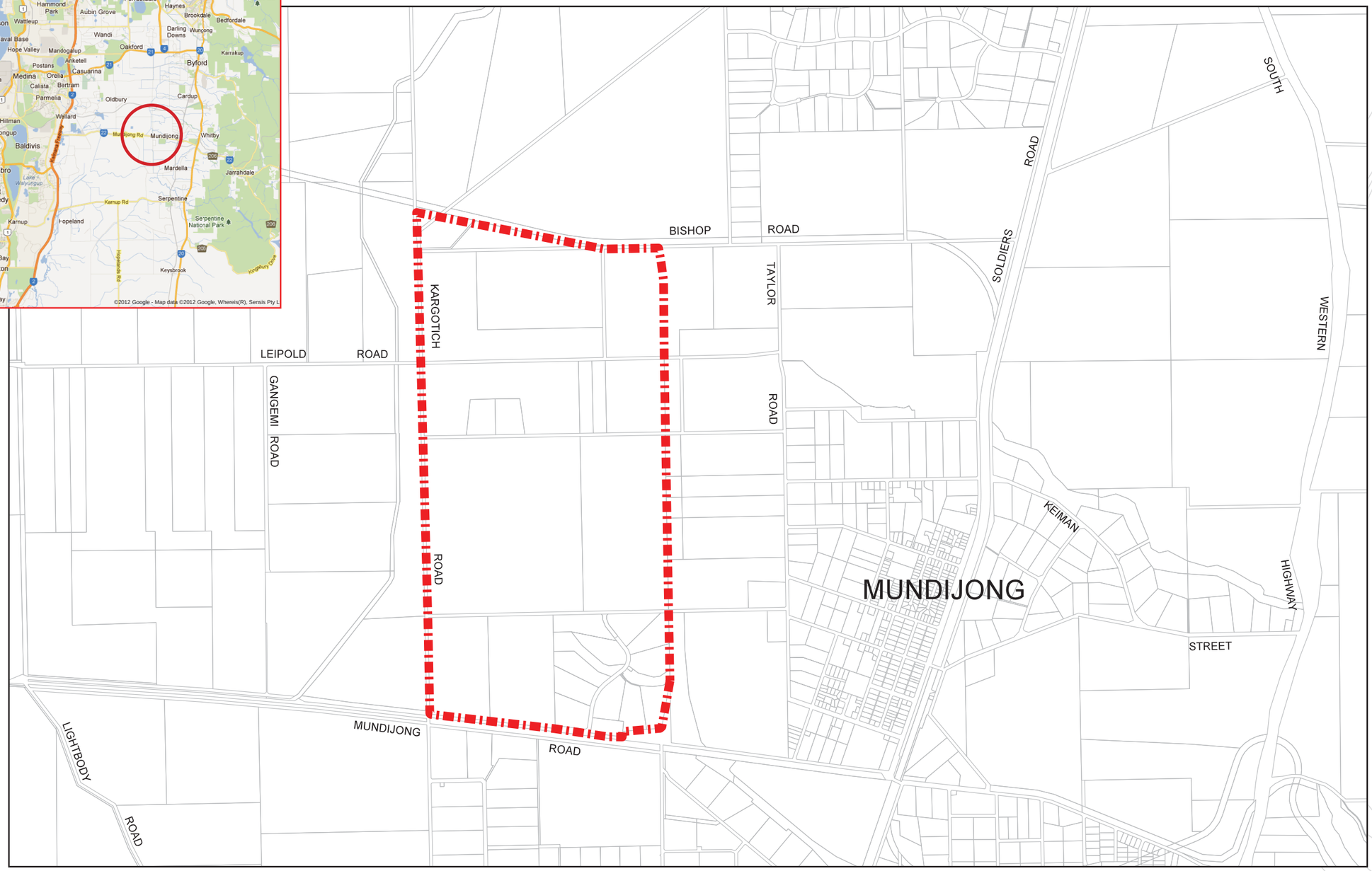


Figure 1 - Location Map

1 - PLANNING SUMMARY

PLANNING FRAMEWORK

Zoning and reservations

The land is currently zoned 'Rural' in the Metropolitan Region Scheme. With respect to adjoining and nearby land the following should be noted:

a) Mundijong Road, adjoining the southern boundary, is a designated 'other regional road'

b) The portion of Mundijong Road is also designated 'bush forever area'

c) Land adjoining the eastern boundary is designated 'primary regional road' in lieu of the southern extension of the Tonkin Highway; and

d) The primary regional road reserve allows for future intersection treatment to Mundijong Road and grade separation of the freight rail line

Refer *Figure 2*

In terms of the Serpentine Jarrahdale Shire's (the Shire) Town Planning Scheme No. 2, the land is included within the following zones:

a) 'Farmlet' zone; and
b) 'Rural' zone.

There are two main areas zoned 'Farmlet' within the structure plan area. One is located in the south east and associated with Pure Steel Lane. The area has been subdivided into 4 hectare allotments and accordingly developed for a range of rural lifestyle pursuits.

The other area adjoins Kargotich Road. Currently no subdivision approval has been issued for this area, although a subdivision guideline plan did accompany the relevant amendment to include the land within the 'Farmlet' zone.

In addition the Scheme identifies an 'area of natural beauty' (No. 33) which bisects the land east west. The following description is provided in Appendix 13:

33. MANJEDAL BROOK
From its source East of Nettleton Road along its length to Kargotich Road.

In relation to areas of natural beauty Clause 7.12.2 of the Scheme states:

A person shall not without the approval of Council at or on a place described in Appendix 13 carry out any development including, but without limiting the generality of the foregoing:

(a) the erection, demolition or alteration of any building or structure (not including farm fencing, wells, bore or troughs and minor drainage works ancillary to the general rural pursuits in the locality);

(b) the clearing of land or removal of trees; or

(c) the erection of advertising signs.

The status of Manjedal Brook is discussed in further detail below.

Key Findings

a) The Metropolitan Region Scheme (MRS) facilitates significant future infrastructure upgrades of critical importance to future industry, including the extension of the Tonkin Highway and the upgrading of Mundijong Road;

b) In order to facilitate industrial development, the MRS will require an amendment to include the land in the 'Industry' zone; and

c) The opportunity, via subsequent structure planning, to incorporate Manjedal Brook as an 'ecological corridor' that also continues to provide a valuable drainage function for the district and future industrial development.

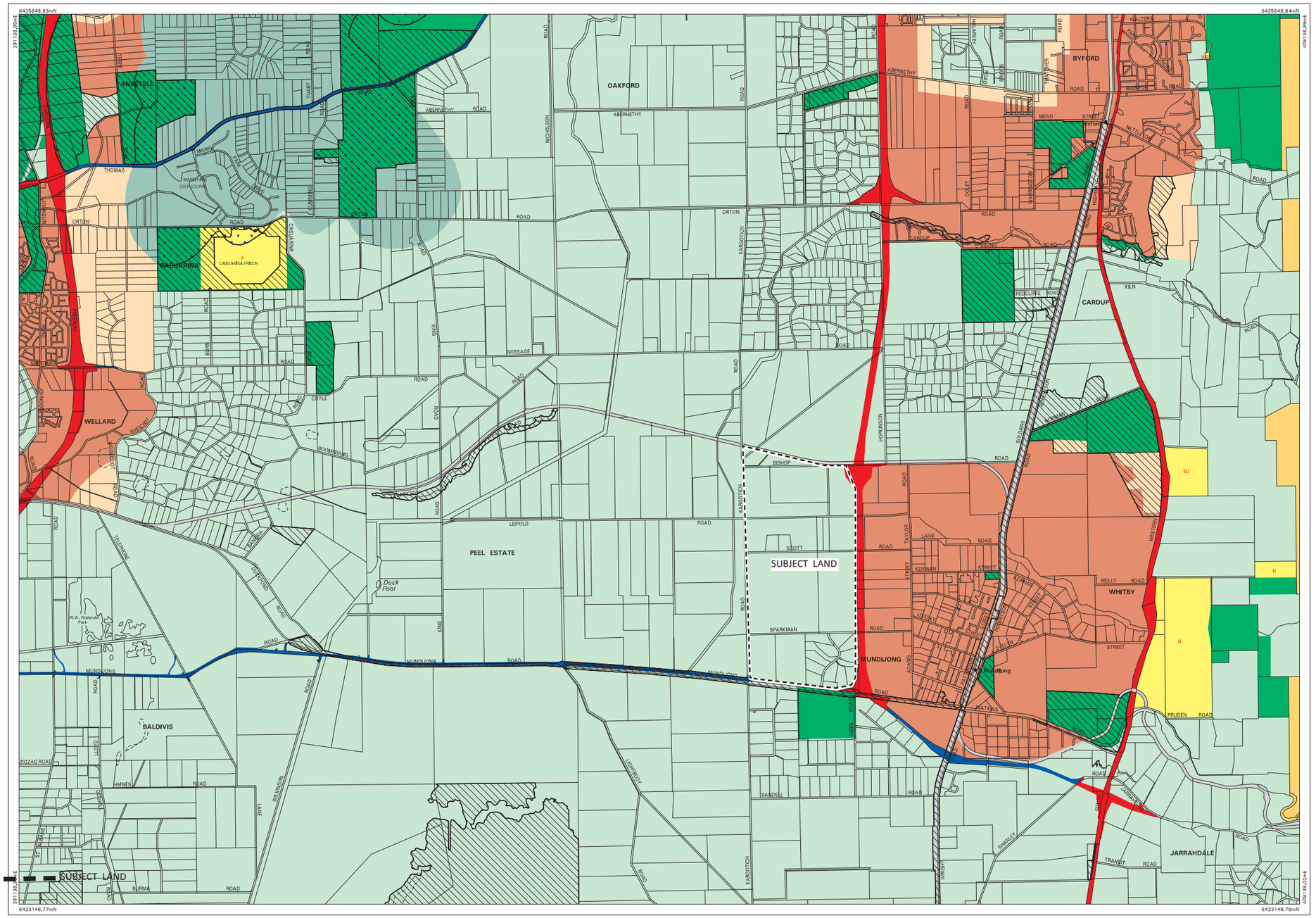
PURPOSE OF DISTRICT WATER MANAGEMENT STRATEGY

The DWMS will support the development of a District Structure Plan (DSP) for West Mundijong. The DSP will be a strategic document which justifies rezoning of the land in 'Industry' in the Metropolitan Region Scheme.

On Page 5 *Figure 2's* inset shows the current zoning of the land under the MRS.

It is proposed that the development will predominantly support general and light industry. Any heavy industry sites will be limited and need to satisfy planning, site and environmental conditions for their consideration.

Typical Flat Plain on Subject Land



Legend

scheme boundary

Reserved lands

- parks and recreation
- R — restricted public access
- railways
- port installations
- State forests
- water catchments
- civic and cultural
- waterways
- primary regional roads
- other regional roads
- public purposes - denoted as follows:
  - H — hospital
  - HS — high school
  - TS — technical school
  - CP — car park
  - U — university
  - CG — Commonwealth Government
  - SEC — State Energy Commission
  - SU — special uses
  - WSD — Water Authority of WA
  - P — prison

Zones

- urban
- urban deferred
- central city area
- Industrial
- special Industrial
- rural
- rural - water protection
- private recreation

Notice of delegation

- bush forever area

Redevelopment schemes

- redevelopment scheme/act area

METROPOLITAN REGION SCHEME

This map has been derived from an electronic version of the scheme held and maintained by the Department of Planning, on behalf of the Western Australian Planning Commission.

This map is one of a set of 38 which depicts the zones and reservations of the Metropolitan Region Scheme as adopted on 30 October 1963. The information shown is correct up to the date shown below as far as the Department and the Commission are aware.

The scheme does not purport to indicate the land use allocation under any local government provision.

Amended to: 23 March 2012

N

METROPOLITAN REGION SCHEME MAP 1:25000 MAP SERIES

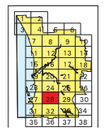
MAP SHEET 28

METROPOLITAN REGION SCHEME MAP

SCALE 1:25000

1000 750 500 250 0 1 2
metres KILometres

INDEX TO ADJOINING 1:25000 MAP SHEETS



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CADASTRAL..... Generated from Landgate Spatial Cadastral Data (SCDI)

PROJECTION..... Universal Transverse Mercator

HORIZONTAL DATUM... Geocentric Datum of Australia 1994

GRID VALUES..... Shown in full for map sheet corners only Map sheets do not conform to standard MGA (GDA) map series)

Figure 2 - Existing M.R.S Zoning

2 - KEY ELEMENTS

Water management strategies for the subject land are based on best practice water sensitive designs that suit the site's constraints. They also provide recognition of the importance of water as a resource across the entire development and surrounding environment. Specific constraints and threats identified for the subject land are discussed in Section 9, and listed below:

CONSTRAINTS AND THREATS

- Wetlands (and associated buffers).
- Waterways/drainage lines and associated flooding.
- High groundwater levels and potential quality issues.
- Acid sulphate soils (ASS) risk.
- Stormwater runoff contaminants from on site and upstream land uses.
- Cost to deliver suitable wastewater disposal and greywater reuse schemes.
- Cost to deliver potable water supply.

OPPORTUNITIES AND MANAGEMENT OPTIONS

The recommended strategies provide an integrated approach through the synthesis of industrial planning and designs to manage, protect and conserve the total water cycle. The plans and designs for the development are appropriate for the subject land's development constraints and unique surrounding environment and providing a sustainable industrial estate.

A summary of the key best water management practice elements that are recommended for implementation within the development to achieve best management practices are outlined below, and visually represented in *Figure 3 page 7*:

WATER QUALITY AND ENVIRONMENTAL PROTECTION

- Establishment of appropriate management practices for foreshore reserves and wetlands along Manjedal Brook.
- Utilisation of water sensitive designs, including bioretention gardens, basins, swales, and flow spreader devices to capture, detain, treat and convey all development runoff.
- Investigation of building design guidelines that encourage structural separation of potentially polluted runoff in work areas from the stormwater runoff pathways.
- Providing lot owners with information relating to the establishment and maintenance of water wise and nutrient wise gardens in their required landscape areas on each development.
- Encourage non-structural best management practices.
- The pre development monitoring of groundwater and surface water quality to establish benchmarks and identify any potential issues.
- The monitoring of storm water outflow rates and quality post-development.

STORMWATER MANAGEMENT AND FLOOD PROTECTION

- Utilisation of best practice to treat, store, convey, control and discharge stormwater runoff;
- Lot storage and treatment of all runoff from the 1 year 1 hour event on the lot.
- Storage and treatment of the 1 year 1 hour event in road reserves; and
- Post development monitoring of water quality.
- No development to be within the 100 year flood ways of the subject land waterways.
- All finished floor levels on lots to be designed to maintain a minimum separation clearance of 500mm to the 1:100 year flood levels of the Manjedal Brook, Oaklands Drain and all flood storage areas.
- All habitable floor levels on lots to be designed to maintain a minimum separation clearance of 300mm to the internal 1:100 year average recurrence interval (ARI) flood levels.
- Protection of buildings and infrastructure with conveyance and storage of flood waters via the open and piped drainage network and road reserves.
- Discharge of 1:10 year flow rates from the site is not to exceed pre development flow rates.
- Discharge of 1:100 year flood flow rates from the site is not to exceed pre development flow rates.
- Storage of predevelopment flood volumes as well as the extra post development runoff, to control downstream flooding.

GROUNDWATER MANAGEMENT

- Ensure development has no negative impact on the groundwater resource, or ecosystems dependent on the resource.
- Filling building and infrastructure sites where necessary so that there is an appropriate clearance to the controlled groundwater level (CGL).
- The installation of a sub-soil drainage pipe network and swale systems at the proposed CGL to control groundwater from rising above this level.
- Treatment of controlled groundwater and the stormwater runoff infiltration via planted swales and basins.
- The monitoring of the groundwater quality and levels across the subject land post development to identify any future detrimental impacts on the groundwater resource.
- There is potential to harvest excess superficial groundwater for use on site or nearby.

WATER CONSERVATION AND SERVICING

- Development to be connected to a reticulated water supply (most likely Water Corporation);
- Encourage water efficient fixtures and fittings for all buildings constructed.
- Encourage lot owners to install a suitable rainwater tank. The tank size will be dependent on the roof area and water usage patterns of the business.
- Encourage greywater reuse schemes for landscape irrigation and business related purposes.
- Public areas, bioretention units and street landscaping will have a strong focus on using locally suitable native water wise species and use of soil amendments to reduce irrigation requirements.
- A reticulated wastewater service is to be supplied, with the potential for some wastewater types to be reused on site or nearby following appropriate treatment.

OTHER ASPECTS

- Future investigations and liaison are to take place with the Department of Indigenous Affairs (DIA) prior to construction, if required, for sites of significance.

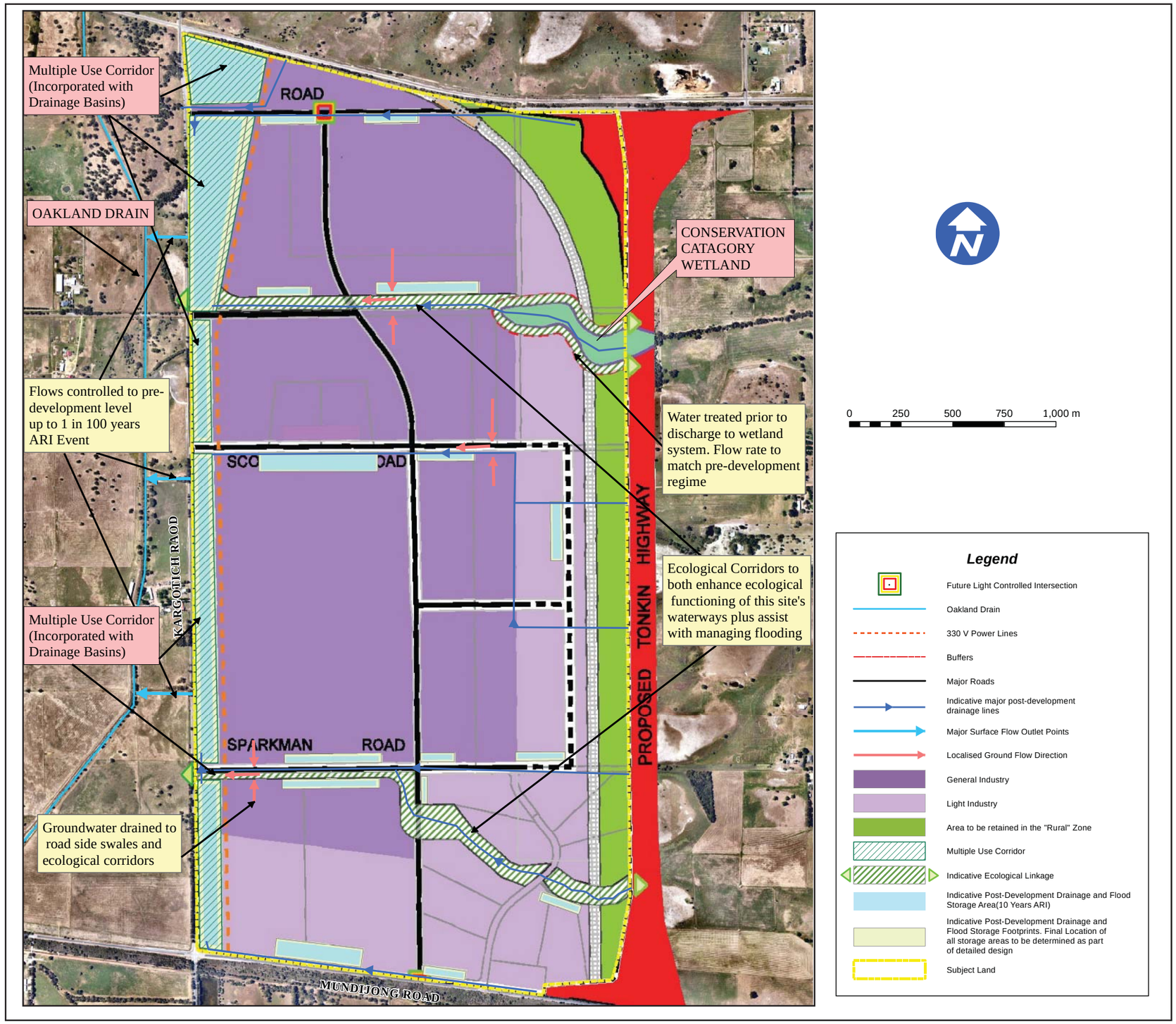


Figure 3 - Key Elements Plan

3 – LANDFORM & SOILS

The subject land is located on the Swan Coastal Plain and the landforms are typical of this area. The land is composed of three (3) main landforms, which are shown in *Figure 4 Page 9* and described below.

Figure 4 Page 9 displays contour information derived for the subject land from LiDAR (Light Detection and Ranging data) modelling.

1. **Wet Flats** – The majority of the site is a mildly sloping wet plain. This landform slopes downwards from east to west with a fall from 25-26mAHD to 16mAHD. The slopes vary between 0.2 and 1% with the slope generally flattening towards the west. These flats are generally sands over loams and clays. The low slopes and predominately sandy surface of this landform produces a low runoff rate until the land becomes waterlogged. These areas are classified as wetlands.
2. **Sand Rises/Ridges** – Low Bassendean sand ridges are located sporadically across the subject land. These are low relief dunes with deep bleached grey sands. The sand ridges rise between 2m and 6m above the surrounding plain with the peaks being up to 27mAHD. The slopes vary from 1 to 5% on the sides of the ridges. The sandy nature of this landform produces a low runoff rate, with most water infiltrating into the soil profile.
3. **Waterways** - There are also a number of minor waterways that traverse or begin on the subject land. Many of these have been modified through drainage works. The largest of these waterways is known as Manjedal Brook. The waterways/drains tend to be incised within the wet flats landform. It is likely that historically these waterways were considerably more braided and less defined.

Shallow Drainage Line

4 – GEOTECHNICAL

GEOLOGY

The superficial formations over the land consist predominately of Pinjarra System alluvial soils overlaid with aeolian Bassendean System sands.

The Pinjarra soils are likely to have a high Phosphorus Retention Index (PRI) while the Bassendean sands are likely to have a low PRI. There is a need for a geotechnical investigation of the site to be undertaken as part of later planning for the area.

CONTAMINATED SITES

An analysis of the Department of Environment and Conservation's (DEC) Contaminated Sites database was undertaken on 9th July 2012, and no known sites were found on the subject land or in the near vicinity.

ACID SULPHATE SOILS (ASS)

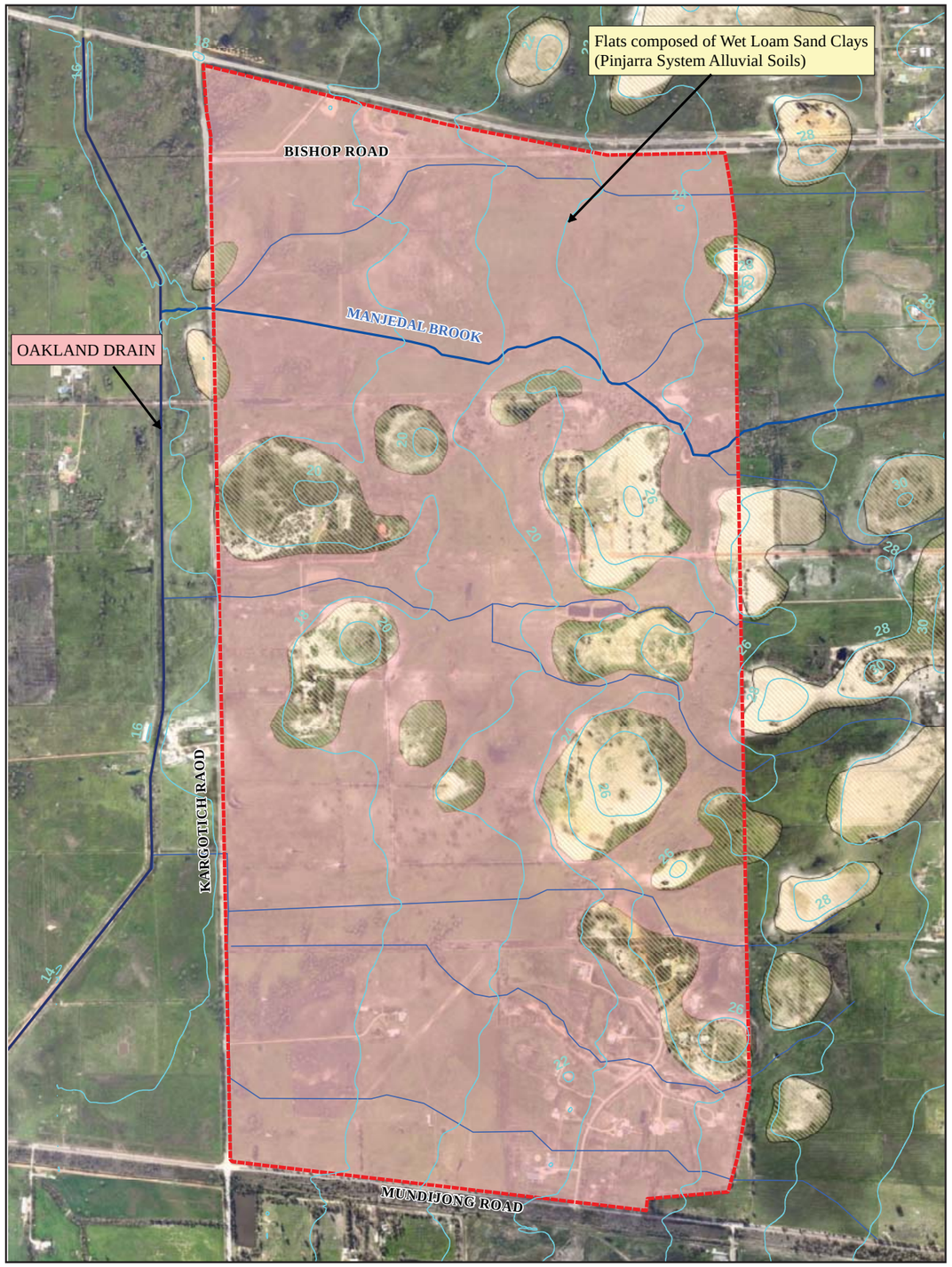
The DEC ASS mapping for the Swan Coastal Plan has modelled the whole subject land as moderate to low disturbance risk of ASS.

To protect on site and downstream water resources, ASS investigations should be undertaken across the subject land to determine the potential and actual ASS risks as part of future investigatory works.

Detailed ASS investigations and management plans (where appropriate) will also be required on land modelled as 'Moderate to Low' in accordance with DEC's 2009 *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes* guidelines if any of the following works are proposed:

- Soil or sediment disturbance of equal to or greater than 100m^3 with excavation from below the natural water table.
- Lowering of the water table, whether temporary or permanent (e.g. for groundwater abstraction, dewatering, installation of new drainage, modification to existing drainage).
- Excavation to or greater than 3m below the natural ground surface level.

The ASS investigations should happen as a condition of subdivision, unless there is evidence of high risk ASS. If this is the case then it may be appropriate to undertake investigation at an earlier stage, should the proposed development stratagies be subject to high risk activities being undertaken.



NOTE:

Entire site is identified as a low to moderate disturbance risk of acid sulphate soils

Legend

- Contours
- Oakland Drain
- Manjedal Brook
- Drainage Lines
- Subject Land

LANDFORMS

- Low Sand Dunes of Bassendean System Aeolian Sands
- Pinjarra System Alluvial Wet Flats

Typical cleared Farmland with Isolated Casuarina Obesa Tress

Figure 4 - Landform, Soil and Geotechnical Plan

5 – ENVIRONMENT

PGV Environmental undertook an environmental assessment of the subject land. The following is a summary of this information and site visits by TME.

WETLANDS AND WATERWAYS

According to the Department of Environment and Conservation's (DEC) Geomorphic Wetlands Swan Coastal Plain dataset (as shown in *Figure 5*), the Paluasplain Multiple Use Wetland (Number 15785) covers the majority of the site. The Multiple use wetlands areas are predominately devoid of native vegetation, although there are small areas of isolated *Melaleuca rhaphiophylla, Eucalyptus rudis* and *Casuarina obesa* trees. The main vegetation is composed of pasture species. These areas have limited ecological functioning and therefore provided few habitats for fauna

There is also a small area of Paluasplain Conservation Category Wetland associated with Manjedal Brook that traverses the northern portion of the site This has the reference Number 14945. The overstorey vegetation is largely intact and forms part of a corridor of vegetation along the brook and constructed drain. The understorey is predominately composed of weeds. This area provides some basic habitat value for fauna and acts as a limited corridor for fauna movement.

The other waterways and drains tend to be very degraded in nature, with limited ecological functioning, although there is still likely to be a limited range of fauna that use these waterways. The main flora along the waterways are introduced grasses and pasture weeds. They are likely to be classified as 'D' grade waterways using the Penn and Scott method.

To the south of the site, there is some higher quality wetland type vegetation associated with the reserve along Mundijong Road. This area is regarded as a Paluasplain Conservation Category Wetland (Number 14817).

OTHER AREAS

Some of the sand mounds have parkland cleared native vegetation, with some areas of denser, although degraded native vegetation. The vegetation tends to be dominated by marri trees. This will provide some habitat for wetland and waterway dependent fauna that are also able to use these other vegetation types.

There has also been some windbreak and Landcare planting along fence lines and drains. These will also provide some limited habitat to generalist species.

VEGETATION AND FLORA

The subject land is within the Southwest Botanical Province within the Swan Coastal Plain Bioregion and is dominated by vegetation of the Pinjarra Plain and Bassendean System. Most of the native vegetation however has been cleared.

The different areas of vegetation include:

1. Completely cleared farmland containing pasture grasses, which is the predominant vegetation type over the entire site;
2. *Casuarina obesa* Woodland over pasture grasses which is dominant in the south western corner of the site
3. *Melaleuca rhaphiophylla* (Paperbark) Woodland over pasture grasses which is associated with the Conservation Category Wetland and has some *Eucalyptus rudis* (Flooded Gum);
4. *Corymbia calophylla* Woodland over pasture grasses which is mainly in the area around Scott Road; and
5. *Kingia australis* and *Melaleuca rhaphiophylla* over pasture grasses, which occurs in the north of the site near Bishop Road.

The degraded nature of the site means it is highly unlikely that any Threatened or Priority Flora exist on the site. The priority flora found to the south of Mundijong Road will not be impacted by the development of the subject land.

FAUNA

The degraded nature of the site's vegetation means that there is likely to be limited opportunity for endangered fauna species that rely on wetlands and waterways to use the site. Generalist species, and those suited to agricultural landscapes may be able to make use of the degraded wetland and waterway habitats occurring on site. The waterways also provide some limited ecological linkage function for fauna moving across the site.

6 – HERITAGE AND CULTURAL SITES

There is one Registered Aboriginal Site present on the northern portion of the eastern boundary. It is a scatter site located on a sand rise and doesn't impact on the existing water ways and wetland areas. (see *Figure 5*). There is also another non registered Heritage Place that crosses the eastern boundary towards the south, which is also an artefacts scatter site. This is also located out of the drainage lines that exist on the subject land.

The aboriginal heritage issues are therefore unlikely to affect the water management of the site.

Investigations should be undertaken at future planning stages to ensure that Aboriginal and heritage consent is granted for proposed designs and practices.

All contractors working on any future development of the site will be made aware of their responsibilities under the *Aboriginal Heritage Act 1972* with regard to finding potential archaeological sites. In the event that a potential site is discovered, all work in the area will cease and the DIA will be contacted.

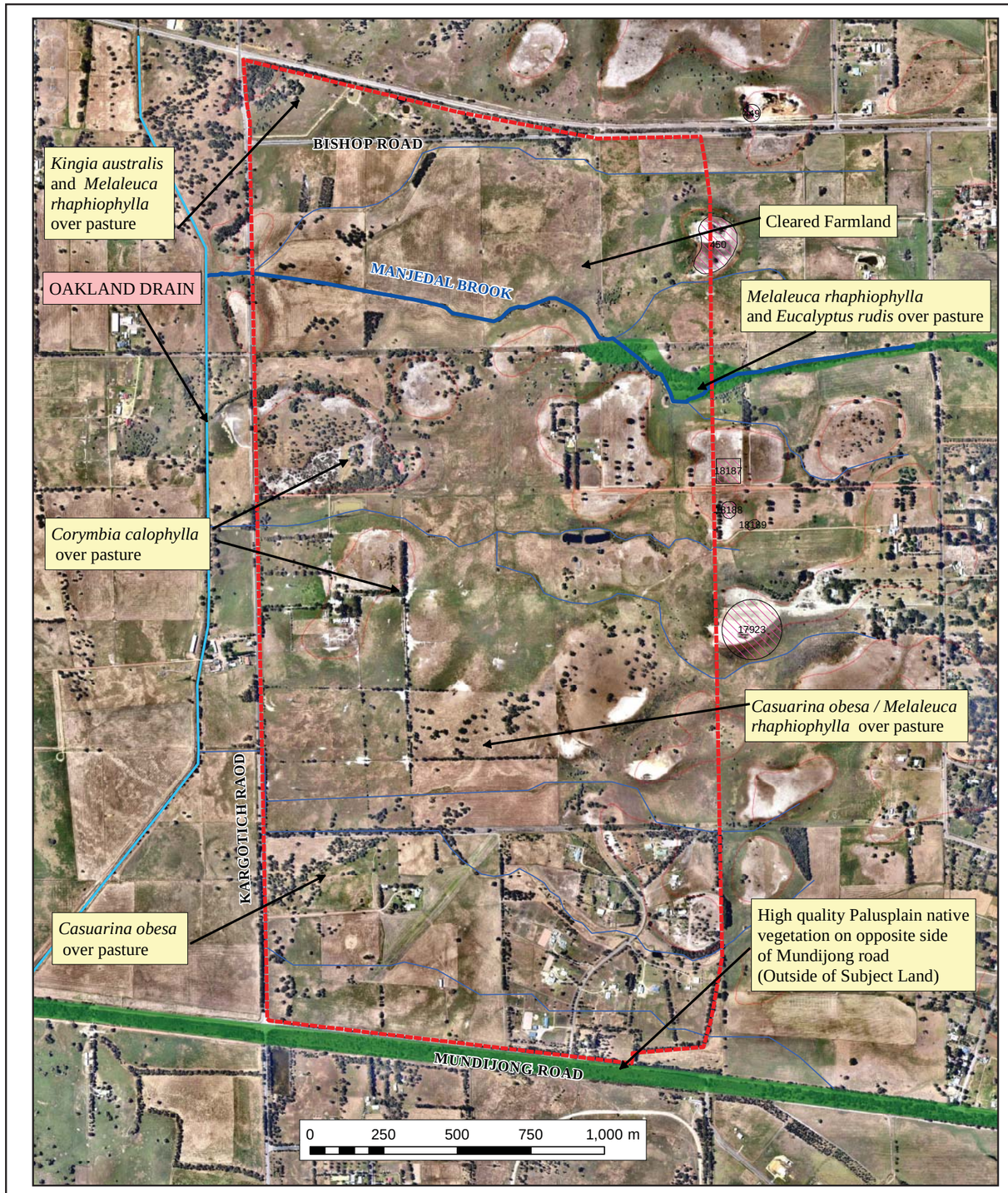


Figure 5 - Environmental & Heritage Plan

7 - GROUNDWATER PRE-DEVELOPMENT

GROUNDWATER INVESTIGATIONS

The Department of Water (DoW)has undertaken broad scale analysis of the regions groundwater levels as part of Perth Regional Aquifer Modelling Systems (PRAMS) model development. Hydrology and groundwater modelling, with a focus on the Lower Serpentine Regional Model (2008) has also been undertaken.

This information was analysed by TME, in conjunction with LIDAR. From this information, indicative groundwater levels for the site were developed.

Maximum, minimum and average maximum groundwater contours were determined as well as the depth to groundwater. From this analysis, the groundwater can be seen to be moving generally in a westerly direction.

Maximum levels ranged from 26mAHD on the eastern boundary down to 16mAHD on the western boundary. Minimum levels fell from 23mAHD to 14.5mAHD and Average levels fell from 24mAHD to 15mAHD. Seasonal variation between the minimum and maximum level was usually between 2m and 3m.

The depth to groundwater varied across the site. Approximately a quarter of the site had water at the surface, with another quarter showing water within 0.5m of the surface. Under some of the sand dunes, the ground water was at least 3m below the surface. A map of groundwater depth can be seen in *Figure 6. page 13.*

Groundwater quality has not been analysed in detail for the subject land. Due to the current land use and soil types present, it is likely that the nutrient levels of the groundwater will be elevated. This has the potential to impact on wetlands and river systems both on and downstream of the subject land.

It is also likely that the pH of the groundwater will be under 7 and have elevated levels of iron and aluminium. The salinity is likely to be in the fresh to brackish range. Groundwater exhibiting the above characteristics is common throughout the eastern portion of the Swan Coastal Plain.

AQUIFER INFORMATION

The subject land is within the Serpentine groundwater area and the Byford 3 sub area.

The DoW was contacted on 10th March 2012 regarding groundwater availability for the subject land. The Yarragadee, was noted as being fully allocated. The Perth-Cattamarra Coal Measures had an allocation over 79,000kL, the Perth Leederville had over 183,500 kL available and the Perth-Superficial Swan had over 11,768,000kL still available. This means there is currently significant groundwater resources that may be used within the development. Applications will need to be made to the DoW at later stages of planning to ascertain the actual water resources available, and in which aquifer. It should also be noted that the thickness of the superficial aquifer is generally thin and may contain clay and colluvial sediments being so close to the scarp. This may impact on the daily yields available due to a reduced hydraulic conductivity.

It should also be noted that the DoW is currently preparing an allocation plan for this area. This may change the allocation limits.

The groundwater management section (Section 13) outlines some indicative groundwater usage figures, based on typical industrial areas.

Typical area where groundwater is seasonally close to surface

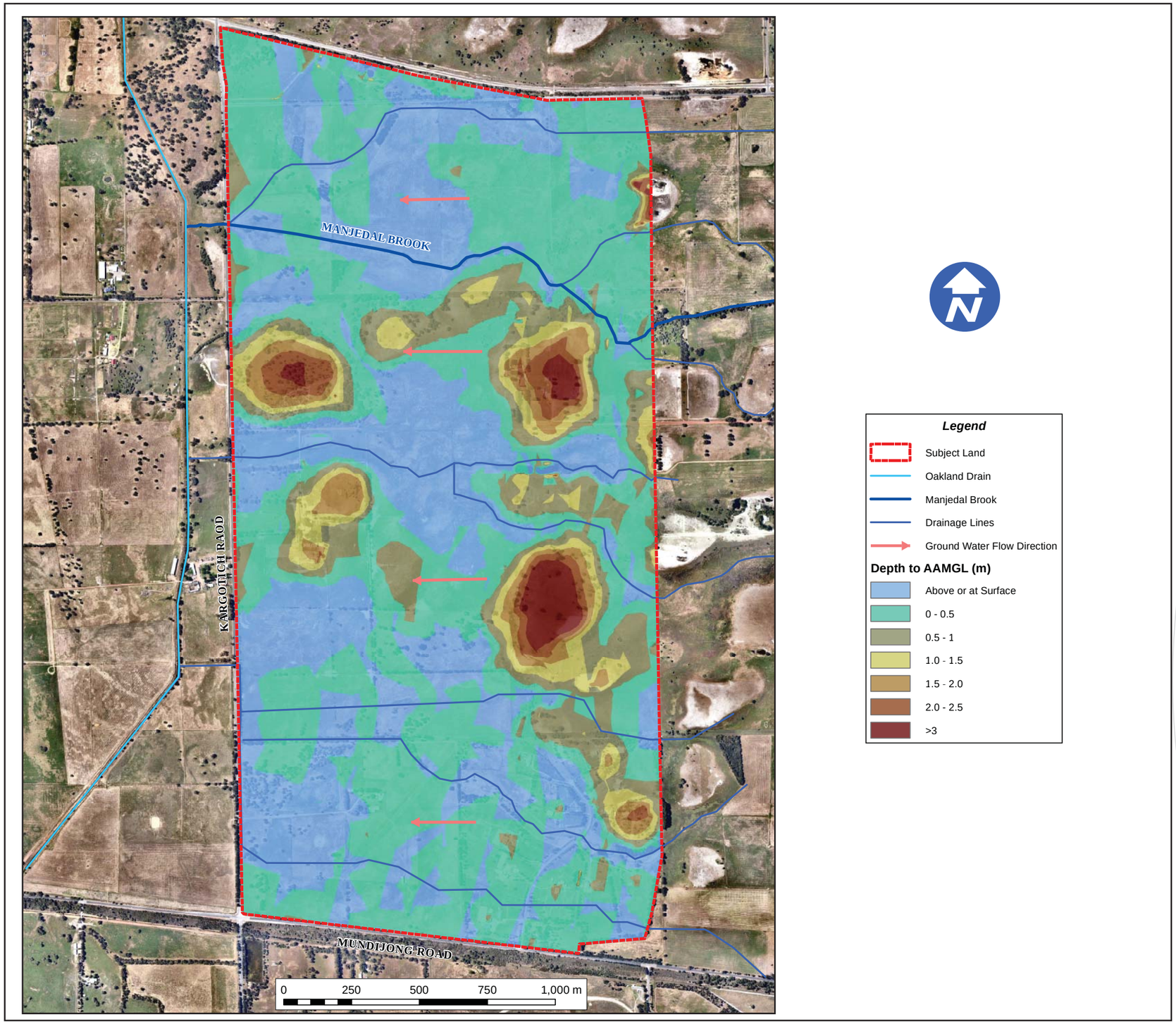


Figure 6 - Groundwater Pre-Development

8 - SURFACE WATER AND DRAINAGE PRE-DEVELOPMENT

The subject land is drained by a number of small drains and waterways that all exit the site on the western boundary. The site is also traversed by larger waterways, including Manjedal Brook, that carry significant flows. These waterways begin on the Darling Scarp. Water generated on the site, and water that enters the site from upstream all flow across Kargotich Road and into Oakland drain. This major Water Corporation drain runs southward, parallel to the subject land. Water from this drain is ultimately discharged into the Serpentine River and Peel Harvey Inlet.

PRE-DEVELOPMENT DRAINAGE ASSESSMENT

The pre-development runoff from the subject land and upstream flows was modelled to determine flows from the 1 in 10 year and 1 in 100 year events. This modelling incorporated original broad scale modelling by the DoW, with more detailed modelling within the subject land by TME.

Flood mapping information for the subject land was obtained from the DoW from their modelling. The major drainage line within the subject land is Manjedal Brook, running from east to west in the northern part of the subject land. There are another eight small drainage lines which transport external inflows during high flow events.

These drainage lines, and onsite run off, converge to three main defined outlets before discharging under Kargotich Road and into Oakland drain. These can be seen in *Figure 7 Page 15*

Pre-development inflows and outflows from the subject land were shown in *Figure 7 Page 15*. Hydrologic Engineering Centres River Analysis System (HEC-RAS) was used for modelling flood and ArcGIS for flood inundation mapping. Cross sections of drainage lines were extracted from LiDAR and inflows from Department of Water modelling were used. The two (2) models could not be fully calibrated together due to lack of data but are considered appropriate for this broad scale study. With further on site flow data and feature survey, a more accurate model can be produced.

A flood inundation map for 1 in 10 year event for the modelling exercise is presented in Figure 7 Page 15. For the 1 in 100 years flood inundation map, DoW modelling was used (Refer *Figure 8 Page 17*). These are flood inundated from external inflows.

For pre-development flows within the subject land, rational method was used for each of sub-catchments. Due to high groundwater level, a 0.5 effective runoff coefficient was used to calculate peak flows for pervious surface and 0.9 for impervious surfaces.

To get an estimate of water stored at site at 1 in 10 and 1 in 100 years Average Recurrence Interval (ARI) event in pre development situation, DRAINS (Developed by Watercom Pty. Ltd.) was utilised. Based on three major outlets, three major catchments were identified. The model identified where the water is stored during the large flood events. *Figures 7 and 8 Pages 15 and 17* show external inflows, three major sub catchments, pre-development flows and outlets. It also shows current storage as overland within the subject land.

The model shows that the existing capacities of the culverts under Kargotich Road are not adequate to cater for even the 1 in 10 years ARI pre-development flow. This results in flooding of the subject land and overtopping of the road.

It should be noted that this analysis is for broad scale study and should be refined in later stage of study.

A summary of the flow rates and storage volumes for the subject land in the 1:10 and1:100 ARI events are shown in *Table 1 Page 14*.

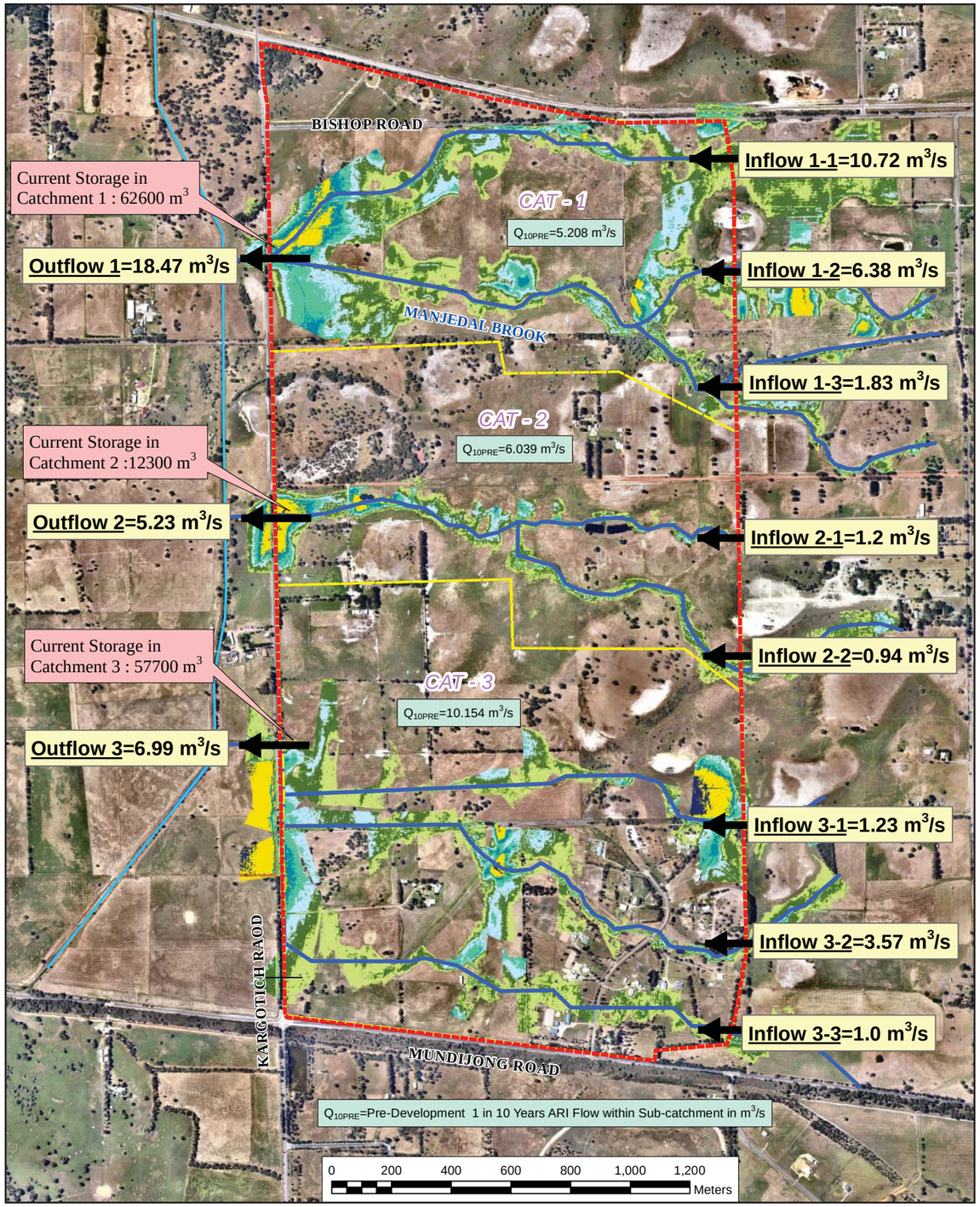
S.No	Catchment	PRE-DEVELOPMENT			
		Pre-Development flow as per DoW Modelling		Volume of Water storing within subject land (Pre-Development)	
		1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)	1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)
1	Catchment 1	18.47	36.59	62600	90400
2	Catchment 2	5.23	8.79	12300	17100
3	Catchment 3	6.99	16.8	57700	76400
	Total			132600	183900

Table 1 Flow rate Summary and Storage Volumes Table

1 Current Volume of Water storing within subject land is calculated from pre-development flow from subjectland (calculated using rational method) + External inflows with permissible outlet discharge as outflow discharge from DoW Model (Pre-development)

2 Additional storage is storage required in addition with Sub-catchment/lot storage (Post-development 1 in 10 yr - Pre-development 1 in 10 yr) to limit discharge from subject land to pre-development stage

3 As current capacity of culverts in Kargotich road is not adequate to release pre-development flow detail analysis should be done in detail phase of design



NOTE:
- External inflows are as per DoW Model and flood inundation is from HECRAS Model without callibration due to lack of data
- Effective Runoff coefficient is assumed as 0.5 due to high ground water
- Calculations to be refined in detail design phase

Figure 7 - 1 in 10 Years ARI Pre-Development Flows

SURFACE WATER QUALITY

No pre-development monitoring has been undertaken at the moment. There is some limited water quality data available for Manjedal Brook, which was collected in October 2007 as part of the Mundijong – Whitby District Structure Plan Environmental Study (2009). The results are typical for waterways on the eastern edge of the Swan Coastal Plain, although nutrient levels were lower than most waterways. This may be due to the larger flows of Spring diluting the results.

The results can be seen in *Table 2 Page 16.*

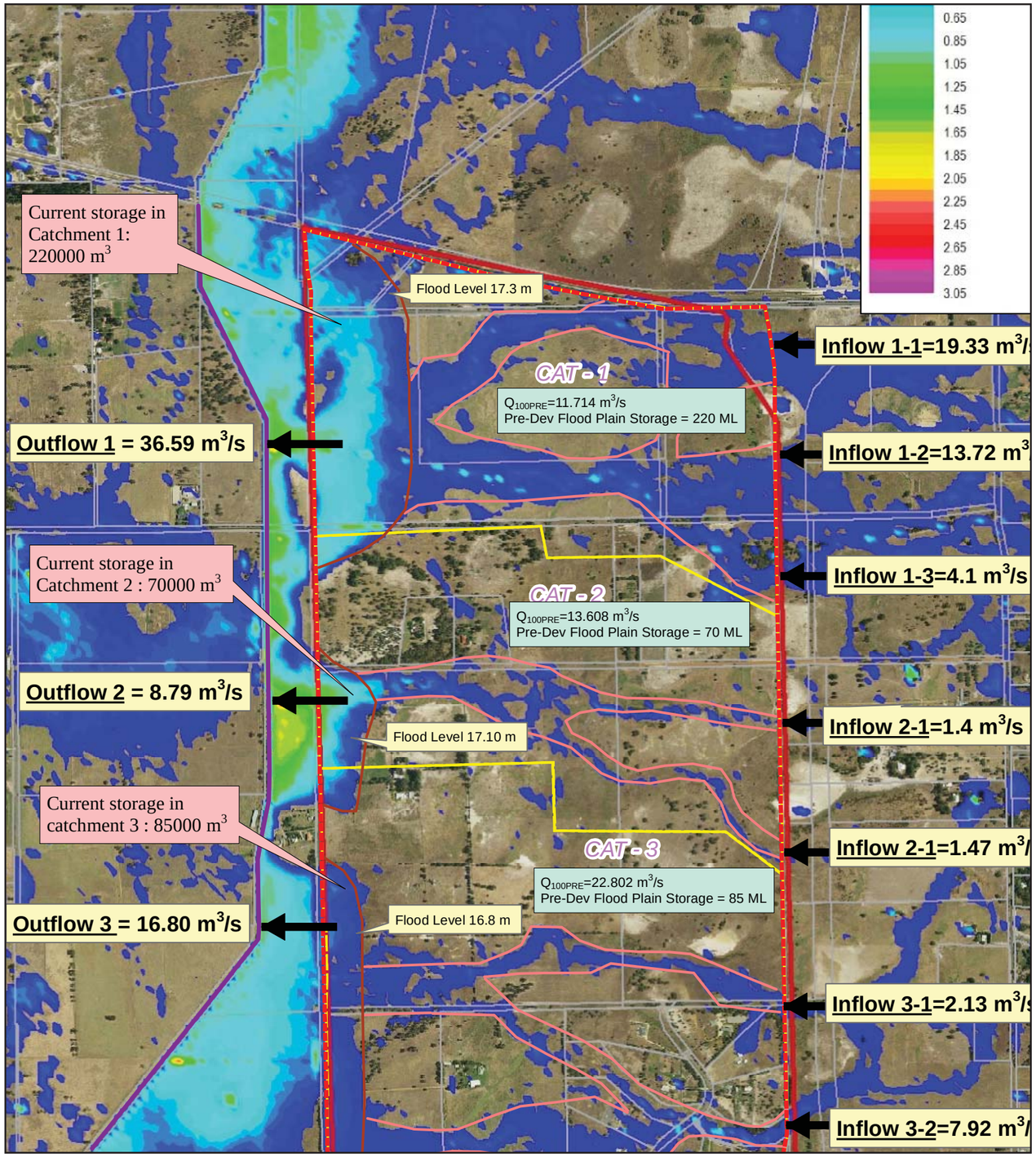
As the subject land is within the Peel Harvey Water Quality Improvement Plan (WQIP) area, the site will need to consider the recommendations outlined within this report. The Estuary and associated waterways are showing signs of stress according to the (WQIP). The Estuary is internationally, nationally and regionally significant for natural fauna and flora, recreation, aesthetics and hydrologic systems. The system has a history of water quality problems, which are derived from its large and diverse catchment and land uses.

More information on how the development of the site can assist with meeting the WQIP recommendations is outlined in *Section 11*: Water Quality Management.

Typical degraded waterway and ponding

Variable	Range	Comments
pH	6.89-8.25	Meets ANZECC water quality objectives
Electrical Conductivity	343 – 1150 µs/cm	Lower conductivity values are often associated with seasonal rainfall
Salinity	0.14 – 0.58 ppt	fresh to slightly brackish
Turbidity	5.30 – 25.8 NTU	
ORP	170-286 mV	
Dissolved Oxygen	82.7 – 138.6%	should avoid falling below 5mg/L to avoid stress to aquatic species
Heavy Metals		Within ANZECC Drinking Water Guideline Values 2004
Total Phosphorus	0.01 to 0.03 mg/L	Meets ANZECC water quality objectives
Reactive Phosphorus	<0.01 mg/L	Meets ANZECC water quality objectives
Total Nitrogen	0.35 mg/L (average) 2.1 mg/L (max)	All but site 3 meets ANZECC water quality objectives
Total Kjeldahl Nitrogen	0.2 – 0.7 mg/L	
Ammonia	>0.105 – 0.118 mg/L	Above ANZECC trigger values
Nitrite and Nitrate (NO_x)	<0.010 - 1.380 mg/L	Mostly less than ANZECC trigger values

Table 2 Surface Water Quality Results



Q_{100PRE}= Pre-development sub- catchment flow in 1 in 100 years ARI (m^3/s)

NOTE:
- External inflows and flood inundation are as per DoW Model
- Pre- Development Floodplain Storage within catchment is as per DoW Mode
- Effective Runoff coefficient is assumed as 0.5 due to high ground water
- Calculations to be refined in detail design phase

0 175 350 700 1,050 1,400
Meters

Legend

- Subject Land
- Oakland Drain
- Indicative 1 in 100 years ARI Pre-development Flood Level near Kargotich Road
- Indicative Flood Plain of waterways in 1 in 100 years ARI in pre-development situation
- Major Catchments
- Drainage Lines

Figure 8 - 1 in 100 Years ARI Pre-Development Flows

9 – CONSTRAINTS, OPPORTUNITIES AND SOLUTIONS

The subject land and surrounds present a range of constraints and opportunities, which will influence the development solutions in relation to water management. *Figure 9* identifies graphically some of the water management related constraints. *Table 3* provides a summary of these threats and a summary of the management options.

The following sections provide additional details and specific water management strategies tailored to this site.

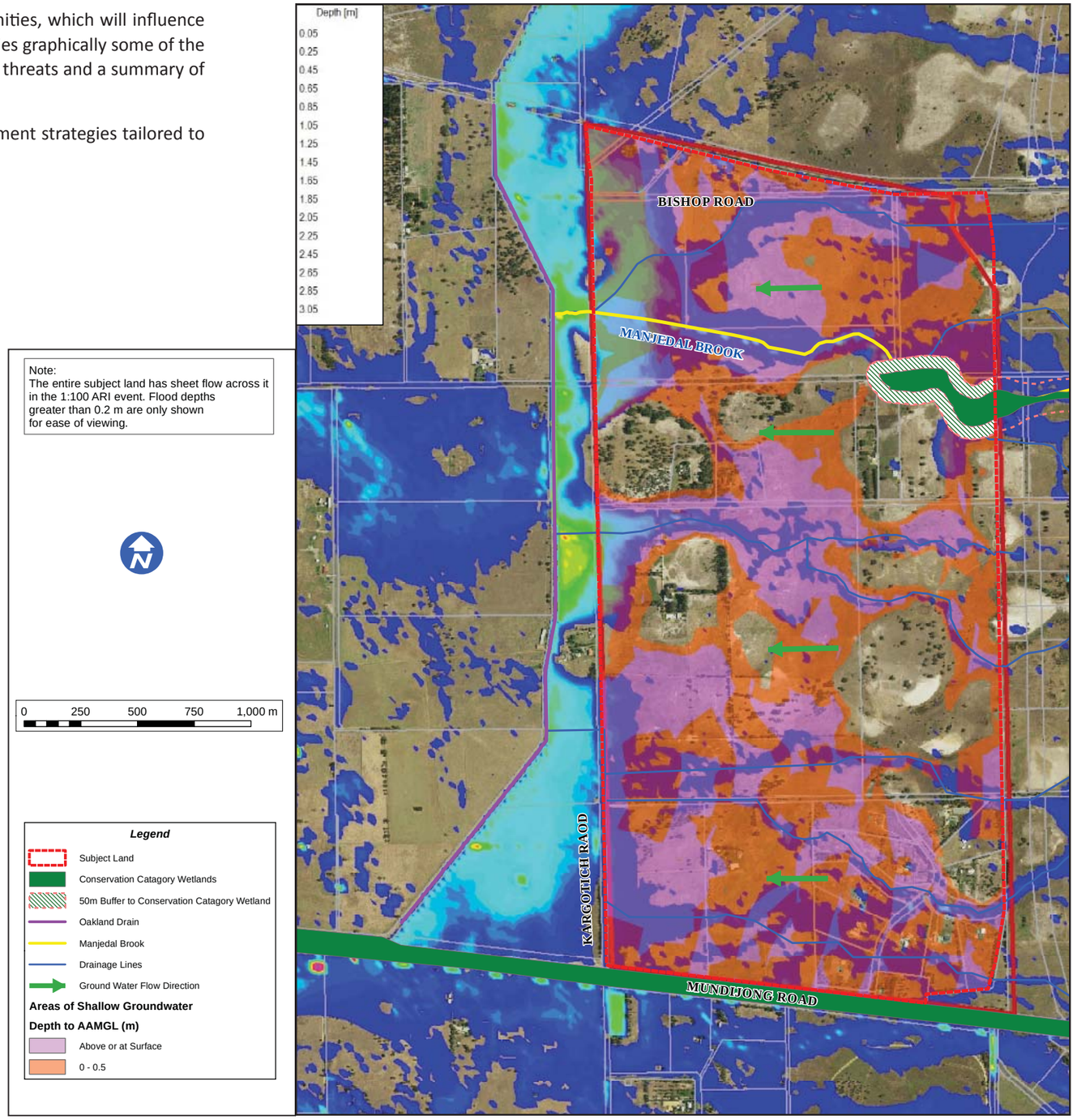


Figure 9 - Opportunities and Constraints Map

Constraints/Threats		Opportunities and Management Options
Aboriginal Heritage Site	**A**	Investigate sites with the Department of Indigenous Affairs to ensure development works satisfies *Aboriginal Heritage Act 1972*.
Wetlands (and associated buffers)	**A**	Creation of buffers around applicable wetlands.
	B	Preparation and implementation of a wetland management plan for appropriate wetlands, including advice on protection and rehabilitation management strategies.
	C	Enhancement of wetlands and their functional areas.
	D	Provide refuge for fauna between the large areas of native vegetation reserved on-site and to natural wildlife corridors by including in ecological linkages.
	E	Encourage planting of locally appropriate native plants in public and private areas to provide linkages between wetlands, reserved native vegetation and wildlife corridors.
	F	Use of Water Sensitive Urban Design (WSUD) techniques to treat and improve water quality that enters wetlands.
	G	Maintenance of existing s flow rates via appropriately designed stormwater and groundwater management designs.
	H	No treatment within the wetland area with some flood storage within buffer area basins designed to mimic seasonal wetlands.
Waterways (and associated foreshore reserves)	**A**	Creation of foreshore reserves (buffers) around applicable waterways which are included within ecological linkages.
	B	Preparation and implementation of a ecological linkages management plan including advice on protection and maintenance management strategies.
	C	Enhancement of drainage lines so that they both transport the required volumes and flow rates while providing habitat for fauna through appropriate design.
	D	Encourage planting of locally appropriate native plants in public and private areas to provide linkages between swales and waterways.
	E	Use of WSUD to treat and improve water quality that enters waterways.
	F	Maintenance of existing water flow rates via appropriately designed stormwater and groundwater management designs.
	H	Potential construction of footpath (or interpretative trail) along and throughecological linkagesto improve recreational facilities and provide an educational resource for the greater community.
Flooding	**A**	No development allowed within the 1:100 floodway of the drainage system.
	B	Use of fill where necessary to achieve the required separation from appropriate flood levels.
	C	Utilise stormwater infrastructure to store and convey runoff during a flood event that protects both infrastructure and receiving water bodies. Post development release flow rates from the subject land will be designed to match pre-development flow rates and includes the existing pre development flood storage volumes.
Stormwater Flow Rate Runoff	**A**	Post development outflow rates to match pre-development rate.
	B	Use of Water Sensitive Urban Design (WSUD) to temporarily store and control the flow rates of stormwater runoff and discharges from the development both on private and public land.
Stormwater Nutrients, Contaminants and Pollutants	**A**	Use of water sensitive urban designs (e.g. bioretention units) to reduce total nutrient loads entering groundwater and leaving the subject land.
	B	Structural separation practices applied at a lot level to minimise pollution from industrial activities.
	C	Introduction of non-structural best management practice. Including provision of educational material to lot owners regarding responsible disposal and use of water from their business.
	D	Landscaping to utilise strategies that will not produce excessive fertiliser requirements and potential leaching of nutrients.
	E	Removal of potentially high nutrient loading agricultural practice currently on the land.
	F	Monitoring of water quality post development to improve treatment strategies, if required.
Groundwater Levels (including high peaks and dependent ecosystems)	**A**	Ensure development has no negative impact on groundwater resource, significant wetlands and waterways influenced by site.
	B	Use of suitable fill where necessary. Suitable fill should be stipulated in future geotechnical investigations, and shall include appropriate permeability requirements and a provision for soil amendments to improve nutrient retention while having a permability which minimises mounding.
	C	Use of suitable fill, roadside swales and sub-soil drainage pipes where necessary to obtain adequate separation between controlled groundwater levels and infrastructure.
	D	Infiltration of stormwater wherever possible on both private and public lands.
	E	Monitoring of groundwater levels pre development to increase the accuracy of the site's AAMGL.
	F	Monitoring of groundwater levels post development to improve management strategies, if required.
Groundwater Quality	**A**	Use of WSUD (e.g. bioretention units) to reduce total nutrient loads entering groundwater.
	B	Treatment of sub-soil pipes that intercept groundwater with WSUD. Potentially this could improve the groundwater resource and dependent ecosystems (e.g. wetlands on-site) from their pre-development conditions.
	C	Landscaping to utilise strategies that will not produce excessive fertiliser requirements and potential leaching of nutrients.
	D	Removal of potentially high nutrient loading agricultural practice currently on the land.
	E	Monitoring of groundwater quality post development to improve treatment strategies, if required.
Acid Sulphate Soils (ASS) Risk	**A**	Undertake a preliminary ASS risk investigation of the site.
	B	Depending on preliminary ASS investigations a detailed ASS investigation and management plan may be required prior to any development (or ground breaking activities).
	C	Use of fill, WSUD and on-site effluent disposal should all minimise the disturbance to the existing soils and therefore minimise the risk of disturbing ASS.
Potentially Low Phosphorous Retention of Soils	**A**	Undertake a geotechnical investigation to determine PRI of soils across the site.
	B	Use of appropriate amended soils (and/or fill) to improve the phosphorous retention capabilities of the soils.
	C	Use of appropriate practices for on-site effluent disposal.
Wastewater Management	**A**	Development to be connected to wastewater collection system, either through connection through to existing offsite infrastructure or a stand alone system.
	B	Encourage greywater reuse schemes for businesses.
	C	Designs to be undertaken in detail at a lot level to ensure system is appropriate for lot conditions, industry use and to be approved by the local government authority.
	D	Investigation into wastewater treatment and reuse schemes.
Potable Water Supply	**A**	Development to be connected to reticulated water supply.
	B	Encourage on-site capture of rainwater for supplement usage.
	C	Encourage of greywater reuse schemes for businesses.
Non Potable Water Supply	**A**	Investigation into wastewater treatment and reuse schemes.
	B	Investigations into superficial aquifer groundwater usage, which will also assist with controlling groundwater levels.
	C	Investigation into large scale groundater usage schemes from Leederville and other deeper aquifers.
	D	Investigation into roof runoff harvesting and reuse schemes at the lot scale.
	E	Develop recommendations for water use efficiency practices and targets for both businesses and irrigation of public areas.

Table 3 Summary of Threats and their management options

10 - DRAINAGE MANAGEMENT STRATEGY

The objectives of the stormwater drainage management for the development area and relevant upstream and down stream flows, are to mimic as close as possible the pre-development flows leaving the subject land and treating the necessary volumes before the water is discharged to receiving water bodies. All modelling and recommendations are in keeping with the modelling undertaken by the Department of Water. Stormwater discharged into the groundwater will similarly incorporate designs to mimic as close as possible the pre-development regimes and reduce nutrient and other potential contaminants entering the groundwater resource.

The subject land is divided into three major sub-catchments based on three major outlets and fourteen sub catchments based on outlets and proposed development. These can be seen in *Figure 11 page 23*.

The primary objectives of the 1:1 year average recurrence interval (ARI) event drainage designs are to treat the stormwater and to protect the ecological functions of receiving natural environments. The priorities for storm events above the 1:1 year event are to control the flow of drainage water throughout the subdivision and release the water from the subdivision at pre-development rates, whilst not creating any negative impacts to surrounding or downstream infrastructure, this will primarily be achieved via temporary storage of runoff and controlled outlets.

The conveyance and storage of the 1:10 year ARI events will be via integration of swales, pipes and storage units throughout the development. Flooding up to and including the 1:100 year ARI event will utilise the 1:10 year infrastructure, with excess runoff to be conveyed and stored within swales, road reserves, multiple use corridors and drainage easements. The protection of private property from inundation and detaining outflow rates into receiving water bodies are the primary objectives of these flood events.

Using *DRAINS* software, peak runoffs were modelled with the Rational method for the critical time of concentration for each catchment derived using the Kinematic flow equation and pre and post peak flow rates determined for each catchment for 1:10 year and 1:100 year events. Total flood storage volumes were also included. Required storage volumes to detain flows for the 1:10 year event back to predevelopment levels were determined by the models with optimising basin sizes so that outlet discharge is limited to the pre-development stage.

The following three sections discuss and provide further details on how water is to be treated, conveyed, stored and discharged in three different ARI scenarios. Also catchment boundaries, discharge points and volumes of flow rates are depicted within the respective sections plans.

A – The 1:1 year 1 hour event.

B – The 1:10 year flood event.

C – The 1:100 year flood event.

The following sections outline the guidelines the development may follow to ensure that best management practices of stormwater management and flood protection are achieved.

Detailed drainage designs, models and drawings will be required at the structure plan and subdivisional stages, to accompany the Local Water Management Strategy (LWMS) and Urban Water Management Plan (UWMP) respectively.

It should also be noted that the flood storage areas are indicative in both size and location. The final size and location are to be determined as part of the detailed design. The storage areas shown are to provide an indication of both the different types of storage needed plus a quantum of their size, at a catchment level.

The Water Corporation drain that traverses the north west of the site is to be managed so that it continues to provide the level of service it was designed for, at a minimum. Its final alignment and sizing it to be determined as part of the detailed design in conjunction with the nearby flood storage areas.

10A - DRAINAGE MANAGEMENT STRATEGY – 1 YEAR 1 HOUR EVENT

The drainage management system for the development will be designed to capture and provide treatment for the 1 year 1 hour event, which effectively captures approximately 95% of all stormwater flow. The designs will also provide protection of the ecological functions for all receiving natural environments post development. For this site, the 1 year 1 hour event equates to 17.2 mm per hour. The flow generated from this rain volume will be collected and treated.

Surface water on the land will take two main directions; infiltration to the groundwater and surface run off. Two separate treatment trains have been designed and specified to treat and manage the two different flow paths.

INFILTRATION TO GROUNDWATER

The majority of the water that falls on pervious surfaces in the development area will infiltrate through to the shallow groundwater because of the high hydraulic conductivity of the imported fill's free draining nature that will be laid across the majority of the developable area. This will include any overflow from installed rainwater tanks, on-site bioretention systems, swale bases and property soak wells. Any fill used will ensure that the fines content of the fill is restricted to less than 5% to promote drainage across the site. Appropriate soil amelioration products will be used where any water infiltrates through gardens, and public spaces where fertilisers would be applied.

Piped subsoil drains will be used to intercept and convey ground water flows to the drainage system and ensure levels across the site do not rise above the designated CGL for the site. These pipes will also ensure the required clearances to lots are maintained, allowing soakwells and basins to function as per their design parameters.

It should be noted that the decrease in evapotranspiration from the pre development to post development means that there is a general increase in groundwater volumes.

The Subsoil system will transport this water out of the soil profile to the swale systems, which is likely to produce a base flow through the drains for an extended period of time.

Rainwater tanks, with air gaps, will be encouraged for each lot and business throughout the development. The tanks would assist in reducing the peak runoff flows from the lots, providing some of their on-site storage requirements especially during summer storm events. Overflow from these will be directed to infiltration areas and soak wells. The base of the soak wells and infiltration areas will be installed generally 300mm above the CGL Water that enters the soak wells will infiltrate into the soil profile and ultimately into the groundwater. There is no direct link between roof runoff and the street drainage network.

Capture of rainwater via tanks with air gaps can also provide opportunities for water conservation.

SURFACE FLOW

Runoff within the development will occur off the lots and off the road reserves. Each lot will be responsible for capturing, detaining and treating all lot runoff for the 1 year 1 hour event on-site. The runoff could be detained and treated by a variety of methods and combinations, including shallow landscaped bioretention basins, rainwater tanks and soak wells.

For the runoff from the road reserves the 1 year 1 hour event will also be captured, detained and treated..

This treatment will generally be provided in road side bioretention gardens and swales. The bioretention gardens and swales will be protected from traffic, where appropriate. They will also be located so that

they do not obstruct lot access. the water entering the bioretention gardens will pass through an amended soil layer to reduce the quantity of sediments and nutrients entering the groundwater. The gardens will be constructed according to the latest FAWB adoption guidelines for filter media in biofiltration systems and the stormwater management manual for wa design guidelines. The three graphs in *Figure 13* are sourced from the Stormwater Management Manual for WA (DOW, 2008) and demonstrate the effectiveness of bioretention systems in removing nutrients from stormwater, when built to the aforementioned guidelines.

A typical arrangement for the swales in each street is shown in *Figure 10.*Bioretention gardens may require irrigation during the initial 2 to 3 years to assist with the establishment of plants. Irrigation and fertiliser applications should be met by storm water runoff after this period, although subsequent watering may still be required in drier years. The units should be designed to latest FAWB guidelines to ensure functionality assists the removal of nutrients, sediments and other potential contaminants from an industrial subdivisions runoff.

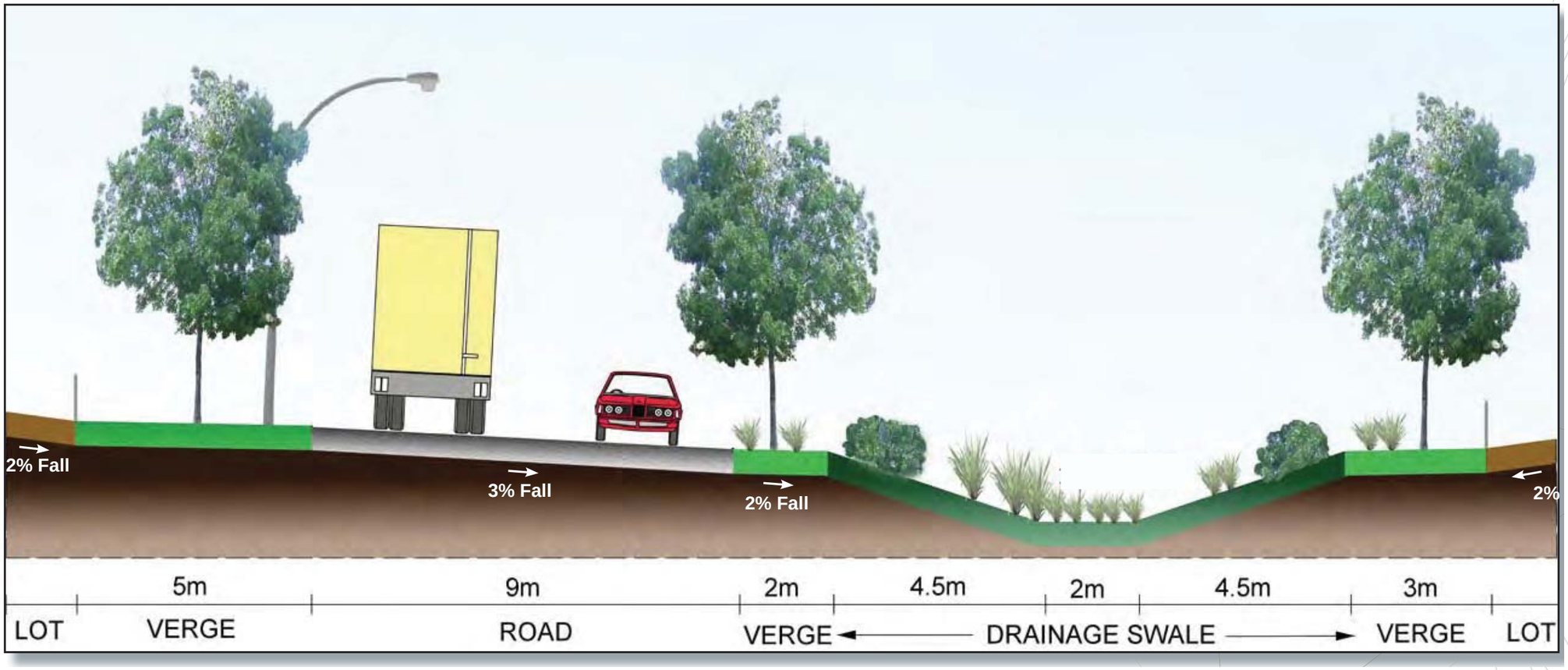


Figure 10- Road and Swale Cross-section Typical Arrangement for major drainage lines (smaller swale for other roads)(Concept only)

10B - DRAINAGE MANAGEMENT STRATEGY – 1:10 FLOOD EVENT

The drainage management system for the subject land is to be designed to manage the 1:10 year ARI events utilising pipe, swale and detention basin systems with controlled outlets. The objective of the drainage systems in 1:10 year events is to store the required volumes of water off the roads and lots, and transport the excess water to drainage infrastructure designed to either convey and/or infiltrate the runoff. The drainage system is to be designed to slow the rate of water flow, allow for partial infiltration of water on-site, and control discharged water out of the development at pre-development rates to the Oakland Drain.

In the 1:10 year event on the post development site, the flows will initially flow to the 1 year 1 hour treatment and storage devices on the lots and road reserves. Once these are filled the flows will then overflow into the swale systems in the road reserves where they will be detained and then conveyed to the outlet of the systems. At the outlet, flow spreaders will be used to reduce velocities to acceptable levels.

As existing drainage lines are not well defined, indicative major drainage lines/swales for post development are proposed to be located along roads without impacting on final drainage flows or significant ecosystems. Adequate sized swales to carry 1 in 10 years external inflows in addition with 1 in 10 years pre-development runoff from sub-catchments with sufficient free-board are to be designed as part of future water management strategies. Detail analysis will be carried out in detail design phase.

In addition to the lot storage to maintain pre-development flow rates, the modelling also shows the requirement of additional storage for external inflows to maintain pre-development flow rates at the final outlets. *Table 4* shows summary of storage requirement to maintain pre-development flow rates which will be refined in later stages of design. This includes the existing pre development storage on the subject land plus the extra generated as part of changing the land use from rural to industrial.

Stormwater that infiltrates to the groundwater during a 1:10 year event will have minimal effect on the flood peak. However, later expressions through seepage into the perforated sub-soil pipe system may occur. If expressions do occur, they may extend the period of time that water will continue to move through the sub-soil pipe network, although at a much reduced rate.

It is not an objective of managing 1:10 year flood events to treat runoff for quality, but the bio retention units and vegetated conveyance swales would allow for trapping and settling of suspended sediments, especially after the flood peak has passed. This is due to the slowing of water near the surfaces of the swales from the in-stream and bank vegetation, and the residence time.

S.No	Catchment	PRE-DEVELOPMENT				POST-DEVELOPMENT				
		Pre-Development flow as per DoW Modelling		Volume of Water storing within subject land (Pre-Development)		Lot /Sub-catchment Storage with outlet discharge of 1 in 10 pre-development(m^3)	Additional storage for 1 in 10 Years ARI (m^3)	Additional storage for 1 in 100 Years ARI (m^3)	Total storage Required	
		1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)	1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)				1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)
1	Catchment 1	18.47	36.59	62600	220000	25700	74000	220000	99700	245700
2	Catchment 2	5.23	8.79	12300	70000	25105	22500	70000	47605	95105
3	Catchment 3	6.99	16.8	57700	85000	43000	81400	85000	124400	128000
		Total		132600	375000	93805	177900	375000	271705	468805

Note:

1 Current Volume of Water storing within subject land is from Department of Water's flood model and advised pre-development floodplain storage within the subject land

2 Additional storage is storage required in addition with Sub-catchment/lot storage (Post-development 1 in 10 yr - Pre-development 1 in 10 yr) to limit discharge from subject land to pre-development stage

3 As current capacity of culverts in Kargotich Road is not adequate to release pre-development flow detail analysis should be done in detail phase of design

Table 4 Post Development flow rates and required storage

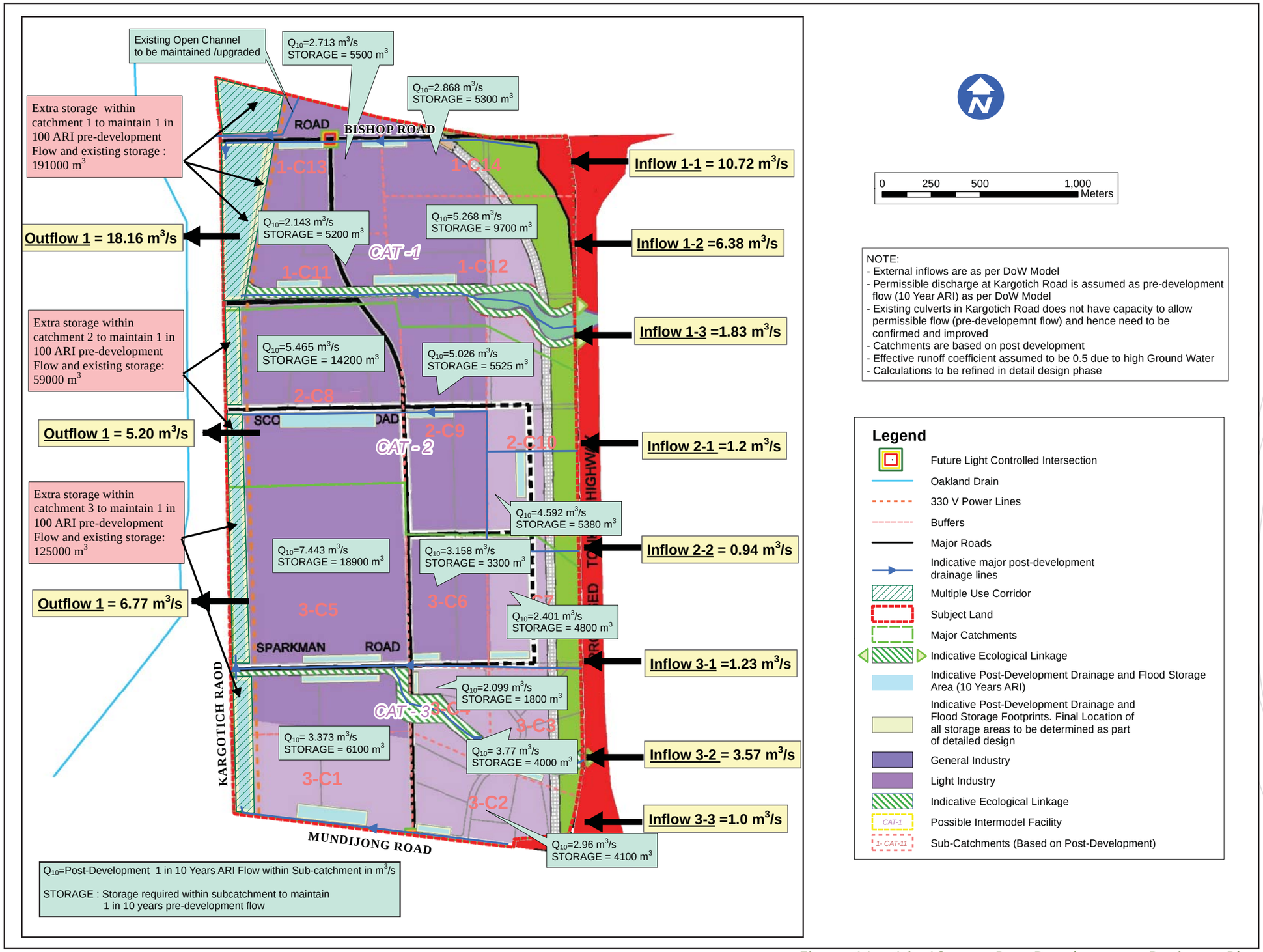


Figure 11 - 1 in 10 year Post Development Drainage Plan

10C - DRAINAGE MANAGEMENT STRATEGY – 1:100 FLOOD EVENT

The development is to be designed to safely convey the 1:100 year ARI flood event so that impacts on infrastructure, the environment and people's safety are minimised. All road and lots levels are to be designed to maintain a minimum 300mm separation clearance between buildings and the internal 1:100 ARI flood levels. A minimum 500mm separation clearance will also be required between building levels and the 1:100 year flood levels of the major waterways that travers the site, as well as the back water effect from Oakland Drain. The 1:100 year flood event's runoff is to predominantly be conveyed via the road reserves, waterways within the ecological corridors and the drainage swale network. The drainage network within the development area would flow at capacity with excess water flooding the adjoining road reserves. Some roads would be expected to partially flood however they shall remain serviceable for emergency vehicles.

During a 1:100 year flood event the roadside swales would flow at capacity with extra water flooding into the adjoining road reserves and public areas. These will fill the drainage basins as well as linking with the larger swales which transport the upstream flows through the development.

Large flows that traverse the site will be mainly conveyed within swale/living stream systems that are designed to handle the designated flow.

Using *DRAINS* software, peak runoffs were modelled with the rational method for the critical time of concentration including 1 in 100 years' external inflows. The drainage investigation modelled that utilisation of the 1 in 1 year 1 hour lot storage in addition with 1 in 10 years storage (outlet with 1 in 10 year pre-development) within sub catchments will require additional storage to maintain final outlet to 1 in 100 year pre-development stage. These storage requirements in addition with sub-catchment storage requirement are shown in *Figure 12 and Table 4.*

It is assumed that outlet flow from the subject land after development to be 1 in 10 years pre-development in 1 in 10 year's event and 1 in 100 years pre-development in 1 in 100 year's event. Detail analysis of existing capacity of outlets at Kargotich Road will be carried out in detail design phase. It is also assumed that flow from upstream on the development to be kept at pre-development flow rates.

The 1 in 100 Years Pre-development flood extents is shown in *Figure 12.* Maximum flood level near outlet 1 is 17.3 m, outlet 2 is 17.1m and outlet 3 is 16.8 m. A flood level separation of 0.5m to the finished floor level should be maintained to these maximum 1 in 100 flood levels.

The flood storage provided is in keeping with the requirements of the Department of Water modelling. The flood storage includes a storage volume that matches the existing pre development storage provided by the landform. By retaining this volume, plus detaining the post development flow rate to the 1 : 100 pre rate, the development will not be increasing the flood risk along Oakland Drain.

The majority of the flood storage is shown in the multiple use corridor on the western edge, plus the basins within the development.The flood storage , to be conservative, does not include available storage in the east-west running multiple use corridors, as it is harder to detain flows in there areas.

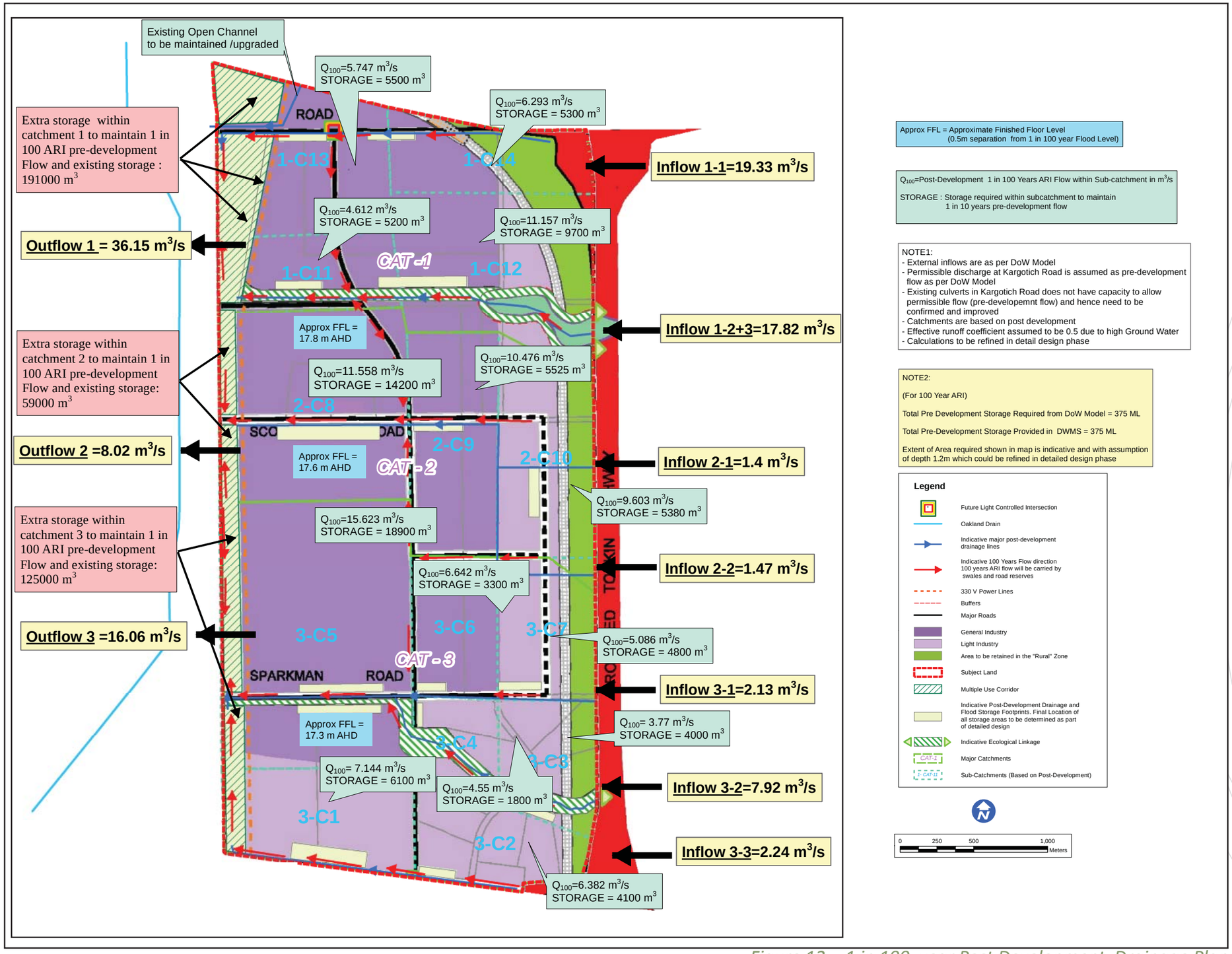


Figure 12 - 1 in 100 year Post Development Drainage Plan

11 - WATER QUALITY MANAGEMENT

The development will utilise a range of best management practices to manage water quality across the site. The major practice will be the implementation of best practice water sensitive designs to manage stormwater up to 1:10 flood events. Most of the other management practices will involve minimising the quantity of nutrients added to the surface and groundwater within the development. The development designs should concentrate on managing practices on lots for effluent disposal and stormwater runoff.

CONSTRUCTION CONTROLS

A key aspect of managing water quality for the development will be involved in the construction of the subdivision. At the subdivision stage of development there will be a requirement to prepare and implement erosion and sediment control plans. Management options should also focus on minimising potential pollutants during the construction phase. The management options may include:

- assessment of erosion risks;
- stabilisation of stock piles;
- minimise the exposure times for disturbed areas;
- sediment curtains, fences, and filters at inlets and other control points;
- cut off drains;
- temporary sediment basins;
- stone mattresses; and
- hydro-mulching and interim plantings.

ON-SITE LOT TREATMENT

It is proposed that individual lot owners will provide attenuation and treatment options for the 1 year 1 hour event lot runoff. The on-site flows can be detained in with a variety of methods including shallow landscaped bioretention basins, rainwater tanks and on-site soak wells.

The most effective method in implementing best practice in industrial precincts is to ensure that pollution sourced from work areas does not discharge into the stormwater infrastructure (the concept of structural separation is displayed in *Figure 13*). Practices that land managers and owners can undertake involve roofing work areas, directing wash-down water to storage or onsite effluent systems, and controlling activities undertaken in areas that link with the stormwater infrastructure. The guiding principles and practices in the construction and management of industrial lots should be an intention to separate areas subject to pollutants and contaminants from paths that would transport water to the stormwater infrastructure. The developer will encourage structural separation, and the local government agencies will be encouraged to ensure elements are included for building application approvals.

Furthermore facilities will be encouraged to be constructed to ensure that contaminated wastewater is separate from uncontaminated wastewater, such as clean stormwater or cooling water, and sewerage.

EDUCATION

Education of employees is very important to ensure that they are knowledgeable about the different systems and potential impacts on the environment that their workplace could have. It is essential for the management of water quality within the subject land that employees are educated on the following:

- The difference between the stormwater and on-site treatment systems for each business;
- Do not sweep or dispose of litter or waste into gutters or drains, and keep the footpath, gutter and outside areas near their business free of litter. This includes providing adequate refuse storage for litter and cigarette butts;
- Where possible, all waste skips and bins should be stored in a designated area with a roof and surrounded by toe walls to prevent any leakage entering the stormwater system;
- Lids on bins and skips should be kept closed to stop loose litter being blown away. This also stops rain getting in which can wash oils, solvents and chemicals out of rags and into the stormwater;
- Spills from loading and unloading operations are a common source of stormwater pollution. Where possible conduct all activities with the potential to pollute water (e.g. loading and unloading, transfer of materials) within roofed and bunded areas or indoors;
- Storage of potential pollutants, including precautions in case of leakages, should be in secured areas. The storage may require roofing, a physical barrier for leaks to leave the storage (e.g. a lip at openings) and possibly a bund if appropriate.
- When moving, pumping, loading or unloading liquids make sure that a spill kit is available for use in case of a spill. Depending on the type of liquid, spill kits can be as simple as a drum full of sand or sawdust and a shovel; and
- How to handle materials to reduce waste and prevent spills.

CONTAMINANT RISK MANAGEMENT

The greatest risk to contamination of the natural environment from the subdivision will be industrial waste which can include petroleum hydrocarbons, heavy metals, surfactants, toxins and/or salts (DoW, 2009b). Details in regards to wastewater management, including contamination risks have been documented in the *Section 14 Water Supply & Wastewater Management*.

As previously mentioned, structural separation and education will be paramount to minimising the risks of contamination from any of the lots within the subdivision. The *Western Australian Business and Environment Manual* developed by the WA Chamber of Commerce and Industry and the Centre of Excellence in Cleaner Production provides an online resource. The manual is designed to assist WA businesses to successfully manage their environmental issues together with their business operations. Importantly it provides information relating to environmental legislative requirements and obligations at local, State and Commonwealth level for a range of industry practices.

Statutory requirements, approvals and managing agencies are outlined in environmental guidelines, codes of practice and *Water Quality Protection Notes* for a range of businesses and activities in Western Australia. Generally the Department of Environment and Conservation, Department of Water and Department of Health are the three major State government agencies involved in waste management and contaminated sites.

Contingency plans and emergency responses should also be developed where appropriate for the industry on the lot. The DoW's *WQPN 10: Contaminant Spills – Emergency Response* is a useful reference for lot owners.

Bio Swale Example - Perth Airport

Bio Swale Example - Perth Airport

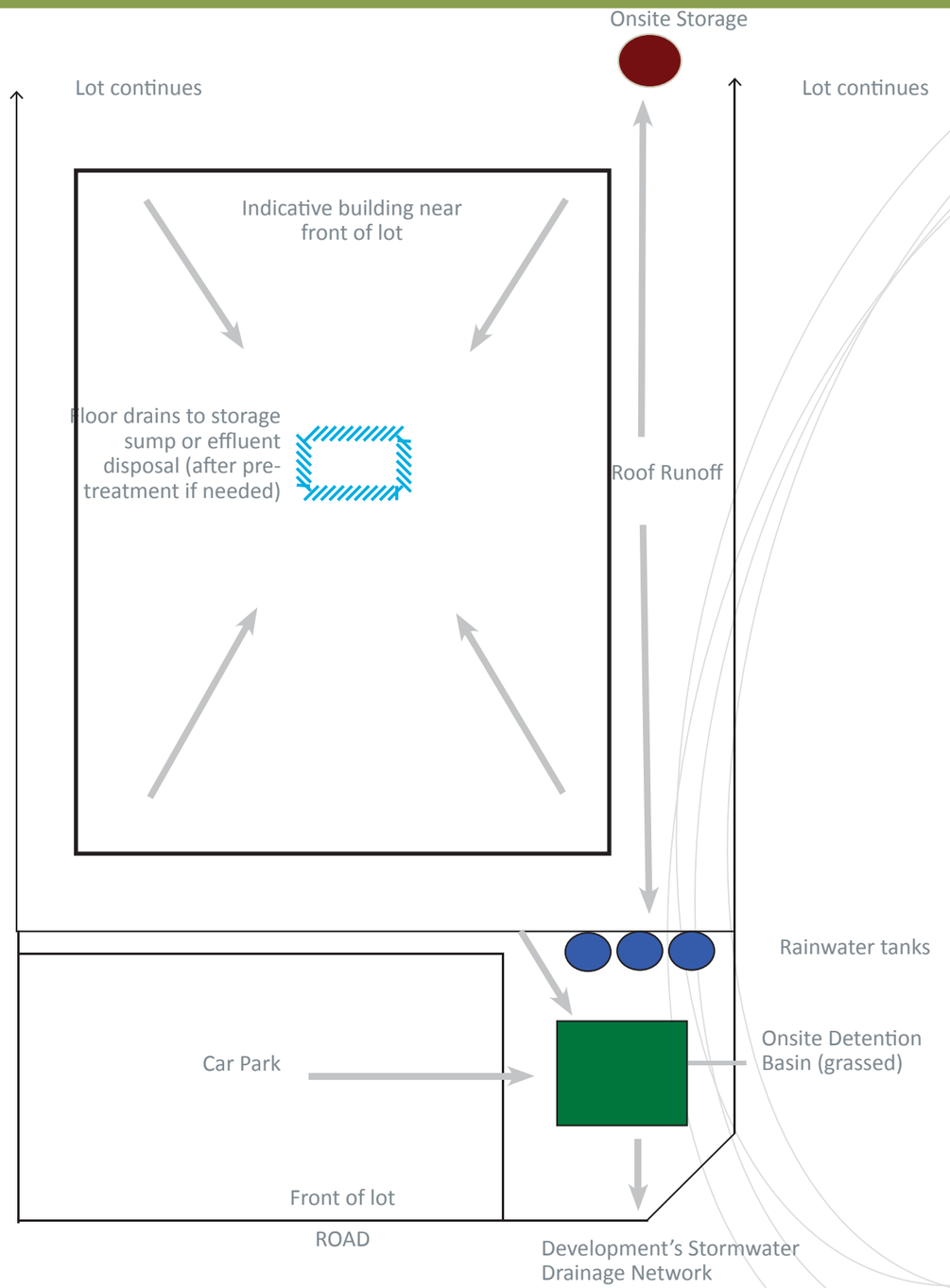


Figure 13 - Structural Separation Concept

BIORETENTION GARDENS

At the time of development, bioretention gardens and swales will be constructed within the road reserves of the development and be sized to capture and treat the 1 year - 1 hour event. The bioretention gardens will be designed and constructed according to the latest *FAWB Adoption Guidelines for Filter Media in Biofiltration Systems* and the *Stormwater Management Manual for WA* design guidelines, and in consultation with the Shire engineers.

A standard bioretention garden will be planted with appropriate native species, which should only require irrigation during the initial 2 to 3 years of establishment, depending on the seasons. They should require no fertiliser application and irrigation demands should be met by stormwater alone, after this initial establishment period, with possible subsequent watering only in drier years. The gardens will be designed to assist in the removal of nutrients and sediments from stormwater before the water reaches the groundwater. The indicative design for the gardens composes a filter media of amended soils to 500mm below the surface, with an average particle size of 0.5mm. A plastic root barrier will also be incorporated to provide a vertical separation layer from surrounding soils to assist in maintaining adequate moisture levels for species planted in the gardens and assist with nutrient reduction. The plants will also assist with nutrient absorption because of the surface area provided by their roots for the formation of bio-films and nutrient uptake. Where practical, saturated zones should also be incorporated in the base of the bioretention gardens.

Bioretention gardens have been demonstrated to achieve a 50% decrease in nitrogen, 80% decrease in phosphorus and a 90% decrease in total suspended soils (DoW's Stormwater Management Manual). The graphs shown on *Figure 14 Page 29* illustrate the potential removal performance of total solids, total nitrogen and total phosphorus by a bioretention garden under FAWB design guideline conditions.

LANDSCAPING

Landscaping within private lots and public areas (including road reserves and drainage reserves) is to have a focus on utilising native species that will require minimal watering and fertiliser application. By implementing this strategy, the landscaping will not contribute to the pollution of the groundwater or surface water generated on the site. Furthermore, by utilising native plants with a high ability to absorb excess nutrients, the landscaping can help remove nutrients within the swale and basin systems, as well as take up nutrients from the groundwater. This can help reduce the overall load of nutrients leaving the site.

MONOTIORING

Pre and post development monitoring of surface and groundwater quality is to be undertaken.

The pre development monitoring will provide a clear picture of the site and the quality of water flowing across the site and through the groundwater. This can be used to set a base line for future monitoring as well as assist with developing any tailored treatment mechanisms to improve the existing and future water quality.

The extent and details of the monitoring programs is dependent on the treatment trains employed throughout the development. Detailed drainage plans for the development will be constructed at the relevant subdivision stage, and from these detailed plans post development surface quality monitoring requirements will be determined in consultation with DoW and the Shire. It is expected that the surface water quality samples would be required at all dispersal points and typically event based.

The Swan Coastal Plain water quality criteria of 0.1 mg/L for total phosphorus and 1.0 mg/L for total nitrogen will be adopted for monitoring of all water discharged from the development area. This criteria has been adopted as the targets for lowland tributaries in the *Peel Harvey Water Quality Improvement Plan*. These targets have been adopted in the Peel-Harvey, Swan Canning and Vasse Wonnerup-Geographe Bay water quality improvement plans, and are considered appropriate guidelines for other regions on the Swan Coastal Plain (DoW, 2010).

Further investigations will be required at the Local Water Management Strategy and Urban Water Management Plan stages to determine monitoring requirements.

District level monitoring will also be subject to a Development Contribution Scheme, to allow for ongoing monitoring.

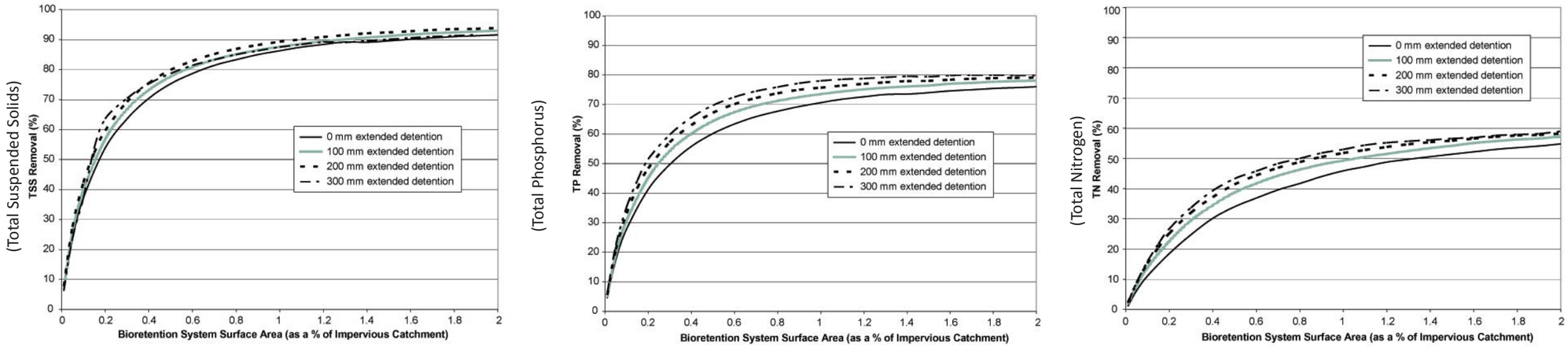


Figure 14 - Removal Performance of Bioretention Systems built to FAWB Specifications (source DOW stormwater management manual)

12 - WATER DEPENDENT ECOSYSTEMS MANAGEMENT

The main water dependent ecosystems (WDE) influenced directly by the development of the subject land are the CC wetland Number 14945 and the waterways that traverse the subject land. There are also a number of downstream and nearby significant WDE that have the potential to be influenced by water management on the subject land. Stormwater and groundwater will be managed so that the significant WDE areas retain hydrologic regimes comparable to pre-development. The water quality of the flows into these ecosystems will be managed through the treatment of surface and groundwater. *Section 11 page 26* of this DWMS details the water quality management for the development. Protection of the ecological functions of the receiving natural environments from the development is detailed below, and visually portrayed in *Figure 15 page 31*.

MANJEDAL BROOK – NORTHERN ECOLOGICAL LINKAGE,

The Manjedal Brook and its associated Conservation Category wetland will be protected through the use of appropriate buffers and a detailed Management Plan. The Management Plan is to detail strategies, practices and an implementation schedule that will provide protection and enhancement opportunities for the water dependent ecosystem. The final buffer distance is to be determined prior to completion of the LWMS. The buffer distance, and the activities that will happen within the buffer will need to be determined by this time. The buffer distance will also be partly determined by the immediate landuses surrounding the area, the direction of groundwater flow and the types of practices and infrastructure employed in the surrounding area to maximise the quality of water that will enter the wetland. Indicative radial distances are show on *Figure 15*, which will need further refining as the development planning progresses.

Treated stormwater runoff is to be controlled into the waterway to retained its pre-development hydro regime or agreed upon rates.

The waterway/wetlands will be located within reserves or public open space (POS), and this zoning will assist in providing appropriate buffers for ecological sustainability.

The length of Manjedal Brook that traverses the site after the recognised Conservation Category wetland area will be enhanced. The degraded waterway will be realigned with the road network. As part of this process the waterway will be configured to act as a stable waterway and will be planted out with appropriate native species. This will enhance the ecological functioning of the waterway compared to its current characteristics of being a weedy drain with erosion issues and limited native species. The waterway and surrounding area will be designated as a ecological linkage.

This whole system is also known as the Northern Ecological Linkage

SOUTHERN ECOLOGICAL LINKAGE

To further enhance the ecological connectivity of the district, an ecological linkage will be developed along a drainage line within the southern third of the site. This is an existing drainage line which is predominately a low flow, ephemeral constructed drain. It currently has little ecological functioning. This drain will be aligned with the road system. It will be planted and landscaped in a similar fashion to the northern ecological linkage.

BIORETENTION SWALES

The bioretention swales that traverse the sites will also act as ephemeral streams and provide habitat values for fauna, especially avifauna and herpetofauna. This will be due to their use of native species for the plantings and the seasonal nature of their water regime, which will minimise small seasonal streams on the Swan Coastal Plain.

GROUNDWATER TREATMENT

Groundwater captured by the subsoil system will be directed to planted swales. These swales will provide an opportunity for the treatment of groundwater discharged to them. Furthermore, the groundwater will assist with the growth of the plants within the base of the swale, helping to increase the wetland/ waterway attributes of the swale system. This treatment of groundwater will also assist with improving the quality of water prior to it leaving the site and entering downstream sensitive environments.

DOWNSTREAM WDE

The downstream WDE will be protected primarily through the management of water on the site. This will include the release of stormwater at pre development rates up to the 1:100 ARI event. Stormwater and groundwater will also be treated so that the water leaving the site will be of an adequate quality to support the ecological functioning of the downstream ecosystems. See Section 11 for more details on water quality management.

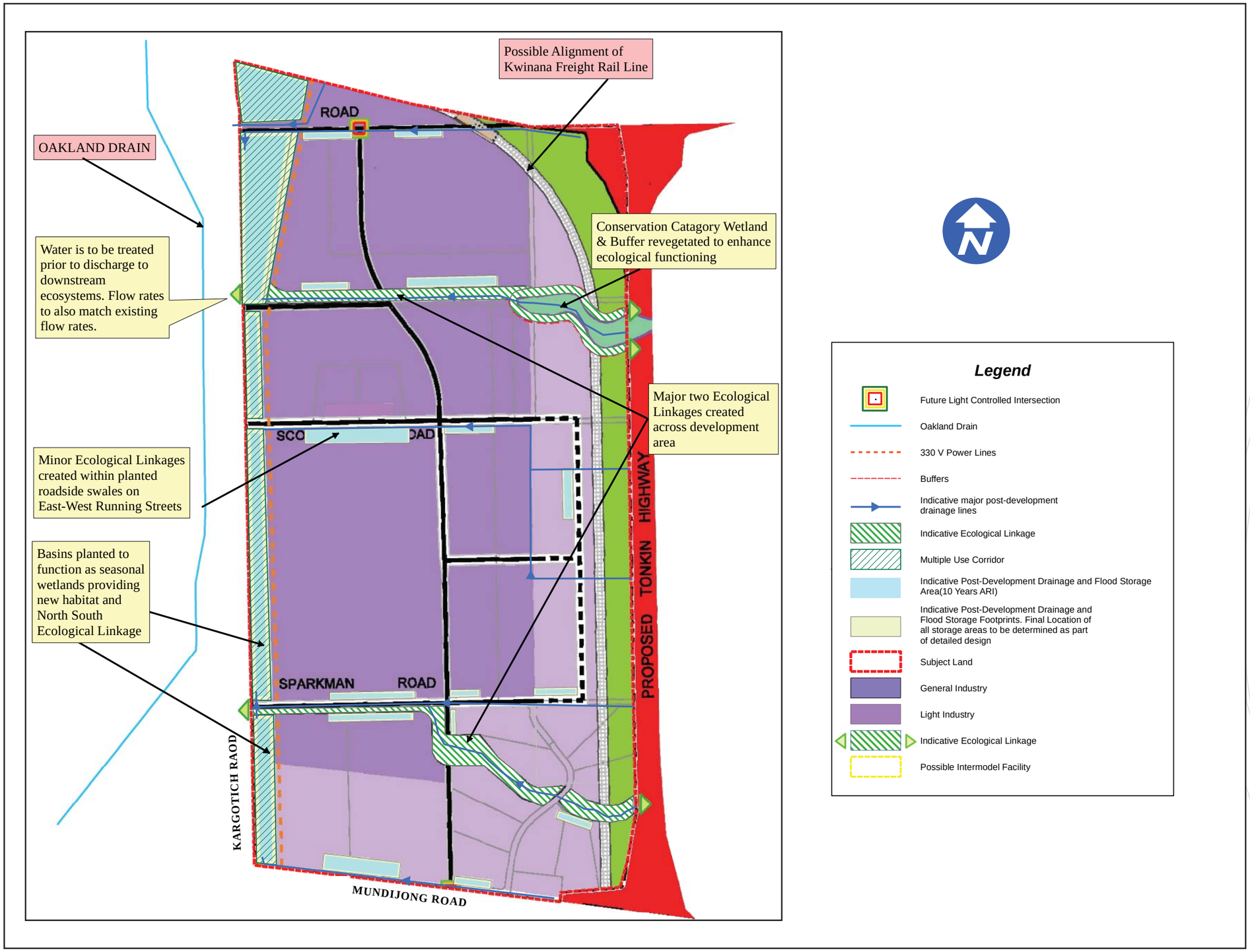


Figure 15- Water Dependent Ecosystem Management

13 - GROUNDWATER MANAGEMENT

The focus of groundwater management for the development area is to maintain groundwater as close as possible to existing average maximum levels, which has been defined as the CGL for the site, while maintaining adequate separation from infrastructure. There may be some modification of groundwater levels within the site; however, the areas that feed the Conservation category wetland on Manjedal Brook and South of Mundijong Road will be maintained at levels that support key wetland functions.

The increase in total groundwater volumes, due to decreased evapotranspiration will be controlled through the subsoil and swale system to minimise the potential rise in groundwater levels.

Opportunities are also to be explored to utilise excess groundwater within the superficial aquifer that is generated due to the lower evapotranspiration of the site post development.

Furthermore groundwater will be managed to achieve a high water quality.

INFRASTRUCTURE SEPARATION

Appropriate separation between lot levels and the CGL will be achieved across the entire subject land. The separation will be achieved through three main methods: use of porous clean fill where necessary; open swales and sub-soil pipes.

The distance between sub-soil pipes will be determined by the permeability of the soil within that section of the development. With subsoils placed along the side boundaries, the separation distance will be approximately 40m. Swales will be along the road reserves and drainage corridors. With this configuration, maximum mounding of groundwater can be kept to approximately 0.4m. This has been determined through modelling which focused on the maximum groundwater mounding from a 1:5 ARI event occurring in the wettest month of the year. For the majority of the time mounding will be significantly less than this. More details on the groundwater mounding modelling can be found in the Fill Assessment report which is included in the CD of attachments.

At the LWMS, more detailed modelling of optimum subsoil spacing and fill levels are to be undertaken, based on the same principals.

Swales will generally be set at the CGL level and will assist in groundwater control. Subsoil drains would also discharge at just above the CGL level to the swales to ensure the subsoils remain free draining between storm events.

By maintaining the groundwater at a level similar to the current average maximum levels, the development will have minimal impact on the groundwater dependent ecosystems that exist on the subject land. Groundwater will still be fed into the wetland systems and the receiving rivers.

Certain areas of industrial lots require less fill to actually function without being impacted upon, or adversely impacting the groundwater. These are areas that don't contain significant infrastructure such as buildings or soakwells. These areas of lower fill requirements include, parking areas, laydown areas and general vehicle movement areas. The drainage basin areas are also able to utilise less fill, provided they are designed to have their bases close to the groundwater. By being close to the groundwater, the basins can actually function similar to an ephemeral wetland.

The building envelopes should require a maximum of 1.0m of fill/separation to the groundwater. The surrounding lot really only requires 0.3m of fill above the maximum groundwater mound (in the middle of the lot). For the spacing of subsoils suggested, this equates to an average fill height of 0.7m (assuming the groundwater is traditionally at the pre development soil surface). On the edges of the lot, the depth to groundwater will be less, tending to be closer to 0.6m -0.7m. These are the areas where stormwater basins/soakwells and buildings etc should preferentially be located.

Porous clean fill will be used where necessary to achieve the required separation. Any fill of imported sands will require compaction to relevant standards. The sand fill will be required to have a high permeability to allow water to easily infiltrate down and into the original soil layer.

A diagrammatic representation of a typical industrial lot can be seen in *Figure 18a page 34*. A diagrammatic representation of how the groundwater system links together can be seen in *Figures 16,17 & 18a/b pages 33 and 34* respectively.

LOWERING OF GROUNDWATER LEVELS

Lowering of groundwater to below the existing annual maximum level can assist with minimising fill. This may be an option for areas away from significant natural environments such as the Manjedal Brook and associated wetlands.

The risk of Acid Sulphate Soils will need to be carefully considered as well, although if the levels are only slightly reduced below the maximum and don't impact the minimum levels, then there is unlikely to be significant impact on both the production of ASS and the mobilisation of acidic groundwater and pollutants mobilised by the increase in acidity. The potential to lower groundwater levels will be limited on the subject land, due to the flat nature of much of the land and the invert of the existing drainage points, which currently control groundwater discharge when it is at its peak. This discharge is controlled by the existing on site drains and the swale drain along the boundary roads.

Due to these limitations, the calculations of fill required for the site have assumed that the AAMGL will be very similar to the post development CGL. For the coarse calculations undertaken, the CGL has been assumed to be at the natural surface of the site. As detailed design is undertake, there may be opportunities for localised lowering of the groundwater to a small degree in the order of 200-300mm.

PUMPING AND REUSE OF GROUNDWATER

Pumping of the superficial groundwater for potential reuse is assumed to not impact the peak groundwater level as the system may fail during critical periods of heavy rain. It may however provide an option for generally keeping the groundwater down. It can also provide a water source for use within the subject land or nearby.

QUALITY MANAGEMENT

Groundwater quality will be improved through the use of soil amendment products incorporated into the development's bioretention systems. This will provide treatment of all surface water runoff collected within the drainage network prior to infiltration into the groundwater. These products bind nutrients and other contaminants that are mobile within water infiltrating from the surface.

ASS MANAGEMENT

Subject to further investigation, the impacts of any actual ASS or potential ASS would be integrated with the works on the site through a detailed ASS Management Plan. Deep sewers are the most likely activity to disturb ASS if any are present on the site. Vacuum or pressure sewer systems may be used to avoid this issue, subject to future detailed design. It is not expected that ASS issues will occur on-site that conventional methods cannot adequately manage.

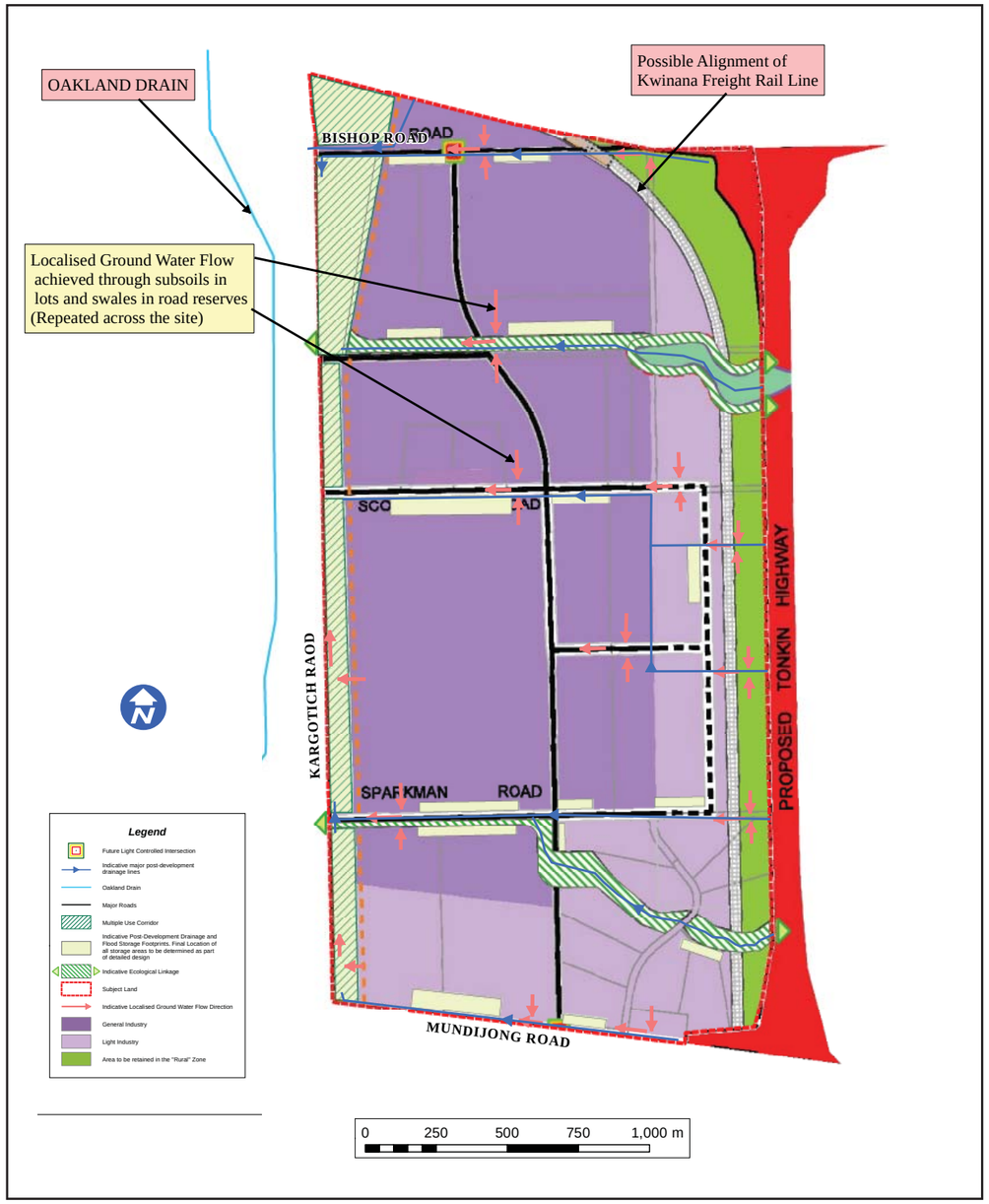


Figure 16- Post Development Ground water Management Plan

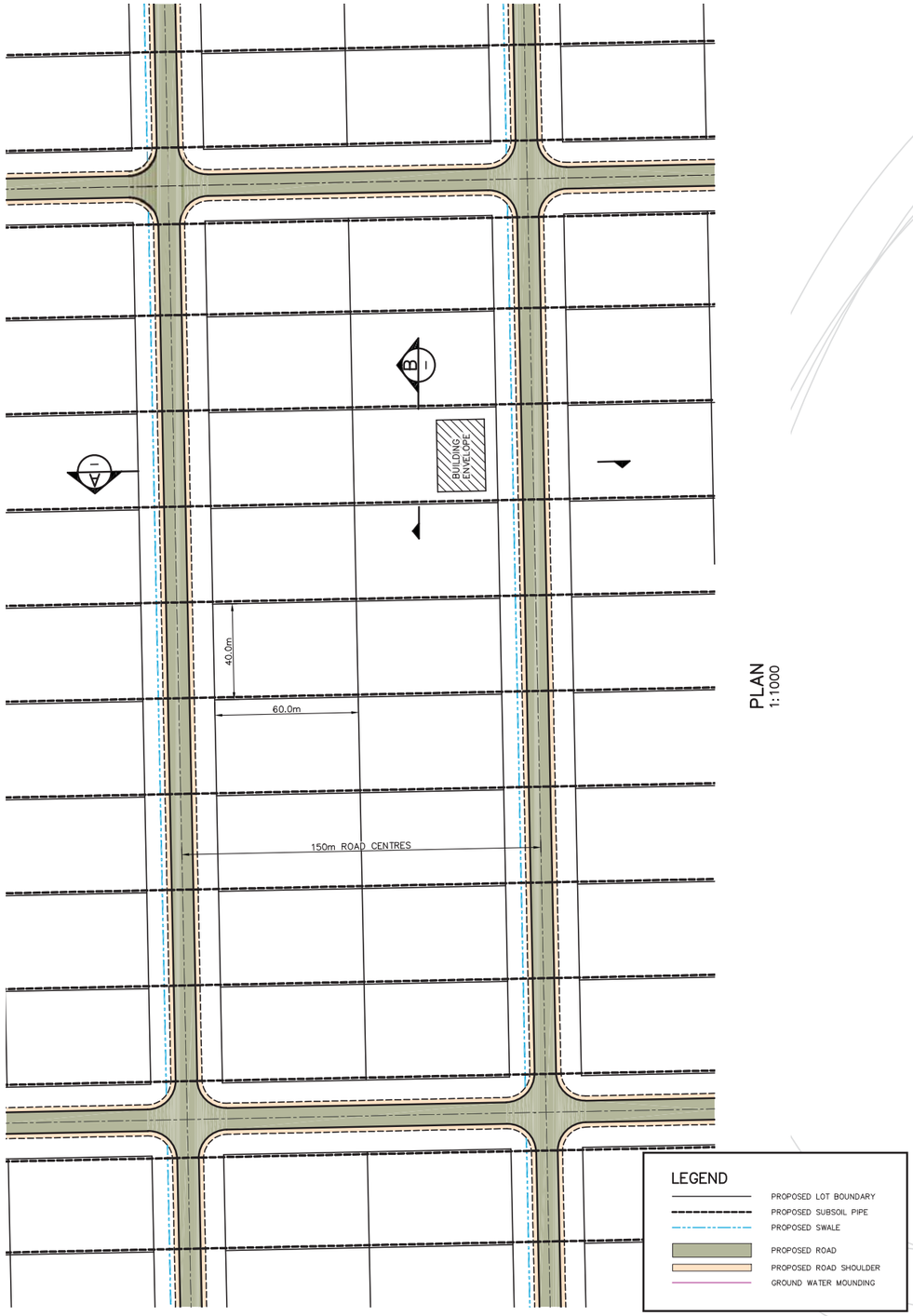


Figure 17- Typical Subsoil and Drainage Layout Plan

MONITORING

Pre and post development monitoring of groundwater levels and quality will be undertaken. The extent and details of the monitoring programs is dependent on the extent and depth of fill required across the development, and any other intrusions of the development on the groundwater management. Detailed earthwork and engineering plans for the development will be constructed at the relevant subdivision stages, and from these detailed plans post development groundwater levels and quality monitoring requirements will be determined in consultation with DoW and the Shire.

Monitoring of the groundwater's quality at the sub-soil discharge points and selected bores will suffice for post-development quality monitoring.

POTENTIAL USE OF GROUNDWATER

The likely use of groundwater is currently unknown, as the actual industries that will use the development has not been confirmed. Rates could vary from no use of groundwater considerable values for some manufacturing process. With regards to potential use of groundwater for irrigation of the multiple use corridors, it is likely that there would be watered for approximately 2 years during establishment.

Depending on the rate of development, their may be a requirement for irrigations an area of between 3 and 6 hectares. Based on these areas and an irrigation rate of approximately 7500L/ha/annum, the groundwater required per annum could be in the order of 22.5KL and 45KL/annum. The future non potable sources, including groundwater is to be confirmed in the Local Water Management Strategy.

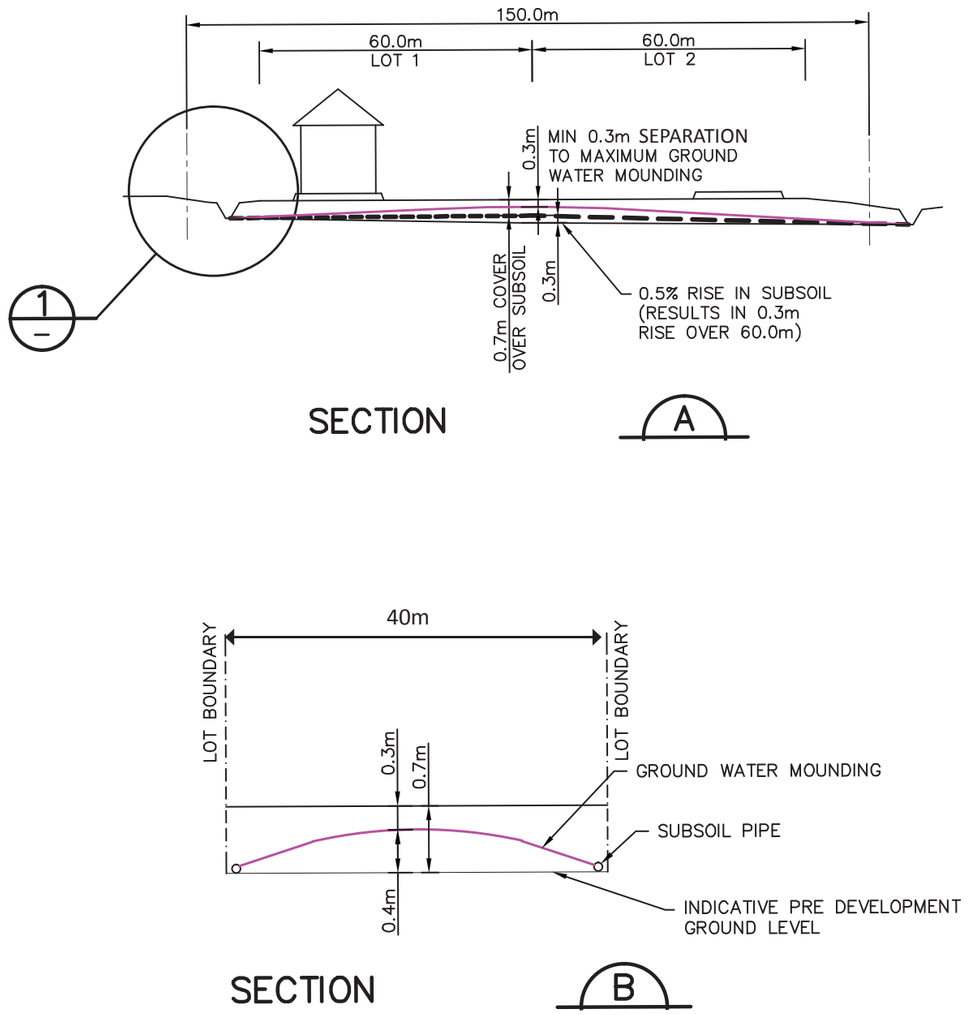


Figure 18a - Typical Lot Ground Water Management

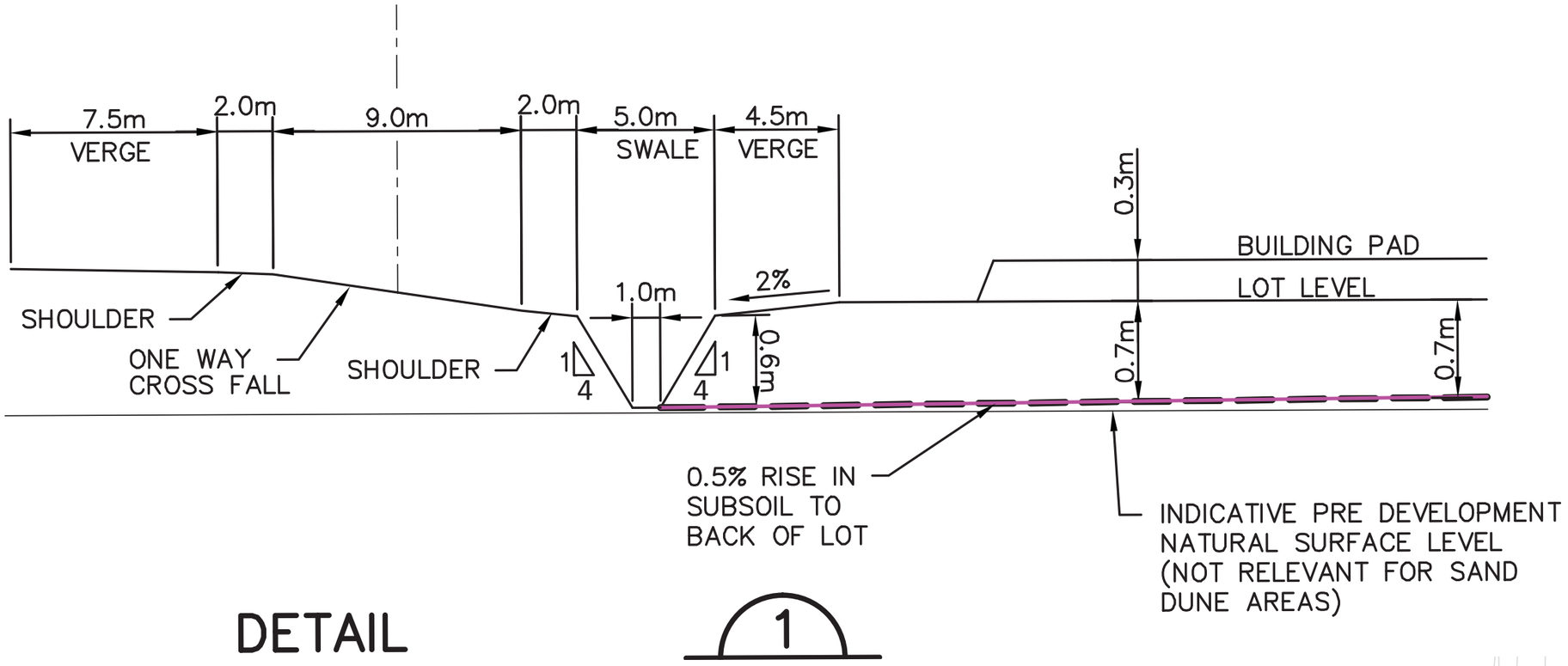


Figure 18b - Subsoil and Drainage Details and Section

14 – WATER SUPPLY AND WASTEWATER MANAGEMENT

WATER SUPPLY

STANDARD POTABLE

The Water Corporation has advised, that subject to further investigations, it might be possible for an initial stage of development to be serviced through extension of existing infrastructure located east of the Tonkin Highway extension near the intersection with Mundijong Road.

The Water Corporation will need to review its long term infrastructure plan to accommodate the water supply for the future industrial development of the whole of the industrial estate. Nevertheless, the related Metropolitan Region Scheme amendment will be an important trigger in activating such a review by the Corporation.

Advice from the Water Corporation on water supply servicing is provided in the CD of Attachments

ALTERNATIVE WATER SUPPLY

The following alternative water supplies are provided in this DWMS so that they may be considered as more detailed investigation are underetaken. Any alternative water supply is to be confirmed in the Local Water Management Strategy.

STORMWATER

Subject to further investigation there is the potential to harvest storm water for processing. This water could potentially be used for industrial uses throughout the year. Alternatively, it could be stored and utilised for the watering of POS areas and sporting facilities.

RAINWATER

There is likely to be significant areas of impervious roof catchment throughout the subject land. This represents an opportunity to harvest and reuse relatively clean water on a lot by lot basis or as an integrated scheme across the industrial precinct.

Due to the higher quality of this water, there is the potential to investigate the option of aquifer recharge.

TREATED RECYCLED WASTEWATER

The Water Corporation is not proposing to construct a wastewater treatment facility within the site, or for that matter anywhere in the locality that can be used for wastewater generated within the development. The Corporation has also stated:

> a) Relative to other industry, industry at West Mundijong is unlikely to generate significant demand for processing water. On this basis it is unlikely that a business case could be developed and supported for installation of infrastructure to enable re-use of treated wastewater at Mundijong

An alternative service provider may however treat wastewater on the subject land via sewer mining, or alternatively bring a supply line back from a treatment plant. Further investigation into this option for the west Mundijong area is being undertaken by Essential Environmental. This investigation highlights the options specifically for the land adjoining to the east, however there is the possibility to expanded it into the subject land as a non potable water source.

Subject to further feasibility, grey water harvesting and recycling by individual industries may still be feasible

GROUNDWATER

There is the possibility to utilise groundwater resources from both shallow and deeper aquifers located under the subject land. These will be subject to licences granted through the Department of Water and relate to the allocations available.

Within the superficial aquifer there is potential to harvest the increase volume of groundwater that is often generated by development of land from agricultural to industrial. This extra water is due to the potential for increase infiltration and reduced evapotranspiration, leading to a build up of water stored within the soil profile. This can be further enhanced through the use of fill which increases the level of available storage height prior to running off the land. This extra groundwater can be harvested through pumping and/or subsoil drainage piping.

A secure storage system would need to be developed in conjunction with this option. Further investigation will be needed prior to completion of the LWMS to determine the feasibility and details of this system. More details are also provided in section 13.

MANAGED AQUIFER RECHARGE SYSTEM

A Managed Aquifer Recharge System may be a viable option to store clean water from the subject land for later use within the development or in nearby areas. One options is to collect excess roof runoff and inject this into an appropriate deeper aquifer. This would also assist with controlling excessive groundwater rise within the superficial aquifer, by reducing the volume of water being infiltrated on site.

Rainwater would require minimal treatment prior to injection into an aquifer, making it a potentially viable source. Other sources may also be viable but are likely to require further treatment to minimise the risk of polluting the chosen aquifer.

A detailed investigation will need to be undertaken into the viability and details of this option. The study should adhere to the Managed Aquifer Recharge Policy developed by the Department of Water.

WASTEWATER

MAINS SEWER

Currently, the subject land is not connected to deep sewerage. It is located adjacent to the Byford sewer district.

The Corporation's long term planning provides for limited capacity to service the area through its future main Byford wastewater pumping station. The exact location of the pumping station is still to be determined but is likely to be in the vicinity of Scott Road. The Water Corporation acknowledges that the future pump station will need to be integrated with planning for both the industrial area and urban expansion east of the future Tonkin Highway extension.

The Water Corporation will need to review its long term infrastructure plan to accommodate future industrial development of the whole of the industrial estate. Nevertheless, the related Metropolitan Region Scheme amendment will be an important trigger in activating such a review by the Corporation.

Advice from the Water Corporation on wastewater servicing is provided in the CD of Attachments

The future wastewater planning will need to consider the types and flow rates of wastewater that will be generated from the industrial area and the suitability of these for discharge to the Water Corporation's wastewater system. Some industries may require their wastewater to be pre treated prior to discharging to the Water Corporation system. Should an agricultural food precinct be developed, there is likely to be a demand for a wastewater system that can accommodate high flows.

ON SITE TREATMENT AND DISPOSAL

The high groundwater within the subject land would make on site disposal difficult. This option could be utilised for some dry industry, especially in the early stages, however is not the preferred option for the development of the entire site.

Should on site treatment and disposal be utilised the following design considerations will need to be included:

- appropriate systems for the site fill and existing soils;
- requirement for installation to be a minimum of 5m from foundations;
- proximity of disposal systems to subsoil systems on-site to ensure no mobilisation of nutrients into subsoil systems;
- any water recycling and/or reuse schemes implemented;
- the source and composition of the wastewater, including quality and contaminants present); and
- the volume of wastewater for the lot (affects type of system installed, number of systems required and area required for the system to function appropriately).
- be in keeping with the relevant Department of Health legislation at that time (currently - Government Sewerage Policy

The onsite disposal systems will require careful design to ensure all objectives are met but there are numerous systems available that would meet most requirements expected with Alternative Treatment technologies.

The DoW's *water Quality Protection Note (WQPN) 51 – Industrial Wastewater Management and Disposal* provides guidance for industrial sites on appropriate facility designs and best operational management practices to minimise risk of contamination. The developer will emphasise the significance of understanding and achieving the notes within this document.

GREYWATER RE-USE SCHEMES

The greatest potential for grey water reuse on this site is at the individual lot level. With appropriately designed on-site effluent treatment systems, the treated effluent may possibly be reused on each lot's landscaped areas or other fit for purpose uses. The feasibility of this option should be undertaken at the LWMS stage in relation to other water supply, treatment and reuse schemes developed for the site.

REGULATIONS

Any of the above schemes where non-drinking water is used will need to comply with the *Draft approval framework for the use of non-drinking water in Western Australia* (DoW).

The schemes will need to comply with the *Australian Guidelines for Water Recycling* where relevant.

There may also be the need for a licensed operator depending on the characteristics of the scheme. This may include having the scheme approved through the Economic Regulation Authority.

Approval by other relevant authorities which may include Department of Health, Department of Water, Department of Environment and Conservation and Local Government Authority, may also be required.

These aspects should be further refined as part of the LWMS's and UWMP's for the subject land.

REQUIREMENT FOR SERVICING STRATEGY

The accompanying draft district structure plan contains provisions requiring subsequent local structure plans to provide a strategy outlining how the servicing requirements of future industry are to be met. Such a strategy will need to address the following factors:

a. Projected wastewater volumes of candidate industries. It is expected that servicing requirements will vary greatly depending on the nature of subsequent industrial development. Very large operations, such as bulk storage, may be of sufficient scale to justify the installation of private schemes subject to the approval of the relevant agencies;

b. Projected water requirements for candidate industries. It is anticipated the majority of industries will be dry being concerned with logistics and storage;

c. Investigations by a consulting engineer demonstrating feasibility of extending existing water and wastewater mains to service development;

d. Where wastewater services are not available or not feasible, to upgrade or extend, alternative wastewater treatment facilities which are capable of meeting the needs of industry and the requirements of approval authorities;

e. Compliance with the Government Sewerage Policy – Department of Health; and

f. Compliance with the Western Australian Planning Commission's development control policy 4.1: Industrial Subdivision.

15 – WATER CONSERVATION

According to the *State Water Plan of 2007* by the Western Australian government, 16% of the state's total water consumption in 2005 was by the commercial and industry sector. The Plan did not set a goal for this sector, unlike the 100kL objective per person set for residential areas.

The state government of Western Australia does however require all businesses that use more than 20,000kL of scheme water per year to participate in the Water Corporation's Waterwise Business Program. This Program involves:

- Undertaking a water management assessment annually with the Water Corporation (or Aqwest);
- Developing a five (5) yearly Water Efficiency Management Plan (WEMP); and
- Annual review of WEMPs and reporting the progress against the water savings action plan.

These are requirements under the *Water Agencies (Water Restrictions) By-laws 1998* and are mandatory. The WEMP involves the preparation and implementation of water consumption targets over a five 5 years period. The business has to monitor water usage throughout each year of the plan, and a report is to be submitted to the Water Corporation annually.

There is an opportunity as part of this process to develop ways to manage, recycle and conserve water within individual businesses and even sectors of the industrial park.

EDUCATION AND AWARENESS

Business owners are to be encouraged to promote water efficient behaviour amongst employees through awareness raising material and opportunities. Possible measures to encourage water efficient behaviour may be:

- Installing signs at all water using fixtures;
- Installing shower timers to encourage shorter showers where these facilities are provided;
- User education for dishwashers, washing machines and glass washers to ensure there is a full load, where these are provided;
- Include water conservation practices in staff or tenant inductions;
- Ensure water conservation or management is continually brought up at meetings;
- Promote their businesses water-saving initiatives or outcomes within the local community;
- Encourage employees to identify water-saving measures; and
- Offer an incentive scheme to encourage water-saving innovations and ideas.

Further details are to be developed in the relevant LWMS's and UWMP's

RAINWATER TANKS

Businesses are to be encouraged to install rainwater tanks, with a level controlled air gap, to reduce the quantity of water consumption from the water mains. The water may be used for a variety of fit for purpose uses, related to the industry and feasible treatment levels.

A suitable tank size should be determined according to the roof area of the buildings on a lot and the water usage practices and applications by the business.

There is also the possibility to utilise a larger scheme that takes excess roof runoff for storage within a suitable aquifer or water body. This scheme will require more detailed investigation prior to the LWMS being completed.

ONSITE INFILTRATION AND STORMWATER DISCHARGE

Excess roof runoff will be directed to a property connection soakwell, rainwater tank or basin. The soils at the site are suggested to infiltrate runoff into the soil profile and groundwater below. Overland runoff from the gardens and hard surfaces around the house, excluding the roof, will be directed predominately to the road drainage network discussed in the drainage management sections. The remainder will infiltrate into the soil and groundwater within the lot. This water will partly assist with maintaining the native landscaping through direct discharge to areas containg this vegetation, and through recharging of the groundwater.

WATERWISE LANDSCAPING

Natural rainfall alone should be sufficient to maintain water wise landscaped areas once established. Front of lot landscaping and street reserve landscaping is to be composed of water wise plantings suited to the local environment.

Details on appropriate species and areas of planting/landscaping are to be established as part of future planning for the site.

The source of water for any landscape irrigation will require further investigation. Details regarding water supply and irrigation of landscape areas are to be provided in the LWMS. The landscaped areas could potentially be watered from groundwater, treated wastewater, harvested stormwater or rainwater.

The use of swales and potentially bioretention gardens, planted with native species will receive a significant portion of their irrigation requirements directly from stormwater runoff.

16 – IMPLEMENTATION FRAMEWORK AND MONITORING

PRE-DEVELOPMENT

GROUNDWATER

Pre-development monitoring for the subject land will need to include a minimum of two (2) years of groundwater levels and quality. This is to include 2 winter peaks. The focus for the monitoring is to determine the maximum and minimum levels of groundwater throughout the year and general quality. These results are to be compared against more regional data produced by DoW and surround developments.

The indicative locations for sampling are shown in *Figure 19 page 40*. These bores should be a minimum of 3m below the surface.

The quality parameters should include the following:

Physical

Electrical Conductivity (EC), pH, salinity, temperature and Alkalinity.

Chemical

Nitrate (as NO3), Ammonia (as N), Total Nitrogen, Total Phosphorous, Filterable Reactive Phosphorous (P), and metals (Al, As, Cd, Cr, Cu, Fe, Mn, Pb, Zn).

SURFACE WATER

Monitoring of quality within the main waterways that traverse then land is recommended. This should happen for a minimum of two (2) year prior to development, with a focus on the period that the waterways are flowing. At least two (2)samples per site should be collected each year. Samples are to be collected at the point at which the waterways enter and exit the subject land. The indicative locations for sampling are shown in *Figure 19 page 40*.
The tested parameters should include:

Physical

Electrical Conductivity (EC), pH, Dissolved Oxygen (DO), salinity, temperature, Oxygen Replacement Potential (ORP) turbidity, total suspended solids and Alkalinity.

Chemical

Nitrate (as NO3), Ammonia (as N), Total Nitrogen, Total Phosphorous, Filterable Reactive Phosphorous (P), and metals (Al, As, Cd, Cr, Cu, Fe, Mn, Pb, Zn).

WETLAND

An assessment of Conservation Categorey Wetland Number 14945 should be undertaken, with this information used as an existing pre development baseline. The assessment should include indicative hydro regimes, flora present, vegetation complexes, weed issues and likely fauna habitat. As part of the surface water and groundwater monitoring regimes, sampling points are to be set up so that they can provide data on the hydro regimes for the wetland.

CONSTRUCTION PHASE

Installation of drainage control structures is to occur ahead of the construction phase of the development. This will include the use of water sensitive design techniques such as sediment curtains, hydro-mulching and temporary detention basins to maintain the quality of the water leaving the development area during construction. The collection pits will be monitored for any damage, including sediment build up and litter accumulation during, and at the completion of, construction to ensure the pit's effectiveness is not diminished post-development.

Some WSUD works, such as planting of Bioretention gardens, may be delayed until building construction is substantially complete. This is to minimise contamination of the system with sediments and other debris generated as part of the building phase.

All contractors working on any future development of the site will be made aware of their responsibilities under the *Aboriginal Heritage Act 1972* with regard to finding potential archaeological sites. In the event that a potential site is discovered, all work in the area will cease and the DIA should be contacted.

POST-DEVELOPMENT

WATER SENSITIVE URBAN DESIGN (WSUD) INFRASTRUCTURE

Routine monitoring within the development area that checks the status of key functional WSUD elements is to be undertaken to ensure they meet specified design requirements. This will include:

- ensuring the inlet and outlet structures are free of debris;
- vegetative cover of the systems is maintained;
- sediment build up is not impeding the functionality;
- erosion is not present;
- soils are not compacted;
- litter is removed; and
- hydrocarbons are not present in the system.

Monitoring of the established WSUD elements operations can provide important insights on the likely performance of them in pollution reduction and stormwater management functionality. Inspection of the WSUD elements will be undertaken by the developer until an agreed upon time between developers and the Shire. The indicative timeframe is for two (2)years after the completion of works with inspections every three months. This is to be reviewed at the LWMS and UWMP stages. *Table 4* summaries the particular items to monitor and the purpose of monitoring, the trigger signs that require immediate action and the maintenance action required.

Compared to traditional engineered structures for stormwater runoff management, the WSUD elements will only require minimal routine maintenance similar to a landscaping and ecological corridor maintenance nature. The most common maintenance is the removal of weeds, debris and siltation. The most time intensive period of maintenance for a vegetated WSUD system is during plant establishment (which typically includes two growing seasons), when supplementary watering, plant replacement and weeding may be required.

It is recommended that vegetated WSUD elements are monitored by personnel with floristic knowledge and/or qualifications, as they will be capable of identifying evasive species within the natively vegetated WSUD systems. Furthermore, personnel in charge of monitoring should have a good understanding of

principles and the functional design of the WSUD elements and the treatment system. The maintenance activities prompted through monitoring activities will generally require coordination between landscape and civil services.

The WSUD elements will be constructed and utilised in different stages so that the functions of the WSUD elements are protected from elevated pollutant loads generated from a developing catchment.

Maintenance inspections should be scheduled to be conducted after a significant storm event. Inspections should focus on ponding time for the different systems, unequal surface flow distribution, sedimentation and scouring, as well as deposition of coarse litter.

Performance monitoring of WSUD elements via detailed water sampling and testing for contaminant concentrations has not been scheduled at this stage. The exact parameters and monitoring schedule is to be further detailed in the LWMS and subsequent UWMP for the site.

GROUNDWATER

Groundwater monitoring may be required post development to determine that the development is not impacting on nearby significant wetlands through changes in levels or poor water quality. The exact parameters and monitoring regime will be determined by the final land uses. For this reason, further details on post development monitoring are to be developed as part of the LWMS and UWMP.

SURFACE WATER

Surface water monitoring may be required post development to determine that the development is not impacting detrimentally on the surface water quality leaving the site. Sampling points should be set up at the discharge points from the subject land or on site significant wetlands. These should be checked against established guidelines and the quality of water entering the site from upstream. The exact parameters and monitoring regime will be determined by the final land uses. For this reason, further details on post development monitoring are to be developed as part of the LWMS and UWMP.

District level monitoring is also likely to be subject to a Development Contribution Arrangment.

WETLAND

The monitoring of the wetland is to be related to the rehabilitation works and the monitoring of water resources above. A Wetland Management Plan should be established for the wetland with this plan outlining the most appropriate monitoring regime. This should be done at the UWMP, with preliminary concepts developed as part of the LWMS.

RESPONSIBILITY AND REPORTING

The developer of the land will be responsible for the monitoring and reporting of all aspects listed above. Advice should be sort from the DoW, DEC and the Shire on exact parameters and regimes.

Information collected from monitoring programs, where necessary should be recorded and provided in an agreed format to the DoW and the Shire and other relevant stakeholders. All monitoring is to be as per the Department of Waters, *Water Monitoring Guidlines for better urban water management strategies and plans - October 2012 or* updated versions of this report

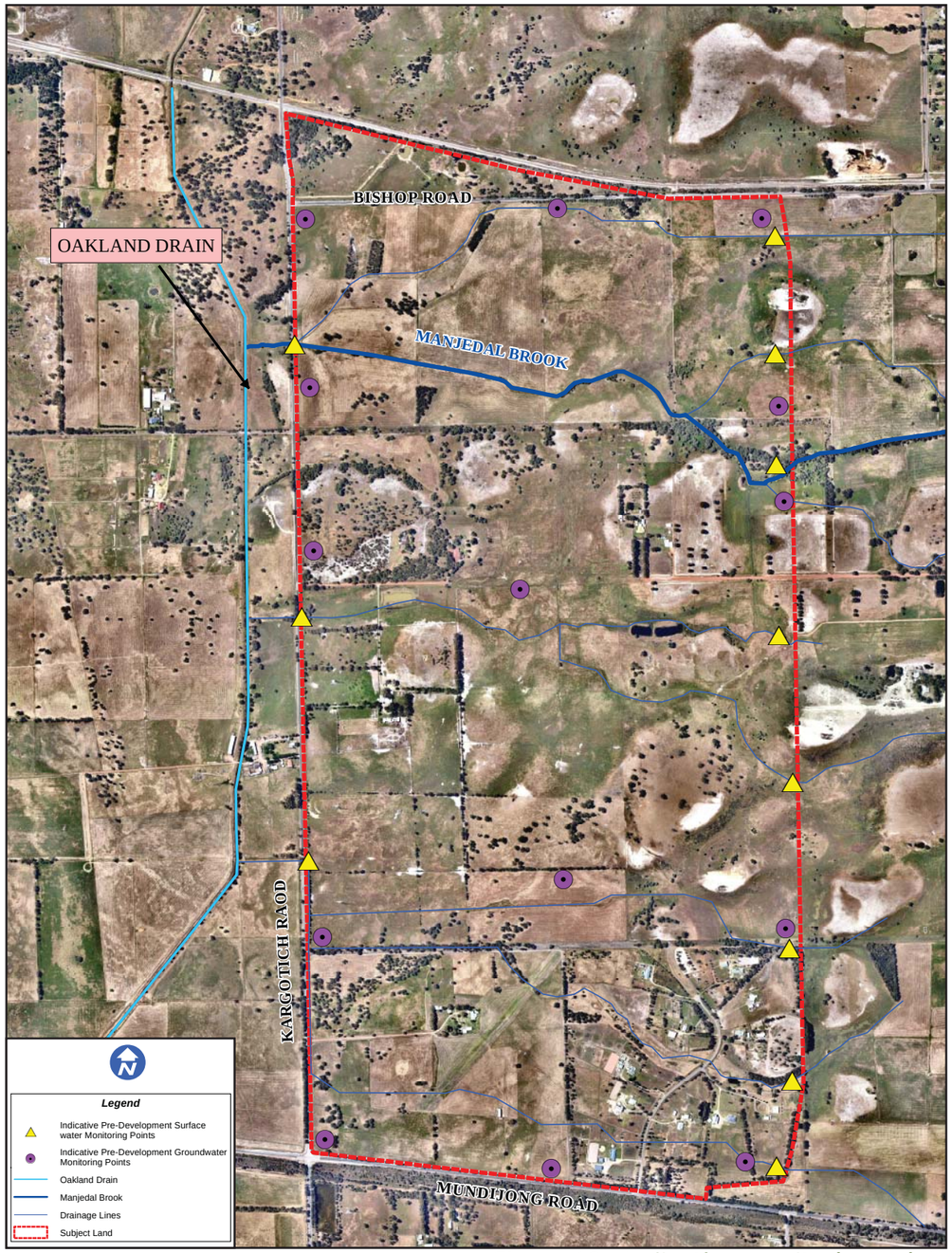


Figure 19 - Indicative monitoring points

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsibility
PRE-DEVELOPMENT						
Groundwater	Quality	To determine pre-development quality to assist with setting base lines for the subject land.	NA	NA	Minimum of two samples a year for 2 years	Developer
	Levels	To determine pre-development levels to assist with setting AAMGL for the subject land.	NA	NA	Monthly sampling over 'winter' period, 3 monthly over summer. Minimum of 2 winters, or as determined at LWMS stage.	Developer
Surface Water	Quality	To determine pre-development quality to assist with setting base lines for the subject land.	NA	NA	Minimum of two samples a year for 2 years, or as determined at LWMS stage.	Developer
CONSTRUCTION PHASE & POST-DEVELOPMENT (more details on this section to be provided in LWMS and UWMP)						
Groundwater	Quality	To determine post-development quality to assist with determining if site is meeting guidelines.	Values siginificantly outside recommended guidelines	Determine cause and rectify	Minimum of two samples a year for 2 years	Developer
	Levels	To determine post-development levelsy to assist with determining if site is meeting guidelines.	Values siginificantly outside recommended guidelines	Determine cause and rectify	Monthly sampling over 'winter' period, 3 monthly over summer. Minimum of 2 winters.	Developer
Drainage Management Systems	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to the City/Shire
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Every 3 months	Developer until handover to the City/Shire
	Sediment and Silt Build Up	Inspection for sediment and silt accumulation within pits, on the surface of bioretention systems and within basins.	Accumulation of large volumes of sediments and/or silts in pits or on the surface (according to City standards).	Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed.	Every 3 months	Developer until handover to the City/Shire
	Compaction	Inspection of filter media for compaction.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without any compaction. If extensive seek expert advice.	Every 3 months	Developer until handover to the City/Shire
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Every 3 months	Developer until handover to the City/Shire
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Every 3 months	Developer until handover to the City/Shire
	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, e.g. alter landscaping maintenance practices, community education). Remove litter.	Every 3 months	Developer until handover to the City/Shire
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Every 3 months	Developer until handover to the City/Shire
	Oil/Hydrocarbons	Inspection for the occurrence of oil on surface.	Oil coverage persists for more than 3 weeks, and is thick.	Notify the EPA of the spill and clean up requirements.	Every 3 months	Developer until handover to the City/Shire
	Surface Water Quality	Sampling of water quality (TSS, TN & TP) at discharge (outlet) points.	0.1mg/L for TP and 1.0mg/L for TN.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination. More detailed assessments may be required.	Every 3 months	Developer
POST-DEVELOPMENT ONLY						
Water Conservation	Water Consumption	Review and report on WEMP to the Water Corporation.	Determined by WEMP and Water Corporation.	Determined by WEMP and Water Corporation.	Yearly for at least 3 years.	Business Owners
Groundwater	Quality	To determine post-development quality and testing to be done at sub-soil discharge points.	0.1mg/L for TP and 1.0mg/L for TN.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination.	Minimum of two samples a year, for at least 3 years.	Developer
	Levels	Monitoring required to sub-soil drainage system is operating as designed.	Levels exceeding controlleg groundwater level.	Undertake appropriate responses to address the issue.	Monthly sampling over 'winter' period, for at least 3 years.	Developer (agreed handover)

Table 5 Monitoring and Maintenance Table

17 – RECOMMENDATIONS FOR FUTURE STUDIES

For future development of the land past the rezoning stage the following additional studies may be required to support the LWMS and subsequent UWMP;

- Preliminary ASS investigation
- Wetland Assessment and Management Plan
- Detailed Earthworks and Services Strategies
- Alternative water supply and treatment options
- Managed Aquifer Recharge assessment
- Detailed Drainage Design

REFERENCES

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ANNEXURE -A-

DRAINAGE STUDY FOR WEST MUNDIJONG INDUSTRIAL AREA

Town Planning Management Engineering

Serpentine Jarrahdale Shire

Drainage Study for West Mundijong Industrial Area




Research, Design & Delivery of Sustainable Development

Date January 2013
Job No. 12099

Project Management Planning Environmental Engineering

WEST MUNDIJONG DRAINAGE STUDY

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DOCUMENT QUALITY CONTROL

Prepared for: **Shire of Serpentine Jarrahdale**

Project: **Drainage Study For West Mundijong Industrial Area**

Project Job No: **12099**

Date: **25th January 2013**

Prepared by: **Bishwa Mishra**

Reviewed by: **Brendan Oversby**

Revision History

Revision No.	Revision Date	Details	Authorised by	Signature
0				
1	24/01/2013	Amendments as per Shire Requirements		

TME Town Planning Management Engineering Pty Ltd
PO Box 733, Bunbury, WA, 6231
Phone 0897914411 Fax 0897914412
ABN 78 138 659 668

1.0 INTRODUCTION

TME Town Planning Management Engineering Pty Ltd (TME) has been engaged by the Shire of Serpentine Jarrahdale (the Shire) to undertake a drainage study of the West Mundijong Industrial Area.

The Subject land is approximately 1.5 Km west of the existing Mundijong town site. The subject land is bounded by Mundijong Road (South), Tonkin Highway Road reserve (East), Bishop Road (North) and Kargotich Road (West). It is approximately 474 hectares in area.

The majority of the site is a mildly sloping wet plain. The landform slopes from East to West with fall from 25-26m AHD to 16m AHD. The slopes vary from 0.2 to 1% with the slope generally flattening towards the West. Low Bassendean sand ridges area located sporadically across the subject land being peak up to 27 m AHD.

The subject land is drained by a number of small drains and waterways that all exit the site on the Western Boundary. The site is also traversed by larger waterways, including Manjedal Brook, that carry significant flows. There are significant external inflows entering the site from East and draining out to West under Kargotich Road to the Department of Water (DoW) drain namely Oakland land which finally drains to the Serpentine River and Peel Harvey Inlet. The Oakland drain runs North to South parallel to the subject land.

The major thrust of this study is to analyse the existing drainage situation and provide indicative storage requirement in post development situation to assist with preparation of District Water Management Strategy. On the basis of availability of information and scope of the study this drainage study is purely intended for District Water Management Strategy and requires refinement and detail study during detail phase of design.

In order to get flood extent of drainage lines within the site Hydrologic Engineering Centres – River Analysis System (*HECRAS*) software is utilised whereas for storage requirements *DRAINS* software is utilised. For external inflows broad scale modelling done by the DoW is used.

2.0 STUDY OBJECTIVES

The study objectives were to:

- Review existing drainage situation of the site;
- Develop HECRAS model for Pre-development situation; and
- Develop drainage models using the latest version of the *DRAINS* computer program. Run the *DRAINS* Model for 10 and 100 year Average Recurrence Interval (ARI) to identify the storage requirements to assist with the preparation of the District Water Management Strategy.

3.0 AVAILABLE INFORMATION

Considerable information was available which includes:

i. Light Detection and Ranging (LiDAR) data of the "Subject Land";

ii. External inflows and flood mapping of the subject land from DoW ; and

iii. Broad scale planning of the subject land by TME.

4.0 METHODOLOGY

Based on the site condition and available information, drainage modelling has been undertaken in two parts. Firstly, drainage lines were identified on the basis of LiDAR and information provided by the DoW. Using ArcGIS and *HEC-GEORAS*, cross sections and other required geometric information were generated and exported to *HECRAS*. Utilising external inflows at 8 locations along the eastern boundary 1 in 10 years and 1 in 100 years steady flood modelling was performed. Roughness of 0.038 was used based on modelling done by the DoW. This should be refined in later stages. Results from *HECRAS* modelling were imported to *ArcGIS* and using *HEC-GEORAS* interface. From this flood mapping was undertaken.

Secondly, using LiDAR and an onsite investigation, which identified existing three (3) outlets, three (3) major catchments and 14 sub catchments were defined. Flow lengths and slopes were also derived from LiDAR.

0.5 pervious and 0.9 impervious effective runoff coefficients were used to reflect the high groundwater table. Since the rational method does not produce hydrographs, Extended Rational Method was used to model flow so that hydrographs could be produced and storage requirement could be derived. The pre development flows were assumed as permissible flow for post development situation. Storage requirements, based on this assumption were estimated by optimising basin sizes in each of the sub catchments running the model several times.

Currently the subject land is storing flood water in higher flood events. To work out the current flood volume within the site in higher flood events, separate drain modelling was performed. Three dummy storage basins were placed near three outlets. With external inflows (provided by the DoW), sub catchment flows calculated by drains model and permissible outflow from three dummy basins as pre-development flows (provided by the DoW), basin sizes were optimised with several runs of the model. These are the volumes that the site currently holds during higher rainfall events and hence assumed extra storage to be provided in addition to the sub-catchment storage requirements.

In summary, the steps utilised in this study were as follows:

i. Gathered available information;

ii. Carried out site inspections;

iii. Prepared HECRAS base model based on external inflows and prepared pre development flood inundation map for drainage lines;

iv. Prepared *DRAINS* base model for pre-development situation and extra storage requirements were estimated by optimising basins with several runs of the model; and

v. Prepared *DRAINS* base model for post-development situation and storage requirements within sub catchments with pre-development flows as permissible outflow from the sub catchment were estimated by optimising basins with several runs of the model.

5.0 SOFTWARE AND MODELLING ASSUMPTIONS

Software Version

DRAINS Version

DRAINS is a Stormwater Drainage System design and analysis program. It is managed by *Watercom Pty Ltd*. The general practice when developing models was to use the latest version of *DRAINS*. Versions 2012.15 was used to generate the runs reported in this study, operating in "Standard hydraulic calculation" mode.

HECRAS Version

Hydrologic Engineering Centres River Analysis System (*HEC- RAS*) performs one-dimensional steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modelling. *HEC-RAS 4.1.0* is used for this study.

Hydrological Model

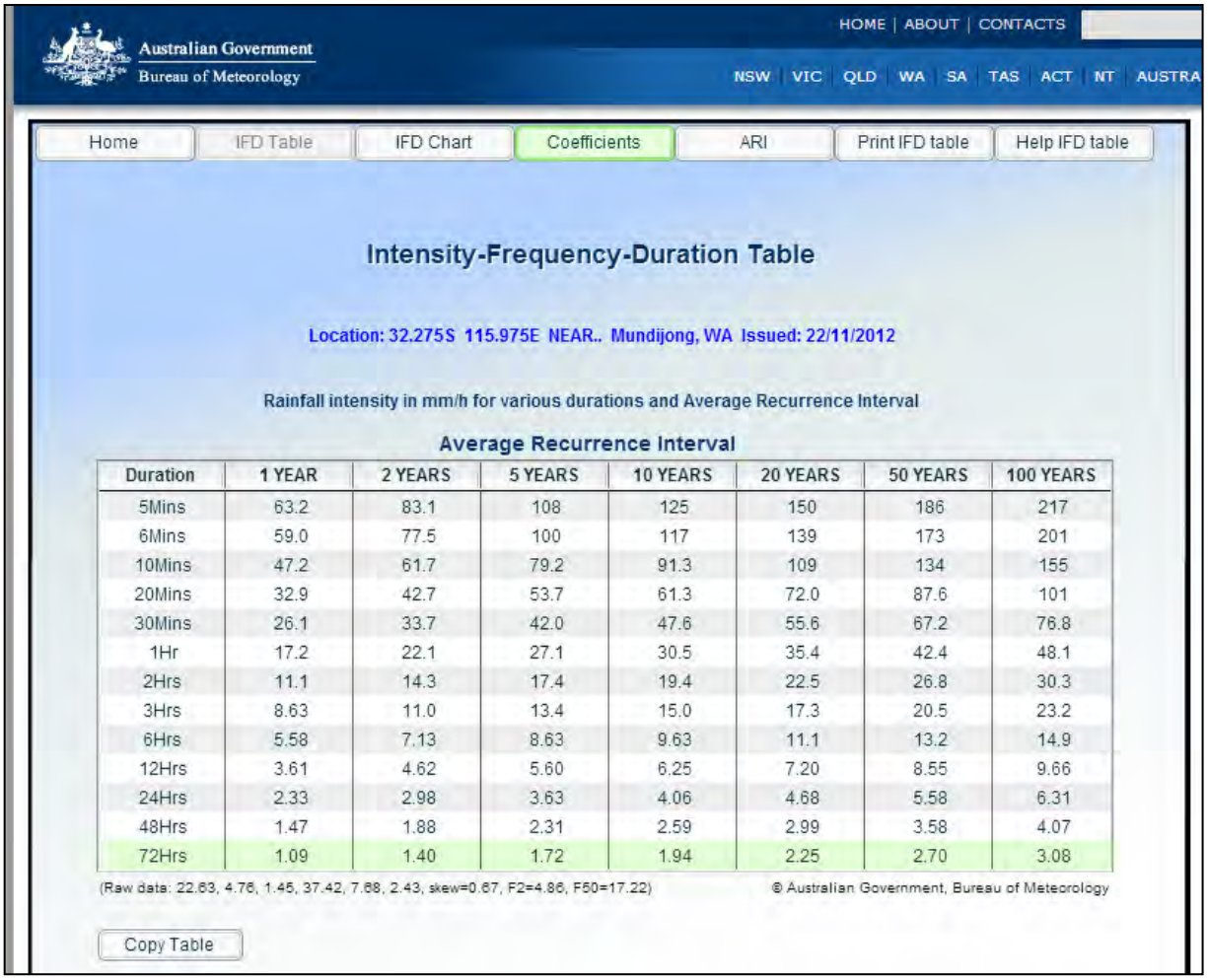
DRAINS
The hydrological model applied in *DRAINS* was an Extended Rational Method model operated in Standard hydraulic calculation which is steady analysis.

HEC-RAS

One dimensional steady flow analysis has been performed and *HEC-GEORAS10* for *ArcGIS 10* is used to prepare flood inundation map.

Rainfall Data

The models utilised the standard rainfall data from BoM's website. The model was run for ARIs of 10 and 100 years storms with durations 5 minutes, 10 minutes, 20 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 3 hours, and 6 hours. Modelling by the DoW showed that the 6 hour event is the critical event for the majority of the site.



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Intensity-Frequency-Duration Table

Location: 32.275S 115.975E NEAR.. Mundijong, WA Issued: 22/11/2012

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

Average Recurrence Interval

Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	63.2	83.1	108	125	150	186	217
6Mins	59.0	77.5	100	117	139	173	201
10Mins	47.2	61.7	79.2	91.3	109	134	155
20Mins	32.9	42.7	53.7	61.3	72.0	87.6	101
30Mins	26.1	33.7	42.0	47.6	55.6	67.2	76.8
1Hr	17.2	22.1	27.1	30.5	35.4	42.4	48.1
2Hrs	11.1	14.3	17.4	19.4	22.5	26.8	30.3
3Hrs	8.63	11.0	13.4	15.0	17.3	20.5	23.2
6Hrs	5.58	7.13	8.63	9.63	11.1	13.2	14.9
12Hrs	3.61	4.62	5.60	6.25	7.20	8.55	9.66
24Hrs	2.33	2.98	3.63	4.06	4.68	5.58	6.31
48Hrs	1.47	1.88	2.31	2.59	2.99	3.58	4.07
72Hrs	1.09	1.40	1.72	1.94	2.25	2.70	3.08

(Raw data: 22.63, 4.76, 1.45, 37.42, 7.88, 2.43, skew=0.67, F2=4.86, F50=17.22)

Copy Table

Sub-Catchments

Sub-catchments were defined based on LiDAR, outlets and post-development. For external inflows, inflows provided by the DoW were incorporated as base flow.

Permissible Outflows

Pre development 1 in 10 years and 1 in 100 years flow (provided by DoW) at three (3) outlets at Kargotich Road is assumed as permissible flows for 1 in 10 years and 1 in 100 years post development situation respectively.

The outlet capacity at Kargotich Road and Oakland drain should be analysed in detail and confirmed in later stages of planning.

Runoff Coefficient

0.5 Effective pervious runoff coefficient and 0.9 impervious runoff coefficients were assumed for this study to reflect the high ground water table on the subject land.

Surface Runoff

The assumed Manning's roughness coefficient for pervious areas was 0.035, and 0.015 was adopted for impervious areas. These coefficients were used in the model for calculation of times of concentration.

Hydraulic Conductivity of Soil

A conservative approach of zero infiltration has been adopted in the present analysis due to the high ground water table. This can be refined in later stages of planning after the actual groundwater depths are known.

6.0 RESULTS

Pre- Development Situation

As explained in the methodology, one dimensional steady flood modelling has been performed for 1 in 10 years and 1 in 100 years after preparing geometric files with LiDAR in *HEC-GEORAS-10* within *ArcGIS10* and importing to *HECRAS 4.1.1*. *Figure 1* (Page 9) shows digital elevation model and 2m contours derived from LiDAR. *Figure 2* (Page 10) shows 1 in 10 years predevelopment flood inundation from external inflows (provided by DoW). 1 in 10 years predevelopment flows within major sub catchments are shown in text boxes which were estimated from *DRAINS* Modelling. Extra storages necessary to limit outflows to 1 in 10 pre development flow are shown in the map, which were estimated from optimisation with *DRAINS* modelling. Similarly 1 in 100 years predevelopment flood inundation due to external flows are shown in *Figure 3* (Page 11). Catchment flows and required extra storages were also estimated using this modelling.

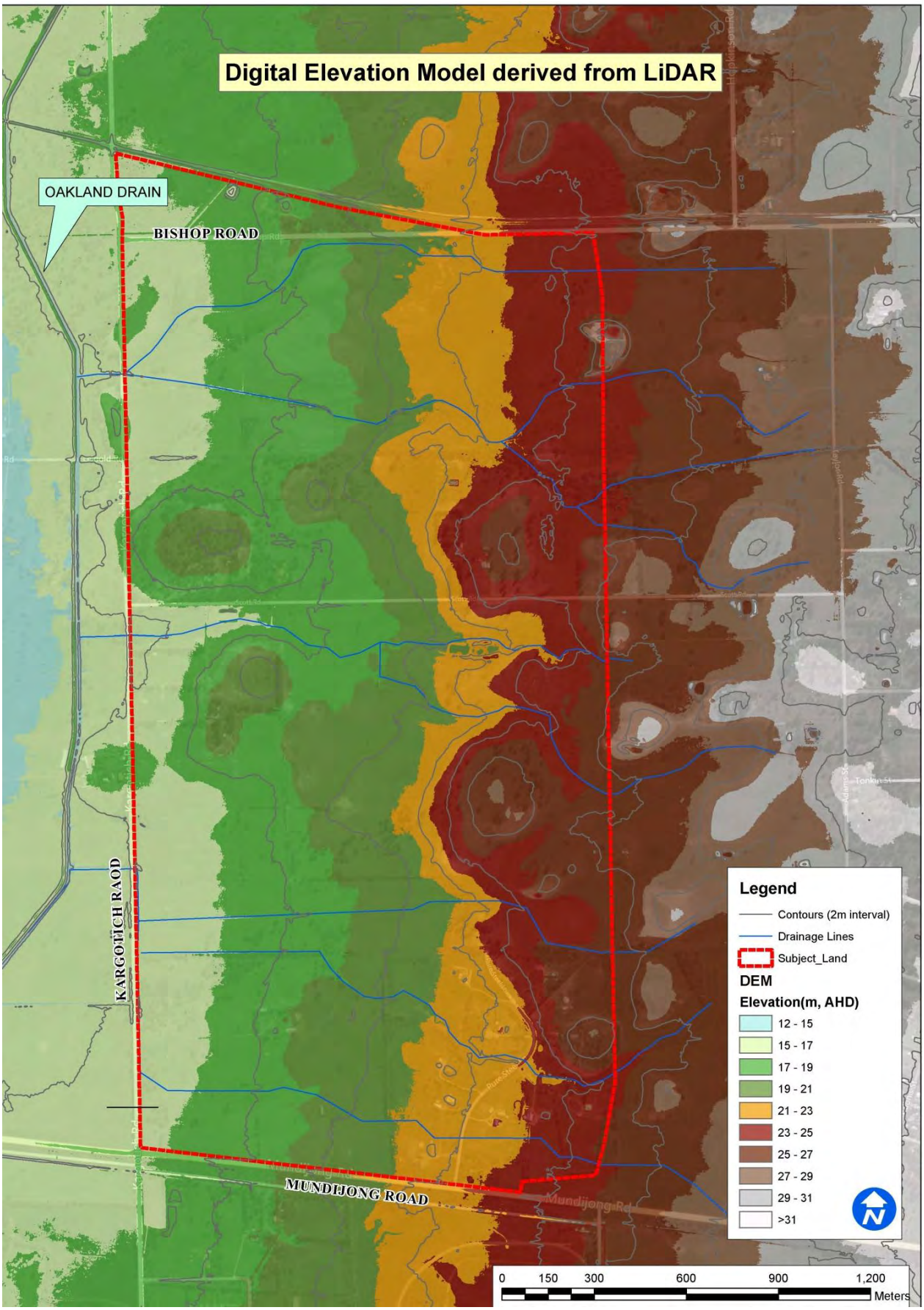

Figure 1 – Digital Elevation Model

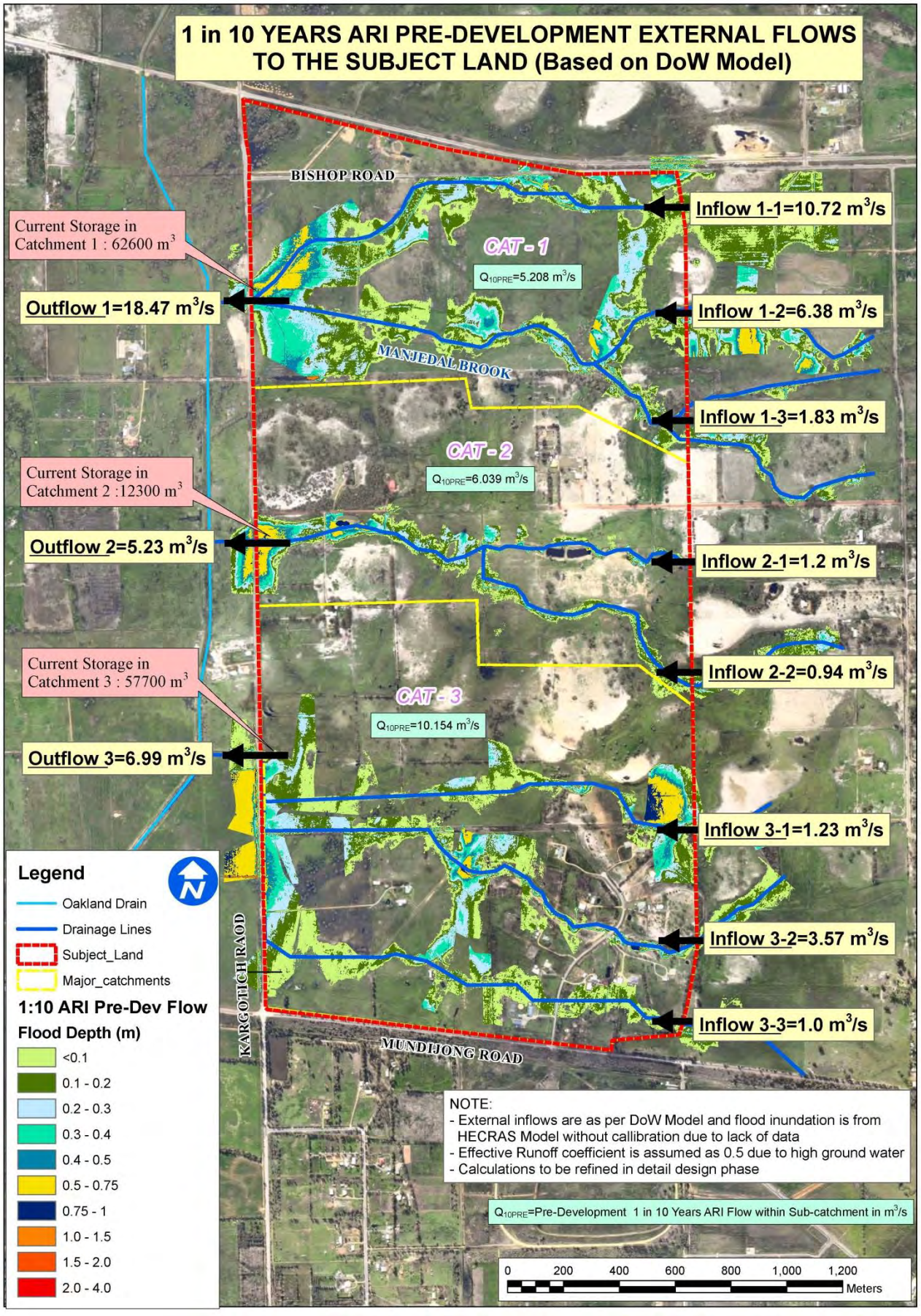

Figure 2 – 1 in 10 years pre development flows due to external inflows

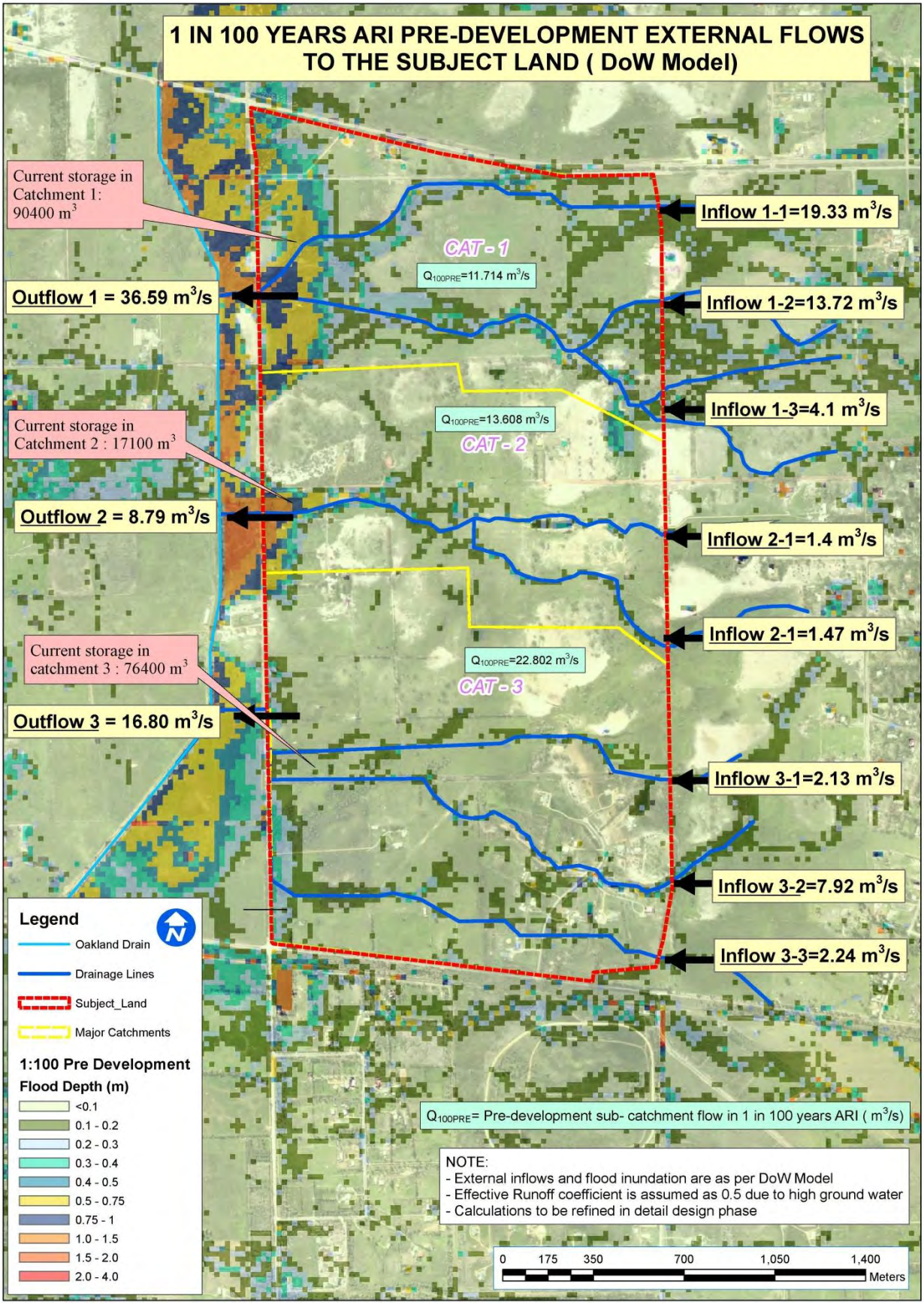

Figure 3 : 1 in 100 years flood inundation map due to external flows (DoW Model)

Post Development Situation

For post development 1 in 10 years and 1 in 100 years, flows were estimated using the *DRAINS* extended rational method and shown in *Figure 4* (Page 13) and *Figure 5* (Page 14) respectively. Assuming corresponding pre-development flow as permissible outflow, basin sizes were optimized in the model and final storage requirements within the sub-catchments were estimated and shown in *Figure 4* (Page 13) and *Figure 5* (Page 14) respectively. Similarly, limiting outgoing flows to corresponding pre-development flows, the final extra storage requirements were estimated by optimising basins in *DRAINS* model. Final extra storage requirements are shown in *Figure 5.*

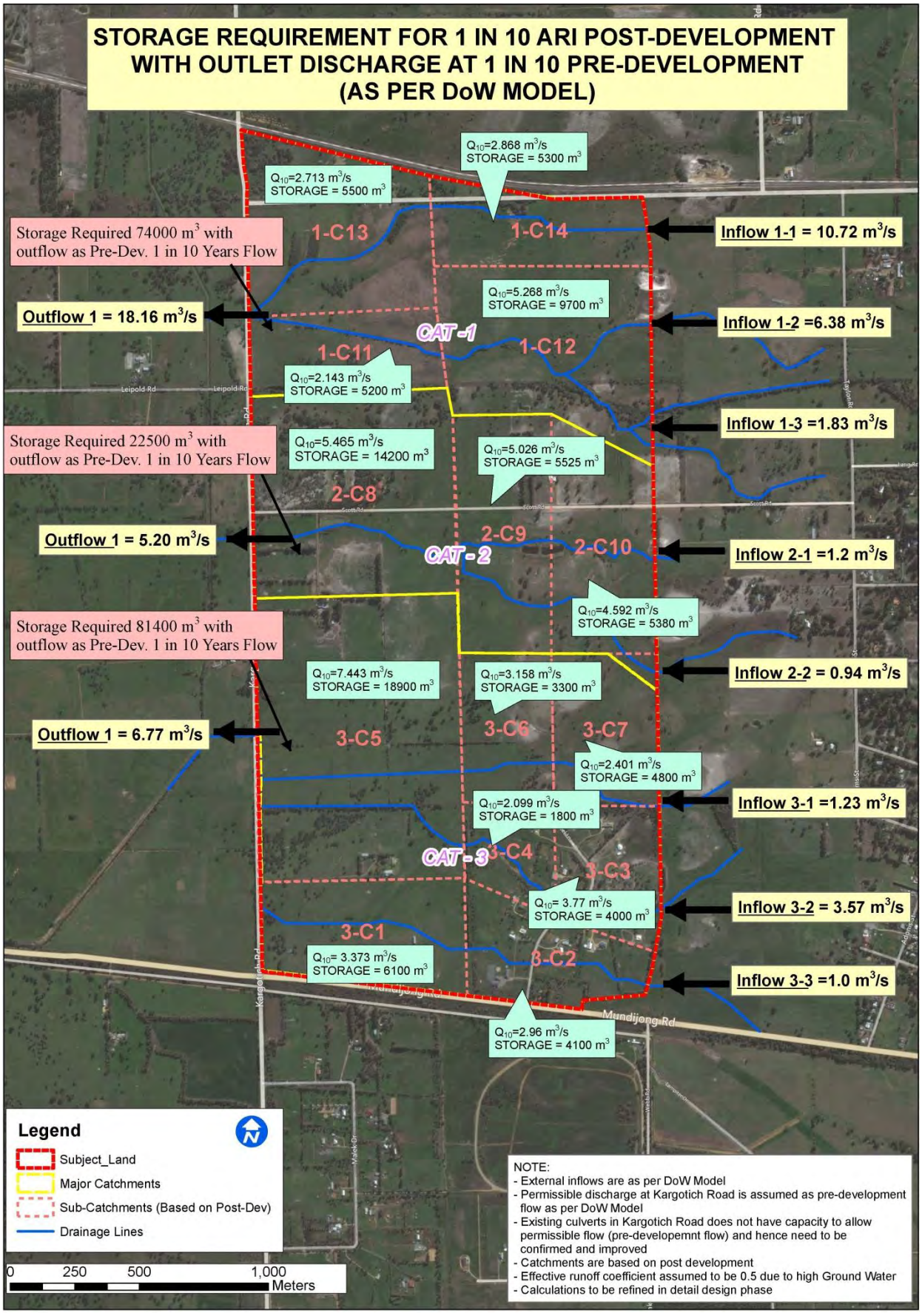

Figure 4 : 1 in 10 years Post-development storage requirements

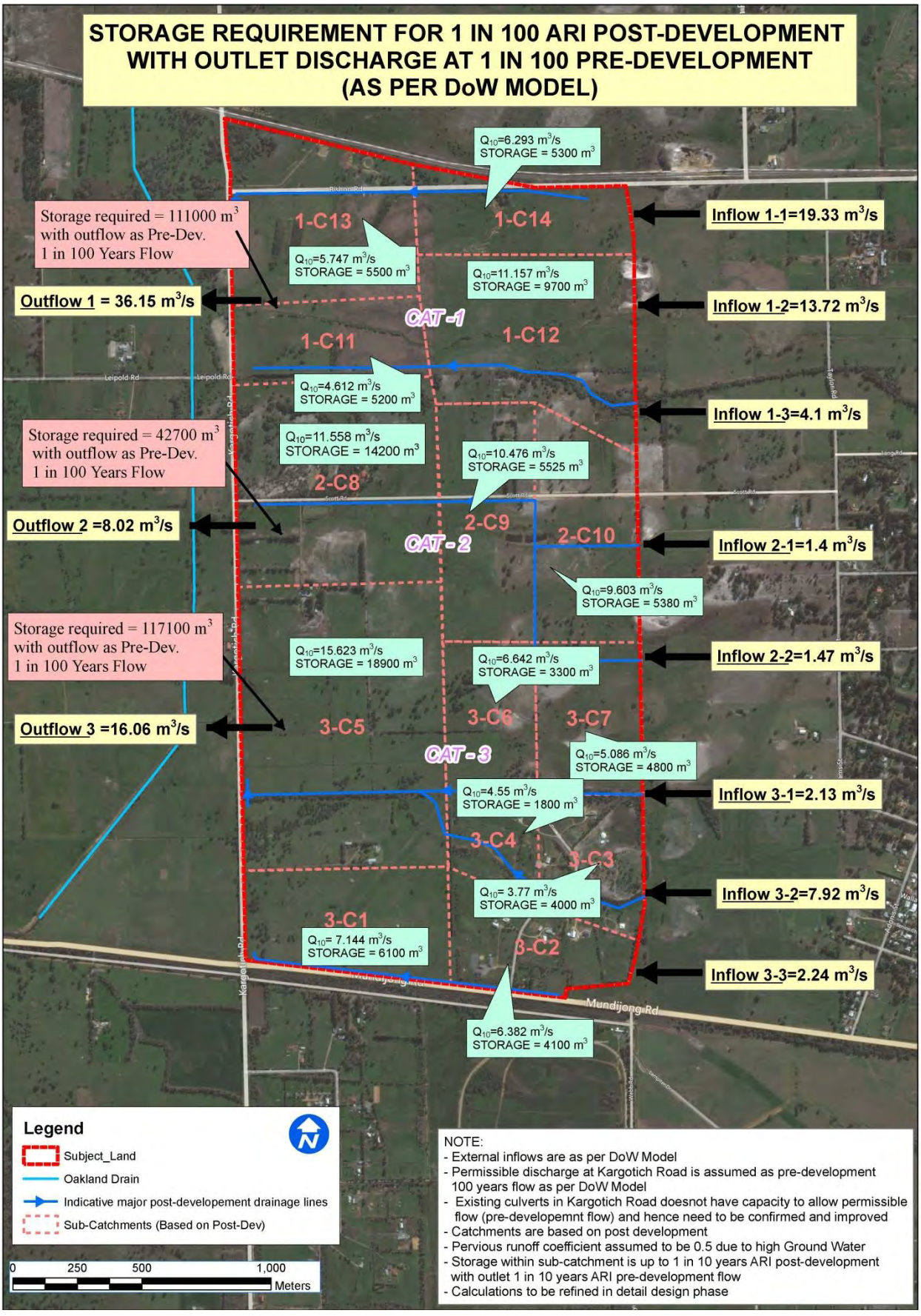

Figure 5 : 1 in 100 years Post-development storage requirements

The following table summarises storage requirements to limit outflow from the subject land to pre development flow;

S.No	Catchment	PRE-DEVELOPMENT				POST-DEVELOPMENT				
		Pre-Development flow as per DoW Modelling		Volume of Water storing within subject land (Pre-Development)		Lot /Sub-catchment Storage with outlet discharge of 1 in 10 pre-development(m^3)	Additional storage for 1 in 10 Years ARI (m^3)	Additional storage for 1 in 100 Years ARI (m^3)	Total storage Required	
		1 in 10 Years ARI (m^3/s)	1 in 100 Years ARI (m^3/s)	1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)				1 in 10 Years ARI (m^3)	1 in 100 Years ARI (m^3)
1	Catchment 1	18.47	36.59	62600	90400	25700	74000	111000	99700	136700
2	Catchment 2	5.23	8.79	12300	17100	25105	22500	42700	47605	67805
3	Catchment 3	6.99	16.8	57700	76400	43000	81400	117100	124400	160100
		Total		132600	183900	93805	177900	270800	271705	364605

Note:

1 Current Volume of Water storing within subject land is calculated from pre-development flow from subject land (calculated using rational method) + External inflows with permissible outlet discharge as outflow discharge from DoW Model (Pre-development)

2 Additional storage is storage required in addition with Sub-catchment/lot storage (Post-development 1 in 10 yr - Pre-development 1 in 10 yr) to limit discharge from subject land to pre-development stage

3 As current capacity of culverts in Kargotich Road is not adequate to release pre-development flow detail analysis should be done in detail phase of design

8.0 CONCLUSIONS AND RECOMMENDATIONS

Due to significant external inflows at various locations to the subject land it is necessary to provide extra storage within the site in addition to other storage required to maintain pre development flows. Estimation of storage requirements presented above is indicative and should be refined and confirmed during the detail design phase. The Current capacity of outlets at Kargotich Road is not adequate for the pre development 1 in 10 and 1 in 100 years flow and hence detail analysis with the site survey data is recommended in the detail design phase. In this study it is assumed that permissible outflow from the site is corresponding to pre-development flows and hence should be confirmed in later stage of study.

APPENDIX C

Local Water Management Strategy

West Mundijong Industrial Area

LOCAL WATER MANAGEMENT STRATEGY

DOCUMENT QUALITY CONTROL

Project Reference		B20013
Ver No.	Purpose	Date
Draft	Client Review	November 30, 2020

Oversby Consulting

Water and Environmental Management

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1 EXECUTIVE SUMMARY

The West Mundijong Industrial Area Local Water Management Strategy (LWMS) has been prepared to support the Structure Planning process for the subject land. The subject land is bounded by Mundijong Road (south), Tonkin Highway Road reserve (east), Bishop Road (north) and Kargotich Road (west). It is approximately 474 hectares in area. The land is approximately 1.5km west of the existing Mundijong town site (see Figure 1).

The subject land has a number of minor water courses that either traverse or begin on the site. This includes waterways that begin on the scarp to the east. All water leaving the site via the surface flows under Kargotich Road and into Oakland's drain, which flows southward. A small section of one of the waterways (Manjedal Brook) is considered a Conservation Category wetland. Around 80% of the remainder of the site is also considered Multiple Use wetland.

The majority of the site has been cleared and is composed of pastures. The remaining native vegetation on the site is degraded. It is usually composed of native overstorey species with none or limited native understorey.

Historically the land has been used for broad acre agricultural purposes, and currently is used for livestock grazing purposes. There are a number of dwellings on the subject land, especially in the rural residential section in the south east corner.

The future Tonkin Highway and rail line are located along the eastern boundary. This area may also include an intermodal area.

The LWMS has been prepared to satisfy the Better Urban Water Management guidelines that require a LWMS to support the current Structure Planning Process.

The objective of the LWMS is to demonstrate how a best management practices approach will achieve the principles, objectives and requirements of total water cycle management. The constraints of the site, proposed land use and surrounding environment have all been investigated to determine potential issues and outline potential strategies to manage, protect and conserve the total water cycle of the local environment and the greater catchment.

The strategies include:

- Integrate water sensitive urban designs (WSUD) into the development and surrounding landscape;
- Achieve water quality targets entering surrounding waterways and the groundwater resource
- Manage water quantity and flooding for the industrial development and hydrological regimes;
- Manage the groundwater resource with close to source treatment trains and to minimise the required fill;
- Investigate opportunities for stormwater, superficial groundwater and greywater harvesting and reuse;
- Investigate innovative schemes for Industrial wastewater management;
- Protect associated ecosystems dependent on water resources from the development; and
- Investigate practical methods to reduce potable water demand.

The effectiveness, efficiency and benefits provided by the best management practices will require a collaborative effort between local governments, developers and relevant regulatory authorities

PURPOSE OF DISTRICT WATER MANAGEMENT STRATEGY

The LWMS will support the development of a Local Structure Plan (LSP) for West Mundijong Industrial Area. The LSP will be a strategic document which guides future industrial subdivisions across the subject land. This LWMS refines the works undertaken as part of the DWMS which assisted with the rezoning of the land to Industry.

It is proposed that the development will predominantly support general and light industry. Any heavy industry sites will be limited and need to satisfy planning, site and environmental conditions for their consideration. The lot size will initially be limited to 2ha. This is to reflect the lack of sewer available. Future subdivision may be undertaken to smaller lots, provided the wastewater management is in keeping with the increased density. This LWMS deals primarily with the 2ha option of subdivision, however it does provide direction on the future subdivision to smaller lots.

SUPPORTING DOCUMENTATION

The LWMS was compiled using information contained within the detailed assessments and reports undertaken for the subject land. These reports listed below have been included on the enclosed CD accompanying the DWMS.

- TME. 2012. West Mundijong Industrial Area Fill Analysis.
- TME. 2012. West Mundijong Industrial Area Feasibility Study.
- PGV Environmental. 2012. West Mundijong Industrial Area Environmental Assessment.
- TME. 2012. Drainage modelling - HECRAS and DRAINS
- Oversby Consulting. 2020. West Mundijong Industrial Area Wetland Management Report
- Urbaqua. 2020. West Mundijong Industrial Modelling Report

Typical flat plain and roadside swale within the subject land

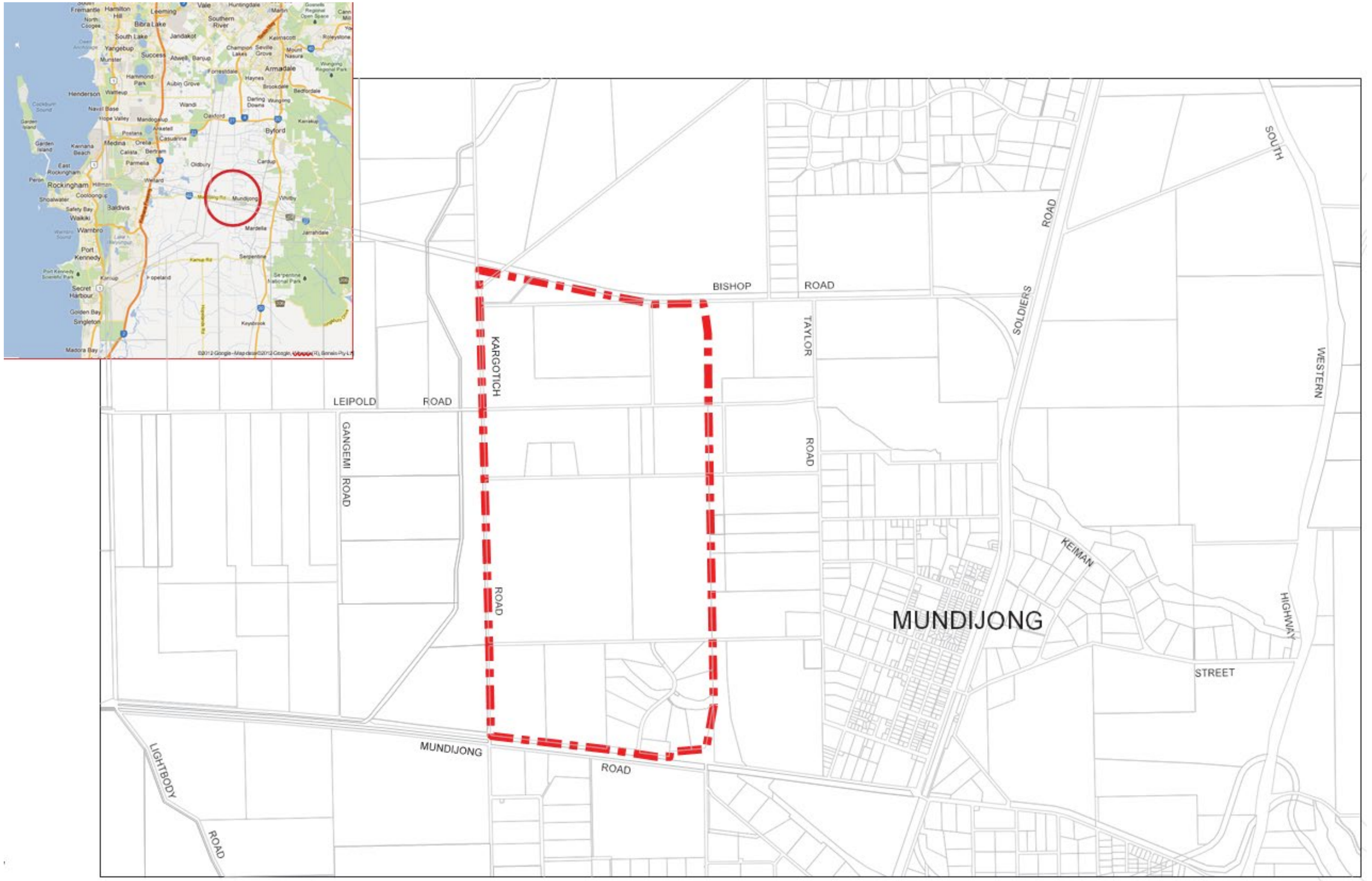


Figure 1 Location Plan

2 KEY ELEMENTS

Water management strategies for the subject land are based on best practice water sensitive designs that suit the site's constraints. They also provide recognition of the importance of water as a resource across the entire development and surrounding environment.

The recommended strategies provide an integrated approach through the synthesis of industrial planning and designs to manage, protect and conserve the total water cycle. The plans and designs for the development are appropriate for the subject land's development constraints and unique surrounding environment and providing a sustainable industrial estate.

A summary of the key best water management practice elements that are recommended for implementation within the development to achieve best management practices are outlined below, and visually represented in Figure 2.

WATER QUALITY AND ENVIRONMENTAL PROTECTION

- Establishment of appropriate management practices for foreshore reserves and wetlands along Manjedal Brook.
- Utilisation of water sensitive designs, including bioretention gardens, basins, swales, and flow spreader devices to capture, detain, treat and convey all development runoff.
- Investigation of building design guidelines that encourage structural separation of potentially polluted runoff in work areas from the stormwater runoff pathways.
- Providing lot owners with information relating to the establishment and maintenance of water wise and nutrient wise gardens in their required landscape areas on each development.
- Encourage non-structural best management practices.
- The pre development monitoring of groundwater and surface water quality to establish benchmarks and identify any potential issues.
- The monitoring of storm water outflow rates and quality post-development.

STORMWATER MANAGEMENT AND FLOOD PROTECTION

- Utilisation of best practice to treat, store, convey, control and discharge stormwater runoff;
- Lot storage and treatment of all runoff up to the 10%AEP on each lot.
- Treatment of the 1EY event in road reserves
- Post development monitoring of water quality.
- No development to be within the 1%AEP floodways of the subject land waterways.
- All finished floor levels on lots to be designed to maintain a minimum separation clearance of 500mm to the 1%AEP flood levels of the Manjedal Brook, Oaklands Drain and all flood storage areas.
- All building floor levels on lots to be designed to maintain a minimum separation clearance of 300mm to the internal 1%AEP flood levels.
- Protection of buildings and infrastructure with conveyance and storage of flood waters via the open and piped drainage network and road reserves.
- Discharge of 10% AEP flow rates from the site is not to exceed pre development flow rates.
- Discharge of 1% AEP flood flow rates from the site is not to exceed pre development flow rates.
- Storage of predevelopment flood volumes as well as the extra post development runoff, to control downstream flooding.

GROUNDWATER MANAGEMENT

- Ensure development has no negative impact on the groundwater resource, or ecosystems dependent on the resource.
- Filling building and infrastructure sites where necessary so that there is an appropriate clearance to the controlled groundwater level (CGL).
- The installation of a sub-soil drainage pipe network and swale systems at the proposed CGL to control groundwater from rising above this level.
- Treatment of controlled groundwater and the stormwater runoff infiltration via planted swales and basins.
- The monitoring of the groundwater quality and levels across the subject land post development to identify any future detrimental impacts on the groundwater resource.
- There is potential to harvest excess superficial groundwater for use on site.

WATER CONSERVATION AND SERVICING

- Development to be connected to a reticulated water supply.
- Encourage water efficient fixtures and fittings for all buildings constructed.
- Encourage lot owners to install a suitable rainwater tank. The tank size will be dependent on the roof area and water usage patterns of the business.
- Encourage greywater reuse schemes for landscape irrigation and business related purposes.
- Public areas Multiple Use Corridors and street landscaping will have a strong focus on using locally suitable native water wise species and use of soil amendments to reduce irrigation requirements.
- 2ha lots are to be developed initially to allow for onsite effluent disposal (for dry industry).

OTHER ASPECTS

- Future investigations and liaison are to take place with the Department of Indigenous Affairs (DIA) prior to construction, for sites of significance.

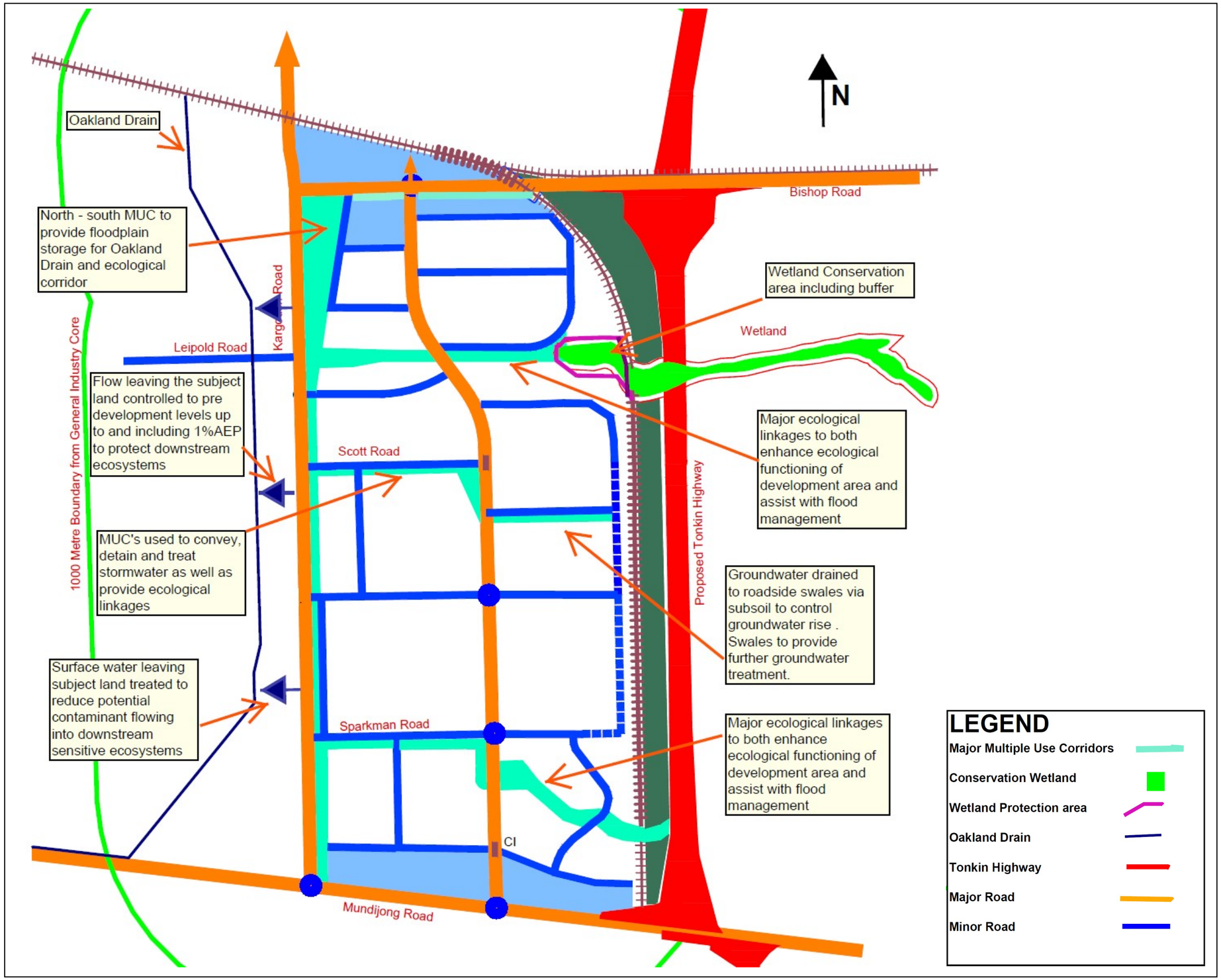


Figure 2 Key Elements Plan

3 LANDFORM & SOILS

The subject land is located on the Swan Coastal Plain and the landforms are typical of this area. The land is composed of three (3) main landforms, which are shown in Figure 4 Page 9 and described below.

Figure 4 Page 9 displays contour information derived for the subject land from LiDAR (Light Detection and Ranging data) modelling.

1. **Wet Flats** – The majority of the site is a mildly sloping wet plain. This landform slopes downwards from east to west with a fall from 25-26mAHD to 16mAHD. The slopes vary between 0.2 and 1% with the slope generally flattening towards the west. These flats are generally sands over loams and clays. The low slopes and predominately sandy surface of this landform produces a low runoff rate until the land becomes waterlogged. These areas are classified as wetlands.

2. **Sand Rises/Ridges** – Low Bassendean sand ridges are located sporadically across the subject land. These are low relief dunes with deep bleached grey sands. The sand ridges rise between 2m and 6m above the surrounding plain with the peaks being up to 27mAHD. The slopes vary from 1 to 5% on the sides of the ridges. The sandy nature of this landform produces a low runoff rate, with most water infiltrating into the soil profile.

3. Waterways - There are also a number of minor waterways that traverse or begin on the subject land. Many of these have been modified through drainage works. The largest of these waterways is known as Manjedal Brook. The waterways/drains tend to be incised within the wet flats landform. It is likely that historically these waterways were considerably more braided and less defined.

Shallow Drainage line to allow for drainage of the flat plains within the subject land

4 GEOTECHNICAL

GEOLOGY

The superficial formations over the land consist predominately of Pinjarra System alluvial soils overlaid with aeolian Bassendean System sands.

The Pinjarra soils are likely to have a high Phosphorus Retention Index (PRI) while the Bassendean sands are likely to have a low PRI. There is a need for a geotechnical investigation of the site to be undertaken as part of later planning for the area.

CONTAMINATED SITES

An analysis of the Department of Environment and Conservation's (DEC) Contaminated Sites database was undertaken on 9th July 2012, and no known sites were found on the subject land or in the near vicinity.

ACID SULPHATE SOILS (ASS)

The DEC ASS mapping for the Swan Coastal Plan has modelled the whole subject land as moderate to low disturbance risk of ASS.

To protect on site and downstream water resources, ASS investigations should be undertaken across the subject land to determine the potential and actual ASS risks as part of future investigatory works.

Detailed ASS investigations and management plans (where appropriate) will also be required on land modelled as 'Moderate to Low' in accordance with DEC's 2009 Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes guidelines if any of the following works are proposed:

- Soil or sediment disturbance of equal to or greater than 100m3 with excavation from below the natural water table.
- Lowering of the water table, whether temporary or permanent (e.g. for groundwater abstraction, dewatering, installation of new drainage, modification to existing drainage).
- Excavation to or greater than 3m below the natural ground surface level.

The ASS investigations should happen as a condition of subdivision, unless there is evidence of high risk ASS. If this is the case then it may be appropriate to undertake investigation at an earlier stage, should the proposed development strategies be subject to high risk activities being undertaken.

Figure 3 Landform, Soil and Geotechnical Plan

5 ENVIRONMENT

PGV Environmental undertook an environmental assessment of the subject land. Oversby Consulting also undertook an assessment of the Manjedal Brook Wetland system. The following is a summary of this information and site visits by Oversby Consulting.

WETLANDS AND WATERWAYS

According to the Department of Environment and Conservation's (DEC) Geomorphic Wetlands Swan Coastal Plain dataset (as shown in Figure 5), the Paluasplain Multiple Use Wetland (Number 15785) covers the majority of the site. The Multiple use wetlands areas are predominately devoid of native vegetation, although there are small areas of isolated Melaleuca rhaphiophylla, Eucalyptus rudis and Casuarina obesa trees. The main vegetation is composed of pasture species. These areas have limited ecological functioning and therefore provided few habitats for fauna

There is also a small area of Paluasplain Conservation Category (CC) Wetland associated with Manjedal Brook that traverses the northern portion of the site This has the reference Number 14945. The overstorey vegetation is largely intact and forms part of a corridor of vegetation along the brook and constructed drain. The understorey is predominately composed of pasture species and environmental weeds as well as isolated rushes. For much of the portion in which the brook is within the CC wetland, it exists as a shallow single channel. There are some minor side channels which would receive flows during flood events. This area provides some basic habitat value for fauna and acts as a limited corridor for fauna movement. A Wetland Management Report has been prepared for this wetland area (see Appendix B).

The other waterways and drains tend to be very degraded in nature, with limited ecological functioning, although there is still likely to be a limited range of fauna that use these waterways. The main flora along the waterways are introduced grasses and pasture weeds. They are likely to be classified as 'D' grade waterways using the Penn and Scott method.

To the south of the site, there is some higher quality wetland type vegetation associated with the reserve along Mundijong Road. This area is regarded as a Paluasplain Conservation Category Wetland (Number 14817).

OTHER AREAS

Some of the sand mounds have parkland cleared native vegetation, with some areas of denser, although degraded native vegetation. The vegetation tends to be dominated by marri trees. This will provide some habitat for wetland and waterway dependent fauna that are also able to use these other vegetation types. There are scattered native trees across some of the paddocks, predominately, C. obesa and M. rhaphiophylla.

There has also been some windbreak and Landcare planting along fence lines and drains. These will also provide some limited habitat to generalist species.

VEGETATION AND FLORA

The subject land is within the Southwest Botanical Province within the Swan Coastal Plain Bioregion and is dominated by vegetation of the Pinjarra Plain and Bassendean System. Most of the native vegetation however has been cleared.

The different areas of vegetation include:

1. Completely cleared farmland containing pasture grasses, which is the predominant vegetation type over the entire site;
2. Casuarina obesa Woodland over pasture grasses which is dominant in the south western corner of the site
3. Melaleuca rhaphiophylla (Paperbark) Woodland over pasture grasses which is associated with the Conservation Category Wetland and has some Eucalyptus rudis (Flooded Gum);
4. Corymbia calophylla Woodland over pasture grasses which is mainly in the area around Scott Rd;and
5. Kingia australis and Melaleuca rhaphiophylla over pasture grasses, which occurs in the north of the site near Bishop Road.

The degraded nature of the site means it is highly unlikely that any Threatened or Priority Flora exist on the site. The priority flora found to the south of Mundijong Road will not be impacted by the development of the subject land.

FAUNA

The degraded nature of the site's vegetation means that there is likely to be limited opportunity for endangered fauna species that rely on wetlands and waterways to use the site. Generalist species, and those suited to agricultural landscapes may be able to make use of the degraded wetland and waterway habitats occurring on site. The waterways also provide some limited ecological linkage function for fauna moving across the site.

6 HERITAGE AND CULTURAL SITES

There is one Registered Aboriginal Site present on the northern portion of the eastern boundary. It is a scatter site located on a sand rise and doesn't impact on the existing water ways and wetland areas. (see Figure 5). There is also another non registered Heritage Place that crosses the eastern boundary towards the south, which is also an artefacts scatter site. This is also located out of the drainage lines that exist on the subject land.

The aboriginal heritage issues are therefore unlikely to affect the water management of the site.

Investigations should be undertaken at future planning stages to ensure that Aboriginal and heritage consent is granted for proposed designs and practices.

All contractors working on any future development of the site will be made aware of their responsibilities under the Aboriginal Heritage Act 1972 with regard to finding potential archaeological sites. In the event that a potential site is discovered, all work in the area will cease and the DIA will be contacted.

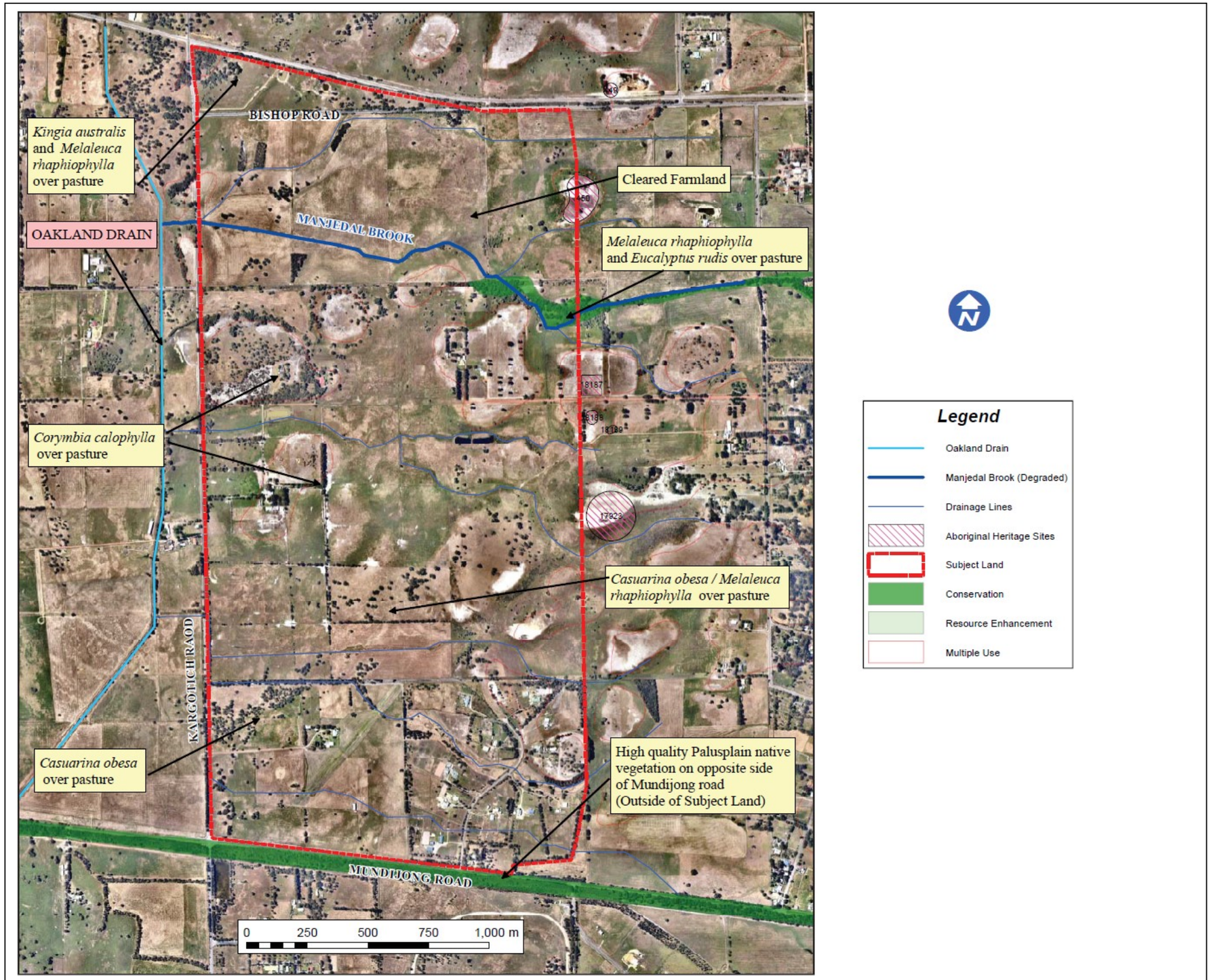


Figure 4 Environmental and Heritage Plan

7 GROUNDWATER HYDROLOGY

GROUNDWATER INVESTIGATIONS

The Department of Water and Environmental Regulation (DWER) has undertaken broad scale analysis of the regions groundwater levels as part of Perth Regional Aquifer Modelling Systems (PRAMS) model development. Hydrology and groundwater modelling, with a focus on the Lower Serpentine Regional Model (2008) has also been undertaken.

As part of the DWMS, this information was analysed by TME, in conjunction with LIDAR. From this information, indicative groundwater levels for the site were developed.

Maximum, minimum and average maximum groundwater contours were determined as well as the depth to groundwater. From this analysis, the groundwater can be seen to be moving generally in a westerly direction.

Maximum levels ranged from 26mAHD on the eastern boundary down to 16mAND on the western boundary. Minimum levels fell from 23mAHD to 14.5mAHD and Average levels fell from 24mAHD to 15mAHD. Seasonal variation between the minimum and maximum level was usually between 2 and 3m.

The depth to groundwater varied across the site. Approximately a quarter of the site had water at the surface, with another quarter showing water within 0.5m of the surface. Under some of the sand dunes, the ground water was at least 3m below the surface. A map of groundwater depth can be seen in Figure 5.

This DWMS data was compared to recently collected groundwater levels as part of the Tonkin Highway expansion. A total of 6 bores, from 5 locations were analysed. All of these occur approximately 50-100m to the east of the subject land boundary of the subject land. These stretched from the north to the south of the eastern side. Their location can be seen in Figure 5.

The levels collected over the 2020 winter and spring period were compared to the PRAMS model and depth modelling undertaken as part of the DWMS.The analysis also considered the closest bore to the subject land with longterm data is 61410151, located next in the north west of the subject land (Bishop Road and Kargotich Road intersection). The levels for 2020 are close to average with a reading of 16.9mAHD (noting that this is above the AAMGL within the PRAMS model of approximately 15.7mAHD). It is however close to the modelled maximum level of 16.8mAHD. The maximum recorded for this bore is 17.18mAHD. This would suggest that in this localised corner groundwater can rise above the general regional groundwater contours. Over much of the subject land groundwater rises until it is intercepted by the drainage network or the low areas of the surface then runs off. This limits further rise.

Given this, although rainfall was below average over winter and early spring, the fact that groundwater was observed to rise to the surface within the subject land, that the 2020 Main Roads data is likely to be close to the average for this location.

The levels in the Tonkin High bores also generally matched relatively closely with the modelled levels determined for the subject land. Based on this analysis, the levels modelled in the DWMS are considered suitable for this LWMS.

A full summary of the analysis can be seen in Appendix C

GROUNDWATER QUALITY

Groundwater quality has not been analysed in detail for the subject land. Due to the current land use and soil types present, it is likely that the nutrient levels of the groundwater will be elevated. This has the potential to impact on wetlands and river systems both on and downstream of the subject land.

It is also likely that the pH of the groundwater will be under 7 and have elevated levels of iron and aluminium. The salinity is likely to be in the fresh to brackish range. Groundwater exhibiting the above characteristics is common throughout the eastern portion of the Swan Coastal Plain.

AQUIFER AND ALLOCATION INFORMATION

The subject land is within the Byford 2 sub area.

The DWER was contacted in October 2020 regarding groundwater availability for the subject land. The Yarragadee, was noted as having no allocation. The Perth-Cattamarra Coal Measures had no current allocation limit, the Perth Leederville had approximately 35% allocation available and the Perth-Superficial Swan had some allocation, noting that the yield rate may be low in some locations, especially towards the east.

This means there is potential groundwater resources that may be used within the development

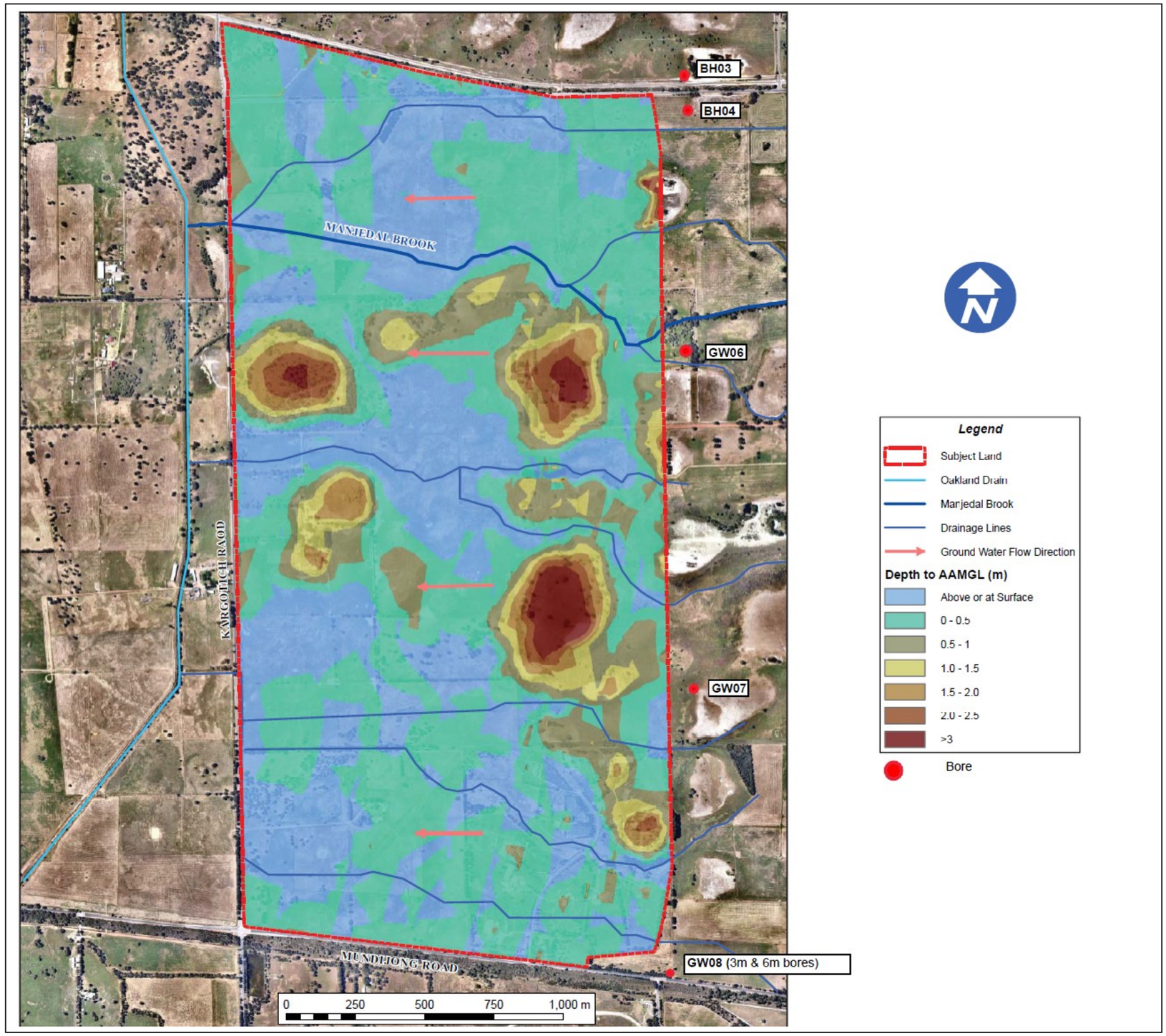


Figure 5 Predevelopment groundwater Plan

8 SURFACE WATER & DRAINAGE PRE-DEVELOPMENT

PREDEVELOPMENT SURFACE WATER.

The major drainage lines within the subject land is Manjedal Brook and its tributaries. These cover the northern portion of the subject land and generally run from east to west. This area is within Catchment 1. There are another 5 small drainage lines which transport external inflows during high flow events, which traverse Catchments 2 and 3.

Water generated on the site, and water that enters the site from upstream all flow across Kargotich Road and into Oakland drain. This major Water Corporation drain runs southward, parallel to the subject land. Water from this drain is ultimately discharged into the Serpentine River and Peel Harvey Inlet. These drainage lines and discharge points can be seen in Figure 6.

PRE-DEVELOPMENT DRAINAGE MODELLING ASSESSMENT

An assessment of the pre-development runoff from the subject land and upstream flows was modelled as part of the DWMS. This was to determine flows from the 1 in 10 year and 1 in 100 year events. This modelling incorporated original broad scale modelling by the Department of Water, with more detailed modelling within the subject land by TME.

Flood mapping information for the subject land was obtained from the DWER modelling and used as the base case. Refinement of this specifically to the subject land as undertaken using DRAINS modelling software.

Hydrologic Engineering Centres River Analysis System (HEC-RAS) was used for modelling flood and ArcGIS for flood inundation mapping. Cross sections of drainage lines were extracted from LiDAR and inflows from Department of Water modelling were used. Based on three major outlets, three major catchments were identified. The model identified where the water is stored during the large flood events.

The model shows that the existing capacity of the culverts under Kargotich Road are not adequate to cater for even the 10% AEP pre-development flow. This results in flooding of the subject land and overtopping of the road.

A refinement of the drainage was undertaken as part of the LWMS process using XP-Storm, as recommended by the Shire of Serpentine Jarrahdale. This allowed for the more detailed modelling necessary. The models were compared so that the results obtained as part of the detailed XP-Storm modelling was in keeping with the initial parameters set out in the DWMS DRAINS modelling. Flows were also converted from Annual Recurrence Interval (ARI) flow to Annual Exceedance Probability (AEP) flows). A summary can be seen in Table 1 with a full comparison in the Modelling Report (Appendix A).

Pre development inflows and outflows from the subject land, as well as the 3 major catchments are shown in figure 6 and 7.

A flood inundation map for 1% AEP equivalent for the modelling exercise is presented in Figure 7. This flood inundation is heavily influenced by the external upstream flows as well as back flooding from Oakland Drain.

The loss parameters used the XP-Storm modelling for the predevelopment scenario are shown in Table 2. These reflect the current rural land use with areas of surface inundation.

Table 1 Comparison of DRAINS vs XP-Storm modelled outflows

Catchment	Drains Post-dev 1% AEP Outflow	XP-Storm Post-dev 1% AEP Outflow
1	36.15 m3/s	39.15 m3/s
2	8.02 m3/s	7.30 m3/s
3	16.06 m3/s	16.51 m3/s

Table 2 Loss Parameters used in XP-Storm Modelling

Land use	Initial Loss (mm)	Proportional Loss (%)
Road	3	0.1
General industry	15	0.1
Light industry	10	0.1
Rural area	7	0.3
POS	8	0.3
Wetland	0	0.0
Commercial	10	0.1

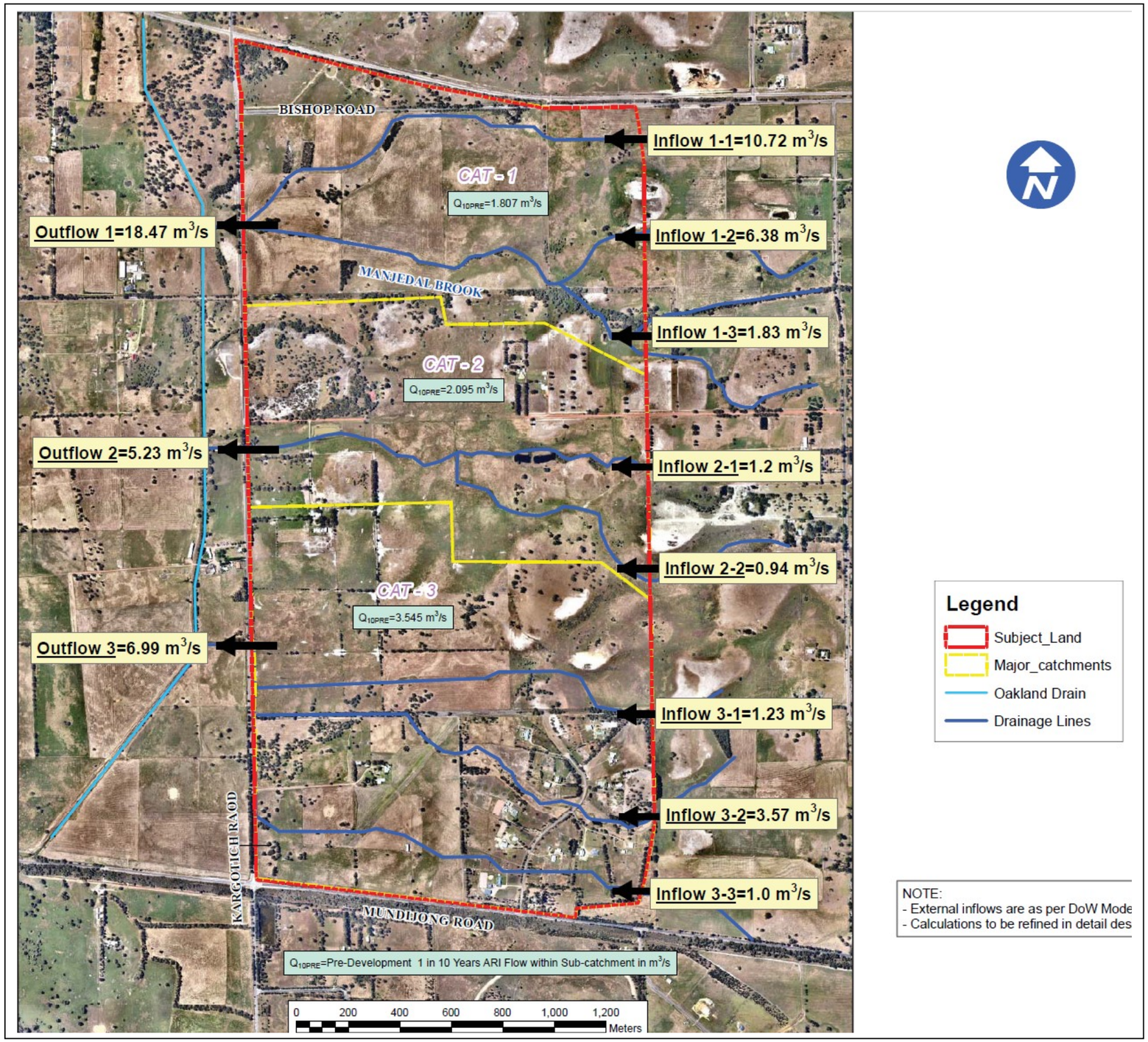


Figure 6 10% AEP Pre Development Scenario (based on historical DoW ARI modelling)

SURFACE WATER QUALITY

No pre-development monitoring has been undertaken to date. There is some limited water quality data available for Manjedal Brook, which was collected in October 2007 as part of the Mundijong – Whitby District Structure Plan Environmental Study (2009). The results are typical for waterways on the eastern edge of the Swan Coastal Plain, although nutrient levels were lower than most waterways. This may be due to the larger flows of Spring diluting the results.

The results can be seen in Table 3.

As the subject land is within the Peel Harvey Water Quality Improvement Plan (WQIP) area, the site will need to consider the recommendations outlined within the WQIP. The Estuary and associated waterways are showing signs of stress according to the (WQIP). The Estuary is internationally, nationally and regionally significant for natural fauna and flora, recreation, aesthetics and hydrologic systems. The system has a history of water quality problems, which are derived from its large and diverse catchment and land uses.

Table 3 Manjedal Brook Surface Water Quality Results

Variable	Range	Comments
pH	6.89-8.25	Meets ANZECC water quality objectives
Electrical Conductivity	343 – 1150 µs/cm	Lower conductivity values are often associated with seasonal rainfall
Salinity	0.14 – 0.58 ppt	fresh to slightly brackish
Turbidity	5.30 – 25.8 NTU	
ORP	170-286 mV	
Dissolved Oxygen	82.7 – 138.6%	should avoid falling below 5mg/L to avoid stress to aquatic species
Heavy Metals		Within ANZECC Drinking Water Guideline Values 2004
Total Phosphorus	0.01 to 0.03 mg/L	Meets ANZECC water quality objectives
Reactive Phosphorus	<0.01 mg/L	Meets ANZECC water quality objectives
Total Nitrogen	0.35 mg/L (average) 2.1 mg/L (max)	All but site 3 meets ANZECC water quality objectives
Total Kjeldahl Nitrogen	0.2 – 0.7 mg/L	
Ammonia	>0.105 – 0.118 mg/L	Above ANZECC trigger values
Nitrite and Nitrate (NO_x)	<0.010 - 1.380 mg/L	Mostly less than ANZECC trigger values

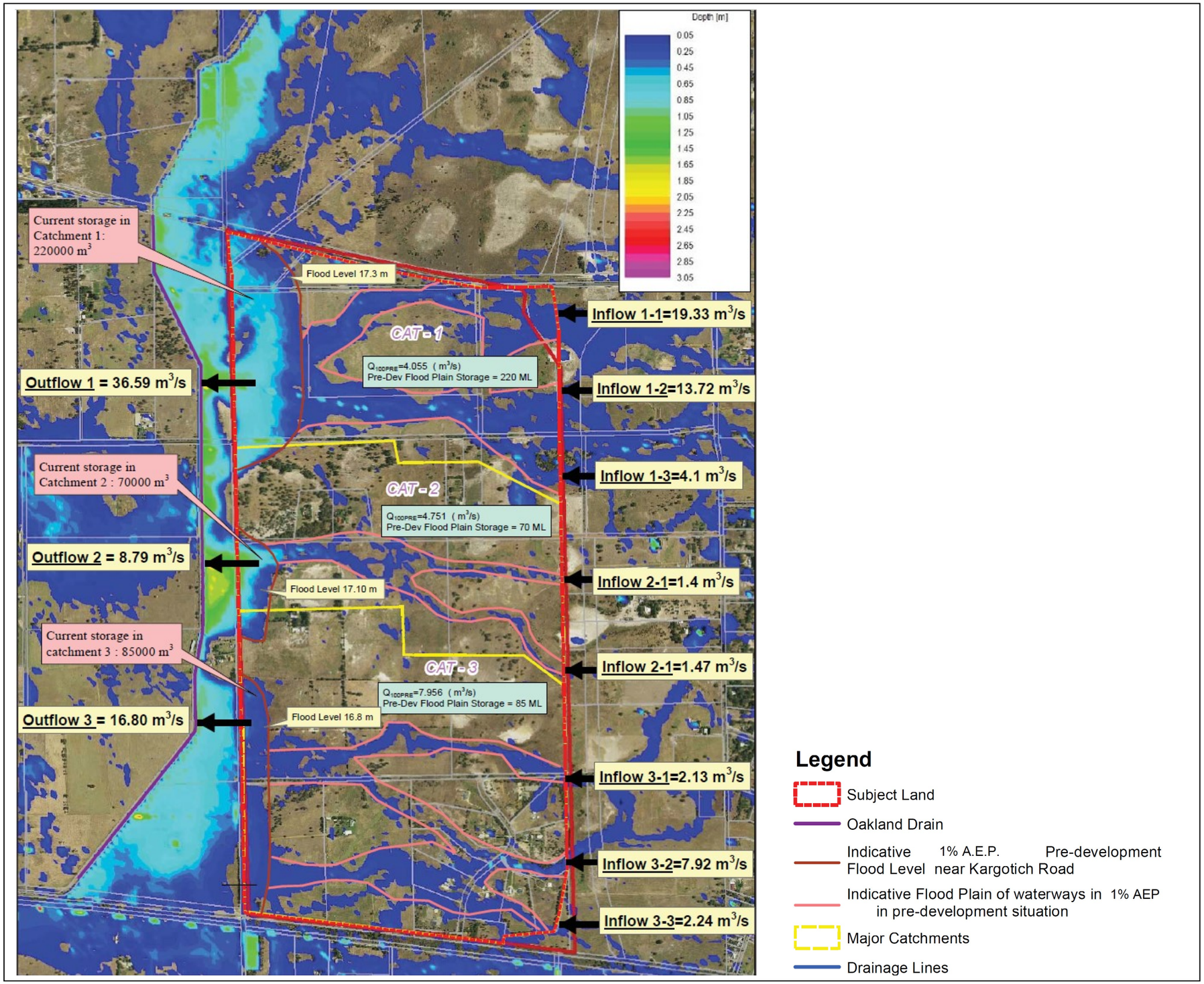


Figure 7 1% AEP Predevelopment Scenario, based on DWER historical modelling

9 DRAINAGE MANAGEMENT STRATEGY

DRAINAGE SUMMARY

The objectives of the stormwater drainage management for the development area and relevant upstream and down stream flows, are to:

- mimic as close as possible the pre-development flows leaving the subject land
- maintain floodplain storage volumes
- treating the necessary volumes before the water is discharged to receiving water bodies or groundwater.

The subject land is divided into three major post development sub-catchments based on three major outlets. These are further divided into twenty one sub catchments based on outlets from proposed development areas. These can be seen in Figure 10 and 11.

The following three sections discuss and provide further details on how water is to be treated, conveyed, stored and discharged in three different flow scenarios.

A – 1EY event

B – The 10% AEP

C – The 1% AEP

These sections outline the guidelines the development may follow to ensure that best management practices of stormwater management and flood protection are achieved.

Detailed drainage designs, models and drawings will be required at the subdivisional stages, to accompany the Urban Water Management Plan (UWMP) for each relevant area.

MODELLING SUMMARY

The following is a summary of the post development modelling, including assumption used to inform the modelling process.

- Management of the 15 mm rainfall event within lots will occur on-lot through the use of shallow landscaped basins, soakwells or rainwater tanks;
- Road runoff from the 15 mm rainfall event within road reserves will be managed in roadside bio-retention gardens and swales;
- Detention of up to the 10% AEP 6 hour event (56.6 mm) within 2 ha lots using basins;
- Conveyance of the 10% and 1% AEP events through roadside swales and a living stream incorporated into landscaped Multiple Use Corridors (MUCs);
- MUCs sized to ensure that the 1% AEP event is contained within the MUC and adjacent road reserve / public open space;
- Flood storage within the MUCs up to the 1% AEP event to reduce on-lot storage requirements;
- Restrict outflow from the site to pre-development rates to prevent an increase in flooding risk downstream; and,
- Ensure that the flood levels of buildings across the site are at least 500 mm above the adjacent water levels within the MUCs, swales and existing waterways.

The hydrology in the model was established with the land uses in the Local Structure Plan provided in Figure 2, losses in Table 2 and the 2016 IFD data, with an ensemble approach (AR&R, 2019). Inflows from the DWER modelling were also incorporated into the XP-Storm model.

The model was run for the 10% and 1% AEP events, with durations of 3, 6, 9, 12, 18 and 24 hours.

On-lot storage will be provided for up to the 10% AEP 6 hour (design) event, with disposal through infiltration into a subsoil network (discharging to adjacent MUCs and swales). To replicate this in the model, a single basin for each sub-catchment was sized, rather than for each 2ha lot. Outflow from the theoretical basins were restricted to a 300 mm pipe (to account for contribution from subsoil discharge) and the storage capacity was refined in the model to on-lot storage requirements. Larger events, including the 1% AEP discharge to the adjacent swales and MUC via overflow from these basins.

The Oakland floodplain storage is to be detained in the North-South Ecological corridor.

The modelled loss parameters assumed for each land use can be seen in Table 3

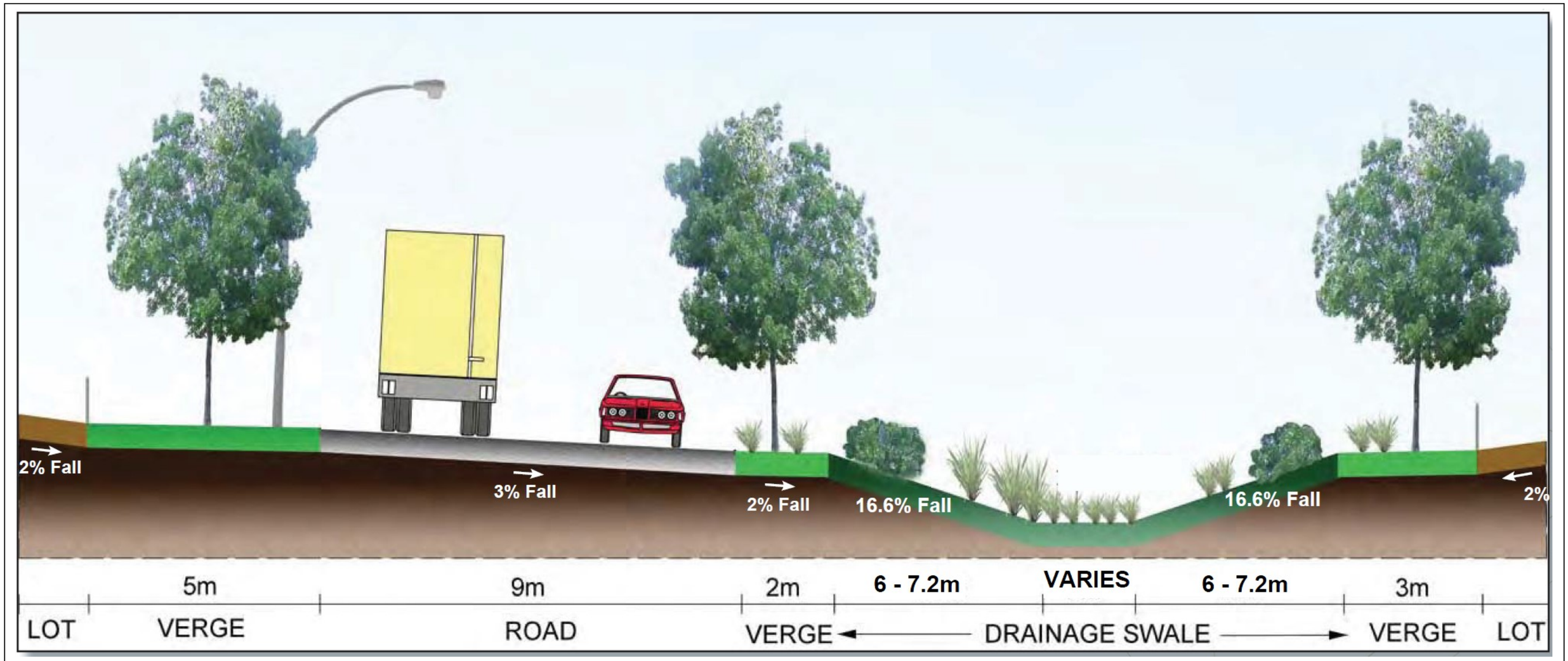


Figure 8 Typical major swale and road cross section

9.1 DRAINAGE MANAGEMENT STRATEGY – 1 EY

The drainage management system for the development will be designed to capture and provide treatment for the first 15mm of rainfall, which is being used as a surrogate for the likely event that will happen annually (1EY). The designs will also provide protection of the ecological functions for all receiving natural environments post development. The flow generated from this rain volume will be collected and treated, both on lots and within the road reserve.

Surface water on the land will take two main directions; infiltration to the groundwater and surface run off. Two separate treatment trains have been designed and specified to treat and manage the two different flow paths.

INFILTRATION TO GROUNDWATER

The majority of the water that falls on pervious surfaces in the development area will infiltrate through to the shallow groundwater because of the high hydraulic conductivity of the imported fill's free draining nature that will be laid across the majority of the developable area. This will include any overflow from installed rainwater tanks, on-site bioretention systems, swale bases and property soak wells. Any fill used will ensure that the fines content of the fill is restricted to less than 5% to promote drainage across the site.

Piped subsoil drains will be used to intercept and convey ground water flows to the drainage system and ensure levels across the site do not rise above the designated controlled groundwater level (CGL) for the site. These pipes will also ensure the required clearances to lots are maintained, allowing soakwells and basins to function as per their design parameters.

Each lot will be responsible for capturing, detaining and treating all lot runoff of the first 15mm on-site. The runoff could be detained and treated by a variety of methods and combinations, including shallow landscaped bioretention basins, rainwater tanks and soak wells.

Rainwater tanks, with air gaps, will be encouraged for each lot and business throughout the development. The tanks will assist in reducing the peak runoff flows from the lots, providing some of their on-site storage requirements especially during summer storm events. Overflow from these will be directed to infiltration areas and soak wells. The base of the soak wells and infiltration areas will generally be installed 300mm above the CGL Water that enters the soak wells will infiltrate into the soil profile and ultimately into the groundwater. There is no direct link between the lots and the street drainage network.

SURFACE FLOW

Runoff within the development will occur off the road reserves during the 1EY.

This water will also be captured and detained and treated.

This will generally be provided in road side bioretention gardens and swales. The bioretention gardens and swales will be protected from traffic. Bioretention gardens will be located so that they do not obstruct lot access and cross overs are to be provided over the swales (noting that appropriate culverts to manage the required flood flows are to be installed). The water entering the bioretention gardens will pass through an amended soil layer to reduce the quantity of sediments and nutrients entering the groundwater. The gardens will be constructed according to the latest FAWB Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual for WA design guidelines

Bioretention gardens may require irrigation during the initial 2 to 3 years to assist with the establishment of plants. Irrigation and fertiliser applications should be met by storm water runoff after this period, although subsequent watering may still be required in drier years.

Table 4 Swale Dimension

Type	Depth	Base Width	Side Slopes
1	1.2 m	25.0 m	1:6
2	1.0 m	1.0 m	1:6
3	1.0 m	2.0 m	1:6
4	1.0 m	4.0 m	1:6
5	0.75 m	2.0 m	1:6
6	1.0 m	18.0 m	1:6
7	1.0 m	8.0 m	1:6
8	1.0 m	10.0 m	1:6
9	1.0 m	20.0 m	1:6

9.2 Drainage Management Strategy – 10% AEP

The drainage management system for the subject land is to be designed to manage the 10% AEP utilising pipe, swale and detention basin systems with controlled outlets. The objective of the drainage systems in the 10%AEP is to release flows from the subject land at the predevelopment rate. This is to be achieved through storage and controlled outlet structures. The drainage system is to be designed to slow the rate of water flow, allow for partial infiltration of water on-site, and control discharged water out of the development at pre-development rates to the Oaklands Drain.

LOT MANAGEMENT

In the 10%AEP, the flows will be directed to the on lot storage devices, including those used in the 1EY scenario for treatment. This water is to be stored and infiltrated into the lots fill/insitu soils, where a portion of it may enter the subsoil network for discharge to the road swale network.

ROAD RESERVE MANAGEMENT

As existing drainage lines are not well defined, indicative major drainage lines/swales will be realigned post development. They are to predominately be located along road edges. The major systems will also be incorporated into MUC. Adequate sized swales to carry 10% AEP external inflows in addition with 10% AEP produced from the subject lands roads have been modelled for the currently proposed road layout. These swales vary in size, depending on their need to carry external flows and the size of the internal catchment feeding them. The location of the swales can be seen in Figure 10 and 11 and the swale sizes can be seen in Figure 9.

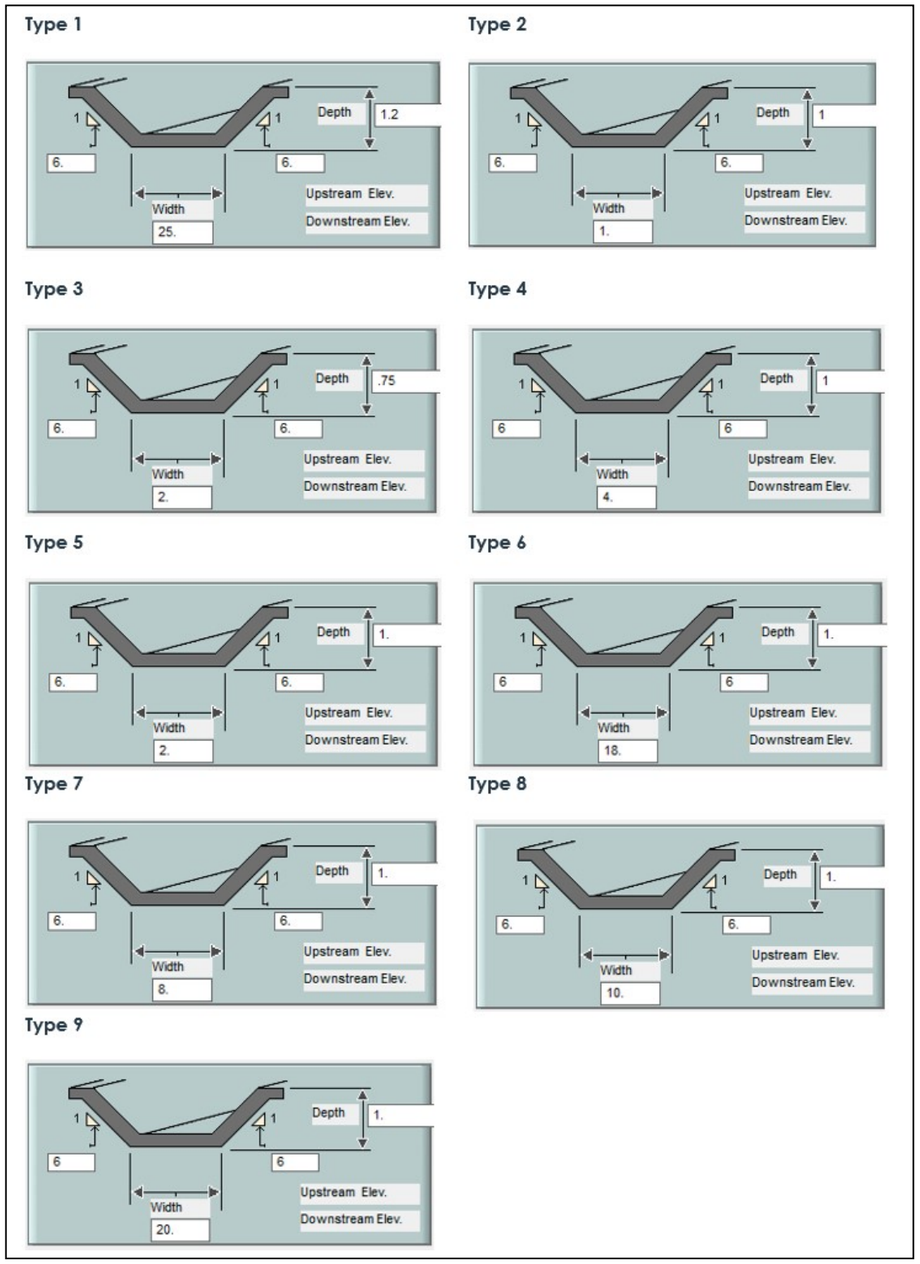
In addition to the lot storage to maintain pre-development flow rates, the modelling also shows the requirement of additional storage for external and internal inflows to maintain pre-development flow rates at the final outlets. Table 6 shows summary of storage requirement to maintain pre-development flow rates which will be refined in later stages of design. This includes the existing pre development storage on the subject land plus the extra generated as part of changing the land use from rural to industrial.

A comparison of the pre and post development modelled flow rates for the 10%AEP can be seen in Table 5.

Stormwater that infiltrates to the groundwater during short term 10% AEP events is likely to only have minimal effect on the flood peak. However, during longer duration storms, especially during peak groundwater level periods, expressions through seepage into the perforated sub-soil pipe system may occur. If expressions do occur, they may extend the period of time that water will continue to move through the sub-soil pipe network. To be conservative, this groundwater seepage effect has been modelled as a 300mm pipe discharge from each subcatchment.

It is not an objective of managing 110%AEP to treat runoff for quality, but the bio retention units and swale vegetation would allow for trapping and settling of suspended sediments, especially after the flood peak has passed. This is due to the slowing of water near the surfaces of the swales from the in-stream and bank vegetation, and the residence time.

Figure 9 Typical cross section of swale types



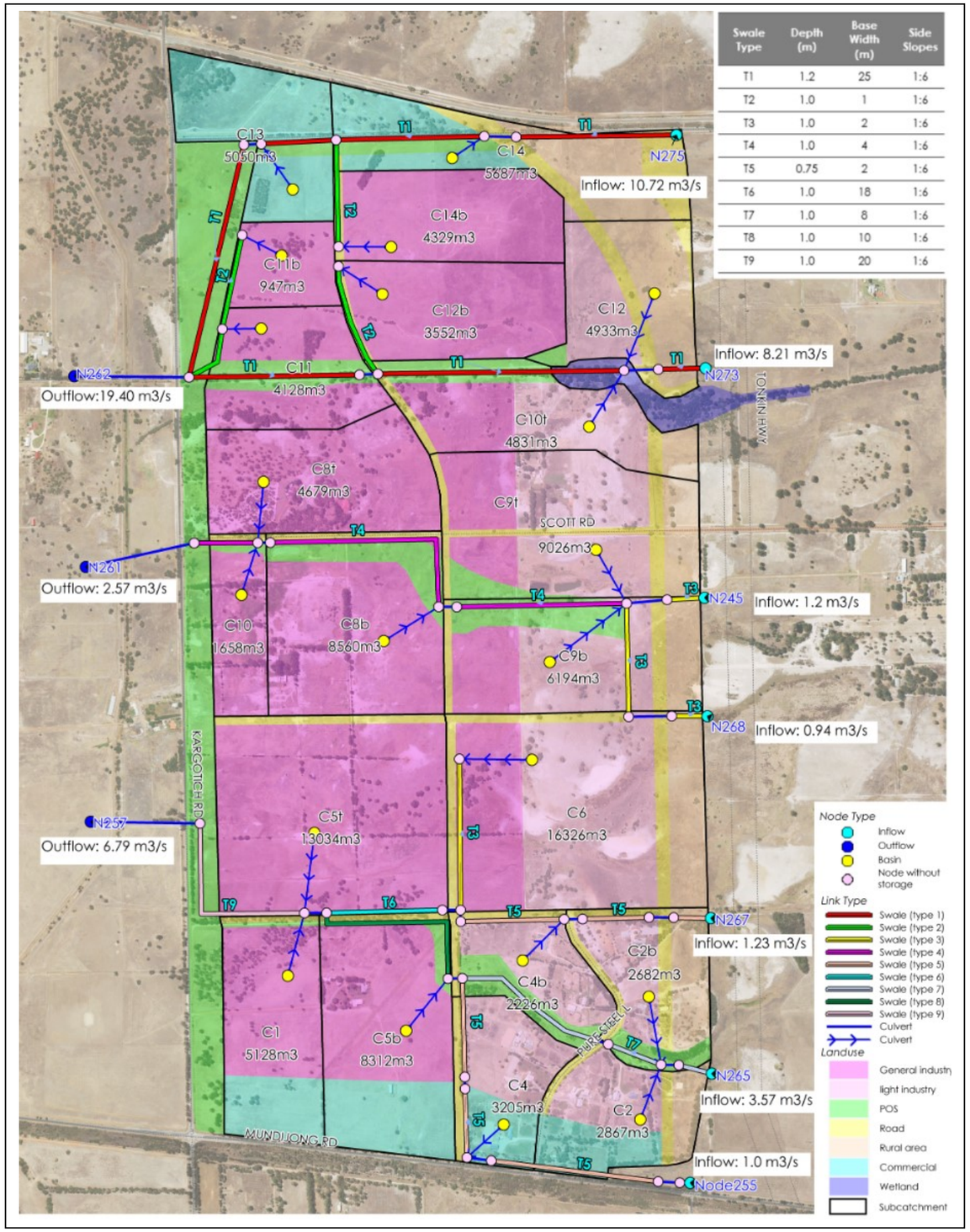


Figure 10 10% AEP Post Development Stormwater Management

9.3 DRAINAGE MANAGEMENT STRATEGY – 1% AEP

The development is to be designed to safely convey the 1%AEP flood so that impacts on infrastructure, and the environment are minimised while also managing people's safety. All road and lots levels are to be designed to maintain a minimum 300mm separation clearance between finished floor levels and the internal 1% AEP flood levels, excluding the major swale network.

For the swale network that incorporate flows from upstream, a minimum 500mm separation clearance will also be required to finished floor levels. This 500mm of separation is also to apply to the flood waters generated by back flooding of the Oakland Drain. .

The 1% AEP's runoff is to predominantly be conveyed via the road reserves and drainage pipes to the swale network and MUC. Here water will fill the swale structure as well as flood out across the surrounding MUC, with potentially some flooding of the adjoining road. Some roads would be expected to partially flood however they should remain serviceable for emergency vehicles.

This network also holds the flood waters so that they are released at predevelopment rates for each of the 3 main catchments. Each swale is controlled by an orifice sized to hold back the flood waters generated. The required storage for each sub catchment to achieve this can be seen in Table 5. A comparison of the pre and post development flows, is shown in Table 5. These storages are all to be achieved prior to the North south green corridor along the western boundary. This is because this green corridor has been set aside to accommodate floodplain storage from Oakland Drain.

This swale network and the MUC/Roads along with the major ecological corridor on the western boundary will assist with holding the required flood plain storage volumes, to minimise downstream flood impacts.

Using DRAINS software, peak runoffs were modelled with the rational method for the critical time of concentration including 1 in 100 years' external inflows. The drainage investigation modelled that utilisation of the 1 in 1 year 1 hour lot storage in addition with 1 in 10 years storage (outlet with 1 in 10 year pre-development) within sub catchments will require additional storage to maintain final outlet to 1 in 100 year pre-development stage. These storage requirements in addition with sub-catchment storage requirement are shown in Figure 11 and Table 7.

Detail analysis of existing capacity of outlets at Kargotich Road, including any potential upgrades is to be carried out in the detail design phase. The trigger will be related to the individual culvert that is affected by development in the corresponding upstream catchment that feed the culvert. This is to include designing a suitable connection from the culvert to the Oakland Drain, that will focus on its sizing and the most appropriate location. The presence of the North South MUC for flood storage provides significant area in which the swale system can be redirected to best line up with landforms and land uses to the west of Kargotich Road.

The northern catchment C13 is to be subject to detailed design to determine the actual final area of development. Should sufficient flood plain storage be achieved south of Bishop Road then the full area may be able to be developed. This is to be determined as part of the relevant UWMP, noting that without detailed analysis the default will be that the current power line easement will the limit of development.

Table 5 Modelled outflows from major catchments

Catchment	Pre-development 10% AEP Outflow	Post-development 10% AEP Outflow	Pre-development 1% AEP Outflow	Post-development 1% AEP Outflow
1	18.47 m^3/s	19.40 m^3/s	36.59 m^3/s	35.56 m^3/s
2	5.23 m^3/s	2.57 m^3/s	8.79 m^3/s	7.12 m^3/s
3	6.99 m^3/s	6.79 m^3/s	16.80 m^3/s	15.91 m^3/s

Table 6 Sub Catchment storage requirements

Sub-Catchment	Sub-Catchment Size (ha)	Storage Volume (m^3)
1	20.06	5,127 m^3
2	15.54	2,866 m^3
2b	16.52	2,682 m^3
4	13.87	3,205 m^3
4b	13.64	2,226 m^3
5b	28.44	8,312 m^3
5t	41.75	13,034 m^3
6	46.31	16,014 m^3
8b	29.30	8,560 m^3
8t	22.16	4,679 m^3
9b	26.81	6,194 m^3
9t	32.78	9,026 m^3
10	9.18	1,658 m^3
10t	21.17	4,831 m^3
11	17.07	4,128 m^3
11b	8.01	947 m^3
12	18.46	4,933 m^3
12b	19.26	3,552 m^3
13	17.06	5,050 m^3
14	23.37	5,687 m^3
14b	18.79	4,329 m^3
TOTAL		**117,352 m^3**

Table 7 Floodplain Storage requirements for Oakland Drain and overall Catchment

Major Catchment	Floodplain Storage within North-South MUC (m^3)
1	191,000
2	59,000
3	125,000

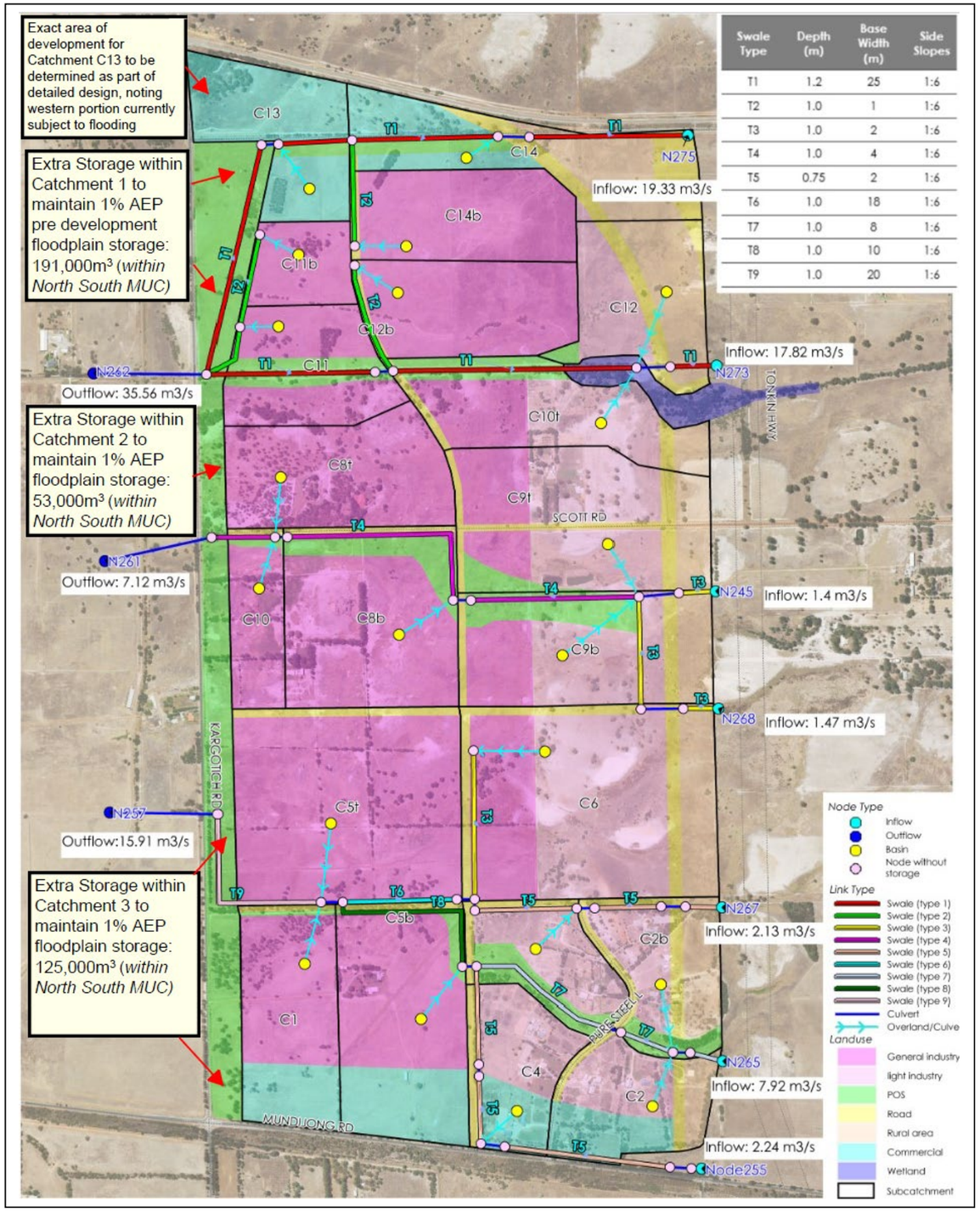


Figure 11 1%AEP Stormwater and Flood Management Plan

10 WATER QUALITY MANAGEMENT

The development will utilise a range of best management practices to manage water quality across the site. The major practice will be the implementation of best practice water sensitive designs to manage stormwater up to 1EY. Most of the other management practices will involve minimising the quantity of nutrients added to the surface and groundwater within the development. The development designs should concentrate on managing practices on lots for effluent disposal and stormwater runoff.

CONSTRUCTION CONTROLS

A key aspect of managing water quality for the development will be implementing suitable management strategies during the construction of the subdivision. At the subdivision stage of development there will be a requirement to prepare and implement erosion and sediment control plans. Management options should also focus on minimising potential pollutants during the construction phase. The management options may include:

- assessment of erosion risks;
- stabilisation of stock piles;
- minimise the exposure times for disturbed areas;
- sediment curtains, fences, and filters at inlets and other control points;
- cut off drains;
- temporary sediment basins;
- stone mattresses; and
- hydro-mulching and interim plantings.

ON-SITE LOT TREATMENT

Individual lot owners will provide attenuation and treatment options for the 1EY runoff. The on-site flows can be detained and treated with a variety of methods including shallow landscaped bioretention basins for hardstand runoff, rainwater tanks for roof runoff and on-site soak wells for areas unlikely to receive polluted runoff.

The most effective method in implementing best practice in industrial precincts is to ensure that pollution sourced from work areas does not discharge into the stormwater infrastructure. Practices that land managers and owners can undertake involve roofing work areas, directing wash-down water to storage or onsite effluent systems, and controlling activities undertaken in areas that link with the stormwater infrastructure. The guiding principles and practices in the construction and management of industrial lots should be an intention to separate areas subject to pollutants and contaminants from paths that would transport water to the stormwater infrastructure. The developer will encourage structural separation, and the local government agencies will be encouraged to ensure elements are included for building application approvals.

Furthermore facilities will be encouraged to be constructed to ensure that contaminated wastewater is separate from uncontaminated wastewater, such as clean stormwater or cooling water, and sewerage.

EDUCATION

Education of employees is very important to ensure that they are knowledgeable about the different systems and potential impacts on the environment that their workplace could have. It is essential for the management of water quality within the subject land that employees are educated on the following:

- The difference between the stormwater and on-site treatment systems for each business;
- Do not sweep or dispose of litter or waste into gutters or drains, and keep the footpath, gutter and outside areas near their business free of litter. This includes providing adequate refuse storage for litter and cigarette butts;
- Where possible, all waste skips and bins should be stored in a designated area with a roof and surrounded by toe walls to prevent any leakage entering the stormwater system;
- Lids on bins and skips should be kept closed to stop loose litter being blown away. This also stops rain getting in which can wash oils, solvents and chemicals out of rags and into the stormwater;
- Spills from loading and unloading operations are a common source of stormwater pollution. Where possible conduct all activities with the potential to pollute water (e.g. loading and unloading, transfer of materials) within roofed and bunded areas or indoors;
- Storage of potential pollutants, including precautions in case of leakages, should be in secured areas. The storage may require roofing, a physical barrier for leaks to leave the storage (e.g. a lip at openings) and possibly a bund if appropriate.
- When moving, pumping, loading or unloading liquids make sure that a spill kit is available for use in case of a spill; and
- How to handle materials to reduce waste and prevent spills.

CONTAMINANT RISK MANAGEMENT

The greatest risk to contamination of the natural environment from the subdivision will be industrial waste which can include petroleum hydrocarbons, heavy metals, surfactants, toxins and/or salts (DoW, 2009b). Details in regards to wastewater management, including contamination risks have been documented in the Section 13 Water Supply & Wastewater Management.

As previously mentioned, structural separation and education will be paramount to minimising the risks of contamination from any of the lots within the subdivision. The Western Australian Business and Environment Manual developed by the WA Chamber of Commerce and Industry and the Centre of Excellence in Cleaner Production provides an online resource. The manual is designed to assist WA businesses to successfully manage their environmental issues together with their business operations. Importantly it provides information relating to environmental legislative requirements and obligations at local, State and Commonwealth level for a range of industry practices.

Statutory requirements, approvals and managing agencies are outlined in environmental guidelines, codes of practice and Water Quality Protection Notes for a range of businesses and activities in Western Australia. Generally the Department of Environment and Conservation, Department of Water and Department of Health are the three major State government agencies involved in waste management and contaminated sites.

Contingency plans and emergency responses should also be developed where appropriate for the industry on the lot. The DoW's WQPN 10: Contaminant Spills – Emergency Response is a useful reference for lot owners.

BIORETENTION GARDENS

At the time of development, bioretention gardens and swales will be constructed within the road reserves of the development. On road systems that don't have an adjoining swale, bioretention gardens are to be constructed and sized to 2% of each equivalent impervious feeding catchment. The bioretention gardens will be designed and constructed according to the latest FAWB Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual for WA design guidelines, and in consultation with the Shire engineers.

The bioretention garden will be planted with appropriate native species, which should only require irrigation during the initial 2 to 3 years of establishment, depending on the seasons. They should require no fertiliser application and irrigation demands should be met by stormwater alone, after this initial establishment period, with possible subsequent watering only in drier years. The gardens will be designed to assist in the removal of nutrients and

sediments from stormwater before the water reaches the groundwater. The indicative design for the gardens composes a filter media of amended soils to 500mm below the surface, with an average particle size of 0.5mm. A plastic root barrier will also be incorporated to provide a vertical separation layer from surrounding soils to assist in maintaining adequate moisture levels for species planted in the gardens and assist with nutrient reduction. The plants will also assist with nutrient absorption because of the surface area provided by their roots for the formation of bio-films and nutrient uptake. Where practical, saturated zones should also be incorporated in the base of the bioretention gardens.

LANDSCAPING

Landscaping within private lots and public areas (including road reserves and drainage reserves) is to have a focus on utilising native species that will require minimal watering and fertiliser application. By implementing this strategy, the landscaping will not contribute to the pollution of the groundwater or surface water generated on the site. Furthermore, by utilising native plants with a high ability to absorb excess nutrients, the landscaping can help remove nutrients within the swale and basin systems, as well as take up nutrients from the groundwater. This can help reduce the overall load of nutrients leaving the site.

MONOTIORING

Pre and post development monitoring of surface and groundwater quality is to be undertaken.

The pre development monitoring will provide a clear picture of the site and the quality of water flowing across the site and through the groundwater. This can be used to set a base line for future monitoring as well as assist with developing any tailored treatment mechanisms to improve the existing and future water quality.

The extent and details of the monitoring programs is dependent on the treatment trains employed throughout the development. Detailed drainage plans for the development will be constructed at the relevant subdivision stage, and from these detailed plans post development surface quality monitoring requirements will be determined in consultation with DWER and the Local Government. It is expected that the surface water quality samples would be required at all dispersal points and typically event based.

The water quality target of 0.1 mg/L for total phosphorus and 1.0 mg/L for total nitrogen will be adopted for monitoring of all water discharged from the development area. These targets have been adopted in the Peel-Harvey water quality improvement plan, and are considered appropriate guidelines for new industrial areas.

Further investigations will be required at each Urban Water Management Plan stages to determine refined monitoring requirements.

11 WATER DEPENDENT ECOSYSTEMS MANAGEMENT

The main water dependent ecosystems (WDE) influenced directly by the development of the subject land are the CC wetland 14945 and the degraded waterways that traverse the subject land. There are also a number of downstream and nearby significant WDE that have the potential to be influenced by water management on the subject land. Stormwater and groundwater will be managed so that the significant WDE areas retain hydrologic regimes comparable to pre-development. The water quality of the flows into these ecosystems will be managed through the treatment of surface and groundwater. Section 10 of this LWMS details the water quality management for the development. Protection of the ecological functions of the receiving natural environments from the development is detailed below, and visually portrayed in Figure 12.

MANJEDAL BROOK – MID NORTHERN ECOLOGICAL LINKAGE,

The Manjedal Brook and its associated Conservation Category wetland will be protected through the use of appropriate buffers and restoration works within the wetland and its associated buffer. Appropriate buffers and works are outlined in more detail in the Wetland Management Report within Appendix B. As a summary, the wetland itself is to be revegetated with understorey species to complement the existing overstorey native vegetation. The surrounding buffer will also be revegetated, with these species grading from riparian species to dryland species as they move up and away from the wetland area. These revegetation works will take place once good weed control has been achieved.

To the north of the wetland, the existing degraded channel may be diverted. This is to assist with brining the channel into the Mid Northern Ecological linkage that is to traverse the unmade Leiopold road reserve. It will also assist with providing a suitable buffer between the main channel and the future industrial development to the north. The indicative realignment can be seen in Figure 13.

Erosion control at key locations within the current main channel is also to be undertaken.

It is proposed that the wetland will be accessible by pedestrians, however general vehicles will be excluded. Appropriate gates systems will be installed to allow for emergency and maintenance vehicles, who's access throughout the site is to be via a perimeter access track. The fence system will also assist with minimising litter entering the wetland.

The length of Manjedal Brook that traverses the site after the recognised Conservation Category wetland area will be enhanced within the MUC along the unmade Leiopold road reserve. As part of this process the waterway will be configured to act as a stable waterway and will be planted out with appropriate native species. This will enhance the ecological functioning of the waterway compared to its current characteristics of being a weedy drain with erosion issues and limited native species. The waterway and surrounding area will be designated as an ecological linkage, providing a corridor from Oakland Drain to the Manjedal Brook system to the east of the subject land.

SOUTHERN AND MIDDLE ECOLOGICAL LINKAGES

To further enhance the ecological connectivity of the district, ecological linkages will be developed to accommodate the 2 main drainage lines to the south of Manjedal Brook. These systems are effectively low flow, ephemeral constructed drains and currently have little ecological functioning. The most southern waterway will keep its current course for its eastern portion, before being realigned along Sparkman Road. The middle drain will be aligned to the future proposed road network, before being aligned to the south of the current Scott Road. This realignment will be composed of a vegetated swale within a MUC. It will be planted and landscaped in a similar fashion to the far northern ecological linkages.

FAR NORTHERN ECOLOGICAL LINKAGE

To further enhance the ecological connectivity of the district, the major drainage swale that is to be constructed along Bishop Road, will also be constructed so that it acts as a riparian ecological linkage. This swale replaces the degraded drain that occurs just to the south of Bishop Road. It will be planted and landscaped in a similar fashion to the southern ecological linkage.

BIORETENTION SYSTEMS

The bioretention systems within road reserves and on private lots will also act as ephemeral wetlands and provide habitat values for fauna, especially avifauna and herpetofauna. This will be due to their use of native species for the plantings and the seasonal nature of their water regime, which will mimic small wetland depressions, commonly see on the Swan Coastal Plain.

GROUNDWATER TREATMENT

Groundwater captured by the subsoil system will be directed to the planted swales. These swales will provide an opportunity for the treatment of groundwater discharged to them. Furthermore, the groundwater will assist with the growth of the plants within the base of the swale, helping to increase the wetland/waterway attributes of the swale system. This treatment of groundwater will also assist with improving the quality of water prior to it leaving the site and entering downstream sensitive environments.

DOWNSTREAM WDE

The downstream WDE's will be protected primarily through the management of water on the site. This will include the release of stormwater at pre development rates up to the 1%AEP. Stormwater and groundwater will also be treated so that the water leaving the site will be of an adequate quality to support the ecological functioning of the downstream ecosystems. See Section 10 for more details on water quality management.

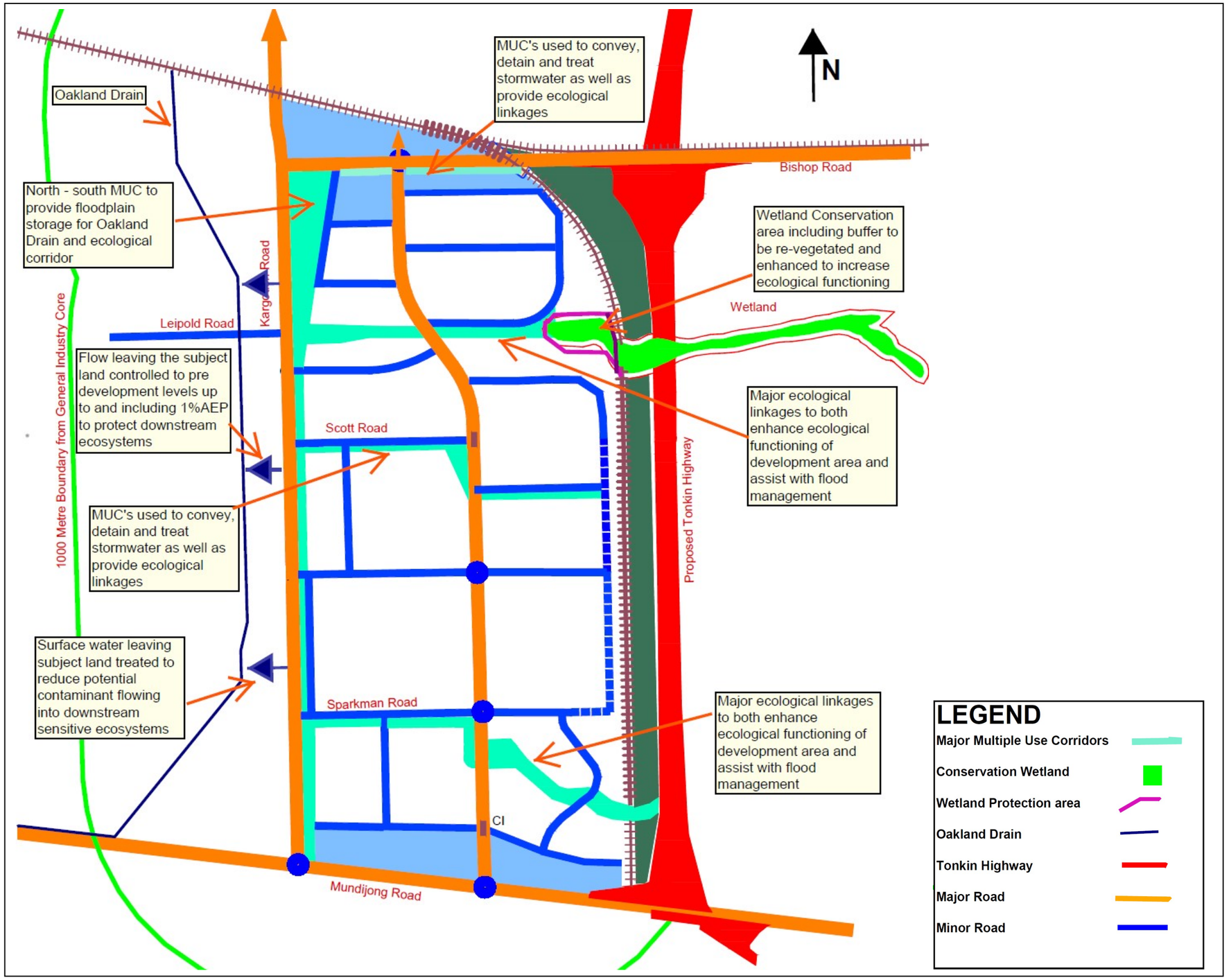


Figure 12 Water Dependent Ecosystem Management

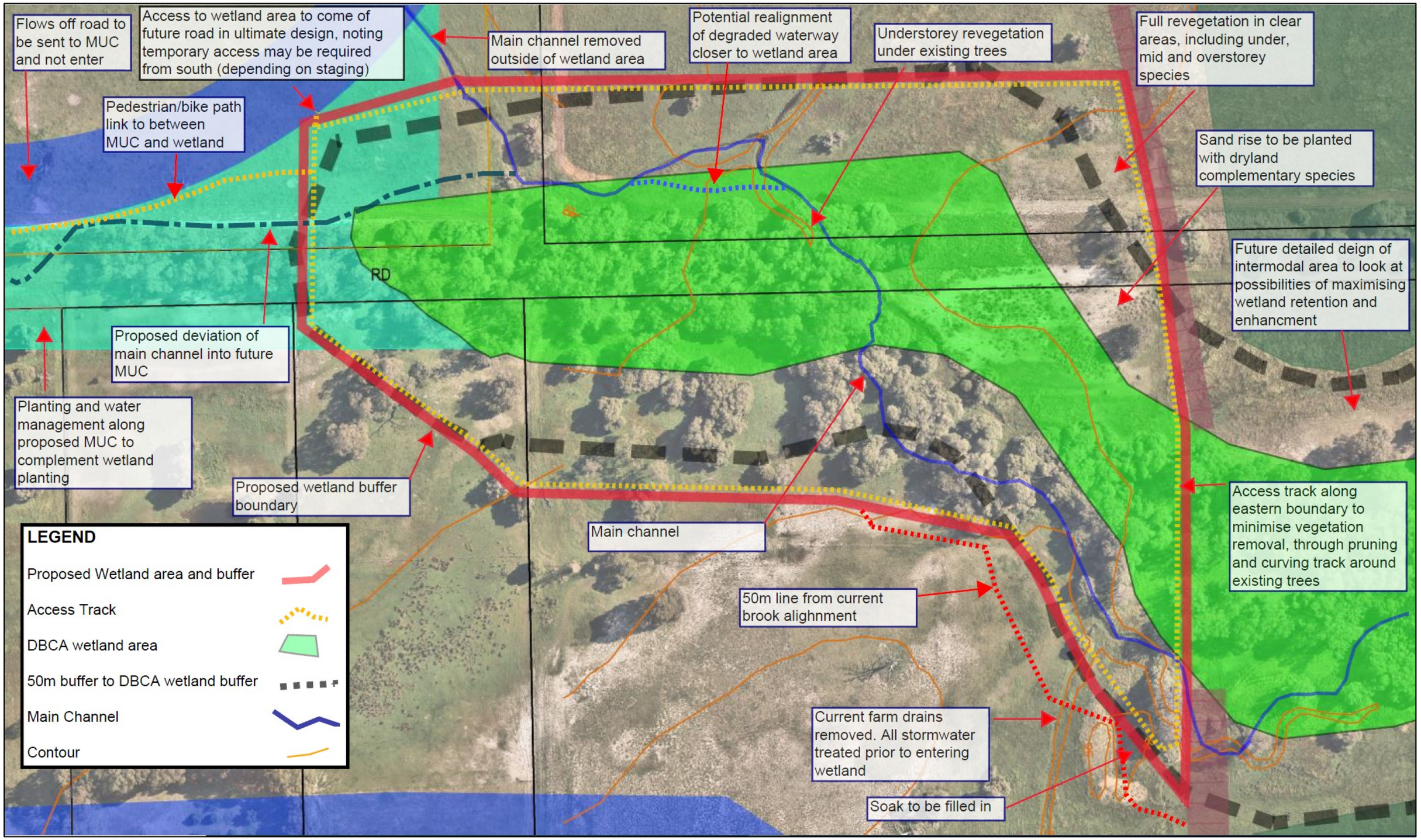


Figure 13 Wetland Management Plan

12 GROUNDWATER MANAGEMENT

The focus of groundwater management for the development area is to maintain groundwater as close as possible to existing average maximum levels, which has been defined as the CGL for the site, while maintaining adequate separation from infrastructure. There may be some modification of groundwater levels within the site; however, the areas that feed the Conservation category wetland on Manjedal Brook will be maintained at levels that support key wetland functions.

Furthermore groundwater will be managed to achieve a high water quality.

Opportunities are also to be explored to utilise excess groundwater within the superficial aquifer that is generated due to the lower evapotranspiration of the site post development.

INFRASTRUCTURE SEPARATION

Appropriate separation between lot levels and the CGL will be achieved across the entire subject land. The separation will be achieved through three main methods: use of porous clean fill where necessary; open swales and sub-soil pipes.

The distance between sub-soil pipes will be determined by the permeability of the soil within that section of the development. Within the proposed 2ha lots, there may be a requirement for both boundary and internal subsoil within each lot, so as to minimise mounding. These subsoil systems are to discharge to the roadside swales and drainage network. The swales and roadside subsoil system will also control groundwater throughout the development area..

The swales will generally be set at the CGL level and will assist in groundwater control. Subsoil drains would also discharge at just above the CGL level to the swales to ensure the subsoils remain free draining between storm events.

With this configuration, mounding of groundwater can be kept to approximately 0.4m

By maintaining the groundwater at a level similar to the current average maximum levels, the development will have minimal impact on the groundwater dependent ecosystems that exist on the subject land. Groundwater will still be fed into the wetland systems and the downstream Oakland Drain.

FILL MINIMISATION

Certain areas of industrial lots require less fill to function without being impacted upon, or adversely impacting the groundwater. These are areas that don't contain significant infrastructure such as buildings or soakwells. These areas of lower fill requirements include, parking areas, laydown areas and general vehicle movement areas. The drainage basin areas are also able to utilise less fill, provided they are designed to have their bases close to the groundwater and are near a subsoil network. By being close to the groundwater, the basins can actually function similar to an ephemeral wetland.

The building envelopes should require a maximum of 1.0m of fill/separation to the groundwater. The surrounding lot area may only require 0.3m of fill above the maximum groundwater mound (in the middle of the lot). For the spacing of subsoils suggested, this equates to an average fill height of 0.7m (assuming the groundwater is traditionally at the pre development soil surface). On the edges of the lot, the depth to groundwater will be less, tending to be closer to 0.6m -0.7m. These are the areas where stormwater basins/soakwells and buildings etc should preferentially be located.

Porous clean fill will be used where necessary to achieve the required separation. Any fill of imported sands will require compaction to relevant standards. The sand fill will be required to have a high permeability to allow water to easily infiltrate down and into the original soil layer.

A diagrammatic representation of a typical 2 hectare industrial lot, with the boundary subsoil network can be seen in Figure 14. Internal subsoil layouts are to be determined as part of the UWMP and Building Application.

LOWERING OF GROUNDWATER LEVELS

Lowering of groundwater to below the existing annual maximum level can assist with minimising fill. This may be an option for areas away from significant natural environments such as the Manjedal Brook and associated wetlands.

The risk of Acid Sulphate Soils will need to be carefully considered as well, although if the levels are only slightly reduced below the maximum and don't impact the minimum levels, then there is unlikely to be significant impact on both the production of ASS and the mobilisation of acidic groundwater and pollutants mobilised by the increase in acidity. The potential to lower groundwater levels will be limited on the subject land, due to the flat nature of much of the land and the invert of the existing drainage points, which currently control groundwater discharge when it is at its peak. This discharge is controlled by the existing on site drains and the swale drain along the boundary roads.

Due to these limitations, the calculations of fill required for the site have assumed that the AAMGL will be very similar to the post development CGL. The CGL has been assumed to be at the natural surface of the site. As detailed design is undertaken, there may be opportunities for localised lowering of the groundwater to a small degree in the order of 200-300mm.

QUALITY MANAGEMENT

Groundwater quality will be improved through the use of soil amendment products incorporated into the development's bioretention systems. This will provide treatment of all surface water runoff collected within the drainage network prior to infiltration into the groundwater. These products bind nutrients and other contaminants that are mobile within water infiltrating from the surface. Groundwater entering the swale network will also receive treatment as it traverses along it.

ASS MANAGEMENT

Subject to further investigation, the impacts of any actual ASS or potential ASS would be integrated with the works on the site through a detailed ASS Management Plan. These will be undertaken on a needs basis as part of subdivision. Deep sewers are the most likely activity to disturb ASS if any are present on the site. The current 2ha development will not include reticulated sewer, minimis ethe ASS disturbance risk. Vacuum or pressure sewer systems may be used to avoid this issue as part of future subdivision to smaller lots, subject to future detailed design. It is not expected that ASS issues will occur on-site that conventional methods cannot adequately manage.

MONITORING

Pre and post development monitoring of groundwater levels and quality will be undertaken. The extent and details of the monitoring programs is dependent on the extent and depth of fill required across the development, and any other intrusions of the development on the groundwater management. Detailed earthwork and engineering plans for the development will be constructed at the relevant subdivision stages, and from these detailed plans post development groundwater levels and quality monitoring requirements will be determined in consultation with DWER and the Shire.

Monitoring of the groundwater's quality at the sub-soil discharge points and selected bores will suffice for post-development quality monitoring

PUMPING AND REUSE OF GROUNDWATER

Pumping of the superficial groundwater for potential reuse is assumed to not impact the peak groundwater level as the system may fail during critical periods of heavy rain. It may however provide an option for generally keeping the groundwater down. It can also provide a water source for use within the subject land or nearby. This usage is detailed in Section 13.

13 WATER SUPPLY & WASTEWATER MANAGEMENT

13.1 WATER SUPPLY

STANDARD MAINS POTABLE

The Water Corporation has advised that potable water may be accessed from Mundijong town site. There may be limited capacity for some industrial processing. This source may be able to supply the early stages of development.

The Serpentine trunk main is located approximately 1 kilometre to the west of the investigation area (Refer Figure 9). This may be accessed for potable water to source the subject land, subject to approvals from the Water Corporation. Another possibility is establishing an elevated reservoir on the scarp to supply the greater area. As part of the elevated reservoir option, it is expected that a distribution main will extend to the site with reticulation connections servicing the development. It is also likely that this distribution main will connect into the existing Mundijong network to reinforce its water supply plus service. There will be significant capital expenses related to the supply of the area with larger volumes of standard potable water. Alternative options are therefore proposed below to assist with the early small scale stages of development.

ALTERNATIVE WATER SUPPLY

Stormwater

There is the potential to harvest storm water for processing. This water could potentially be used for industrial uses and non potable uses within each lot.

Rainwater

There is likely to be significant areas of impervious roof catchment throughout the subject land. This represents an opportunity to harvest and reuse relatively clean water on a lot by lot basis.

Due to the higher quality of this water, there is the potential to investigate the option of aquifer recharge.

Treated recycled Wastewater

As part of producing the DWMS liaison was undertaken with the Water Corporation. At this point in time the Corporation is not proposing to construct a wastewater treatment facility within the site, or for that matter anywhere in the locality in the near future. that would allow for water to be treated to a level where it could be reused on site.. The Corporation has also stated that relative to other industry, industry at West Mundijong is unlikely to generate significant demand for processing water, especially as 2ha dry industry lots. On this basis it is unlikely that a business case could be developed and supported for installation of infrastructure to enable re-use of treated wastewater at Mundijong

Subject to further feasibility, individual lots may still be able to treat their on lot wastewater for reuse. This will be on a lot by lot basis.

Groundwater

There is the possibility to utilise groundwater resources from both shallow and deeper aquifers located under the subject land. These will be subject to licences granted through DWER and will relate to the allocations available at the time.

Within the superficial aquifer there is potential to harvest the increase volume of groundwater that is often generated by development of land from agricultural to industrial. This extra water is due to the potential for increase infiltration and reduced evapotranspiration, leading to a build up of water stored within the soil profile. This can be further enhanced through the use of fill which increases the level of available storage height prior to running off the land. This extra groundwater can be harvested through pumping and/or subsoil drainage piping. This water may be able to harvested during peak groundwater flow periods (late winter to early spring), either for immediate use of storage.

A secure storage system would need to be developed in conjunction with this option. Further investigation will be needed as part of the relevant UWMP, should a particular development area want to undertake this process. The extraction may also require a groundwater licence for using the superficial aquifer groundwater.

Managed Aquifer Recharge System

A Managed Aquifer Recharge System may be a viable option to store clean water from the subject land for later use within the development or in nearby areas. One options is to collect excess roof runoff and inject this into an appropriate deeper aquifer. This would also assist with controlling excessive groundwater rise within the superficial aquifer, by reducing the volume of water being infiltrated on site. The disperse nature of the 2ha lot configuration means that at this point in time that any proposal would be on a lot by lot basis.

Rainwater would require treatment prior to DWER agreed standards prior to injection into an aquifer. The comparatively clean quality of roof rainwater may make this a viable source. The economics of the treatment may however mean that at a lot by lot basis, that tank storage is more viable.

Other sources may also be viable for aquifer injection but are likely to require further treatment to minimise the risk of polluting the chosen aquifer.

A detailed investigation will need to be undertaken into the viability and details of this option. The study should adhere to the Managed Aquifer Recharge Policy developed by DWER.

13.2 WASTEWATER

MAINS SEWER

Currently, the subject land is not connected to deep sewerage.

There Scott Street wastewater pumping station location is to the east of the subject land. Advice to date is that this will not take water from the subject land. Should this change in the future, it is likely the area required for the pumping station and its buffer may increase. The plant would also be uphill of the subject land, requiring pumping of effluent to this point.

This wastewater is to be sent from Mundijong to the East Rockingham wastewater treatment plant.

The future wastewater planning, when lots are subdivided below 2ha, will need to consider the types and flow rates of wastewater that will be generated from the industrial area and the suitability of these for discharge to the Water Corporation’s wastewater system. Some industries may require their wastewater to be pre treated prior to discharging to the Water Corporation system. Should an agricultural food precinct be developed, there is likely to be a demand for a wastewater system that can accommodate high flows.

ON SITE TREATMENT AND DISPOSAL

The 2ha development option that is being used to inform this LWMS allows for on site effluent disposal to be undertaken for dry industries. The high groundwater within the subject land needs to be taken into account as part of each lot’s on site disposal.

The onsite treatment and disposal is to be in keeping with the requirements of 2019 Government Sewage Policy by the Department of Health (DoH) and DWER's Water Quality Protection Note (WQPN) 51 – Industrial Wastewater Management and Disposal.

This is to include a Site and Soil Evaluation of each development area as part of the subdivision process.

As a summary, the on site effluent disposal systems are to be:

- appropriate systems for the site fill and existing soils;
- requirement for installation to be a minimum of 5m from foundations;
- located so that there is no mobilisation of nutrients or other contaminants into subsoil systems;
- A minimum of 100m from drains and waterways
- Appropriate for the volume and quality of the water being treated, as well as taking into account likely future expansions.

The onsite disposal systems will require careful design to ensure all objectives are met.

GREYWATER RE-USE SCHEMES

The greatest potential for grey water reuse on this site is at the individual lot level. With appropriately designed on-site effluent treatment systems, the treated effluent may possibly be reused on each lot's landscaped areas or other fit for purpose uses. The feasibility of this option should be undertaken at the building licence stage and on a lot by lot basis.

REGULATIONS

Any of the above schemes where non-drinking water is used will need to comply with the Guideline for the approval of non-drinking water systems in Western Australia, by DWER.

The schemes will also need to comply with the Australian Guidelines for Water Recycling where relevant.

There may also be the need for a licensed operator depending on the characteristics of the scheme, such as schemes that cross lot boundaries. This may include having the scheme approved through the Economic Regulation Authority.

Approval by other relevant authorities which may include DoH, DWER, DBCA and the Local Government Authority, may also be required.

These aspects should be further refined as part of the UWMP's developed for each section of the subject land.

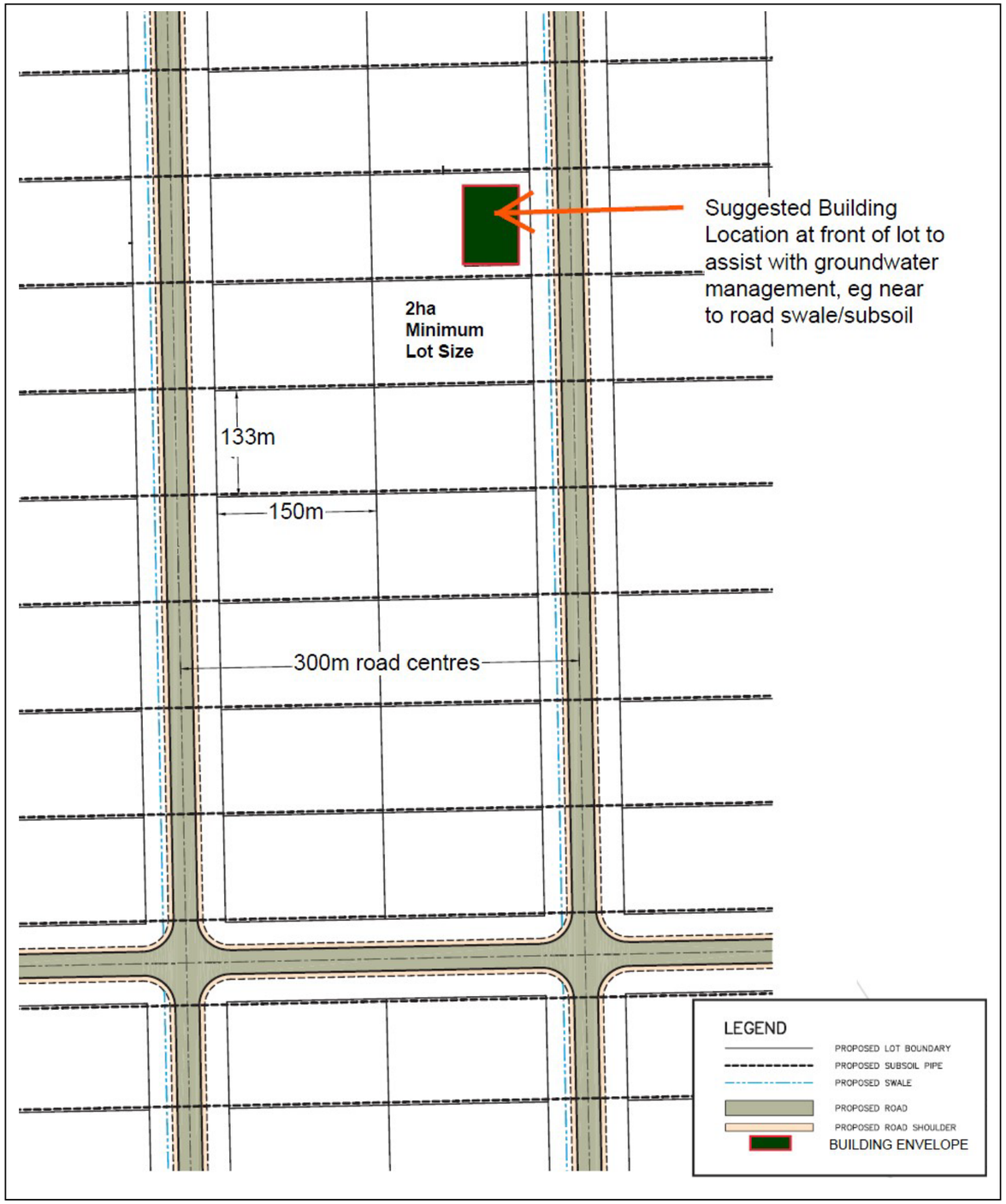


Figure 14 Typical subsoil and swale alignment to control groundwater

14 WATER CONSERVATION

According to the State Water Plan of 2007 by the Western Australian government 16% of the state's total water consumption in 2005 was by the commercial and industry sector. The Plan did not set a goal for this sector, unlike the 100kL objective per person set for residential areas.

The state government of Western Australia does however require all businesses that use more than 20,000kL of scheme water per year to participate in the Water Corporation's Waterwise Business Program. This Program involves:

- Undertaking a water management assessment annually with the Water Corporation;
- Developing a 5 yearly Water Efficiency Management Plan (WEMP); and
- Annual review of WEMPs and reporting the progress against the water savings action plan.

These are requirements are under the Water Agencies (Water Restrictions) By-laws 1998 and are mandatory. The WEMP involves the preparation and implementation of water consumption targets over a 5 year period. The business has to monitor water usage throughout each year of the plan, and a report is to be submitted to the Water Corporation annually.

There is an opportunity as part of this process to develop ways to manage, recycle and conserve water within individual businesses and even sectors of the industrial park.

EDUCATION AND AWARENESS

Business owners are be encouraged to promote water efficient behaviour amongst employees through awareness raising material and opportunities. Possible measures to encourage water efficient behaviour may be:

- Installing signs at all water using fixtures;
- Installing shower timers to encourage shorter showers where these facilities are provided;
- User education for dishwashers, washing machines and glass washers to ensure there is a full load, where these are provided;
- Include water conservation practices in staff or tenant inductions;
- Ensure water conservation or management is continually brought up at meetings;
- Promote their businesses water-saving initiatives or outcomes within the local community;
- Encourage employees to identify water-saving measures; and
- Offer an incentive scheme to encourage water-saving innovations and ideas.

Further details are to be developed in the relevant UWMP's

RAINWATER TANKS

Businesses are to be encouraged to install rainwater tanks, with a level controlled air gap, to reduce the quantity of water consumption from the water mains. The water may be used for a variety of fit for purpose uses, related to the industry and feasible treatment levels.

A suitable tank size should be determined according to the roof area of the buildings on a lot and the water usage practices and applications by the business.

ONSITE INFILTRATION and STORMWATER DISCHARGE

The sites stormwater that is directed to the bioretention gardens and swales, as well as the water infiltrated to the groundwater will assist with providing irrigation to the sites landscaping. The use of this water for direct and indirect irrigation of these plants offsets the need for other water sources to be used to provide irrigation of the subject lands landscaping plant.

WATERWISE LANDSCAPING

Natural rainfall alone should be sufficient to maintain Waterwise landscaped areas once established. Front of lot landscaping and street reserve landscaping is to be composed of waterwise plantings suited to the local environment.

Details on appropriate species and areas of planting/landscaping are to be established as part of future planning for the site and reflected in the UWMP.

The source of water for any landscape irrigation is also to be outlined in the UWMP, noting that there is no proposed longterm landscape irrigation proposed on the road reserves and MUC.. The landscaped areas of lots, as well as the MUC could potentially be watered from groundwater, treated wastewater, harvested stormwater or rainwater.

15 IMPLEMENTATION FRAMEWORK & MONITORING

15.1 PRE-DEVELOPMENT

GROUNDWATER

Pre-development monitoring for the subject land will need to include a minimum of 2 years of groundwater levels and quality. The focus for the monitoring is to determine the maximum and minimum levels of groundwater throughout the year and general quality. These results are to be compared against more regional data produced by DWER and surround developments. Each UWMP area is to undertake its own groundwater monitoring, unless it can prove that the data collected at nearby locations is sufficient.

The indicative minimum locations for sampling are shown in Figure 15. These bores should be a minimum of 3m below the surface. There may be some modification of the exact locations, depending on how each UWMP is undertaken.

The quality parameters should include the following:

Physical

Electrical Conductivity (EC), pH, salinity, temperature and Alkalinity.

Chemical

Nitrate (as NO3), Ammonia (as N), Total Nitrogen, Total Phosphorous, Filterable Reactive Phosphorous (P), and metals (Al, As, Cd, Cr, Cu, Fe, Mn, Pb, Zn).

SURFACE WATER

Monitoring of quality within the main waterways that traverse then land is recommended. This should happen for a minimum of 2 year prior to development, with a focus on the period that the waterways are flowing. At least 2 samples per site should be collected each year. Samples are to be collected at the point at which the waterways enter and exit the subject land. The indicative locations for sampling are shown in Figure 15.

The tested parameters should include:

Physical

Electrical Conductivity (EC), pH, Dissolved Oxygen (DO), salinity, temperature, Oxygen Replacement Potential (ORP) turbidity, total suspended solids and Alkalinity.

Chemical

Nitrate (as NO3), Ammonia (as N), Total Nitrogen, Total Phosphorous, Filterable Reactive Phosphorous (P), and metals (Al, As, Cd, Cr, Cu, Fe, Mn, Pb, Zn).

WETLAND

A Detailed Management Plan should be produced for the Conservation Category wetland 14945. This is to include information on the current condition so be used a base for post development monitoring. The assessment should include indicative hydro regimes, flora present, vegetation complexes, weed issues and likely fauna habitat. As part of the surface water and groundwater monitoring regimes, sampling points are to be set up so that they can provide data on the hydro regimes for the wetland.

15.2 CONSTRUCTION PHASE

Installation of drainage control structures is to occur ahead of the construction phase of the development. This will include the use of water sensitive design techniques such as sediment curtains, hydro-mulching and temporary detention basins to maintain the quality of the water leaving the development area during construction. The collection pits will be monitored for any damage, including sediment build up and litter accumulation during, and at the completion of, construction to ensure the pit's effectiveness is not diminished post-development.

All contractors working on any future development of the site will be made aware of their responsibilities under the Aboriginal Heritage Act 1972 with regard to finding potential archaeological sites. In the event that a potential site is discovered, all work in the area will cease and the DIA should be contacted.

15.3 POST-DEVELOPMENT

WSUD INFRASTRUCTURE

Routine monitoring within the development area that checks the status of key functional WSUD elements is to be undertaken to ensure they meet specified design requirements. This will include:

- ensuring the inlet and outlet structures are free of debris;
- vegetative cover of the systems is maintained;
- sediment build up is not impeding the functionality;
- erosion is not present;
- soils are not compacted;
- litter is removed; and
- hydrocarbons are not present in the system.

Monitoring of the established WSUD elements operations can provide important insights on the likely performance of them in pollution reduction and stormwater management functionality. Inspection of the WSUD elements will be undertaken by the developer until an agreed upon time between developers and the Shire. The indicative timeframe is for 2 years after the completion of works with inspections every three months. This is to be reviewed as part of each UWMP. Table 8 summaries the particular items to monitor and the purpose of monitoring, the trigger signs that require immediate action and the maintenance action required.

Compared to traditional engineered structures for stormwater runoff management, the WSUD elements will only require minimal routine maintenance many of these related to a landscaping and ecological corridor maintenance nature. The most common maintenance is the removal of weeds, debris and siltation. The most time intensive period of maintenance for a vegetated WSUD system is during plant establishment (which typically includes two growing seasons), when supplementary watering, plant replacement and weeding may be required.

It is recommended that vegetated WSUD elements are monitored by personnel with floristic knowledge and/or qualifications, as they will be capable of identifying evasive species within the natively vegetated WSUD systems. Furthermore, personnel in charge of monitoring should have a good understanding of principles and the functional design of the WSUD elements and the treatment system. The maintenance activities prompted through monitoring activities will generally require coordination between landscape and civil services.

The WSUD elements will be constructed and utilised in different stages so that the functions of the WSUD elements are protected from elevated pollutant loads generated from a developing catchment.

Maintenance inspections should be scheduled to be conducted after a significant storm event. Inspections should focus on ponding time for the different systems, unequal surface flow distribution, sedimentation and scouring, as well as deposition of coarse litter.

Performance monitoring of WSUD elements via detailed water sampling and testing for contaminant concentrations has not been scheduled at this stage. The exact parameters and monitoring schedule is to be further detailed in the LWMS and subsequent UWMP for the site.

GROUNDWATER

Groundwater monitoring may be required post development to determine that the development is not impacting on nearby significant wetlands through changes in levels or poor water quality. The exact parameters and monitoring regime will be determined by the final land uses. For this reason, further details on post development monitoring are to be developed as part of the UWMP.

SURFACE WATER

Surface water monitoring may be required post development to determine that the development is not impacting detrimentally on the surface water quality leaving the site. Sampling points should be set up at the discharge points form the subject land or on site significant wetlands. These should be checked against established guidelines and the quality of water entering the site from upstream. The exact parameters and monitoring regime will be determined by the final land uses. For this reason, further details on post development monitoring are to be developed as part of the UWMP.

WETLAND

The monitoring of the wetland is to be related to the rehabilitation works and the monitoring of water resources above. A Detailed Wetland Management Plan will outline the appropriate monitoring regime. This should be done at the UWMP. Preliminary concepts are outlined in the Attached Wetland Management Report (Appendix B).

15.4 RESPONSIBILITY AND REPORTING

The developers of the land will be fully responsible for the monitoring and reporting of all aspects listed above. Advice should be sort from the DWER, DBCA and Shire on exact parameters and regimes.

All information collected from monitoring programs, should be recorded and provided in an agreed format, prepared by the developer, to the relevant authority. If a trigger value for a contingency action is reached, a more detailed report on the occurrence, its impact and proposed action to prevent recurrence is to be compiled by the developer and submitted to the relevant authority.

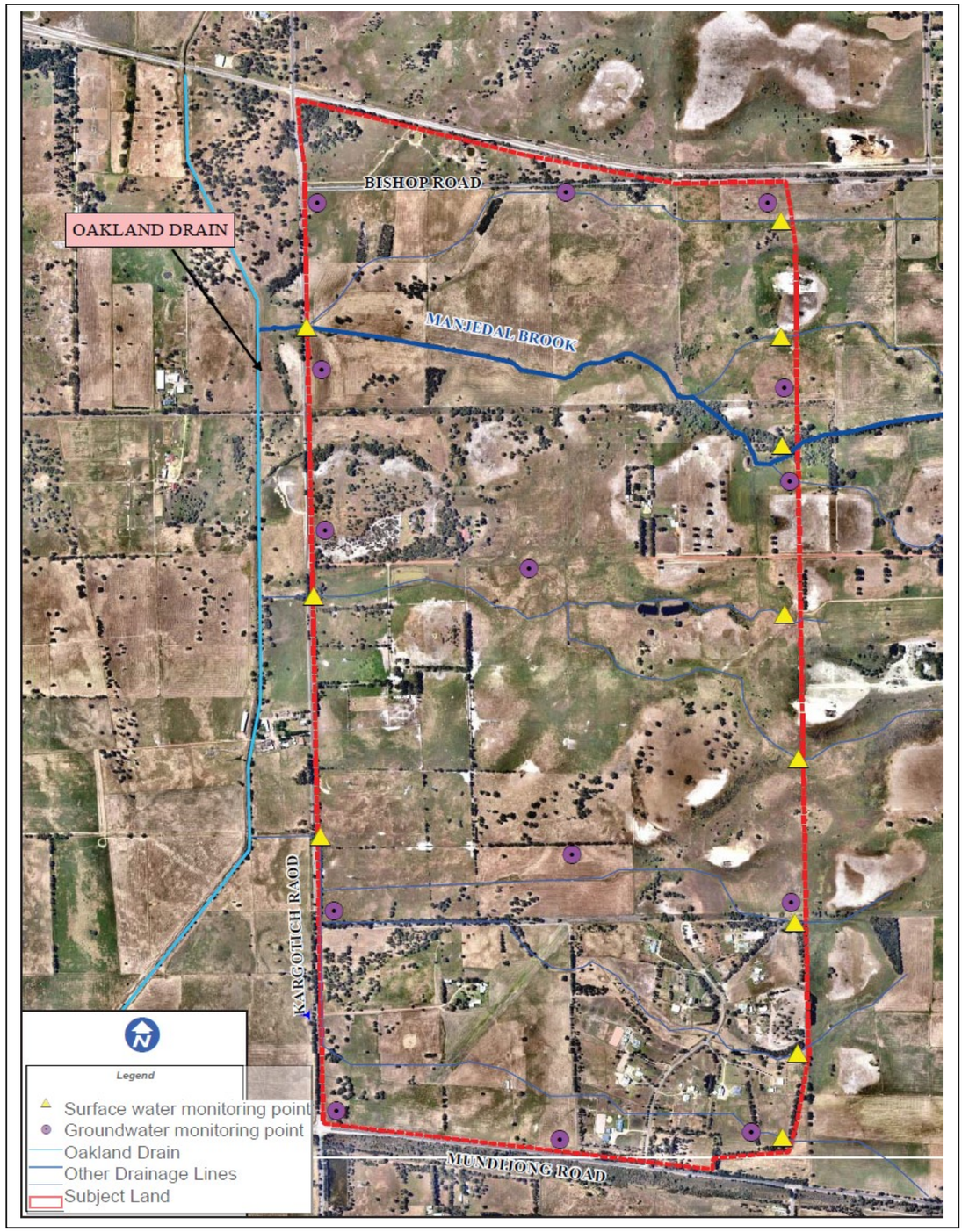


Figure 15 Indicative monitoring points

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsibility
PRE-DEVELOPMENT						
Groundwater	Quality	To determine pre-development quality to assist with setting base lines for the subject land.	NA	NA	Minimum of two samples a year for 2 years	Developer
	Levels	To determine pre-development levels to assist with setting AAMGL for the subject land.	NA	NA	Monthly sampling over 'winter' period, 3 monthly over summer. Minimum of 2 winterss.	Developer
Surface Water	Quality	To determine pre-development quality to assist with setting base lines for the subject land.	NA	NA	Minimum of two samples a year for 2 years	Developer
CONSTRUCTION PHASE & POST-DEVELOPMENT (more details on this section to be provided in UWMP)						
Groundwater	Quality	To determine post-development quality to assist with determining if site is meeting guidelines.	Values siginificantly outside recommended guidelines	Determine cause and rectify	Minimum of two samples a year for 2 years	Developer
	Levels	To determine post-development levelsy to assist with determining if site is meeting guidelines.	Values siginificantly outside recommended guidelines	Determine cause and rectify	Monthly sampling over 'winter' period, 3 monthly over summer. Minimum of 2 winters.	Developer
Drainage Management Systems	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to the City/Shire
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Every 3 months	Developer until handover to the City/Shire
	Sediment and Silt Build Up	Inspection for sediment and silt accumulation within pits, on the surface of bioretention systems and within basins.	Accumulation of large volumes of sediments and/or silts in pits or on the surface (according to City standards).	Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed.	Every 3 months	Developer until handover to the City/Shire
	Compaction	Inspection of filter media for compaction.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without any compaction. If extensive seek expert advice.	Every 3 months	Developer until handover to the City/Shire
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Every 3 months	Developer until handover to the City/Shire
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Every 3 months	Developer until handover to the City/Shire
	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, e.g. alter landscaping maintenance practices, community education). Remove litter.	Every 3 months	Developer until handover to the City/Shire
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Every 3 months	Developer until handover to the City/Shire
	Oil/Hydrocarbons	Inspection for the occurrence of oil on surface.	Oil coverage persists for more than 3 weeks, and is thick.	Notify the EPA of the spill and clean up requirements.	Every 3 months	Developer until handover to the City/Shire
	Surface Water Quality	Sampling of water quality (TSS, TN & TP) at discharge (outlet) points.	0.1mg/L for TP and 1.0mg/L for TN.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination. More detailed assessments may be required.	Every 3 months	Developer
POST-DEVELOPMENT ONLY						
Water Conservation	Water Consumption	Review and report on WEMP to the Water Corporation.	Determined by WEMP and Water Corporation.	Determined by WEMP and Water Corporation.	Yearly	Business Owners
Groundwater	Quality	To determine post-development quality and testing to be done at sub-soil discharge points.	0.1mg/L for TP and 1.0mg/L for TN.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination.	Minimum of two samples a year	Developer
	Levels	Monitoring required to sub-soil drainage system is operating as designed.	Levels exceeding controlled groundwater level.	Undertake appropriate responses to address the issue.	Monthly sampling over 'winter' period.	Developer (agreed handover)

Table 8 Monitoring and Maintenance

16 RECOMMENDATIONS FOR FUTURE STUDIES

For future development of the land past the Structure Planning stage the following additional studies may be required to support the subsequent UWMP's;

- ASS investigation
- Detailed Wetland Management Plan
- Detailed Earthworks and Services Strategies
- Alternative water supply and treatment options
- Managed Aquifer Recharge assessment (as relevant)
- Detailed Drainage Design

17 REFERENCES

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Appendix AWEST MUNDIJONG INDUSRIAL MODELLING REPORT

Appendix BWEST MUNDIJONG WETLAND MANAGEMENT REPORT

APPENDIX C GROUNDWATER ANALYSIS SUMMARY

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West Mundijong Industrial Area

WEST MUNDIJONG INDUSTRIAL AREA WETLAND MANAGEMENT REPORT

PREPARED FOR SHIRE OF SERPENTINE JARRAHDALE

B20013 | 29 October 2020

Oversby Consulting Pty Ltd
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DOCUMENT CONTROL

ISSUE	DATE	ISSUE DETAILS	AUTHOR
1	29 October 2020	Submission for Client Review	BCO
2	24 November 2020	Updated version with Client comments	BCO

TABLE OF CONTENTS

Appendix A - Figures

1 INTRODUCTION

This Wetland Management Plan (WMP) has been prepared to support the Local Structure Plan prepared for the Conservation Category wetland located in the north east of the West Mundijong Industrial area.

This report is in accordance with the Department of Water and Environmental Regulation (DWER) (previously Department of Environment and Conservation, DEC) Guidelines checklist for preparing a wetland management plan (DEC, 2008). It has been prepared in consultation with relevant stakeholders including officers from the Shire of Serpentine Jarrahdale.

The report outlines restoration and management tasks to be undertaken in regard to the wetland areas and associated buffers to protect the wetland, provide an overall improvement in the ecological value of the wetland areas, and a functional buffer between wetlands and adjacent land uses.

2 TENURE, LANDOWNERSHIP AND MANAGEMENT ORDERS

The Manjedal Brook wetland, that falls within the Structure Plan area is on Lot 8 and 402 Scott Road and Lots 5 and 1680 Bishop Road as well as the unmade Leipold Road Reserve. It extends east into Lot 403 Scot Road, which is designated as the future Tonkin Hwy road reserve.

The wetland extends further eastward from the subject land up the Manjedal Brook

3 ZONING AND LANDUSE

The retained wetland area zoned Industrial in the MRS. The wetland area, with a 50m buffer, has been set aside as an Ecological Corridor as part of the District Structure Planning Process.

On the eastern boundary, the zoning has remained as Rural, however this is likely to be changed as part of detailed design for the rail corridor. The Tonkin Hwy is zoned as a Primary Road.

4 WETLAND HISTORY

The Manjedal Brook Wetland was originally a semi defined and braided waterway, with wetland characteristics. Much of the buffering native vegetation has been removed for agricultural purposes and grazing has removed the majority of the native vegetation closer to the brook. Soaks have been created along the edge of the wetland area and low level farm crossings have also bee constructed to assist with farm machinery and stock movement.

Anecdotal accounts from the current longterm landholder suggests that flows through the waterway have reduced over the last 30 years, most likely due to a combination of a drying climate and upstream damming/water use.

4.1 CULTURAL HERITAGE

4.1.1 INDIGENOUS HERITAGE

A search of the DPLH Aboriginal Heritage Inquiry System indicates no Registered Aboriginal Sites or Other Heritage Places within the wetland area. A registered site (181817) is located approximately 200mm to the south on a small sand rise.

4.1.2 NON-INDIGENOUS HERITAGE

Manjedal Brook is shown as being surveyed by the Heritage Council (P8482) with it being listed as not needing further assessment and having no Statutory Heritage Listing.

5 SITE CHARACTERISTICS

5.1 OVERALL STRUCTURE PLAN AREA

The land subject to structure planning is approximately 474 hectares (ha) in area. The subject land is bounded by Mundijong Road (south), Tonkin Highway Road reserve (east), Bishop Road (north) and Kargotich Road (west). The land is approximately 1.5km west of the existing Mundijong town site. A location plan for the site is provided in Figure 1.

The subject land has a number of minor water courses that either traverse or begin on the site. This includes waterways that begin on the scarp to the east. All water leaving the site via the surface, flows under Kargotich Road and into Oakland's drain, which flows southward. Around 80% of the site is considered a Paluasplain Multiple Use wetland (Number 15785).

The majority of the site has been cleared and is composed of pastures. The remaining native vegetation on the site is degraded. It is usually composed of native overstorey species with none or limited native understorey.

Historically the land has been used for broad acre agricultural purposes, and currently is used for livestock grazing purposes. There are a number of dwellings on the subject land, especially in the rural residential section in the south east corner.

The future Tonkin Highway and Kwinana freight rail line are located along the eastern boundary. This area may also include an intermodal area.

5.2 WETLAND MANAGEMENT AREA

A small section of one of the waterways (Manjedal Brook) is considered a Paluasplain Conservation Category wetland (reference number 14945). This is located on the eastern boundary of the site, in the northern half of the site. For the purposes of this report this wetland will be referred to as the Manjedal Brook wetland. The location can be seen in Figure 1, 2 and 3. It is also surrounded by a Multiple Use wetland.

The wetland area that is the subject of this report is limited to the Conservation Categorey Wetland area to the west of the rail corridor shown in Figure 1. This is to be referred to as the Retained Wetland.

The remaining wetland areas within the subject area is assumed to be developed as part of the transport corridors of the rail line and Tonkin Highway, as well as the intermodal area joining these 2 corridors.

5.2.1 EXISTING NATURAL ENVIRONMENT

Climate

The subject area is within a temperate Mediterranean climate of cool wet winters and hot dry summers. Average rainfall is approximately 830mm, since 1975, with annual evaporation around 2080.

The effect of this climate, in conjunction with its terrain, means that there is a yearly seasonal rise in groundwater during winter and early spring. There is also likely to be more flow in through the brook during the winter/spring period. Sporadic flows may also occur during summer storm activity during warmer months

Geology, geomorphology and soils

The superficial formations over the subject land consist predominately of Pinjarra System alluvial soils overlaid with aeolian Bassendean System sands. The Manjedale Brook itself sits within the Pinjarra soil type, however it is likely that it is receiving groundwater flows from the small Bassendean sand rises that occur directly to the south. This is supported by the 2 soaks created at the point where the Bassendean low dues end, near the brook.

Alluvium sediments associated with the brook are also likely, however there was little evidence of non Pinjarra soils being located within the Manjedal Brook Wetland area.

Surface Water Hydrology and channel attributes

The Manjedal Brook Wetland sits within Oakland Drain Catchment. The Brook starts on the Scarp before winding across the flatter Pinjarra Plains. The Brook generally flows westward across the subject land and discharges across the western boundary at Kargotich road. It enters the Oakland Drain approximately 100m to the west of the subject land.

The peak flows of the Manjedal Brook as it enters the subject land are approximately 1.83m3/s for the 10% AEP and 4.1m3/s in the 1% AEP event. Modelling also shows the wetland inundated by flood waters approximately 0.25m or less during these flows.

For most of the wetland area, there is a single drainage channel. This is generally 2 – 3.5m wide and varies from 500mm to 1.2m deep approximately. Small shallow side channels appear in the eastern third of the Manjedal Brook Wetland area. These channels are approximately half the depth of the main channel and 2/3rds of the width. These can be seen in Photos 1-3. There are also small areas of cemented coffee rock in this area which forms small riffle areas. These can be seen in Photo 4 and 5.

Photo 1: Main Channel

Photo2: *Side Channel*

Photo 3: Side channel

Photo 4: Dry side channel with coffee rock base

Photo 5: Main channel with coffee rock riffle

Photo 6: Main channel with coffee rock riffle

Approximately half way up the channel, a cemented crossing has been created. This has minimal impact on most flows, as the concrete is close to the base of the channel. The channel location can be seen in Figure 2 and Photo 7 below.

Photo 7: Shallow concrete crossing

Some erosion control has been undertaken on the outward bends of the main channel. This is a combination of metal sheeting and metal fence posts, as can be seen in Photo 8.

Photo 8: Erosion control using metal sheeting and metal fence posts.

There is also a small soak on the edge of the wetland. This is on the edge of the main channel and is fed by groundwater. It is not directly connected to the main channel, but may receive some water into it during flows that overtop the main

channel bank. Two minor farm drains flow into the south side of the wetland area, where they join with the main channel. The soak can be seen in Photo 9 and the drain in Photo 10. Both can also be located on Figure 2..

Photo 9: Soak with channel behind (under tree line)

Photo 10: Minor farm drain.

Vegetation and flora

The subject land is within the Southwest Botanical Province within the Swan Coastal Plain Bioregion and is dominated by vegetation of the Pinjarra Plain and Bassendean System. Most of the native vegetation however has been cleared.

The Manjedal Brook Wetland contains some overstorey native vegetation and is generally classified as *Melaleuca rhaphiophylla* (Paperbark) Woodland over pasture grasses.

Site inspection in July and September 2020 provided a more detailed assessment of the flora present in the wetland and immediate surrounds. As summary of this inspection is found below and visually represented in Figure 2

The overstorey vegetation was predominately *M. rhaphiophylla, with isolated Eucalyptus rudis* (Flooded Gum) trees present in the core of the wetland area. There was also isolated *Juncus subsecundus* plants. The photo below is typical of the wetland area.

Photo 11:Typical wetland vegetation complex near channel

Photo 12: Typical wetland vegetation complex near channel

Further out there was also some isolated *Melaleuca pressiana* and *Corymbia callophylla* trees, within the paddocks. There was also isolated patches of *Juncus pallidus*.


;

Photo 13: Typical pasture with Cape tulip and scattered M. pressiana

Photo 14: Typical pasture with scattered C. calophylla

The understorey was predominately pasture and weed species. These included

- Cape Tulip
- Cape Weed
- Arum Lily
- Cotton Bush
- Annual introduced grasses eg rye grass
- African Lovegrass
- Kikuyu
- Soursob
- Wild onion

There was also woody weeds present, with those being isolated fig and poplar trees.

Fauna

The fauna habitat on site is likely to be best suited to generalist species, given its degraded nature.

There may be some movement of wetland/waterway dependant fauna across the site too, given the linear nature of the degraded vegetation liking to other areas of vegetation offsite.

A detailed fauna assessment has not been undertaken.

Disease and animal impacts

Other than typical diseases and pest attacks of *E. rudis*, there was no noticeable other significant diseases. Grazing by stock has affected the understorey plant mix and is limiting seedling recruitment. There is some limited trunk damage due to stock rubbing.

5.2.2 ACCESS

Currently the site is used for general grazing. There is no fencing to control stock access to the wetland area when they are within the adjoining pasture areas. Property boundary fences are present. There is no evidence of public access.

6 MANAGEMENT STRATEGIES

6.1 SUMMARY OF MANAGEMENT COMMITMENTS

The purpose of the WMP is to ensure the conservation and protection of the wetlands for ecological benefit while also complementing the surrounding landuses. This includes the following objectives:

- Protecting and enhancing native vegetation in the wetland;
- Protecting and enhancing the fauna habitat values of the area;
- Maintaining the existing hydrology of the wetland;
- Maintaining/improving the water quality within the wetland and in the groundwater;
- Controlling invasive weeds in the wetland;
- Managing stormwater quality and flow from the surrounding industrial areas, prior to the water entering the wetland and buffer
- Rehabilitating degraded areas to enhance the ecological functioning of the wetland;
- Providing wetland buffers that will protect the wetland;
- Providing appropriate levels of public access in and around the wetland buffers to enable community interaction with the environment whilst maintaining wetland values; and
- Managing construction impacts on the wetland.
- Managing the interface with the rail corridor

6.2 GENERAL MANAGEMENT CONSIDERATION

The wetland that is the subject of this report has remained unmanaged for some time in relation to enhancing the ecological attributes and functioning. Preparation and implementation of the WMP provides an opportunity to undertake management activities and enhance the environmental values of this wetland area and associated buffers.

The general recommended management actions are designed to protect and enhance the wetland area to be retained. These management actions assume that the wetland area from the Kwinana Freight Rail line east will eventually be completely developed. For this reason, the management actions relate to the area to the west of the rail line. This area is termed the Retained Wetland.

As well as the Retained wetland area, a 50m buffer is generally proposed around the wetland (excluding the eastern boundary). This area also generally has Palusplain characteristics, except for the areas of low sand rise.

Due to the shape of the 50m buffer (as per Figure 4), some areas have been squared off to facilitate future boundary alignments and lot useability. The likely buffer area can also be seen in Figure 4. The final buffer are is to be determined as part of the detailed design during subdivision of this portion of land.

On the western boundary, the wetland and buffer merge into the east west Multiple Use Corridor. This area will still be managed primarily for wetland management protection.

Some of the management strategies designed to enhance the wetland and its surround are shown visually in Figure 4. Further details are also outlined below.

6.3 ECOLOGICAL LINKAGES

The Retained Wetland forms part of the area set aside as an East-West Ecological Linkage across the proposed industrial area. This linkage makes use of the remnant vegetation within the unmade Leipold Road Reserve. Having a wider area of revegetation and enhancement within the Retained Wetland and buffer area, will assist with providing a refuge habitat within this Linkage. It is noted that much of the wetland characteristics are likely to be lost from the rail line east across to the far side of the Tonkin Highway. As part of the detailed design of this section, it is recommended that large culverts be utilised to allow for fauna movement. This includes culverts that sit above the average winter water level, so as to allow for terrestrial fauna movement (while also assisting with flood flows). If possible, an open vegetated channel should be kept/created within the intermodal area, as this will greatly assist with fauna movement, compared to the entire section being piped.

6.4 WEED CONTROL

All declared weeds and woody weeds within the Remaining Wetland and Buffer are to be controlled so that none remain at the end of the Maintenance period (assumed to be 3 years after Practical Completion of implementation works is achieved).

Other weeds are to be controlled so that they have minimal impact on the revegetation and functioning of the wetland and buffer area. All non-declared weeds should be kept to less than 5% cover for the duration of the Implementation and Maintenance period.

The management authority after handover should continue to mange weeds to minimise their impact on the wetland and buffer areas.

It is proposed a weed management program be implemented as part of the subdivision process of the localised area. This would include physical and chemical control methods, depending on the weeds species. All weed control is to be done in such a way that the chemical and physical impacts are not detrimental to the wetlands health and functioning. All care should be taken to avoid any remnant understorey species and tree samplings in weed control works which could be potentially protected and retained. While the application of glyphosate based herbicide will effectively control the majority of weeds present in the WMP area, there are some weed species present which may require more specific control actions

6.5 REVEGETATION

The wetland area is to be revegetated with appropriate native species. For much of the wetland area, this will consist of planting predominately understorey species, due to the currently native overstory. In areas devoid of a native overstorey, a full suite of wetland species should be planted.

Erosion control planting will be undertaken on the main and side channel banks, using appropriate sedges and rushes. This is to provide habitat and minimise future erosion of the channel.

In the buffer areas, the species will grade from wetland plants to dryland plants as the conditions change. Much of the buffer area is devoid of native vegetation, so a full suite of understorey, mid storey and overstorey species will be planted. The bare areas should be ripped to 0.4m deep where ever possible.

Planting densities will generally be 1 plant/m2, increasing to 3-4 sedges/rushes/m2 in the wetter areas.

Revegetation is to be undertaken after the weed burden is reduced to a manageable level and at least 12 months after weed control is initiated. An indicative species list has been provided in Table 1. This is to be refined as part of detailed design. The site should be weed free prior to planting.

The ground should also be ripped outside the drip line of any native trees. Under existing native overstorey hand augering can be used to assist with planting.

Table 1: Indicative Wetland Species List

Species	Growth Form
Wetland Wet Areas	
Understorey	
Baumea juncea	Rush / sedge
Baumea preissii	Rush / sedge
Juncus pallidus	Rush / sedge
Juncus subsecundus	Rush / sedge
Lepidosperma longitudinale	Rush / sedge
Mid Storey	
Melaleuca lateritia	Shrub
Melaleuca preissiana	Tree
Melaleuca rhaphiophylla	Tree
Melaleuca viminea	Shrub
Hakea varia	Shrub
Taxandria linearifolia	Shrub
Overstorey	
Eucalyptus rudis	Tree
Corymbia calophylla	Tree
Casuarina obesa	Tree

Table 2: Dry buffer indicative species list

Species	Growth Form
Dry Buffer Areas	
Understorey	
Acacia pulchella	Shrub
Acacia stenoptera	Shrub
Kennedia prostrata	Groundcover
Dianella revoluta	Herb
Mid Storey	
Viminaria juncea	Shrub
Kunzea glabrescens	Shrub
Melaleuca viminea	Shrub
Jacksonia furcellata	Shrub
Beaufortia purpurea	Shrub
Calothamnus quadrifidus	Shrub
Acacia saligna	Shrub
Hakea sp	Shrub
Banksia sp	Shrub
Kingia australis	Shrub like
Overstorey	
Corymbia calophylla	Tree

6.6 CLEARING OF VEGETATION

There is to generally be no clearing of native vegetation within the wetland and buffer area. There may be a requirement to undertake some judicious clearing along the eastern boundary to allow for the firebreak and maintenance track. This is to be kept to a minimum and where possible, involve trimming rather than removal of the existing trees.

6.7 STORMWATER MANAGEMENT

All stormwater treatment and detention from flows generated within the surrounding development will occur outside of the wetland area and buffer. After treatment all flows up to the 10% AEP will be released into the wetland at predevelopment rates. The wetland and buffer will form part of the 1% flood storage, in a similar vein to what it does now.

6.8 GROUNDWATER MANAGEMENT

Groundwater will continue to be fed to the wetland. The sand fill proposed for the development will act similar to the currently occurring sand dunes that adjoin the wetland and buffer area. The subsoil pipe network will control potential groundwater rise, sending water to the planted swale network for treatment. Here it will join with the stormwater flows, before flowing to the wetland.

6.9 DISTURBANCE OF ACID SULPHATE SOILS

The Department of Water and Environment Regulation (DWER) ASS risk mapping indicates that the site is located in an area having moderate to low to moderate risk of ASS occurrence. The disturbance of ground in this area is likely to be minimal. Should any excavation be required, then appropriate ASS management should be undertaken to reduce potential risks.

6.10 EROSION CONTROL

There are some localised areas of minor erosion along the main channel. This is predominately due to undercutting on the outer bends of the channel. The landowner has previously addressed this with metal sheeting and metal fence posts. This material is to be removed. To control the erosion, appropriate sized rocks along the base and worst areas should be placed so as to deflect flows away from the bare soil banks. Sedges and rushes should be planed between the rocks to allow for long term stabilisation. In areas less prone to erosion, pinned jute matting with sedge and rush planting is appropriate to allows for short-term and long-term erosion control.

6.11 FILLING OF SOAKS

For public safety and mosquito control, it is recommended that the soaks are filled. They should be back filled with the spoil that has been left alongside them, and revegetated over. This will take away the potential drowning risk as well as reducing the non flowing water area where mosquitos may breed.

6.12 IMPACT ON NATIVE FAUNA

It is recommended that a fauna relocation program be implemented prior to site works on areas outside of the wetland and buffer to minimise direct impact on fauna. Should the wetland enhancement program be well underway, it may be possible to transfer some fauna toe the wetland area.

6.13 INTRODUCTION OF DISEASE AND PATHOGENS

Soil borne pathogens, dieback (Phytophthora cinnamomi) and honey fungus (Armillaria luteobubalina) have the potential to significantly alter the structure of vegetation communities, causing the death of habitat trees and, in the case of Phytophthora, eradicating susceptible species. No evidence of these pathogens are present on site, as such no specific management measures are proposed other than monitoring of overall vegetation health.

6.14 CHEMICAL AND FERTILISER USE

Turf and introduced plant species should not be installed in the wetland buffers or adjoining MUC areas. Planting within the MUC areas should utilise native species to minimise water and nutrient requirements as well as the potential for wees. It will also enhance the ecological linkage of the area.
There is to be no application of fertilisers within Remnant Wetland and buffer areas

6.15 MANAGEMENT OF RUBBISH AT SITE

Formalisation of the wetland by way of establishing the reserve areas and installing appropriate fencing and gates will assist with reducing rubbish entering the wetland and buffer. This includes along the rail corridor
Mesh fencing to 1.8m along the industrial lot boundary will assist with reducing windblown rubbish. Having the entire area restricted to non maintenance and emergency vehicles will assist with reducing the possibility of illegal dumping. The fence a gate network is to be installed as early as possible in the subdivision/development process and prior to the general public being able to access the area.

The vegetated swales will also trap rubbish prior to entering the wetland area

6.16 FIRE

A Bushfire Management Plan will need to be prepared as part of future detailed design. A fire management track is to be created around the outside of the wetland buffer. This is to be 6m wide clear area with a 3m wide limestone or similar surface within it. This fire track will also assist with maintenance access to the wetland.
Control of perennial grasses and weeds will also reduce the fire hazard.

Depending on the sensitivity of the surrounding land use, there may be a requirement to utilise lower height species towards the edge of the buffer. This will assist with reducing potential fire impacts offsite, while still providing ecological habitat around the wetland. The need for this is to be determined as part of future detailed design.

6.17 COMMUNITY USE AND ACCESS

The Retained Wetland area and buffer is unlikely to have a public adjoining road. An access road for maintenance is likely to come off the industrial road to the north. This can also be designed to allow access by pedestrian and cyclists, while excluding motorbikes and other motorised vehicles. The access road will link to the fire access track to allow for a loop track. The access will also link to the adjoining Multiple Use Corridor, facilitating pedestrian and riding movement.

Fencing is to also be designed to minimise undesirable access. Locked gates will be used from the northern road, allowing access for maintenance and emergency vehicles only. The boundary to industrial lots is to be standard industrial mesh fences to a minimum of 1.8m high, with no access gates to the wetland.

6.18 REALIGNMENT OF DEGRADED CHANNEL

To facilitate a better outcome with joining the wetland to the future Multiple Use Corridor, some minor realignment of the main channel to the north of the wetland area is proposed. The realignment is to include appropriate native planting, rock riffling and other elements so that the channel is a stable. It is also to be created to enhance the ecological functioning of the waterway and the surrounding wetland areas. The exact alignment and shape is to be determined as part of detailed design.

7 FUTURE WORKS

7.1 DETAILED WETLAND MANAGEMENT PLAN

A full Wetland Management Plan should be undertaken as part of the subdivision of the lots in which the wetland and buffer occur. It is to be done as part of the first adjoining development. It will provide more detailed information in relation to the implementation works required as well as an updated on the condition of the wetland and surrounding areas. Measurable targets are also to be included, to outline the steps to the successful to maintain and enhance the wetland and buffer area. These will be incorporated into a Maintenance Schedule so that targets can be regularly reviewed and acted upon as necessary.

7.2 IMPLEMENTATION TIMING

Implementation of the wetland management works is to occur in parallel with the industrial development of the surrounding area. The development will likely occur in stages and the recommended works as detailed on this report be undertaken at the time of the first adjacent industrial development.

7.3 REVIEW

The recommendations in the WMP have been devised for restoration activities to be undertaken and guide the ongoing future management of the wetlands. It may be that a review of some of the recommendations is required over time, in light of monitoring performance from previous stages.

A review of ongoing progress of wetland management works is to be assessed annually by a qualified professional for a period of three years following the completion of residential development. Following this, the appropriate authority (most likely the Shire of Serpentine Jarrahdale will resume responsibility of on-going management and maintenance requirements.

The wetland management may also be modified, depending on the final configuration of the proposed intermodal area and the potential to retain some wetland attributes in this portion.

Appendix A Figures

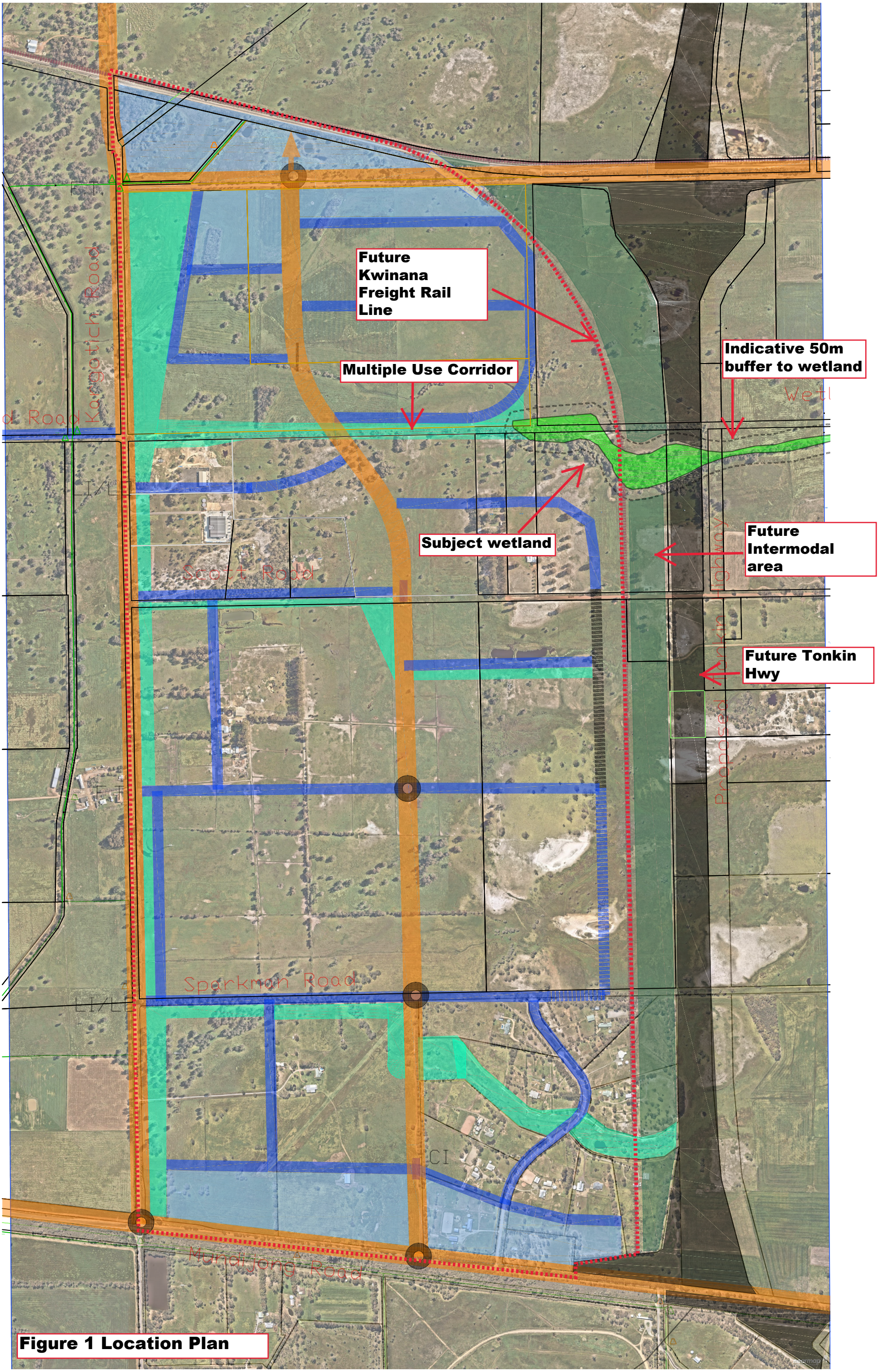

Figure 1 Location Plan

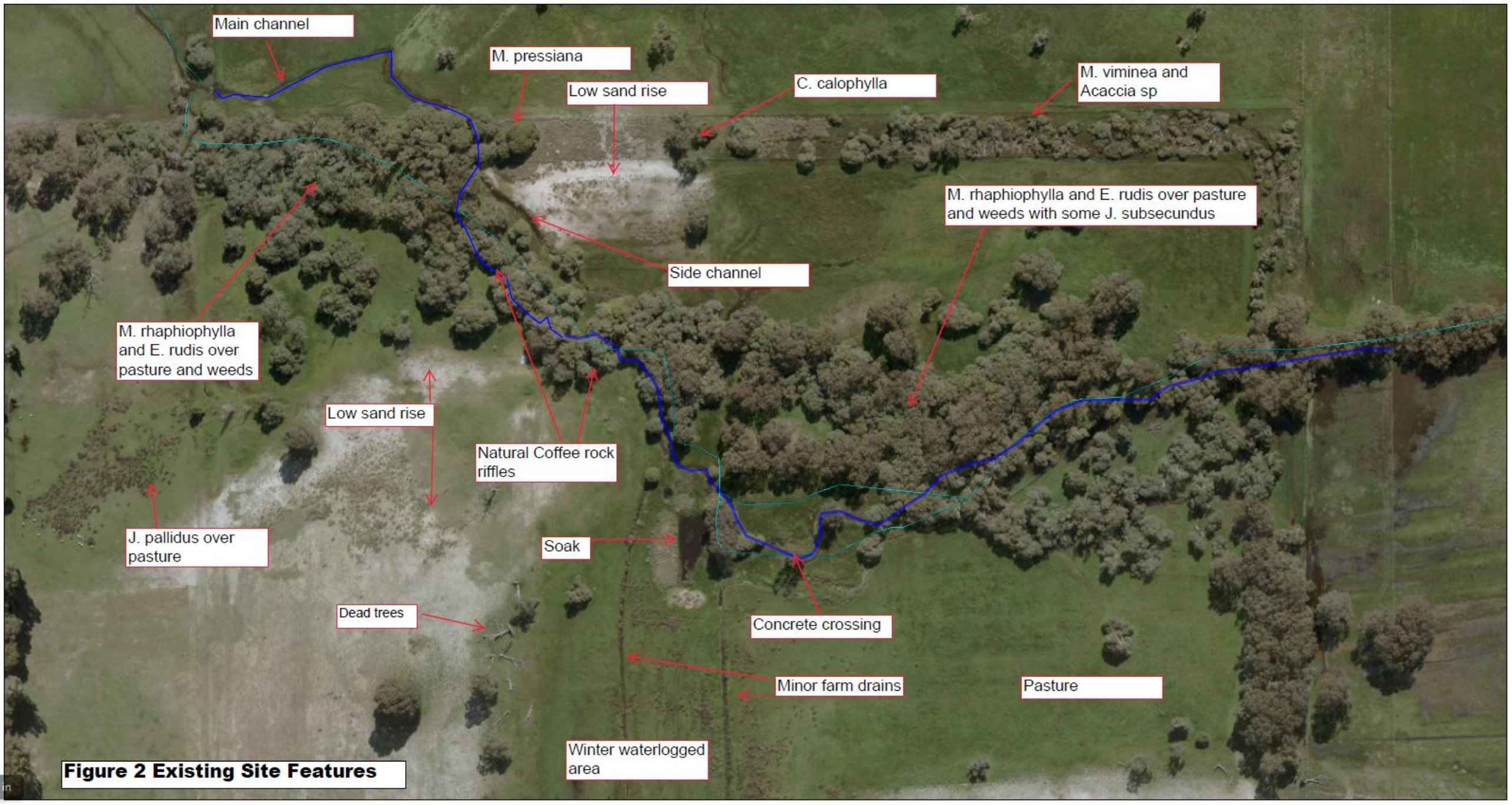

Figure 2 Existing Site Features

Figure 3: Wetland Categorys

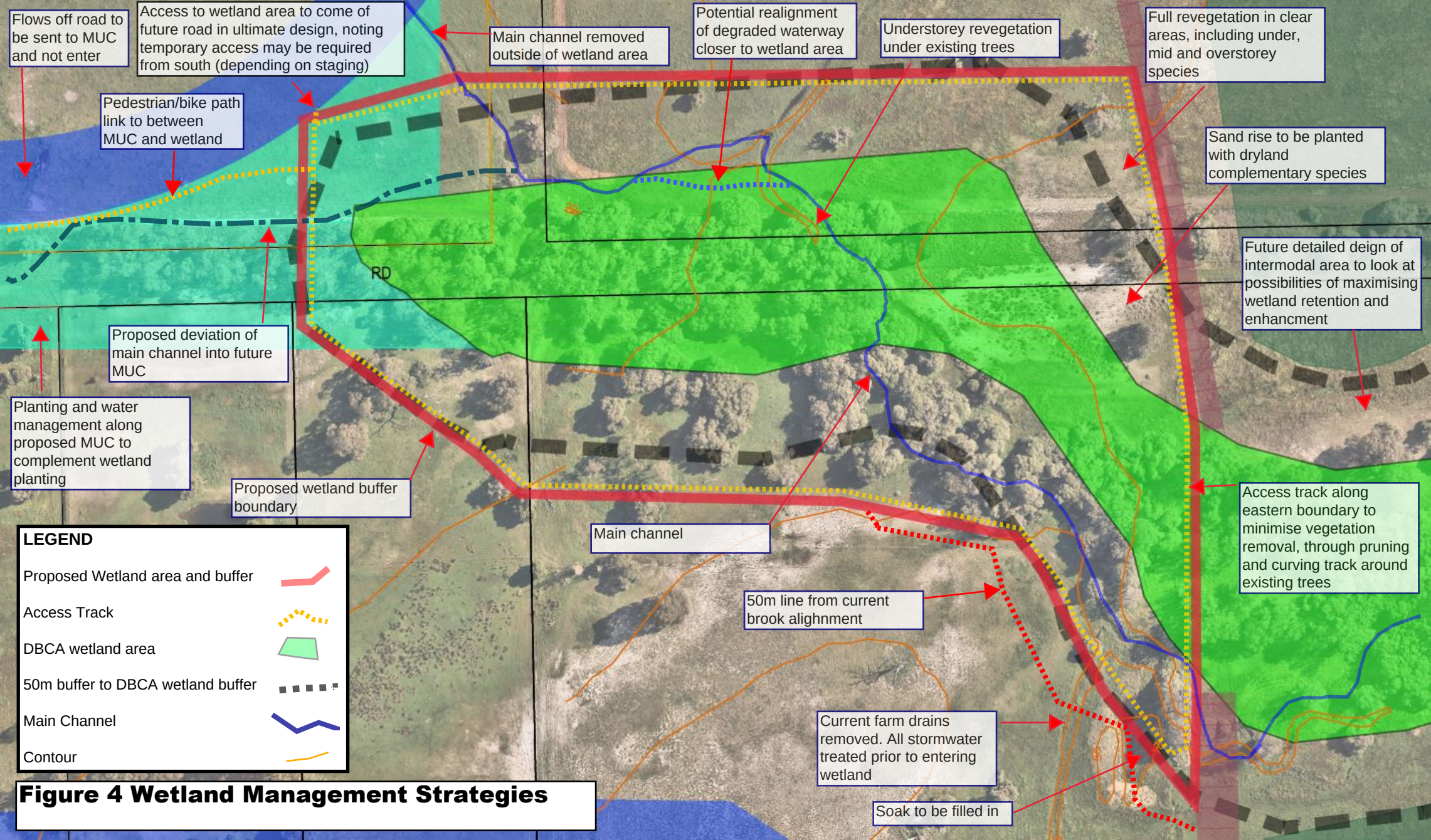

Figure 4 Wetland Management Strategies

Contact Details

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APPENDIX D

Traffic Impact Statement

Technical Memorandum

Title	**West Mundijong Structure Plan** **Strategic Traffic Advice**		
Client	TME Town Planning Management Engineering Pty Ltd	**Project No**	CEP02161
Date	07/11/2012	**Status**	Version 1
Author	Elaine Chan	**Discipline**	Traffic and Transport
Reviewer	Jacob Martin	**Office**	Perth

1 Introduction

TME Town Planning Management Engineering Pty Ltd commissioned Cardno to prepare a Strategic Traffic Advice Note for the West Mundijong Structure Plan. The area is located in the Shire of Serpentine-Jarrahdale and is bounded by Bishop Road to the north, the proposed Tonkin Highway extension to the east, Mundijong Road to the south, and Kargotich Road to the west. The following tasks were undertaken:

- Comparison of the proposed land uses to existing land use and ROM data
- Update of traffic projections including generation, distribution and assignment to the network
- SIDRA analysis of critical intersections for the two options provided (Option 1 and Option 3)
- Determine intersection control and road reserve requirements (Geometric Design)

Two options provided for assessment, with the following characteristics:

1. Option 1
   - Intermodal facility located adjacent to the proposed Tonkin Highway;
   - A spine road runs along the centre of the West Mundijong from Bishop Road to Mundijong Road;
   - Scott Road, Sparkman Road and a new road connect with the spine road to Kargotich Road.
2. Option 3
   - Intermodal facility is located adjacent to Kargotich Road;
   - A major internal road runs beside the intermodal facility from Bishop Road to Sparkman Road;
   - Scott Road and Sparkman Road connect as a loop road;
   - Only Sparkman Road connects with Kargotich Road as the western end of Scott Road becomes the intermodal facility.

It has been assumed by the Department of Transport that the intermodal facility will handle approximately 250,000 TEU (Twenty feet Equivalent container) per year.

Layouts of the two options are included at **Appendix A**.

Figures 1 and 2 show the existing configuration of the critical intersections assessed.

Figure 1 Existing Mundijong Road/Kargotich Road Intersection Layout

Figure 2 Existing Kargotich Road/Bishop Road Intersection Layout

2 Traffic Data

2.1 Link Count Data

Main Roads Western Australia (MRWA) conducted link count surveys of Kargotich Road and Mundijong Road, in November 2008. These data have been analysed for the AM and PM peak periods. **Figure 3 and 4** show the average hourly volumes across the surveyed weekday period. The raw data are included in **Appendix B**.

Figure 3 Kargotich Road Average Weekday Hourly Volumes

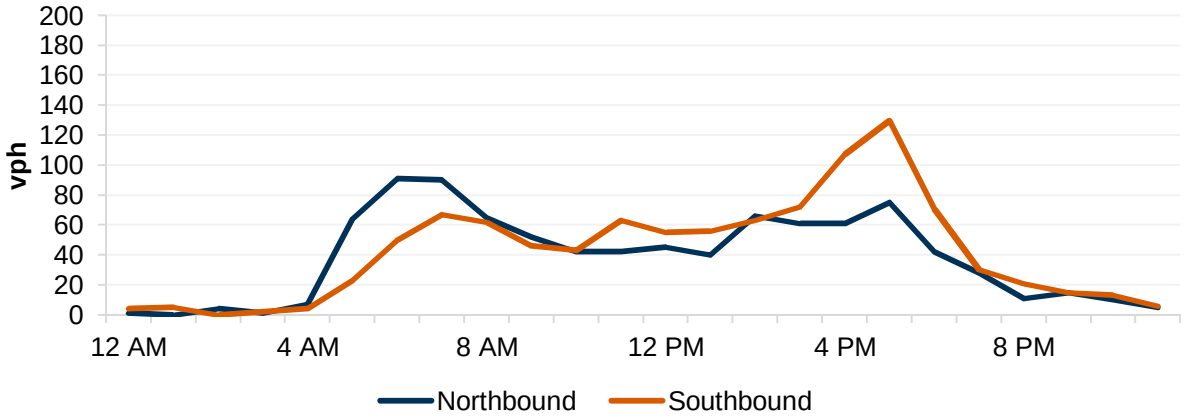


Figure 4 Mundijong Road Average Weekday Hourly Volumes

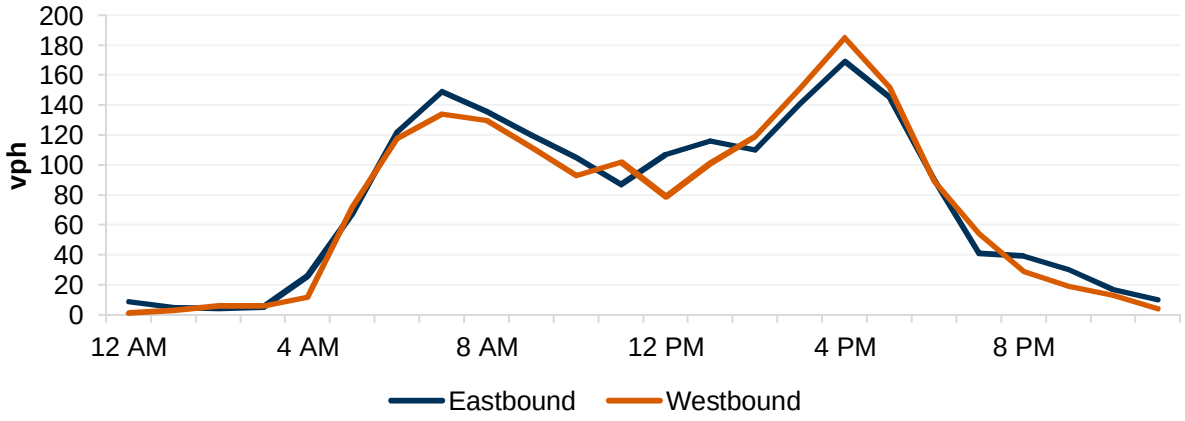


Table 2 summarises the average traffic volumes data.

Table 2 Average Traffic Volumes

Average Traffic Volumes	Kargotich Road	Mundijong Road
AM Peak Hour	157 vph (7am-8am)	283 vph (7am-8am)
PM Peak Hour	205 vph (5pm-6pm)	354 vph (4pm-5pm)
Daily	1926 vph	3635 vph
% of AM Peak to Daily	8.2%	7.8%
% of PM Peak to Daily	10.6%	9.7%
Directional split	North 48%/South 52%	East 51%/West 49%

2.2 2031 Modelling Data

MRWA has undertaken regional traffic modelling for the Shire of Serpentine-Jarrahdale as part of the Regional operations Model (ROM). This model includes the anticipated traffic for full build out of the Byford-Mundijong area by 2031, with assumptions regarding land use mix and lot yields as obtained from developers. However, this modelling is not consistent with the proposed industrial land uses within the proposed West Mundijong cell. Therefore, for the purpose of this strategic advice, the ROM output is assumed to represent the ultimate (2031) background traffic volumes in the vicinity of the development.

Figure 5 shows the daily link volumes extracted from the MRWA 2031 model data in the vicinity of the study area. The entire map is included in **Appendix B**.

Figure 5 Extract from MRWA 2031 Model

2.3 Background Traffic Volumes

In determining the 2031 Background traffic volumes for the surrounding road network, the MRWA link count and modelling data were considered. The data for Kargotich Road does not show sufficient evidence for a growth of traffic volumes, therefore a conservative linear growth rate of 2% has been assumed. The data for Mundijong Road indicates a linear growth rate of 28% and is considered to be appropriate as it is expected that there will be a lot of residential, commercial and industrial developments in the Byford-Mundijong region over the next 20 years.

2.4 Development Trip Generation

Trip generation for the proposed land uses has been estimated generally in accordance with *The Institute of Transportation Engineers (ITE): Trip Generation 7th Edition.*

For the purpose of determining potential trip generation demand rates, the proposed land uses has been classified as per the following ITE classifications:

Table 3 ITE Classification

ITE Land Use	ITE Classification	ITE Classification Code
Intermodal Facility	Truck Terminal	030
Light Industry	General Light Industrial	110
General Industry	General Heavy Industrial	120

**Note that the closest description of activities from ITE classification have been used for the proposed land uses.*

Table 4 summarises the trip generation rates for each peak and daily time period.

Table 4 ITE Trip Generation Rates

ITE Land Use	ITE Land Use Code	Trip Generation Rates	
		AM Peak Hour	PM Peak Hour
Truck Terminal	030	0.66 trips/employee	0.62 trips/employee
General Light Industrial	110	0.48 trips/employee	0.51 trips/employee
General Heavy Industrial	120	0.40 trips/employee	0.40 trips/employee

Additionally, entry and exit distribution for the proposed land uses are expected be as follows.

Table 5 ITE Directionality Rates

ITE Land Use	AM Peak Hour		PM Peak Hour	
	IN	OUT	IN	OUT
Truck Terminal	40%	60%	47%	53%
General Light Industrial	87%	13%	29%	71%
General Heavy Industrial	85%	15%	30%	70%

Table 6 and 7 summarise the expected trip generation of each option for the proposed land uses by applying the above trip rates and entry/exit distributions.

Table 6 Trip Generation – Option 1

Land Use	Development Yields	AM Peak Hour		PM Peak Hour		Daily Volumes
		IN	OUT	IN	OUT	
Truck Terminal	805 employees	213 trips	319 trips	235 trips	265 trips	5,627 trips
General Light Industrial	1,448 employees	605 trips	90 trips	214 trips	524 trips	4,373 trips
General Heavy Industrial	2,278 employees	775 trips	137 trips	273 trips	638 trips	1,868 trips
Total		**1,592 trips**	**546 trips**	**722 trips**	**1,427 trips**	**11,868 trips**

As estimated above, the proposed land uses for Option 1 are expected to generate **2,138 trips during AM peak hour** and **2,149 trips during PM peak hour**.

Table 7 Trip Generation – Option 3

Land Use	Development Yields	AM Peak Hour		PM Peak Hour		Daily Volumes
		IN	OUT	IN	OUT	
Truck Terminal	950 employees	251 trips	376 trips	277 trips	312 trips	6,641 trips
General Light Industrial	2,309 employees	964 trips	144 trips	342 trips	836 trips	6,974 trips
General Heavy Industrial	1,417 employees	482 trips	85 trips	170 trips	397 trips	1,162 trips
Total		**1,697 trips**	**605 trips**	**788 trips**	**1,545 trips**	**14,777 trips**

As estimated above, the proposed land uses for Option 3 are expected to generate **2,302 trips during AM peak hour** and **2,334 trips during PM peak hour**.

It is expected that vehicle demand for the proposed land uses will consist private vehicles, delivery and service vehicles and semi-trailer trucks. The percentage of heavy vehicles has been calculated as 15% of the total traffic volumes.

2.5 Traffic Distribution

Based on the location of key attractions and generators, proposed land uses trips have been generated, distributed and assigned to the external network.

The distributed proposed land uses AM and PM peak hour traffic volumes for the two options are included in **Appendix C**.

2.6 SIDRA Analysis

Analysis of the traffic impacts of the proposed development has been carried out for the following intersections under these initial conditions.

> Mundijong Road/Kargotich Road– assessed with existing four-way Stop controlled configuration
> Mundijong Road/Spine Road – assessed with three-way Stop controlled configuration (Option 1 only)
> Kargotich Road/Spine Road – assessed with three-way Stop controlled with channelised right turn treatment configuration (Option 3 only)
> Kargotich Road/Bishop Road – assessed with three-way Stop controlled with channelised right turn treatment configuration
> Bishop Road/Spine Road – assessed with three-way Stop controlled configuration

The five identified intersections have been analysed for the year 2031 using the SIDRA v5.1 analysis program. This program calculates the performance of intersections based on input parameters, including geometry and traffic volumes. The Degree of Saturation (DOS), Average Delay and 95th Percentile Queue operational measures can be evaluated as follows:

> **Degree of Saturation (DOS)**: is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for varied traffic flow up to one for saturated flow or capacity. The generally accepted upper limits for the DOS (where it is considered that the operation of the intersection is constrained) are:
  - 0.80 for un-signalised intersections
  - 0.85 for roundabouts
  - 0.95 for signalised intersections
> **Level of Service (LOS)**: is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of services, designated from A to F, with Level of Service A representing the best operating condition (i.e. free flow) and Level of Service F the worst (i.e. forced or breakdown flow).
> **Average Delay**: is the average of all travel time delays for vehicles through the intersection. An un-signalised intersection can be considered to be operated at capacity where the average delay exceeds 40 seconds for any movement;
> **95% Queue**: is the queue length below which 95% of all observed queue lengths fall.

Intersections that fail to meet the above operational measures are accessed with signalised configuration and adjustments made to the geometry layout.

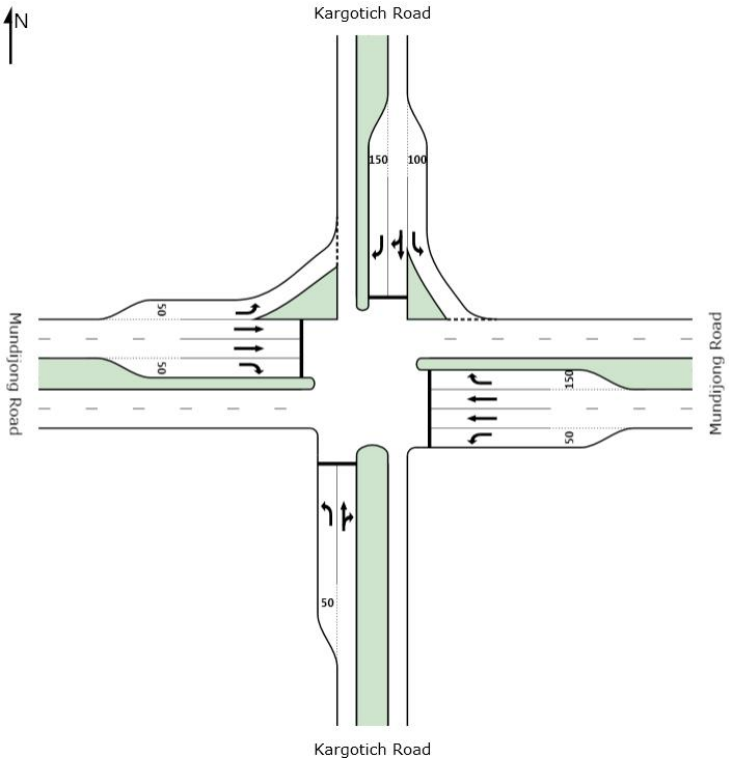
All SIDRA outputs referenced herein are included at **Appendix D**.

2.6.1 Mundijong Road/Kargotich Road Intersection

Cardno analysed the Mundijong Road/Kargotich Road intersection for the year 2031 with the existing four-way Stop controlled configuration. The results indicate that this intersection will operate over acceptable capacity limits by 2031 under both Option 1 and 3. Therefore upgrade works are required to cater for the future traffic demand.

The assessment below analyses the Mundijong Road/Kargotich Road intersection for the year 2031 with a potential signalised configuration. **Figure 6** is a SIDRA layout representation of the intersection at this location.

Figure 6 Mundijong Road/Kargotich Road Intersection Layout – Signalised Configuration



The results of the SIDRA analysis for this intersection is summarised below.

Table 8 Mundijong Road/Kargotich Road Intersection 2031 Performance – Signalised Configuration – Option 1

Intersection Approach		2031 AM Peak				2031PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Kargotich Rd - S	L	0.007	46.5	D	0.3	0.006	45.3	D	0.2
	T	0.793	39.9	D	35.7	0.770	38.6	D	37.6
	R	0.793	54.0	D	35.7	0.770	52.7	D	37.6
Mundijong Rd - E	L	0.348	49.1	D	13.8	0.480	49.7	D	19.4
	T	0.458	9.4	A	73.1	0.692	12.1	B	134.0
	R	0.239	36.8	D	22.6	0.204	36.5	D	19.1
Kargotich Rd - N	L	0.031	20.8	C	2.6	0.069	20.6	C	6.0
	T	0.354	35.2	D	14.3	0.745	37.8	D	37.6
	R	0.354	49.3	D	14.7	0.745	51.9	D	38.2
Mundijong Rd - W	L	0.224	15.3	B	8.3	0.068	15.1	B	2.1
	T	0.861	29.9	C	186.8	0.875	32.4	C	190.5
	R	0.007	46.6	D	0.3	0.007	46.6	D	0.3

From above it is noted that this intersection will operate within acceptable capacity limits in 2031 for Option 1. Therefore it is recommended that the intersection to be upgraded to a signalised intersection.

Table 9 Mundijong Road/Kargotich Road Intersection 2031 Performance – Signalised Configuration – Option 3

Intersection Approach		2031 AM Peak				2031PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Kargotich Rd - S	L	0.007	46.5	D	0.3	0.004	44.1	D	0.3
	T	0.793	40.0	D	35.8	0.534	34.9	C	37.4
	R	0.793	54.1	D	35.8	0.534	49.0	D	37.4
Mundijong Rd - E	L	0.190	42.7	D	12.2	0.548	56.0	E	22.5
	T	0.442	9.3	A	69.5	0.649	14.2	B	135.9
	R	0.809	42.7	D	126.8	0.617	45.2	D	67.0
Kargotich Rd - N	L	0.151	19.2	B	12.2	0.529	22.3	C	57.9
	T	0.510	35.9	D	21.1	0.816	42.0	D	69.1
	R	0.510	50.0	D	21.6	0.816	56.1	E	69.1
Mundijong Rd - W	L	0.702	22.2	C	53.7	0.206	16.5	B	9.9
	T	0.839	30.7	C	145.6	0.801	27.5	C	167.2
	R	0.007	46.6	D	0.3	0.008	52.1	D	0.3

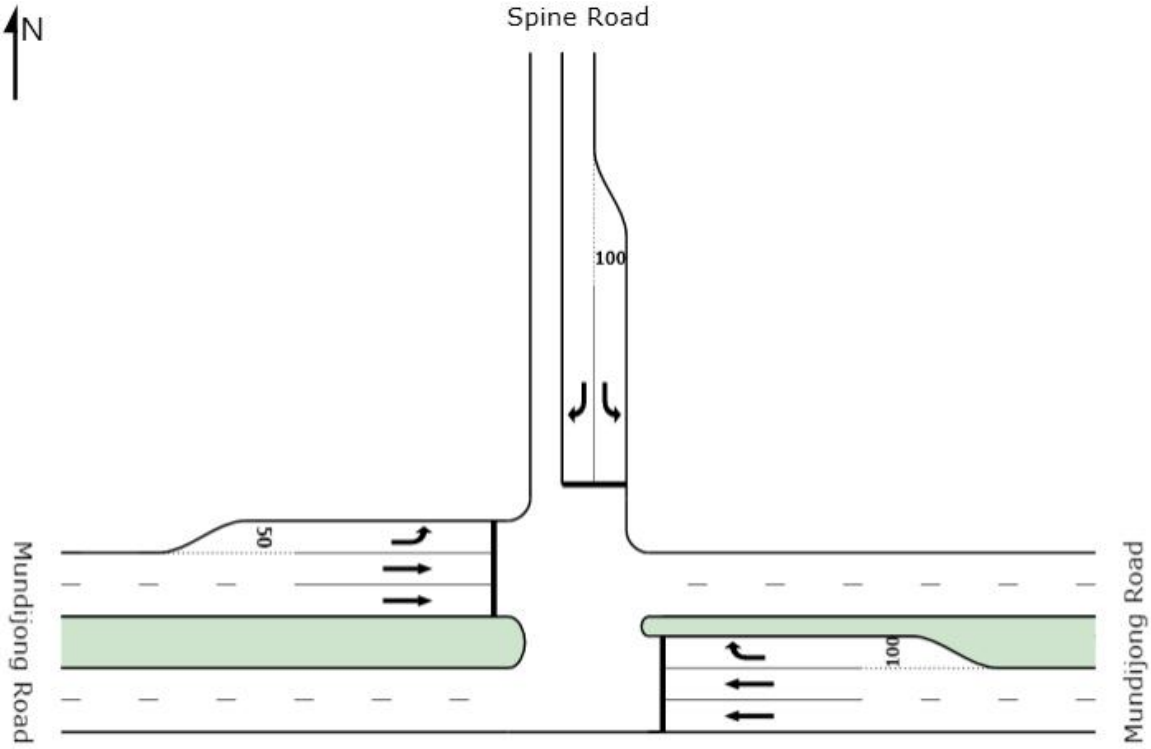
From above it is noted that this intersection will operate within acceptable capacity limits in 2031 for Option 3. Therefore it is recommended that the intersection to be upgraded to a signalised intersection.

2.6.2 Mundijong Road/Spine Road Intersection(for Option 1 only)

Cardno analysed the Mundijong Road/Spine Road intersection for the year 2031 with a three-way Stop controlled configuration. The results indicate that this intersection will operate over acceptable capacity limits in 2031. Therefore upgrade works are required to cater for the future traffic demand.

The assessment below analyses the Mundijong Road/Spine Road intersection for the year 2031 with the signalised configuration. **Figure 7** is a SIDRA layout representation of the intersection at this location.

Figure 7 Mundijong Road/Spine Road Intersection Layout – Signalised Configuration



The results of the SIDRA analysis for this intersection is summarised below.

Table 10 Mundijong Road/Spine Road Intersection 2031 Performance – Signalised Configuration – Option 1

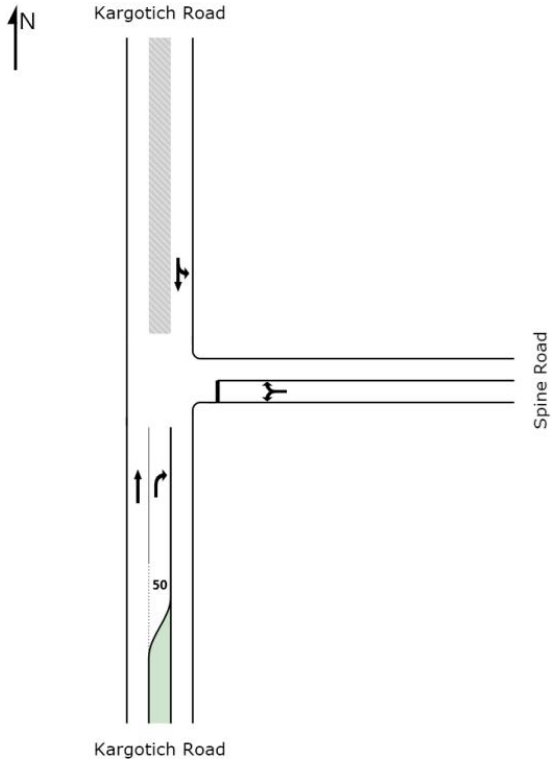
Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Mundijong Rd - E	T	0.396	3.6	A	54.1	0.666	14.1	B	171.5
	R	0.820	47.7	D	120.2	0.819	65.7	E	64.4
Spine Rd - N	L	0.786	49.8	D	39.8	0.885	48.8	D	163.2
	R	0.217	44.1	D	9.7	0.275	36.7	D	37.6
Mundijong Rd - W	L	0.685	34.1	C	54.7	0.310	33.0	C	21.9
	T	0.809	26.8	C	161.6	0.872	37.8	D	254.7

From above it is noted that this intersection will operate within acceptable capacity limits in 2031 with Option 1. Therefore it is recommended that the intersection to be upgraded to a signalised intersection.

2.6.3 Kargotich Road/Spine Road Intersection

The assessment below analyses the Kargotich Road/Spine Road intersection for the year 2031 with the three-way Stop controlled with channelised right turn treatment configuration (Option 3 only). **Figure 8** is a SIDRA layout representation of the intersection at this location. The diagram below is considered a conservative representation, as it is likely that two (2) cars egressing from the Spine Road would be capable to stage at the stop line (for left and right turning movements respectively)

Figure 8 Kargotich Road/Spine Road Intersection Layout – Stop Controlled Configuration



The results of the SIDRA analysis for this intersection is summarised below.

Table 11 Kargotich Road/Spine Road Intersection 2031 Performance – Stop Controlled Configuration – Option 3

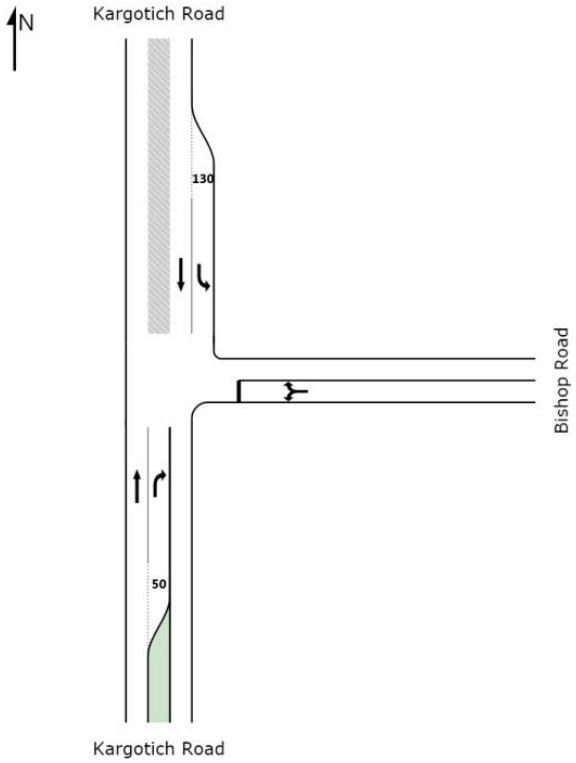
Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Kargotich Rd - S	T	0.108	0.0	A	0.0	0.084	0.0	A	0.0
	R	0.627	16.8	C	48.8	0.220	15.7	C	7.8
Spine Rd - E	L	0.213	13.3	B	6.6	0.719	17.2	C	77.6
	R	0.213	12.8	B	6.6	0.719	16.7	C	77.6
Kargotich Rd - N	L	0.072	14.3	B	0.0	0.107	14.3	B	0.0
	T	0.072	0.0	A	0.0	0.107	0.0	A	0.0

From above it is noted that this intersection will operate within acceptable capacity limits in 2031 with Option 3. No upgrade works are required to cater for the future traffic demand. The requirements for the channelized right turn are a result of the relatively high speeds and proportion of heavy vehicles likely along Kargotich Road.

2.6.4 Kargotich Road/Bishop Road Intersection

The assessment below analyses the Kargotich Road/Bishop Road intersection for the year 2031 with the three-way Stop controlled with channelised right turn treatment configuration. **Figure 9** is a SIDRA layout representation of the intersection at this location. The diagram below is considered a conservative representation, as it is likely that two (2) cars egressing from the Spine Road would be capable to stage at the stop line (for left and right turning movements respectively)

Figure 9 Kargotich Road/Bishop Road Intersection Layout – Stop Controlled Configuration



The results of the SIDRA analysis for this intersection is summarised below.

Table 12 Kargotich Road/Bishop Road Intersection 2031 Performance – Stop Controlled Configuration – Option 1

Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Kargotich Rd - S	T	0.082	0.0	A	0.0	0.053	0.0	A	0.0
	R	0.013	14.5	B	0.3	0.061	14.6	B	1.6
Bishop Rd - E	L	0.117	11.8	B	3.6	0.042	11.9	B	1.2
	R	0.117	11.6	B	3.6	0.042	11.7	B	1.2
Kargotich Rd - N	L	0.003	14.3	B	0.0	0.013	14.3	B	0.0
	T	0.001	0.0	A	0.0	0.006	0.0	A	0.0

From above it is noted that this intersection will operate within acceptable capacity limits in 2031 with Option 1. No upgrade works are required to cater for the future traffic demand. The requirements for the channelized right turn are a result of the relatively high speeds and proportion of heavy vehicles likely along Kargotich Road.

Table 13 Kargotich Road/Bishop Road Intersection 2031 Performance – Stop Controlled Configuration – Option 3

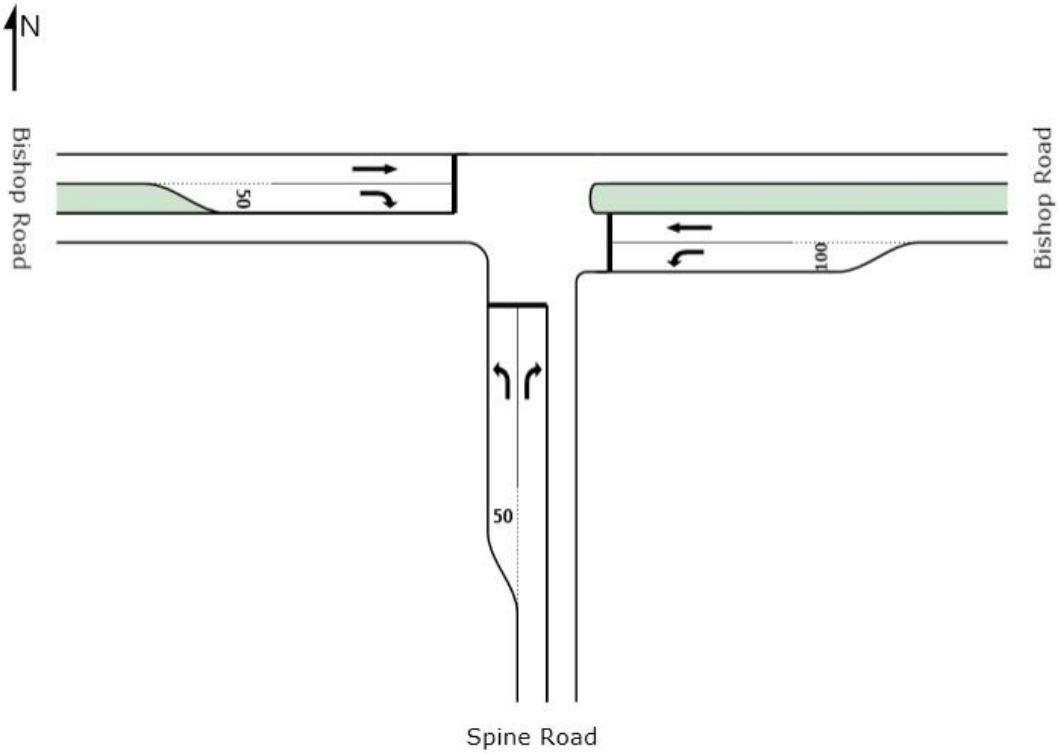
Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Kargotich Rd - S	T	0.080	0.0	A	0.0	0.053	0.1	A	0.0
	R	0.287	14.7	B	9.2	0.238	14.6	B	7.2
Bishop Rd - E	L	0.237	12.1	B	8.1	0.220	11.4	B	7.5
	R	0.237	11.9	B	8.1	0.220	11.2	B	7.5
Kargotich Rd - N	L	0.019	14.3	B	0.0	0.008	14.3	B	0.0
	T	0.001	0.0	A	0.0	0.003	0.0	A	0.0

From above it is noted that this intersection will operate within acceptable capacity limits in 2031 with Option 3. No upgrade works are required to cater for the future traffic demand.

2.6.5 Bishop Road/Spine Road Intersection

The assessment below analyses the Bishop Road/Spine Road intersection for the year 2031 with the three-way Stop controlled configuration. **Figure 10** is a SIDRA layout representation of the intersection at this location.

Figure 10 Bishop Road/Spine Road Intersection Layout – Stop Controlled Configuration



The results of the SIDRA analysis for this intersection is summarised below.

Table 14 Bishop Road/Spine Road Intersection 2031 Performance – Stop Controlled Configuration – Option 1

Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Spine Rd - S	L	0.008	13.4	B	0.2	0.006	11.4	B	0.2
	R	0.576	17.9	C	32.2	0.863	24.0	C	134.0
Bishop Rd - E	L	0.404	6.8	A	0.0	0.219	6.8	A	0.0
	T	0.060	0.0	A	0.0	0.021	0.0	A	0.0
Bishop Rd - W	T	0.010	0.0	A	0.0	0.048	0.0	A	0.0
	R	0.008	11.8	B	0.2	0.005	8.7	A	0.2

From above it is noted that this intersection will operate within acceptable capacity limits in 2031 with Option 1. No upgrade works are required to cater for the future traffic demand.

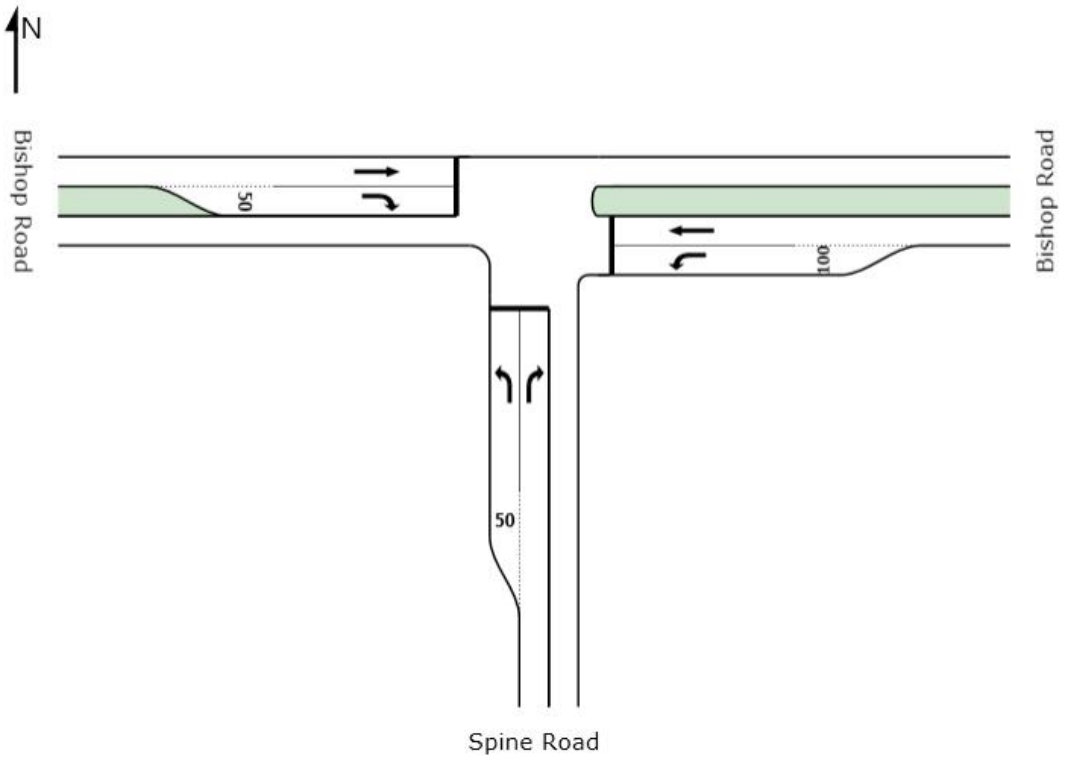
Table 15 Bishop Road/Spine Road Intersection 2031 Performance – Stop Controlled Configuration – Option 3

Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Spine Rd - S	L	0.011	15.3	C	0.3	0.007	12.5	B	0.2
	R	0.417	25.0	D	13.9	1.417	777.4	F	1992.2
Bishop Rd - E	L	0.460	6.8	A	0.0	0.163	6.8	A	0.0
	T	0.122	0.0	A	0.0	0.128	0.0	A	0.0
Bishop Rd - W	T	0.171	0.0	A	0.0	0.149	0.0	A	0.0
	R	0.011	14.5	B	0.3	0.005	9.3	A	0.2

From above it is noted that this intersection will operate well over acceptable capacity limits for the 2031 PM peak scenario under Option 3. Upgrade works are required to cater for the future traffic demand. This is a result of the projected volumes of right-turning egress movements onto Bishop Road headed towards Tonkin Highway.

The assessment below analyses the Bishop Road/Spine Road intersection for the year 2031 with a possible signalised configuration. **Figure 11** is a SIDRA layout representation of the intersection at this location.

Figure 11 Bishop Road/Spine Road Intersection Layout – Signalised Configuration



The results of the SIDRA analysis for this intersection is summarised below.

Table 16 Bishop Road/Spine Road Intersection 2031 Performance – Signalised Configuration – Option 1

Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Spine Rd - S	L	0.015	28.6	C	1.0	0.014	20.7	C	0.9
	R	0.944	59.0	E	127.4	0.799	32.6	C	210.5
Bishop Rd - E	L	0.973	27.4	C	170.8	0.799	46.3	D	137.6
	T	0.144	12.8	B	16.6	0.076	27.5	C	10.0
Bishop Rd - W	T	0.017	5.6	A	1.8	0.121	19.2	B	19.7
	R	0.032	37.4	D	1.2	0.047	54.4	D	1.8

From above it is noted that this intersection will operate within acceptable capacity limits during the 2031 PM peak scenario under Option 1, though it operates close to capacity during the 2031 AM peak hour. Therefore it is recommended that the intersection to have a Stop controlled configuration under Option 1.

Table 17 Bishop Road/Spine Road Intersection 2031 Performance – Signalised Configuration – Option 3

Intersection Approach		2031 AM Peak				2031 PM Peak			
		DOS	Delay(s)	LOS	95% Queue(m)	DOS	Delay(s)	LOS	95% Queue(m)
Spine Rd - S	L	0.030	34.4	C	1.1	0.012	17.9	B	0.8
	R	0.733	39.6	D	31.6	0.802	29.2	C	188.2
Bishop Rd - E	L	1.000*	21.8	C	163.2	0.766	42.9	D	87.3
	T	0.259	9.3	A	30.7	0.601	31.6	C	65.3
Bishop Rd - W	T	0.244	3.5	A	25.4	0.410	20.8	C	61.6
	R	0.030	34.6	C	1.1	0.040	45.9	D	1.5

**1.000 due to short lane*

From above it is noted that this intersection will operate within acceptable capacity limits in 2031 under Option 3. Therefore it is recommended that the intersection to be upgraded to a signalised intersection with Option 3.

2.7 Geometric Design

According to the existing MRWA Restricted Access Vehicle (RAV) network, the largest vehicle that is allowed to access the West Mundijong, with the proposed Tonkin Highway extension, is likely to be a RAV4 Network vehicle. A generally equivalent vehicle is a 26m long B-Double (Class 10).

Appendix E provides concept design as well as the detail of the cross sections and road reserve widths of the roads at the intersections included in this assessment. These widths would likely be retained for the relevant road sections.

APPENDIX A
PROPOSED LAYOUTS

POSSIBLE ALIGNMENT OF KWINANA FREIGHT RAIL LINE

BISHOP ROAD

BISHOP ROAD

TAYLOR ROAD

LEIPOLD ROAD

GANGEMI ROAD

KARGOTICH ROAD

SCOTT ROAD

SPARKMAN ROAD

PROPOSED TONKIN HIGHWAY

MUNDIJONG ROAD

MUNDIJONG

50m

200m

NOTES

Co-location of freight rail line and power lines (330kv) subject to further liaison with Department of Transport and Western Power

LEGEND

- SUBJECT LAND
- EXISTING CADASTRE
- ROADS
- INTERMODEL FACILITY (Indicative Size and Shape) Warehousing, Storage & Logistics. Rolling stock maintenance & Servicing
- BUFFERS
- GENERAL INDUSTRY Manufacture of building products. Low emission processing raw materials. Fuel Storage and handling. Heavy Machinery (sales,servicing & distribution)
- LIGHT INDUSTRY Transport Depot. Limited Showrooms Trade Display
- POTENTIAL DRAINAGE BASIN INDICATIVE SIZE
- EXISTING DWELLINGS
- 330 V POWER LINES
- CONSERVATION CATEGORY WETLAND
- INDICATIVE ECOLOGICAL LINKAGES
- INDICATIVE SECONDARY ECOLOGICAL LINKAGES
- INDICATIVE BUFFER AREA (FINAL BUFFER AREA SUBJECT TO FURTHER DETAILED INVESTIGATION)
- PROPOSED RAIL LINK
- EXISTING KWINANA FREIGHT RAIL

WORKING DRAFT

Preliminary District Structure Plan
West Mundijong
Shire of Serpentine Jarrahdale
Option 1

187.5m 0 375 750m

1 : 7500 @ A1 or 1 : 15000 @ A3
ALL DISTANCES ARE IN METRES

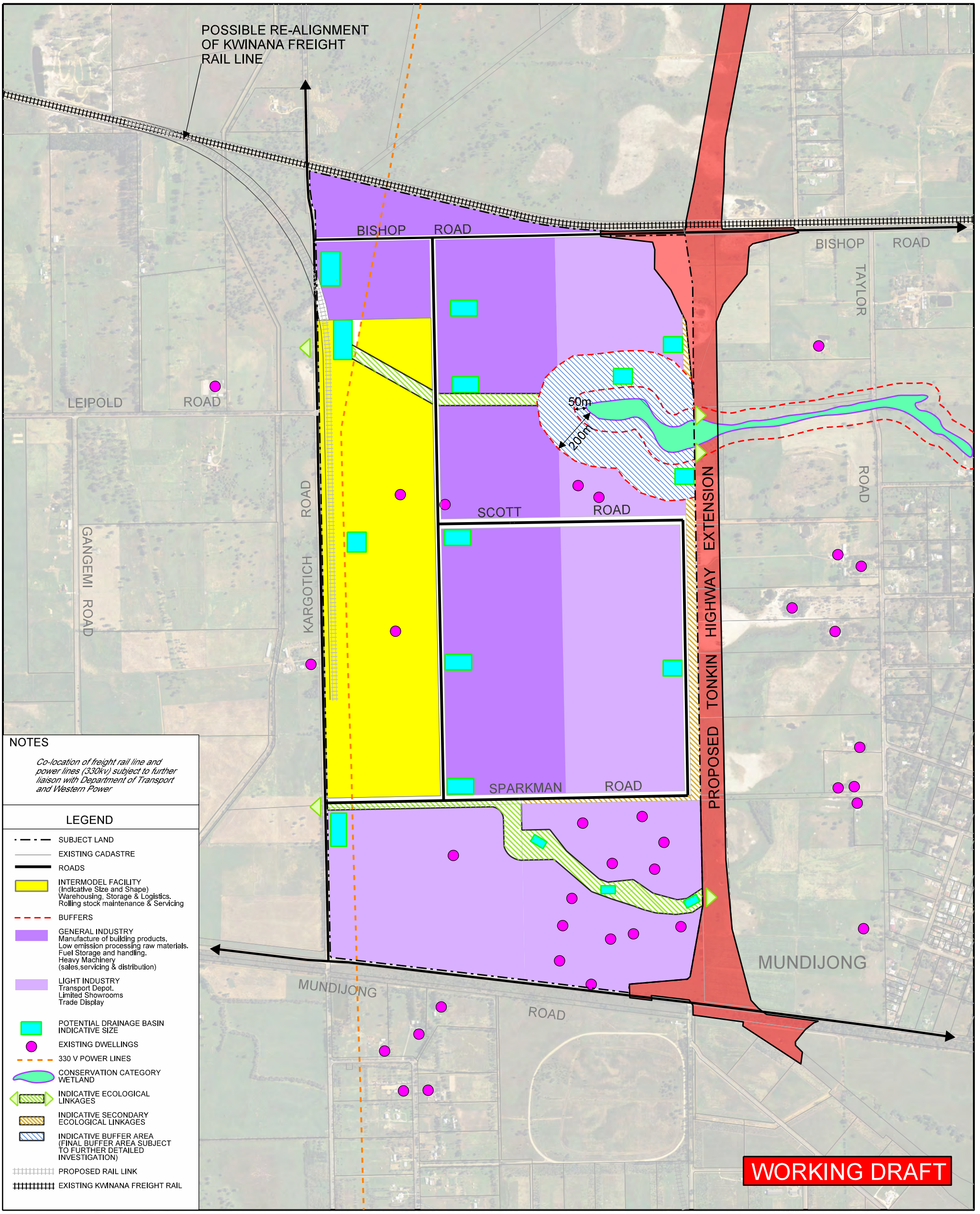
REVISION	DESCRIPTION	DRAFTER	DATE
J			
I			
H			
G			
F			
E			
D			
C			
B			
A	UPDATES TO CCW AND LEGEND	JW	09082012

ORIGINAL PLANNER:	KK
ORIGINAL DRAFTER:	JW
CREATED DATE:	01/06/2012
AERIAL DATA:	LANDGATE ECW
CADASTRAL DATA:	LANDGATE 2012
TOPOGRAPHIC DATA:	MGA

12106P-SP-01opt1A

THIS PLAN HAS BEEN PREPARED FOR PLANNING PURPOSES.
AREAS, CONTOURS AND DIMENSIONS SHOWN ARE SUBJECT TO SURVEY.

TME Town Planning Management Engineering Pty Ltd (08) 9791 4411 www.tme.net.au



Preliminary District Structure Plan
West Mundijong
Shire of Serpentine Jarrahdale
Option 3

187.5m 0 375 750m

1 : 7500 @ A1 or 1 : 15000 @ A3
ALL DISTANCES ARE IN METRES

REVISION	DESCRIPTION	DRAFTER	DATE
J			
I			
H			
G			
F			
E			
D			
C			
B			
A	UPDATES TO CCW	JW	09082012

ORIGINAL PLANNER:	KK
ORIGINAL DRAFTER:	JW
CREATED DATE:	01/06/2012
AERIAL DATA:	LANDGATE ECW
CADASTRAL DATA:	LANDGATE 2012
TOPOGRAPHIC DATA:	MGA

12106P-SP-01opt3A

THIS PLAN HAS BEEN PREPARED FOR PLANNING PURPOSES.
AREAS, CONTOURS AND DIMENSIONS SHOWN ARE SUBJECT TO SURVEY.

TME Town Planning Management Engineering Pty Ltd (08) 9791 4411 www.tme.net.au

APPENDIX B
TRAFFIC DATA

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**Mundijong Rd (1080004)**
Site No:	**5419**	Location Description:	**W of Patterson Rd (SLK 0.01)**
Date Range:	**11 Nov 2008 to 14 Nov 2008**	Count Type:	**Axle Pairs**

Average Vehicle Volume

Hour	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		Mon - Fri		Mon - Sun	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
0000					6	0	12	1							9	1	9	1
0100					3	3	7	2							5	3	5	3
0200					3	3	4	8							4	6	4	6
0300					6	8	4	4							5	6	5	6
0400					25	10	26	13							26	12	26	12
0500					71	78	65	65							68	72	68	72
0600					125	117	118	118							122	118	122	118
0700					154	142	143	126							149	134	149	134
0800					142	131	130	128							136	130	136	130
0900					126	129	114	95							120	112	120	112
1000					113	102	97	84							105	93	105	93
1100					84	113	89	91							87	102	87	102
1200					95	98	118	59							107	79	107	79
1300					119	101	113	100							116	101	116	101
1400					120	119	100	119							110	119	110	119
1500					149	149	133	153							141	151	141	151
1600					165	200	173	170							169	185	169	185
1700					136	159	154	145							145	152	145	152
1800					100	93	79	85							90	89	90	89
1900					43	47	39	60							41	54	41	54
2000					38	33	40	25							39	29	39	29
2100					35	24	24	14							30	19	30	19
2200					16	9	17	16							17	13	17	13
2300					11	3	9	4							10	4	10	4
24hr					1885	1871	1808	1685							1851	1784	1851	1784

Peak Statistics

		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		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					0700	0715	0745	0845							0745	0715	0745	0715
	1/4 Hr Vol					41	48	44	38							41	41	41	41
	1/2 Hour					0645	0715	0745	0830							0730	0715	0730	0715
	1/2 Hr Vol					78	83	83	72							79	75	79	75
	1 Hour					0700	0715	0730	0800							0730	0700	0730	0700
	1 Hr Vol					154	147	159	128							156	134	156	134
	1 Hr Fact					.939	.7656	.9034	.8421							.9512	.8171	.9512	.8171
	2 Hour					0645	0715	0630	0700							0630	0700	0630	0700
	2 Hr Vol					299	278	285	254							291	264	291	264
PM	1/4 Hour					1615	1600	1615	1700							1615	1700	1615	1700
	1/4 Hr Vol					52	57	49	53							51	51	51	51
	1/2 Hour					1600	1545	1600	1645							1600	1645	1600	1645
	1/2 Hr Vol					94	103	92	96							93	99	93	99
	1 Hour					1530	1600	1615	1615							1530	1615	1530	1615
	1 Hr Vol					187	200	175	185							172	189	172	189
	1 Hr Fact					.899	.8772	.8929	.8726							.8515	.9265	.8515	.9265
	2 Hour					1515	1545	1545	1545							1515	1545	1515	1545
	2 Hr Vol					323	375	328	331							322	353	322	353
Peak	12 Hour					0615	0615	0600	0600							0615	0600	0615	0600
	12 Hr Vol					1532	1564	1482	1388							1506	1474	1506	1474

Weekly Volume by Hour

Traffic Flow:	**Directional**	Road Name:	**Kargotich Rd (1080009)**
Site No:	**2023**	Location Description:	**N of Bishop Rd (SLK 9.67)**
Date Range:	**11 Nov 2008 to 14 Nov 2008**	Count Type:	**Axle Pairs**

Average Vehicle Volume

Hour	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		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	0	3							1	4	1	4
0100					0	4	0	5							0	5	0	5
0200					2	0	5	0							4	0	4	0
0300					0	1	2	2							1	2	1	2
0400					8	5	6	3							7	4	7	4
0500					61	24	67	22							64	23	64	23
0600					102	50	80	49							91	50	91	50
0700					80	68	100	65							90	67	90	67
0800					67	65	62	59							65	62	65	62
0900					54	48	49	43							52	46	52	46
1000					45	33	39	53							42	43	42	43
1100					45	64	39	62							42	63	42	63
1200					44	56	46	54							45	55	45	55
1300					44	55	35	57							40	56	40	56
1400					59	66	72	59							66	63	66	63
1500					60	74	61	70							61	72	61	72
1600					58	102	64	111							61	107	61	107
1700					87	117	63	142							75	130	75	130
1800					48	68	36	74							42	71	42	71
1900					20	33	36	27							28	30	28	30
2000					11	21	11	21							11	21	11	21
2100					12	13	18	17							15	15	15	15
2200					8	17	11	8							10	13	10	13
2300					4	5	5	6							5	6	5	6
24hr					921	993	907	1012							918	1008	918	1008

Peak Statistics

		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		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					0630	0700	0700	1115							0600	0700	0600	0700
	1/4 Hr Vol					31	33	31	23							27	27	27	27
	1/2 Hour					0630	0645	0700	0700							0600	0645	0600	0645
	1/2 Hr Vol					54	47	54	40							48	43	48	43
	1 Hour					0600	0645	0700	0645							0600	0645	0600	0645
	1 Hr Vol					102	73	100	71							91	72	91	72
	1 Hr Fact					.8226	.553	.8065	.8452							.8426	.6667	.8426	.6667
	2 Hour					0600	0700	0600	0645							0600	0700	0600	0700
	2 Hr Vol					182	133	180	132							181	129	181	129
PM	1/4 Hour					1730	1730	1415	1715							1545	1715	1545	1715
	1/4 Hr Vol					28	35	27	44							23	36	23	36
	1/2 Hour					1730	1715	1415	1715							1730	1715	1730	1715
	1/2 Hr Vol					48	62	48	80							40	71	40	71
	1 Hour					1700	1700	1415	1700							1700	1700	1700	1700
	1 Hr Vol					87	117	85	142							75	130	75	130
	1 Hr Fact					.7768	.8357	.787	.8068							.8333	.9155	.8333	.9155
	2 Hour					1545	1600	1400	1600							1545	1600	1545	1600
	2 Hr Vol					152	219	133	253							141	236	141	236
Peak	12 Hour					0600	0645	0530	0645							0515	0645	0515	0645
	12 Hr Vol					745	820	722	852							729	836	729	836

Byford - Mundijong Redevelopment (V2007 Mode factors)
Plot of 2031 volumes using network and land use as specified by client

Perth Metropolitan Network
Unadjusted Total Traffic Volumes (Factor vols X 100)

Main Roads Western Australia
Transport Modelling Section

IMPORTANT NOTE:
This plan depicts the results of regional traffic modelling undertaken by Main Roads WA, in conjunction with the Serpentine Jarrahdale Shire. All land use and road network inputs within the modelled study area were provided to Main Roads by the Shire of Serpentine / Jarrahdale. The land use outside the study area represents trend case land use forecasts as provided by the Department of Planning.

The modelling was undertaken having regard to the best information available at that point in time and will need to be regularly reviewed and updated. The modelling assumed a complete build-out (post 2031) scenario for the localities of Byford and Mundijong-Whitby. This regional modelling is intended to be used as a basis for more detailed transport assessments for planning proposals including but not limited to, district structure plans, local structure plans, subdivision and development applications.

While every effort has been made to ensure the accuracy of the information herein provided, neither Main Roads nor the Serpentine Jarrahdale Shire cannot accept any responsibility for any action taken or costs incurred based on this information.

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- 4 Lanes Each Direction
- · ROM zone numbers

Wed 06 Oct 2010 TRIPS Project T:\Zone1160\Y2031\AssYr\Y2010\Projects\ByfordV07\TRIPABC.PRJ
T:\ZONE1160\Y2031\ASSYR\Y2010\PROJNETS\BYFORDV07\FINAL_LOAD.NET
T:\Zone1160\Y2031\AssYr\Y2010\Projects\ByfordV07\LVP_ByfordMundijong_2031(V2007)_2.vpr

MRWA Updated Base Network - Version 2010

cube

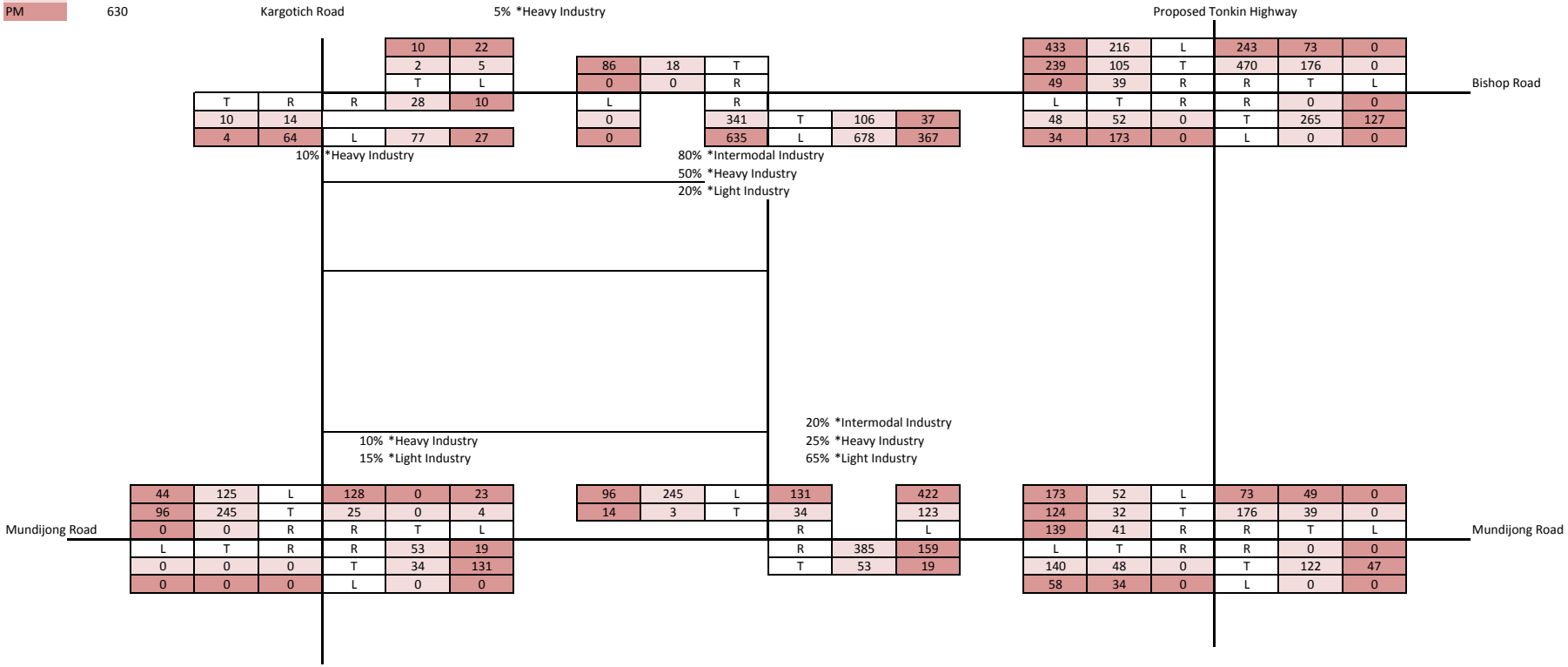
APPENDIX C
TRAFFIC GENERATION & DISTRIBUTION

Cardno
Shaping the Future

CEP02161 West Mundijong Sp Traffic Advice

Option 1 IN+OUT Development Traffic Volumes (Include 15% HV)

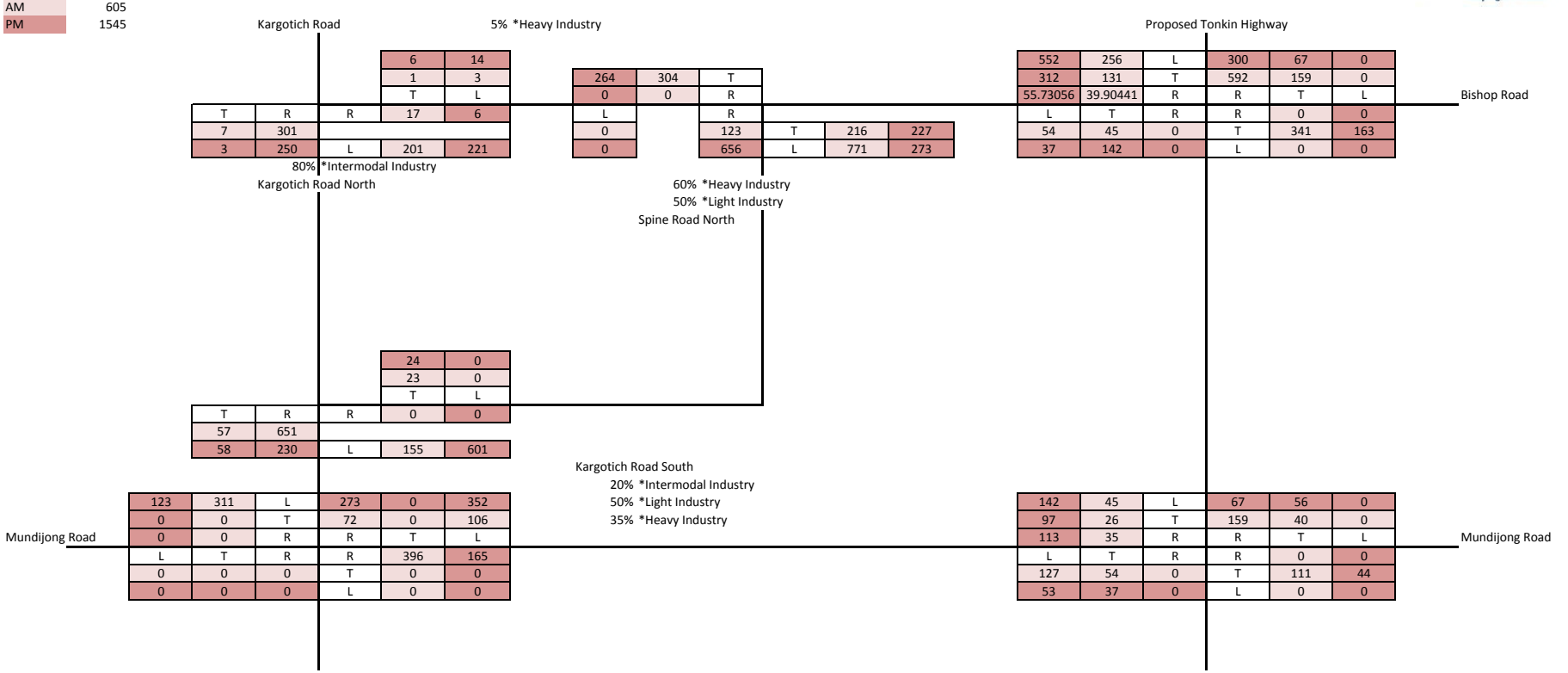
AM	1403
PM	630



CEP02161 West Mundijong Sp Traffic Advice

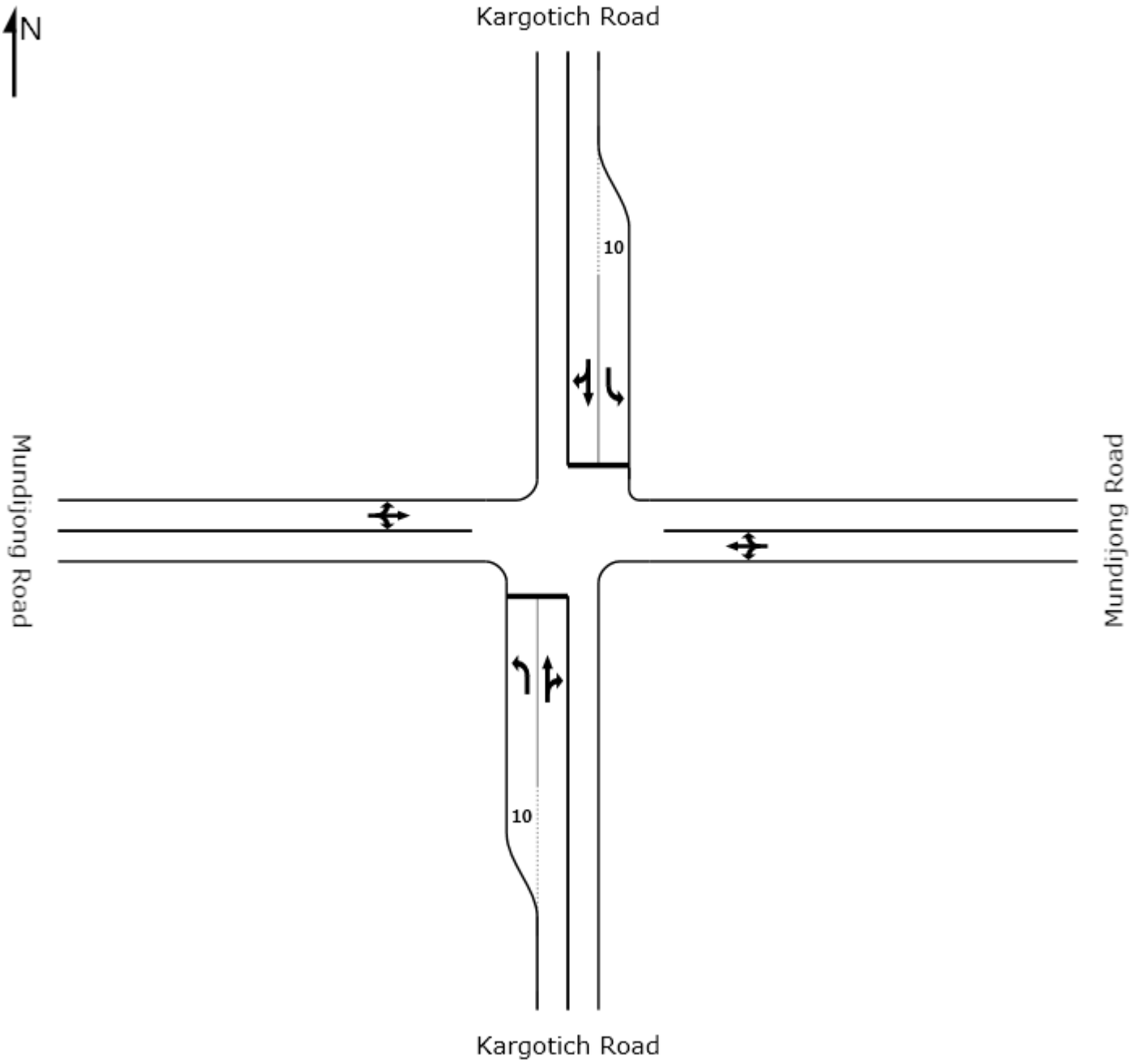
Option 3 IN+OUT Development Traffic Volumes (Include 15% HV)

AM	605
PM	1545



				6	14					552	256	L	300	67	0
				1	3	264	304	T		312	131	T	592	159	0
				T	L	0	0	R		55.73056	39.90441	R	R	T	L
T	R	R	17	6		L		R		L	T	R	R	0	0
7	301					0		123	T	216	227	54	45	0	T	341	163
3	250	L	201	221		0		656	L	771	273	37	142	0	L	0	0
				24	0												
				23	0												
				T	L												
T	R	R	0	0													
57	651																
58	230	L	155	601													
123	311	L	273	0	352					142	45	L	67	56	0
0	0	T	72	0	106					97	26	T	159	40	0
0	0	R	R	T	L					113	35	R	R	T	L
L	T	R	R	396	165					L	T	R	R	0	0
0	0	0	T	0	0					127	54	0	T	111	44
0	0	0	L	0	0					53	37	0	L	0	0

APPENDIX D
SIDRA OUTPUTS


N
Kargotich Road
10
Mundijong Road
Mundijong Road
10
Kargotich Road

MOVEMENT SUMMARY

Site: 2031 AM BG+Opt 1

Mundijong Road/Kargotich Road
2031 AM Background + Option 1 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.007	37.3	LOS E	0.0	0.2	0.87	0.97	45.4
2	T	8	15.0	1.950	1794.7	LOS F	77.2	609.8	1.00	2.96	1.5
3	R	109	15.0	1.950	1794.6	LOS F	77.2	609.8	1.00	3.05	1.5
Approach		118	15.0	1.950	1779.7	LOS F	77.2	609.8	1.00	3.02	1.6
East: Mundijong Road											
4	L	50	15.0	2.270	2305.4	LOS F	797.2	6297.9	1.00	0.00	1.2
5	T	931	15.0	2.270	2291.5	LOS F	797.2	6297.9	1.00	0.00	1.2
6	R	103	15.0	2.270	2305.3	LOS F	797.2	6297.9	1.00	4.07	1.2
Approach		1084	15.0	2.270	2293.4	NA	797.2	6297.9	1.00	0.39	1.2
North: Kargotich Road											
7	L	24	15.0	1.000[3]	279.2	LOS F	3.1	24.9	1.00	1.07	9.3
8	T	10	15.0	1.750	1438.7	LOS F	61.8	488.3	1.00	2.71	1.9
9	R	95	15.0	1.750	1438.7	LOS F	61.8	488.3	1.00	2.77	1.9
Approach		129	15.0	1.750	1223.0	LOS F	61.8	488.3	1.00	2.45	2.3
West: Mundijong Road											
10	L	202	15.0	0.814	133.4	LOS F	65.0	513.2	1.00	0.00	18.3
11	T	1224	15.0	0.814	119.5	LOS F	65.0	513.2	1.00	0.00	18.5
12	R	1	15.0	0.814	133.3	LOS F	65.0	513.2	1.00	1.55	18.4
Approach		1427	15.0	0.814	121.5	NA	65.0	513.2	1.00	0.00	18.5
All Vehicles		2758	15.0	2.270	1097.6	NA	797.2	6297.9	1.00	0.40	2.5

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

3 x = 1.00 due to short lane. Refer to the Lane Summary report for information about excess flow and related conditions.

MOVEMENT SUMMARY

Site: 2031 PM BG+Opt 1

Mundijong Road/Kargotich Road
2031 PM Background + Option 1 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.091	279.7	LOS F	0.2	1.6	0.99	1.00	9.2
2	T	2	15.0	2.083	2026.5	LOS F	87.1	688.2	1.00	3.14	1.4
3	R	123	15.0	2.083	2026.4	LOS F	87.1	688.2	1.00	3.22	1.4
Approach		126	15.0	2.083	2012.6	LOS F	87.1	688.2	1.00	3.20	1.4
East: Mundijong Road											
4	L	69	15.0	2.279	2321.6	LOS F	1134.0	8958.8	1.00	0.00	1.2
5	T	1370	15.0	2.279	2307.7	LOS F	1134.0	8958.8	1.00	0.00	1.2
6	R	88	15.0	2.279	2321.5	LOS F	1134.0	8958.8	1.00	3.89	1.2
Approach		1527	15.0	2.279	2309.2	NA	1134.0	8958.8	1.00	0.22	1.2
North: Kargotich Road											
7	L	55	15.0	1.000[3]	108.8	LOS F	3.1	24.9	1.00	1.06	21.1
8	T	16	15.0	4.267	5944.9	LOS F	253.8	2004.9	1.00	4.83	0.5
9	R	240	15.0	4.267	5944.9	LOS F	253.8	2004.9	1.00	4.99	0.5
Approach		311	15.0	4.267	4912.8	LOS F	253.8	2004.9	1.00	4.28	0.6
West: Mundijong Road											
10	L	64	15.0	0.774	1043.1	LOS F	289.6	2288.2	1.00	0.00	2.6
11	T	1199	15.0	0.774	1029.2	LOS F	289.6	2288.2	1.00	0.00	2.7
12	R	1	15.0	0.774	1043.0	LOS F	289.6	2288.2	1.00	1.25	2.6
Approach		1264	15.0	0.774	1029.9	NA	289.6	2288.2	1.00	0.00	2.7
All Vehicles		3228	15.0	4.267	2047.5	NA	1134.0	8958.8	1.00	0.64	1.4

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

3 x = 1.00 due to short lane. Refer to the Lane Summary report for information about excess flow and related conditions.

MOVEMENT SUMMARY

Site: 2031 AM BG+Opt 3

Mundijong Road/Kargotich Road
2031 AM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.006	34.7	LOS D	0.0	0.1	0.85	0.95	47.4
2	T	8	15.0	1.950	1792.3	LOS F	77.0	608.3	1.00	2.97	1.5
3	R	109	15.0	1.950	1792.2	LOS F	77.0	608.3	1.00	3.08	1.5
Approach		118	15.0	1.950	1777.4	LOS F	77.0	608.3	1.00	3.06	1.6
East: Mundijong Road											
4	L	50	15.0	7.968	12560.6	LOS F	1571.7	12416.1	1.00	0.00	0.2
5	T	897	15.0	7.968	12546.7	LOS F	1571.7	12416.1	1.00	0.00	0.2
6	R	446	15.0	7.968	12560.5	LOS F	1571.7	12416.1	1.00	5.64	0.2
Approach		1393	15.0	7.968	12551.6	NA	1571.7	12416.1	1.00	1.81	0.2
North: Kargotich Road											
7	L	60	15.0	1.000[3]	96.9	LOS F	3.1	24.9	1.00	1.04	23.2
8	T	76	15.0	3.633	4810.1	LOS F	206.5	1631.6	1.00	4.18	0.6
9	R	142	15.0	3.633	4810.1	LOS F	206.5	1631.6	1.00	4.30	0.6
Approach		278	15.0	3.633	3792.9	LOS F	206.5	1631.6	1.00	3.56	0.7
West: Mundijong Road											
10	L	388	15.0	0.787	109.4	LOS F	64.4	508.8	1.00	0.00	21.5
11	T	980	15.0	0.787	95.5	LOS F	64.4	508.8	1.00	0.00	21.6
12	R	1	15.0	0.787	109.4	LOS F	64.4	508.8	1.00	1.59	21.6
Approach		1369	15.0	0.787	99.5	NA	64.4	508.8	1.00	0.00	21.6
All Vehicles		3158	15.0	7.968	5980.0	NA	1571.7	12416.1	1.00	1.22	0.5

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

3 x = 1.00 due to short lane. Refer to the Lane Summary report for information about excess flow and related conditions.

MOVEMENT SUMMARY

Site: 2031 PM BG+Opt 3

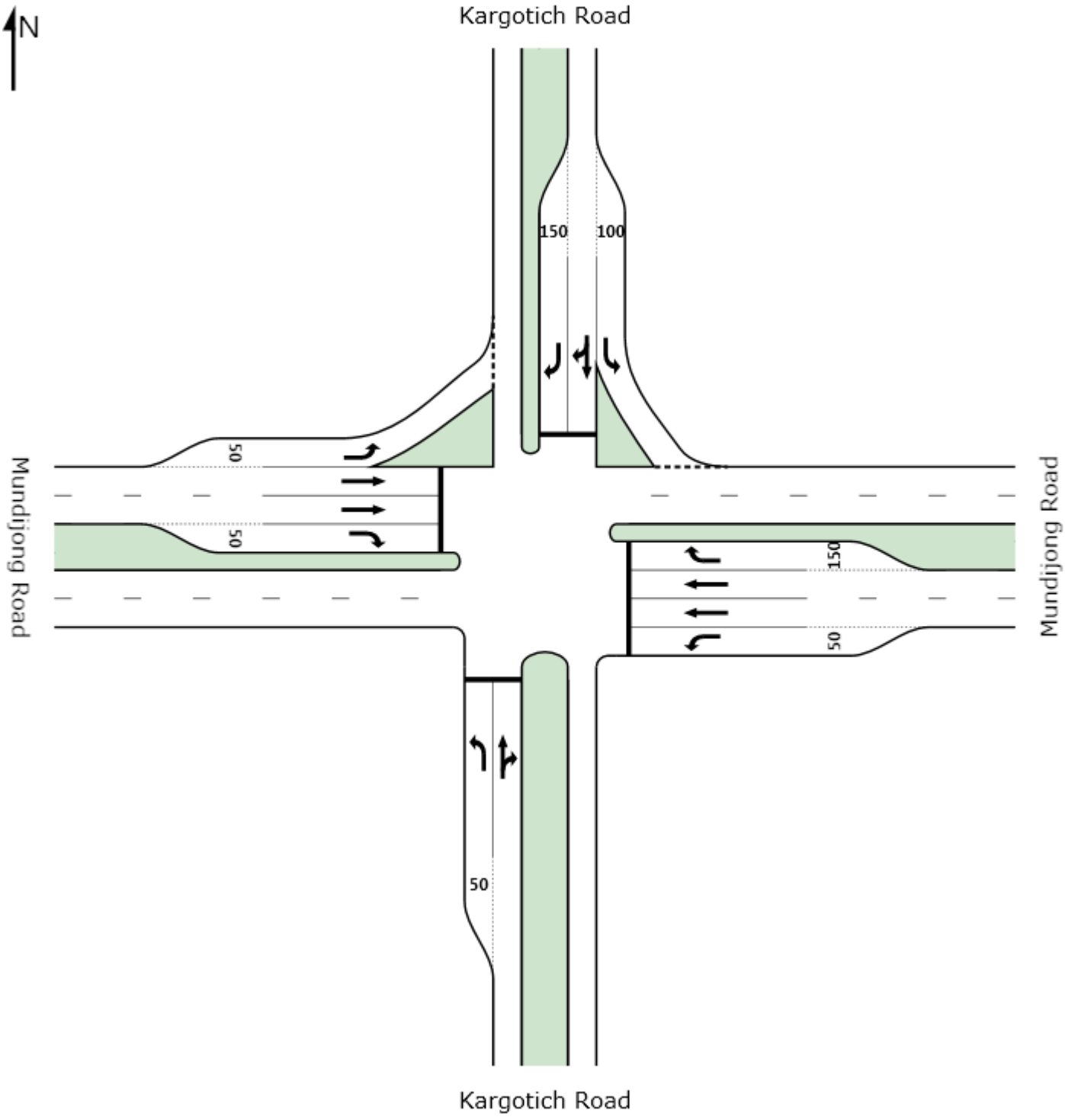
Mundijong Road/Kargotich Road
2031 PM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.033	116.8	LOS F	0.1	0.6	0.97	1.00	19.9
2	T	2	15.0	2.083	2027.5	LOS F	87.2	688.7	1.00	3.13	1.4
3	R	123	15.0	2.083	2027.4	LOS F	87.2	688.7	1.00	3.21	1.4
Approach		126	15.0	2.083	2012.3	LOS F	87.2	688.7	1.00	3.19	1.4
East: Mundijong Road											
4	L	69	15.0	4.479	6279.7	LOS F	1554.7	12282.0	1.00	0.00	0.4
5	T	1239	15.0	4.479	6265.8	LOS F	1554.7	12282.0	1.00	0.00	0.5
6	R	233	15.0	4.479	6279.6	LOS F	1554.7	12282.0	1.00	5.06	0.4
Approach		1541	15.0	4.479	6268.5	NA	1554.7	12282.0	1.00	0.77	0.5
North: Kargotich Road											
7	L	60	15.0	1.000[3]	96.9	LOS F	3.1	24.9	1.00	1.04	23.2
8	T	340	15.0	12.083	20011.3	LOS F	853.7	6744.2	1.00	5.79	0.1
9	R	385	15.0	12.083	20011.2	LOS F	853.7	6744.2	1.00	5.98	0.1
Approach		785	15.0	12.083	18489.1	LOS F	853.7	6744.2	1.00	5.52	0.2
West: Mundijong Road											
10	L	143	15.0	0.729	365.0	LOS F	134.0	1058.6	1.00	0.00	7.3
11	T	1103	15.0	0.729	351.1	LOS F	134.0	1058.6	1.00	0.00	7.4
12	R	1	15.0	0.729	364.9	LOS F	134.0	1058.6	1.00	1.31	7.3
Approach		1247	15.0	0.729	352.7	NA	134.0	1058.6	1.00	0.00	7.4
All Vehicles		3699	15.0	12.083	6722.7	NA	1554.7	12282.0	1.00	1.60	0.4

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

3 x = 1.00 due to short lane. Refer to the Lane Summary report for information about excess flow and related conditions.


N
Kargotich Road
150
100
50
50
Mundijong Road
150
50
Mundijong Road
50
Kargotich Road

MOVEMENT SUMMARY

Site: 2031 AM BG+Opt 1

Mundijong Road/Kargotich Road
2031 AM Background + Option 1 Traffic Volumes
Signals - Fixed Time Cycle Time = 70 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.007	46.5	LOS D	0.0	0.3	0.93	0.60	38.3
2	T	8	15.0	0.793	39.9	LOS D	4.5	35.7	1.00	0.88	35.0
3	R	109	15.0	0.793	54.0	LOS D	4.5	35.7	1.00	0.88	34.9
Approach		118	15.0	0.793	53.0	LOS D	4.5	35.7	1.00	0.88	35.0
East: Mundijong Road											
4	L	50	15.0	0.348	49.1	LOS D	1.7	13.8	0.98	0.74	37.0
5	T	931	15.0	0.458	9.4	LOS A	9.3	73.1	0.62	0.55	68.7
6	R	103	15.0	0.239	36.8	LOS D	2.9	22.6	0.83	0.79	44.1
Approach		1084	15.0	0.458	13.8	LOS B	9.3	73.1	0.66	0.58	63.0
North: Kargotich Road											
7	L	24	15.0	0.031	20.8	LOS C	0.3	2.6	0.53	0.73	58.7
8	T	10	15.0	0.354	35.2	LOS D	1.8	14.3	0.98	0.73	37.7
9	R	95	15.0	0.354	49.3	LOS D	1.9	14.7	0.98	0.75	37.2
Approach		129	15.0	0.354	42.9	LOS D	1.9	14.7	0.90	0.74	39.9
West: Mundijong Road											
10	L	202	15.0	0.224	15.3	LOS B	1.0	8.3	0.26	0.75	66.1
11	T	1224	15.0	0.861	29.9	LOS C	23.7	186.8	0.98	1.00	44.6
12	R	1	15.0	0.007	46.6	LOS D	0.0	0.3	0.93	0.60	38.3
Approach		1427	15.0	0.861	27.9	LOS C	23.7	186.8	0.88	0.96	46.7
All Vehicles		2758	15.0	0.861	24.1	LOS C	23.7	186.8	0.80	0.80	50.8

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2031 PM BG+Opt 1

Mundijong Road/Kargotich Road
2031 PM Background + Option 1 Traffic Volumes
Signals - Fixed Time Cycle Time = 70 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.006	45.3	LOS D	0.0	0.2	0.92	0.60	39.0
2	T	2	15.0	0.770	38.6	LOS D	4.8	37.6	1.00	0.88	35.5
3	R	123	15.0	0.770	52.7	LOS D	4.8	37.6	1.00	0.88	35.3
Approach		126	15.0	0.770	52.4	LOS D	4.8	37.6	1.00	0.87	35.4
East: Mundijong Road											
4	L	69	15.0	0.480	49.7	LOS D	2.5	19.4	0.99	0.76	36.7
5	T	1370	15.0	0.692	12.1	LOS B	17.0	134.0	0.78	0.70	63.3
6	R	88	15.0	0.204	36.5	LOS D	2.4	19.1	0.82	0.78	44.3
Approach		1527	15.0	0.692	15.2	LOS B	17.0	134.0	0.79	0.71	59.9
North: Kargotich Road											
7	L	55	15.0	0.069	20.6	LOS C	0.8	6.0	0.53	0.75	59.0
8	T	16	15.0	0.745	37.8	LOS D	4.8	37.6	1.00	0.86	36.1
9	R	240	15.0	0.745	51.9	LOS D	4.8	38.2	1.00	0.86	35.9
Approach		311	15.0	0.745	45.6	LOS D	4.8	38.2	0.92	0.84	38.6
West: Mundijong Road											
10	L	64	15.0	0.068	15.1	LOS B	0.3	2.1	0.22	0.74	66.4
11	T	1199	15.0	0.875	32.4	LOS C	24.1	190.5	0.99	1.03	42.9
12	R	1	15.0	0.007	46.6	LOS D	0.0	0.3	0.93	0.60	38.3
Approach		1264	15.0	0.875	31.6	LOS C	24.1	190.5	0.96	1.01	43.6
All Vehicles		3228	15.0	0.875	26.0	LOS C	24.1	190.5	0.87	0.85	48.9

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 2031 AM BG+Opt 3

Mundijong Road/Kargotich Road
2031 AM Background + Option 3 Traffic Volumes
Signals - Fixed Time Cycle Time = 70 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.007	46.5	LOS D	0.0	0.3	0.93	0.60	38.3
2	T	8	15.0	0.793	40.0	LOS D	4.5	35.8	1.00	0.88	35.0
3	R	109	15.0	0.793	54.1	LOS D	4.5	35.8	1.00	0.88	34.9
Approach		118	15.0	0.793	53.0	LOS D	4.5	35.8	1.00	0.88	35.0
East: Mundijong Road											
4	L	50	15.0	0.190	42.7	LOS D	1.5	12.2	0.90	0.75	40.4
5	T	897	15.0	0.442	9.3	LOS A	8.8	69.5	0.61	0.54	69.0
6	R	446	15.0	0.809	42.7	LOS D	16.1	126.8	0.98	0.93	40.4
Approach		1393	15.0	0.809	21.2	LOS C	16.1	126.8	0.74	0.67	55.3
North: Kargotich Road											
7	L	126	15.0	0.151	19.2	LOS B	1.5	12.2	0.49	0.77	60.8
8	T	10	15.0	0.510	35.9	LOS D	2.7	21.1	1.00	0.76	37.1
9	R	142	15.0	0.510	50.0	LOS D	2.7	21.6	1.00	0.77	36.8
Approach		278	15.0	0.510	35.5	LOS D	2.7	21.6	0.77	0.77	44.8
West: Mundijong Road											
10	L	388	15.0	0.702	22.2	LOS C	6.8	53.7	0.59	0.82	57.2
11	T	980	15.0	0.839	30.7	LOS C	18.4	145.6	0.99	0.97	44.0
12	R	1	15.0	0.007	46.6	LOS D	0.0	0.3	0.93	0.60	38.3
Approach		1369	15.0	0.839	28.3	LOS C	18.4	145.6	0.88	0.93	47.0
All Vehicles		3158	15.0	0.839	26.7	LOS C	18.4	145.6	0.81	0.80	49.4

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

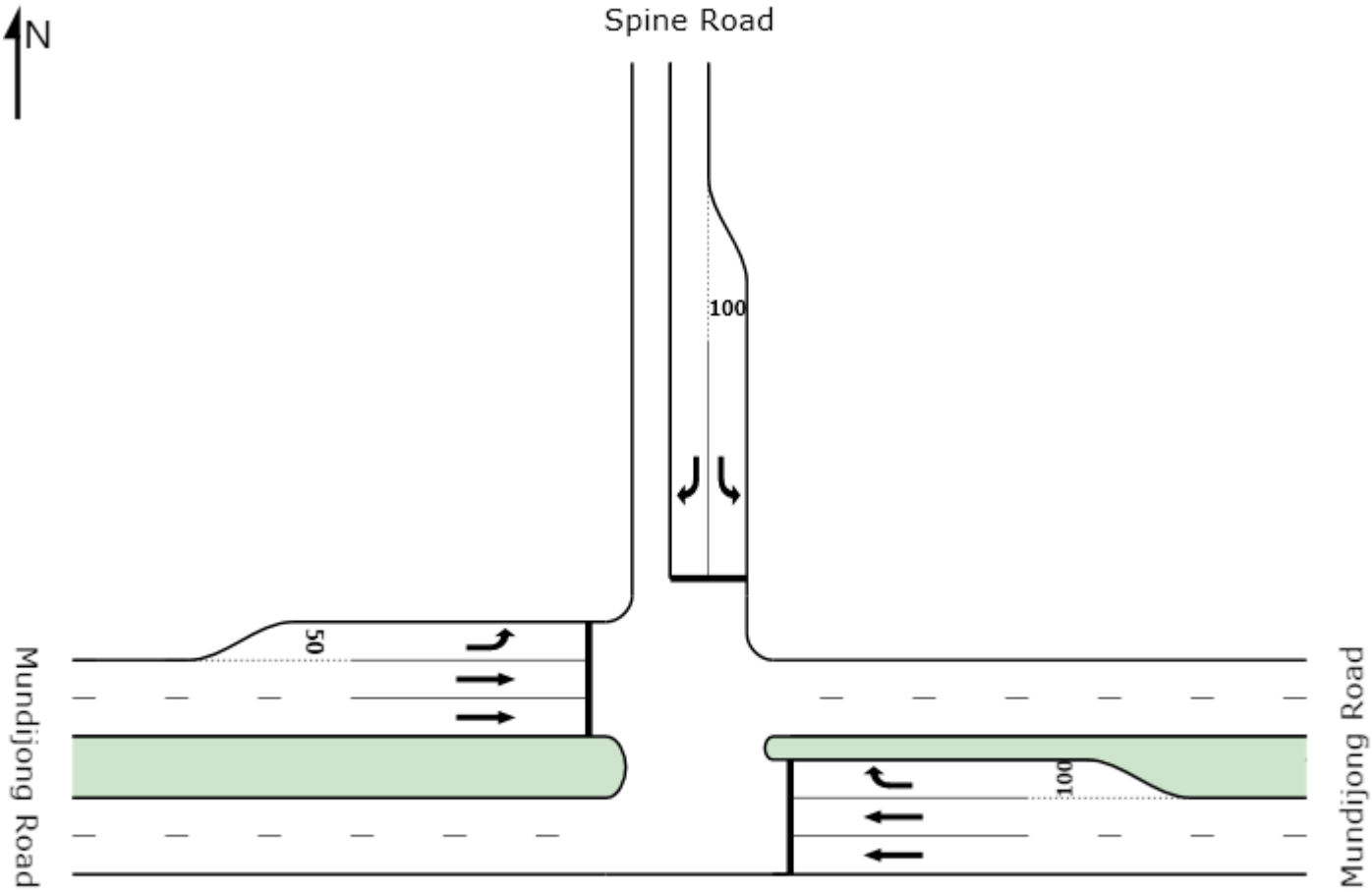
Site: 2031 PM BG+Opt 3

Mundijong Road/Kargotich Road
2031 PM Background + Option 3 Traffic Volumes
Signals - Fixed Time Cycle Time = 80 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
1	L	1	15.0	0.004	44.1	LOS D	0.0	0.3	0.85	0.62	39.6
2	T	2	15.0	0.534	34.9	LOS C	4.7	37.4	0.96	0.77	37.4
3	R	123	15.0	0.534	49.0	LOS D	4.7	37.4	0.96	0.80	37.1
Approach		126	15.0	0.534	48.8	LOS D	4.7	37.4	0.96	0.80	37.1
East: Mundijong Road											
4	L	69	15.0	0.548	56.0	LOS E	2.8	22.5	1.00	0.77	34.0
5	T	1239	15.0	0.649	14.2	LOS B	17.2	135.9	0.76	0.69	60.6
6	R	233	15.0	0.617	45.2	LOS D	8.5	67.0	0.95	0.83	39.0
Approach		1541	15.0	0.649	20.7	LOS C	17.2	135.9	0.80	0.71	54.3
North: Kargotich Road											
7	L	384	15.0	0.529	22.3	LOS C	7.3	57.9	0.65	0.82	57.0
8	T	16	15.0	0.816	42.0	LOS D	8.8	69.1	1.00	0.93	34.2
9	R	385	15.0	0.816	56.1	LOS E	8.8	69.1	1.00	0.93	34.0
Approach		785	15.0	0.816	39.3	LOS D	8.8	69.1	0.83	0.88	42.3
West: Mundijong Road											
10	L	143	15.0	0.206	16.5	LOS B	1.3	9.9	0.32	0.76	64.4
11	T	1103	15.0	0.801	27.5	LOS C	21.2	167.2	0.95	0.90	46.4
12	R	1	15.0	0.008	52.1	LOS D	0.0	0.3	0.94	0.60	35.6
Approach		1247	15.0	0.801	26.3	LOS C	21.2	167.2	0.88	0.88	47.9
All Vehicles		3699	15.0	0.816	27.5	LOS C	21.2	167.2	0.84	0.81	48.5

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.


N
Spine Road
100
50
100
Mundijong Road
Mundijong Road

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 1

Mundijong Road/Spine Road
2031 AM Background + Option 1 Traffic Volumes
Signals - Fixed Time Cycle Time = 75 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
East: Mundijong Road											
5	T	1050	15.0	0.396	3.6	LOS A	6.9	54.1	0.39	0.35	81.4
6	R	385	15.0	0.820	47.7	LOS D	15.2	120.2	1.00	0.92	31.4
Approach		1435	15.0	0.820	15.5	LOS B	15.2	120.2	0.55	0.50	61.1
North: Spine Road											
7	L	123	15.0	0.786	49.8	LOS D	5.0	39.8	1.00	0.95	28.7
9	R	34	15.0	0.217	44.1	LOS D	1.2	9.7	0.96	0.73	30.5
Approach		157	15.0	0.786	48.6	LOS D	5.0	39.8	0.99	0.90	29.1
West: Mundijong Road											
10	L	245	15.0	0.685	34.1	LOS C	6.9	54.7	0.76	0.84	39.6
11	T	1111	15.0	0.809	26.8	LOS C	20.5	161.6	0.96	0.91	47.0
Approach		1356	15.0	0.809	28.1	LOS C	20.5	161.6	0.92	0.90	45.8
All Vehicles		2948	15.0	0.820	23.1	LOS C	20.5	161.6	0.74	0.71	50.2

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

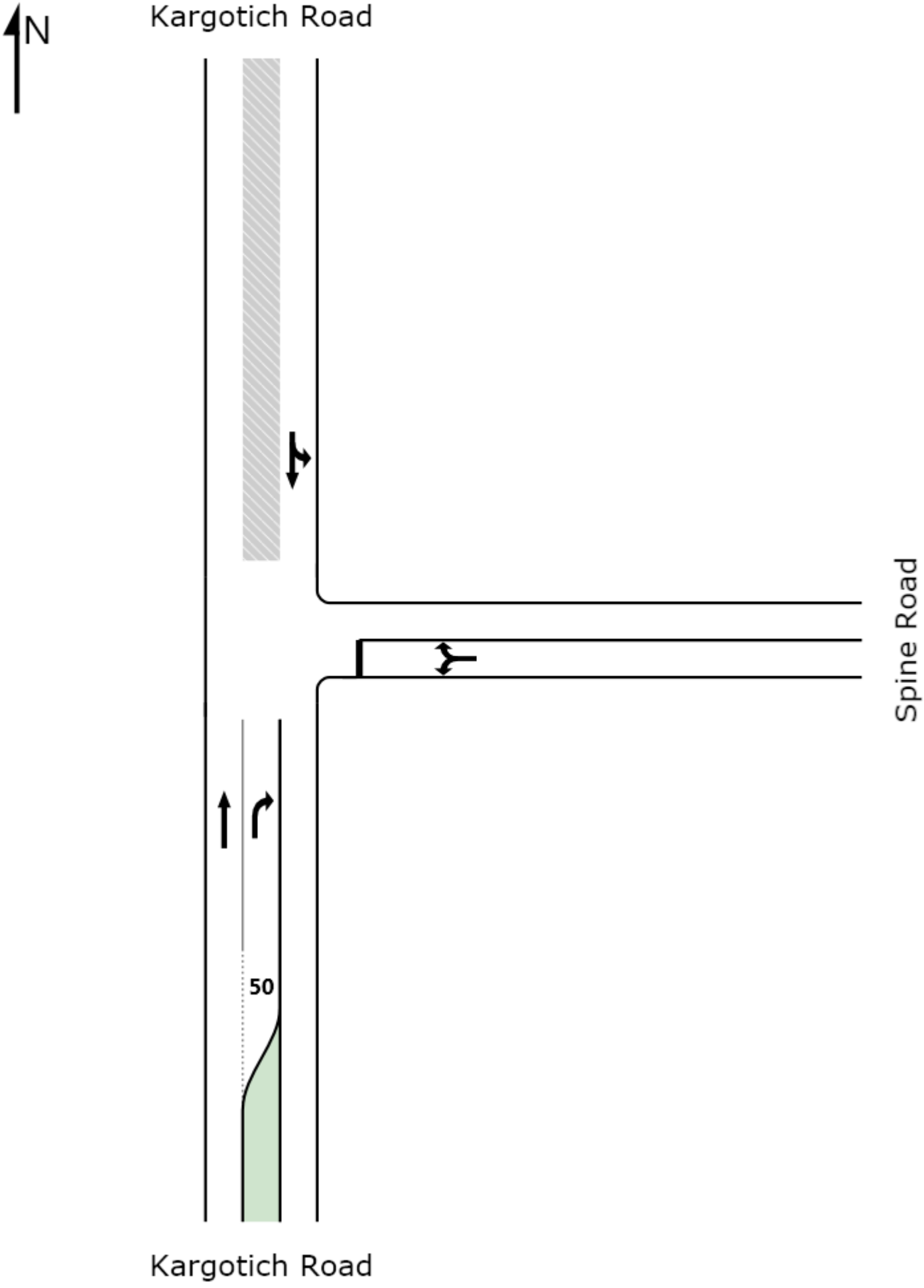
Site: 31 PM BG+Opt 1

Mundijong Road/Spine Road
2031 PM Background + Option 1 Traffic Volumes
Signals - Fixed Time Cycle Time = 95 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
East: Mundijong Road											
5	T	1395	15.0	0.666	14.1	LOS B	21.7	171.5	0.73	0.66	61.0
6	R	159	15.0	0.819	65.7	LOS E	8.2	64.4	1.00	0.90	24.7
Approach		1554	15.0	0.819	19.4	LOS B	21.7	171.5	0.76	0.69	54.8
North: Spine Road											
7	L	422	15.0	0.885	48.8	LOS D	20.7	163.2	1.00	0.93	29.0
9	R	131	15.0	0.275	36.7	LOS D	4.8	37.6	0.82	0.78	33.2
Approach		553	15.0	0.885	45.9	LOS D	20.7	163.2	0.96	0.90	29.9
West: Mundijong Road											
10	L	96	15.0	0.310	33.0	LOS C	2.8	21.9	0.66	0.78	40.4
11	T	1272	15.0	0.872	37.8	LOS D	32.2	254.7	0.99	0.99	39.7
Approach		1368	15.0	0.872	37.5	LOS D	32.2	254.7	0.97	0.98	39.8
All Vehicles		3475	15.0	0.885	30.7	LOS C	32.2	254.7	0.87	0.84	42.8

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.


N
Kargotich Road
Spine Road
50
Kargotich Road

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 3

Kargotich Road/Spine Road
2031 AM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
2	T	192	15.0	0.108	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
3	R	651	15.0	0.627	16.8	LOS C	6.2	48.8	0.46	0.75	59.2
Approach		843	15.0	0.627	13.0	NA	6.2	48.8	0.35	0.58	67.2
East: Spine Road											
4	L	155	15.0	0.213	13.3	LOS B	0.8	6.6	0.32	0.87	46.6
6	R	5	15.0	0.213	12.8	LOS B	0.8	6.6	0.32	1.03	47.1
Approach		160	15.0	0.213	13.3	LOS B	0.8	6.6	0.32	0.88	46.6
North: Kargotich Road											
7	L	5	15.0	0.072	14.3	LOS B	0.0	0.0	0.00	1.27	63.6
8	T	123	15.0	0.072	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
Approach		128	15.0	0.072	0.6	NA	0.0	0.0	0.00	0.05	98.4
All Vehicles		1131	15.0	0.627	11.6	NA	6.2	48.8	0.31	0.56	65.2

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

MOVEMENT SUMMARY

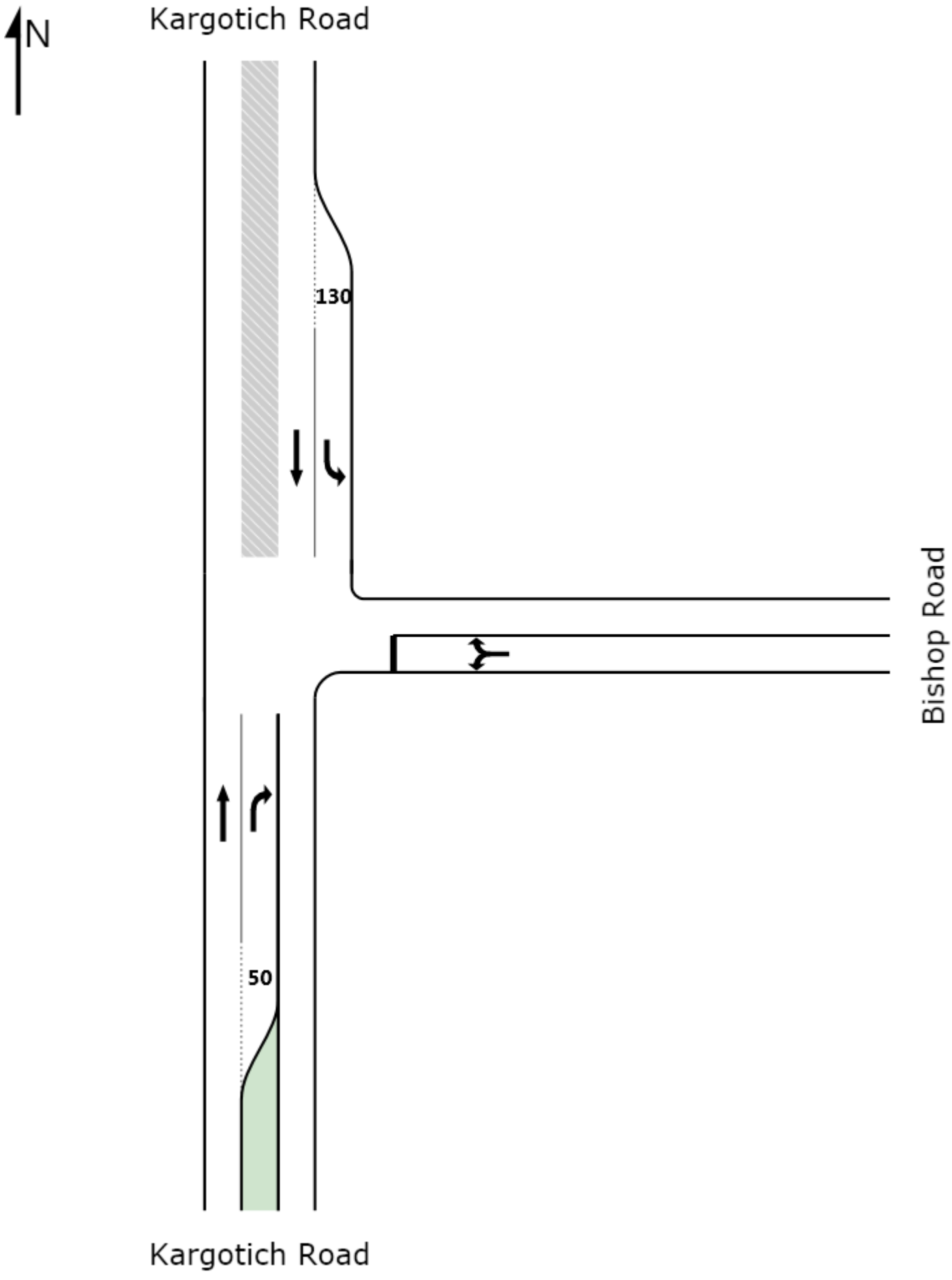
Site: 31 PM BG+Opt 3

Kargotich Road/Spine Road
2031 PM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
2	T	149	15.0	0.084	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
3	R	230	15.0	0.220	15.7	LOS C	1.0	7.8	0.37	0.75	61.0
Approach		379	15.0	0.220	9.5	NA	1.0	7.8	0.23	0.46	74.9
East: Spine Road											
4	L	601	15.0	0.719	17.2	LOS C	9.8	77.6	0.66	1.07	44.2
6	R	5	15.0	0.719	16.7	LOS C	9.8	77.6	0.66	1.16	44.7
Approach		606	15.0	0.719	17.2	LOS C	9.8	77.6	0.66	1.07	44.2
North: Kargotich Road											
7	L	5	15.0	0.107	14.3	LOS B	0.0	0.0	0.00	1.27	63.6
8	T	184	15.0	0.107	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
Approach		189	15.0	0.107	0.4	NA	0.0	0.0	0.00	0.03	98.9
All Vehicles		1174	15.0	0.719	12.0	NA	9.8	77.6	0.41	0.71	56.2

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.


N
Kargotich Road
130
Bishop Road
50
Kargotich Road

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 1

Kargotich Road/Bishop Road
2031 AM Background + Option 1 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
2	T	145	15.0	0.082	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
3	R	14	15.0	0.013	14.5	LOS B	0.0	0.3	0.05	0.76	63.2
Approach		159	15.0	0.082	1.3	NA	0.0	0.3	0.00	0.07	96.4
East: Bishop Road											
4	L	77	15.0	0.117	11.8	LOS B	0.5	3.6	0.02	0.98	47.3
6	R	28	15.0	0.117	11.6	LOS B	0.5	3.6	0.02	1.01	47.5
Approach		105	15.0	0.117	11.7	LOS B	0.5	3.6	0.02	0.98	47.3
North: Kargotich Road											
7	L	5	15.0	0.003	14.3	LOS B	0.0	0.0	0.00	0.77	63.6
8	T	2	15.0	0.001	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
Approach		7	15.0	0.003	10.2	NA	0.0	0.0	0.00	0.55	73.1
All Vehicles		271	15.0	0.117	5.6	NA	0.5	3.6	0.01	0.43	68.3

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

MOVEMENT SUMMARY

Site: 31 PM BG+Opt 1

Kargotich Road/Bishop Road
2031 AM Background + Option 1 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
2	T	95	15.0	0.053	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
3	R	64	15.0	0.061	14.6	LOS B	0.2	1.6	0.12	0.73	62.7
Approach		159	15.0	0.061	5.9	NA	0.2	1.6	0.05	0.30	83.8
East: Bishop Road											
4	L	27	15.0	0.042	11.9	LOS B	0.2	1.2	0.09	0.93	47.3
6	R	10	15.0	0.042	11.7	LOS B	0.2	1.2	0.09	0.98	47.5
Approach		37	15.0	0.042	11.8	LOS B	0.2	1.2	0.09	0.95	47.4
North: Kargotich Road											
7	L	22	15.0	0.013	14.3	LOS B	0.0	0.0	0.00	0.77	63.6
8	T	10	15.0	0.006	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
Approach		32	15.0	0.013	9.8	NA	0.0	0.0	0.00	0.53	74.0
All Vehicles		228	15.0	0.061	7.4	NA	0.2	1.6	0.05	0.43	72.6

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 3

Kargotich Road/Bishop Road
2031 AM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
2	T	142	15.0	0.080	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
3	R	301	15.0	0.287	14.7	LOS B	1.2	9.2	0.20	0.70	62.2
Approach		443	15.0	0.287	10.0	NA	1.2	9.2	0.13	0.48	73.2
East: Bishop Road											
4	L	201	15.0	0.237	12.1	LOS B	1.0	8.1	0.07	0.95	47.1
6	R	17	15.0	0.237	11.9	LOS B	1.0	8.1	0.07	1.02	47.4
Approach		218	15.0	0.237	12.1	LOS B	1.0	8.1	0.07	0.95	47.2
North: Kargotich Road											
7	L	31	15.0	0.018	14.3	LOS B	0.0	0.0	0.00	0.77	63.6
8	T	1	15.0	0.001	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
Approach		32	15.0	0.018	13.8	NA	0.0	0.0	0.00	0.74	64.6
All Vehicles		693	15.0	0.287	10.8	NA	1.2	9.2	0.11	0.64	60.8

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

MOVEMENT SUMMARY

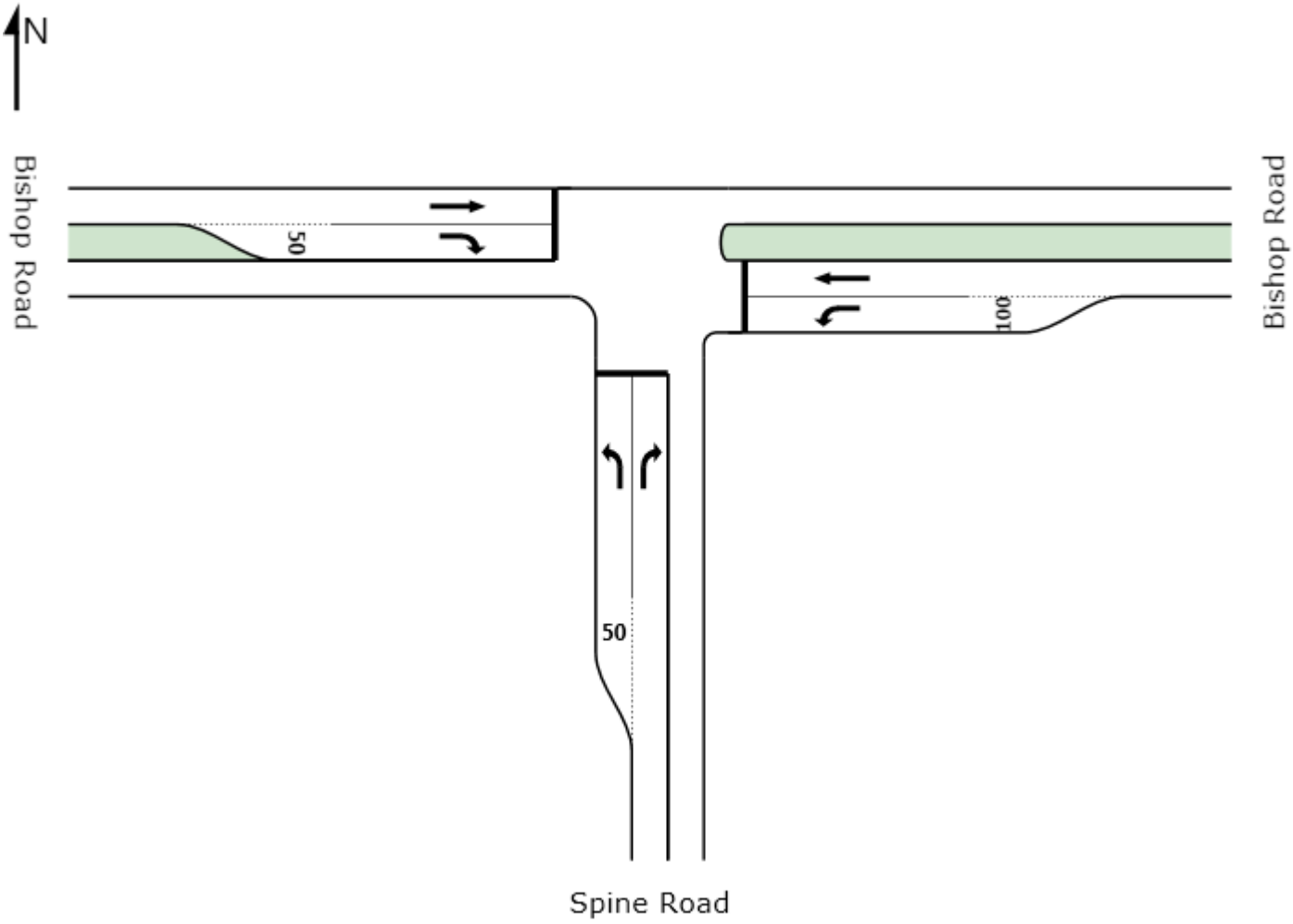
Site: 31 PM BG+Opt 3

Kargotich Road/Bishop Road
2031 AM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Kargotich Road											
2	T	94	15.0	0.053	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
3	R	250	15.0	0.238	14.6	LOS B	0.9	7.2	0.19	0.70	62.2
Approach		344	15.0	0.238	10.6	NA	0.9	7.2	0.13	0.51	71.5
East: Bishop Road											
4	L	221	15.0	0.220	11.4	LOS B	1.0	7.5	0.07	0.95	47.6
6	R	6	15.0	0.220	11.2	LOS B	1.0	7.5	0.07	1.02	47.9
Approach		227	15.0	0.220	11.4	LOS B	1.0	7.5	0.07	0.95	47.7
North: Kargotich Road											
7	L	14	15.0	0.008	14.3	LOS B	0.0	0.0	0.00	0.77	63.6
8	T	6	15.0	0.003	0.0	LOS A	0.0	0.0	0.00	0.00	100.0
Approach		20	15.0	0.008	10.0	NA	0.0	0.0	0.00	0.54	73.6
All Vehicles		591	15.0	0.238	10.9	NA	1.0	7.5	0.10	0.68	58.8

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.


N
Bishop Road
Bishop Road
50
100
50
Spine Road

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 1

Bishop Road/Spine Road
2031 AM Background + Option 1 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.008	13.4	LOS B	0.0	0.2	0.49	0.86	39.1
3	R	341	15.0	0.576	17.9	LOS C	4.1	32.2	0.69	1.19	36.2
Approach		346	15.0	0.576	17.8	LOS C	4.1	32.2	0.69	1.19	36.3
East: Bishop Road											
4	L	678	15.0	0.404	6.8	LOS A	0.0	0.0	0.00	0.61	43.3
5	T	106	15.0	0.060	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
Approach		784	15.0	0.404	5.9	NA	0.0	0.0	0.00	0.53	44.1
West: Bishop Road											
11	T	18	15.0	0.010	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
12	R	5	15.0	0.008	11.8	LOS B	0.0	0.2	0.63	0.71	39.3
Approach		23	15.0	0.010	2.6	NA	0.0	0.2	0.14	0.16	47.2
All Vehicles		1153	15.0	0.576	9.4	NA	4.1	32.2	0.21	0.72	41.5

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

MOVEMENT SUMMARY

Site: 31 PM BG+Opt 1

Bishop Road/Spine Road
2031 PM Background + Option 1 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.006	11.4	LOS B	0.0	0.2	0.34	0.84	40.3
3	R	635	15.0	0.863	24.0	LOS C	17.0	134.0	0.89	1.66	33.0
Approach		640	15.0	0.863	23.9	LOS C	17.0	134.0	0.88	1.65	33.0
East: Bishop Road											
4	L	367	15.0	0.219	6.8	LOS A	0.0	0.0	0.00	0.61	43.3
5	T	37	15.0	0.021	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
Approach		404	15.0	0.219	6.2	NA	0.0	0.0	0.00	0.56	43.8
West: Bishop Road											
11	T	86	15.0	0.048	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
12	R	5	15.0	0.005	8.7	LOS A	0.0	0.2	0.47	0.60	41.6
Approach		91	15.0	0.048	0.5	NA	0.0	0.2	0.03	0.03	49.4
All Vehicles		1135	15.0	0.863	15.7	NA	17.0	134.0	0.50	1.13	37.3

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 3

Bishop Road/Spine Road
2031 AM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.011	15.3	LOS C	0.0	0.3	0.58	0.89	37.8
3	R	123	15.0	0.417	25.0	LOS D	1.8	13.9	0.82	1.09	32.4
Approach		128	15.0	0.417	24.6	LOS C	1.8	13.9	0.81	1.09	32.5
East: Bishop Road											
4	L	771	15.0	0.460	6.8	LOS A	0.0	0.0	0.00	0.61	43.3
5	T	216	15.0	0.122	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
Approach		987	15.0	0.460	5.3	NA	0.0	0.0	0.00	0.48	44.6
West: Bishop Road											
11	T	304	15.0	0.171	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
12	R	5	15.0	0.011	14.5	LOS B	0.0	0.3	0.73	0.80	37.3
Approach		309	15.0	0.171	0.2	NA	0.0	0.3	0.01	0.01	49.7
All Vehicles		1424	15.0	0.460	6.0	NA	1.8	13.9	0.08	0.43	44.1

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.

MOVEMENT SUMMARY

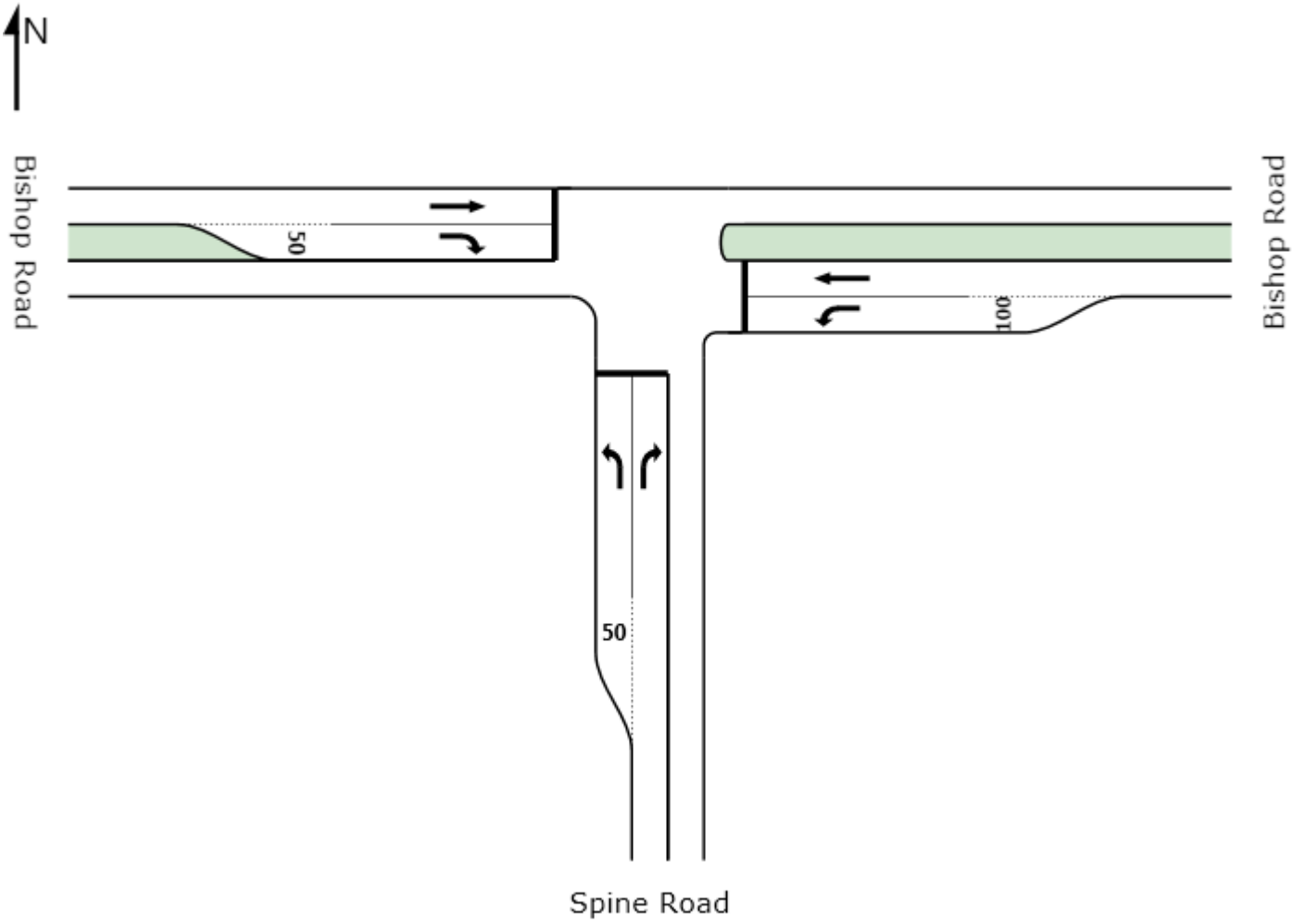
Site: 31 PM BG+Opt 3

Bishop Road/Spine Road
2031 PM Background + Option 3 Traffic Volumes
Stop (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.007	12.5	LOS B	0.0	0.2	0.45	0.84	39.6
3	R	656	15.0	1.417	777.4	LOS F	252.2	1992.2	1.00	14.36	2.5
Approach		661	15.0	1.417	771.6	LOS F	252.2	1992.2	1.00	14.26	2.6
East: Bishop Road											
4	L	273	15.0	0.163	6.8	LOS A	0.0	0.0	0.00	0.61	43.3
5	T	227	15.0	0.128	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
Approach		500	15.0	0.163	3.7	NA	0.0	0.0	0.00	0.33	46.1
West: Bishop Road											
11	T	264	15.0	0.149	0.0	LOS A	0.0	0.0	0.00	0.00	50.0
12	R	5	15.0	0.005	9.3	LOS A	0.0	0.2	0.52	0.62	41.1
Approach		269	15.0	0.149	0.2	NA	0.0	0.2	0.01	0.01	49.8
All Vehicles		1430	15.0	1.417	358.0	NA	252.2	1992.2	0.46	6.71	5.2

Level of Service (LOS) Method: Delay (HCM 2000).
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 used.


N
Bishop Road
Bishop Road
50
100
50
Spine Road

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 1

Bishop Road/Spine Road
2031 AM Background + Option 1 Traffic Volumes
Signals - Fixed Time Cycle Time = 65 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.015	28.6	LOS C	0.1	1.0	0.81	0.65	29.7
3	R	341	15.0	0.944	59.0	LOS E	16.1	127.4	1.00	1.27	20.7
Approach		346	15.0	0.944	58.6	LOS E	16.1	127.4	1.00	1.26	20.8
East: Bishop Road											
4	L	678	15.0	0.973	27.4	LOS C	21.6	170.8	1.00	0.90	30.3
5	T	106	15.0	0.144	12.8	LOS B	2.1	16.6	0.65	0.52	36.9
Approach		784	15.0	0.973	25.4	LOS C	21.6	170.8	0.95	0.85	31.0
West: Bishop Road											
11	T	18	15.0	0.017	5.6	LOS A	0.2	1.8	0.42	0.30	42.9
12	R	5	15.0	0.032	37.4	LOS D	0.2	1.2	0.93	0.65	26.4
Approach		23	15.0	0.032	12.5	LOS B	0.2	1.8	0.53	0.38	37.8
All Vehicles		1153	15.0	0.973	35.1	LOS D	21.6	170.8	0.96	0.96	27.1

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 31 PM BG+Opt 1

Bishop Road/Spine Road
2031 PM Background + Option 1 Traffic Volumes
Signals - Fixed Time Cycle Time = 95 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.014	20.7	LOS C	0.1	0.9	0.54	0.64	33.6
3	R	635	15.0	0.799	32.6	LOS C	26.7	210.5	0.91	0.90	28.1
Approach		640	15.0	0.799	32.5	LOS C	26.7	210.5	0.91	0.90	28.2
East: Bishop Road											
4	L	367	15.0	0.799	46.3	LOS D	17.4	137.6	0.99	0.93	23.7
5	T	37	15.0	0.076	27.5	LOS C	1.3	10.0	0.77	0.58	29.0
Approach		404	15.0	0.799	44.6	LOS D	17.4	137.6	0.97	0.90	24.1
West: Bishop Road											
11	T	86	15.0	0.121	19.2	LOS B	2.5	19.7	0.66	0.53	33.1
12	R	5	15.0	0.047	54.4	LOS D	0.2	1.8	0.96	0.65	21.7
Approach		91	15.0	0.121	21.1	LOS C	2.5	19.7	0.68	0.53	32.1
All Vehicles		1135	15.0	0.799	35.9	LOS D	26.7	210.5	0.91	0.87	26.8

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

MOVEMENT SUMMARY

Site: 31 AM BG+Opt 3

Bishop Road/Spine Road
2031 AM Background + Option 3 Traffic Volumes
Signals - Fixed Time Cycle Time = 60 seconds (Optimum Cycle Time - Minimum Delay)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.030	34.4	LOS C	0.1	1.1	0.92	0.65	27.5
3	R	123	15.0	0.733	39.6	LOS D	4.0	31.6	1.00	0.91	25.7
Approach		128	15.0	0.733	39.4	LOS D	4.0	31.6	1.00	0.90	25.8
East: Bishop Road											
4	L	758	15.0	1.000[3]	21.8	LOS C	20.7	163.2	0.98	0.90	33.0
5	T	229	15.0	0.259	9.3	LOS A	3.9	30.7	0.61	0.51	39.3
Approach		987	15.0	1.000	18.9	LOS B	20.7	163.2	0.90	0.81	34.2
West: Bishop Road											
11	T	304	15.0	0.244	3.5	LOS A	3.2	25.4	0.39	0.33	44.9
12	R	5	15.0	0.030	34.6	LOS C	0.1	1.1	0.92	0.65	27.4
Approach		309	15.0	0.244	4.0	LOS A	3.2	25.4	0.39	0.34	44.5
All Vehicles		1424	15.0	1.000	17.5	LOS B	20.7	163.2	0.80	0.71	34.9

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

3 x = 1.00 due to short lane. Refer to the Lane Summary report for information about excess flow and related conditions.

MOVEMENT SUMMARY

Site: 31 PM BG+Opt 3

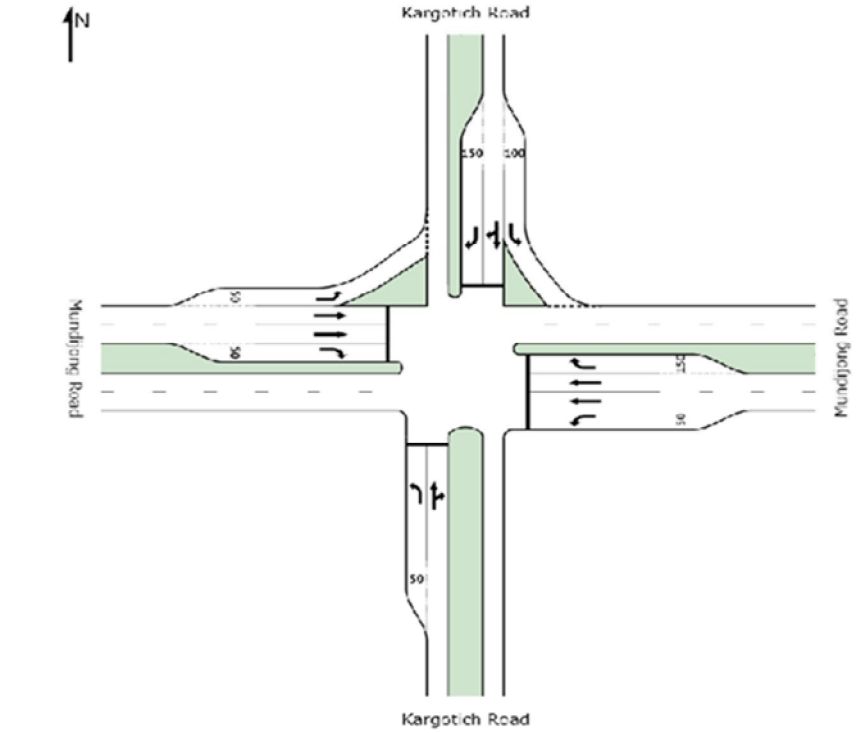
Bishop Road/Spine Road
2031 PM Background + Option 3 Traffic Volumes
Signals - Fixed Time Cycle Time = 80 seconds (Optimum Cycle Time - Minimum Delay)

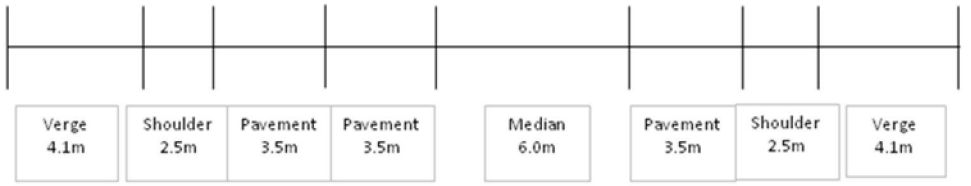
Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Spine Road											
1	L	5	15.0	0.012	17.9	LOS B	0.1	0.8	0.53	0.64	35.2
3	R	656	15.0	0.802	29.2	LOS C	23.8	188.2	0.91	0.91	29.5
Approach		661	15.0	0.802	29.2	LOS C	23.8	188.2	0.90	0.91	29.5
East: Bishop Road											
4	L	273	15.0	0.766	42.9	LOS D	11.1	87.3	1.00	0.92	24.7
5	T	227	15.0	0.601	31.6	LOS C	8.3	65.3	0.95	0.79	27.3
Approach		500	15.0	0.766	37.8	LOS D	11.1	87.3	0.98	0.86	25.8
West: Bishop Road											
11	T	264	15.0	0.410	20.8	LOS C	7.8	61.6	0.80	0.67	32.1
12	R	5	15.0	0.040	45.9	LOS D	0.2	1.5	0.95	0.65	23.8
Approach		269	15.0	0.410	21.2	LOS C	7.8	61.6	0.80	0.67	31.8
All Vehicles		1430	15.0	0.802	30.7	LOS C	23.8	188.2	0.91	0.85	28.5

Level of Service (LOS) Method: Delay (HCM 2000).
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
SIDRA Standard Delay Model used.

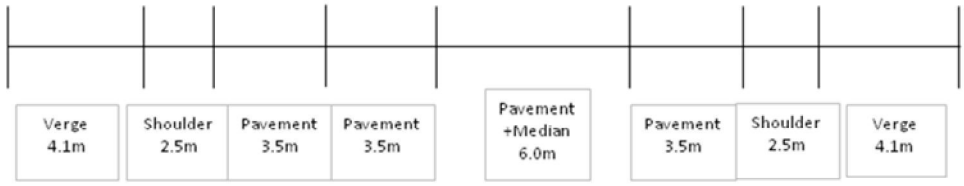
APPENDIX E
GEOMETRIC DESIGN





Kargotich Road South

Total road reserve width required = 29.7m

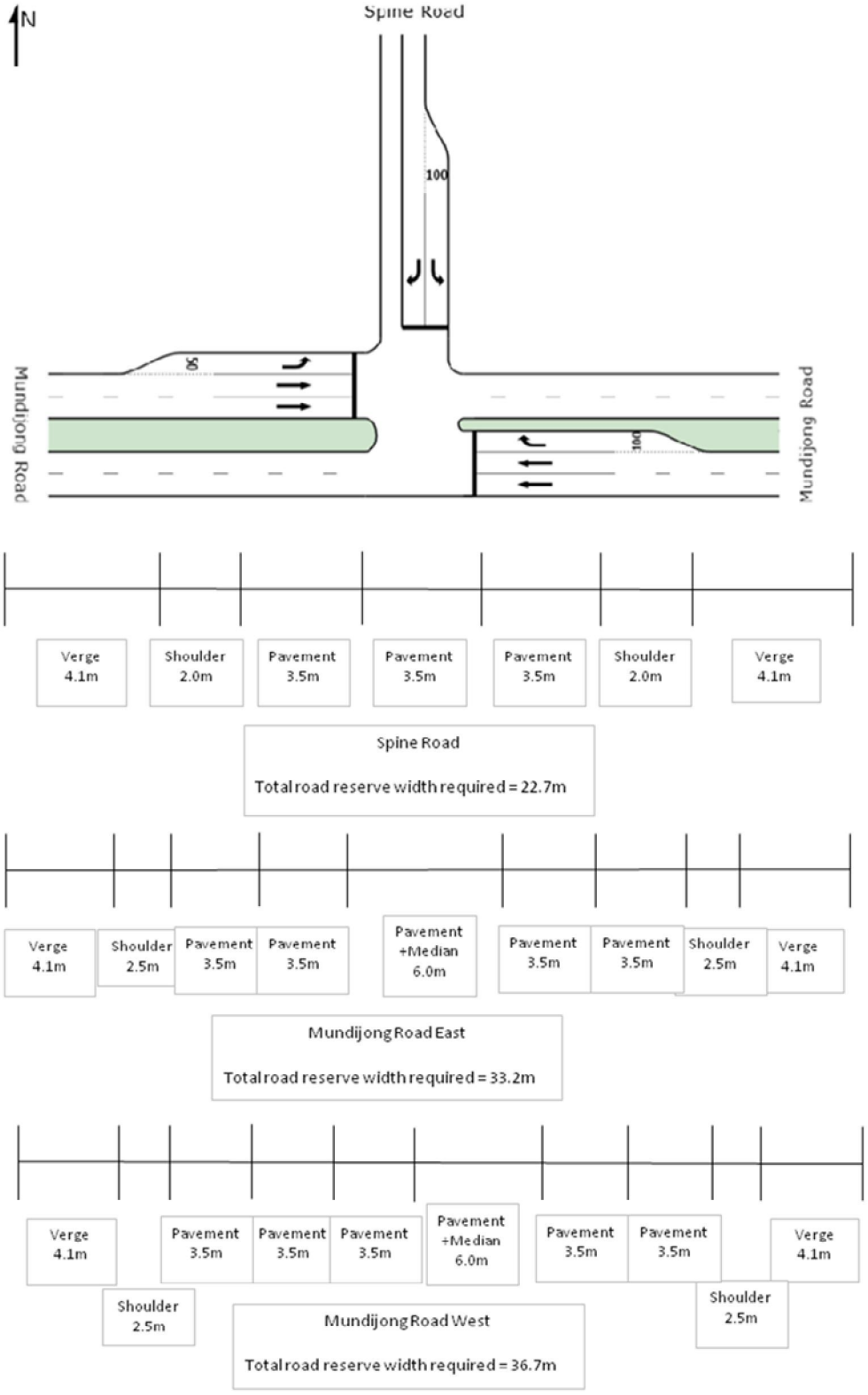


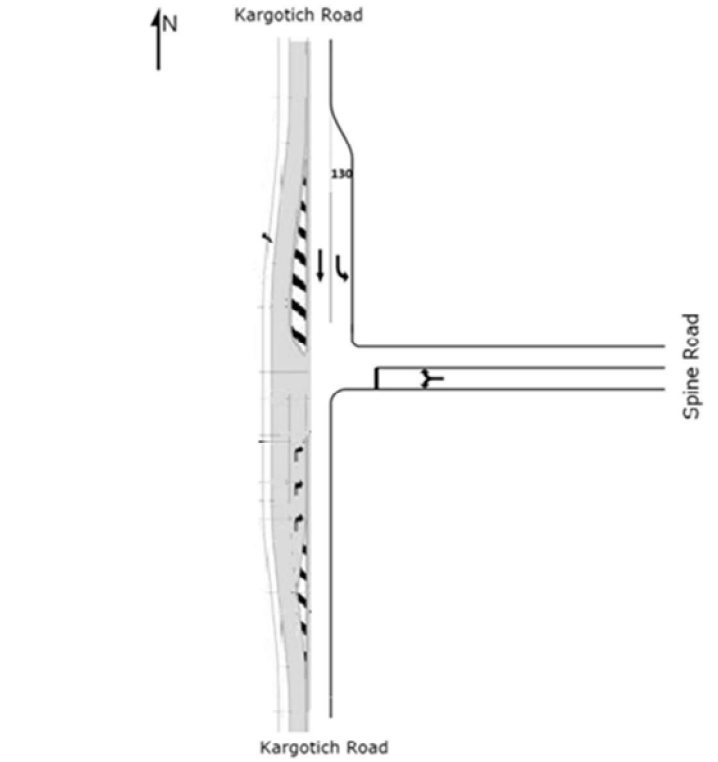
Kargotich Road North

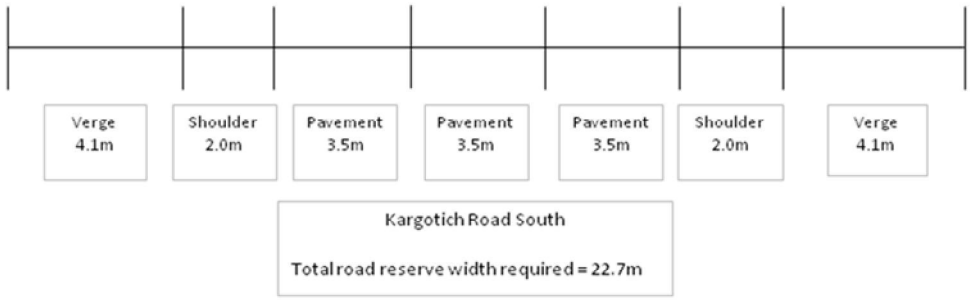
Total road reserve width required = 29.7m

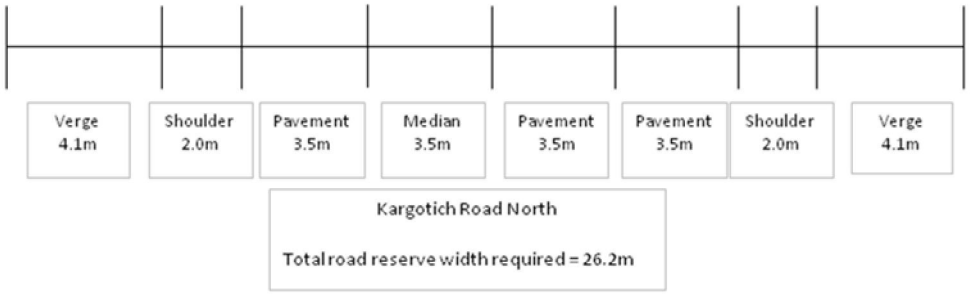
Mundijong Road

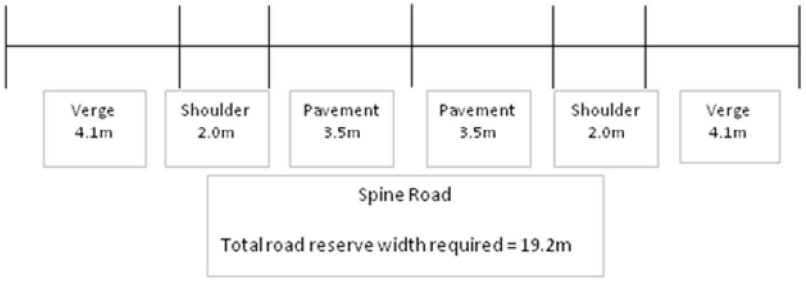
Total road reserve width required = 36.7m

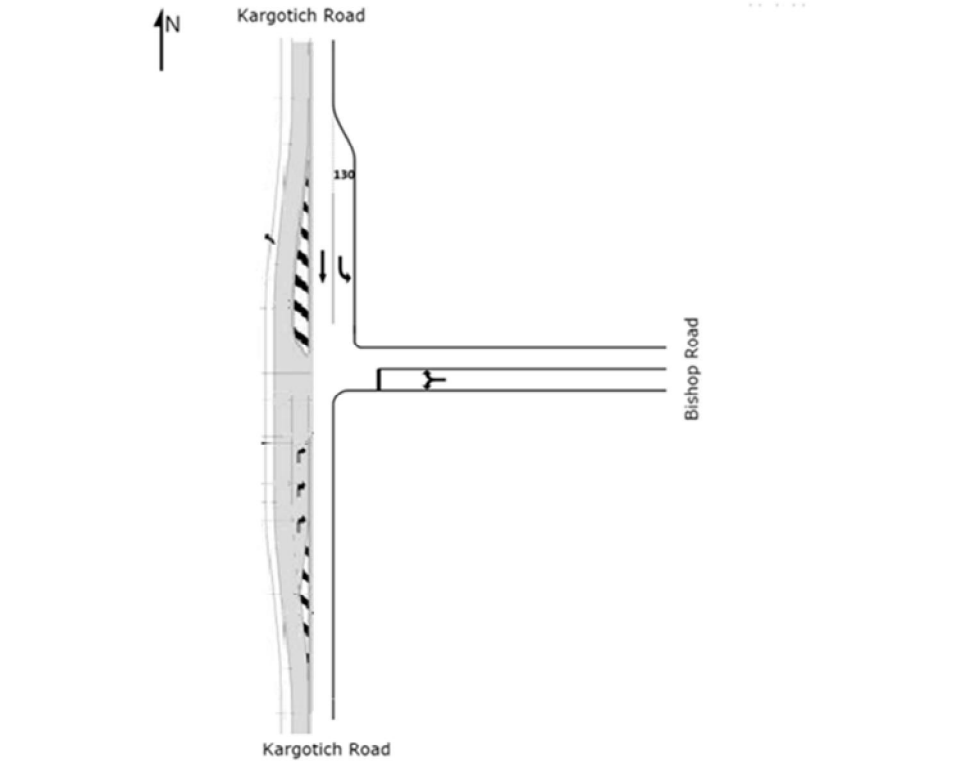

N
Spine Road
100
Mundijong Road
Mundijong Road
Verge 4.1m
Shoulder 2.0m
Pavement 3.5m
Pavement 3.5m
Pavement 3.5m
Shoulder 2.0m
Verge 4.1m
Spine Road
Total road reserve width required = 22.7m
Verge 4.1m
Shoulder 2.5m
Pavement 3.5m
Pavement 3.5m
Pavement +Median 6.0m
Pavement 3.5m
Pavement 3.5m
Shoulder 2.5m
Verge 4.1m
Mundijong Road East
Total road reserve width required = 33.2m
Verge 4.1m
Shoulder 2.5m
Pavement 3.5m
Pavement 3.5m
Pavement 3.5m
Pavement +Median 6.0m
Pavement 3.5m
Pavement 3.5m
Shoulder 2.5m
Verge 4.1m
Mundijong Road West
Total road reserve width required = 36.7m


N
Kargotich Road
130
Spine Road
Kargotich Road


Verge 4.1m
Shoulder 2.0m
Pavement 3.5m
Pavement 3.5m
Pavement 3.5m
Shoulder 2.0m
Verge 4.1m
Kargotich Road South
Total road reserve width required = 22.7m

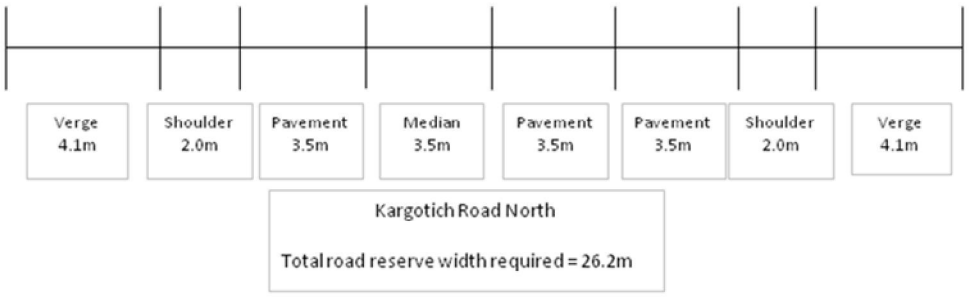

Verge 4.1m
Shoulder 2.0m
Pavement 3.5m
Median 3.5m
Pavement 3.5m
Pavement 3.5m
Shoulder 2.0m
Verge 4.1m
Kargotich Road North
Total road reserve width required = 26.2m


Verge 4.1m
Shoulder 2.0m
Pavement 3.5m
Pavement 3.5m
Shoulder 2.0m
Verge 4.1m
Spine Road
Total road reserve width required = 19.2m



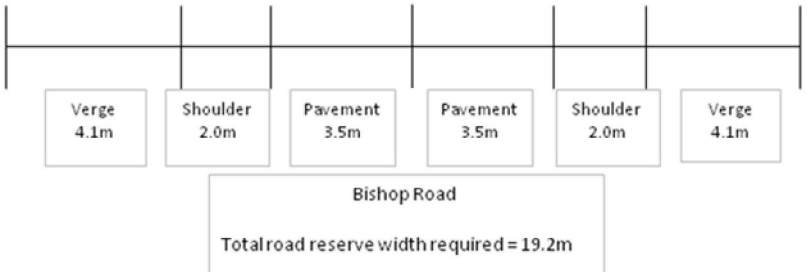
Kargotich Road South

Total road reserve width required = 22.7m



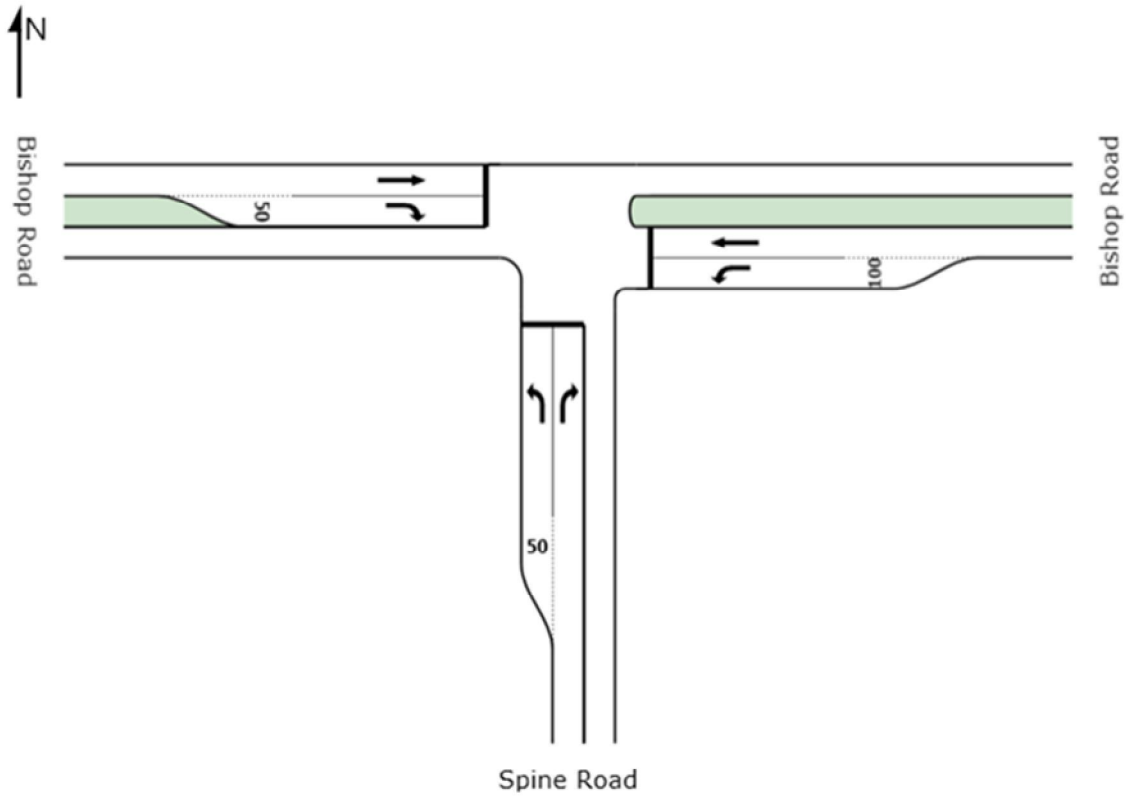
Kargotich Road North

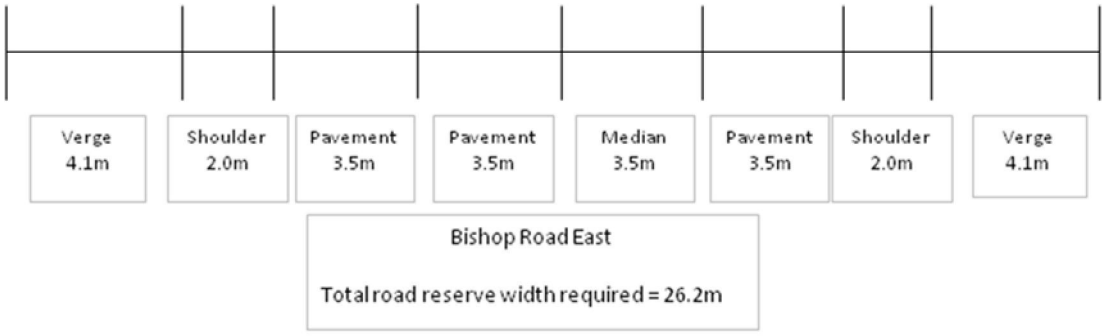
Total road reserve width required = 26.2m



Bishop Road

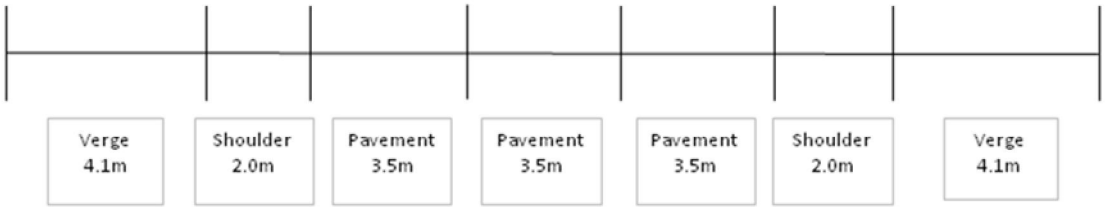
Total road reserve width required = 19.2m





Bishop Road East

Total road reserve width required = 26.2m



Spine Road
Bishop Road West

Total road reserve width required = 22.7m

APPENDIX E

Bushfire Assessment

West Mundijong Industrial Area
Bushfire Hazard Assessment

Prepared by Calibre Consulting
for the Shire of Serpentine Jarrahdale

Version A
July 2015

Job No. 15140

COMMERCIAL IN CONFIDENCE

TME Town Planning Management Engineering Pty Ltd
Trading as

Brown Consulting (Aust)

Unit 5, 53 Victoria Street
Bunbury WA 6230

PO Box 733
Bunbury WA 6231

Ph: 08 9791 4411

DOCUMENT CONTROL

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Issue	Date	Issue Details	Author	Checked
A	24/07/2015	Preliminary for review	GL	

TABLE OF CONTENTS

FIGURES

APPENDICES

1 INTRODUCTION

TME Town Planning Management Engineering Pty Ltd trading as Calibre Consulting (Aust) has been engaged to prepare a Bushfire Hazard Assessment for the West Mundijong Industrial area.

The subject land is located on the western side of the Mundijong townsite as shown in Figure 1. It is bounded by Mundijong Road (south), Tonkin Highway Road reserve (east), Kwinana freight rail (north) and Kargotich Road (west) and has an overall area of approximately 474 hectares.

This report has been prepared to ensure that appropriate regard will be given to Planning for Bush Fire Protection Guidelines (2010) in the proposed subdivision design and development of the site. The aim is to ensure that bush fire hazards are considered at all stages of the planning process so as to avoid increased fire risk to life and property through inappropriately located or designed land use and development.

The site is subject to Amendment No 187 to the Shire of Serpentine Jarrahdale Town Planning Scheme No 2. This proposes to include the land in the Urban Development zone with special conditions being added to Appendix 15 of the Scheme.

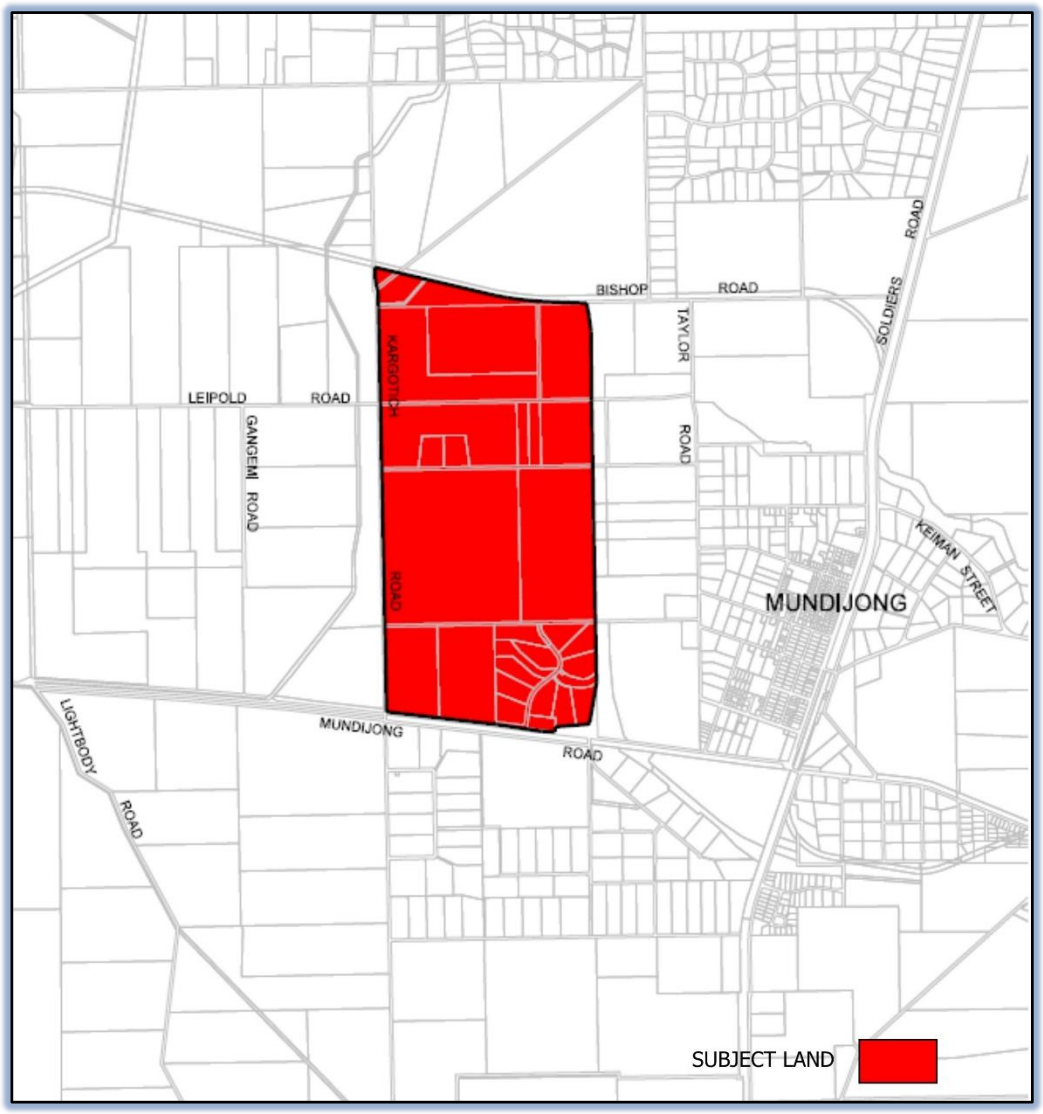


Figure 1 Location Plan

2 EXISTING CONDITIONS

There are twenty eight existing allotments of various sizes and a drainage reserve as shown in Figure 2. The land is predominantly cleared and used for general farming in particular grazing. There is also a concentration of rural lifestyle development in the south eastern margins of the area around Pure Steel Lane.

The existing site conditions are shown in Figure 3 and site photographs are contained in Appendix 1.

Manjedal Brook extends across the northern portion of the site and there are wetlands on the eastern portion of the site. Bush Forever Site No 360 extends along Mundijong Road.

There is a transmission line along Kargotich Road and a railway line on the northern boundary.

The site gently slopes from downwards from east to west with elevations ranging from approximately 25m AHD to 15m AHD.

Mundijong[1] has a mean maximum temperature ranging between 15 degrees in July to 30 degrees in January. There is an average rainfall of 1156mm per annum.

It has an annual average of:

- 60 days with temperature greater than 30 degrees;
- 16 days above 35 degrees; and
- 1 day above 40 degrees.

In summer (February) there is typically

- A morning easterly breeze of an average speed of 14 kmh; and
- An afternoon sea breeze from the south west of 14 kmh.

The morning easterly breezes are often stronger “katabatic” winds coming off the escarpment. They typically occur between December and April each year.

The vegetation on the site is described as[2]:

- Completely cleared containing pasture grasses, which is the predominant vegetation type over the entire site;
- Casuarina obesa (Sheoak) Woodland over pasture grasses which is dominant in the south western corner of the site;
- Melaleuca rhaphiophylla (Paperbark) Woodland over pasture grasses which is associated with the Conservation Category Wetland and has some Eucalyptus rudis (Flooded Gum).
- Corymbia calophylla Woodland over pasture grasses which is mainly in the area around Scott Road.
- Kingia australis and Melaleuca rhaphiophylla over pasture grasses, which occurs in the north of the site near Bishop Road.

Many exotic Australian native trees and shrubs have been planted in road reserves and paddock fence-lines including Rose Gums (Eucalyptus grandis), Broad-leafed Paperbark (Melaleuca quinquenervia), Swamp Mahogany (E. robusta) and River Red Gum (E. camaldulensis).

[1] Bureau Meteorology Karnet weather station – site no 9111
[2] PGV Environmental 2012 West Mundijong Industrial Area Environmental Assessment Page 19

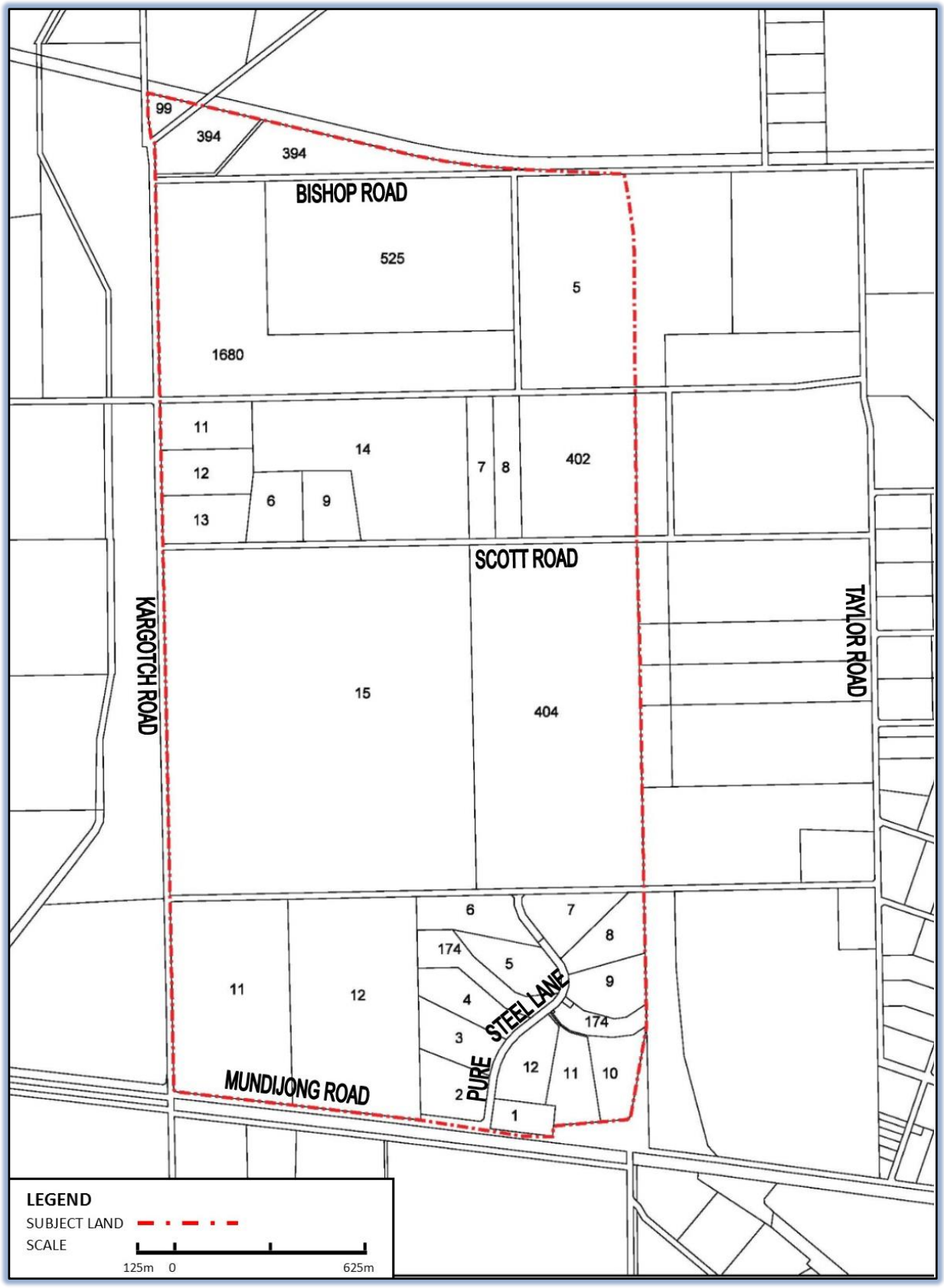


Figure 2 Cadastral Plan

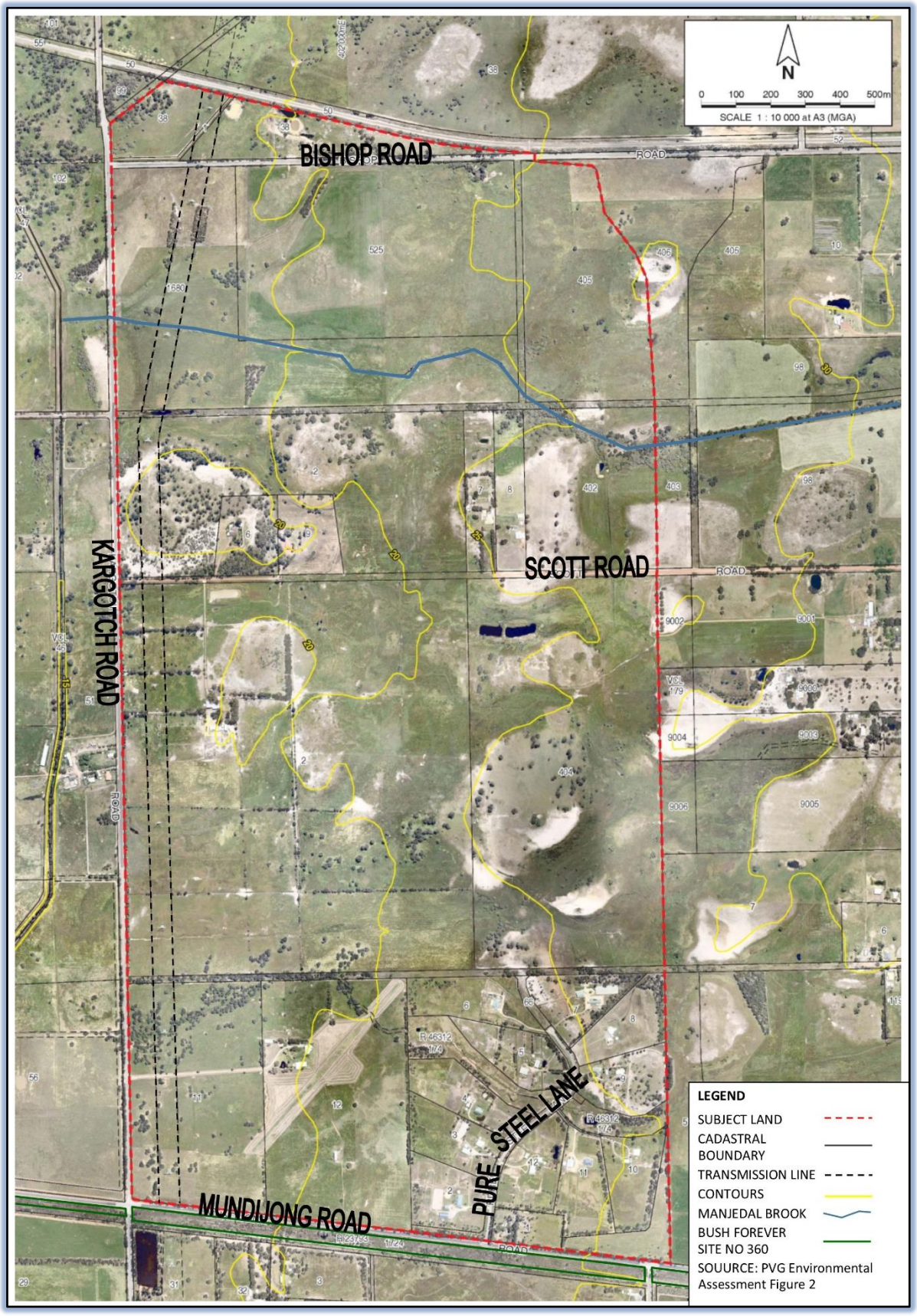


Figure 3 Existing Conditions

3 POLICY FRAMEWORK

3.1 BUSHFIRE MANAGEMENT

The State Government is currently introducing a new Bushfire Management Framework which is comprised of:

- State Planning Policy 3.7 Planning for Bushfire Risk Management;
- Planning for Bushfire Risk Management Guidelines;
- State Bushfire Prone Maps; and
- Planning and Development (Bushfire Risk Management) Regulations 2014.

SPP 3.7 assists in reducing the risk of bushfire to people, property and infrastructure by encouraging a conservative approach to strategic planning, subdivision, development and other planning decisions proposed in bushfire-prone areas.

Of relevance to this proposal are the following provisions:

6.1 Planning or development applications within identified bushfire-prone areas are to undertake a bushfire hazard assessment (low, moderate or extreme), prepared by a fire consultant, in accordance with the methodology set out in the Planning for Bushfire Risk Management Guidelines.

6.2 Planning proposals or development applications relating to land that has or will have a bushfire hazard level above low are to comply with these policy measures.

6.3 Any planning proposal or development application which will result in the introduction or intensification of development in an area that has or will have an extreme bushfire hazard level, and/or requires construction standards of BAL-40 or BAL-FZ, shall not be supported unless it can be demonstrated that the risk can be reduced to comply with policy measure 6.4 or the proposal is considered to be unavoidable development as per policy measure 6.6.

6.4 Any planning proposal or development application in an area that has or will have a moderate bushfire hazard level, and where construction standards at or between BAL-12.5 and BAL-29 may apply, may be approved where it can be undertaken in accordance with policy measure 6.5.

6.5 Any planning proposal or development application to which this policy applies shall be accompanied by a Bushfire Management Plan

The Office of Bushfire Risk Management (OBRM) is preparing the State Bushfire-Prone Area Maps. The mapping will define bushfire prone land which includes land with vegetated areas of more than one hectare and land within one hundred metres of this. The State Bushfire Prone Maps will be gazetted following the approval of the Fire and Emergency Services Amendment Bill 2015.

Four months after the gazettal of the State Bushfire Prone Maps it is proposed to gazette the Planning and Development (Bushfire Risk Management) Regulations 2014. The regulations are intended to ensure appropriate bushfire risk management measures are applied bushfire prone areas. They require that a bushfire attack level (BAL) assessment is undertaken before a new habitable building or land use is constructed in a bushfire prone area; and require development approval for habitable buildings on sites with an extreme bushfire risk.

The specifications for the State Bushfire Prone Maps and the Regulations describe bushfire prone vegetation as being classified vegetation (excluding unmanaged grasslands) which:

1. Are greater than 1 hectare in size; and
2. Single areas of the above vegetation that are between 0.25 and 1 hectare in area and are within 100 metres of other parcels of vegetation greater than 1 hectare in size.

Revised versions of State Planning Policy 3.7 Planning for Bushfire Risk Management and the Planning for Bushfire Risk Management Guidelines are intended to be re-advertised shortly.

3.2 PLANNING FOR BUSH FIRE PROTECTION GUIDELINES

The Planning for Bush Fire Protection Guidelines (DFES & WAPC - 2010) is the principal reference document in Western Australia for fire management in subdivisions and related development in rural and in urban/rural communities. It promotes five key principles which are summarised below:

The guidelines contain a set of performance criteria and acceptable solutions that new subdivision and developments are required to meet in bush fire prone areas. They also contain the methodology for the preparation of a bushfire hazard assessment.

3.3 AUSTRALIAN STANDARD AS3959 (2009)

AS3959 Construction of Building in Bush Fire Prone Areas provides measures for improving the ability of buildings to withstand burning debris, radiant heat and flame contact during a bush fire. The lower the separation distance from bushfire prone vegetation, the higher the standard of construction is required for buildings.

The Standard contains six Bushfire Attack Levels (BAL) categories being BAL-Low; BAL 12.5; BAL – 19; BAL - 29; BAL – 40 and BAL – FZ.

It also contains the vegetation classification system which the hazard assessment is based upon but with the following two important variations:

- Open woodland and shrubland vegetation types are classified on the basis of the understory; and
- Unmanaged grassland ie more than 100mm in height is classified.

Clause 2.2.3.2 of AS3959 states that a BAL Low rating can be applied when/to:

(a) Vegetation of any type that is more than 100m from the site.

(b) Single areas of vegetation less than 1ha in area and not within 100m of other areas of vegetation being classified.

(c) Multiple areas of vegetation less than 0.25ha in area and not within 20m of the site, or each other.

(d) Strips of vegetation less than 20m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20m of the site or each other, or other areas of vegetation being classified.

(e) Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.

(f) Low threat vegetation.

Low threat vegetation is defined as grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks.

4 PROPOSED DEVELOPMENT (ASSETS)

The proposed structure plan is shown in Figure 3.

The structure plan provides for[3]:

- A general industrial core and supporting light industrial areas or precincts to the east and south.
- The possible realignment of the Kwinana freight rail and an intermodal facility;
- Creation of ecological corridors with the potential to facilitate drainage, environmental rehabilitation, conservation of wetlands and passive recreation where practical;
- A multiple purpose corridor which occupies the area between Kargotich Road and the overhead 330 kv power lines.

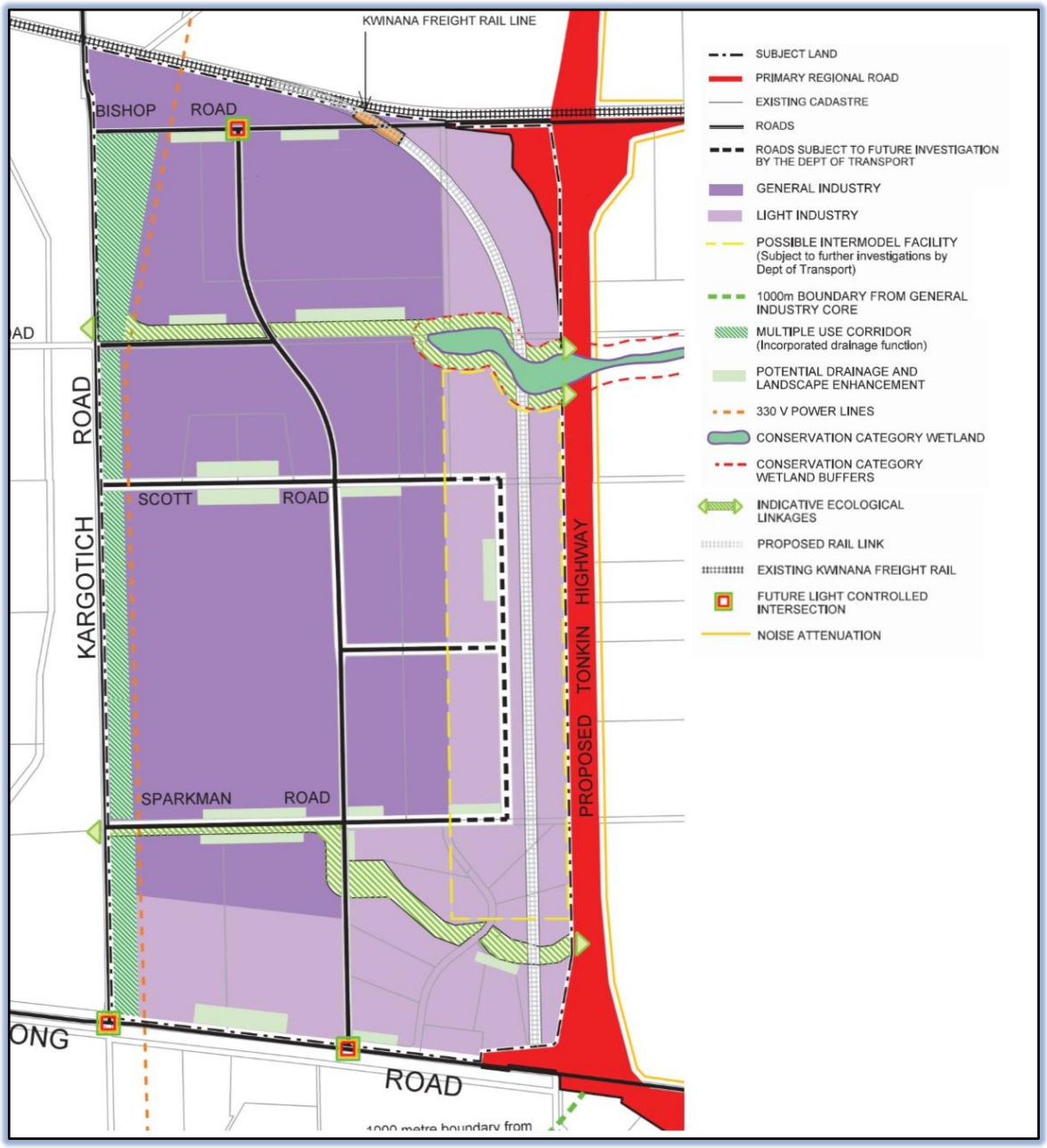


Figure 4 Proposed Structure Plan

[3] TME (2014) West Mundijong Industrial Area District Structure Plan report page 26

5 HAZARD ASSESSMENT

5.1 UNDEVELOPED LAND

This refers to the site in its current condition (July 2015) before the proposed development has occurred. The classified vegetation is shown in Figure 5 and photographs of the vegetation are contained in Appendix 1.

The bushfire hazard assessment has been prepared based upon the existing site conditions, vegetation and environmental report. The bushfire hazard primarily relates to the vegetation on the site, the type and extent (area) of vegetation and its characteristics. Appendix 1 of the Planning for Bushfire Protection Guidelines provides the methodology for determining the bush fire hazard. This classifies vegetation based on tree height and the percentage of canopy cover.

The characteristics of the different hazard categories are:-

Low hazard areas will generally be:

- Areas devoid of standing native vegetation (less than 0.25 ha cumulative area);
- Areas which due to climatic or vegetation (eg rainforest) conditions, do not experience bush fires;
- Inner urban or suburban areas with maintained gardens and very limited native standing vegetation (less than 0.25 ha cumulative area); or
- Pasture or cropping areas with very limited native standing vegetation that is a shrubland, woodland or forest.

Moderate hazard areas will generally be:

- Areas containing pasture or cropping areas with slopes in excess of 10°;
- Open woodlands;
- Open shrublands;
- Low shrubs with slopes of less than 10° or flat land; or
- Suburban areas with some native tree cover.

Extreme hazard areas will generally be:

- Forests; woodlands or tall shrubs.

Figure 6 shows the bush fire hazard rating for the subject land based upon the above classifications.

- The uncleared areas within and adjoining the site are classified as having an extreme fire hazard rating;
- Open woodlands are classified as a moderate hazard rating as the understory vegetation is not considered;
- The pasture areas are classified as having a low hazard rating irrespective of whether this is unmanaged grassland or not; and
- The cleared areas which are within 100m of the areas with an extreme or moderate hazard rating are to be assigned a moderate hazard rating to reflect the increased level of risk.

The 2014 draft Planning for Bushfire Risk Management Guidelines; (Appendix 2 Bushfire Hazard Assessment) introduces a significant change to the hazard assessment criteria. It stipulates that that land with a “low” hazard rating which is located within 100m of land with an “extreme” or “moderate” hazard rating shall be classified as having a “moderate” hazard rating so as to reflect the increased level of risk. This has been shown in Figure 6.

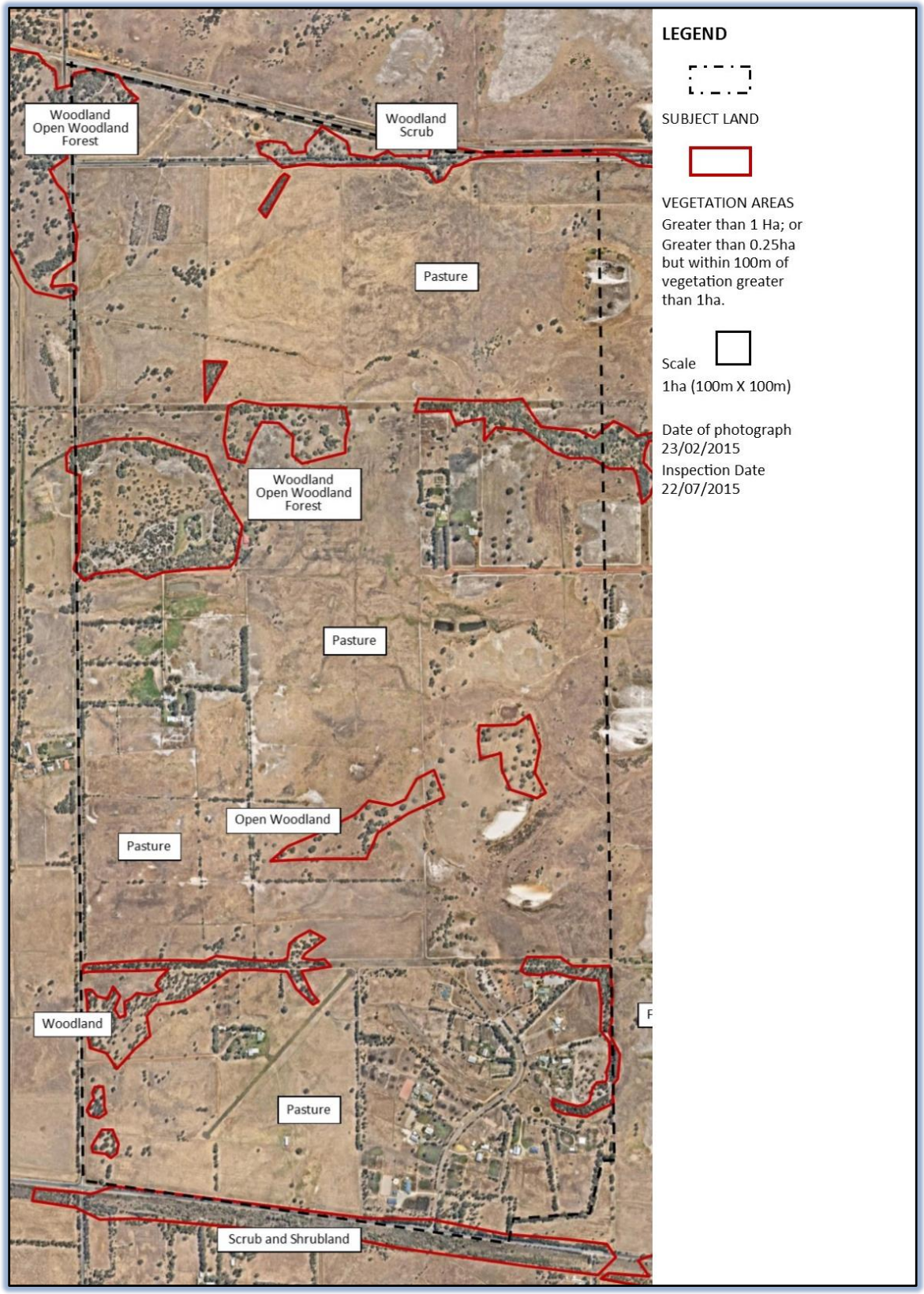
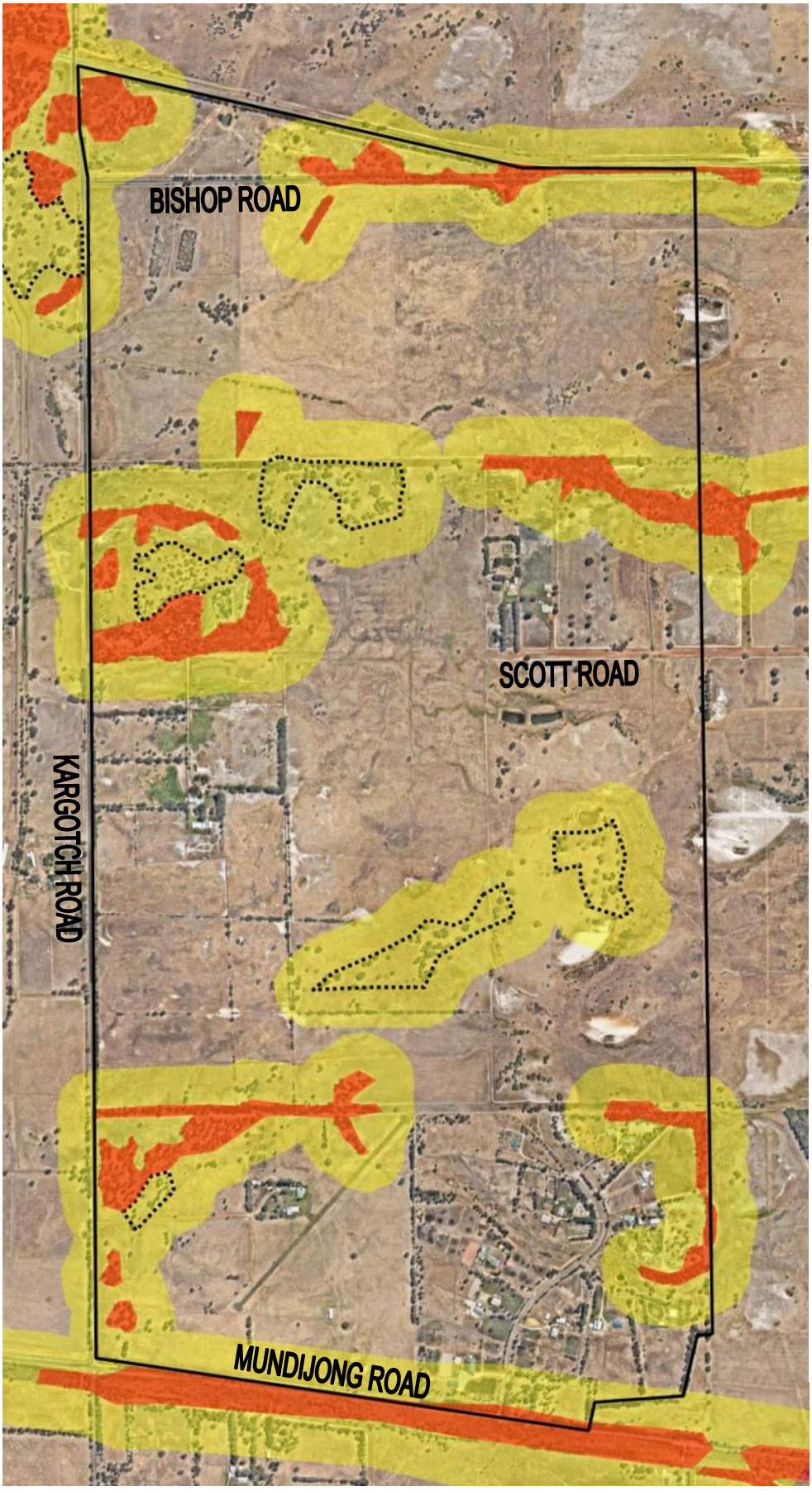


Figure 5 Classified Vegetation



LEGEND

SUBJECT LAND

EXTREME HAZARD

MODERATE HAZARD (See Note 2)

CLASSIFIED VEGETATION WITH A MODERATE HAZARD RATING

LOW HAZARD

SCALE 0 100m

NOTES

1 The hazard mapping has been prepared in accordance with the methodology contained in Appendix 1 of Planning for Bush Fire Protection Guidelines (2010).

2 The draft 2014 Bushfire Risk Management Guidelines Appendix 2 designates that land with a "low" hazard rating which is located within 100m of land with an "extreme" or "moderate" hazard rating shall also be classified as having a "moderate" hazard rating so as to reflect the increased level of risk.

3 Vegetation areas are defined as being:
* Greater than 1 Ha; or
* Greater than 0.25ha but within 100m of vegetation greater than 1ha.

4 Low Hazards includes pasture and cropping areas.

5 Moderate Hazards includes open woodlands and open shrublands.

6 Extreme Hazards include forest, woodlands and tall shrubs.

Date of photograph 23/02/2015
Inspection Date 22/07/2015

N W E S

FIGURE 6
WEST MUNDIJONG
BUSHFIRE HAZARD UNDEVELOPED LAND

REVISION	DESCRIPTION	AUTHOR	DATE
F			
E			
D			
C			
B			
A	Preliminary	GL	24/07/2015

THIS PLAN HAS BEEN PREPARED FOR PLANNING PURPOSES AREAS, CONTOURS AND DIMENSIONS SHOWN ARE SUBJECT TO SURVEY.

calibre CONSULTING

REF No 15140P

5.2 DEVELOPED LAND

This refers to how the site is intended to be developed as shown in Figure 3.

Clauses 6.2, 6.3 and 6.4 of SPP3.7 all refer to “have or will have” in terms of the hazard level. A hazard assessment solely based upon the undeveloped land has limited use as it does not consider:

- What land will be cleared in the proposed development thereby reducing the hazard level; or
- What land will be revegetated in the proposed development thereby increasing the hazard level.

This also then becomes a critical factor in assessing where AS3959 might apply to future buildings.

Of relevance to the future hazard assessment are:

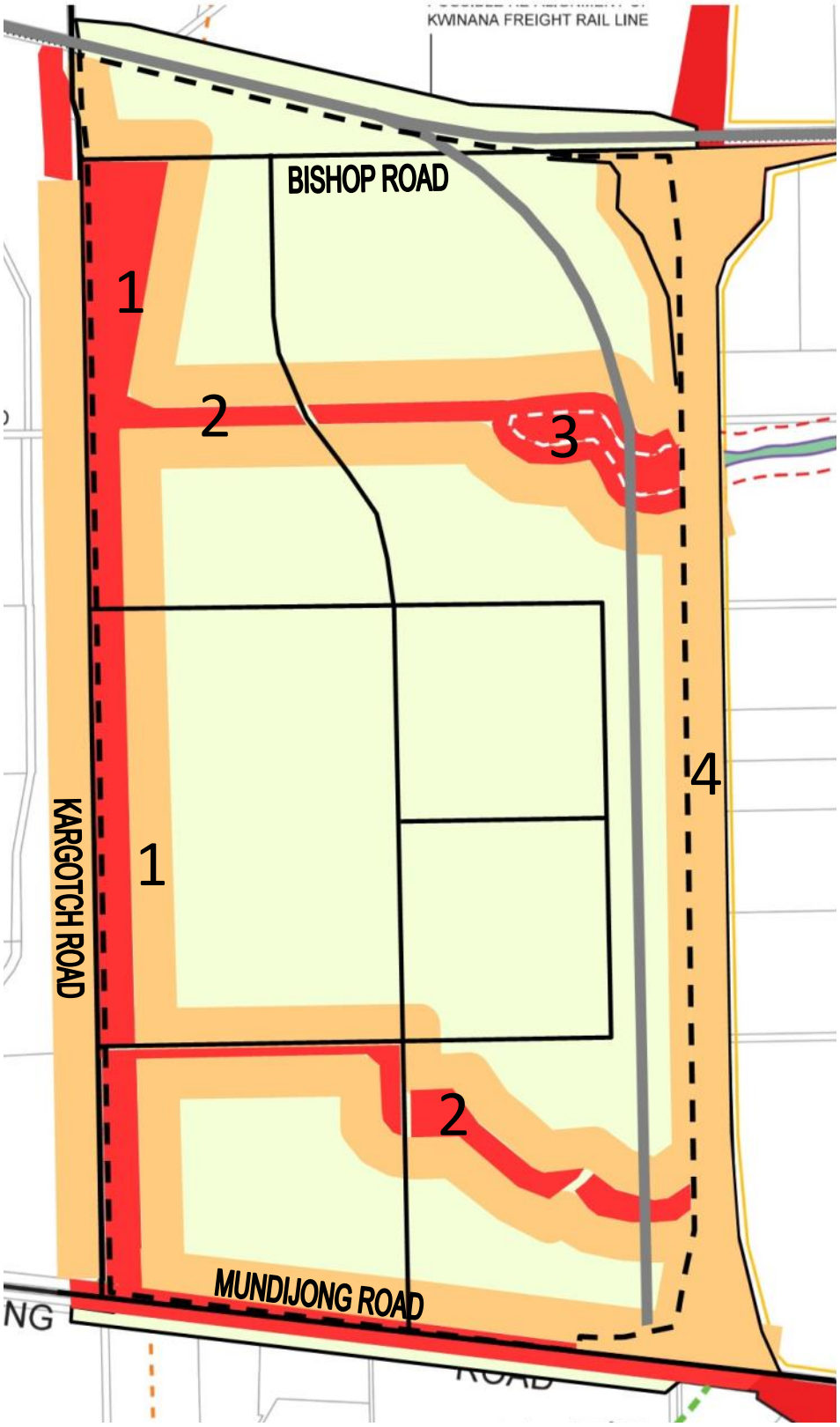
- The proposed revegetation buffer to the conservation wetland. It is assumed that this will be 50m wide.
- The proposed ecological linkages especially parallel to Manjedal Brook; and
- The proposed multiple use corridor along Kargotich Road

The definition of the ecological linkages or multiple use corridor as classified vegetation will depend upon the final planting specifications and dimensions of the corridor. If the planting are more than 20m wide then they are likely to be classified. These areas may not be classified is they are developed as a managed parkland environment in accordance with Clause 2.2.3.2 of AS3959.

In accordance with Clause 4.3 of SPP3.7 a precautionary approach should be taken. Hence these areas should be defined as potentially being bushfire prone land in order that the bushfire threat can be further assessed in the design of the development.

The hazard assessment for the developed land is shown in Figure 7. This assumes that any existing remnant vegetation within individual sites will be cleared during construction. The existing classified vegetation on the external site boundaries has been included as there is no certainty what will occur with this. The exception being the Bush Forever Site along Mundijong Road which is expected to be preserved.

The classifications in Figure 7 also vary from the standard methodology as it shows vacant land along the Tokin Highway extension as a moderate hazard. This is because pending the construction of the highway this land is likely to have unmanaged grasslands and the BAL ratings under AS3959 will extend for 50m from this.



LEGEND

SUBJECT LAND	
EXTREME HAZARD	
MODERATE HAZARD	
LOW HAZARD	

NOTES

1 The hazard rating is subject to confirming the design and landscaping specifications for the proposed multiple use corridors.

2 The hazard rating is subject to confirming the design and revegetation specifications for the proposed ecological corridors.

3 A 50m revegetated buffer to the wetland is expected to have classified vegetation.

4 The Tonkin Hwy extension has been shown as a moderate hazard on the basis that it is likely to have unmanaged grassland. The BAL Low setback from this is 50m.

5 The plan does not take into account any staging as this is not known at this time.

FIGURE 7
WEST MUNDIJONG
BUSHFIRE HAZARD DEVELOPED LAND

REVISION	DESCRIPTION	AUTHOR	DATE
F			
E			
D			
C			
B			
A	Preliminary	GL	24/07/2015

THIS PLAN HAS BEEN PREPARED FOR PLANNING PURPOSES AREAS, CONTOURS AND DIMENSIONS SHOWN ARE SUBJECT TO SURVEY.

calibre CONSULTING

REF No 15140P

6 ISSUES

State Bushfire Prone Maps

The State Bushfire Prone Maps have not been gazetted at the time of this report. It is understood that Council has requested that unmanaged grasslands be included in the mapping.

This will potentially significantly increase the area of bushfire prone land and it may include the majority of the site.

SPP3.7 and Regulations

State Planning Policy 3.7 is yet to be finalised and it is understood that it will be re-advertised for public comment. Similarly the Planning and Development (Bushfire Risk Management) Regulations 2014 may also be modified.

The Planning and Development (Bushfire Risk Management) Regulations 2014 may require that a BAL assessment is undertaken on all bushfire prone land shown on the State Bushfire Prone Maps. This is irrespective of the area defined in this report.

It will be necessary to review this report when the final versions of these documents are available.

BAL Assessments

The classification of the vegetation for the hazard assessment in the Planning for Bushfire Protection Guidelines is more generalised than that contained in AS3959. Two key differences are that the Planning for Bushfire Protection Guidelines:

- Does not include Unmanaged Grasslands as a vegetation type; and
- Includes open Woodlands and Shrubland as vegetation classes in their own right. AS3959 (Table 2.3) stipulates that open Woodlands and Shrubland are to be classified on the basis of the understory vegetation. For most of these areas on the site this would then be Unmanaged Grassland.

The Planning for Bushfire Protection Guidelines predominantly use foliage cover and tree height to determine the type of vegetation. AS3959 also uses this system especially for the Simplified Method for determining the Bushfire Attack Level (BAL). The alternative Detailed Method gives more consideration to the existing fuel loads and these are shown below.

Vegetation Classification	Surface Fuel Load (t/ha)	Overall Fuel Load (t/ha)
Forest	25	35
Woodland	15	25
Shrubland	15	15
Scrub	25	25
Mallee/Mulga	8	8
Grassland	45	4.4

This potentially means that areas which may be classified as Forest, Woodland and Shrubland could still have a BAL ratings assigned on the basis of Unmanaged Grassland due to the low fuel loads.[4]

Application of AS3959

The National Construction Code (Building Regulations 2012) only applies the AS3959 Construction Standards to Class 1, 2 or 3 buildings or associated Class 10a buildings i.e. dwellings and outbuildings. There is no ability through the building permit application process to impose these standards to other building classes i.e. industrial or commercial buildings.

[4] Under the proposed Bushfire Consultant accreditation system the use of the Detailed Methodology for BAL assessments will only be able to be done by a Level 3 practitioner.

It is noted that many industrial buildings by the nature of their design are potentially able to comply with the construction standards, especially BAL-12.5.

Therefore the structure plan or amendment provisions must provide a means for implementing, as far as is practicable, suitable construction standards.

Staging of Development

The hazard assessment shown in Figure 7 (Developed Land) does not take into account any issues which might arise due to the staging of the development. This specifically relates to remnant vegetation which is retained on the undeveloped stage being classified vegetation.

This issue also includes unmanaged grasslands which might exist on the undeveloped land or staging. While pasture or cropping areas might be considered to be low hazard any unmanaged grassland is a defined vegetation class for the purpose of determining the Bushfire Attack Level in accordance with AS3959. The BAL – Low rating is applied 50m from unmanaged grassland rather than the normal 100m.

This has been an issue particularly with service corridors where the land is reserved and left vacant for many years before being developed. The most obvious example of this in the subject land is the extension of Tonkin Highway.

7 CONCLUSION

The subject land and the area surrounding it has pockets of vegetation which are potentially a bushfire hazard. The overall threat is lower than compared to areas of State Forest because the understory has largely been removed as the land has been developed for farming purposes.

While the pasture are recognised as having a low bushfire hazard rating, they will pose a bushfire threat if they cure during summer and are not slashed, cropped or grazed.

The severity of a bush fire will depend upon the vegetation fuel loadings; the weather conditions prevailing at the time and the implementation of appropriate fire management measures. There are three main ways of modifying the level of bushfire risk:

- By ensuring that built assets are not placed in fire-prone areas and that structures meet standards of construction that reduce their vulnerability;
- By reducing the frequency of ignitions that result from arson; and
- By managing the landscape so as to minimise the risk of damage to life and assets.

The proposed development will be introducing substantial values (property and businesses) into the locality. It will result:

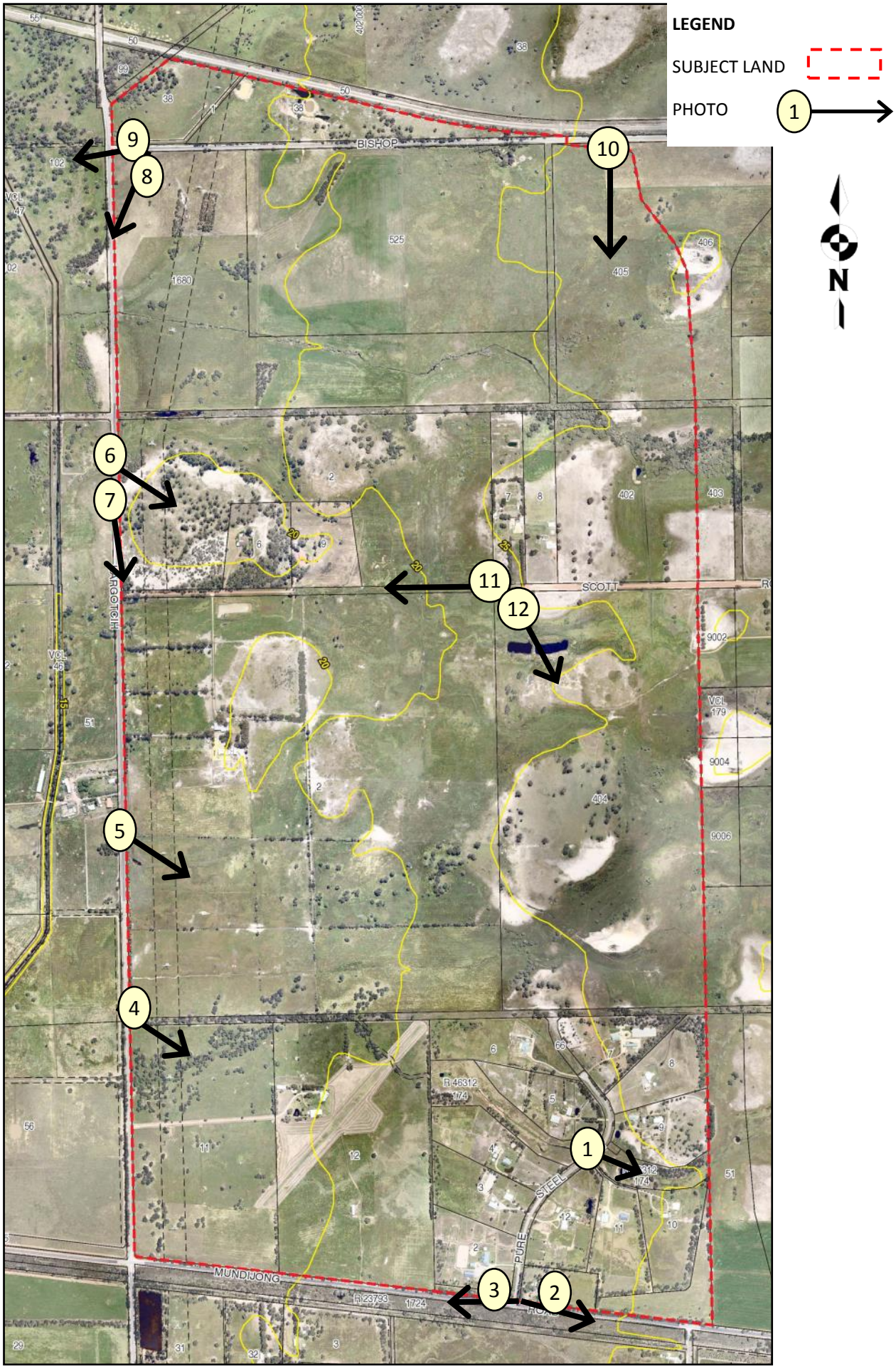
- In the reduction of the hazard by the removal of large areas of the existing vegetation including grasslands; and
- In the creation of additional hazards by the development of ecological corridors, revegetation buffers and landscaping.

It is therefore recommended that:

1. This hazard assessment report be revised following the modification of State Planning Policy 3.7 Planning for Bushfire Risk Management; the gazettal of the State Bushfire Prone Maps Planning and the Development (Bushfire Risk Management) Regulations 2014.
2. That in accordance with State Planning Policy 3.7 that a bushfire management plan be prepared for the proposed Amendment and development.
3. That any bushfire management plan consider the specifications and design for the landscaping and/or revegetation of the proposed multiple use corridor; ecological corridors and wetland buffer areas.
4. That the proposed provisions of Appendix 15 DA6 contained in the Amendment be modified to reference both the preparation and implementation of a bushfire management plan.
5. That the Amendment or any subsequent structure plan address the application of bushfire construction standards for commercial and industrial buildings parallel to those in AS3959.

APPENDIX 1 SITE PHOTOGAPHS

22 JULY 2015



APPENDIX 1 SITE PHOTOGAPHS 22 JULY 2015

Photo 1

Drainage reserve
Pure Steel Lane
Unmanaged grass-land

Photo 2

Looking east along Mundijong Road.
Bush Forever site on southern side

Photo 3

Looking west along Mundijong Road.
Bush Forever site on southern side

Photo 4

Looking east from Kargotich Road.
Sheoak woodland

APPENDIX 1 SITE PHOTOGAPHS 22 JULY 2015

Photo 5

Looking east from Kargotich Road. Pasture

Photo 6

Looking east from Kargotich Road. Unmanaged grass-land

Photo 7

Looking south along Kargotich Road.

Photo 8

Looking south from Bishop Road towards Kargotich Road.

APPENDIX 1 SITE PHOTOGAPHS 22 JULY 2015

Photo 9

Bishop / Kargotich Roads intersection Looking west Woodland

Photo 10

Looking south from Bishop Road. Pasture with wet-land vegetation in the background

Photo 11

Looking west along Scott Road from end of the pavement.

Photo 12

Looking south from Scott Road .

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08 6477 1144 | admin@bushfireprone.com.au

Bushfire Management Plan (Hazard Level Assessment)

West Mundijong Industrial Precinct

Shire of Serpentine - Jarrahdale

Project Number: 168900

Assessment Date: 11 November 2016

Report Date: 23 November 2016

Plan Details

BMP Template v5.1 ©2016 BPP Group Pty Ltd

Plan Version	Submitted to	Submitted Date
v1.0	Proponent	30-Nov-16

Plan Version	Amendment Record	Submitted Date
v1.1	Updated BHL map and classified vegetation photos from DFES comments	17-Jan-17

Compliance Statement

This Bushfire Management Plan (the Plan) meets the requirements of both the *State Planning Policy No. 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) and the supporting *Guidelines for Planning in Bushfire Prone Areas* (WAPC 2015; the 'Guidelines').

Author	Bushfire Planning and Design (BPAD) Accreditation		Signature
Alex Aitken	Level 2 Bushfire Planning Practitioner	BPAD37739	

BPP Group Pty Ltd t/a Bushfire Prone Planning ACN: 39 166 551 784

Reviewed/Approved	Bushfire Planning and Design (BPAD) Accreditation		Signature
Kathy Nastov	Level 3 Bushfire Planning and Design Practitioner	BPAD27794	

BPP Group Pty Ltd t/a Bushfire Prone Planning ACN: 39 166 551 784

Contents

Appendices

1 Executive Summary

This Bushfire Management Plan (the Plan) has been prepared to support a proposed Scheme Amendment for the West Mundijong Industrial Precinct as part of the Town Planning Scheme No. 2 Amendment 187 within the Shire of Serpentine - Jarrahdale.

The scheme amendment subject site of approximately 474ha is within a designated bushfire prone area and the Proposal requires the application of *State Planning Policy No. 3.7: Planning in Bushfire Prone Areas* (SPP 3.7). The assessed bushfire risk is considered to be manageable and will be achieved by the identified stakeholders implementing and maintaining the bushfire risk management measures that are presented in this Plan.

This bushfire hazard level assessment demonstrates that compliance against the four elements of the Bushfire Protection Criteria can be achieved in subsequent planning stages. As the future land use will comprise of industrial uses such as fuel stations and other high risk land uses there are areas where it is proposed to exclude or limit the development in areas in or adjacent to extreme or moderate bushfire hazard.

In future planning stages, all proposed developments or subdivisions will be able to comply with the bushfire protection criteria with the design and construction of vehicle access, water supply and building location appropriately to reduce the effects of the bushfire risk.

Future buildings within 100 metres of classified vegetation will be constructed to standards which correspond to the determined BALs, as required by *AS 3959-2009 Construction of buildings in bushfire prone areas.*

If there are any future proposed 'high-risk' or 'vulnerable' land uses within the scheme amendment area and the assessed BAL is greater than BAL-12.5 an Emergency evacuation and/or emergency risk management plan will be required to specifically address the risk of a bushfire event impacting on the development.

2 Application of SPP 3.7

The *State Planning Policy No. 3.7: Planning in Bushfire Prone Areas* (SPP 3.7) provides the foundation for land use planning to address bushfire risk in Western Australia.

This Proposal must consider SPP 3.7 and, if required, comply with its policy measures. The determination of this requirement is presented below.

Application of SPP 3.7 Policy Measures – Primary Triggers	
The subject Proposal is a higher order strategic planning document, a strategic planning proposal or a subdivision or development application:	✓
The project site is in a designated bushfire prone area on the WA Map of Bushfire Prone Areas:	✓
The project site is not located in a designated bushfire prone area on the WA Map of Bushfire Prone Areas but the existing vegetation type and condition dictate that it should be:	
The project site is in an area not yet designated as bushfire prone but is proposed to be developed in a way that introduces a bushfire hazard (*Guidelines for Planning in Bushfire Prone Areas WAPC 2015 s3.2.2*):	
Application of SPP 3.7 Policy Measures – Secondary Trigger/s	
The Proposal is a strategic planning proposal, subdivision or development application relating to land that has or will have a Bushfire Hazard Level above low and/or where a Bushfire Attack Level rating above BAL-LOW applies (SPP 3.7 s6.2):	✓
The subject Proposal is a development application for the construction or/and use of a single house or ancillary dwelling on a lot or lots greater than 1100m^2 and subject to BAL-40 or BAL-FZ (LPS Amendment Regulations 2015):	
The subject Proposal is a development application for the construction or/and use of a habitable building (other than a single house or ancillary dwelling), or a specified building on any lot size and subject to a BAL rating above BAL-LOW (LPS Amendment Regulations 2015):	

3 Commissioning and the Land Use Proposal

Bushfire Prone Planning (BPP Group Pty Ltd) has been commissioned to carry out the assessments and prepare the required bushfire planning documentation to accompany the proponent's planning submission associated with their proposed land use project.

Commissioning Record	
Landowner / Proponent:	Shire of Serpentine - Jarrahdale
BPP Commissioned by:	Robert Casella- Shire of Serpentine - Jarrahdale
Purpose:	To support a proposed local structure plan
Project Location	
Subject Site and Address:	Area bordered by Kargotich Road, Bishop Road, Mundijong Road and future Tonkin Highway extension
Local Government:	Shire of Serpentine Jarrahdale
Zoning and R-Code:	Rural, Farmlet
Project Description	
Description:	Land use rezoning of area from Rural and Farmlet to Urban Development including General Industry and Light Industry
Building Class:	-
Lot Areas:	Overall area 474 ha

Figure 3.1

Proposed Development

West Mundijong Industrial Precinct
Jarrahdale

LEGEND

- Subject Lots
- Other Lots

Green Corridors

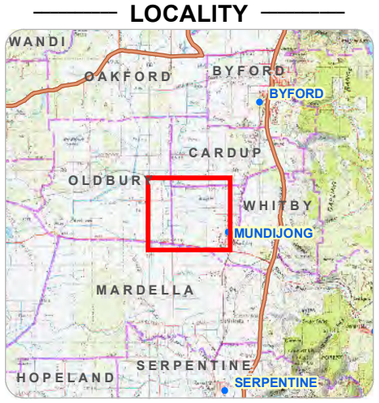
- Retained Vegetation
- Wetland
- Wetland Buffer
- Proposed Roads

SCALE (A3)

0 250 500 750

Metres

LOCALITY



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Aerial Image: Landgate Aug 2016

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator
Map created on: 28-Nov-16
Map compiled by: Bruce Greentree

4 The Planning Submission and the Documents Required

Policy measures in *SPP 3.7* (and further instruction in the associated document *Guidelines for Planning in Bushfire Prone Areas WAPC 2015*) set out the bushfire planning information (including bushfire risk assessments) that are to accompany a planning submission. It is dependent on the type of proposal and stage of the development process. In most circumstances this information is to be presented in the form of a Bushfire Management Plan (BMP).

The Planning Submission – Stage and Specific Land Use or Development	
Planning Stage:	Strategic - local planning scheme or amendment
For Submission to:	WA Planning Commission (WAPC)
Project Type:	Change of land use
'Vulnerable' Land Use:	Yes
'High Risk' Land Use:	Yes
'Minor' Development:	No
'Unavoidable' Development:	No

This Bushfire Management Plan will include the information indicated by the check mark. If an item is checked it is required by either: SPP 3.7 or by a local government variation. It may also have been prepared at an earlier planning stage and therefore re-included or included by the assessor as it improves the information presented in this Bushfire Management Plan.

Bushfire Hazard Level Assessment	Bushfire Attack Level Contour Map	Bushfire Attack Level Assessment	Identify any issues arising from the BAL contour map or BAL assessment	Identify and specifically address the list of issues related to strategic level planning and defined in the *Guidelines s5.2*	Demonstrate compliance with the Bushfire Protection Criteria can be achieved in subsequent planning stages	Demonstrate compliance with the Bushfire Protection Criteria
✓				✓	✓	

For vulnerable and high risk land use and development in areas with an extreme bushfire hazard level and/or areas where BAL-40 or BAL-FZ applies, the following additional bushfire planning information will accompany and/or be included in this Bushfire Management Plan.

Vulnerable Land Use		High Risk Land Use	Minor Development	Unavoidable Development
Provision for Emergency Evacuation	Emergency Evacuation Plan for Proposed Occupants	Risk Management Plan for Flammable On-site Hazards	Statements Against SPP 3.7 s6.7.1 items (a) to (d)	Statements Against SPP 3.7 s6.7.2 items (b) and (d)
✓		✓		

Note that for vulnerable and high risk land uses involving Class 4 to Class 9 buildings, the planning process focuses on location, siting, vehicular access and firefighting water supply and not building construction requirements - as the Building Code of Australia only applies to Classes 1, 2, 3 and associated Class 10a buildings or decks. However, the construction requirements as set out in AS 3959 – 2009 can be utilised voluntarily to enhance a buildings survivability if it is subject to a bushfire.

5 Assessment of Bushfire Risk

5.1 Vegetation Identification and Classification

5.1.1 Existing Vegetation

All vegetation within 100 metres of the subject site has been identified and classified or excluded and presented in Table 5.1.1. This has been done with accordance with *AS 3959-2009* and reference to the *Visual Guide for Bushfire Risk Assessment in WA* (WAPC February 2016).

The vegetation has been assessed as it will be in its mature state and where deemed appropriate, in its unmanaged state. The areas of classified vegetation that will determine bushfire risk are defined on the topography and vegetation map Figure 5.1. Representative photos of each vegetation area is presented after the table.

Table 5.1.1: Vegetation types identified, the applied classification and effective slope

All Vegetation Within 100 metres of Subject Site			
Vegetation Area	**Identified Types (AS3959) or Description if 'Excluded'**	**Applied Classification**	**Effective Slope Under Classified Vegetation (degrees)**
1	Offsite Open Woodland B-06	Class B Woodland	0-5
2	Offsite Woodland B-05	Class B Woodland	0-5
3	Onsite Open Woodland B-06	Class B Woodland	0-5
4	Onsite Grassland	Class G Grassland	0-5
5	Offsite Grassland	Class G Grassland	0-5
6	Offsite Open Woodland B-06	Class B Woodland	0-5
Note: When more than one vegetation type is present each type is classified separately with the worst case scenario being applied. The predominant vegetation is not necessarily the worst case scenario.			

Vegetation Area 1 **Classification Applied:** Class B Woodland

Assessment Comment: offsite open woodland, eucalypt, sheoak, grass understorey

Photo ID: 1a

Photo ID: 1b

Vegetation Area 2 **Classification Applied:** Class B Woodland

Assessment Comment: offsite woodland, shrub & grass understorey, revegetation roadside reserve

Photo ID: 2a

Photo ID: 2b

Vegetation Area 3 **Classification Applied:** Class B Woodland

Assessment Comment: onsite open woodland, eucalypt and sheoak groves, canopy cover 10-20%- variable over large areas

Photo ID: 3a

Photo ID: 3b

Vegetation Area 3 **Classification Applied:** Class B Woodland

Assessment Comment: onsite open woodland, partly managed farmlet lots, various eucalypt species and grass understorey

Photo ID: 3c

Photo ID: 3d

Vegetation Area 3 **Classification Applied:** Class B Woodland

Assessment Comment: onsite open woodland with grass understorey

Photo ID: 3e

Photo ID: 3g

Vegetation Area 4 **Classification Applied:** Class G Grassland

Assessment Comment: onsite grassland, crops, unmanaged grass, grazed pasture

Photo ID: 4a

Photo ID: 4b

Vegetation Area 4 **Classification Applied:** Class G Grassland

Assessment Comment: onsite grassland with open woodland in background

Photo ID: 4c

Photo ID: 4d

Vegetation Area 5 **Classification Applied:** Class G Grassland

Assessment Comment: offsite grassland, cropping, grazing pasture

Photo ID: 5a

Photo ID: 5b

Vegetation Area 5 **Classification Applied:** Class G Grassland

Assessment Comment: offsite grassland, cropping, grazing pasture

Photo ID: 5c

Photo ID: 5d

Vegetation Area 5 **Classification Applied:** Class G Grassland

Assessment Comment: offsite grassland along Taylor Rd, <10% canopy cover

Photo ID: 5e

Vegetation Area 6 **Classification Applied:** Class B Woodland

Assessment Comment: offsite woodland associated with rural residential areas east of Adam Street

Photo ID: 6a

5.1.2 Vegetation Excluded from Classification

Certain areas and vegetation within 100m of the subject site may be assessed as 'low threat or non-vegetated'. These are to be excluded from classification and are therefore rated BAL-LOW. They must be managed to maintain the specifications set out in AS3959-2009 s2.2.3.2 in perpetuity (refer to Appendix 3 'Vegetation Classification Exclusions').

Managed gardens surrounding private property have been excluded from classification as presenting a low bushfire threat as per AS 3959-2009s2.2.3.2 (f).

5.1.3 Expected On-site Vegetation Changes Due to Proposed Subdivision or Development

In assessing vegetation for bushfire threat, consideration must be given to possible future vegetation changes likely on the site that is being assessed, particularly those that would have the potential to increase the bushfire risk.

This may be due to growth of existing vegetation or growth of planned landscape plantings, including future roadside or water course re-vegetation. There must be careful consideration of the creation of vegetation corridors where they join offsite vegetation and may provide a route for fire to enter an area of future development.

For this Bushfire Management Plan, the future vegetation within the subject lots has been considered. Existing onsite vegetation is sown pasture and is classified Grassland. It is expected that in the future this will be maintained as low threat vegetation. It will meet *AS 3959-2009 s2.2.3.2* requirements (refer Appendix 3 'Vegetation Classification Exclusions').

The proposal currently retains some areas of native vegetation adjacent to Manjedal Creek and several ecological corridors within the subject site. These ecological corridors may be revegetated or maintained as the existing classified vegetation. See Figure 3.1 for areas of retained vegetation.

Figure 5.1

Topography & Classified Vegetation

West Mundijong Industrial Precinct
Jarrahdale

LEGEND

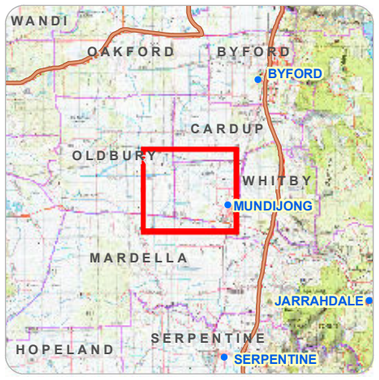
- Subject Lots
- Other Lots
- Photo Locations
- Area of Interest - 100m extent
- Existing Hydrant

Classified Vegetation
- Class (B) Woodland
- Class (G) Grassland

Green Corridors
- Retained Vegetation
- Wetland
- Wetland Buffer

SCALE (A3)
0 250 500 750
Metres

LOCALITY



N

Aerial Image: Landgate Aug 2014

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator
Map created on: 17/01/2017
Map compiled by: Bruce Greentree

BUSHFIRE PRONE PLANNING

5.2 Bushfire Hazard Level (BHL) Assessment

"A Bushfire Hazard Level assessment provides a 'broad-brush' means of determining the potential intensity of a bushfire for a particular area. The Bushfire Hazard Level assessment assists in informing the suitability of land contained within strategic planning proposals for future subdivision and development.

The Bushfire Hazard Level assessment categorises land within a designated bushfire prone area as having a low, moderate or extreme bushfire hazard level. Different hazard levels may be assigned to different parts of individual lots.

Bushfire Hazard Level assessments allow for early strategic consideration of bushfire risk which can then be used to inform the more detailed stages that follow, ensuring all issues are considered, identified and properly addressed at the earliest possible time ('Guidelines' s4.1)".

For a summary of the assessment methodology refer to Appendix 2. BHL assessments are required to accompany all strategic planning proposals unless the future lot layout of the Proposal is known in which case a BAL Contour Map is more appropriate (SPP 3.7 s6.3).

Assessment Results

The results of the Bushfire Hazard Level assessment detailing the vegetation type, class and the hazard levels assigned, are presented in Table 5.2.1 and visually in Figure 5.2 as a bushfire hazard level map pre development and then Figure 5.2.1 as a post development bushfire hazard level map. If additional assessment inclusions are required in this Plan, they are identified in Table: 5.2.2.

Table 5.2.1: BHL assessment

Bushfire Hazard Level Assessment	
Data Used (methodology as per the 'Guidelines' Appendix 2):	**site inspection + aerial map data**
Assessed Area	**Bushfire Hazard Level**
Land inside the external boundary of the subject site:	**Moderate + Extreme**
Land within 100 metres of external boundary of the subject site:	**Moderate + Extreme**

The Bushfire Hazard Level mapping demonstrates that the Bushfire Hazard Level to which future and existing buildings will be exposed, will be reduced after development.

Table 5.2.2: Required additional assessment.

Required Additional Assessment	
If any of the assessed area is determined to have an Extreme BHL this will trigger further considerations. Can the extreme hazard level be initially reduced to low or moderate and then maintained for the life of the development?	**No**
A 'Yes' response requires that Section 7 of this Plan 'Bushfire Risk Management Measures' will outline how this will be achieved. A 'No' response requires that the indicative Bushfire Attack Levels for the subject site will need to be BAL-29 or lower in order to be considered suitable for development – unless the development meets the definition of 'unavoidable' development.	
Are the indicative Bushfire Attack Levels for the subject site BAL-29 or lower?	**Yes**
Is this proposal for 'minor' or 'unavoidable' development?	**No**

5.2.1 Identification of Specific Issues Arising from BHL Assessment

As this proposal is for a scheme amendment there are no specific proposed plans with respect to new development or subdivision the future bushfire hazard levels are proposed to be reduced as any future developments will manage the unmanaged grassland and therefore reduce the overall bushfire risk to the area.

The proposed public open space as part of Manjedal Creek and the ecological corridors will be retained and maintained as native vegetation will require buffers to the areas limiting the developments. These areas will be highlighted in the BAL Contour map that will indicate a post development bushfire risk from surrounding and internal retained vegetation.

The post development bushfire hazard level Figure 5.2.1 shows the hazard level with the assumption that the internal areas with the development will be maintained as low bushfire hazard level with the moderate and extreme hazards associated with the retained native vegetation and external vegetation. Any future development within located in the moderate bushfire hazard will require future planning stages to evaluate the bushfire risk in greater detail.

Figure 5.2

Bushfire Hazard Level

Pre Developement

West Mundijong Industrial Precinct
Jarrahdale

LEGEND

- Subject Lots
- Other Lots
- Area of Interest - 100m extent

Green Corridors

- Retained Vegetation
- Wetland
- Wetland Buffer
- Proposed Roads

Bushfire Hazard Mapping

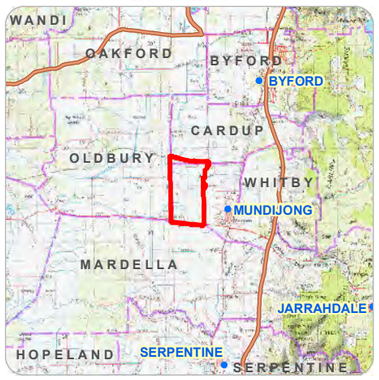
- Extreme Bushfire Hazard
- Moderate Bushfire Hazard
- Low Bushfire Hazard

SCALE (A3)

0 250 500 750

Metres

LOCALITY



N

Aerial Image: Landgate Aug 2016

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator
Map created on: 28-Nov-16
Map compiled by: Bruce Greentree

Figure 5.2.1

Bushfire Hazard Level

Post Developement

West Mundijong Industrial Precinct
Jarrahdale

LEGEND

- Subject Lots
- Other Lots
- Area of Interest - 100m extent

Green Corridors

- Retained Vegetation
- Wetland
- Wetland Buffer
- Proposed Roads

Bushfire Hazard Mapping

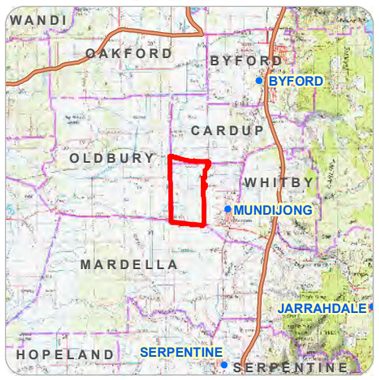
- Extreme Bushfire Hazard
- Moderate Bushfire Hazard
- Moderate 100m Buffer
- Low Bushfire Hazard

SCALE (A3)

0 250 500 750

Metres

LOCALITY



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Aerial Image: Landgate Aug 2016

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator
Map created on: 28-Nov-16
Map compiled by: Bruce Greentree

Disclaimer and Limitation: This map has been prepared for bushfire management planning purposes only. All depicted areas, contours and any dimensions shown are subject to survey. Bushfire Prone Planning does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.

5.3 Bushfire Attack Level (BAL) Assessment – BAL Contour Map

BAL assessment procedure applied to this assessment:	**Simplified procedure 'Method 1' (AS 3959-2009)**
Vegetation assessment:	**Physical site inspection**

Refer to Appendix 2 'Bushfire Risk Management – Understanding the Methodology', for a summary of the BAL assessment procedures.

Description and Purpose of the BAL Contour Map

A Bushfire Attack Level (BAL) Contour Map identifies land suitable and unsuitable for development and guides the location of building envelopes within a development site. The BAL Contour Map is a scale map of a development site (which can include proposed or an existing lot layout), which identifies indicative BAL ratings across the development site and within the immediate surrounding area. The map illustrates potential bushfire attack levels and radiant heat impacts in relation to any classified vegetation that will remain within 100 metres of the assessment area once development is constructed i.e. when the land has been cleared and all the subdivision works have been undertaken. It needs to take into account any vegetation that will remain or will be introduced when the works are complete (source: *WAPC Factsheet "BAL Contour Maps" Version 2 January 2016*).

BAL Contour Map Interpretation

The contour map will present different coloured contour intervals constructed around the classified bushfire prone vegetation. These represent the different Bushfire Attack Levels (BAL's) that exist as the distance increases away from the classified vegetation. Each BAL represents a set range of radiant heat flux (refer to Appendix 2) that can be generated by the bushfire in that vegetation. The width of each shaded contour interval is determined by calculations involving vegetation type, fuel structure, ground slope, and climatic conditions (i.e. the expected fire behaviour) and are unique to a site and can vary across a site.

BAL Contour Map and 'Class G Grassland'

Grassland vegetation types may have been identified and classified on the subject site (refer to the Vegetation and Topography Map in Figure 5.1). Where this is the situation for the subject Proposal, and it is considered appropriate by the assessor, the BAL contour map produced for this Plan will exclude the area of Class G Grassland. Therefore, the displayed BAL contours will exist for all classified vegetation types except Grassland.

The rationale for this approach is to be able to derive meaningful information from the contour map. If Grassland was to be contoured the entire mapped area could potentially be BAL-FZ and therefore be presented as a sole colour – providing no useful information.

Grassland is commonly not native vegetation. From a practical perspective, it can be easily managed to a low bushfire threat state and generally will not require approval for its removal. Section 7.3 of this Plan details the management measure required to reduce any classified Grassland to a BAL rating of BAL-LOW.

Figure 5.3

BAL Contour Map

Overview

West Mundijong Industrial Precinct
Jarrahdale

LEGEND

- Subject Lots
- Other Lots
- Area of Interest - 100m extent

Bushfire Attack Levels (Method 1)

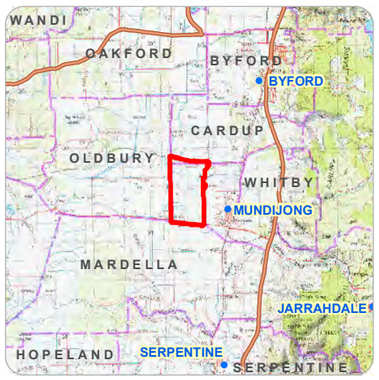
- BAL FZ (Indicative only)
- BAL 40 (Indicative only)
- BAL 29 (Indicative only)
- BAL 19 (Indicative only)
- BAL 12.5 (Indicative only)
- BAL LOW (Indicative only)

SCALE (A3)

0 250 500 750

Metres

LOCALITY



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Aerial Image: Landgate Aug 2016

BAL Contour Table	
Woodland	
Slope > 0° - 5°	Distance (m)
BAL FZ	< 13
BAL 40	13 - < 17
BAL 29	17 - < 25
BAL 19	25 - < 35
BAL 12.5	35 -< 100
Grassland	
Slope > 0° - 5°	Distance (m)
BAL FZ	< 7
BAL 40	7 - < 9
BAL 29	9 - < 14
BAL 19	14 - < 20
BAL 12.5	20 - < 50

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator
Map created on: 28-Nov-16
Map compiled by: Bruce Greentree

Figure 5.3.1

BAL Contour Map

North

West Mundijong Industrial Precinct
Jarrahdale

LEGEND

- Subject Lots
- Other Lots
- Area of Interest - 100m extent

Bushfire Attack Levels (Method 1)

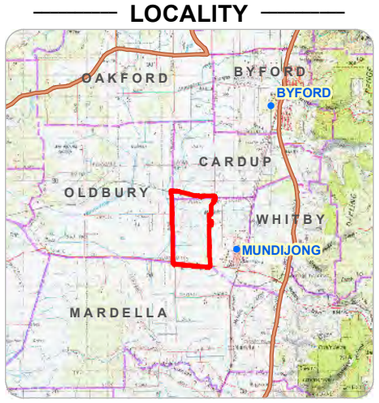
- BAL FZ (Indicative only)
- BAL 40 (Indicative only)
- BAL 29 (Indicative only)
- BAL 19 (Indicative only)
- BAL 12.5 (Indicative only)
- BAL LOW (Indicative only)

SCALE (A3)

0 250 500

Metres

LOCALITY



Aerial Image: Landgate Aug 2016

BAL Contour Table	
Woodland	
Slope > 0° - 5°	Distance (m)
BAL FZ	< 13
BAL 40	13 - < 17
BAL 29	17 - < 25
BAL 19	25 - < 35
BAL 12.5	35 -< 100
Grassland	
Slope > 0° - 5°	Distance (m)
BAL FZ	< 7
BAL 40	7 - < 9
BAL 29	9 - < 14
BAL 19	14 - < 20
BAL 12.5	20 - < 50

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator
Map created on: 28-Nov-16
Map compiled by: Bruce Greentree

Figure 5.3.2

BAL Contour Map

South

West Mundijong Industrial Precinct
Jarrahdale

LEGEND

- Subject Lots
- Other Lots
- Area of Interest - 100m extent

Bushfire Attack Levels (Method 1)

- BAL FZ (Indicative only)
- BAL 40 (Indicative only)
- BAL 29 (Indicative only)
- BAL 19 (Indicative only)
- BAL 12.5 (Indicative only)
- BAL LOW (Indicative only)

SCALE (A3)

0 250 500

Metres

LOCALITY

N

Aerial Image: Landgate Aug 2016

BAL Contour Table	
Woodland	
Slope > 0° - 5°	Distance (m)
BAL FZ	< 13
BAL 40	13 - < 17
BAL 29	17 - < 25
BAL 19	25 - < 35
BAL 12.5	35 -< 100
Grassland	
Slope > 0° - 5°	Distance (m)
BAL FZ	< 7
BAL 40	7 - < 9
BAL 29	9 - < 14
BAL 19	14 - < 20
BAL 12.5	20 - < 50

BUSHFIRE PRONE PLANNING

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator
Map created on: 28-Nov-16
Map compiled by: Bruce Greentree

5.3.1 BAL's as Indicated / Determined by the Contour Map

BUSHFIRE PRONE PLANNING'S INTERPRETATION AND USE GUIDE
(of information derived from the BAL Contour Map)

The Primary Use of BAL Contour Mapping - Planning

BAL contour mapping is primarily a planning tool that can give an overview as to the suitability of a site for development with respect to the extent to which bushfire is a potential threat to future buildings and persons on the subject land.

The mapping considers the development site (i.e. all existing or proposed lots) and does not consider the bushfire risk at an individual lot level and over different development time frames. Rather it is assessing the situation that will exist when the entire development has been completed, including any vegetation management that would reasonably be expected to take place as part of establishing buildings on the lots. On this basis, it helps decision makers determine the suitability of the proposed development for planning approval.

As a result, there will be situations where, for the purposes of planning, classifiable vegetation is not contoured. However, at a specific point in time (prior to full completion of a development) this vegetation may impact on a proposed buildings BAL rating.

A Secondary Use of BAL Contour Mapping - Building

Building approval (and the issue of a building permit) requires that a BAL rating is determined for an actual building and not just a lot or a building envelope (i.e. an 'area'). Determination of this BAL rating must consider the actual location of a building within an individual lot and its separation distance from any classified vegetation at the actual time of applying for building approval. It is a site-specific assessment based on the buildings design and location at a given point in time.

This specific assessment (BAL report and BAL certificate) required for a building application cannot always be derived from an assessment that is primarily designed to inform planning decisions. As a result, there are limitations to obtaining a single BAL rating for a future building of unknown location, from a BAL contour map assessment.

Nonetheless, there are limited specific situations where the required building application information (i.e. a BAL Certificate) might be obtained quickly and cost effectively from a BAL contour map assessment. When these 'determined' BAL's can be derived is explained on the following page.

Indicative BAL's

If the assessed BAL for a lot or building envelope (the 'area') is stated as being 'indicative', it is because that 'area' is impacted by more than one BAL contour interval and/or classifiable vegetation remains on the lot, or on adjacent lots, that can influence a future building's BAL rating (and this vegetation may have been omitted from being contoured for planning purposes e.g. Grassland or when the assumption is made that all onsite vegetation can be removed and/or modified). In this report the indicative BAL is presented as either the highest BAL impacting the 'area' or as a range of achievable BAL's within the 'area' – whichever is the most appropriate.

The BAL rating that will apply to any future building within that 'area' will be dependent on:

1. vegetation management onsite; and/or
2. vegetation remaining on adjacent lots; and/or
3. the actual location of the future building within that 'area'.

A BAL Certificate cannot be provided for future buildings within an 'area' with an indicative BAL until the location of any future building has been determined. It usually requires an onsite visit and a BAL assessment report to be produced before the certificate can be issued.

Determined BAL's

If the assessed BAL for a Lot or building envelope (the 'area') or existing building, is stated as being 'determined' it is because that 'area' or building is impacted by a single BAL contour interval. This has been determined by offsite classified vegetation, and no classifiable vegetation currently exists on the lot or on adjacent lots (i.e. it has been cleared to a minimal fuel, low bushfire threat state).

As a result, a determined BAL can be provided in this limited situation because:

1. No classified vegetation is required to be removed or modified to achieve the determined BAL, either within the lot or on adjacent lots (or if vegetation is excluded from classification, it is reasonable to assume it will be maintained in this state into the future); and
2. A future building can be located anywhere within the 'area' and be subject to the determined BAL rating; and
3. The degree of certainty is more than sufficient to allow for any small discrepancy that might occur in the mapping of the BAL contours.

A BAL Certificate (referring to the BAL Contour Map assessment) can be provided for a future building on those 'areas' assessed as having a determined BAL.

(Note: The only limitation to a BAL Certificate being derived from a BAL contour map is if significant time has passed since the original assessment and the vegetation needs to be reassessed and the BAL contour map updated. If a BAL Certificate has previously been issued, it will only remain valid for one year).

5.3.2 Identification of Specific Issues Arising from BAL Contour Map

The proposed BAL contour map presented in Figure 5.3 (overview plan) is based on the future developments. Classified vegetation within the development area will be managed as low threat areas with the main areas of BAL 12.5 or greater rated lots to be on the external boundaries and those adjacent to the retained native vegetation and ecological corridors.

Figures 5.3.1 and 5.3.2 show enlarged maps of the northern and southern areas to indicate the details of indicative BAL ratings for the areas associated with the retained native vegetation and ecological corridors. The BAL contours show only indicative BAL ratings and any new development will require further assess to determine any future development BAL ratings.

5.4 Existing Habitable Buildings on Subject Site – Assessed BAL's

The existing building within the subject site have not been assessed as part of the Bushfire hazard level assessment as this proposal is for the strategic level scheme amendment proposed by the Shire of Serpentine – Jarrahdale.

6 Environmental Considerations

"Many bushfire prone areas also have high biodiversity values. SPP 3.7 Policy objective 5.4 recognises the need to consider bushfire risk management measures alongside environmental, biodiversity and conservation values" ('Guidelines' s2.3).

"Clearing of native vegetation in Western Australia requires a clearing permit under Part V, Division 2 of the Environmental Protection Act 1986 unless clearing is for an exempt purpose. Exemptions from requiring a clearing permit are contained in Schedule 6 of the Act or are prescribed in the Environmental Protection Regulations" ('Guidelines' s2.3).

6.1 Native Vegetation and Re-vegetation

Establishing development in bushfire prone areas can adversely affect the retention of native vegetation through clearing associated with the creation of Asset Protection and Hazard Separation Zones. Where loss of vegetation is not acceptable or causes conflict with landscape or environmental objectives, it will be necessary to consider available options to minimise the removal of native vegetation.

Options to Minimise Removal of Native Vegetation	Considered and Implemented in this Proposal
Reduce lot yield	N/A
Cluster development	Yes
Construct building to a higher standard as per BCA and AS 3959-2009	Yes
Modify the development location	Yes
Comments:	

Does this planning proposal satisfy bushfire protection requirements within the boundaries of the land being developed so as not to impact on the bushfire and environmental management of neighbouring reserves, properties or conservation covenants?	Yes

Where, as part of the Proposal, revegetation of waterway foreshore, wetland or coastal buffers is necessary for their protection or management, this bushfire management plan will need to assess the ability and practicality of maintaining vegetation separation distances corresponding to determined BAL's.

Re-vegetation of riparian and/or coastal areas is part of this Proposal. Can the required BAL separation distance be maintained into the future?	Yes
Have any other landscape plans applying to this Proposal been considered in assessing the potential change in bushfire risk into the future	Yes

If any of the above applies, further information is presented in Section 7 'Bushfire Risk Management Measures'.

The retained native vegetation and ecological corridors that will be proposed as public open space should be managed so not increase the bushfire risk to any adjacent properties.

7 Bushfire Risk Management Measures

7.1 The Bushfire Protection Criteria – Assess and Demonstrate Compliance

State Planning Policy 3.7 Planning in Bushfire Prone Areas (Dept. of Planning and WAPC 2015) requires an assessment against the bushfire protection criteria requirements contained in the *Guidelines for Planning in Bushfire Prone Areas (WAPC 2015 s4.5 and Appendix 4).*

This assessment is to accompany any strategic planning proposal, subdivision application or development application.

Strategic planning proposals need to demonstrate that compliance can be achieved in subsequent planning stages. Subdivision and development applications must demonstrate compliance within the boundary of the subject site or provide justification for those criteria that are not able to be fully met.

The bushfire protection criteria are divided into four elements location, siting and design, vehicular access and water.

For each element, there is:

1. An intent stating the required outcome (overall aim);
2. A performance principle that is a general statement of how best to achieve the intent; and
3. One or more specific criteria to be addressed and for which an acceptable solution is provided as an example of one way of meeting the criteria (and therefore the elements intent).

A proposals compliance with each element is determined by either one or a combination of the following:

1. For each relevant criterion, fully meeting the requirements of the acceptable solution (which automatically achieves the intent for that criteria); and/or
2. For one or more relevant criteria, not fully meeting the requirements of the acceptable solution but achieving the requirements of the performance principle by employing a relatively minor variation on the acceptable solution; and/or
3. For one or more relevant criteria, developing an alternative solution that will achieve the performance principle.

Bushfire Prone Planning presents the required assessment against all the bushfire protection criteria as a separate table for each element and includes the intent, the performance principle and acceptable solution examples, for convenient reference.

Summarised Outcome for the Proposal of the Assessment Against the Bushfire Protection Criteria							
Element *each element consists of one or more criteria*	**Complies With the Acceptable Solution for ALL Relevant Criteria** *or will comply*	**Achieves the Intent of the Element for ALL Relevant Criteria** *or will achieve*	**Required Basis of the Planning Assessment**				**Notes**
			Acceptable Solutions	**Performance Principle**			
			Complies with the Acceptable Solution for ALL Relevant Criteria *or will comply*	**Achieves the Intent of the Element (or will achieve)**		**As Minor or Unavoidable Development**	
				For one or more criterion, the given acceptable solution is not fully met. A variation of the solution is provided and justified.	*An Alternative Solution is Developed*		
Location	Will in the Future	Will in the Future	✓			N/A	
Siting and Design of Development	Will in the Future	Will in the Future	✓				
Vehicular Access	Will in the Future	Will in the Future	✓				
Water	Will in the Future	Will in the Future	✓				

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 (to be complied with to meet the intent and used to develop alternative solutions): 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 minor or 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	**Further Explanation**	**Compliance**	**Assessment Statements**
A1.1 Development Location The strategic planning proposal, subdivision and development application is located in an area where the bushfire hazard assessment is or will, on completion, be moderate or low **OR** The development is subject to BAL-29 or below.	Land is most suitable for land use intensification where hazard levels are low. Where there is an extreme bushfire hazard level or requirements for use of BAL-40 or BAL-FZ construction standards, the land is not considered suitable for development unless it meets the definition of minor or unavoidable development (which requires WAPC, DFES and local planning approval).	Will Fully Comply with the Acceptable Solution	The subject site is located within a designated bushfire prone area. By implementing the positioning and vegetation management measures identified in this Plan the proposed scheme amendment can meet the acceptable solution of being subject to BAL-29 or below. It does not require the use of BAL-40 or BAL-FZ construction standards.

Bushfire Protection Criteria - Element 2 - Siting and Design of Development

Intent: To ensure that the siting and design of development *(note: not building/construction design)* minimises the level of bushfire impact.

Performance Principle P2 (to be complied with to meet the intent and used to develop alternative solutions): The intent may be achieved where 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 risk that applies to the site. That it minimises the bushfire risk to people, property and infrastructure, including compliance with AS3959 if appropriate.

Acceptable Solution Either or both solutions to be met to the extent that it satisfies Element 1.	**Further Explanation**	**Compliance**	**Assessment Statements**
A2.1 Asset Protection Zone (APZ) Every building is surrounded by an Asset Protection Zone (minimum of twenty metres wide), depicted on submitted plans, which meets the defined requirements. **OR** Where a full 20 metre APZ is not possible the APZ should be sufficient enough to ensure the potential radiant heat impact of a fire does not exceed 29 kW/m^2. The specifications for the establishment and maintenance of the APZ are stated in Appendix 3 and Appendix 4.	The APZ is a low fuel area immediately surrounding a habitable or specified building. All requirements in A2.1 are essential and must be achieved to ensure compliance. If the implementation of protection zones was to result in the loss of vegetation that is not acceptable or causes conflict with landscape and environmental objectives, then the development may need to be modified.	Will Fully Comply with the Acceptable Solution	The proposed scheme amendment can meet the acceptable solution: This is achieved by: • Incorporating an APZ, to the extent possible within the boundary of the lot, into the landscaping surrounding the any future building work and maintaining it to comply with specified requirements into the future; • The extent of the APZ being established within the boundary of the lot results in the potential radiant heat impact of a fire on the proposed building work not exceeding 29kW/m^2

Bushfire Protection Criteria - Element 2 - Siting and Design of Development (continued)			
Acceptable Solution Either or both solutions to be met to the extent that it satisfies Element 1.	**Further Explanation**	**Compliance**	**Assessment Statements**
A2.2 Hazard Separation Zone (HSZ) Every building and its contiguous APZ is surrounded by a Hazard Separation Zone (minimum of 80 metres wide), depicted on submitted plans, that meets the defined requirements. **OR** A HSZ may not be required if the proposed construction meets the standard appropriate to the BAL for that location and the determined BAL does not exceed BAL-29. The specifications for the establishment and maintenance of the HSZ are stated in Appendix 4.	Hazard separation should be provided between extreme bushfire hazards and buildings to create a combined separation distance of 100m (50m for unmanaged grassland) in order to protect them from burning embers, radiant heat and direct flame contact. The minimum hazard separation distance may be reduced by compliance with AS 3959 which requires that as the distance from the vegetation is reduced, the construction standard must be increased.	Will Fully Comply with the Acceptable Solution	The proposed scheme amendment can meet the acceptable solution by: • Establishing and maintaining a HSZ that meets all defined requirements, or • A determined BAL not exceeding BAL-29; • Applying the construction standard corresponding to a determined BAL rating as per AS 3959-2009; and • Any future buildings that are Class 4-9 buildings are not required under the Building Code of Australia to be constructed to the standard corresponding to the determined BAL rating as set out in AS3959-2009.

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 (to be complied with to meet the intent and used to develop alternative solutions): The intent may be achieved where 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	Further Explanation	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 and the public at all times and under all weather conditions.	This is to apply to access routes leading into a subdivision as well as those within a subdivision. All access should accommodate type 3.4 fire appliances (4WD 7t chassis). Two-way access should be provided as a public road, however, where a public road cannot be provided (and this will need to be demonstrated by the proponent providing justification), an emergency access way may be considered.	Will Fully Comply with the Acceptable Solution	Access and egress to two different locations will be incorporated in the design of any future developments. The current scheme amendment provides safe access and egress to two different destinations via the proposed road network. As a sealed public roads they will be available to all residents and the public at all times and under all weather conditions.

Bushfire Protection Criteria - Element 3 - Vehicular Access (continued)

Intent: To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.

Performance Principle P3 (to be complied with to meet the intent and used to develop alternative solutions): The intent may be achieved where 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	Further Explanation	Compliance	Assessment Statements
A3.2 Public Road Minimum trafficable surface of 6m. Constructed to meet the technical requirements stated in Appendix 5.	In special circumstances, where ≤8 lots serviced, a minimum 4m trafficable surface for a maximum of 90 might be approved.	Will Fully Comply with the Acceptable Solution	Existing and future public roads will meet the technical requirements of the guidelines
A3.3 Cul-de-sacs - (includes dead-end roads). A maximum length of 200m with a 17.5m turnaround. 600m length if cul-de-sacs services ≤8 lots and is joined to another cul-de-sac by an emergency access way of <600m). Constructed to meet the technical requirements stated in Appendix 5.	Should be avoided in bushfire prone areas as they do not provide access/egress in different directions. Where no alternative exists this will need to be demonstrated by the proponent including if the lot layout already exists. Cul-de-sac is to connect to a public road.	N/A	
A3.4 Battle-axe Maximum length 600m, minimum width 6m, passing bays @ 200m, turnaround area @ 500m and at house site. Constructed to a minimum of private driveway standards. Constructed to meet the technical requirements stated in Appendix 5.	Should be avoided in bushfire prone areas If no alternative exists this will need to be demonstrated by the proponent.	N/A	

Bushfire Protection Criteria - Element 3 - Vehicular Access (continued)			
Acceptable Solutions	**Further Explanation**	**Compliance**	**Assessment Statements**
A3.5 Private Driveways Are required where a house is >50m from a public road. Passing bays @ 200m, turnaround area @ 500m and within 50m of house. Bridges/culverts to support 15t. All weather surface. Constructed to meet the technical requirements stated in Appendix 5.		Will Fully Comply with the Acceptable Solution	All private driveways that are >50m in length will be required to comply with the technical requirements of the guidelines
A3.6 Emergency Access Way Provided as a right of way or public access easement in gross (maximum length of 600m) to ensure accessibility to the public and fire services in emergencies. It should comply with minimum standards for a public road and be signposted. Constructed to meet the technical requirements stated in Appendix 5.	An access way that does not provide through access to a public road is to be avoided in bushfire prone areas. Where no alternative exists this will need to be demonstrated by the proponent. It is to be provided as an alternative link to a public road during emergencies.	N/A	
A3.7 Fire Service Access Routes - (perimeter roads) Provided as rights of way or public access easements in gross; all weather surface and allow for two-way traffic; dead-end roads not permitted; turnarounds every 500m; less than 600m to a public road and be signposted. Constructed to meet the technical requirements stated in Appendix 5.	Fire service access routes should be established to separate bushfire prone areas from developed areas and to provide access within and around the edge of the subdivisions and related development. To be used during bushfire suppression operations and prevention work.	N/A	
A3.8 Firebreak Width Lots greater than 0.5 hectares must have an internal perimeter firebreak of a minimum width of three metres or to the level prescribed in the local firebreak notice issued by the local government.		Will Fully Comply with the Acceptable Solution	The lots will comply with the requirements of the local government annual firebreak notice issued under s33 of the Bush Fires Act 1954.

Bushfire Protection Criteria - Element 4 – Water

Intent: To ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.

Performance Principal P4 (to be complied with to meet the intent and used to develop alternative solutions): The intent may be achieved where the subdivision, development or land use is provided with a permanent and secure supply that is sufficient for firefighting purposes.

Acceptable Solution	Further Explanation	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 DFES. Constructed to meet the technical requirements stated in Appendix 6.	The Water Corporations 'No 63 Water Reticulation Standard' is deemed to be the baseline criterion for developments and should be applied unless local water supply authorities' conditions apply. Additionally, any local government variation must be met (s8.4).	Will Fully Comply with the Acceptable Solution	A reticulated water supply is not currently available to the site and future provision to install hydrants may be required. Hydrants will be required to be installed to Water Corp and DFES standard DS63.
A4.2 Non-Reticulated Areas Water tanks for firefighting purposes with a hydrant or standpipe are provided. Minimum of 50,000l/tank; minimum 1 tank/25 lots (or part thereof); house ≤2km from a tank; 20min turnaround time for 2.4 appliance; hardstand area suitable for 3.4 appliance within 3m of tank Must meet the technical requirements stated in Appendix 6. Any local government variation must also be met (s8.4).	The specification of the requirements for the proposal being assessed will be set by the water supply authority and DFES. A procedure must be in place to ensure that water tanks are maintained at or above the designated capacity at all times, including home tanks on single lots. This could be in the form of an agreement with the local government and the fire service. Water tanks and associated facilities are vested in the relevant local government	Will Fully Comply with the Acceptable Solution	If a reticulated water source is not installed to the subject site several strategic water tanks could be installed to the specifications of the Guidelines.
A4.3 Non-reticulated Areas (Individual Lots) Single lots above 500 m^2 need a dedicated static water supply on the lot that has the effective capacity of 10,000 litres. Must meet the technical requirements stated in Appendix 6.	A4.3 is only for use if creating one additional lot and cannot be applied cumulatively.	N/A	

7.2 Location of Buildings and Applicable BAL's

Future buildings on the proposed lots are to be located in areas where an appropriate Bushfire Attack Level rating can be achieved and where minimal removal of valuable existing native vegetation is required to achieve this rating. The intent is to have the subject land of this Proposal located in an area where the bushfire hazard level is, or will on completion, be moderate or low or be subject to a maximum Bushfire Attack Level of BAL-29.

The proposed subdivision is unlikely to be approved if the indicative BAL rating for future buildings on any proposed lots is either BAL-40 or BAL-FZ as it is unacceptable on planning grounds. The exception will be if it meets the definition of unavoidable development ('Guidelines' s5.4 and s5.7). If this applies the appropriate additional assessment and input from the relevant authorities, if required, is included in this Plan.

Any future buildings within the scheme amendment area may be required to comply with AS3959-2009 construction standards dependent on a determined BAL being undertaken on the development. As the whole site is currently within a bushfire prone area as per the Map of Bushfire prone Areas (DFES) a BAL assessment will be required.

If future buildings are Class 4-9 these may not be required to comply with AS3959-2009 but will be required to undertaken some bushfire mitigation and comply with the Guidelines for planning in bushfire prone areas.

Any future high risk land uses that are proposed within the West Mundijong Industrial Precinct are advised to be located greater than 100m from the retained vegetation associated with Manjedal Creek or the ecological corridors proposed as part of this scheme amendment. By developing outside of these areas the risk of bushfire will be reduced to these high risk developments. This is based on the proviso that all the existing unmanaged grassland will be managed.

7.3 Vegetation Management

Ongoing Maintenance of Assessed Vegetation

1. Where any existing or planned re-vegetation has been assessed as "low threat" (meeting AS 3959-2009 Section 2.2.3.2 requirements) and excluded from classification then this area will be managed to continue to meet those requirements (refer to Appendix 3) and enable the buildings to retain their determined BAL ratings;

2. Any classified vegetation onsite (i.e. within a subject lot) that has directly contributed to the determined BAL rating for a given building, will be managed such as to not change that vegetation to a higher risk classification; and

3. Where a local government issues an annual firebreak notice under s33 of the Bush Fires Act 1954, this will be complied with.

Bushfire Protection Zones

The *Guidelines for Planning in Bushfire Prone Areas (WAPC 2015)* set out the requirements to create an Asset Protection Zone (APZ) and a Hazard Separation Zone (HSZ). The aim of these bushfire protection zones is to have a fire of diminishing intensity and flame length as it approaches development. These reduced fuel loads will reduce the intensity of radiant heat onto the buildings, thereby increasing their survivability. This will also be important for firefighter and occupant's safety during fire suppression activities.

Asset Protection Zone (APZ) – This is to be established, within a subject lot's boundary such that a building will not be subject to a BAL rating greater than BAL-29. On a lot size where it is possible to achieve, it is to be a minimum width of 20 metres and increased when directed to the width required such that such that a building will not be subject to a BAL rating greater than BAL-29.

The APZ must be maintained as either a non-vegetated area or as low threat vegetation managed in a minimal fuel condition as per AS 3959-2009 s2.2.3.2 (e) and (f). A minimal fuel condition is stated in the standard as meaning "there is insufficient fuel available to significantly increase the severity of the bushfire attack" and being "recognisable as short cropped grass for example to a nominal height of 100mm."

Hazard Separation Zone (HSZ) - Where the lot size permits, a Hazard Separation Zone (HSZ) should also be established.

Refer to Appendix 3 and Appendix 4 for specific technical requirements.

Establishing the APZ

An Asset Protection Zone (APZ) creating a low fuel area will be required to be incorporated into the landscaping surrounding current and any future buildings on the proposed lots.

Vegetation will be removed from this site to enable construction to take place. It is proposed to clear this vegetation to the extent that it achieves either the minimum width of 20m, as specified in the Guidelines for an APZ, or the minimum required separation distances based on a Determined BAL on any future buildings/development.

Minimum Vegetation Separation Distances

The future development within the subject area will need to be maintain a separation distance from any classified vegetation associated with any future development to meet the BAL assessed at a later stage. The minimum distances for the existing classified vegetation is shown in Table 7.3.1.

This minimum separation distance from any classified vegetation, that corresponds to the proposed building's assessed BAL will be maintained as either a non-vegetated area or as low threat vegetation managed in a minimal fuel condition as per AS 3959-2009 s2.2.3.2 (e) and (f). A minimal fuel condition is stated in the standard as meaning "there is insufficient fuel available to significantly increase the severity of the bushfire attack" and being "recognisable as short cropped grass for example to a nominal height of 100mm." Refer to Appendix 3 of this Plan for further detail.

It is also recognised that the local government issues an annual firebreak notice under s33 of the Bush Fires Act 1954 and this will be complied with.

Table 7.3.1: Minimum separation distance for classified vegetation

Relevant Fire Danger Index (AS3959-2009 Table 2.1)	80
BAL Determination Method	Method 1 as per AS 3959-2009 s2.2.6 and Table 2.4.3. Refer to Appendix 2 this Plan

Vegetation Area	Applied Vegetation Classification	Effective Slope Under the Classified Vegetation (degrees)	Achievable BAL's			
			BAL-29	BAL-19	BAL-12.5	BAL-LOW
			Identified by stating the separation distance (in metres) to classified vegetation that is required to achieve the corresponding BAL rating. (Refer below Table for further explanation)			
1	Class B Woodland	0-5	17-<25	25-<35	35-<100	Risk of Ember Attack
2	Class B Woodland	0-5	17-<25	25-<35	35-<100	Risk of Ember Attack
3	Class B Woodland	0-5	17-<25	25-<35	35-<100	Risk of Ember Attack
4	Class G Grassland	0-5	9-<14	14-<20	20-<100	Risk of Ember Attack
5	Class G Grassland	0-5	9-<14	14-<20	20-<100	Risk of Ember Attack
6	Class B Woodland	0-5	17-<25	25-<35	35-<100	Risk of Ember Attack

7.4 Vehicular Access

The internal layout, design and construction of public and private vehicular access and egress in the subdivision/development must allow emergency and other vehicles to move through it safely at all times and specifically during a bushfire event.

It is the developer's responsibility to ensure that subdivision and development design allow for the bushfire protection criteria for vehicular access be met as per the 'Guidelines'. How this Proposal complies with the bushfire protection criteria is set out in s7.1 with additional information and justification presented below if necessary.

The current proposed road network will be designed and constructed to provide public and emergency service vehicles access and egress to two different destinations with the public roads to be compliant with the technical requirements of the Guidelines. If any future private driveways are to greater then 50m from the public road, the driveway will be required to comply with the guidelines.

In future planning stages the vehicle access will be achieved to comply with the requirements of the Guidelines.

7.5 Firefighting Water Supply

The intent is to ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire. This intent may be achieved where the subdivision, development or land use is provided with a permanent and secure supply that is sufficient for firefighting purposes.

A reticulated water supply does not exist within the structure plan area but is proposed to be installed as part of the redevelopment. As the area is to be General Industry and Light Industry to comply with the WaterCorp DS63 standard hydrants will be required to be installed every 100m.

The required hydrants, water tanks, couplings and access will be installed as per the technical requirements detailed in Appendix 6 and DFES standards.

7.6 Building Construction Standards

7.6.1 Future Habitable Buildings on the Subject Site

Building Classes 1, 2, 3 and 10a

The Building Code of Australia (BCA) contains bushfire construction requirements that are applied to residential buildings of Class 1, 2 or 3 and associated Class 10a buildings and decks. These are required by the BCA to be constructed to reduce the risk of ignition from a bushfire at a level that corresponds to the potential risk for a given situation (determined as a BAL rating). The BCA references *AS3959-2009 Construction of buildings in bushfire prone areas* or the *(NASH) Standard – Steel Framed Construction in Bushfire Prone* Areas (for Class 1a and 1b buildings only) as deemed to satisfy solutions that provide one way of complying with the Building Code's bushfire performance requirements.

(Note: Higher construction standards can be applied by a local government or as a part of an alternative solution that might be presented in this Plan to enable compliance with the Bushfire Protection Criteria).

Building Classes 4 - 9

The BCA bushfire performance requirements do not apply to Class 4 – Class 9 buildings unless imposed by the relevant local government (or voluntarily adopted).

However, determining the BAL ratings of proposed Class 4-9 buildings allows for them to be:

- Sited appropriately and have classified vegetation removed and /or managed such that their exposure to flames, radiant heat and embers is as low as is practically possible.
- Constructed to the standard corresponding to the BAL rating if the developer, owner or local government deem it is prudent and necessary.

Bushfire Prone Planning Recommendation - When the subject site is in a designated bushfire prone area and the determined BAL is BAL-LOW, AS3959-2009 does not provide construction requirements. However, Bushfire Prone Planning considers a building in this situation to still be at some risk of an ember attack. Therefore, to improve the protection for occupants as well as the building itself, we recommend that consideration be given to constructing the proposed building works to the standard corresponding to a BAL of BAL-12.5.

7.6.2 Existing Habitable Buildings on the Subject Site

Class 1, 2 and 3 buildings and Class 10a associated buildings and decks, constructed prior to the requirement to comply with bushfire performance requirements, do not need to meet these requirements.

Buildings of Class 4 to Class 9 are not required by the Building Code of Australia (BCA) to be constructed to comply with bushfire performance requirements.

The *Guidelines for Planning in Bushfire Prone Areas (WAPC 2015)* state, "The policy measures of *SPP 3.7* and these Guidelines are not to be applied retrospectively" (Guidelines s2.2). Further, the WA Building Commission 'Building in Bushfire Prone Areas' information note states "Building standards and regulations are generally not retrospective".

Therefore, retrospectively upgrading a building to comply with the bushfire performance requirements can only be a recommendation.

Bushfire Prone Planning Recommendation: *As the existing buildings exist in a bushfire prone area and may be subject to a bushfire attack, Bushfire Prone Planning recommended that some degree of upgrading be considered to improve the protection for occupants and the building's survivability. At a minimum protection from ember attack should be considered (i.e. constructed to the standard required for BAL-12.5).*

The existing buildings within the study site have not been assessed as part of this bushfire management plan.

8 Specific Land Uses

State Planning Policy 3.7 Planning in Bushfire Prone Areas (Department of Planning and WAPC 2015) sets out in policy measure 6.6 what is required for 'vulnerable' or 'high risk' land uses to be supported in bushfire prone areas subject to BAL-12.5 or higher.

8.1 Vulnerable Land-Use – Definition / Application / Requirements

Is this Bushfire Management Plan (BMP) to accompany a development application for building work associated with a land use that is considered a 'vulnerable' land use?	No
Is a Bushfire Evacuation Plan for Proposed Occupants to be provided as a separate document and be considered as forming a part of this Bushfire Management Plan?	No
Is the required content of a Bushfire Evacuation Plan for Proposed Occupants to be provided as an addition to the proponents existing emergency evacuation plan?	No
In certain circumstances the required information to fully compile the Bushfire Evacuation Plan (e.g. position, names and contact numbers for responsible persons) is not available at the development application stage. In such a situation the responsibility to complete the required details prior to occupancy of the subject building will noted in the Landowner/Proponent Responsibilities section of this BMP. Does this situation apply to this application?	Yes

Information reference: SPP 3.7 *Planning in Bushfire Prone Areas* (Department of Planning and WAPC 2015 s6.6 and s7) and the *Guidelines for Planning in Bushfire Prone Areas* (WAPC 2015 s5.5):

Definition and Application

SPP 3.7 defines vulnerable land use as a land use where persons may be less able to respond in a bushfire emergency. The 'Guidelines expand this and state that vulnerable uses of land are typically those that are considered to have occupants with a lesser capacity to respond in the event of a bushfire and that may present evacuation challenges.

The intent of the policy measure "is to recognise that such sites require special consideration when located in bushfire prone areas. This will ensure that bushfire risk management is sufficiently addressed in the planning assessment of these land uses".

Examples of 'vulnerable' land uses include (but are not limited to) hospitals, nursing homes and retirement villages, tourist accommodation including camping grounds and ecotourism, childcare centres, educational establishments, places of worship and corrective institutions. The definition may also encompass places of assembly, retail and office premises, as well as subsidiary uses of residential development, such as family day care centres or home businesses, and essential infrastructure such as energy, transport, telecommunications and other utilities.

In general terms the following scenarios might need to be considered as vulnerable land uses:

a. Where persons are present that have a lesser physical/mental capacity to respond to emergencies;
b. Where occupancy might be transient in nature;
c. Where greater numbers of persons may be present at certain times;
d. Where occupants are typically not fully familiar with the building or area.

Required Information

1. In areas where BAL-12.5 to BAL-29 applies, a subdivision or development application will not be supported unless it is accompanied by a Bushfire Management Plan (BMP) jointly endorsed by the relevant local government and the State authority for emergency services;
2. The BMP is to include an assessment against the bushfire protection criteria requirements demonstrating compliance within the boundary of the development site.
3. Subdivision applications are to make provision for emergency evacuation;
4. Development applications should include a bushfire evacuation plan for proposed occupants; and
5. Where BAL-40 or BAL-FZ applies, applications will not be supported unless they meet the definition of 'minor' or 'unavoidable' development.

This proposal for the scheme amendment does not currently propose any 'vulnerable' land uses but in the future, there may be development that is categorised as vulnerable and if in a BAL-12.5 to BAL-29 area an Emergency Evacuation plan will be required to be developed for this future development.

8.2 High Risk Land Use – Definition / Application / Requirements

Is this Bushfire Management Plan (BMP) to accompany a development application for building work associated with a land use that is considered a 'high risk' land use?	Yes
Is a Risk Management Plan for flammable on-site hazards to be provided as a separate document and be considered as forming a part of this Bushfire Management Plan?	Yes
Is the required content of the Risk Management Plan for flammable on-site hazards to be provided as an addition to the proponents existing emergency planning?	Yes
	-

Information reference: SPP 3.7 *Planning in Bushfire Prone Areas* (Dept. of Planning and WAPC 2015 s6.6 and s7) and the *Guidelines for Planning in Bushfire Prone Areas* (WAPC 2015 s 5.6).

Definition and Application

SPP 3.7 defines high risk land use as a land use which may lead to the potential ignition, prolonged duration and/or increased intensity of a bushfire. Such uses may also expose the community, firefighters and the surrounding environment to dangerous, uncontrolled substances during a bushfire event. The 'Guidelines' provide examples of such uses including (but not limited to) service stations, landfill sites, bulk storage of hazardous materials, fuel depots and certain heavy industries as well as military bases, power generating land uses, saw-mills, highways and railways.

Required Information

1. In areas where BAL-12.5 to BAL-29 applies that a subdivision or a development application will not be supported unless it is accompanied by a Bushfire Management Plan (BMP) jointly endorsed by the relevant local government and the State authority for emergency services;
2. The BMP is to include an assessment against the bushfire protection criteria requirements demonstrating compliance within the boundary of the development site.
3. Development applications should include a Risk Management Plan for any flammable on-site hazards. This may include establishing an appropriate Asset Protection Zone (APZ) or Hazard Separation Zone (HSZ). It may determine that a reduction in on-site flammable material or appropriate storage of such material, would be required to reduce the threat, among other considerations.; and
4. Where BAL-40 or BAL-FZ applies, applications will not be supported unless they meet the definition of 'minor' or 'unavoidable' development.

As this proposal is for the scheme amendment to be rezoned as General Industry and Light Industry this could include high risk developments such as fuel depots and service stations, there will be a requirement for these high risk developments to have an Emergency Risk Management plan to address the specific risk that bushfire incidents will have on the future development. As there are no specific high risk land uses proposed as part of this proposal this will need to be addressed at a later planning stage.

9 Compliance Statements - of the Proposal and this Plan

This section of the Plan makes statements with respect to the Proposal's compliance against the components of the WA framework for bushfire risk management. It also states how the content of this BMP satisfies the requirements of SPP 3.7.

The key components of the WA framework for bushfire risk management are summarised in Appendix 1.

9.1 State Planning Policy No. 3.7: Planning in Bushfire Prone Areas

SPP 3.7 Policy Objectives - Proposal Compliance Statement		The Proposal Meets Objectives
s5.1	Avoid any increase in the threat of bushfire to people property and infrastructure	**Yes**
Implementation of the bushfire risk management measures as set out in this Plan, including meeting the requirements of the bushfire protection criteria; will avoid any increase in the threat of bushfire.		
s5.2	Identify and consider bushfire risks in decision-making at all stages of the planning and development process (to reduce vulnerability to bushfire).	**Yes**
The bushfire risks have been identified and assessed, as relevant for the stage of this planning submission, using the tools prescribed in *SPP 3.7* (and the associated document *Guidelines for Planning in Bushfire Prone Areas WAPC 2015*). Refer to Section 5 'Assessment of Bushfire Risk'.		
s5.3	Ensure that all stages of planning submissions take into account bushfire protection requirements and include specified bushfire protection methods.	**Yes**
The bushfire protection requirements and any specified protection methods, relevant for the stage of this planning submission, have been taken into account and presented in Section 7 'Bushfire Risk Management Measures'.		
s5.4	Achieve an appropriate balance between bushfire risk management measures; biodiversity conservation values; environmental protection and biodiversity management; and landscape amenity, with consideration of climate change.	**Yes**
The components of this objective have been considered along with the requirements set out in the 'Guidelines' s2.3. Identifying and addressing issues relevant for the stage of this planning submission is presented in this Plan in Section 6 'Environmental Considerations'.		

SPP 3.7 Policy Measures – BMP Compliance Statement		This BMP is Compliant
s6.1	Higher order strategic planning documents in bushfire prone areas	**Yes**
The requirements stated in SPP 3.7 s6.3 include provision of high level consideration of relevant bushfire hazards when identifying or investigating land for future development.		
s6.2	Strategic planning proposals, subdivision and development applications	**N/A**
s6.3	Information to accompany strategic planning proposals	**Yes**
The requirements stated in SPP 3.7 s6.3 include provision of a Bushfire Hazard Level assessment (or a BAL contour map if lots are known), identify issues arising from the relevant assessment and demonstrate that compliance with the Bushfire Protection Criteria can be achieved in subsequent planning stages. Refer to Section 5 of this Plan.		
s6.4	Information to accompany subdivision applications	**N/A**
s6.5	Information to accompany development applications	**N/A**
s6.6	Vulnerable or high risk land uses (subdivision and development applications).	**Yes**
In areas where BAL-12.5 to BAL-29 applies, subdivision applications should make provision for emergency evacuation (presented in this Section 7 of this Plan). Development applications should include an emergency evacuation plan for proposed occupants and/or a risk management plan for any flammable on-site hazards (presented as a separate document). In areas where BAL-40 or BAL-FZ applies, development applications will additionally require statements against the items of SPP 3.7 s6.7.1 and s6.7.2 (included in Section 7 of this Plan).		

SPP 3.7 Policy Measures – BMP Compliance Statement		This BMP is Compliant
s6.7	Strategic planning proposals, subdivision or development applications in areas where an extreme BHL and/or BAL-40 or BAL-FZ applies	**N/A**
These will not be supported unless the proposal is considered to be • Minor development (for specific development applications only, refer to s5.2 5.3) and requiring statements against the items of SPP 3.7 s6.71 (included in Section 7 of this Plan); or • Unavoidable development and requiring statements against the items of SPP 3.7 s6.72 (included in Section 7 of this Plan).		
s6.8	Advice of State/relevant authority/s for emergency services to be sought	**Yes**
For all stages of planning proposals, advice from relevant authorities has been sought, considered and is referenced in Section 7 of this Plan where: • compliance with SPP 3.7 policy measures is unlikely to be achieved; • additional/alternative measures are proposed; and/or • this application contains unavoidable development or vulnerable or high-risk land uses		
s6.9	Advice of State/relevant agencies/authorities for environmental protection to be sought	**N/A**
For all stages of planning proposals, advice from relevant authorities has been sought, considered and is referenced in Section 7 of this Plan where: • The clearing of vegetation within protected environmentally sensitive areas is proposed • Substantial clearing of native vegetation is proposed • Development abuts land managed by a State or Federal authority		
s6.10	Bushfire conditions may be imposed by the decision maker (detailed requirements including modifications and/or conditions)	**N/A**
WAPC and/or the local government may, as a condition of approval, require that a notification be placed on certificates of title and notice of the notification on the deposited plan advising that the lots are in a designated bushfire prone area and subject to a Bushfire Management Plan. This is noted in Section 10 'Responsibilities for Implementation and Maintenance'.		

9.2 Guidelines for Planning in Bushfire Prone Areas (WAPC 2015 as amended)

The 'Guidelines' are designed to assist in the interpretation of SPP3.7's objectives and policy measures. As such they have been referenced and complied with in compiling this Bushfire Management Plan which is to accompany the planning submission. This Plan contains, as a minimum, the information required as per the 'Guidelines' checklist.

9.3 Bushfire Protection Criteria (WAPC 2015 'Guidelines')

The proposed land use has been assessed against the bushfire protection criteria. The assessment of the bushfire risk management measures (i.e. those relevant to each element) and the demonstration of how the proposal meets the criteria are presented in Section 7.1 of this Plan - 'Bushfire Protection Criteria - Assess and Demonstrate Compliance'.

Where the proposal has not been able to fully meet an acceptable solution for a given element or an alternative solution is proposed, then the appropriate sub section of Section 7 'Bushfire Risk Management Measures', demonstrates how the Proposal will comply with the performance principle and the intent of that element. Any required advice and recommendations from DFES and other referral authorities will be included.

9.4 Local Variations to Bushfire Protection Criteria

Are there any endorsed local variations to the bushfire protection criteria (e.g. through a local planning policy) that are to apply to the proposed land use and therefore addressed in Section 7 'Bushfire Risk Management Measures' of this Plan?	No
Does the proposal satisfy the local variations to the bushfire protection criteria?	N/A

9.5 WA Building Act 2011

Relevant regulations associated with the Act are the *Building Regulations 2012* and the Building *Amendment Regulations (No 3)* 2015. The legislation adopts the Building Code of Australia as the minimum technical requirement for the design and construction of buildings and certain other structures in WA and prescribes applicable building standards for certain classes of buildings located in areas designated by the Fire and Emergency Services Commissioner as bushfire prone areas (identified on the Map of Bushfire Prone Areas).

Is this land use proposal at a planning stage at which lot layout is known and construction of buildings (any class) is being proposed?	No

If the response is 'No', then this Proposal is at a planning stage where specific compliance with the Building Act 2011 is not required – rather it will apply at future planning stages. However, if a BAL Contour Map and/or BAL assessment has been provided as part of this Plan, they can apply and may be able to be used for any future planning application (at the applicable planning stage involving construction of buildings).

If the response is 'Yes', then one of the situations below will apply to this proposal.

The Nature of this Land Use Proposal	Applicable
A proposal for a single house or ancillary dwelling (Class 1); or a specified building located in a bushfire prone area on a lot less than 1100m2 or on a lot equal to or greater than 1100m2 but subject to a BAL of BAL-29 or less, does not need to lodge a development application (but will require a building permit application). However, the relevant local government can additionally require that a development application is submitted for planning approval. Bushfire construction requirements will apply in both cases.	N/A
A proposal for a single house or ancillary dwelling (i.e. Class 1); or a specified building located in a bushfire prone area on a lot equal to or greater than 1100m2 but subject to BAL-40 or BAL-FZ must lodge a development application and bushfire construction requirements will apply.	N/A
A proposal, regardless of lot size, for a habitable building other than a single house or ancillary dwelling (i.e. Class 2 or 3 residential or accommodation buildings); or a specified building, located in a bushfire prone area, must lodge a development application and bushfire construction requirements will apply.	N/A
A proposal, regardless of lot size, for mixed use, commercial, industrial buildings or public facilities (i.e. Class 4-9 buildings), located in a bushfire prone area, and must lodge a development application. Bushfire construction requirements will not apply (unless the local government additionally requires them to apply).	N/A

This Proposal is for a planning stage that does not yet require compliance with the *WA Building Act 2011.* However, the obligation for future buildings to be constructed to the standard corresponding to the determined bushfire attack levels is noted in Section 10 of this Plan 'Responsibilities for Implementation and Maintenance'.

9.6 AS 3959 Construction of Buildings in Bushfire Prone Areas (2009 as amended)

This Proposal complies with the methodology set out in *AS 3959* to classify vegetation that is a bushfire threat and to calculate the bushfire attack levels presented as a BAL Contour Map and/or a BAL assessment in Section 5 of this Plan 'Assessment of Bushfire Risk'.

For the construction of any Class 1, 2, 3 buildings and associated Class 10a buildings and decks, this land use proposal will comply with the construction requirements, set out in *AS 3959,* that correspond to the determined bushfire attack level/s for the subject site. This obligation is stated in Section 9 of this Plan 'Responsibilities for Implementation and Maintenance'.

9.7 Local Government Firebreak Notice

This Proposal complies with the requirements of the relevant local government notice by stating the landowner's obligations in Section 10 of this Plan 'Responsibilities for Implementation and Maintenance.' Additionally, the obligation is noted in Section 7.3 'Vegetation Management'.

9.8 Other Applicable Local Government Documents

This Plan provides the required information such that this Proposal can comply with the requirements of:

- Scheme Amendment Report, Shire of Serpentine - Jarrahdale, Town Planning Scheme No. 2 Amendment No. 187 (March 2016)
- West Mundijong Industrial Area, Bushfire Hazard Assessment, Prepared by Calibre Consulting for the Shire of Serpentine Jarrahdale (July 2015)

10 Responsibilities for Implementation & Maintenance

This section sets out the responsibilities of landowners/proponents (including future landowners), builders and local government in relation to the implementation and maintenance of the requirements of SPP 3.7 and the 'Guidelines'.

10.1 Landowner / Proponent Responsibilities (and those acting on their behalf)

Implementation

- Ensure anyone listed as having responsibility under the Plan has endorsed it and is provided with a copy for their information. This includes the landowners/proponents, local government and any other authorities or referral agencies ('Guidelines' s4.6.3).

- Construction of public roads and cul-de-sacs must comply with the standards (Appendix 5 'Vehicular Access').

- Construction of emergency access ways, fire service access routes and associated signs and gates must comply with the standards (Appendix 5 'Vehicular Access').

- Construction of private driveways and battle axes must comply with the standards (Appendix 5 'Vehicular Access').

- Installation of a reticulated water supply must comply with the standards (Appendix 6 'Water') or the requirements set out by the relevant local government.

- For a non-reticulated water supply, ensure that the emergency water supply structure for firefighting purposes (tanks, couplings and access) is constructed to comply with the standards (s7.5 'Fire Fighting Water Supply' and Appendix 6 'Water') or to the standard set out by the relevant local government.

- A procedure must be in place to ensure that the emergency water supply tanks are maintained at or above designated capacity, including home tanks on single lots, at all times ('Guidelines Appendix 4 'Bushfire Protection Criteria').

- Implement the low fuel Asset Protection Zone (APZ) and where applicable the Hazard Separation Zone (HSZ) as per s7.3 'Vegetation Management' and Appendix 4 'APZ and HSZ'.

- Ensure all future buildings the landowner/proponent has responsibility for, are designed and constructed in full compliance with the requirements of the WA Building Act 2011 and the referenced Building Code of Australia (BCA), and with any identified additional requirements of the relevant local government. This should include due consideration of constructing any Class 4-9 buildings to the standard corresponding to their determined BAL even though not required by the BCA.

  For any Class 1, 2, or 3 buildings and associated Class 10a buildings or decks this will include compliance with AS 3959-2009 *Construction of Buildings in Bushfire Prone Areas* (2009 as amended) and/or the National Association of Steel Housing – *(NASH) Standard – Steel Framed Construction in Bushfire Prone Areas,* whereby construction standards corresponding to the assessed BAL will be applied (Appendix 2 'Bushfire Risk Assessment – Methodology Explained').

- Any future 'high-risk'or 'vulnerable' land uses proposed within the scheme amendment area will require to have emergency evacuation plans and/or emergency risk management plans if in an area where the determined BAL is >BAL-12.5

Deposited Plan and Certificate of Title – Potential Obligation

The WAPC may condition a subdivision application approval with a requirement for the landowner / proponent to place a notification onto the certificate(s) of title and a notice of the notification onto the diagram or plan of survey (deposited plan). This will be done pursuant to Section 165 of the Planning and Development Act 2005 ('Hazard etc. affecting land, notating titles as to:') and applies to lots with a determined BAL rating of BAL-12.5 or above.

The notification will be required to state: 'This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land'.

The local government may condition a development application approval with a requirement for the landowner/proponent to register a notification onto the certificate of title (and may need to be included on the deposited plan). This will be done pursuant to Section 70A Transfer of Land Act 1893 as amended ('Factors affecting use and enjoyment of land, notification on title:'). This is to give notice of the bushfire hazard and any restrictions and/or protective measures required to be maintained at the owner's cost.

This condition ensures that:

1. Landowners/proponents are aware their lot is in a designated bushfire prone area and of their obligations to apply the stated bushfire risk management measures; and

2. Ensures that potential purchasers are alerted to the Bushfire Management Plan so that future landowners/proponents can continue to apply the bushfire risk management measures that have been established in the Plan.

Maintaining Compliance

- Current and future landowners/proponents must continue to apply the bushfire management measures set out in this Plan. They must inform any builders (of future structures on a Lot) of the existence of the Plan and the responsibilities it contains.

- The landowner/proponent is responsible for the ongoing review and implementation of the Bushfire Management Plan to ensure that the bushfire risk management measures remain effective. Bushfire plans do not expire and should be seen as a 'living document'. They may require updating in certain circumstances, including (but not limited to) if site conditions change, if further details are required at subsequent stages of the planning process or to reflect new technologies or methodologies in best practice bushfire risk management ('Guidelines' s4.6.4 and s4.6.5).

- Respond to and comply with fire protection or hazard management notices issued by the local government. This includes compliance with the Shire of Serpentine – Jarrahdale Annual Fire Break Notice (the current requirements can be found on the Shire of Serpentine – Jarrahdale website), issued under s33 of the Bush Fires Act 1954 as directed by the 'Guidelines' s6.1 and referenced in this Plan s7.3 'Vegetation Management', s9.7 'Local Government Firebreak Notice' and Appendix 4 'APZ and HSZ'.

- Maintain the low fuel Asset Protection Zone (APZ) within the Lot boundary and where applicable the Hazard Separation Zone (HSZ) as per s7.2 'Vegetation Management' and Appendix 4 'APZ and HSZ'.

- The stated minimum separation distance (refer to s7.3 Table 7.3.1) from any classified vegetation, that corresponds to a future assessed BAL, must be maintained as either a non-vegetated area or as low threat vegetation managed in a minimal fuel condition as per AS 3959-2009 s2.2.3.2 (e) and (f). A minimal fuel condition is stated in the standard as meaning "there is insufficient fuel available to significantly increase the severity of the bushfire attack" and being "recognisable as short cropped grass for example to a nominal height of 100mm." Refer to Appendix 3 of this Plan for further detail.

- Where any existing or planned re-vegetation has been assessed as "low threat" (meeting AS 3959-2009 Section 2.2.3.2 requirements) and excluded from classification then this area will be managed to continue to meet those requirements and enable the buildings to retain their determined BAL ratings.

- The landowner/occupier has responsibility for the emergency water supply tank on a single lot for the purposes of firefighting. They must ensure that the tank is maintained in good condition and has the specified couplings. A procedure must be in place to ensure that water tanks are maintained at or above designated capacity at all times (refer to s7.5 'Fire Fighting Water Supplies' and Appendix 6 'Water')

- For the emergency water supply tank/s that have been installed to service multiple lots, be aware of the arrangement that is in place regarding who has the responsibility for maintaining the emergency water supply tank at or above designated capacity at all times. This could be in the form of an agreement with the local government and the fire service. Check that this is being complied with (refer to s7.5 'Fire Fighting Water Supplies' and Appendix 6 'Water').

10.2 Builder Responsibilities

The builder (generally named on the building permit) is responsible for ensuring that the building or incidental structure to which a building permit applies is, on completion, compliant with the Building Code of Australia (BCA).

For Classes 1a, 1b, 2, 3 and associated 10a buildings or decks located in a designated bushfire prone area, compliance with the BCA requires that these buildings are constructed to the requirements corresponding to their bushfire attack level rating.

The construction standards for Class 1a and 1b buildings are contained in:

- *AS 3959 - 2009 Construction of buildings in bushfire prone areas; or*
- National Association of Steel Housing – *(NASH) Standard – Steel Framed Construction in Bushfire Prone Areas*.

The construction standards for Classes 2, 3 and associated 10a buildings or decks are contained in:

- *AS 3959 - 2009 Construction of buildings in bushfire prone areas.*

The building/s must also comply with any additional local government requirements.

For any Class 4-9 buildings the builder must comply with any construction requirements that are additional to those contained in the BCA. Of particular issue is any requirement, made by the relevant local government or the owner, to construct to the standard corresponding to the determined BAL for proposed buildings.

10.3 Local Government Responsibilities

Implementation

- Provide advice where the clearing of locally significant vegetation is proposed.

- Register this Bushfire Management Plan and keep a record of the sites referred to for the purpose of identify servicing and infrastructure gaps ('Guidelines' s4.6.4).

Maintaining Compliance

- Develop and maintain district bushfire fighting services and facilities.

- Monitor landowner compliance with the annual firebreak notice issued under s33 of the Bush Fires Act 1954.

- For firefighting water tanks and associated facilities vested in the relevant local government a procedure must be in place to ensure that water tanks are maintained in good operational condition and at or above designated capacity at all times. This could be in the form of an agreement with the fire service ('Guidelines' Appendix 4, this Plan s7.5 'Fire Fighting Water Supply').

On land vested in their control, the local government must give due consideration to future actions that have the potential of changing the BAL ratings that an existing habitable building (or existing assessed development site) is subject to. Broadly these actions include:

1. Any planned revegetation of an area; and/or
2. The reduction of any vegetation management over an area that has in the past been actively managed to a minimal fuel condition and would most reasonably be expected to continue to be managed this way.

Specifically, the local government should:

1. Not revegetate an area/s to the extent that it would increase the BAL rating an existing neighbouring habitable building (or assessed development site) is subject to. The area (ha) and location (relative to any classified vegetation) of any revegetation with respect to how it would be assessed from a bushfire perspective (as per AS 3959-2009), must be considered.

2. Continue to manage vegetation to a minimum fuel condition on areas that have been assessed as low threat vegetation in a Bushfire Attack Level assessment if:
    a. The area has been correctly excluded from classification as per AS 3959-2009 s2.2.3.2 (f); and
    b. The exclusion of this area from classification has directly resulted in a neighbouring existing habitable building (or assessed development site), being subject to a BAL-Low rating.

11 Appendices – Advisory Information Only

Appendix 1
The WA Framework for Bushfire Risk Management

This section of the Bushfire Management Plan sets out the applicable legislation, regulations, policies, guidelines, documents, and associated bushfire risk assessments that a Bushfire Management Plan will need to reference and where applicable, comply with. Statements of compliance against these requirements, as required by the 'Guidelines', are presented in Section 8 of this Plan.

The state government of WA has committed to addressing bushfire through the implementation of a risk-based system of land-use planning and development that aims to reduce the risk of bushfire.
The legislative means of facilitating this is through the ***Planning and Development Act 2005*** and its interaction with the ***Fire and Emergency Services Act 1998*** and the ***Building Act 2011***.

Planning and Development (Local Planning Schemes) Amendment Regulations 2015

These regulations are given effect under the ***Planning and Development Act 2005***. The *Planning and Development (Local Planning Schemes) Regulations 2015* are amended to introduce 'Schedule 2 Part 10A 'Bushfire Risk Management' which establishes the *deemed provisions relating to bushfire risk management.*

"The deemed provisions relating to bushfire risk management work with the State Planning Policy 3.7: Planning in Bushfire Prone Areas (SPP 3.7) and Guidelines for Planning in Bushfire Prone Areas (Guidelines); Map of Bushfire Prone Areas; Building Regulations 2012 and Building Code of Australia to guide planning and development proposals in bushfire prone areas to ensure bushfire risk is properly managed.

The deemed provisions provide a mechanism to require a development approval, and through this the application of SPP 3.7 and the Guidelines, to development on sites where BAL-40 or BAL-Flame Zone (FZ) applies. SPP 3.7 sets out the planning hierarchy and the information required at each stage of the planning process whilst the Guidelines provide information on how SPP 3.7 should be implemented" (source: WAPC Planning Bulletin 111/2015 Planning in Bushfire Prone Areas).

The ***deemed bushfire provisions***:

- Only apply to development that is proposed on a site in a designated bushfire prone area.
- Override any existing local planning scheme provisions relating to bushfire, including any inconsistent provisions, apart from special control areas.

- Are in addition to any provisions relating to development in a bushfire prone area that apply to a special control area.
- Can be supplemented by a local planning scheme (by implementing a special control area) but not varied or exempted.
- Are applied and work through the following legislation, regulations, policies, guidelines, and documents – each of which this Bushfire Management Plan will address.

Map of Bushfire Prone Areas

The Map of Bushfire Prone Areas identifies land that has been designated as being bushfire prone by the Fire and Emergency Services Commissioner under the *Fire and Emergency Services (Bushfire Prone Areas) Order 2015* as part of the ***Fire and Emergency Services Act 1998***.

Designation as a bushfire prone area (highlighted as pink on the map) reflects the potential of bushfire to affect that site. It acts as a mechanism for initiating further assessment in the planning and building process. This can involve bushfire risk assessment and management measures being required in planning submissions and activation of the bushfire construction requirements of the Building Code of Australia.

State Planning Policy No. 3.7: Planning in Bushfire Prone Areas (SPP 3.7)

This policy is made under the ***Planning and Development Act 2005*** and provides the foundation for land use planning to address bushfire risk management in Western Australia.

SPP 3.7 applies to every stage of the planning process (i.e. all higher order strategic planning documents; strategic planning proposals; subdivision and development applications) in designated bushfire prone areas. It also applies to an area not yet designated as bushfire prone but is proposed to be developed in a way that introduces a bushfire hazard (*Guidelines for Planning in Bushfire Prone Areas WAPC 2015 s3.2.2*).

The objectives of this policy are to:

- Ensure that all stages of land use planning (higher order strategic planning documents; strategic planning proposals; subdivision and development applications) identify and consider bushfire risk and apply specified bushfire protection measures; and
- To have an outcome that will avoid any increase in the threat of bushfire to people, property and infrastructure, preserve life and achieve an appropriate balance between bushfire risk management measures and all environmental conservation aspects.

Policy measures to achieve the objectives are defined and:

- They vary according to the type and scale of the planning proposal and stage of the development process;
- They set out the information to be prepared for each type of proposal; and
- They refer to the Guidelines *for Planning in Bushfire Prone Areas (WAPC 2015)* as supporting this policy and providing the procedural detail for assessment and presentation of the required information.

Guidelines for Planning in Bushfire Prone Areas (WAPC 2015 as amended)

These Guidelines are designed to supplement and assist in the interpretation of SPP3.7's objectives and policy measures. They provide advice on how bushfire risk is to be addressed when planning, designing or assessing a planning proposal.

As an endorsed standard (by the Office of Bushfire Risk Management), these Guidelines, in conjunction with SPP 3.7, are the predominant documents in the State for use by decision making authorities and referral agencies, during the consideration of strategic planning proposals, subdivisions and development applications.

The Guidelines set out the interrelationships between, and requirements for, various assessment tools used to assess risk in the planning context, as prescribed by SPP 3.7. These include:

- A Bushfire Hazard Level assessment;
- A Bushfire Attack Level (BAL) Contour Map;
- A Bushfire Attack Level (BAL) assessment;
- The Bushfire Protection Criteria; and
- A Bushfire Management Plan

The 'Guidelines' reference the Bushfire Attack Level descriptions and assessment methodologies that are defined in AS 3959.

Bushfire Protection Criteria

The bushfire protection criteria (set out in the 'Guidelines Appendix 4) are a performance based system of assessing bushfire risk management measures. An assessment against the criteria is to be undertaken for any strategic planning proposal, subdivision and development application for a

site that has or will on completion, have a bushfire hazard level above 'Low or a BAL rating above BAL-LOW.

The protection criteria consist of four elements: Location; Siting and Design of Development; Vehicular Access; and Water.

Each element has three components: Intent; Acceptable Solutions; and a Performance Principle. How to apply the Criteria is set out in the 'Guidelines' s4.5.2.

Local Variations to Bushfire Protection Criteria

Local governments may seek to add or to modify the acceptable solutions to recognise special local or regional circumstances (e.g. topography / vegetation / climate which reinforce the intent of a particular bushfire protection element and apply across a defined locality.

These endorsed (by WAPC and DFES) variations will be in the form of a local planning scheme amendment /provision or special control area. Currently they may be in the form of a local planning policy.

WA Building Regulations 2012

- These regulations exist under the **WA Building Act 2011** and adopt the **Building Code of Australia** as the minimum technical requirements for the design and construction of buildings and certain other structures in WA.
- The majority of development in WA requires a building permit before construction can commence. This process typically occurs after the planning process.
- The Regulations include the **Building Amendment Regulations (No.3) 2015** that prescribe applicable building standards for buildings located in areas designated by the Fire and Emergency Services Commissioner as bushfire prone areas (identified on the Map of Bushfire Prone Areas).

Building Code of Australia (BCA)

- The BCA provides minimum technical requirements for the construction of buildings. These are presented as Volumes One and Two of the National Construction Code series.
- The BCA requires an assessment of the potential intensity of bushfire attack for specific classes of residential buildings located in designated bushfire prone areas (Classes 1a, 1b, 2, 3 and associated 10a buildings or decks).
- The BCA requires that these buildings are constructed to the requirements corresponding to their bushfire attack level rating.

- Compliance with BCA bushfire requirements for Class 1a and 1b buildings in designated bushfire prone areas can be demonstrated by compliance with:
    a. Australian Standard *AS 3959 Construction of buildings in bushfire prone areas; or*
    b. National Association of Steel Housing – *(NASH) Standard – Steel Framed Construction in Bushfire Prone Areas.*
- Compliance with BCA bushfire requirements for Classes 2, 3 and associated 10a buildings or decks in designated bushfire prone areas can be demonstrated by compliance with:
    a. Australian Standard *AS 3959 Construction of buildings in bushfire prone areas.*

AS 3959 Construction of Buildings in Bushfire Prone Areas (2009 as amended)

The objective of this Standard is to prescribe construction details for buildings to reduce the risk of ignition from a bushfire, appropriate to the:

a) Potential for ignition caused by embers, radiant heat or flame generated by a bushfire; and
b) Intensity of the bushfire attack on the building.

To achieve this, the Standard defines six categories of Bushfire Attack Level (BAL), details their assessment methodology and specifies constructions standards corresponding to each.

Western Australia Bush Fires Act 1954 (as amended)

'An Act to make better provision for diminishing the dangers resulting from bush fires, for the prevention, control and extinguishment of bush fires'. Matters addressed in the Act include prohibited burning times, total fire bans, bushfire control and extinguishment

The Act sets out the authority given to local government which enables them to:

- Control and extinguish bushfires
- Establish and maintain Bushfire Brigades
- Require landowners and/or occupiers to install and maintain firebreaks to their required specifications
- Require landowners and/or occupiers manage bushfire fuel loads upon the land to their required specifications

The applicable document is the annually issued ***Firebreak Notice*** published by the relevant local government that sets out the obligations for landowners and/or occupiers.

Other Applicable Local Government Documents

These may include:

- Local planning scheme provisions.
- Local planning strategy references to bushfire risk management.
- Local planning strategy references to environment.
- Applicable structure plans
- Special control area provisions
- Previous planning approvals

Other Documents

These may include:

- Any existing Bushfire Management Plan, Bushfire Hazard Level assessment or BAL assessment prepared over the site.
- Relevant landscaping plans applicable to the subject site.

Appendix 2
Bushfire Risk Assessment – Understanding the Methodology

In SPP 3.7 'bushfire risk' is defined as "the chance of a bushfire igniting, spreading and causing damage to people, property and infrastructure."

"Before a strategic planning proposal, subdivision or development application can be considered, it is necessary to understand the extent of the bushfire hazard and its potential to affect people, property and infrastructure. An assessment of bushfire risk is a key component of deciding whether a strategic planning proposal, subdivision or development application should be approved in an area with a potential bushfire threat (from the 'Guidelines')."

Policy measures in *SPP 3.7* (and the associated document *Guidelines for Planning in Bushfire Prone Areas WAPC 2015*) prescribe the various assessment tools to be used to assess bushfire risk in the planning context. These are:

- Bushfire Hazard Level assessment;
- Bushfire Attack Level (BAL) Contour Map;
- Bushfire Attack Level (BAL) assessment;
- Bushfire protection criteria; and
- Bushfire Management Plan

The intent of this Appendix 'Bushfire Risk Assessment – Understanding the Methodology' is to provide an overview of the methodology used in assessing the Bushfire Hazard Level and the Bushfire Attack Level.

Bushfire Hazard Level Assessment Methodology

Used at a strategic planning level, this methodology rates bushfire hazards into three potential categories of low, moderate and extreme by considering the following characteristics:

- Vegetation types and areas
- Effective ground slope under the vegetation threat
- Existing land use on and around the area being assessed
- Prevailing climatic conditions when appropriate

These results are then presented as a Bushfire Hazard Level Map.

Bushfire Attack Level Assessment Methodology

The Australian Standard *AS 3959-2009 Construction of Buildings in Bushfire Prone Areas* defines a Bushfire Attack Level (BAL) as:

"A means of measuring the severity of a building's potential exposure to ember attack, radiant heat and direct flame contact, using increments of radiant heat expressed in kilowatts per metre squared, and is the basis for establishing the requirements for construction to improve protection of building elements from attack by bushfire."

AS 3959-2009 defines six categories of Bushfire Attack Level (BAL) (*AS 3959 Appendix G*); provides the assessment methodology (*AS 3959 s2 and Appendix B);* and specifies constructions standards corresponding to each BAL (*AS 3959 s3 Table 3.1*). The BAL's and corresponding descriptions of the predicted levels of exposure and heat flux exposure thresholds are contained in the table on the following page.

AS 3959-2009 provides two methods to calculate Bushfire Attack Levels:

1. **Method 1 -** a simplified procedure that involves five procedural steps to determine the BAL. It is subject to some limitations of the circumstances in which it can be used.
2. **Method 2 -** a detailed procedure using calculations to determine BALs where a more specific result is sought or site conditions are outside the scope of Method 1. In particular, the use of Method 2 is to apply if the effective slope under the classified vegetation is greater than 20^0 down slope (and no more than 30^0 down slope) and the slope of the land between the site and the classified vegetation is no more than 20^0 regardless of slope type.

Method 1 – Summarised Procedure

- Determination of the area to be assessed
- Determine predominant vegetation type(s) within 100 metres of the site and classify
- Determination of distance of the site, building or building envelop from the classified vegetation type(s)
- Determination of the effective slope under the classified vegetation type(s)
- Determination of BAL's - Forest Fire Danger Index (FFDI) of 80 is used for WA

Separation Distance: *The distance from a subject site (or building) to a specific area of classified vegetation (i.e. the bushfire threat) is labelled in the tables of this Plan as a separation distance. This distance is measured to a point in the vegetation area represented by the "edge of the vegetation" as per AS 3959 -2009 s2.2.4 and the "base of the bushfire prone vegetation (not the canopy)" as per the BAL Assessment [Basic] Factsheet Version 1 December 2015 WAPC. The exact point of measurement is then decided by the assessor on the basis of the fuel structure and expected fire behaviour. If a*

precautionary approach is considered appropriate to a given situation the measurement will be taken at the canopy line.

Bushfire Attack Level Definitions and Corresponding Sections Specifying Construction Requirements (Source: *AS 3959-2009, Appendix G and Table 3.1*)		
Bushfire Attack Level (BAL)	**Description of Predicted Bushfire Attack and Levels of Heat Flux Exposure**	**Construction Section of AS 3959**
BAL - LOW	There is insufficient risk to warrant specific construction requirements but there is still some risk.	4
BAL - 12.5	There is risk of ember attack. The construction elements are expected to be exposed to a heat flux not greater than 12.5 kW/m^2	3 and 5
BAL - 19	There is a risk of ember attack and burning debris ignited by wind borne embers and a likelihood of exposure to radiant heat. The construction elements are expected to be exposed to a heat flux not greater than 19 kW/m^2	3 and 6
BAL - 29	There is an increased risk of ember attack and burning debris ignited by wind borne embers and a likelihood of exposure to an increased level of radiant heat. The construction elements are expected to be exposed to a heat flux not greater than 29 kW/m^2	3 and 7
BAL - 40	There is a much increased risk of ember attack and burning debris ignited by wind borne embers, a likelihood of exposure to a high level of radiant heat and some likelihood of direct exposure to flames from the fire front. The construction elements are expected to be exposed to a heat flux not greater than 40 kW/m^2	3 and 8
BAL - FZ	There is an extremely high risk of ember attack and burning debris ignited by wind borne embers, a likelihood of exposure to an extreme level of radiant heat and direct exposure to flames from the fire front. The construction elements are expected to be exposed to a heat flux greater than 40 kW/m^2	3 and 9

Method 2 – Summarised Procedure

- Determine the relevant FDI or wind speed
- Determine classified vegetation type(s), height and fuel loads
- Determine the effective slope under the classified vegetation
- Determine the slope of the land between the site and classified vegetation
- Determine the distance of the site from classified vegetation
- Calculate the flame length and determine the flame width
- Determine the elevation of receiver/buildings
- Calculate the radiant heat flux
- Determination of BAL's

Appendix 3
Vegetation Classification Exclusions (AS 3959-2009 s2.2.3.2)

Certain vegetation can be excluded from being classified in which case the Bushfire Attack Level shall be rated as BAL-LOW and no bushfire specific construction requirements apply. Such vegetation is one or a combination of the following:

a) Vegetation of any type that is more than 100m from the site.

b) Single areas of vegetation less than 1ha in area and not within 100m of other areas of vegetation being classified.

c) Multiple areas of vegetation less than 0.25ha in area and not within 20m of the site or each other.

d) Strips of vegetation less than 20m in width regardless of length and not within 20m of the site or each other, or other areas of vegetation being classified.

e) Non-vegetated areas, including waterways, roads, footpaths, buildings, and rocky outcrops.

f) Low threat vegetation, including grassland managed in a **minimal fuel condition** (i.e. insufficient fuel available to significantly increase the severity of a bushfire attack – recognisable as short cropped grass to a nominal height of 100mm for example), maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks.

Appendix 4
Technical Requirements – Bushfire Protection Criteria (APZ & HSZ)

A vital and effective component of managing the potential bushfire risk to people, property and infrastructure is creating bushfire protection zones in which fire fuel loads are reduced and maintained. They are an integral part of subdivision and development design and appropriately designed will greatly assist with bushfire prevention and suppression operations.

The *Guidelines for Planning in Bushfire Prone Areas (WAPC 2015, Appendix 4)* set out the requirements to create an Asset Protection Zone (APZ) and a Hazard Separation Zone (HSZ). The aim of these bushfire protection zones is to have a fire of diminishing intensity and flame length as it approaches development. These reduced fuel loads will reduce the intensity of radiant heat onto the buildings, thereby increasing their survivability.

The APZ is a low fuel area immediately surrounding a habitable or specified building and is designed to prevent direct flame contact with buildings and it improves safety for firefighters and occupants during fire suppression activities. Maintaining this zone in a minimal fuel condition is essential and firefighters are not obliged to protect an asset if they think the separation distance between the dwelling and vegetation is unsafe.

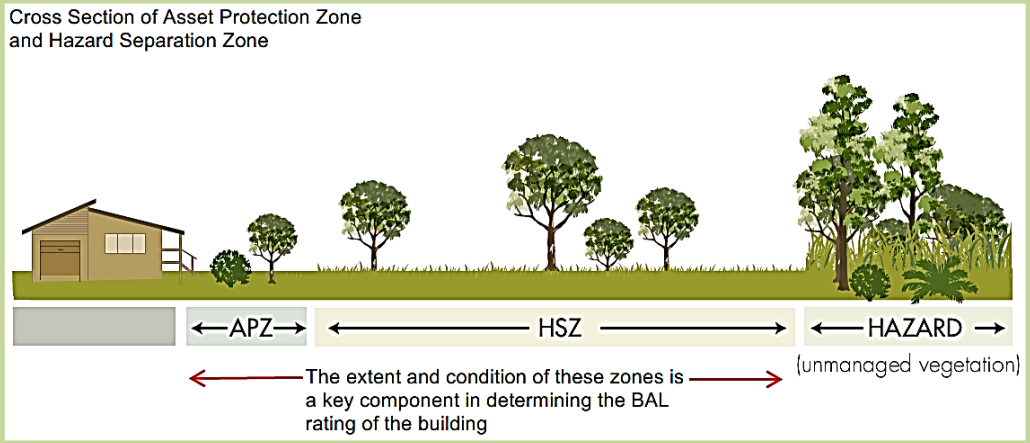
Note that individual local governments may vary their specifications of the APZ from those indicated below. These specifications will be contained in their Firebreak and Fuel load notices and are to be complied with.

Asset Protection Zone (APZ) Requirements (source: 'WAPC Guidelines')

- **Width:** 20 metres measured from any external wall of the building or building envelope. Where the slope increases above 10^0, the APZ should be increased to ensure the potential radiant heat impact of a fire does not exceed 29 kW/m^2 (i.e. a BAL-29 rating on the building).
- **Location:** the APZ should be accommodated within the boundaries of the lot on which the building is situated. Where a full 20 metre APZ is not possible the APZ should be sufficient enough to ensure the potential radiant heat impact of a fire does not exceed 29 kW/m^2 (i.e. a BAL-29 rating on the building).
- **Fine Fuel Load:** reduced to and maintained at 2 t/ha. (DFES guidance-keep grasses short, remove leaves, twigs, dead material within shrubs and trailing bark, and prune branches to 2 metres above the ground).
- **Trees:** crowns are a minimum distance of 10 metres apart (a small group of trees within close proximity to one another may be treated as one crown provided the combined crowns do not exceed the area of a large or mature crown size for that species) and no crowns overhang the building.
- **Shrubs/Trees:** no tall shrubs or tree foliage within two metres of a building
- **Sheds and Fences:** within the APZ are constructed using non-combustible materials (e.g. iron, brick, limestone, metal post and wire) and sheds do not contain flammable materials.

Additional DFES Guidance

a) Do not clump shrubs close to a building. Ensure there is a gap between shrubs and buildings of three times their mature height.
b) Store firewood at least 20 metres away from the building.
c) Keep gutters free of leaves and other combustible material.
d) Roof mounted evaporative coolers to be fitted with ember screens.
e) Gas cylinders to vent away from a building and be tethered to prevent falling over.
f) Driveways and access ways must allow for safe passage of a fire appliance to all buildings on the land.
g) Land owners/occupiers must maintain compliance with the local government's annual firebreak notice issued under s33 of the Bush Fires Act 1954.
h) Barriers such as driveways, lawns, ovals, orchards and pathways surrounding dwellings can form part of a APZ. Locate them to maximise building protection.



Hazard Separation Zone (HSZ) Requirements (source: 'WAPC Guidelines')

The 'Guidelines' set out the requirement for a physical separation between extreme bushfire hazard areas and development in low and moderate hazard areas both around and within subdivisions.

- **Width:** a minimum of 80 metres measured from the outer edge of the APZ for any vegetation classified in AS3959 as forest, woodland, closed shrub, open shrub, mallee/mulga and rainforest OR 30 metres, measured from the outer edge of the APZ, for unmanaged grassland.
- **Location:** within the boundaries of the lot on which the building is situated or, where this is not possible or desirable, within the boundaries of the development precinct in which the building is proposed to be located.
- **Fine Fuel Load:** dead material <6mm diameter and live material <3mm is to be reduced to and maintained at 5 - 8 t/ha for jarrah/marri dominated forest and woodlands, below 12 -15 t/ha in mallee heath and below 15 t/ha in karri forest.
- **Exception -** a HSZ may not be required if the proposed construction meets the standard appropriate to the assessed BAL for that location/building and that BAL does not exceed BAL-29.

The intent is to create a combined minimum separation distance of 100 metres between the buildings and the hazard (50 metres if unmanaged grassland). This separation distance may be reduced if the development is compliant with AS 3959 (i.e. as the distance from classified vegetation is reduced, the construction standard must be increased) or by using a performance principle assessment.

Appendix 5
Technical Requirements - Bushfire Protection Criteria (Vehicular Access)

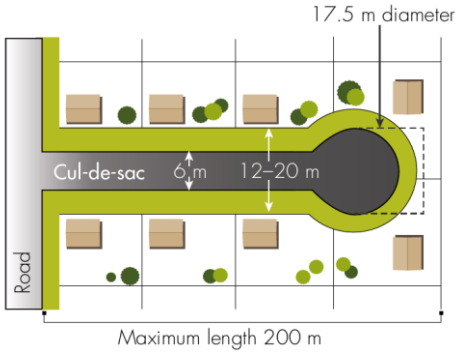
Vehicular Access – Technical Requirements of Acceptable Solutions - Part 1

Source: *Guidelines for Planning in Bushfire Prone Areas WAPC 2015*

Acceptable Solution 3.3 Cul-de-sacs (including a dead-end road)

Their use in bushfire prone areas should be avoided. Where no alternative exists then the following requirements are to be achieved:

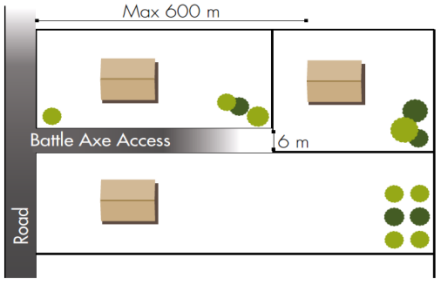
- Maximum length is 200m. If public emergency access is provided between cul-de-sac heads (as a right of way or public access easement in gross), the maximum length can be increased to 600m provided no more than 8 lots are serviced and the emergency access way is less than 600m in length;
- Turnaround area requirements, including a minimum 17.5m diameter head to allow type 3.4 fire appliances to turn around safely;
- The cul-de-sac connects to a public road that allows for travel in two directions; and
- Meet the additional design requirements set out in Part 2 of this appendix.



Acceptable Solution 3.4 Battle-axe

Their use in bushfire prone areas should be avoided. Where no alternative exists then the following requirements are to be achieved:

- Maximum length 600m and minimum width 6m; and
- Comply with minimum standards for private driveways.



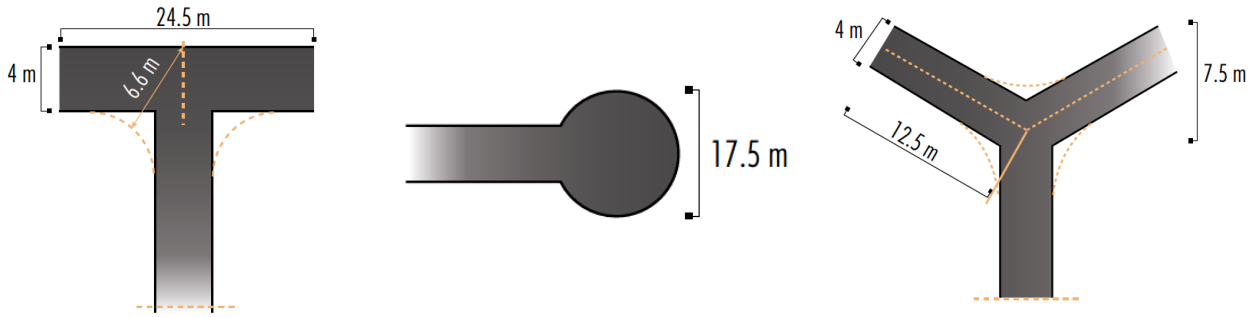
Acceptable Solution 3.5 Private Driveways

The following requirements are to be achieved:

- The design requirements set out in Part 2 of this appendix; and

Where the house site is more than 50 metres from a public road:

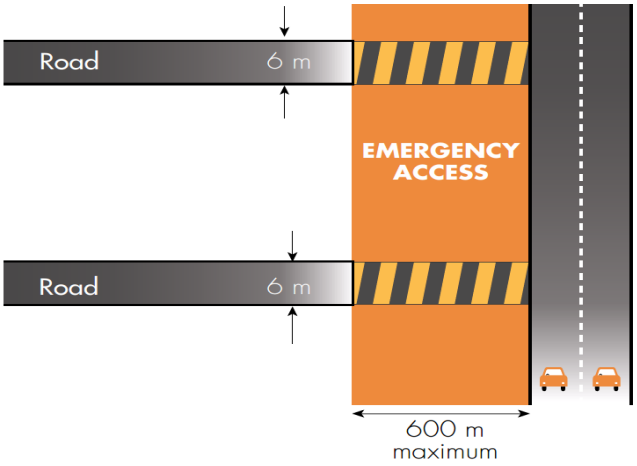
- Passing bays every 200 metres with a minimum length of 20 metres and a minimum width of two metres (ie combined width of the passing bay and constructed private driveway to be a minimum six metres);
- Turn-around areas every 500 metres and within 50 metres of a house, designed to accommodate type 3.4 fire appliances to turn around safely (ie kerb to kerb 17.5 metres);
- Any bridges or culverts are able to support a minimum weight capacity of 15 tonnes; and
- All weather surface (i.e. compacted gravel, limestone or sealed).



Acceptable Solution 3.6 Emergency Access Way

An access way that does not provide through access to a public road is to be avoided bushfire prone areas. Where no alternative exists, an emergency access way is to be provided as an alternative link to a public road during emergencies. The following requirements are to be achieved:

- No further than 600 metres from a public road;
- Must be signposted including where they ajoin public roads;
- Provided as a right of way or public access easement in gross;
- Where gates are used they must not be locked and they must be a minimum width of 3.6 metres with design and construction approved by local government (refer to the example in this appendix); and
- Meet the additional design requirements set out in Part 2 of this appendix.



Acceptable Solution 3.7 Fire Service Access Routes (Perimeter Roads)

Are to be established to provide access within and around the edge of subdivision and related development and to provide direct access to bushfire prone areas for firefighters and link between public road networks for firefighting purposes. Fire service access is used during bushfire suppression activities but can also be used for fire prevention work. The following requirements are to be achieved:

- No further than 600 metres from a public road (driveways may be used as part of the designated fire service access;
- Dead end roads not permitted;
- Allow for two-way traffic (i.e. two 3.4 fire appliances);
- Provide turn-around areas designed to accommodate 3.4 fire appliances and to enable them to turn around safely every 500m (i.e. kerb to kerb 17.5 metres);
- All weather surface (i.e. compacted gravel, limestone or sealed) and have erosion control measures in place;
- Must be adequately sign posted;
- Where gates are used they must be a minimum width of 3.6 metres with design and construction approved by local government (refer to the example in this appendix) and may be locked (use a common key system);
- Meet the additional design requirements set out in Part 2 of this appendix;
- Provided as right of ways or public access easements in gross; and
- Management and access arrangements to be documented and in place.

A3.8 Firebreak Width

Lots greater than 0.5 hectares must have an internal perimeter firebreak of a minimum width of three meters or to the level as prescribed in the local firebreak notice issued by the local government.

Vehicular Access - Technical Requirements of Acceptable Solutions - Part 2 Source: *Guidelines for Planning in Bushfire Prone Areas WAPC 2015*					
Technical Component	Vehicular Access Types				
	Public Roads	Cul-de-sacs	Private Driveways	Emergency Access Ways	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	4.5	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 cross-fall	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

* A six metre trafficable surface does not necessarily mean paving width. It could, for example, include four metres of paving and one metre of constructed road shoulders. In special circumstances, where 8 lots or less are being serviced, a public road with a minimum trafficable surface of four metres for a maximum distance of ninety metres may be provided subject to the approval of both the local government and DFES.

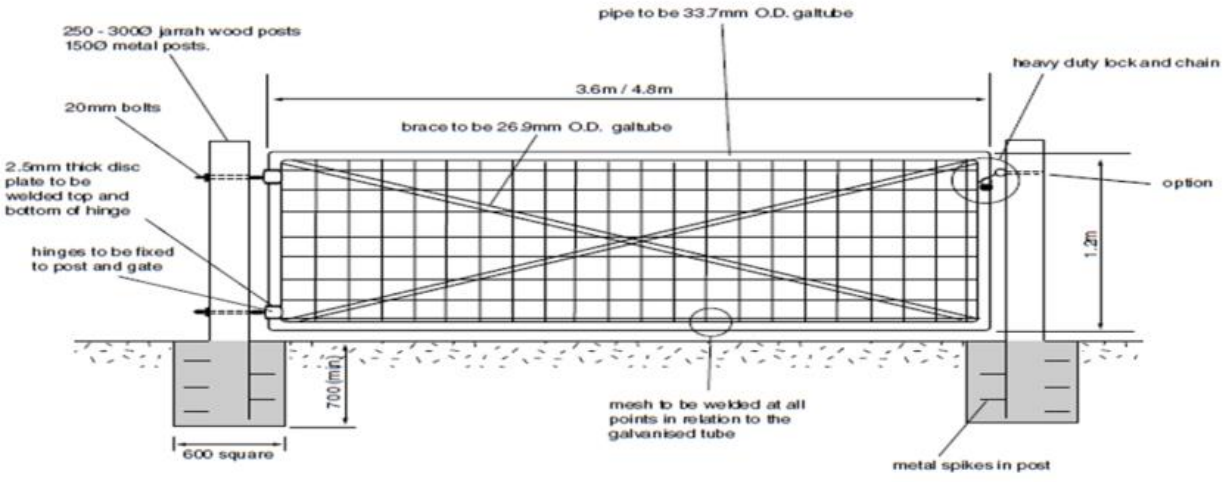
Vehicular Access - Technical Requirements of Acceptable Solutions

Gates and Signs

(example requirements – check with local government)

Gates (Bollards)

- Minimum width 3.6m
- Design and construction to be approved by relevant local government.
- Emergency access way gates must not be locked.
- Fire service access route gates may be locked but only with a common key that is available to local fire service personnel.
- Bollards will be to the relevant local government specifications



Note: Mesh to be metric mesh 46G5 and galvanised finish complete with fittings.

Signs

- Minimum height above ground of 0.9m.
- Lettering height to be 100mm.
- To display the words (as appropriate) “Emergency Access Only” or “Fire Service Access – No Public Access”.
- Design and construction to be approved by the relevant local government.
- Size 600mm x 400mm.
- Sign colour red, base (white) area is reflective background.
- Rounded corners, radius 20mm.
- White key-line 3mm wide, 3mm from outside edge.
- Suggested mounting hole six 6mm diameter.

Appendix 6
Technical Requirements - Bushfire Protection Criteria (Water)

Source: *Guidelines for Planning in Bushfire Prone Areas WAPC 2015* and DFES website

Acceptable Solution 4.1 Reticulated Areas

The requirement is to supply a reticulated water supply, together with fire hydrants, in accordance with the specifications set by DFES and the relevant water supply authority (WA Water Corporation or Aqwest - Bunbury or Busselton Water). The Water Corporation's 'No 63 Water Reticulation Standard' is deemed to be the baseline criteria for developments and should be applied unless local water supply authority's conditions apply. Key specifications in the most recent version/revision of the design standard include:

- ***Residential Standard*** – hydrants are to be located so that the maximum distance between the hydrants shall be no more than 200 metres.

- ***Commercial Standard*** – hydrants are to be located with a maximum of 100 metre spacing in Industrial and Commercial areas.

- ***Rural Residential Standard*** – where minimum site areas per dwelling is 10,000 m^2 (1ha), hydrants are to be located with a maximum 400m spacing. If the area is further subdivided to land parcels less than 1ha, then the residential standard (200m) is to be applied.

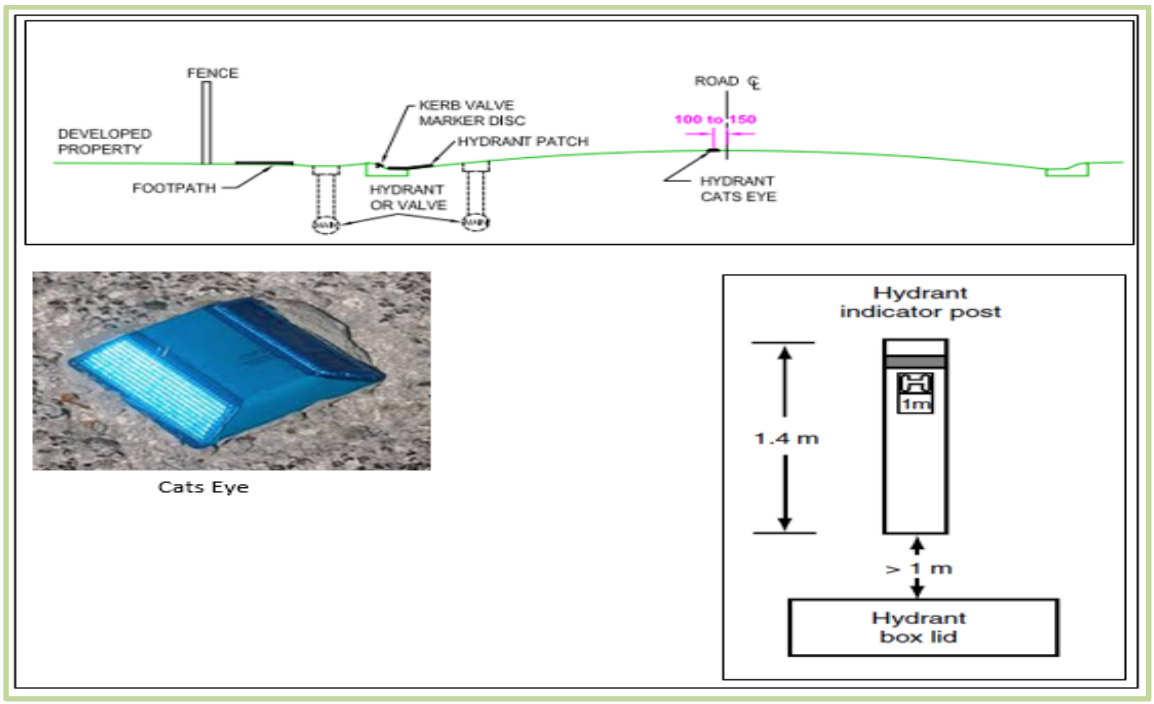


Figure A4.1: Hydrant Location and Identification Specifications

Acceptable Solution 4.2 Non-Reticulated Areas

Static water supplies are used by firefighters in areas where there is no reticulated water supply. Water tanks are the only acceptable static water source acceptable to meet Element 4 (Water) of the Bushfire Protection Criteria as per the *Guidelines for Planning in Bushfire Prone Areas (WAPC 2015) Appendix 4*.

The requirements for the development being assessed can be increased by the relevant local government. If a variation applies it will be noted in s7.1 and s7.4.

Volume:	50,000 litres per tank
Ratio of tanks to lots:	1 tank per 25 lots (or part thereof)
Location:	No more than two kilometres to the furthermost house site within the residential development to allow a 2.4 fire appliance to achieve a 20-minute turnaround time at legal road speeds.
Tank Construction:	Above ground tanks constructed using concrete or metal. Stands of raised tanks are constructed using non-combustible materials and heat shielding where applicable (required for metal stands).
Pipe Construction:	Galvanised or copper (PVC if buried 300mm below ground).
Access:	Hardstand and turnaround areas suitable for a 3.4 appliance (i.e. kerb to kerb 17.5metres) are provided within three metres of each tank.
Couplings:	Tanks are to be fitted with a full flow gate (not ball) valve and a 100mm cam-lock coupling of metal/alloy construction (source: DFES). Examples below:
	 
Ownership and Responsibility:	Water tanks and associated facilities are vested in the relevant local government. A procedure must be in place to ensure that water tanks are maintained at or above designated capacity at all times.

Acceptable Solution 4.3 Non-Reticulated Areas - Individual Lots

This solution is only for use if creating one additional lot and cannot be applied cumulatively (*Guidelines for Planning in Bushfire Prone Areas WAPC 2015 Appendix 4)*.

Single lots above 500 m^2 need a dedicated static water supply on the lot that has an effective capacity of 10,000 litres (*Guidelines for Planning in Bushfire Prone Areas WAPC 2015)*.

An Example Local Government Requirement:

Volume:	Minimum 10,000 litres (effective) per tank dedicated to firefighting purposes. The storage tank must not facilitate sharing the water for domestic use (danger of contamination).
Tank Construction:	Above ground tanks constructed using concrete or metal.
Pipe Construction:	Galvanised or copper (PVC if buried 300mm below ground).
Access:	Hardstand and turnaround area suitable for a 3.4 appliance (i.e. kerb to kerb 17.5metres) is provided at the tank.
Couplings:	Tanks are to be fitted with a full flow gate (not ball) valve and a 50mm or 100mm cam-lock coupling of metal/alloy construction. Examples below:
Responsibility:	A procedure must be in place to ensure that water tanks are maintained at or above designated capacity at all times.

Recommended coupling 50mm