Bullsbrook South Structure Plan

Great Northern Highway,
Bullsbrook South Urban Expansion Area

ROWE GROUP DESIGN



OUR REF: 9714_IND02F

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Record of Endorsement

This structure plan is prepared under the provisions of the City of Swan Local Planning Scheme No. 17

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

15 MAY 2026 ..... Date

Signed for and on behalf of the Western Australian Planning Commission

.....

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

Rhianne Fiander ..... Witness

19 May 2026 ..... Date

19 May 2036 ..... Date of Expiry

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Executive Summary

This Structure Plan has been prepared by Rowe Group on behalf of Mirvac as a precursor to the subdivision and development of the land known as the Bullsbrook South Urban Expansion Area, comprising approximately 187 hectares of Urban zoned land along the Great Northern Highway, extending north from Stock Road through to the existing Bullsbrook Townsite ('the subject land').

This Structure Plan provides detailed supporting justification to demonstrate the development potential for the land and confirms the land is appropriate for urban residential subdivision. The Structure Plan is supported by relevant technical appendices, providing detail on key considerations, including the proposed servicing strategy for the land, traffic management, water management, fire management and tree retention. The Structure Plan has been guided by an indicative subdivision concept, prepared with consideration to Liveable Neighbourhoods guiding principles.

The preparation of the Structure Plan has been undertaken in consultation with key landowners, the City of Swan, the Department of Planning, Lands and Heritage, Water Corporation and other key stakeholders.

The Structure Plan has been prepared to ultimately satisfy the requirements of the *Planning and Development (Local Planning Schemes) Regulations 2015* and the City of Swan *Local Planning Scheme No. 2*, to facilitate subdivision and development of the Structure Plan Area for residential purposes.

In this regard, the Structure Plan seeks to satisfy the following objectives:

- Provide a framework to guide the use, subdivision and development of the land for residential and commercial purposes
- Provide a residential environment that responds to the existing topography, natural features, and surrounding rural landscape.
- Provide a diversity of residential lot product.
- Maximising the protection of existing mature trees within the site, where possible.
- Creation of a public open space network, providing opportunities for a well connected pedestrian and cyclist network, and multi-functional spaces.

The Structure Plan area is identified for Urban Expansion under the WAPC's North East Sub-Regional Planning Framework, and 'Future Residential' under the City of Swan's Bullsbrook Townsite District Structure Plan. The Framework seeks to accommodate 3.5 million people within the Perth and Peel Regions by 2050, and is intended to guide State Government agencies, local government and the wider community on the urban form of the Perth and Peel metropolitan areas over the next 30 years. While placing a focus on infill development, the Framework acknowledges a need to provide targeted expansion of existing urban areas, including the Bullsbrook South Urban Expansion Area (the subject land). The subject land is identified as 'Short-Medium (2015-2031)' in the Sub-Regional Planning Frameworks 'Urban Staging' mapping.

This Structure Plan therefore seeks to facilitate urban residential development in accordance with the overarching planning framework, and more importantly, seeks to accommodate the anticipated population growth for the region and facilitate the delivery of State and Local Government priority housing supply targets.

Structure Plan Summary

Item	Data	Section Number Referenced in Part 2 of Report
Total area covered by the Structure Plan	187 hectares (approx.)	2.1.3
Area of each land use proposed: ▪ Residential ▪ Commercial ▪ GNH – Yarrimbah Drive Intersection (road widening area within LSP boundary)	 ▪ 99.08 ha ▪ 2.24 ha (2 sites) ▪ 0.14ha	5.1.1
Total estimated lot yield	2,000, subject to detailed design	5.3
Estimated number of dwellings	2,000, subject to detailed design	5.3
Estimated residential site density	20 dwellings per residential site hectare	5.3
Estimated population	5,600 people (based on 2.8 persons per household)	5.3
Number of high schools	nil	5.7
Number of primary schools	1	5.7
Estimated commercial floor space	5,000m² NLA	5.6
Estimated area and percentage of total public open space given over to: ▪ Regional open space ▪ District open space ▪ Playing Fields ▪ Local and Neighbourhood Parks	 ▪ nil ▪ 5.9ha, 20% (Nambad Brook) ▪ 3.4ha, 12% ▪ 22.56ha, 77%	5.4
Estimated percentage of natural areas	▪ 32.09ha total green space, 178% of Structure Plan area ▪ Credited open space – 27.67ha ▪ Nambad Brook Conservation Reserve – 2.62ha. ▪ Approximately 449 Black Cockatoo Habitat Trees to be retained, subject to detailed design.	5.4

Note: All information and areas are approximate only and are subject to survey and detailed design.

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Technical Appendices

Appendix Number	Document Title	Nature of Document	Referral/Approval Agency	Approval status and Modifications
1	Engineering Servicing Report	Supporting		
2	Transport Impact Assessment	Requires Approval	City of Swan and MRWA	MRWA supported
3	Environmental Assessment Report	Supporting	-	-
4	Local Water Management Strategy	Requires Approval	City of Swan and DWER	DWER Approved
5	Bushfire Management Plan	Requires Approval	City of Swan	
6	Retail Needs Assessment	Supporting	-	
7	Acoustic Assessment	Supporting	-	-
8	Landscape Master Plan and Public Open Space Strategy	Supporting	-	-

Part One
Implementation

1. Structure Plan Area and Operation

1.1. Structure Plan Area

This Structure Plan applies to Lots 4, 900 Yarrimbah Drive (formerly Lage Road) , Lots 2, 5, 6, 61, 100, 100, 201, 400, 802 Great Northern Highway and Part Lots 20, 803 and 1011 ('the Structure Plan Area'), being the land contained within the inner edge of the line denoting the Structure Plan boundary on the Structure Plan map

Refer **Plan 1 – Structure Plan Map**.

1.2. Structure Plan Content

This Structure Plan comprises the following sections:

- Part One – Implementation; includes the Structure Plan map (Plan 1) and outlines the requirements that will be applied when assessing subdivision and development applications over the land to which the structure plan relates.
- Part Two – Explanatory Section; is to support the Structure Plan contained in Part One by providing the background and explanatory information used to prepare the Structure Plan.
- Technical Appendices; contains all technical and specialist reports prepared in support of the Structure Plan.

1.3. Structure Plan Operation

In accordance with Schedule 2, Part 4 of the *Planning and Development (Local Planning Schemes) Regulations 2015 (Regulations)*, this Structure Plan shall come into operation when it is approved by the Western Australian Planning Commission (WAPC) pursuant to Schedule 2, Part 4, Clause 22 of the Regulations.

Pursuant to clause 27(1) of Schedule 2 of the Regulations:

> *A decision-maker for an application for development approval or subdivision approval in an area covered by a structure plan that has been approved by the Commission is to have due regard to, but is not bound by, the structure plan when deciding the application.*

Pursuant to clause 28(1) of Schedule 2 of the Regulations, this Structure Plan has effect for a period of 10 years, commencing on the day the WAPC approves the plan.

The operation of the Structure Plan shall be in accordance with the City of Swan Local Planning Scheme No. 17 ('LPS 17') and the *Planning and Development (Local Planning Schemes) Regulations 2015* ('the Regulations').

2. Purpose

The purpose of this Structure Plan is to facilitate the subdivision and development of the Structure Plan area for residential purposes (and associated land uses, including a neighbourhood centre).

The subdivision and development of the land is to occur having due regard to the key objectives for the Structure Plan as denoted below:

- Provide a framework to guide the use, subdivision and development of the land for residential and commercial purposes (including associated land uses).
- Provide a residential environment that responds to the existing topography, natural features, and surrounding rural landscape.
- Provide a diversity of residential lot product.
- Maximising the protection of existing mature trees within the site, where possible.
- Creation of a public open space network, providing opportunities for a well connected pedestrian and cyclist network, and multi-functional spaces.

3. Staging

At the time of Structure Plan approval, the provision of regional infrastructure had not been committed for the entire Structure Plan area. The staging of the subdivision and development of the land will be primarily informed by the delivery and capacity of waste water infrastructure across the site.

Based on the current servicing strategy (being those lots capable of connection to the existing reticulated sewerage service), the initial stages of development (approximately 560 lots) are anticipated to comprise the land north of Yarrimbah Drive, with the first stages (approximately 80 lots) intending to be delivered Q4, 2025 (subject to timing for the relevant approvals). Following the delivery of the first (approximate) 560 lots north of Yarrimbah Drive, development will then be progressed in an orderly staged manner, and it must be demonstrated the proposed lots can be connected to reticulated sewerage service and a suitable water supply.

Subject to the provision of service infrastructure, development is anticipated to occur at a rate of approximately 100 lots per annum (subject to market forces) and be developed at a rate of approximately 30 – 50 lots per stage, in response to the market demand at the time of development.

4. Subdivision and Development Requirements

4.1. Land Use Zones and Reserves

Plan 1- Structure Plan Map designates the land uses, zones and reserves applicable to the Structure Plan Area. Land use permissibility within the Structure Plan Area shall be in accordance with the corresponding zone or reserve under the City of Swan Local Planning Scheme No.17.

4.1.1. Residential Zone

Subdivision and development of the land is to be undertaken in accordance with the Structure Plan and the residential densities outlined in Part 2, Section 3.3.

A Residential Density Code Plan is to be approved at the time of subdivision.

4.1.2. General Commercial Zone

The following provisions apply to land within the "Commercial' zone, as per the Structure Plan (Plan 1):

a) Land use permissibility within the Commercial zone shall be in accordance with the 'General Commercial' zoning under City of Swan Local Planning Scheme No. 17.

b) A Local Development Plan shall be prepared as a condition of subdivision approval, which is to stipulate the primary controls applicable to future development within the Commercial zone.

4.1.3. Road Reserves

Road reserves provided in the Structure Plan area are distributed generally in accordance with **Plan 1 – Structure Plan Map**, and cross-sections are generally as per WAPC's Liveable Neighbourhoods, as outlined in **Table 1** below.

Classification	Application	Design
Integrator B	Yarrimbah Drive between Great Northern Highway and eastern spine road	29.2m reserve width. Modified cross section to enable meandering of road pavement for tree retention. No direct lot access permitted between Great Northern Highway and western spine road.
Neighbourhood Connector B	Yarrimbah Drive, east of eastern spine road	19.4m reserve width.
Neighbourhood Connector A	Stock Road	Neighbourhood Connector A between Great Northern Highway and South-central spine road. At subdivision stage, Stock Road may need to be further extended, decided on a case by case basis. Its design is not to prejudice the extension of Stock Road further east of the Structure Plan area for evacuation and/or for public transport purposes.
Neighbourhood Connector (Transitional)	North central spine road (north of Yarrimbah Drive and east of Lot 800)	24m-29m reserve width. Can be 26m width with no direct vehicle access from residential lots if a north-south connection through Lot 800 has not been provided.
Neighbourhood Connector A (Unique)	South central spine road (south of Yarrimbah Drive to Stock Road)	24.4m-26m reserve width, but can be reduced to 22.4m for tree retention purposes on a case-by-case basis. Detailed road design to explore varied cross sections at subdivision stage, which may consider the removal of median in lieu of widened verge to provide for shared/ dual use path and additional landscaping to the satisfaction of the City of Swan.
Neighbourhood Connector A	▪ South western road (south of Yarrimbah Drive to south central spine road) ▪ Link along the primary school's southern boundary (between the south western road and the south central spine road) ▪ Western spine road (north of Yarrimbah Drive to Lot 800)	24.4m reserve width
Neighbourhood Connectors	Internal intersection spacings	Internal intersections to be subject to further investigation and detailed design at subdivision stage.
Access Street and Laneway	All other roads	Access Street B – 17.9m reserve width. Access Street C – 15.4m reserve width. Access Street D – 15m-15.4m reserve width (reduced to 13.2m adjacent to public open space), or wider where required for bushfire management. Laneway (or service road) – 6m reserve width.

Table 1: Proposed Road Classifications

4.1.4. Public Open Space

Public open space is to be provided generally in accordance with the **Plan 1 – Structure Plan Map**.

The Structure Plan is to provide a minimum 10 per cent of the gross subdivisible area as public open space, in accordance with the WAPC's Liveable Neighbourhoods requirements.

The area identified as *Conservation* on **Plan 1 – Structure Plan Map** is to be provided in addition to the 10% credited public open space and ceded free of cost to the Crown and vested for the purpose of Conservation (and/or foreshore management). This is intended be a separate reserve to the surrounding public open space, which will be finalised at the subdivision approval stage.

4.1.5. Extractive Industry Separation

No subdivision for residential lots will be approved within the 500m separation distance to the extractive industry operation (Midland Brick clay quarry) on Lot 202 Great Northern Highway, Bullsbrook, until the Department of Energy, Mines, Industry Regulation and Safety advises the WAPC that residential uses can be supported due to changes to operations. This does not restrict the creation of roads and public open space within the separation distance.

4.2. Density and Development

4.2.1. Density and R-Codes

Plan 1 – Structure Plan Map designates the residential density code ranges applicable to subdivision and development within the Structure Plan area. Subdivision and development within the Structure Plan Area is to be in accordance with a Residential Density Code Plan, to be approved at the time of subdivision.

The following density code ranges are designated across the Structure Plan:

- **Low Density:** comprises a range between 'R12.5 – R25'. A base code of R25 is applicable to majority of the Structure Plan area.
- **Medium Density:** comprises a range of 'R30 – R40', and is applicable to areas of high amenity and access.

Having consideration for Liveable Neighbourhoods and Directions 2031 targets, the Structure Plan Area shall provide for a targeted average of 22 dwellings per site hectare and 15 dwellings per gross urban hectare. Locational considerations and market demand shall be considered in applying densities within the Structure Plan area at the time of subdivision.

4.2.1.1. Residential Density Code Plan

Having consideration for the density code ranges prescribed by the Structure Plan, a Residential Density Code Plan is to be submitted at the time of application for subdivision to the WAPC. The Residential Density Code Plan is to be submitted for the entire Structure Plan area but may be reviewed and updated at the time of each subdivision application, where subdivision and development is intended to be delivered in stages.

Where a revised Residential Density Code Plan is submitted with subsequent subdivision applications, it shall indicate the following:

a) The allocation of specific residential density codes to the proposed lots;

b) Residential density codes already designated to the previously approved lots (where applicable); and

c) The balance of lots subject to future subdivision applications.

The Residential Density Code Plan will allocate specific Residential Density Codes to the proposed street block/lots (as the case requires). Once approved by the WAPC, the Residential Density Code Plan forms part of the Structure Plan.

A Residential Density Code Plan(s) is not required if the WAPC considers the subdivision is for one or more of the following:

a) the amalgamation of lots;

b) facilitating the provision of access, service or infrastructure; or

c) the subdivision of land which, by virtue of its zoning or reservation under the Structure Plan, cannot be developed for residential purposes; or

d) is in accordance with a previously approved Residential Density Code Plan.

4.2.2. Locational Criteria

The allocation of residential density codes within the Structure Plan area shall generally be in accordance with the following criteria:

a) **R12.5 – R20:** shall generally be applied to residential lots with one or more of the following characteristics.

   i) Located along the eastern edge of the Structure Plan area, serving as a low-density interface to the adjacent rural residential area; and/or

   ii) Located where topography and/or other site considerations require larger lots.

b) **R25:** shall generally apply as the base density code throughout the Structure Plan area.

c) **R30 – R40:** may be applied to residential lots with one or more of the following characteristics:

   i) Located within 400 metres of the Neighbourhood Centre;

   ii) Located within close proximity to public open space;

   iii) Located within close proximity of a Neighbourhood Connector (other such key distributor road); and/or

   iv) Located at the end of street blocks or other strategic locations to create a diverse streetscape and desired built-form character.

4.2.3. Local Development Plans

Local Development Plans may be prepared for lots with one or more of the following attributes:

a) Lots abutting public open space or foreshore reserve;

b) Lots zoned 'Commercial'; and/or

c) Lots where specific design considerations are required.

Where a Local Development Plan is required, a condition of subdivision approval should be imposed by the WAPC, requiring the preparation, approval and implementation of a Local Development Plan.

4.2.4. Interface with Adjoining Areas

The Structure Plan abuts the approved Bullsbrook Central Structure Plan (Kingsford Estate) to the north. Future subdivision and development within the Structure Plan area shall provide for a seamless connection with the adjoining development, with regard to road connections and reserve cross sections, public open space connectivity and interface, and residential densities and built form outcomes.

The Structure Plan abuts 'Landscape' zoned land to the east, to be developed for rural residential purposes. In accordance with the Bullsbrook Townsite District Structure Plan and relevant approvals for that land, Yarrimbah Drive is to extend, forming a physical edge between the two developments. To ensure appropriate management of this interface, lower density ranges (with an anticipated R12.5 density coding) have been provided along the eastern edge to ensure an appropriate Rural to Urban land use transition.

4.2.5. Heritage

The Structure Plan Area comprises sites of Aboriginal Cultural Heritage significance, as mapped on the Department of Planning, Lands and Heritage Aboriginal Cultural Heritage Inquiry System. Appropriate review of the sites and implementation of any relevant mechanisms for minimising impact shall be considered prior to commencement of ground disturbing works.

4.3. Other Requirements

4.3.1. Tree Retention

The Structure Plan endeavours to retain existing mature trees in public open space and road reserves where possible, subject to detailed design.

Prior to the commencement of subdivision works, a *Construction and Local Tree Management Plan* shall be approved and implemented for each stage of development.

The *Construction and Local Tree Management Plan* shall consider the following in relation to tree retention and tree planting measures:

a) Ensure fill and earthworks design facilitates protection, where possible.

b) Have consideration of detailed engineering and landscape design requirements.

c) Have consideration for tree species, size and health in determining retention priority via a plan of which trees are proposed to be retained and which are proposed to be removed.

d) A description and plan showing how a ten per cent tree canopy coverage can be achieved in the period between the project completion and planted trees reaching maturity (including street trees).

4.3.2. Bushfire Management

Land within the Structure Plan area is mapped as being bushfire prone under the Department of Fire and Emergency Services Bushfire Prone Mapping.

This Structure Plan is supported by a Bushfire Management Plan, prepared in accordance with *State Planning Policy 3.7 – Planning in Bushfire Prone Areas* ('SPP 3.7'). Any development on land within the Structure Plan area shall be constructed in accordance with the recommendations made by the Bushfire Management Plan and shall comply with the requirements of *Australian Standard 3959 – Construction of Buildings in Bushfire Prone Areas*.

Bushfire management requirements will ultimately be considered as part of future applications to subdivide or develop land within the Structure Plan area. A site specific Bushfire Management Plan, where applicable, may be required at that time. As a minimum, a Bushfire Attack Level Contour Plan, prepared in accordance with an approved Bushfire Management Plan, will be required to be submitted at the time of lodgement of an application for subdivision and/or development approval.

4.3.3. Foreshore Management

The Nambad Brook traverses the northern portion of the Structure Plan area in an east-west direction.

The Structure Plan designates a Conservation area aligning with the Nambad Brook foreshore area, as defined by a biophysical assessment of the site.

The Conservation area (Nambad Brook foreshore area) shall be retained generally as depicted on **Plan 1 – Structure Plan Map**. The Conservation area and surrounding public open space are to be managed in accordance with the Local Water Management Strategy. Detailed engineering, hydrological and landscape design undertaken as part of any future subdivision and/or development of the land shall have consideration to the appropriate management of the Conservation area and interface with adjoining land uses.

4.3.4. Kangaroo Management

A Kangaroo Management Plan is to be submitted for approval by the City of Swan in consultation with the Department of Biodiversity, Conservation and Attractions, and should demonstrate a strategy for the identification, management and/or relocation of kangaroos in accordance with the City of Swan's *Local Planning Policy 1.15: Kangaroo Management*. The Kangaroo Management Plan should also identify the type of licensing required to be obtained by the Department of Biodiversity, Conservation and Attractions to this effect.

4.3.5. Transport Noise

The Structure Plan area adjoins the Great Northern Highway on its western boundary.

The Structure Plan is supported by an Acoustic Assessment, prepared in accordance with *State Planning Policy 5.4 – Road and Rail Noise*. Subdivision and development of land within the Structure Plan area shall comply with any recommendations outlined in the Acoustic Assessment, and may require:

- A notification being placed on the Certificate of Title(s) of affected lots to advise landowners of potential for noise impacts from the Great Northern Highway.
- Dwellings being constructed to comply with relevant Quiet House Design Packages.

The management of transport noise mitigation requirements will ultimately be considered as part of future applications to subdivide or develop land within the Structure Plan area. A condition of subdivision or development approval, requiring the preparation, approval and implementation of a Noise Management Plan, where applicable, may be required at that time.

4.3.6. Infrastructure Requirements

At the time of Structure Plan approval, the provision of regional infrastructure had not been committed for the entire Structure Plan area. All infrastructure necessary to service the future subdivision and development of the Structure Plan area shall be upgraded, modified, or extended, where applicable. This shall be considered as part of detailed engineering design, required as a condition of subdivision approval. In particular, any subdivision or development application is to demonstrate the proposed lots are capable of connection to a reticulated sewerage service and a suitable water supply. No approval for subdivision or development is to be issued without prior confirmation of the servicing capacity for the proposed lots.

Otherwise, the Engineering Services Report provided at **Appendix 1** outlines generally the relevant service extension and utility upgrade requirements for the Structure Plan area, including the required and planned reticulated sewerage and wastewater infrastructure requirements.

The intersection of Yarrimbah Drive and Great Northern Highway will require upgrading to facilitate the residential subdivision and development of the Structure Plan area. Detailed intersection design will be required to be considered as part of any subdivision and/or development application for the land, including consideration for any road widening. This is outlined in the Transport Impact Assessment provided at **Appendix 2**.

4.3.7. Development Contributions

The Structure Plan area is subject to contributions toward the costs of common infrastructure, in accordance with City of Swan's Developer Contribution Area No.7 (DCA 7) and applicable Development Contribution Plan (DCP 7), prepared pursuant to *Clause 5A.2: Development Contribution Areas* and Schedule 13 of the City of Swan Local Planning Scheme No. 17.

5. Additional Details

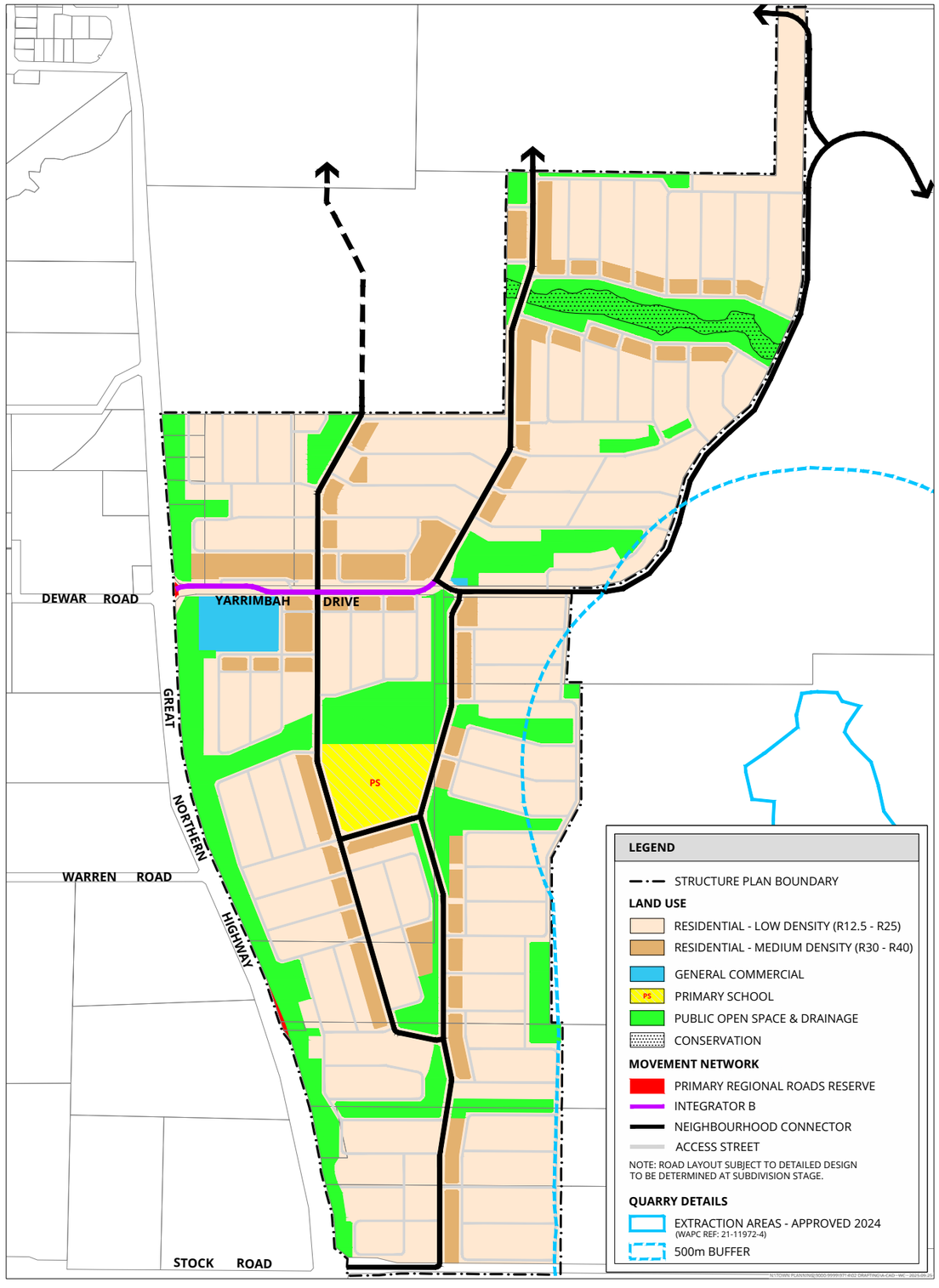
The details of additional information required to be submitted and the stage which it is to be submitted, are summarised below.

Additional Information / Purpose	Approval Stage	Responsible Agency (Consultation Required)
Bushfire Management Plan (Review) or Bushfire Attack Level Contour Plan	Subdivision or Development Application	City of Swan Department of Fire and Emergency Services
Noise Management Plan	Condition of Subdivision Approval	City of Swan Main Roads WA
Residential Density Code Plan	Subdivision Application	Western Australian Planning Commission
Construction and Local Tree Management Plan	Condition of Subdivision Approval	City of Swan
A Public Open Space summary table to demonstrate the proposed and cumulative public open space (that is not funded by the DCP) provided by a subdivider over the parent/current landholdings to inform cash in-lieu requirements.	Subdivision Application	Western Australian Planning Commission City of Swan
Demonstrate that proposed lots can be connected to a reticulated sewerage service and a suitable water supply	Subdivision Application	Western Australian Planning Commission Water Corporation Water Corporation
Foreshore Management Plan	Condition of Subdivision Approval	City of Swan

Table 2: Information to be Submitted with an Application

Condition of Subdivision Approval	Responsible Authority
Local Development Plan	City of Swan Western Australian Planning Commission (if required)
Urban Water Management Plan	City of Swan

Table 3: Information Required as Condition of Subdivision Approval



Plan 1. Structure Plan Map

Part Two
Explanatory Section

1. Introduction and Purpose

This Structure Plan has been prepared on behalf of Mirvac to facilitate the development of the Bullsbrook South Urban Expansion Area for residential purposes. This Structure Plan has been prepared in accordance with the *Planning and Development (Local Planning Schemes) Regulations 2015* and is herein referred to as the 'Bullsbrook South Structure Plan', 'Structure Plan' or 'LSP'.

The Structure Plan has been prepared to satisfy the requirements of the City of Swan Local Planning Scheme No. 17, as well as the *Planning and Development (Local Planning Schemes) Regulations 2015*.

1.1. Purpose

The purpose of this report is to provide the relevant background and explanatory information, forming the basis of the Bullsbrook South Structure Plan. In this regard, the Structure Plan seeks to provide:

- A site and context analysis outlining the physical, community, planning and governance context relevant to the Structure Plan area;
- An opportunities and constraints analysis of the subject land, and the identification of the key design objectives and considerations;
- An overview of stakeholder and community engagement that has occurred to inform the preparation of the Structure Plan; and
- A detailed explanation of the design response to the site and context analysis, opportunities and constraints analysis, and stakeholder engagement, with consideration to the WAPC's Liveable Neighbourhoods principles and objectives.

The Structure Plan will guide future land use and development over the subject land and provide a framework for more detailed planning at subdivision. The following sections provide further detail and explanation for the Structure Plan Part 1 provisions.

Refer **Figure 1 – Site Plan**.

1.2. Objectives

The objectives of the Bullsbrook South Structure Plan are to:

- Provide a framework to guide the use, subdivision and development of the land for residential and commercial purposes.
- Provide a residential environment that responds to the existing topography, natural features, and surrounding rural landscape.
- Provide a diversity of residential lot product.
- Maximising the protection of existing mature trees within the site, where possible.
- Creation of a public open space network, providing opportunities for a well connected pedestrian and cyclist network, and multi-functional spaces.
- Detail the strategy for the provision of servicing infrastructure, including appropriate development staging.

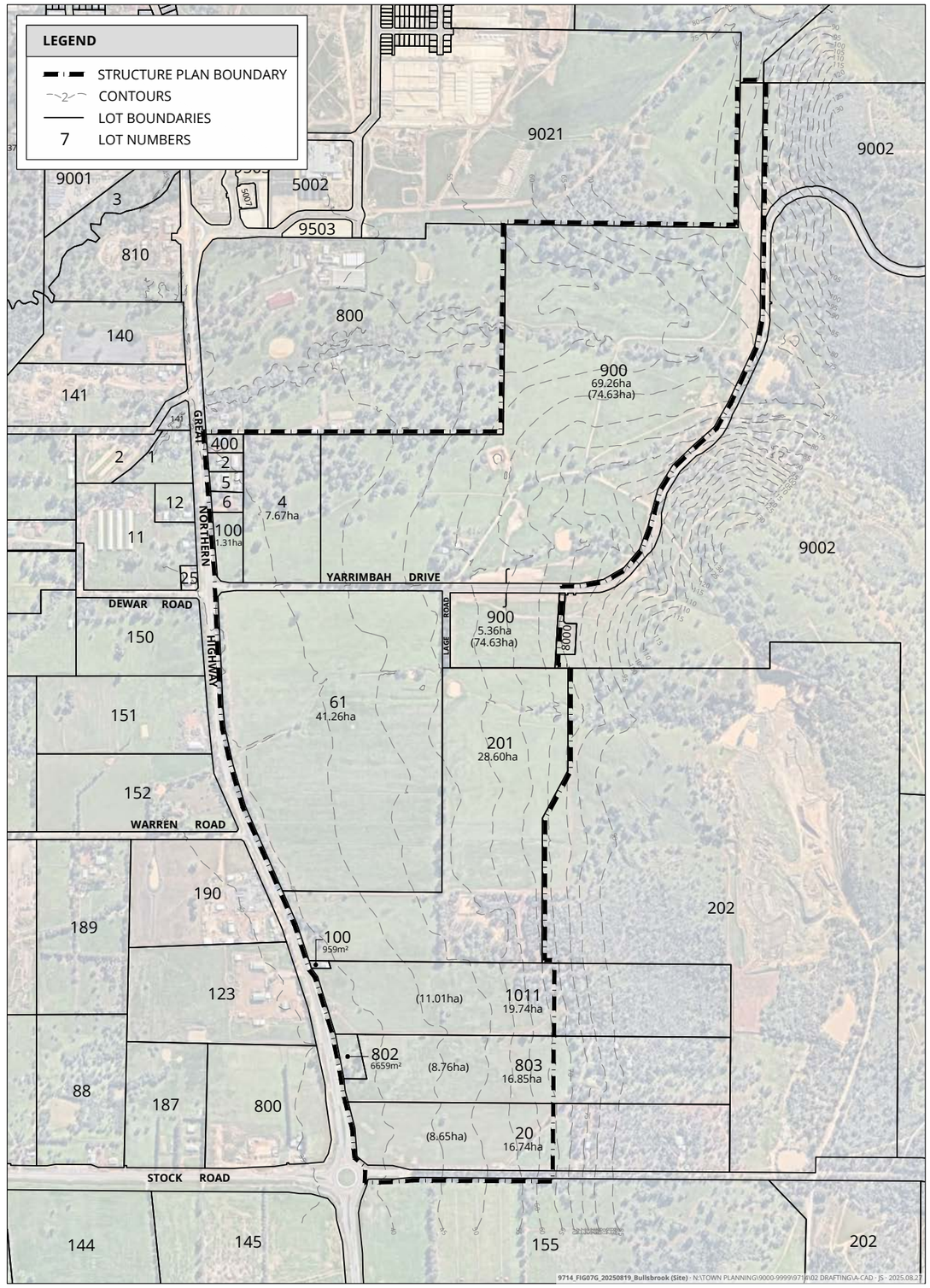


Figure 1. Site Plan

1.3. Project Team

The following multidisciplinary project team has been engaged by the Proponent to progress the preparation of the Structure Plan:

Discipline	Consultant
Acoustic Management	Lloyd George Acoustics
Bushfire Management	Bushfire Prone Planning
Civil Engineering and Servicing	Colliers
Environmental	Western Environmental
Hydrology and Water Management	Pentium Water
Landscape	Emerge
Project Management	Mirvac
Survey	MNG
Traffic	Uloth & Associates
Town Planning and Urban Design	Rowe Group

Table 4: Project Team



2. Site and Context Analysis

2.1. Physical Context

2.1.1. Location

The subject land is located within the north-east corridor of the Perth metropolitan area, within the municipality of the City of Swan (the 'City'). The land is located approximately 32 kilometres north-east of the Perth Central Business District and 21 kilometres north-east of the Midland Strategic Regional Centre.

Refer **Figure 2 – Regional Location**.

The subject land is situated within the suburb of Bullsbrook, approximately 800 metres south of the existing Bullsbrook Townsite. Land to the immediate north of the site is zoned 'Urban' under the MRS and is being progressively developed for residential purposes as the 'Kingsford Estate' and Bullsbrook District Centre. Land east of the subject land is zoned 'Rural' under the MRS and is progressively being developed for Rural Living purposes.

The land is bound on its western boundary by Great Northern Highway, a 'Primary Regional Road' under the Metropolitan Region Scheme. Further west, the land is zoned 'Industrial' and is being progressively developed to accommodate a diverse range of industrial land uses.

Refer **Figure 3 – Local Location**.

Figure 2. Regional Location

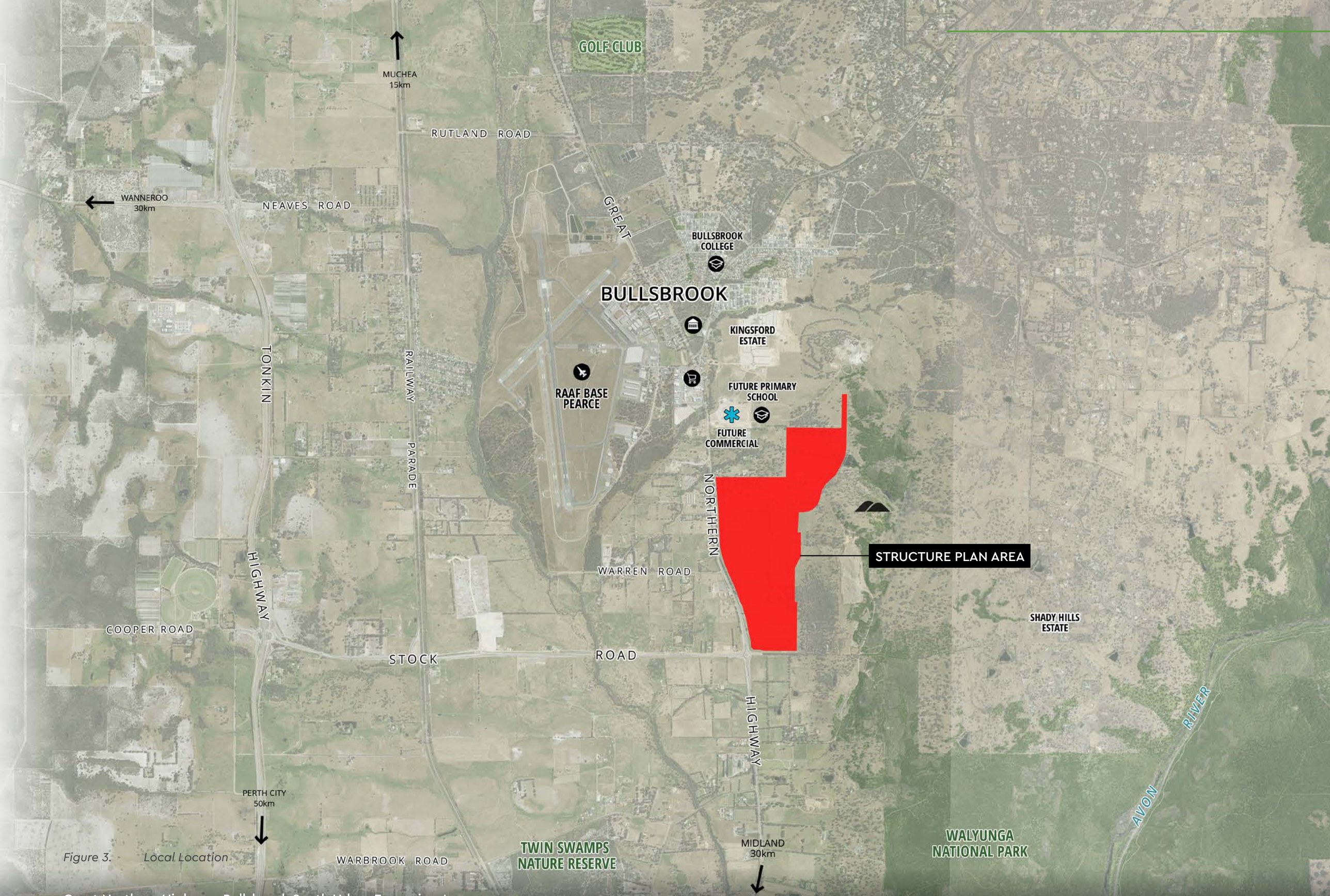


Figure 3. Local Location

2.1.2. Surrounding Area and Land Use

The Structure Plan area abuts the Bullsbrook Central Structure Plan to its northern boundary. The Bullsbrook Central Structure Plan comprises the Kingsford residential estate and the Bullsbrook District Centre, progressively being developed. Preparation of the Structure Plan has had consideration for ensuring future subdivision and development will provide for a seamless connection with the adjoining development, with regard to road connections and reserve cross sections, public open space connectivity and interface, and residential densities and built form outcomes.

Further northeast of the Structure Plan is an existing landfill facility. This site has ceased accepting waste (since 2018), with the licence expiring on 22 October 2024. This operation does not impact the subject land.

The Structure Plan abuts 'Landscape' zoned land to the east, to be developed for rural residential purposes. In accordance with the Bullsbrook Townsite District Structure Plan and relevant approvals for that land, Yarrimbah Drive has been extended, forming a physical edge between the two developments. To ensure appropriate management of this interface, lower density ranges are proposed along the eastern edge to ensure an appropriate Rural to Urban land use transition.

Located further east, is a clay extraction operation, which imposes a 500-metre separation buffer. This buffer only marginally extends into the subject land at certain points, managed appropriately through design (deliberate location of road reserves and public open space). This buffer is not an impediment to the development of the land for residential purposes and detailed within the Environmental Assessment Report provided at **Appendix 3**.

The Stock Road reserve forms the southern edge of the Structure Plan area. Land south of Stock Road primarily comprises of rural land uses. Stock Road is the primary east-west connection through the region, providing access between the Great Northern Highway to the Tonkin Highway.

Great Northern Highway forms the western edge of the Structure Plan. Areas of transitional public open space are proposed along the Great Northern Highway interface to allow for an appropriate setback for acoustic and amenity purposes.

Land west of Great Northern highway comprises existing and contemplated industrial land uses. The existing and planned industrial land uses do not impact the Structure Plan area, with any relevant buffers or land use transitions to be managed within that zone.

Refer **Figure 3 – Local Location**.

2.1.3. Tenure, Ownership and Buildings

The Structure Plan comprises 15 land parcels and the existing Yarrimbah Drive (formerly Lage Road) reserve, legally described in **Table 5** (below).

Lot No.	Street Address	Area	Plan No.	Vol/Folio	Proprietor
900	61 Lage Road, Bullsbrook	74.62ha	P420367	4008/65	George Humphery Park Gary Alexander Park Dale Humphery Park McRae Investments Pty Ltd Yarrimbah Nominees Pty Ltd
4	Lot 4 Lage Road, Bullsbrook	7.67ha	D59157	1642/965	Yarrimbah Nominees Pty Ltd McRae Investments Pty Ltd Dale Humphery Park George Humphery Park Gary Alexander Park
100	Lot 100 Great Northern Highway, Bullsbrook	1.31ha	D6254	1634/859	McRae Investments Pty Ltd Yarrimbah Nominees Pty Ltd
6	2416 Great Northern Highway, Bullsbrook	0.44ha	P31211	2574/500	Debra Karen Bozanich George Michael Bozanich
5	2422 Great Northern Highway, Bullsbrook	0.45ha	P31211	2574/499	Websterdog Bare Pty Ltd
2	2424 Great Northern Highway, Bullsbrook	0.44ha	D22890	2890/788	Graham Clive Palmer
400	2428 Great Northern Highway, Bullsbrook	0.45ha	P403953	2890/789	Jason John Kelly Lisa Marie Kelly
61	2342 Great Northern Highway, Bullsbrook	41.26ha	P42250	2582/885	Timevalley Pty Ltd
201	2306 Great Northern Highway, Bullsbrook	28.6ha	P403408	2880/161	Marlin Bullsbrook Property Holdings Pty Ltd
100	2286 Great Northern Highway, Bullsbrook	0.096ha	P27953	2053/531	Jason Edward Bounsell
Part Lot 1011	2274 Great Northern Highway, Bullsbrook	11.01ha (19.74ha)	P44362	4029/710	Marlin Property Investment Holdings Pty Ltd
802	2258 Great Northern Highway, Bullsbrook	1.31ha	P419739	4008/939	Riverbell Holdings Pty Ltd
Part Lot 803	2242 Great Northern Highway, Bullsbrook	8.76ha (16.85ha)	P419739	4008/940	Riverbell Holdings Pty Ltd
Part Lot 20	2234 Great Northern Highway, Bullsbrook	8.65ha (16.74ha)	P422363	4032/595	Dennis John Manuel Ellen Gray Manuel

Table 5: Cadastral Information.

The Structure Plan comprises a combined land area of approximately 187 hectares (including the Yarrimbah Drive reserve), and with a total frontage of approximately 1.5 kilometres to Great Northern Highway.

The subject land has historically been used for agricultural pursuits, including cropping and grazing. This has resulted in the majority of the land being in a degraded state, and generally cleared of any remnant vegetation. There are some, limited areas of remnant vegetation adjacent to the existing creek lines that traverse the land in an east-west direction, and scattered trees throughout. There are existing dwellings and other agricultural outbuildings located within the subject land.

2.1.4. Environment

The following provides a summary of the environmental conditions and constraints relating to the subject land. For further detailed information, refer to the following technical reports:

- Engineering Servicing Report contained at **Appendix 1**.
- Environmental Assessment Report ('EAR') contained at **Appendix 3**.
- Local Water Management Strategy ('LWMS') contained at **Appendix 4**.

2.1.4.1. Topography and Landform

The topography of the Structure Plan area generally climbs from west to east, from levels in the range of RL 37 metres to 42 metres AHD along Great Northern Highway. Nearing the eastern boundary, the land increases steeply from RL 60 metres AHD to levels in the order of RL 90 metres AHD.

2.1.4.2. Soils and Geology

Regional scale geological mapping indicates that soils comprise of the following soil profiles:

- **Schist** - grey to pale grey, highly schistose quartz mica schist. Located on the eastern portion of the site.
- **Granite** - mesocratic, fine to coarse-grained, ranges in composition from granodiorite to granite, adamellite being commonest variety. Located in the north-eastern corner of the site.
- **Sandy Slit** - strong brown, firm, friable, dispersive in part, occasional pebbly horizons with little matrix containing quartzite, quartz, granite, laterite of colluvial origin. Located across majority of the site.
- **Sand** – very pale brown, medium to coarse-grained, well sorted, little fines, sub-angular to rounded quartz and feldspar, of colluvial origin. Located in the northern portion of the site.
- **Sand Over Pebbly Silt** – sand very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin. Overlying strong brown silt with common fine to occasionally coarse grained, sub-rounded laterite, quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand of alluvial origin. Located across the north-western portion of the site.

A Preliminary Geotechnical Investigation was undertaken for the site by Galt Geotechnics, provided at **Appendix 4** of the enclosed Engineering Services Report (**Appendix 1**). The Geotechnic Assessment concludes the findings are generally consistent with the above.

Subsoil surface conditions vary across the site. The typical soil profiles are summarised as follows:

- Generally northern parts of the site:
  - Sandy GRAVEL/Silty GRAVEL (GP/GM) – fine to coarse grained, angular to sub-rounded, brown, about 5% to 20% non-plastic fines extending from the surface to depths of typically between 0.3 metres to 0.5 metres; overlying
  - Clayey SAND/ SAND (SC/SP) – fine to coarse grained, orange brown, 5 – 15% low to medium plasticity fines extending to depths of between 0.9 metres and 2.4 metres;
  - Extremely Weathered ROCK/ ROCK – possibly quartz rich, metamorphic rock present from depths of between 0.9 metres and 2.8 metres.
- Central portion of the site:
  - Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 metres.
- Central and south of the site:
  - Thin and irregular layer of granular gravel or sand, typically about 0.3 metres to 0.4 metres thick; overlying Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 metres.

2.1.4.2.1. Acid Sulphate Soils

The Department of Water and Environmental Regulation ('DWER') Acid Sulphate Soil (ASS) Risk Mapping identifies the majority of the subject land as having low to no risk of actual acid sulphate soils present at depths less than 3 metres. A small portion located within the south east of the Structure Plan area is identified as having moderate to low risk of actual acid sulphate soils present at depths less than 3 metres.

On this basis, Acid Sulphate Soils are not expected to impact the development potential of the land for residential purposes. Any associated risk of Acid Sulphate Soils may be appropriately managed in accordance with DWER Guidelines through the subdivision implementation process.

2.1.4.2.2.Contaminated Sites

The DWER Contaminated Sites Database does not identify any known contaminated sites within the subject land or immediate surrounds.

2.1.4.3. Flora and Vegetation

The Structure Plan area is generally located within the mapped extent of the 'Guilford' vegetation complex. A portion of the land, located on the northeast boundary is located within the 'Darling Scarp' vegetation complex.

Western Environmental undertook a survey of the Structure Plan area, and confirmed the following vegetation types are present:

- **Paddocks-Paddock with Isolated Trees vegetation type:**

  This vegetation type is the most widespread within the site. It comprises of paddock with very isolated *Corymbia calophylla* and *Eucalyptus wandoo* over pasture grasses.

- **VT01 – Marri and Wandoo over Paddock vegetation type:**

  This vegetation type occurs on across approximately 17% of the land, occurring on flats and lower hillslopes. It comprises of scattered paddock trees and denser groves of *Corymbia calophylla* and *Eucalyptus wandoo* over pasture grassland with mid and ground stratum absent.

- **Planted Trees - Windbreaks, Gardens, Revegetation vegetation type:**

  This vegetation type generally occurs within a cluster, located within the southern extent of the Structure Plan area and along the western boundary abutting Great Northern Highway. It comprises of planted areas with species typically non endemic including *Eucalyptus camaldulensis Eucalyptus grandis*, *Corymbia citriodora* and endemic *Casuarina obesa*.

- **Drain-Minor Drainage Line vegetation type:**

  This vegetation type occurs on a west-east rend within a minor portion central of the Structure Plan area. Comprises of a Minor drainage line with Eucalyptus wandoo over pasture grass. The Drainage line has been modified in several sections. No riparian associated species present.

- **Creek-Creek with Flooded Gum vegetation type:**

  Occurs along the Nambad Brook. Comprising of Open woodland of *Eucalyptus rudis*, *Corymbia calophylla* and scattered *Eucalyptus wandoo*. Very occasional *Melaleuca rhaphiophylla* and *Taxandria linearifolia*. Ground stratum pasture grasses. Comprises highly degraded riparian vegetation zone.

- **VT02 Wandoo Over Paddocks vegetation type:**

  Occurs along the base of hills. Stands of *Eucalyptus wandoo*. Trees have been previously cleared and are coppicing as multi stem mallee forms. Vegetation is subject to ongoing sheep grazing which has supressed/ removed the ground and mid stratum.

All of the above listed vegetation types identified by the Survey are classified as in Completely Degraded Condition as a result of historic clearing for agriculture and ongoing grazing.

2.1.4.4. Weeds and Pest Management

Mapping of weed and pest species undertaken as part of the Environmental Assessment Report (**Appendix 3**) revealed the presence of *Asparagus asparagoides* (bridal creeper) along the verges of Yarrimbah Drive and declared Pest *Gomphocarpus fruticosus* (cotton bush) was recorded from three large occurrences in open paddocks and drainage lines. Both of the above-mentioned species are identified as a *'Declared Pest and Weed of National Significance'*.

Under the Declared Pest listing by the Department of Primary Industries and Regional Development ('DPIRD'), these species are required to be managed to reduce the number and distribution. The management of pests and weeds will be undertaken prior to the subdivision and development of the land. It is anticipated a 'Pest and Weed Management Plan' will be required as a condition of Subdivision Approval.

2.1.4.5. Fauna and Habitat

A Basic Fauna Survey and targeted Black Cockatoo Habitat Assessment were carried out by Western Environmental determine the fauna values associated with the subject land.

The survey identified four fauna habitats within the Structure Plan area:

- FHT-01 Isolated Paddock Tree;
- HT-02 Planted Eucalypts;
- FHT-03 Sheoak Windbreaks; and
- FHT-04 Wandoo Regrowth/.

The majority of the land supports scattered paddock trees with denser groves of *Corymbia calophylla* and *Eucalyptus wandoo* over pasture, and is classified as supporting habitat for native fauna. However noting, the lack of mid and ground layer greatly reduces habitat quality. The wandoo regrowth provides the highest relative value but, as this habitat extends over a small portion of the site (0.87%) and occurs as scattered patches, the importance of this habitat to native fauna is limited. The remainder of the site supports planted trees and shrubs, which provide varying habitat values depending on plant species and density.

Two conservation species were observed within the Structure Plan area:

- Carnaby's black cockatoo listed as 'endangered' under the EPBC Act; and
- Forest red-tailed black cockatoo listed as 'Vulnerable' under EPBC Act.

In addition, 23 further species of conservation significance have potential to occur within the Structure Plan area. Twenty species were identified as a 'low likelihood of occurrence'. The remaining three species were identified as follows:

- High-likelihood: *Calyptorhynchus* banksii naso (Forest red-tailed black cockatoo) – Vulnerable
- High likelihood: *Zanda latirostris* (Carnaby's black cockatoo) – Endangered.
- Medium likelihood: *Falco peregrinus* (Peregrine falcon) – Other Specially Protected Species.



Given the fragmented nature of existing native vegetation within the site, it is considered unlikely the site would contain any habitat critical to the survival of any terrestrial fauna species or any species of conservation significance. Where possible, trees will be retained as part of construction, with tree retention opportunities to be identified as part of the detailed design phase.

2.1.4.5.1. Black Cockatoo Habitat Opportunities

During the survey, 572 potential breeding trees were recorded within the Structure Plan area, described as follows:

- The large majority (536) of potential breeding trees did not show any signs of potential nesting hollow development.
- Thirty-five trees were identified as possessing a small hollow with insufficient entry diameter size to support nesting or internal dimensions unsuitable for hollows.
- One Marri tree was identified as possessing a hollow with sufficient entry diameter to support a suitable nesting hollow. A follow up inspection of internal dimensions may be required to allow more detailed understanding of actual suitability.
- Approximately 7.22 hectares of low to moderate Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo foraging habitat exists on the land, and extensive areas of foraging habitat for both species occur adjacent to the site and in the wider area.

The Indicative Concept Plan, provided at **Figure 19**, reflects the designs consideration towards the retention of potential black cockatoo breeding trees and high-quality foraging trees within the Structure Plan area. It is currently anticipated up to 449 Black Cockatoo habitat trees could be retained on site in public open space and road reserve, subject to detailed engineering design. Where trees are to be retained, these will be detailed within the 'Construction and Local Tree Management Plan' ('CLTMP') to be prepared at subdivision implementation stage.

The site contains foraging habitat for Black cockatoos, which are listed as *Matters of National Environmental Significance* ('MNES') under the *Environmental Protection and Biodiversity Conservation Act* ('EPBC Act'). Construction work undertaken following the approval of subdivision or development applications has the potential to impact this foraging habitat, and therefore impact the MNES. However, based on the ecological survey work undertaken and the preliminary subdivision layout designs prepared for the site, it is considered these potential impacts would not be significant. Therefore, a referral to the Department of Climate Change, Energy, the Environment and Water ('DCCEEW') for a determination as to whether the proposed development of the site constitutes a 'controlled action' requiring an EPBC Act approval is not currently required, given only potentially significant impacts trigger the referral process.

Once the detailed designs have been progressed to subdivision and/or development application stage, there will be sufficient certainty to confirm the extent of any impact to the Black Cockatoo species and whether a referral to DCCEEW under the EPBC Act is required.

2.1.4.6. Conservation and Foreshore Reserves

The Nambad Brook traverses the northern portion of the site in an east west direction.

A biophysical assessment of the Nambad Brook was undertaken via a desktop analysis of existing data, as well as through a site assessment in May 2023, to delineate the foreshore reserve. Biophysical criteria are the factors used in determining the extent of a foreshore reserve. The biophysical assessment was undertaken in accordance with *River Restoration No 16 Determining Foreshore Reserves* (2001).

The site assessment identified a clearly defined channel for the Nambad Brook, with an approximate incised flowing channel of a depth of between 1 to 1.5 metres and between 2 and 10 meters wide. Fringing this is a waterway platform of between 5-25 meters width either side. Sections of this platform may experience flow during peak events, however specific hydrology is required to understand extent.

A vegetation and habitat site assessment was undertaken and focused on the extent of riparian vegetation to assist in defining the waterway. Riparian vegetation is defined by the presence of species known to occur within or directly adjacent to waterways. In the Nambad Brook, a small number of plants of riparian associated species *Melaleuca rhaphiophylla* and *Taxandria linearifolia* were present. Mature flooded gum (*Eucalyptus rudis*) trees are present within the channel feature. Flooded gum occurs within riparian zones, but also occurs in seasonally damp situations outside of these, however was used as an indicator species in the biophysical assessment. Riparian vegetation, although severely degraded, is considered present within the Nambad Brook.

The extent of the foreshore reserve, defined by the biophysical assessment, is identified on the Structure Plan as 'conservation'. This conservation area is contained within public open space, as designated by the Structure Plan.



Great Northern Highway, Bullsbrook South Urban Expansion Area

2.1.5. Hydrology

2.1.5.1. Groundwater

The Structure Plan area is underlain by the Perth-Superficial, Perth-Leederville, and Perth-Yarragadee aquifers.

Groundwater underlying the site generally has a south-westerly flow direction. The historical maximum groundwater level across the site has been estimated from groundwater level data monitored at locations within and adjacent to the site, as well as long-term Department of Water and Environmental Regulation monitoring. The estimated maximum groundwater levels generally range from 5 to 22 metres below ground level. Whilst there is expected to be at least several metres separation to the superficial aquifer, there is potential for shallow perched groundwater to occur at the site given the soil conditions.

2.1.5.2. Surface Hydrology

Several non-perennial watercourses and agricultural drains traverse the site from east to west, with culverts beneath Great Northern Highway connecting these to drains down-gradient of the site, which ultimately discharge into the Ellen Brook located approximately 1.5 kilometres west of the site.

The Nambad Brook has been identified as the most significant watercourse within the site and transects the northeastern portion.

2.1.5.3. Wetlands

The Department of Biodiversity, Conservation and Attraction mapping identifies a 'Multiple Use' category wetland across approximately 90% of the subject land. The wetland is listed as 'flat' and the wetland type as 'palusplain.' The identification of the wetland is not considered a constraint to the development of the land.

There are no Resource Enhancement Wetlands (REW) or Conservation Category Wetlands (CCW) within the site, and the nearest CCW is located approximately 300 metres to the west of the site.

2.1.6. Bushfire Management

Portions of the subject land are identified on the Department of Fire and Emergency Services ('DFES') mapping as being bushfire prone. Therefore, as required by *State Planning Policy 3.7: Planning in Bushfire Areas* (SPP 3.7), a Bushfire Management Plan has been prepared for the site in support of this Structure Plan, with a copy provided at **Appendix 5**. The Bushfire Management Plan has been prepared in accordance with the requirements set out under the *Guidelines for Planning in Bushfire Prone Areas* (the Guidelines) and *Australian Standard 3959 Construction of buildings in bushfire prone areas* ('AS 3959').

As part of preparation of the Bushfire Management Plan, a Bushfire Attack Level ('BAL') Contour Plan has been prepared for the site which is based on:

- Assessment of vegetation within 100 metres of the site, with vegetation classified or excluded in accordance with AS 3959. This includes identification of pre-development and post-development vegetation, with the vegetation likely to be different given existing vegetation within the site will be removed or become low threat vegetation (in the form of public open space).
- Consideration of bushfire hazards as per **Appendix 2** of the Guidelines.
- Determination of effective slope under classified vegetation in the post-development scenario.

Overall, the Structure Plan can achieve the bushfire protection criteria outlined within **Appendix 4** of the Guidelines, with all future residential development capable of achieving a Bushfire Attack Level Rating of BAL-29 or below. A summary of how the criteria have been achieved is provided in **Table 6**.

Refer **Appendix 5 - Bushfire Management Plan**.

Element	Site Response to Bushfire Protection Criteria
Element 1: Location	Based on the indicative subdivision layout, all future dwellings constructed within the site can be located such that the applicable maximum BAL ratings are BAL-29 or less. Where temporary hazards exist, asset Protection Zones ('APZ') can be established to achieve a BAL Rating of BAL-29 or below for the adjacent land.
Element 2: Siting and Design	Based on the indicative subdivision layout, at completion, all future dwellings constructed within the site can be located such that the maximum BAL ratings within the site are BAL-29 or less. A perimeter Asset Protection Zone ('APZ') will be sited in the road reserves, footpaths and any applicable landscaping areas, Where any part of the required APZ dimension is vegetated for the purposes of landscaping, it will be managed in accordance with the technical requirements established by the Schedule 1: 'Standards for Asset Protection Zones (Guidelines). Will be managed in accordance with APZ standards.
Element 3: Vehicular Access	The site will have good access both internally and to the existing road network when all roads have been constructed. Yarrimbah Drive will provide a direct connection to Great Northern Highway, which provides egress in both north-east and south-west directions. Second egress will be provided by the future development of the Kingsford Precinct, until such time as the roads have been constructed, the construction technical requirements established by the Guidelines and/or the Local Government will be complied with.
Element 4: Water	Future residential lots within the site will be serviced by a reticulated water supply and water hydrant network, to be confirmed in future stages of subdivision and development. Fire hydrants will be spaced according to Water Corporation and DFES standards and provide emergency services with access to an adequate water supply.

Table 6: Summary of Bushfire Protection Criteria.

2.1.7. Physical Infrastructure and Services

An Engineering Servicing Report has been prepared in support of the Structure Plan by Pritchard Francis. The findings of the Engineering Servicing Report are summarised below and are provided in **Appendix 1**.

2.1.7.1. Wastewater Reticulation

The reticulated sewer and wastewater outfall is one of the more complex issues for development of the subject land. However, with consideration of the development staging and the timing of additional downstream infrastructure provided by the Water Corporation, the land is capable of being appropriately serviced.

Included within the Engineering Servicing Report (**Appendix 1**), is a specific Reticulated Sewer and Wastewater Outfall Strategy.

This Strategy documents the extent of the subject land that lies within the currently sewer serviced Bullsbrook Central sewer catchment, as well as the primary sewer catchment staging for the balance of the project, within Bullsbrook South. The Strategy illustrates that, having regard to the planning approval timeframes and the market take up of currently serviced land, the forecast for additional sewer infrastructure generally aligns with the Water Corporation's planning and delivery timeframes for the progression of the urban front.

The development timeframes in the context of the wastewater infrastructure and the Bullsbrook South Urban Expansion Area are reflected in **Figure 4**, demonstrating the Structure Plan is therefore capable of being serviced.

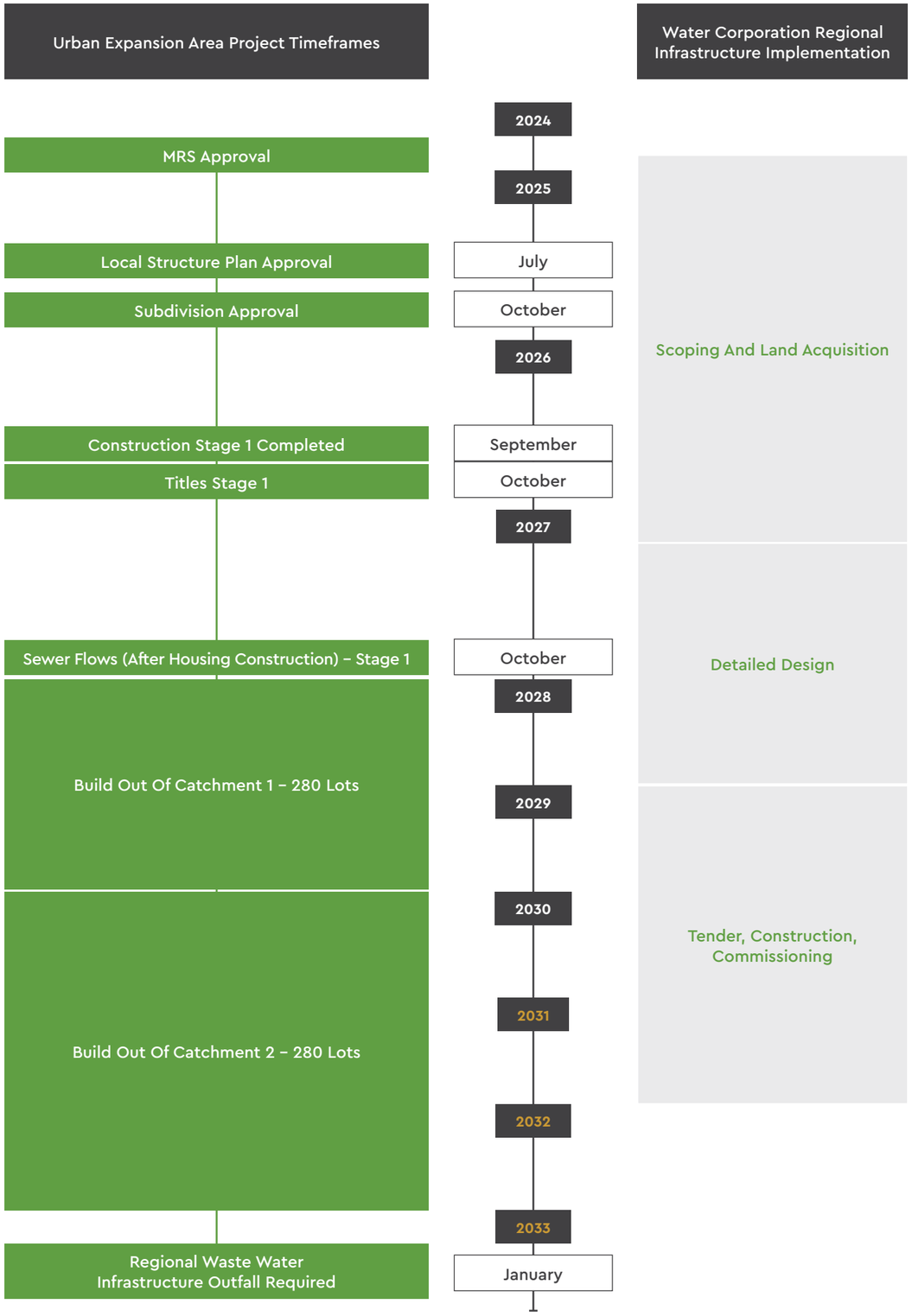


Figure 4. Bullsbrook South Urban Expansion Area Timeframe

2.1.7.2. Water Reticulation

There is existing water supply infrastructure on the western side of the site, located in the Great Northern Highway reserve. This includes a diameter 300mm ductile iron (DI) main that feeds the Bullsbrook Townsite district level supply tanks. It is unlikely this main would be used as a reticulation point for the proposed development.

On that basis, it is understood that as part of future planning for water supply to the north of the site (in the Kingsford Estate) there is a diameter 250mm reticulation main proposed in Squadron Boulevard and a 150mm diameter main in Wylde Boulevard that could be extended to service the subject land. These reticulation mains are proposed to be reinforced with a future diameter 300mm MCSL pipe that runs through the Kingsford Estate and out to Great Northern Highway, at an intersection just north of Nambad Brook. This is another option for future water supply of the subject land.

In terms of water distribution infrastructure, the current Bullsbrook Townsite supply tanks have a top water level of RL 120 metres AHD and a maximum supply level of 112 metres AHD. This is above the nominated maximum levels of RL 90 metres AHD on the eastern side of the Structure Plan, currently contemplated by the Servicing Strategy for the proposed development. It is understood from discussions with the Water Corporation, a high-level water tank to help reinforce the existing supply tanks is due for construction in 2027/28. This will assist in further reinforcing the current supply capacity and increasing the maximum supply level above RL 140 metres AHD.

The Structure Plan area is therefore capable of being serviced with reticulated water supply.

2.1.7.3. Power

The subject land is currently serviced by aerial power on the western side of Great North Highway and a high voltage spur line running along Yarrimbah Drive to service a RAAF radar and existing residents on the adjoining rural properties. This line has a 22 kV capacity, of which there is approximately 500 kVA available. This is supplied from the Bullsbrook Zone substation which, from current mapping, indicates there is 9 MVA available.

Whilst this load is likely sufficient for the initial stages of development, it would be prudent for Western Power to continue future planning for the greater Bullsbrook area to confirm continuity of supply.

For the development of the subject land, a high voltage connection under the Great Northern Highway will be required. This will need to be looped back to the distribution main in time to create a double source of supply. This could be done with a secondary connection to the existing aerials on Great Northern Highway or with connection to the high voltage infrastructure installed for the Centre to the north of the site.

The Structure Plan area is capable of being serviced with an appropriate power supply.

2.1.7.4. Telecommunications

The subject land is currently serviced by multiple optic fibre in the Great Northern Highway reserve. These networks are capable of extension to service the proposed development.

There are a number of opportunities for residential suppliers in the area, including NBN Co and Opticomm.

Telecommunications infrastructure is therefore readily available to service the future residential development of the Structure Plan area.

2.1.7.5. Gas Reticulation

There is currently no existing gas supply within the subject land or Bullsbrook Townsite Area generally. It is anticipated a gas supply will not be investigated or planned to service this development.

Notwithstanding, ATCO has advised a 10 kilometre network mains extension could enable servicing of the development if considered in the future. To facilitate this, the predicted scope of works is as follows:

- Network tie-in at Apple Street, Upper Swan, and Rail Crossing (ARC);
- 850m of DN225PE Apple Street to Great Northern Highway;
- 9,000m of DN225PE from the junction of Apple Street and Great Northern Highway and Yarrimbah Drive, Bullsbrook;
- Installation methodology = Horizontal Directional Drilling (HDD);
- 500m x Open Cut in road reserve; and
- 500m x Open Cut in verge.

2.1.8. People Movement

2.1.8.1. Existing Road Network

Great Northern Highway runs along the western boundary of the subject land, providing the primary north-west connection through the region. Great Northern Highway is reserved as a 'Primary Regional Road' under the Metropolitan Region Scheme. It is classified as a 'Primary Distributer' under the Main Roads WA Functional Road Hierarchy, comprising a single carriageway road with an approximate 40 metre wide reserve. Great Northern Highway has a speed limit of 110km/hour, decreasing to 60km/hour where built up in the Townsite.

Yarrimbah Drive is an existing road extending through the subject land, intersecting with Great Northern Highway, generally opposite Dewar Road.

Stock Road adjoins the site on its southern boundary, Stock Road is currently identified as an 'Access Road' under the Main Roads WA Functional Road Hierarchy. West of the Great Northern Highway, Stock Road is reserved as an 'Other Regional Road' under the Metropolitan Region Scheme. Stock Road serves as the primary east west connector through the region, providing a connection between Great Northern Highway and Tonkin Hghway.

2.1.8.2. Existing Pedestrian and Cyclist Network

There are currently no pedestrian or cyclist facilities within the subject land.

2.1.8.3. Existing Public Transport

The site is currently serviced by Transperth Bus Route 311, which travels from Midland Station to/ from Bullsbrook via Great Northern Highway. There are three bus stop locations along Great Northern Highway adjacent to the subject land.

2.1.8.4. Metronet Morley-Ellenbrook Line Project

The State Government's Metronet project will add approximately 21 kilometres as a spur line from the existing Midland Line east of the Bayswater Station to connect the areas of Morley, Noranda and beyond to Ellenbrook. Due to be completed in 2024, Ellenbrook Station will be the northern terminus and include a Bus interchange and associated parking area. The journey time to the Perth CBD from Ellenbrook station is expected to be 30 minutes.

It is understood that planning for this northern extension has taken into account future growth of the Bullsbrook Townsite, and extensions to the rail / bus network are capable of being extended as the growth and development in this locality occurs; ultimately providing a relatively direct public transport route to the Perth CBD.

2.2. Community Context

2.2.1. People

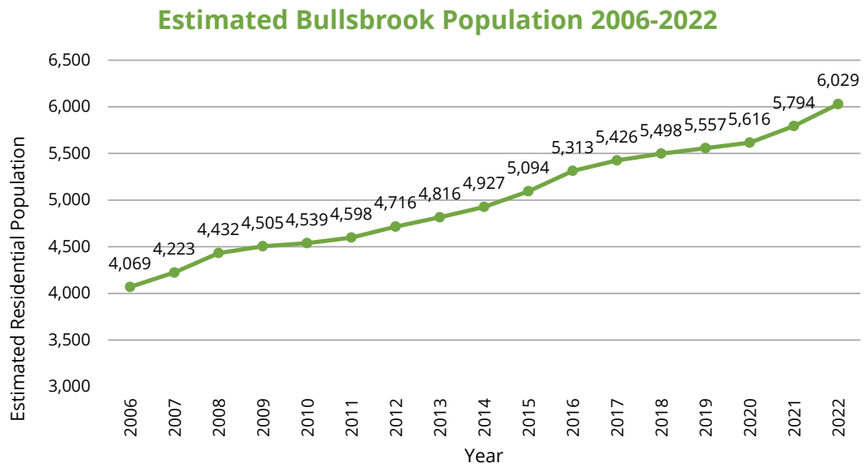
To understand the population and demographic context of the locality, a review of the Australian Bureau of Statistics ('ABS') Census data was undertaken. The below analysis of Bullsbrook refers the Suburb of Bullsbrook, defined as Area Code *SAL50207* by the ABS.

This review has been complemented by further analysis provided by .id Informed analysis and the 'Bullsbrook South Needs Assessment' prepared by Taktics4, provided in **Appendix 6**.

2.2.1.1. Population

The estimated resident population of Bullsbrook on 30 June 2022 was 6,029 people (.id 2023). The historical population from 2001 to 2021 is depicted in the graph below. Bullsbrook has experienced steady population growth since 2006, experiencing growth at an average per annum rate of 2.5%, peaking between 2015 and 2017.

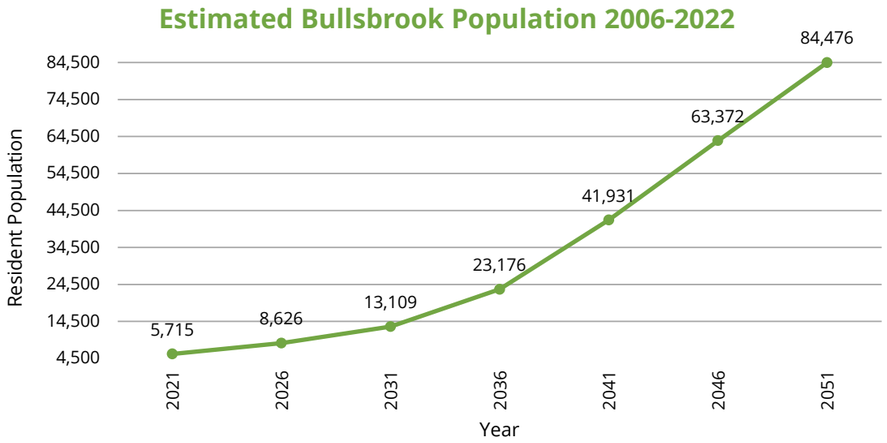
In comparison to the City of Swan, Bullsbrook's population growth is occurring at a lesser rate, with the City's growth occurring at an average rate of 3.2% per annum.



Source: Australian Bureau of Statistics, Regional Population Growth, Australia (3218.0) (.id informed decisions, 2023)

The population of Bullsbrook is anticipated to experience significant growth over the next 30 years, with the WAPC's North-east sub-regional planning framework and City of Swan Local Planning Strategy projecting an additional 175,000 residents are to be accommodated across the locality from 2020-2030.

Population forecasts for the suburb of Bullsbrook are reflected in the graph below.



Source: Population and household forecasts, 2021 to 2051, prepared by .id (informed decisions), February 2023.

Based on the above, Bullsbrook is forecasted to experience a per annum growth rate of 9.3% from 2021 to 2051, with population growth anticipated to peak in the years between 2036-2041. This is based on an increase of over 5,862 households during the period, with the average number of persons per household rising from 2.68 to 2.89 by 2036 (.id, 2023).

The drivers of population change can be attributed to changes in zoning and therefore increased residential development, with the following residential development assumptions contemplated within Bullsbrook across the next thirty years.

Short Term to Medium Term:

- Bullsbrook Heights
- Bullsbrook Landing
- Kingsford (Bullsbrook Central)

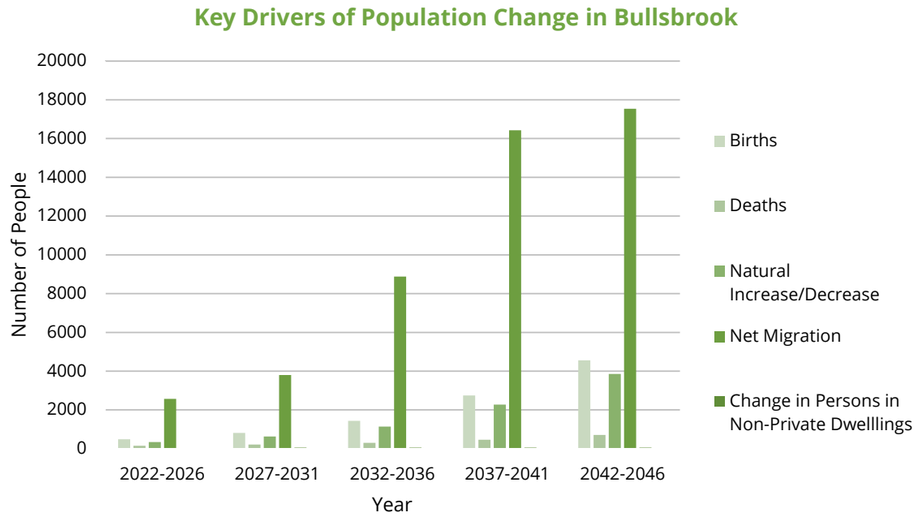
Medium to Long Term:

- Bullsbrook South (as contemplated by the Structure Plan)
- Bullsbrook Townsite Hurd Road
- Hepburn East
- Hepburn West

Long Term:

- East Gnangara
- North Bennett Springs Marshall
- Bullsbrook North Investigation Area
- Ellenbrook North

In consideration of the contemplated residential development for Bullsbrook, the key drivers for population growth are dominated by 'net migration', with the other key drivers reflected in the below graph.



Source: Population and household forecasts, 2021 to 2051, .id (informed decisions), February 2023.

2.2.1.2. Demographics

The key demographic indicators for Bullsbrook have been summarised in **Table 7** below. As of 2021, the median age within the study area was 37, compared to 35 years in the City of Swan and 37 within the Greater Perth area. Family compositions within Bullsbrook area are dominated by the 'couple family with children category' demonstrating the need for appropriately sized family homes within the Local Structure Plan area.

Demographic Indicator	Bullsbrook	City of Swan	Greater Perth
Median Age	37 years	35 years	37 years
People / Household	2.8 people	2.5 people	2.6 people
Family Composition			
▪ Couple family with children	34.9%	36.1%	32.0%
▪ Couple family without children	28.8%	22.9%	25.4%
▪ One parent family	1.3%	12.6%	10.3%
▪ Other families	1.1%	1.2%	1.1%
▪ Group household	2.3%	2.6%	3.4%
▪ Lone person	15.7%	20.3%	24.0%
▪ Other	5.9%	4.3%	3.9%
University Qualification	10.8%	17%	26.5%
Trade Qualification	29.4%	24.6%	20.3%

Table 7: Bullsbrook Demographic Profile (ABS Census Data, 2021; .id (informed decisions), February 2023)

The graph below depicts age groups within the study area and Greater Perth as a percentage of each population. The graph reflects Bullsbrook generally has higher age categories, with the age categories 45-49, 50-54 and 55-59 above the Greater Perth percentage for the applicable categories.



2.2.2. Housing

The Study Area is predominantly characterised by single detached housing, with a very small percentage of semi-detached, row or terrace house, townhouse etc. A breakdown of the dwelling occupancy, dwelling size and weekly house payments are summarised in **Table 8** below.

Key Housing Indicator	Bullsbrook	City of Swan	Greater Perth
Dwelling Structure			
▪ *Separate House*	98.9%	87.1%	75.61%
▪ *Medium Density*	0.3%	10.4%	17.58%
▪ *High Density*	0%	1.1%	6.12%
▪ *Caravan, Cabin or Houseboat*	0%	0.5%	0.30%
▪ *Other*	0.5%	0.8%	0.24%
Dwelling Occupancy			
▪ *Occupied*	90.6%	93.4%	91.7%
▪ *Unoccupied*	9.1%	6.4%	8.2%
Number of Bedrooms	3.7 bedrooms	3.3 bedrooms	3.3 bedrooms
Median Monthly Mortgage Repayment	$1950	$1842	$1907
Median Weekly Rent	$350	$340	$350

Table 8: Bullsbrook Housing Profile (ABS Census Data, 2021; .id (informed decisions), February 2023)

In consideration of the above, the Structure Plan recognises the opportunity to provide areas of medium density housing, near the proposed primary school and Neighbourhood Centre, and in other areas of high amenity and access, in accordance with the principles of Liveable Neighbourhoods for allocating density.

As abovementioned, the population of Bullsbrook is anticipated to experience an average growth rate of 8.9% per annum over the next thirty years. Accordingly, it is understood the number of dwellings in



Bullsbrook, to be provided across the Local Structure Plan area and adjacent developments will rapidly increase. The dwelling forecasts for Bullsbrook are summarised in **Table 9** below.

Area	Number of Dwellings		Increase between 2021–2051	
	2021	***2051***	***Number***	***Percentage***
Bullsbrook	2129	29,680	+ 56,658	+ 96.2%
City of Swan	58,872	115,530	+ 27, 551	+ 1,2938

Table 9: Dwelling Forecasts, 2021 to 2051 (.id (informed decisions), February 2023)

The anticipated number of dwellings across Bullsbrook highlights the strategic importance of delivering Bullsbrook South to the market in an appropriate and staged manner, which will accommodate the growing population of the City of Swan and the Greater Perth area.

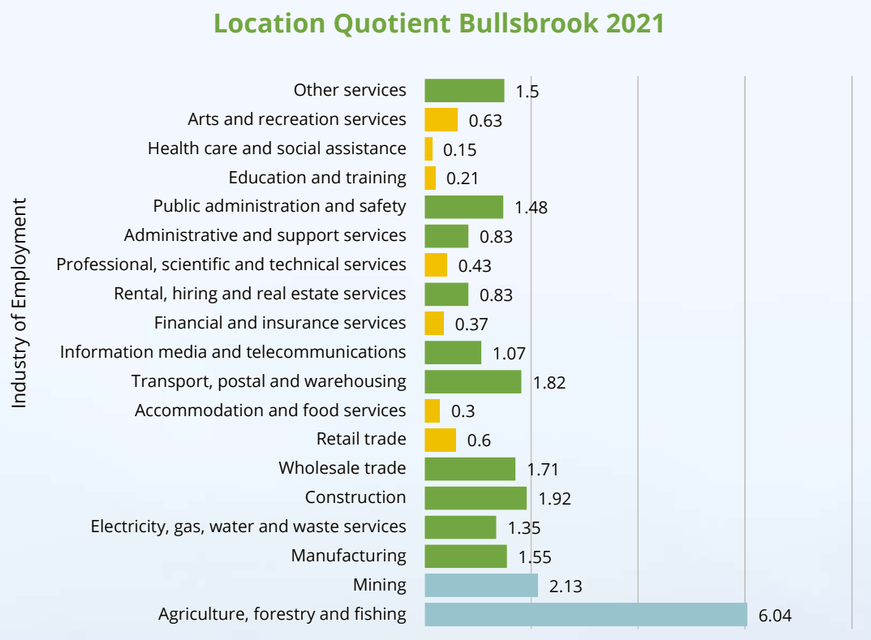
2.2.3. Economy

2.2.3.1. Current Economic Overview

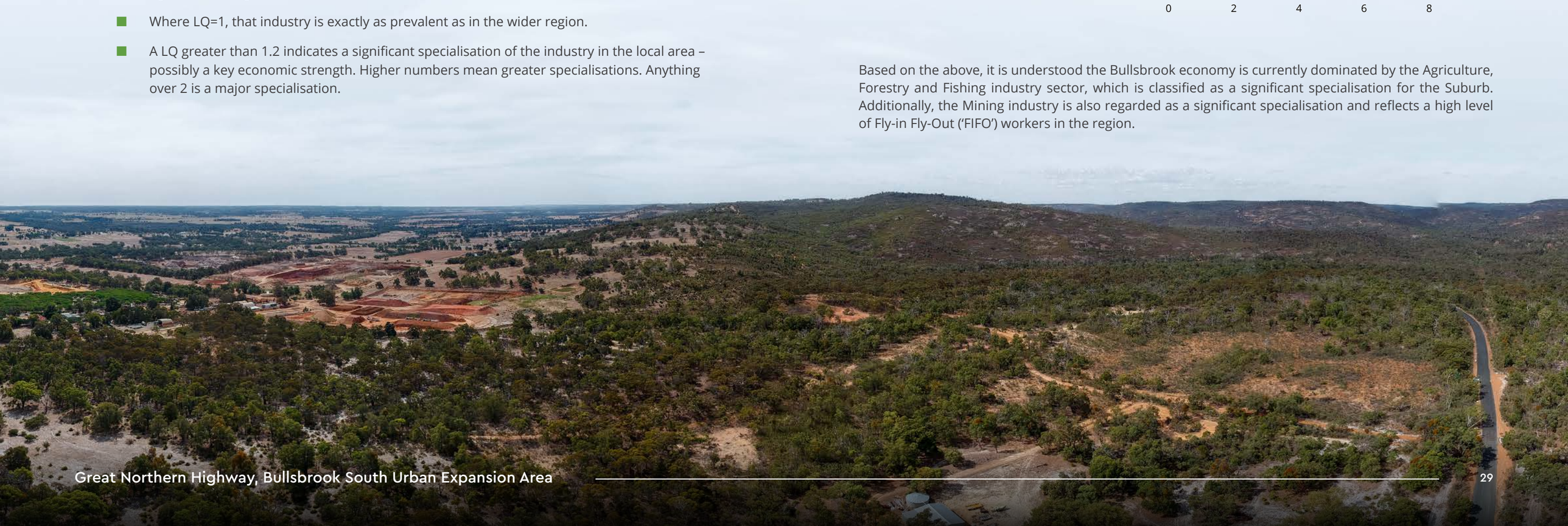
The Gross Regional Product for the broader City of Swan area has been steadily increasing since 2001, producing approximately $11.37 billion in 2022, representing 3.01% of the state's Gross State Product.

To assist in determining the key industries of the Bullsbrook area, Industry Location Quotients for 2021 are provided in the graph below. An Industry Location Quotient is an economic tool used to compare the local economy to the wider region. On this basis, Bullsbrook (Suburb) has been used as the local economy and Greater Perth (Greater Capital City) as the reference economy. Location quotients assist with determining key industries of an area and reflect the weaknesses of an area. To assist in this understanding, the following is noted:

- Where LQ=1, that industry is exactly as prevalent as in the wider region.
- A LQ greater than 1.2 indicates a significant specialisation of the industry in the local area – possibly a key economic strength. Higher numbers mean greater specialisations. Anything over 2 is a major specialisation.
- A LQ between 0.8 and 1.2 means the industry is broadly similar in importance in the local area compared to the comparison region and could be seen as representative.
- An LQ under 0.8 indicates an industry which is more important in the region than the local area, and may represent an economic weakness or opportunity for growth (economy.id, 2023)



Based on the above, it is understood the Bullsbrook economy is currently dominated by the Agriculture, Forestry and Fishing industry sector, which is classified as a significant specialisation for the Suburb. Additionally, the Mining industry is also regarded as a significant specialisation and reflects a high level of Fly-in Fly-Out ('FIFO') workers in the region.



Great Northern Highway, Bullsbrook South Urban Expansion Area

To allow for continued steady economic growth and diversification of its economic base, Bullsbrook is required to accommodate future land uses which promote industries with an LQ of 0.8 and below, currently considered to be an economic weakness or importantly, an opportunity for growth.

In this regard, it is understood there is an opportunity for the Local Structure Plan to accommodate land uses with the following industries of employment:

- Retail Trade
- Accommodation and Food Services
- Financial and Insurances Servies
- Professional, Scientific and Technical Services
- Education and Training
- Health Care and Social Assistance
- Arts and Recreation Services

It is anticipated the above uses may be provided through the proposed Neighbourhood Centre, and therefore assist in the economic diversification of Bullsbrook.

2.2.3.2. Socioeconomic Overview

To understand the economic context of the locality, a review of the Australian Bureau of Statistics ('ABS') Census data was undertaken, this is supported by the Retail Needs Assessment (**Appendix 6**).

Key Economic Indicator	Bullsbrook	City of Swan	Greater Perth
Unemployment Rate	4.4%	5.4%	5.3%
Workforce Participation	66.5%	67.5%	65.2%
Median Weekly Household Income	$1,866	$1,850	$1,865

Table 10: Economic Indicators

As noted above, the local Bullsbrook economy is largely dominated by the 'Agricultural, Forestry and Fishing' industry and the 'Mining' industry, with a high workforce participation rate, as shown in **Table 10**.

In addition to the above, the Retail Needs Assessment notes the following in regard to the Bullsbrook resident labour force:

- An average personal income 3% below the Perth average;
- An average of 2.3 incomes per dwelling which is 13% higher than Perth average;
- An average household income which is 2% below the Perth average;
- A higher representation of dwellings with mortgages (56% of dwellings) than Perth (42%);
- An average mortgage commitment which is 2% below Perth averages; and
- An average rental commitment which is 5% below Perth averages.

Based on the above, it is understood there is an opportunity to provide more affordable housing. This may be achieved by allocating medium density areas which allow for smaller terrace homes accessible to young homebuyers seeking to purchase their first or second homes. Medium density areas are to be strategically located in accordance with the principles of Liveable Neighbourhoods and is discussed further in Section 5 of the Report.

2.2.4. Culture, Values, and Identity

2.2.4.1. Culture and History

As noted in the City of Swan's Bullsbrook Local Area Plan, the Bullsbrook area has a history spanning to over 40,000 years, with the south-west of Western Australia inhabited by Noongar Aboriginal people. Walyunga National Park, located south-east of the subject land contains the largest known Aboriginal campsite in Perth and was still in use in the late 19th century.

European settlement of Bullsbrook occurred in approximately 1827, with first titles of the land referred to as 'Swan location 191', granted in 1840 to George Fletcher Moore. Swan Location 191 comprised of 6000 acres of land predominantly used for sheep grazing and other agricultural uses.

The construction of the Midland Railway line and West Bullsbrook railway siding in 1897 led to migration into the town, leading to the development of the Bullsbrook Townsite. The formalisation of the Townsite occurred with the construction of the Royal Australian Air Force (RAAF) Base Pearce and associated personnel housing, with the Townsite establishing itself as an important commercial centre.

Presently, Bullsbrook has shifted from its origin as a farming community and defence base and is recognised now for its mix of semi-rural living and connection to the Perth hills and bushland. Bullsbrook is now shifting towards accommodating a growing community to be guided by the Bullsbrook Townsite District Structure Plan and facilitated through local structure planning.

2.2.4.2. Local Identity and Character

The name 'Bullsbrook' derives from the watercourse 'Bulls Brook,' which flowed adjacent to the area and is believed to be associated with Lieutenant Henry Bull, who was granted Swan Location 1 on 15 May 1831 or from Richard 'Bull' Jones, one of Henry Bull's servants.

The Bullsbrook area is recognised for its proximity to notable landforms and natural assets, including the Avon Valley National Park and the Walyunga National Park. In addition to this, the RAAF base is strongly attributed to the character of Bullsbrook, with its interwar architecture forming a key part of the Bullsbrook identity.

2.2.4.3. Community Values

In preparation of the City of Swan *Bullsbrook Local Area Plan* (2018), the City of Swan undertook community workshops and consultation to engage with the local Bullsbrook community. The engagement included key topics, comprising of governance, social environment, economic environment, natural environment, as aligned with the City of Swan *Strategic Community Plan 2017-2027*.

The key priorities of the Bullsbrook community, as defined in the Bullsbrook Local Area Plan (2018) include:

- Mitigate the impacts of extractive industries;
- Improve the visual aesthetics of the Bullsbrook townsite;
- Support the strong social capital within Bullsbrook;
- Ensure that the growth of Bullsbrook does not compromise the valued rural amenity and natural environment of the Bullsbrook local area; and
- Provide adequate sporting facilities.

These key priorities have been addressed through the preparation of this Structure Plan.

2.2.4.4. Heritage

2.2.4.4.1. Aboriginal Cultural Heritage

The Department of Planning, Lands and Heritage Aboriginal Cultural Heritage Inquiry System identifies three (3) registered Aboriginal Heritage Sites over the subject land, being:

- **Aboriginal Heritage Site ID 3525: Ellen Brook: Upper Swan** – Registered as a place of creation / dreaming narrative. Comprises an expansive area extending generally from Muchea East Road in the north to Gnangara Road in the south.
- **Aboriginal Heritage Site ID 3583: Ki-It Monger Brook 2** – Registered as place of ritual/ ceremonial; creation/ dreaming narrative; modified tree. Comprises a large area, generally north of Nambad Brook and extending beyond the boundaries of the subject land.
- **Aboriginal Heritage Site ID 4362: South Bullsbrook** – Registered as a place comprising artefacts/ scatter. Comprises a smaller area, generally south of Yarrimbah Drive and extending approximately over half of the subject land.

Whilst the presence of these sites is not considered an impediment to the development of the land, an Archaeological Survey has been undertaken and a Section 18 Consent progressed. The consideration for any relevant and appropriate management requirements will be determined through the assessment and will inform future stages of planning and development.

2.2.4.4.2. European Heritage

A search of the State Heritage Office register has identified there are no sites of State Heritage significance within the subject land or immediate surrounds. No World Heritage or National Heritage places are located within a 5-kilometre radius of the subject land.

2.2.5. Social infrastructure and Services

As noted in the Bullsbrook Townsite District Structure Plan, the Bullsbrook Townsite community is currently serviced by the following key community facilities, as outlined in **Table 11** below.

Facility Type	Name
Community Building	Pickett Park Hall West Bullsbrook Hall Bullsbrook Neighbourhood Centre (youth facility, cheche and activity room) Bullsbrook Community Library Bullsbrook Child Health Care and Preschool Bullsbrook Sports Club
BMX and Skate Park	Bullsbrook Skate Park and BMX track West Bullsbrook BMX Track and Play Park
Sporting Facilities and Infrastructure	Pickett Park Oval Pickett Park basketball/netball courts and lawn bowls Lowrey Park Pavilion and tennis courts District Schools (soccer filed, gymnasium, dance studio and hard courts)
Parks and Reserves	Lowrey Park Ballad Park Brearley Park Burley Park Wally Jones Park Wattlebark Park
Additional Facilities (private open space)	Various Bushland Areas Chequers Golf Club and bushland State Equestrian Centre Various bridle trails

Table 11: Existing Community Infrastructure Facilities

In addition to the above key community infrastructure facilities, Bullsbrook contains the following additional key social infrastructure and services,

- Bullsbrook IGA
- Post Office
- Pharmacy
- Food and Beverage
- Medical Centre
- Hardware Store
- Automotive Services
- Veterinary Services
- Bullsbrook College (K-12)

Additional social infrastructure and services are anticipated to be accommodated in the future Bullsbrook District and Neighbourhood Centres, as discussed in further detail in Section 5 of this report. The proposed centres are anticipated accommodate a range of uses including health-related and medical services which contribute to supporting community wellbeing.

The Structure Plan will accommodate the Lage Road Playing Fields, co-located with the proposed primary school and comprising approximately 3.4 hectares. The Lage Road playing fields are an identified Development Contribution Item under Development Contribution Area 7 (DCA 7).

2.3. Legislative and Policy Context

2.3.1. Zoning and Reservations

2.3.1.1. Metropolitan Region Scheme

The subject land is currently zoned 'Urban' under the provisions of the Metropolitan Region Scheme ('MRS').

Refer **Figure 5 – Metropolitan Region Scheme Zoning**.

2.3.1.2. City of Swan Local Planning Scheme No. 17

The subject land is currently zoned 'Residential Development' under the provisions of the City of Swan Local Planning Scheme No. 17 ('LPS 17'). The Residential Development zone provides a mechanism for the approval of a Structure Plan over the land.

The land is also included within Development Contribution Area 7 under the provisions of LPS 17.

Refer **Figure 6 – City of Swan Local Planning Scheme No. 17 Zoning**.

2.3.2. Regional Planning Strategies

2.3.2.1. Perth and Peel @ 3.5 Million

The *Perth and Peel @ 3.5 Million* suite of documents was prepared and released by the WAPC in March 2018, setting a framework for the development of the Perth and Peel regions in the lead up to the estimated population growth to 3.5 million people by the year 2050. It notes that approximately 800,000 new homes would be required to accommodate the predicted population and sets targets to deliver these through a mix of infill and greenfield development, with targets of 47% and 53% respectively. The document provides a framework that intends to meet the various targets identified within *Directions 2031* and the *State Planning Strategy 2050*.

Perth and Peel @ 3.5 Million provides four separate planning frameworks for the Central, North-West, North-East and South Metropolitan Peel sub-regions. In this regard, the Structure Plan is located within the *North-East Sub-Regional Planning Framework* ('Framework').

2.3.2.2. North-East Sub-Regional Planning Framework

The spatial plans that form part of the Framework identify the subject land for 'Urban Expansion'.

Refer **Figure 7 - Sub-Regional Planning Framework.**

Population projections for the North-East sub-region anticipate a more than 50 percent increase in the region, growing from 209,156 people in 2011 to over 450,500 people in 2050; with this growth predominantly occurring within the municipality of the City of Swan. The Framework sets a target of 25,690 new dwellings within the municipality by 2050, reflecting the expectation of the Bullsbrook Townsite accommodating a planned, significant population increase. The subject land is identified as 'Short-Medium (2015-2031)' in the Sub-Regional Planning Frameworks 'Urban Staging' mapping.

Refer **Figure 8 – Sub-Regional Planning Framework: Urban Staging Plan**.

2.3.2.3. Bullsbrook Freight and Industrial Land Use Planning Strategy (Draft)

The *Bullsbrook Freight and Industrial Land Use Planning Strategy* ('BFILUPS') is intended to provide a strategic vision for the future development of the industrial land, service infrastructure and transport requirements, including support for a proposed intermodal terminal. The BFILUPS was advertised for public comment in early 2022 and is yet to be finalised and presented to the WAPC for endorsement.

The BFILUPS area is located directly west of the subject land, on the opposite side of Great Northern Highway, with this area (Precinct A) representing the existing Industrial zoned land. Great Northern Highway forms the physical edge separating the identified industrial land and proposed residential land within the Structure Plan. In addition to this, public open space is proposed to be provided adjacent to Great Northern Highway on the eastern boundary of the Structure Plan, forming an appropriate separation between the land uses.

In this regard, it is understood there are no restrictions on the development of the subject land resulting from the existing and planned industrial land uses to the west of Great Northern Highway.

The BFILUPS demonstrates the broader Bullsbrook Industrial Area will adequately cater for industrial land demand within the North-East metropolitan corridor in the short, medium and long term. In this regard, it is anticipated the future residential development proposed by the Structure Plan will support a local employment base for the area.

Refer **Figure 9 – Bullsbrook Freight and Industrial Land Use Planning Strategy (Draft)**.

2.3.3. Local Planning Strategies

2.3.3.1. City of Swan Local Planning Strategy

The City of Swan *Local Planning Strategy* ('Strategy') was prepared by the City and endorsed by the WAPC on 30 June 2020, setting out the strategic framework for development within the City of Swan municipality to 2030. *Map 1: Local Planning Strategy* identifies the majority of the subject land as a 'Future Urban Area', consistent with the urban land use proposed by *Perth and Peel @3.5 million*.

Refer **Figure 10 – Local Planning Strategy Map**.

Map 4: Activity Centres, Community Facilities and Housing of the Strategy identifies the subject land as a growth area being delivered in the medium term. Three other future urban areas are identified in the Strategy, being North Ellenbrook, West Ellenbrook and Gidgegannup.

Having regard to the progressively developing Bullsbrook Townsite, Bullsbrook South is considered to represent a logical and appropriate growth corridor. It is acknowledged the development timeframe of the Bullsbrook Future Urban Areas is 'Medium-Long (2022+)' term, consistent with the urban staging identified for the North Ellenbrook Growth Area. The planning and development of the land, as proposed within the Structure Plan, is consistent with this timeframe.

The development of the land for urban purposes is consistent with the land use designation for the subject land under the City's Local Planning Strategy.

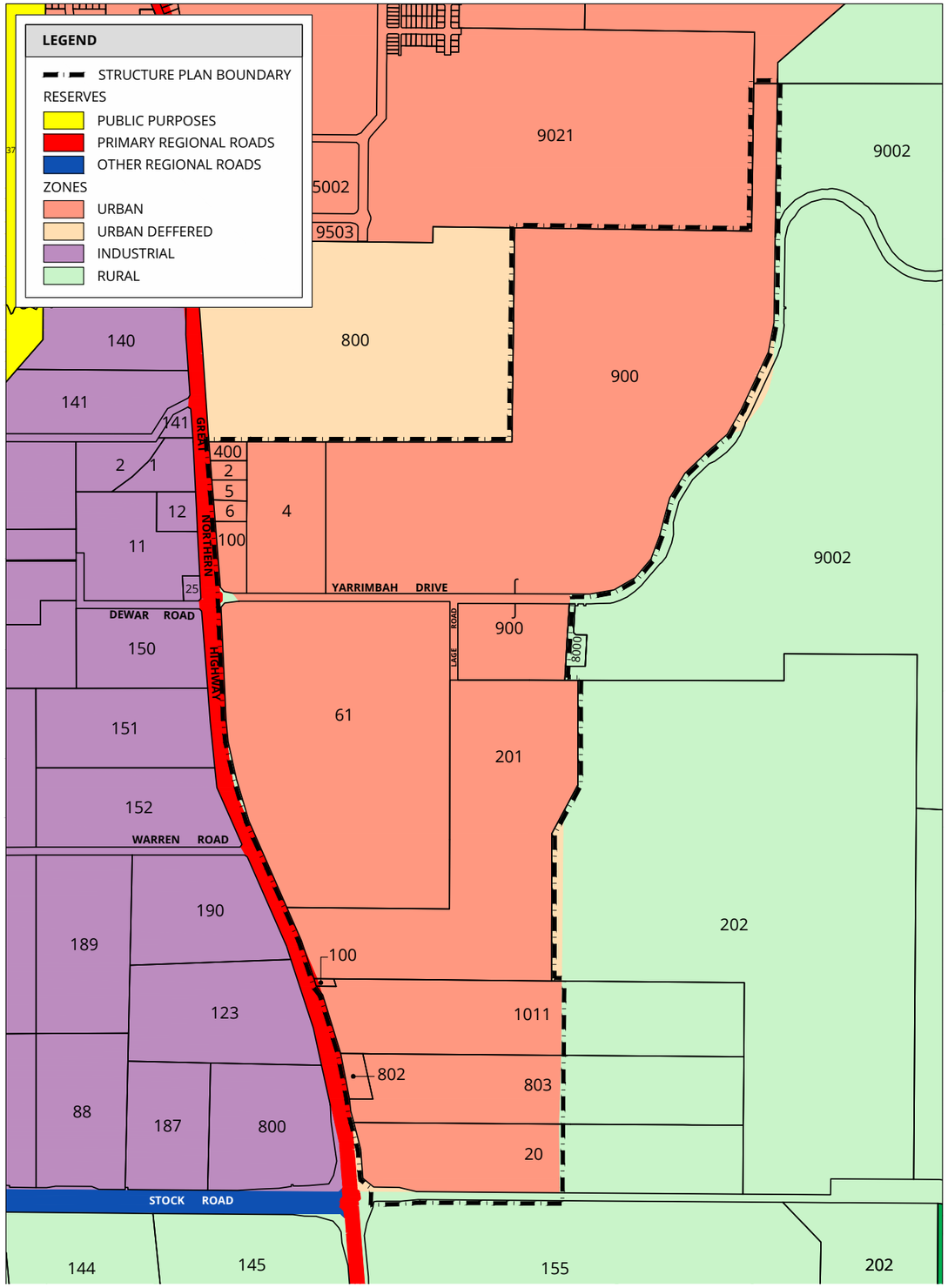


Figure 5. Metropolitan Region Scheme Zoning

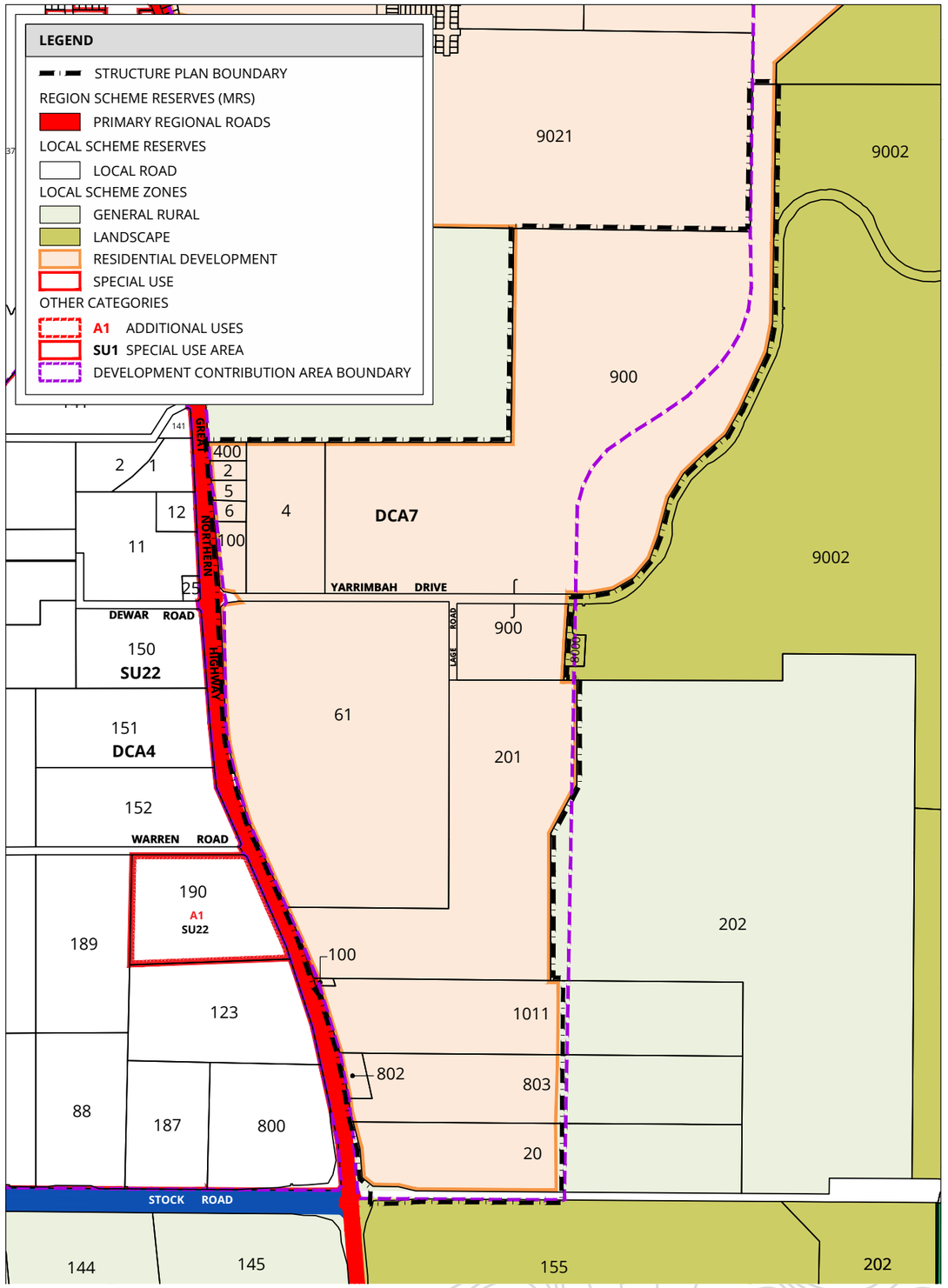


Figure 6. City of Swan Local Planning Scheme No. 17 Zoning

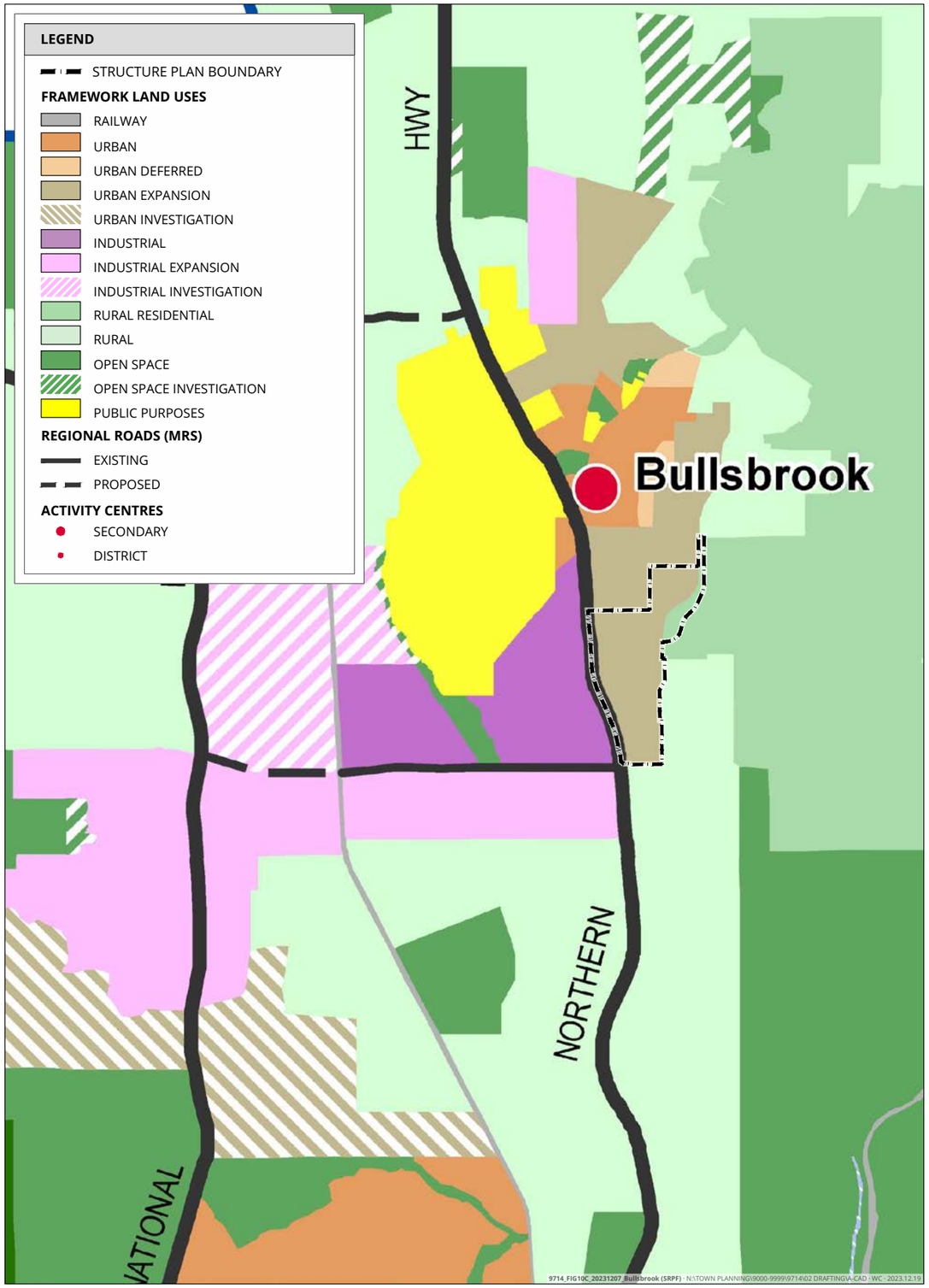


Figure 7. Sub-Regional Planning Framework

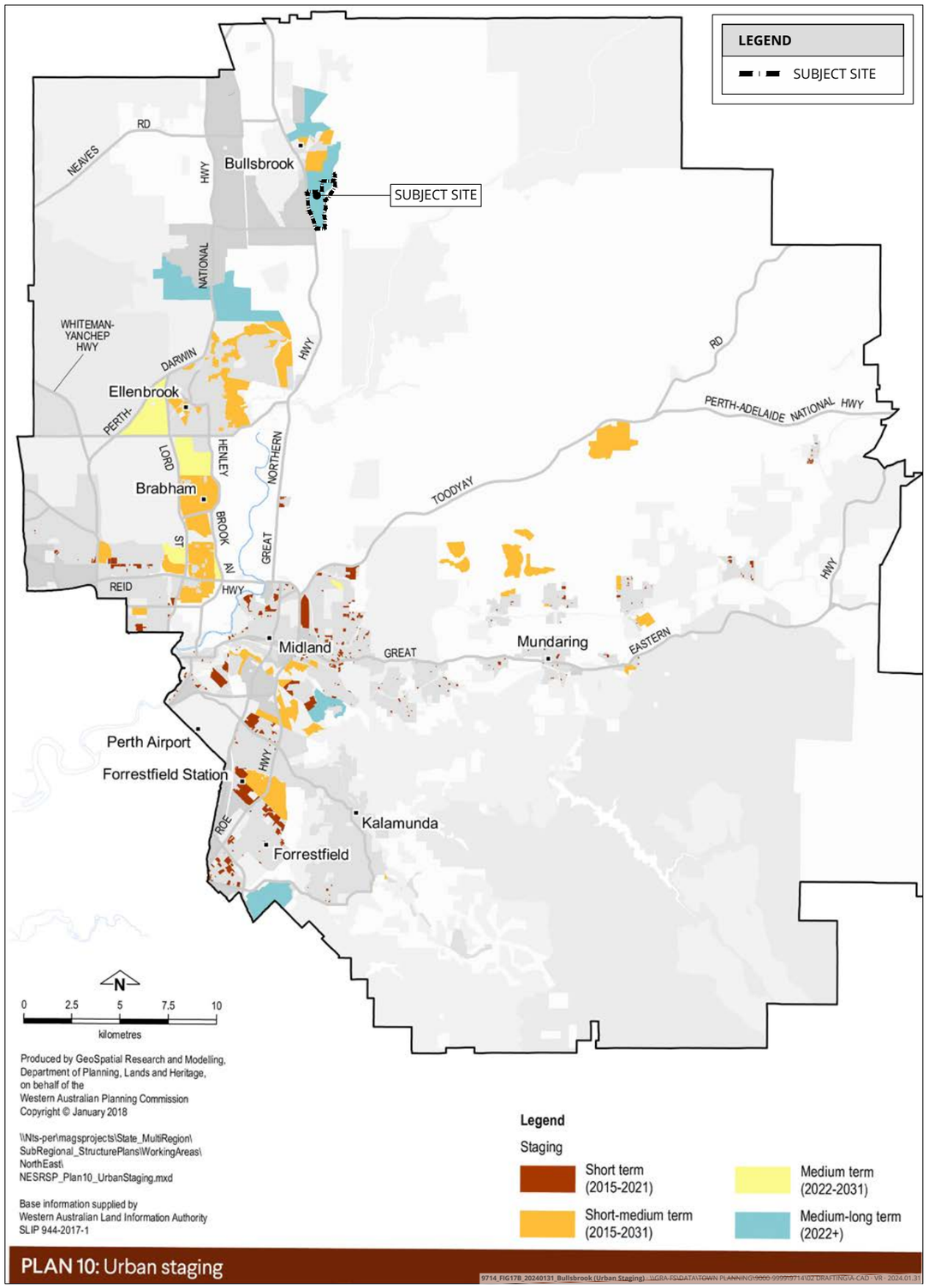


Figure 8. Sub-Regional Planning Framework: Urban Staging Plan.

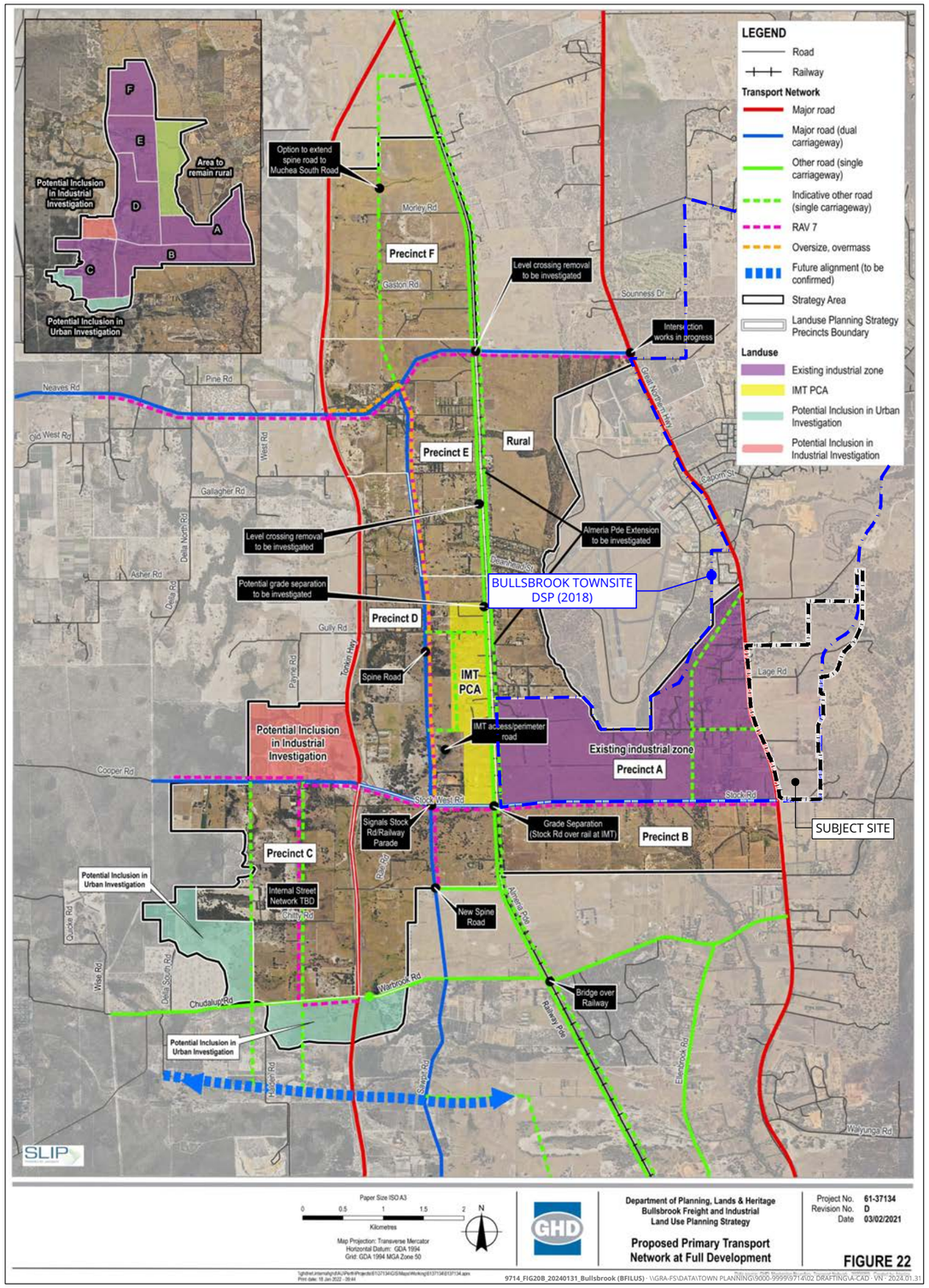


Figure 9. Bullsbrook Freight and Industrial Land Use Planning Strategy (Draft).

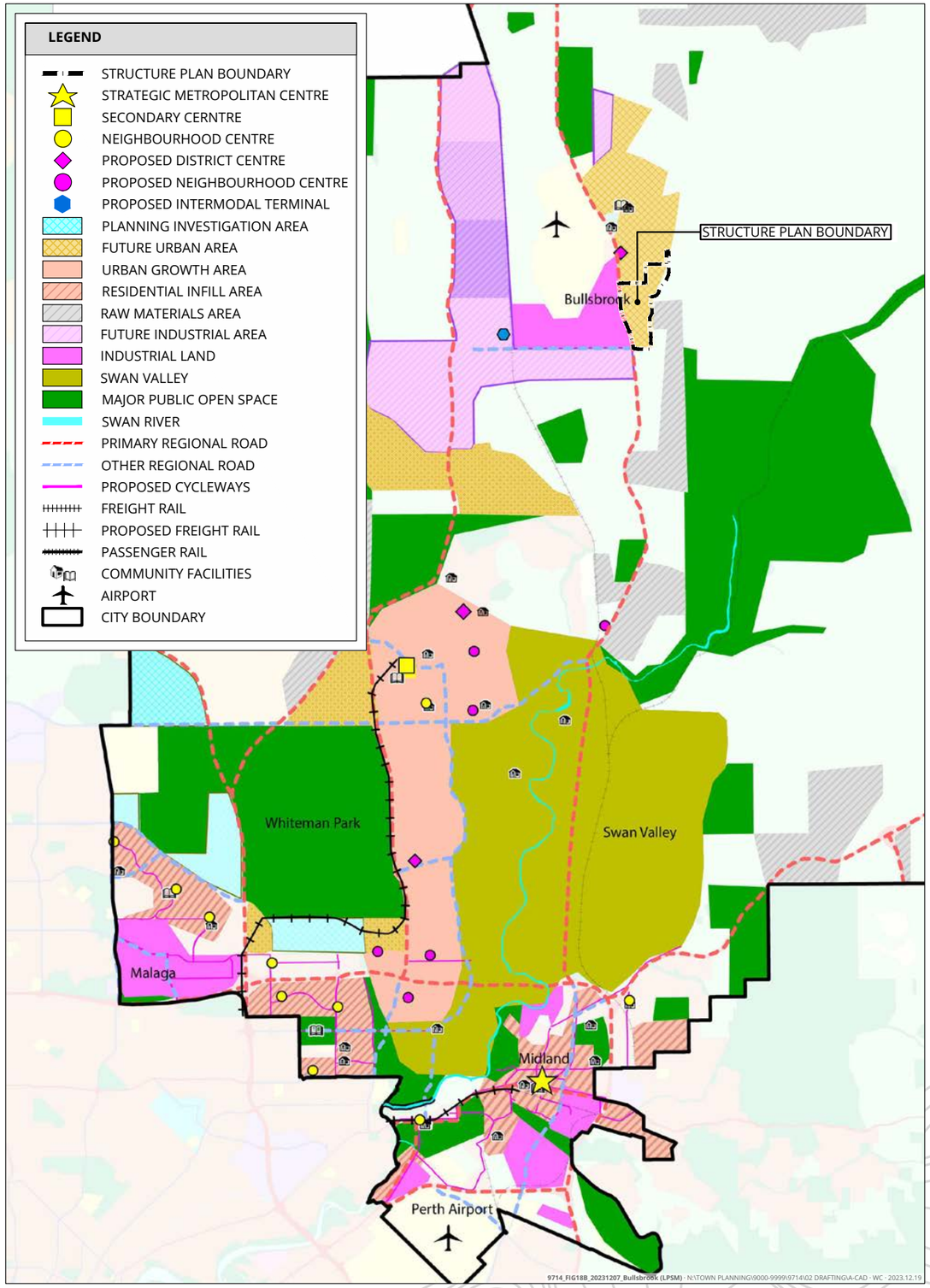


Figure 10. City of Swan Local Planning Strategy

2.3.3.2. City of Swan Strategic Community Plan 2021–2031

The City of Swan *Strategic Community Plan* ('Community Plan') was adopted in 2021 and sets out the City's vision, aspirations and objectives for a ten-year period. The Community Plan has five (5) broad strategic result areas covering: the Natural Environment, Economic, Social, Built Environment and Governance areas.

Additionally, the Community Plan identifies emergent themes which intend to guide the delivery of work within the City of Swan and are outlined as follows:

- **Sustainable growth:** We are committed to economic growth and diversity, balanced with natural environment and heritage to ensure the City provides local services, industry access, local employment and diverse places to live.
- **Community partnerships and connections:** Community interactions and connections in the City are important and form the basis of our places. The City's strength is the people, the connections within activated local areas bringing energy, security and a sense of belonging for all ages and cultures. The City is focussed on engaging and partnering with the community in their decisions to realise this vision
- **Caring for our environment:** The City is committed to caring for and protecting the environment and our history and heritage. The community is proud of the City's beautiful natural environment, its bushland, open spaces, the Swan Valley and Swan River with its natural and diverse beauty.

The proposed Structure Plan has been considered the above themes in its preparation. The Structure Plan will seek to achieve the following:

- Provide an opportunity for economic growth, increasing economic diversification through the proposed Centre;
- Provide a diversity of housing which balances affordability and retention of the natural landscape, achieved through providing low and medium density housing;
- Provide attractive and accessible public open space areas which encourage community interaction and engagement;
- Seek to ensure passive surveillance over public open space areas, creating a safe and secure public realm;
- Ensure the Nambad Brook is appropriately protected through the implementation of foreshore management measures; and
- Designing public open space areas to maximise tree retention.

2.3.3.3. City of Swan Local Biodiversity Strategy

The City of Swan's *Local Biodiversity Strategy* ('Biodiversity Strategy') has been prepared for the purpose of protecting, retaining and managing the network of natural areas which support the diversity of local indigenous biodiversity within the region.

The proposed Structure Plan comprises the Nambad Brook, a tributary of the Ellen Brook, classified as a Local Natural area within the Biodiversity Strategy. The Nambad Brook has been categorised with a Biodiversity Protection Level of 'Protection.' The Strategy identifies the key goal for land identified for 'Protection' is to:

> *Use a variety of processes available to ensure the retention of natural areas to ensure it's continued existence and viability.*

In accordance the above goal, and the vision and objectives of the Biodiversity Strategy, the Structure Plan seeks to *protect* the Nambad Brook by ceding the land as 'foreshore reserve', identified on the Structure Plan as conservation, and be wholly contained within public open space. Accordingly, the Structure Plan seeks to retain any remnant vegetation along the Brook and protect the biodiversity values of the City of Swan.

It is anticipated any future subdivision and development of the land will formally include the foreshore reserve as a 'local conservation reserve,' and will likely require the creation of a Reserve Management Plan providing for the protection of biodiversity values of the reserve.

2.3.3.4. City of Swan Urban Forest Plan

The City of Swan's *Urban Forest Plan* sets out a vision for the future management and expansion of the City's urban forest, seeking to increase the overall percentages of tree canopy coverage, maximise the social, economic and ecological benefits attributed to trees, in addition to improving the aesthetic values throughout the City.

The proposed Structure Plan satisfies the objectives and provisions of the Urban Forest Plan by:

- Providing approximately 15.6% of the Structure Plan area as credited public open space (with a total 17% of green space, including the foreshore reserve), well in excess of the minimum 10% requirement under Liveable Neighbourhoods;
- Designing areas of public open space around the retention of trees – that is, locating areas of public open space to maximise the retention of existing trees;
- Seeking to retain approximately 449 existing mature trees (where detailed engineering design permits), in addition to the planting of additional new trees in road verges and public open space;
- Undertaking a targeted tree survey as part of the Environmental Assessment Report to identify the location, species and quality of existing vegetation on site, informing design outcomes;
- Widened and modified road reserve widths to accommodate the retention of trees where possible;
- Developing a parcel of land that has previously been cleared for paddocks, thereby reducing the need for additional clearing of extensive bushland in order to provide for housing supply; and

The structure planning process and subsequent detailed design will respond to the objectives and provisions of the Urban Forest Plan and in doing so, seek to contribute to improving the urban forest of Bullsbrook.

2.3.3.5. City of Swan Local Commercial and Activity Centres Strategy (2017)

The City of Swan *Local Commercial Strategy* (the Commercial Strategy) was adopted in 2017, following the preparation of retail needs assessment prepared for the City. The Commercial Strategy aims to give effect to *State Planning Policy 4.2 Activity Centres for Perth and Peel*, in addition to *Directions 2031* and associated sub-regional strategies. The Commercial Strategy seek to describe a vision for the future development of commercial and activity centres, providing a set of core principles which will guide planning for centres.

The Commercial Strategy outlines five core principles, outlines as follows:

- Support a viable activity centres hierarchy;
- Encourage a genuine mix of uses in centres;
- Drive local economic development opportunities;
- Support new opportunities which complement the centre hierarchy and provide positive outcomes for the community; and
- Support Midland as the Strategic Metropolitan Centre serving the region.

The identification of a Neighbourhood Centre within the proposed Structure Plan is consistent with the Commercial Strategy, which identifies a future Neighbourhood Centre for Bullsbrook South. The Bullsbrook South Neighbourhood Centre is also identified within the Bullsbrook District Structure Plan.

The proposed centre is anticipated to accommodate a 3,500 sqm NLA supermarket and up to 10-15 shops (1,500 sqm NLA), creating a total retail floor space of 5,000 sqm NLA, and is supported by the findings of a Retail Needs Assessment.

The proposed Structure Plan also respects the hierarchy of activity centres within the City and is in line with the Commercial Strategy principles. The findings and recommendations of the Retail Needs Assessment are discussed further in Section 5.8 of this report and copy of the Assessment is included in **Appendix 6**.

2.3.4. State Planning Policies

2.3.4.1. State Planning Policy No. 2.4 – Basic Raw Materials

State Planning Policy No. 2.4 – Basic Raw Materials ('SPP 2.4') seeks to guide the use and extraction of basic raw materials from land where such extraction is considered appropriate on planning and environmental grounds.

The subject land is not identified as a resource under Basic Raw Materials mapping.

Land to the east is identified as a clay resource under the Basic Raw Materials mapping. This is consistent with the existing extraction licences for that area. As discussed, there is an existing 500 metre buffer associated with the existing clay extraction operation. This buffer only marginally intersects portions of the eastern boundary of the subject land. The Structure Plan seeks to address this through the location of road interface and public open space, to ensure minimal impact on the future residential development whilst this buffer remains.

Refer **Appendix 3 – Environmental Assessment Report**.

2.3.4.2. State Planning Policy No. 2.9 – Planning for Water (Draft)

The WAPC has prepared the draft *State Planning Policy No. 2.9 – Planning for Water* ('draft SPP 2.9') and supporting Guidelines, which were advertised for public comment in 2021. Draft SPP 2.9 and the associated Guidelines seek to consolidate and replace several existing State planning policies, including *SPP 2.7 – Public Drinking Water Source Policy* and *SPP 2.9 – Water Resources*.

The draft policy was prepared to ensure planning and development considers water resource management and includes appropriate water management measures to achieve optimal water resource outcomes. In this regard, a Local Water Management Strategy ('LWMS') has been prepared in accordance with the draft SPP 2.9, in support of the Structure Plan. The LWMS demonstrates the proposed development can appropriately manage stormwater, groundwater and will not negatively impact the surrounding environment. The LWMS is discussed further in **Section 5.5** of this Report, demonstrating the proposal is consistent with the objectives of draft SPP 2.9.

Refer **Appendix 4 – Local Water Management Strategy**.

2.3.4.3. State Planning Policy No. 3 – Urban Growth and Settlement

State Planning Policy No. 3 – Urban Growth and Settlement ('SPP 3') sets out the principles and considerations in promotion of sustainable growth across Western Australia. A number of key objectives of SPP 3, as outlined below, are relevant to this Structure Plan:

- To promote a sustainable and well-planned pattern of settlement across the State, with sufficient and suitable land to provide for a wide variety of housing, employment, recreation facilities and open space.
- To build on existing communities with established local and regional economies, concentrate investment in the improvement of services and infrastructure and enhance the quality of life in those communities.
- To manage the growth and development of urban areas in response to the social and economic needs of the community and in recognition of relevant climatic, environmental, heritage and community values and constraints.
- To promote the development of a sustainable and liveable neighbourhood form which reduces energy, water and travel demand whilst ensuring safe and convenient access to employment and services by all modes, provides choice and affordability of housing and creates an identifiable sense of place for each community.
- To coordinate new development with the efficient, economic and timely provision of infrastructure and services.

The proposed Structure Plan is consistent with the abovementioned objectives for future urban growth. Consideration of the strategic and physical context of the subject site is discussed further within this document and more detailed design provisions are to be addressed and considered at the subdivision stage.

2.3.4.4. State Planning Policy No. 3.6 – Infrastructure Contributions

State Planning Policy No. 3.6 – Infrastructure Contributions ('SPP 3.6') was adopted by the WAPC in 2021. It seeks to set out the principles and requirements that apply to the establishment and collection of infrastructure contributions in greenfield and brownfield areas. Infrastructure items may include public open space, foreshore reserves, schools, roads, utilities, and other community services and facilities.

The Bullsbrook South area is already contemplated by the Development Contribution Area No.7 ('DCA') Special Control Area under the City of Swan Local Planning Scheme No.17, which relates to the existing Bullsbrook Townsite Development Contribution Plan.

Refer **Section 5.8.3** of this Report.

2.3.4.5. State Planning Policy No. 3.7 – Planning in Bushfire Prone Areas

State Planning Policy No. 3.7 – Planning in Bushfire Prone Areas ('SPP 3.7') outlines the measures for strategic planning, subdivision and development applications to reduce the impact of bushfire on property and infrastructure.

The subject land is identified as a Bushfire Prone Area on the Department of Fire and Emergency Services ('DFES') mapping. Accordingly, a Bushfire Management Plan is required to support any strategic planning applications for the development the subject land, prepared in accordance with the requirements of SPP 3.7. A Bushfire Management Plan has therefore been prepared by Bushfire Prone Planning in support of this Structure Plan.

Refer **Appendix 5 – Bushfire Management Plan**.

The outcome of the Bushfire Management Plan demonstrates that, subject to further detailed planning, the future residential development of the land will be subject to a moderate or low bushfire hazard level and can be appropriately managed to further mitigate the risk. This is discussed in further detail in **Section 2.1.6** of this report.

2.3.4.6. State Planning Policy No. 5.1 – Land Use Planning in the Vicinity of Perth Airport

State Planning Policy No. 5.1 – Land Use Planning in the Vicinity of Perth Airport ('SPP 5.1') was adopted by the WAPC in 2015 for the purpose of protecting Perth Airport from the unreasonable encroachment of noise sensitive (incompatible) development. While the subject land is not within the Perth Airport aircraft noise area, SPP 5.1 is considered a relevant planning instrument in the context of the proximity of the subject land to the Royal Australian Air Force ('RAAF') Pearce Air Base.

SPP 5.1 sets out specific zoning and development criteria for land affected by the various intervals of the Australian Noise Exposure Forecast ('ANEF') contours. Whilst in locational proximity, the subject land is not impacted by any critical ANEF contour and accordingly, the proposed development is consistent with the provisions of SPP 5.1, as confirmed within the attached Acoustic Assessment.

Refer **Appendix 7 – Acoustic Assessment**.

2.3.4.7. State Planning Policy No. 5.4 – Road and Rail Noise

State Planning Policy No. 5.4 – Road and Rail Noise ('SPP 5.4') was prepared to assist in minimising the adverse impact of road and rail noise on noise sensitive land uses and/or development, within the specified trigger distance of strategic freight and major traffic routes (including both Great Northern Highway and Stock Road). SPP 5.4 has informed the preparation of the proposed Structure Plan and Indicative Subdivision Concept Plan **(Figure 19)**, in providing for a vegetated green buffer along the western edge of the subject land (adjacent to Great Northern Highway).

A detailed acoustic assessment has been prepared in support of the Structure Plan which confirms future residential lots that may be impact by noise can be appropriately mitigated through the application of standard 'Quiet House Design' noise insulation packages.

Refer **Appendix 7 – Acoustic Assessment**.

2.3.5. Operational Policies

2.3.5.1. Liveable Neighbourhoods

Liveable Neighbourhoods represents the Western Australian Planning Commission's ('WAPC') primary policy to guide the design and assessment of residential structure plans and subdivision. The underlying objective of Liveable Neighbourhoods is to create safe, sustainable and attractive neighbourhoods with a strong site responsive identity that reduces dependency on private vehicles, and are more energy and land efficient. As such, Liveable Neighbourhoods seeks to promote an urban structure based on walkable, mixed-use neighbourhoods with interconnected street patterns. It functions by drawing together key policy aspects into a single 'integrated planning and assessment policy' to provide for a performance-based approach to planning assessment. These aspects include:

- Community;
- Movement;
- Lot Layout;
- Urban Water Management;
- Public Open Space;
- Utilities;
- Activity Centres; and
- Schools.

Liveable Neighbourhoods identifies a series of objectives and requirements for structure plans that, when met, demonstrate compliance with the overall outcomes sought by Liveable Neighbourhoods. These objectives and requirements relate to items such as road layout, relationship of housing to open space and schools, school location/distribution, public open space layout and location, and housing densities.

Working with the site constraints, the Structure Plan has been prepared to satisfy the various objectives and requirements of Liveable Neighbourhoods to ensure more detailed proposals at subdivision stage are also capable of satisfying the relevant criteria.

2.3.6. Local Planning Policies

The following City of Swan Local Planning Policies are to be addressed and considered through the subdivision and detailed design stages:

- POL-C-061 Filling of Land
- POL-E13.11 Inclusion of Pedestrian Accessways in Residential Subdivision
- POL-LP-1-12 Public Open Space and Community Buildings
- POL-LP-11 Variation to Deemed to Comply Requirements of the R-Codes Medium Density Single House Development Standards
- POL-TP-125 Building and Development Standards – Commercial Zones
- POL-C-104 Environmental Planning

2.3.7. Existing Structure Plans

2.3.7.1. Bullsbrook Townsite District Structure Plan

The *Bullsbrook Townsite District Structure Plan* was approved by the WAPC in April 2018 to guide the future development of the broader Bullsbrook area, and to reflect the population and density targets identified within *Perth and Peel @ 3.5 Million* and preceding *Directions 2031 and Beyond* suite of documents.

The District Structure Plan identifies Bullsbrook South generally for 'Future Residential' development, consistent with the land use designation under the *North-East Sub-Regional Planning Framework*. The District Structure Plan identifies a Neighbourhood Centre on either side of Yarrimbah Drive, to be provided access from a new intersection between Yarrimbah Drive and Great Northern Highway, and a high level public open space / conservation network (surrounding the Nambad Brook foreshore).

The proposed Structure Plan is generally consistent with the District Structure Plan and the range of land uses contemplated. The proposed Structure Plan has been prepared to further refine and detail the local public open space network, the movement network, vegetation retention, residential density, and staging.

Refer **Figure 11 – Bullsbrook Townsite District Structure Plan Map**.

2.3.7.2. Bullsbrook Central Structure Plan – Kingsford

The Structure Plan area abuts the Bullsbrook Central Structure Plan to its northern boundary, and comprises the Kingsford residential estate. The Bullsbrook Central Structure Plan was approved by the WAPC in May 2019, and was subsequently amended in November 2022 to include additional land and exclude land comprising the Kingsford Town Centre Precinct Plan.

The Kingsford residential estate and town centre are progressively being developed.

Preparation of this Structure Plan has had consideration for ensuring future subdivision and development will provide for a seamless connection with the adjoining development within Kingsford, with regard to road connections and reserve cross sections, public open space connectivity and interface, and residential densities and built form outcomes.

2.3.7.3. Kingsford Town Centre Precinct Plan

The Kingsford Town Centre Precinct Plan comprises the Bullsbrook District Centre, within the Kingsford estate. The Kingsford Town Centre Precinct Plan was approved by the WAPC in November 2022.

The Town Centre is intended to service the growing residential community of Bullsbrook, including the Bullsbrook South, Central and Northern precincts.

The Town Centre will accommodate the following mix of land uses:

- A major supermarket
- Specialty stores
- Café
- Medical Services
- Recreation facilities
- Public Primary School
- Pedestrian focused Main Street
- Range of residential lots / dwellings

The Town Centre will be developed over a number of years in multiple stages. The Town centre will provide a key employment and activity node for the wider Bullsbrook locality.

2.3.7.4. City of Swan Structure Plan No.11 (Rural Residential Development)

The City of Swan Structure Plan No. 11 comprises Lot 301 Stock Road and Lot 302 Yarrimbah Drive (formerly Lage Road), and adjoins the Structure Plan area to the east. Structure Plan No. 11 was approved by WAPC November 2014 and subsequently amended in February 2020.

Structure Plan No. 11 comprises future rural residential development (approximately 219 lots) in accordance with the objectives of the Landscape Zone.

One of the key considerations in the design and approval of Structure Plan No. 11 was fire management. As part of that design response was a commitment to providing public access to Great Northern Highway from the existing Shady Hills estate and other residents to the east of Clarkson Road. This included the retention and extension of Lage Road (now Yarrimbah Drive) around the perimeter of the site. The proposed Structure Plan retains this road connection.

Whilst serving an important fire management function, the road interface also provides a hard edge between the Urban and Rural land uses. To ensure appropriate management of this interface, lower density ranges (with an anticipated R12.5 density coding) are proposed along the eastern edge to ensure an appropriate Rural to Urban land use transition.

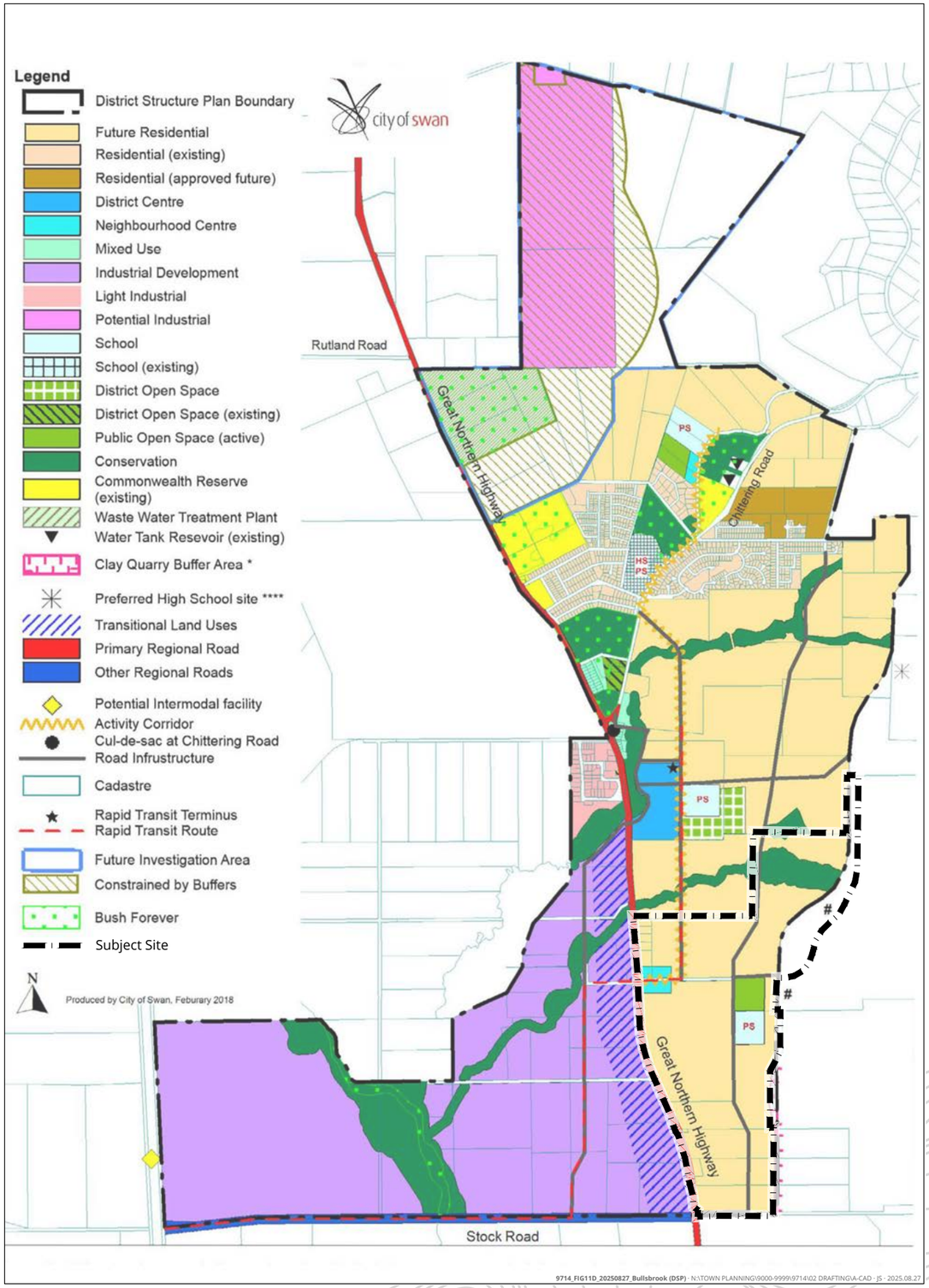


Figure 11. Bullsbrook Townsite District Structure Plan Map

3. Stakeholder Engagement

3.1. Pre-Lodgement Engagement

There was a significant amount of pre-lodgement engagement undertaken in the preparation of the Structure Plan and Urban Deferred Lifting request for the site. This engagement was primarily in relation to resolving an appropriate servicing strategy for the land, specifically wastewater infrastructure.

Whilst pre-lodgement discussions were centred around the servicing strategy for the site, the Structure Plan was also addressed more generally, helping to inform the overall design considerations for the site.

The following table provides a summary of the key meetings and discussions undertaken as part of pre-lodgement engagement for the Structure Plan (and associated Urban Deferred Lifting).

Date	Agency / Stakeholder	Attendees	Summary / Outcomes
18 June, 2022	Water Corporation	▪ Water Corporation representatives ▪ Landowner representatives ▪ Rowe Group & civil engineering consultant	Overview of land supply and servicing priorities. Proposed strategy. Seek Water Corporation support.
28 June, 2022	Office of Minister for Planning	▪ Emma de Jagar ▪ Isla Finlay ▪ Landowner representatives ▪ Rowe Group & consultants	Provide Briefing Note. Overview of land supply and servicing priorities. Proposed strategy.
7 July, 2022	Office of Member for Swan Hills	▪ Jessica Shaw (MLA) ▪ John Carrol ▪ Landowner representatives ▪ Rowe Group & consultants	Provide Briefing Note. Overview of land supply and servicing priorities. Proposed strategy.
19 Aug, 2022	Office of Minister for Water	▪ Luke Clark (Chief of Staff) ▪ Landowner representatives ▪ Rowe Group & consultants	Provide Briefing Note. Overview of land supply and servicing priorities. Proposed sewer strategy.
23 Sep, 2022	Local MLA	▪ Jessica Shaw (MLA) ▪ Landowner representatives ▪ Rowe Group & consultants	Provide Briefing Note. Highlight proposed sewer strategy and need for servicing resolution.
2 Nov, 2022	Office of Minister for Water	▪ David Kelly (now former), Minister for Water and senior advisor ▪ Jessica Shaw, MLA, Member for Perth Hills ▪ Water Corp representatives ▪ Emma De Jaeger (Planning Minister's Office) ▪ Landowner representatives ▪ Rowe Group & Prichard Francis consultants	Provide Briefing Note. Highlight proposed sewer strategy and need for servicing resolution.
18 Nov, 2022	Office of Premier	▪ David Coggin (Premier's Office) ▪ Josh Jerga (Premier's Office) ▪ Emma De Jaeger (Planning Minister's Office) ▪ Landowner representatives ▪ Rowe Group & Prichard Francis consultants	Provide Briefing Note and review of meeting with Minister for Water. Highlight proposed sewer strategy and need for servicing resolution.
20 Nov, 2022	City of Swan	▪ Leon Van der Linde, Ian Humphrey (CoS) ▪ Rowe Group	Discuss North East Corridor, including Bullsbrook South, servicing strategy and need for support.
19 June, 2023	City of Swan	▪ Leon Van Der Linde	Email seeking City support to concurrent LSP.
7 July, 2023	City of Swan	▪ Leon Van der Linde (CoS) ▪ Mat Selby (DPLH) ▪ Rowe Group	Email from City to DPLH. Confirming City's support for concurrent assessment of UDL, LPS 17 rezoning and LSP.
10 July, 2023	Water Corporation	▪ Water Corporation (Scott Moorhead, Brett Coombes, Mark Busher, Russell Nelson, Peter Howard) ▪ Mirvac ▪ McFerran Advisory ▪ Pritchard Francis	Urban Deferred Lifting pre-lodgement meeting with Water Corporation. Discussion on sewer infrastructure constraints and requirements to service the Bullsbrook South Urban Expansion Area.
4 Sept, 2023	WAPC Chairman	▪ WAPC (Chairman David Caddy, Mat Selby, Anthony Muscara). ▪ Mirvac. ▪ Rowe Group ▪ McFerran Advisory ▪ Pritchard Francis.	Meeting. Discussion on sewer infrastructure constraints and requirements to service the Bullsbrook South Urban Expansion Area.
11 Sept, 2023	City of Swan	▪ City of Swan (Ian Humphrey, John Elliott, Philip Russell, Leon Van der Linde) ▪ Rowe Group	Urban Deferred Lifting pre-lodgement meeting with City of Swan. Discuss Lodgement of UDL Request and key matters to be addressed within Structure Plan. Discussion of lodgement and timing of Structure Plan.
6 Oct, 2023	WAPC/DPLH	▪ Mathew Selby	Letter of approval from WAPC for concurrent UDL / LSP assessment.

Date	Agency / Stakeholder	Attendees	Summary / Outcomes
16 Oct, 2023	Minister's Office	▪ Emma de Jager (Planning Minister's Office) ▪ Lauren Betteridge (Water Minister's Office) ▪ Mirvac ▪ Rowe Group	Meeting to update on planning and servicing strategy. Discussion on timing for infrastructure delivery and housing supply priorities.
26 Oct, 2023	Water Corporation	▪ Mark Busher	Email. Update on sewer infrastructure planning for the Bullsbrook South Urban Expansion Area.

Table 12: Summary of Pre-Lodgement Engagement

3.2. Post-Lodgement Engagement

In accordance with the requirements of the *Planning and Development (Local Planning Schemes) Regulations 2015* – Schedule 2 – Deemed Provisions ('Regulations'), Structure Plans arerequired to be publicly advertised and referred to any public authority or utility service provider, as relevant. Public advertising is required to be undertaken for a minimum of 42 days.

Public advertising would typically occur by way of letters being sent to owners and occupiers who, in the opinion of the City, are likely to be affected by the proposed Structure Plan. In addition, advertising of the Structure Plan must occur by way of a notice being published on the City's website. Advertising may also occur by way of local newspapers, a sign being placed on the site, and documents being made available at the City's office.

In terms of service agencies and utility providers, the Structure should be referred to the following agencies/utility providers:

- Main Roads WA;
- Water Corporation;
- Western Power;
- Department of Biodiversity, Conservation and Attractions;
- Department of Water and Environmental Regulation;
- Department of Fire and Emergency Services;
- Department of Education.

Following public advertising, the City is required, in accordance with the Regulations, to consider all submissions received and provide a recommendation to the WAPC on the progression of the Structure Plan.

Further engagement may also be required to satisfy obligations under the *Aboriginal Heritage Act 1972*, the *Environmental Protection Act 1986*, and the *Environment Protection and Biodiversity Conservation Act 1999*.



4. Opportunities and Constraints

4.1. SWOT Analysis Overview

The following analysis has been provided in response to the physical, community and policy considerations as outlined within Section 2 of this Report. The following strengths, weaknesses, opportunities, and threats identified are considered within the design response of the Structure Plan.

SWOT Analysis	
Strengths	▪ Situated within an Urban growth corridor Considered in previous planning – Sub-Regional Planning Framework, District Structure Plan. ▪ Well located in relation to major transport routes/infrastructure. ▪ Proximity to future industrial employment node east of Great Northern Highway – employment opportunities.
Weaknesses	▪ Proximity to Clay Extraction Site. ▪ Distance from Perth. ▪ Corridor in early stages of development maturity - lack of social infrastructure and employment opportunities, car dependence (requires travel out of area for work etc).
Opportunities	▪ Retention of scattered mature trees within Nambad Brook reserve, areas of public open space and road reserves. ▪ Landform to provide view corridors and interest.
Threats	▪ Service infrastructure availability, specifically wastewater planning and capacity.

Table 13: SWOT Analysis

The site context considerations which have informed the design response are reflected below.

Refer **Figure 12 to 17– Site Context Analysis Plans**.

Refer **Figure 18 – Site Context Analysis**.

4.2. Design Objectives and Consideration

The Bullsbrook South Structure Plan has been prepared in response to a number of factors, including the Bullsbrook Townsite District Structure Plan, technical input from the multi-disciplinary team of sub-consultants, the site and context analysis, and the identified opportunities and constraints of the subject land.

The subject land benefits from a high degree of existing amenity, offered by both the proximity to the existing Bullsbrook Townsite and the natural amenity offered by the adjacent land holdings and existing trees within the site. The vision and objectives of the Structure Plan are to:

- Maintain a strong connection with the existing and progressively developing Kingsford Estate.
- Retention of the existing creek line (Nambad Brook) within the subject land, to maintain strong sense of place and provide for east-west linear public open space.
- Where possible, provide for the retention of existing paddock trees.
- Provide for an interconnected movement network to facilitate active transport.
- Provide residential street blocks that will facilitate a range of densities and diversity of housing product.



Figure 12. Site

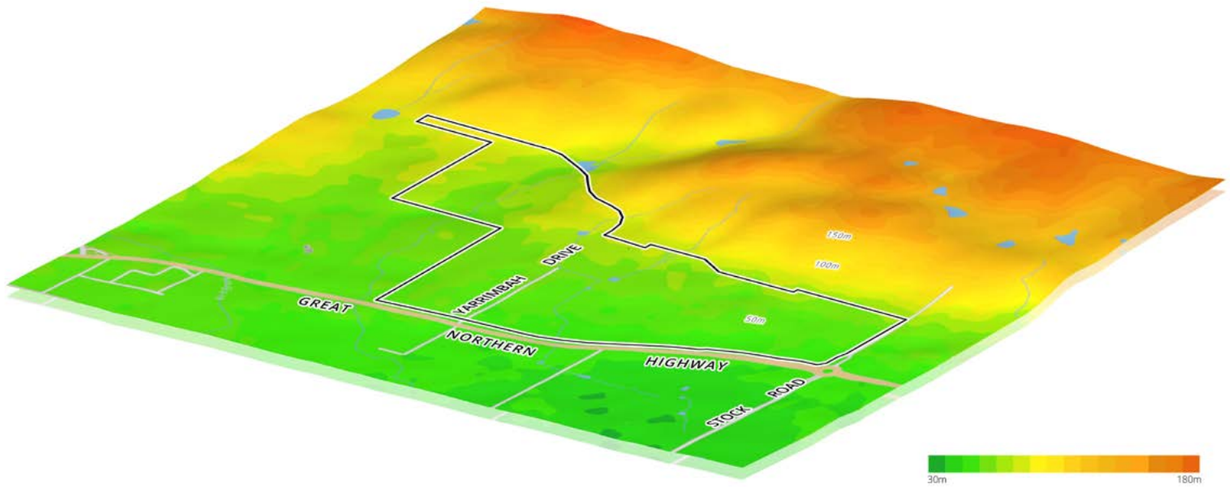


Figure 13. Topography



Figure 14. Existing Hydrology



Figure 15. Site Views



Figure 16. Existing Trees and Vegetation

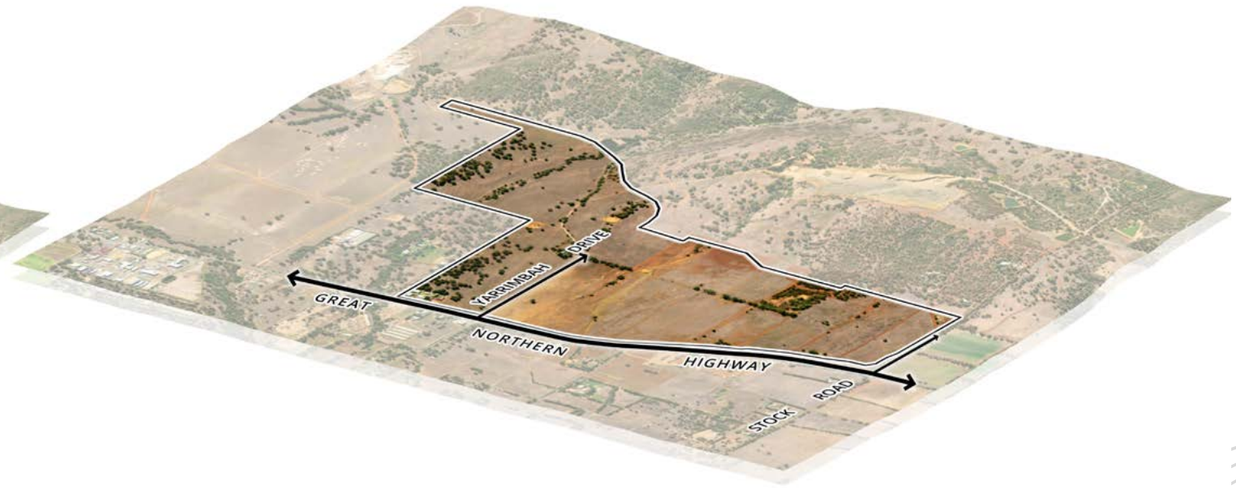


Figure 17. Existing Access

5. Design Response

5.1. Community Design

5.1.1. Land Use

The Structure Plan sets out land use, residential densities, public open space, public and private transport provision, environmental considerations, hydrological and servicing requirements.

The Structure Plan comprises residential development with density codes ranging from R12.5 to R40. The Structure Plan also comprises areas of public open space and a neighbourhood centre.

The following describes the design response to the site and context analysis outlined in Section 2 of this Report and addresses the relevant elements of Liveable Neighbourhoods. Please also refer to the Land Use Summary Table provided within the Executive Summary on Page IV of this Report.

The Structure Plan layout has been carefully considered within the broader context of Bullsbrook. The proposed Structure Plan contributes a residential development opportunity within an underutilised parcel of land, adjacent to an existing residential development (Kingsford) and townsite. It is well located adjoining Great Northern Highway to the east and Stock Road to the south, which provide connections to major transport infrastructure.

Refer **Plan 1 – Structure Plan**.

Refer **Figure 19 – Indicative Subdivision Concept**.

Land Use Summary

Total Area (approx.)	187 hectares
Area of each Land Use within Structure Plan:	
▪ Residential (net) (residential cells only)	99.08 hectares
▪ Primary School	3.75 hectares
▪ Neighbourhood Centre	2.24 hectares
Estimated Residential Lot Yield (subject to detailed design)	2,000 lots
Estimated Population Yield (@ 2.8 people per household)	5,600 people
Number of Primary Schools	1 school
Provision of Public Open Space	
▪ Public Open Space (Total Provided Green Space)	32.09hectares
▪ Credited Public Open Space @10% GSA (Required)	17.46 hectares
Note: All land areas are indicative only and subject to detailed design at subdivision and development stage.	

Table 14: Land Use Summary

5.1.2. Design Response

The Structure Plan has been designed in response to the physical context of the subject land which has determined the indicative residential layout, including;

- Cadastral boundaries;
- Topography;
- Climatic conditions;
- Water management;
- Mitigation of bushfire threat;
- Retention of key views towards Perth City; and
- Retention of Bullsbrook character and notable sense of place.

As discussed in Section 2.14 of this Report, there are limited environmental features throughout the subject land, having regard to its former use for grazing paddocks. Notwithstanding, the Structure Plan has been prepared to facilitate the retention and revegetation of the two existing creek lines, as well as providing opportunities for the limited paddock trees throughout the site to be retained within areas of public open space and within road reserves, where possible.

As detailed design and planning progresses, further opportunities for tree retention will be accommodated where possible. Such opportunities may include the earthworks strategy, water management and landscape design, size and location of road reserves, and is subject to further refinement at subdivision stage.

5.1.3. Design Philosophy and Objectives

The design philosophy for the Structure Plan has been considered in the broader context of the Bullsbrook Townsite's evolution as a logical extension to the Perth Metropolitan Region, and as an emerging place of employment and housing opportunity.

The urban design considerations of the proposed development seek to celebrate the land's sense of place and location at the foothills of the Darling Ranges, whilst being sympathetic to the changing character of the area. The layout provides for a range of dwelling types and lifestyles within an interconnected pedestrian friendly environment in proximity to the amenities and provisions required to support the existing and growing community.

The urban layout has been undertaken in accordance with the Bullsbrook District Structure Plan, its connections and interface with adjoining land uses, both existing and proposed. The urban design has been considered in the context of major road connections to the broader metropolitan area as well as the immediate sounds, including the commercial components of the District Centre, the site's interface with Great Northern Highway, landform and natural features.

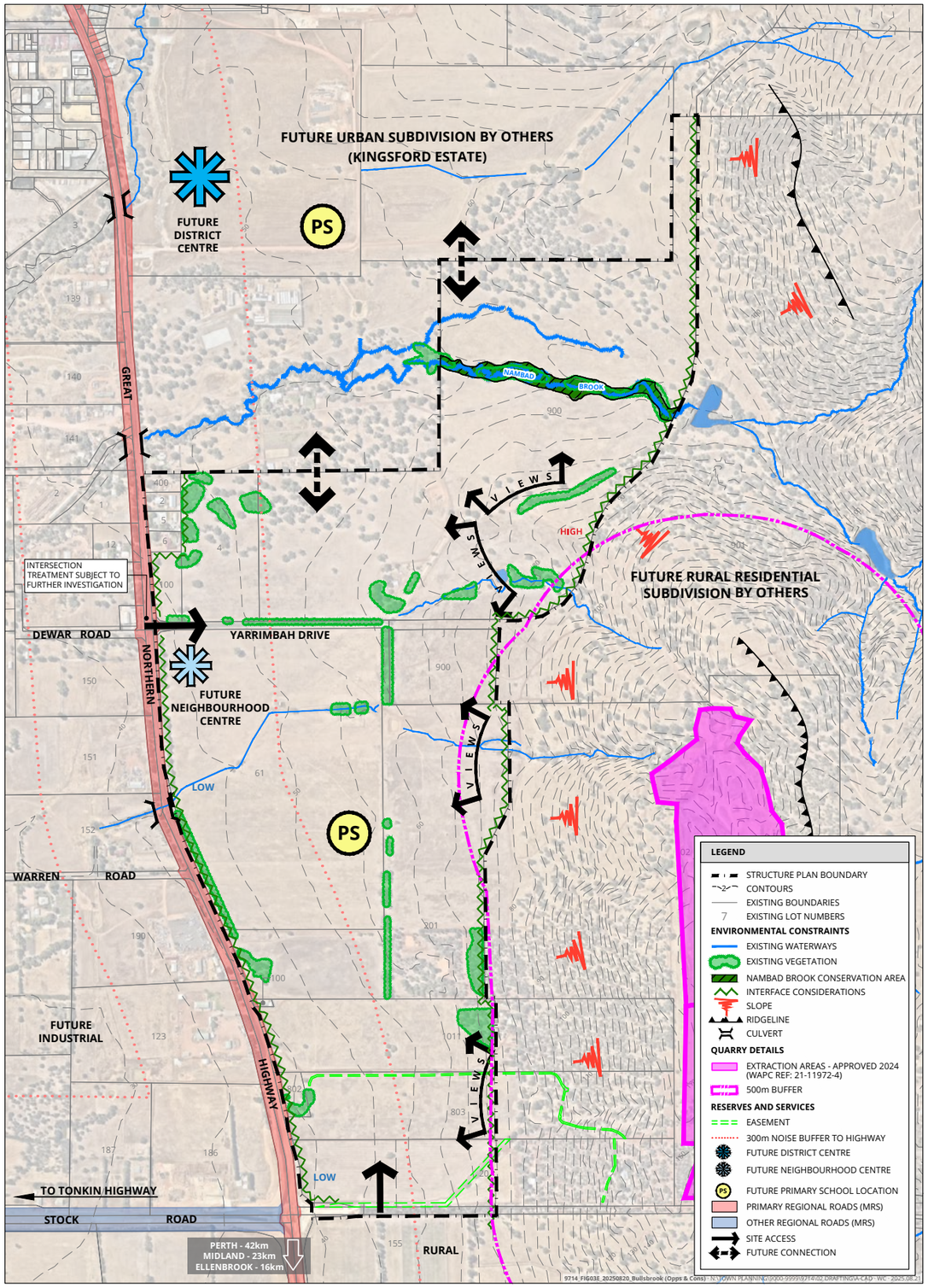


Figure 18. Site Context Analysis

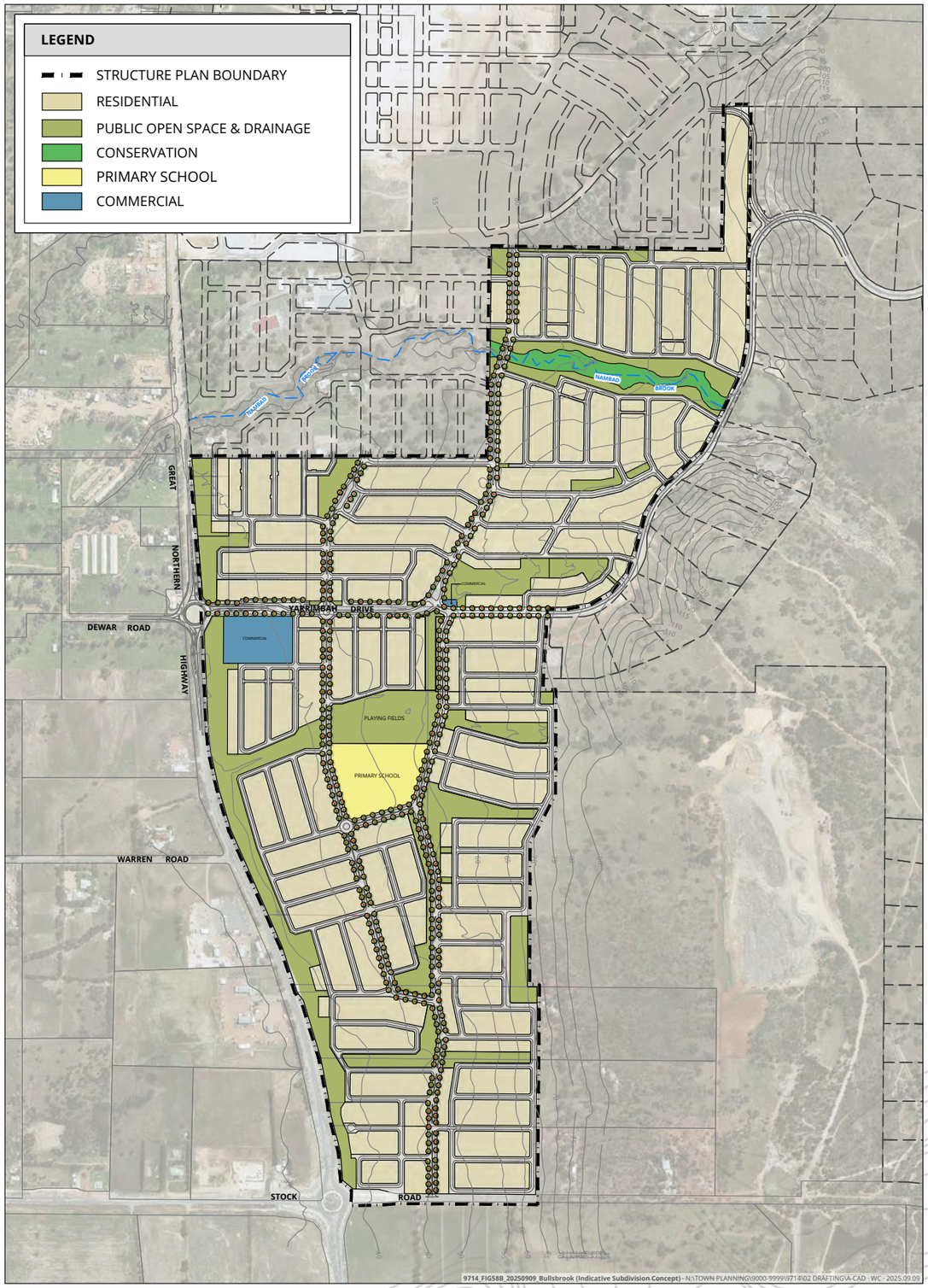


Figure 19. Indicative Subdivision Concept

5.2. Movement Network

A Transport Impact Assessment has been prepared in support of this Structure Plan and has informed the concept planning for the site. The following provides a summary of the existing and contemplated movement network, as depicted on the Indicative Concept Plan.

Refer **Appendix 2 – Transport Impact Assessment**.

5.2.1. Existing Road Network

Great Northern Highway

Great Northern Highway runs along the western boundary of the subject land, providing the primary north-west connection through the region.

Great Northern Highway is reserved as a 'Primary Regional Road' under the Metropolitan Region Scheme. It is classified as a 'Primary Distributer' under the Main Roads WA Functional Road Hierarchy, comprising a single carriageway road with an approximate 40 metre wide reserve. Great Northern Highway has a speed limit of 100km/hour, decreasing to 60km/hour where built up around the existing Townsite.

Current traffic counts from Main Roads WA indicate Great Northern Highway (south of Warren Road) carries approximately 7,600 vehicles per day (May 2022).

Yarrimbah Drive (Formerly Lage Road)

Yarrimbah Drive (Formerly Lage Road) is an existing road through the subject land in an east-west direction, intersecting with Great Northern Highway, generally opposite Dewar Road.

Yarrimbah Drive is identified as an 'Access Road' under the Main Roads WA Functional Road Hierarchy.

Yarrimbah Drive will provide the primary access from Great Northern Highway for the initial development stages for the subject land.

Stock Road

Stock Road adjoins the site on its southern boundary, and upon completion of extension and upgrade works, will provide the primary east-west connection through the region, west of Great Northern Highway to Tonkin Highway. The intersection of Stock Road and Great Northern Highway has recently been upgraded to include a roundabout.

Stock Road is currently identified as an 'Access Road' under the Main Roads WA Functional Road Hierarchy. West of the Great Northern Highway, Stock Road is reserved as an 'Other Regional Road' under the Metropolitan Region Scheme.

Stock Road upgrades are included in the existing Development Contribution Plan for the Bullsbrook Townsite (DCA 7).

5.2.2. Proposed Road Network

The proposed road hierarchy for the Structure Plan (refer **Figure 20 – Indicative Movement Network**) has been determined from modelling based on the indicative subdivision layout and provides for simple and efficient vehicle movements through the site.

The movement network reflects a north-south and east-west modified grid configuration, with direct connections to the road network within the Kingsford estate to the north. The street block lengths are consistent with the requirements of Liveable Neighbourhoods, providing for connectivity and permeability through the site, for both pedestrians and vehicles.

Primary external access to the site is provided from Great Northern Highway via Yarrimbah Drive and Stock Road.

Consistent with the District Structure Plan, two north-south spine roads are proposed through the site, distributing traffic between Stock Road in the south and the future District Centre in the Kingsford estate to the north. These connectors are intended to distribute traffic movements internally and reduce reliance on Great Northern Highway for residential traffic movements.

As required by the *City of Swan Structure Plan No. 11*, Yarrimbah Drive has been extended to the east and deviated north along the boundary of the Structure Plan area, providing a third north-south connector through to Kingsford.

Refer **Figure 20 – Indicative Movement Network**.



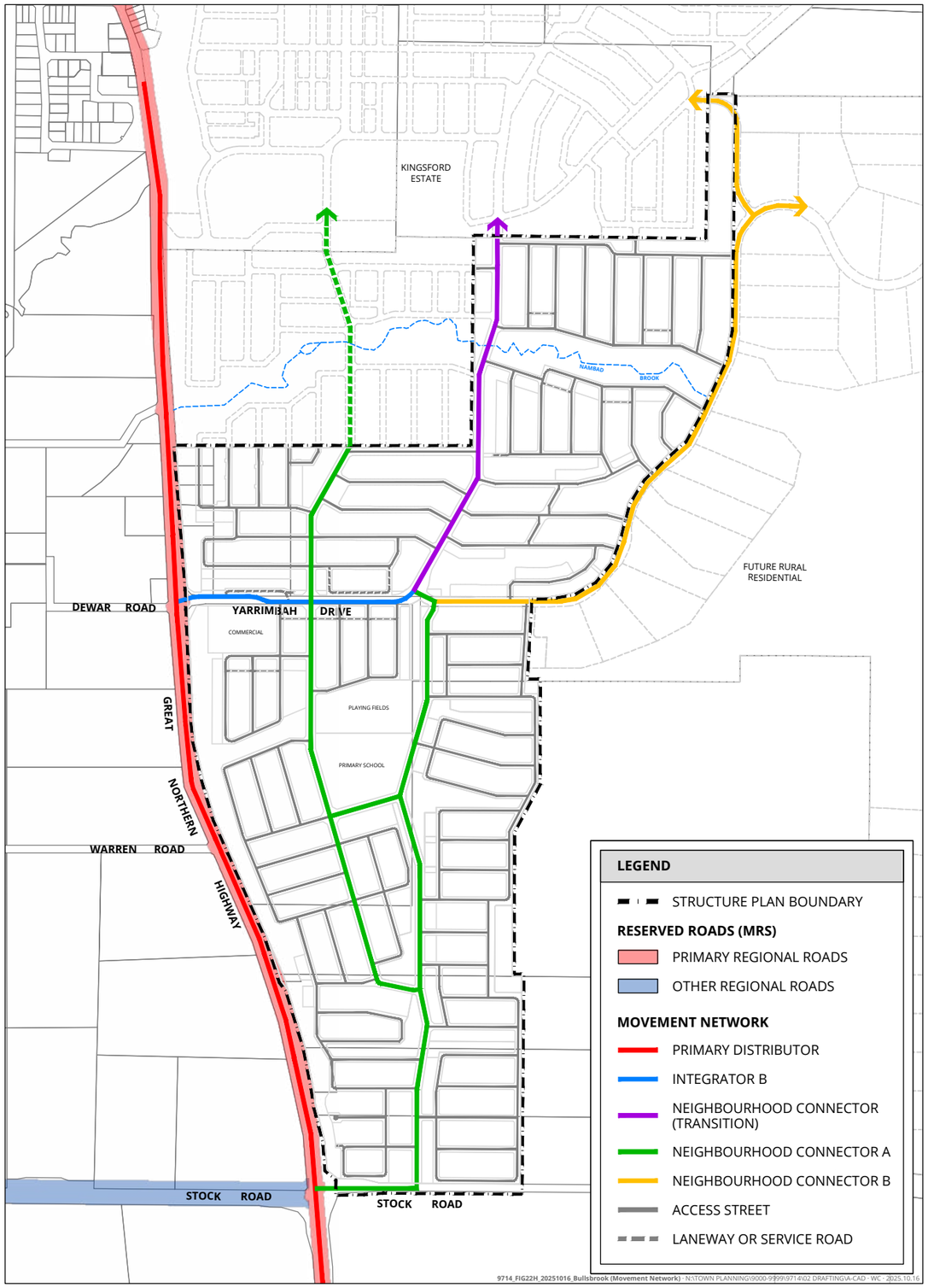


Figure 20. Indicative Movement Network

5.2.2.1. Traffic Volumes and Road Hierarchy

The indicative road network is proposed to comprise of the following road classifications:

Classification	Application	Design
Integrator B	Yarrimbah Drive between Great Northern Highway and eastern spine road	9.2m reserve width. Modified cross section to enable meandering of road pavement for tree retention. No direct lot access permitted between Great Northern Highway and western spine road.
Neighbourhood Connector B	Yarrimbah Drive east of eastern spine road	19.4m reserve width.
Neighbourhood Connector A	Stock Road	Neighbourhood Connector A between Great Northern Highway and South-central spine Road. At subdivision stage, Stock Road may need to be further extended, decided on a case by case basis. Its design is to not prejudice the extension of Stock Road further east of the structure plan area for evacuation and/or public transport purposes.
Neighbourhood Connector (Transitional)	North central spine road (north of Yarrimbah Drive and east of Lot 800)	24-29m reserve width. Can be 26m in width with no direct vehicle access from residential lots if a north-south connection through Lot 800 has not been provided.
Neighbourhood Connector A (Unique)	South central spine road (south of Yarrimbah Drive to Stock Road)	24.4m-26m reserve but can be reduced to 22.4m for tree retention purposes on a case-by-case basis. Detailed road design to explore varied cross sections at subdivision stage, which may consider the removal of median in lieu of widened verge to provide for shared/ dual use path and additional landscaping to the satisfaction of the City of Swan.
Neighbourhood Connector A	▪ South western road (south of Yarrimbah Drive to south central spine road) ▪ Link along the primary school's southern boundary (between the south western road and the south central spine road) ▪ Western spine road (north of Yarrimbah Drive to Lot 800)	24.4m reserve width.
Neighbourhood Connectors	Internal intersection spacings	Internal intersections to be subject to further investigation and detailed design at subdivision stage.
Access Street and Laneway	All other roads	Access Street B – 17.9m reserve width. Access Street C – 15.4m reserve width. Access Street D – 15m-15.4m reserve width (reduced to 13.2m adjacent to public open space) or wider where required for bushfire management. Laneway (or service road) – 6m reserve width.

Table 15: Proposed Road Classifications

The proposed development of the Structure Plan area is estimated to generate a total of 28,900 vehicle trips per day, with 2,567 trips during the AM peak hour and 3,213 trips during the PM peak hour.

Yarrimbah Drive is expected to carry 12,300 vehicles per day, reducing to 6,500 vehicles per day east of the western spine road. Based on anticipated traffic volumes, Yarrimbah Drive is classified as an Integrator B between Great Northern Highway and the eastern spine road, and a Neighbourhood Connector B further east. Due to anticipated traffic volumes, no direct lot access is permitted from the section of Yarrimbah Drive between Great Northern Highway and the western spine road.

The eastern spine road is expected to carry between 5,800 and 6,800 vehicles per day, north of Yarrimbah Drive, and the western spine road is expected to carry between 5,400 and 6,500 vehicles per day, north of Yarrimbah Drive. South of Yarrimbah Drive, traffic volumes reduce to between 2,700 vehicles per day for the eastern spine road, and between 1,800 and 4,900 vehicles per day for the western spine road. Based on anticipated traffic volumes, the eastern spine road is classified as a Neighbourhood Connector A north of Yarrimbah Drive, downgrading to a Neighbourhood Connector B south of Yarrimbah Drive. The western spine road is classified as a Neighbourhood Connector A.

The minimum intersection spacing for all-movement access along a Neighbourhood Connector should be 40 metres, in accordance with Liveable Neighbourhoods. Therefore, a number of contemplated intersections within the Structure Plan area may need to be restricted to left in/left out, subject to detailed design.

All other roads are classified as Access Streets and Laneways.

5.2.3. Proposed Intersections and Upgrades

The intersection of Great Northern Highway and Stock Road has recently been upgraded to a roundabout as part of the construction of Stock Road.

The proposed access arrangements, comprising a 4-way intersection at Great Northern Highway-Yarrimbah Drive-Dewer Road and a 4-way intersection at Great Northern Highway-Stock Road are based on the Main Roads WA Ultimate Road Access Strategy for Great Northern Highway.

Great Northern Highway-Yarrimbah DriveLage Road-Dewer Road intersection

The existing intersection of Great Northern Highway-Yarrimbah Drive-Dewer Road includes a right turn auxiliary lane for right turns in to Dewer Road. No turn lane treatments for access in to Yarrimbah Drive exist, due to the relatively short stagger distance between Dewer and Yarrimbah. It is not possible to retain this configuration once development progresses within the Structure Plan area and traffic volumes increase.

The Great Northern Highway-Yarrimbah Drive-Dewer Road intersection was initially identified for upgrade to a 4-way signalised intersection. However, the City of Swan's *Bullsbrook Residential Townsite – Development Contribution Plan* (DCA 7) (September 2021) shows a roundabout is now proposed. This is also reflected in current MRWA planning. This ultimate roundabout is anticipated to be similar in size to the recently constructed roundabout at Stock Road and will require some acquisition of adjoining land for intersection widening.

In collaboration with MRWA, the roundabout has been progressed to a 15% design detail, providing for interim and ultimate access arrangements. The intersection operation analysis suggests the ultimate roundabout will be required at 0.85 saturation (MRWA preference). Depending on timing for the delivery of northern connections through to the Kingsford estate, the ultimate roundabout may not be required for approximately 10-12 years (to approximately 2037), or up to approximately 1,210 dwellings.

Intersection upgrades are included in the existing Development Contribution Plan for the Bullsbrook Townsite (DCA 7).

5.2.4. Public Transport

The site is currently serviced by Transperth Bus Route 311, which travels from the Midland Train Station to/from Bullsbrook via Great Northern Highway. There are three bus stop locations along Great Northern Highway adjacent to the subject site.

Additional bus services can be accommodated within the proposed road hierarchy via Yarrimbah Drive and Stock Road, and north-south through the site along the spine roads. The District Structure Plan identifies a possible future rapid transit route along the western spine road. This can be accommodated in the proposed Structure Plan.

The State Government's Metronet project will add approximately 21 kilometres as a spur line from the existing Midland Line east of the Bayswater Station to connect the areas of Morley, Noranda and beyond to Ellenbrook. Due to be completed in 2024, Ellenbrook Station will be the northern terminus and include a Bus interchange and associated parking area. The journey time to the Perth CBD from Ellenbrook station is expected to be 30 minutes. It is understood that planning for this northern extension has taken into account future growth of the Bullsbrook Townsite, and extensions to the rail / bus network are capable of being extended as the growth and development in this locality occurs; ultimately providing a relatively direct public transport route to the Perth CBD.

Figure 21 (Active and Public Transport) identifies the existing and potential bus routes through the Structure Plan area.

5.2.5. Pedestrian and Cycling Access

The pedestrian and cycling network is detailed as part of the landscape strategy and Transport Impact Assessment, prepared in support of the Structure Plan (refer **Appendices 2** and **8**), and is depicted on **Figure 21 (Active and Public Transport)**.

In accordance with Liveable Neighbourhoods, as a minimum, pedestrian paths will be required on at least one side of all residential streets. Shared use and cycle paths have also been considered in the design of the Structure Plan pedestrian network hierarchy, including consideration for connection to the wider cycle network.

The Indicative Concept Plan (Refer **Figures 19** and **21**) provides for a legible movement network, providing for good pedestrian permeability. The lineal and connected public open space network will also provide for a high amenity pedestrian environment, also providing safe walking and cycling routes to and from the proposed primary school, as an alternate to travelling along the roads.

Refer **Figure 21 – Active and Public Transport**.

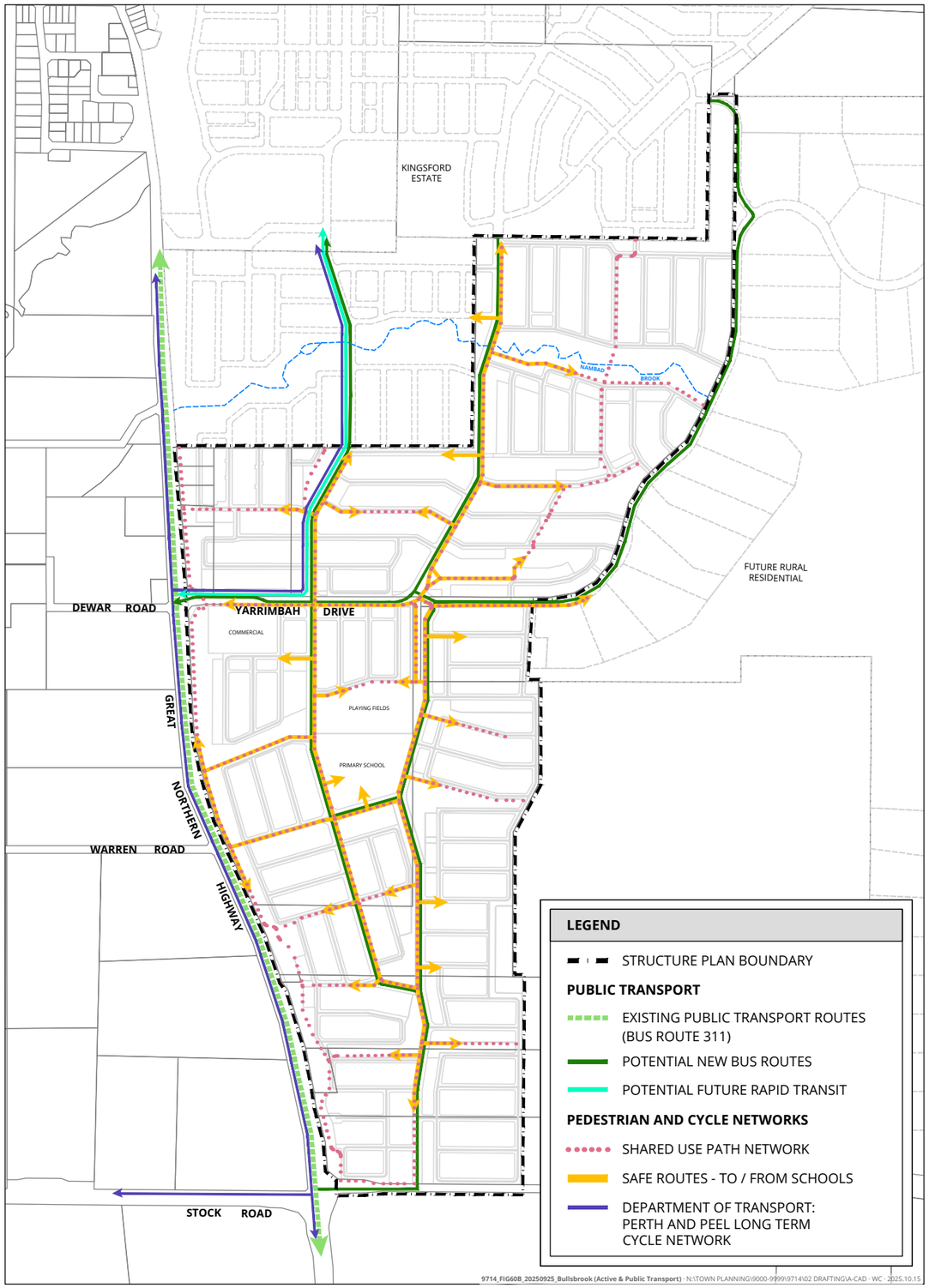


Figure 21. Active and Public Transport

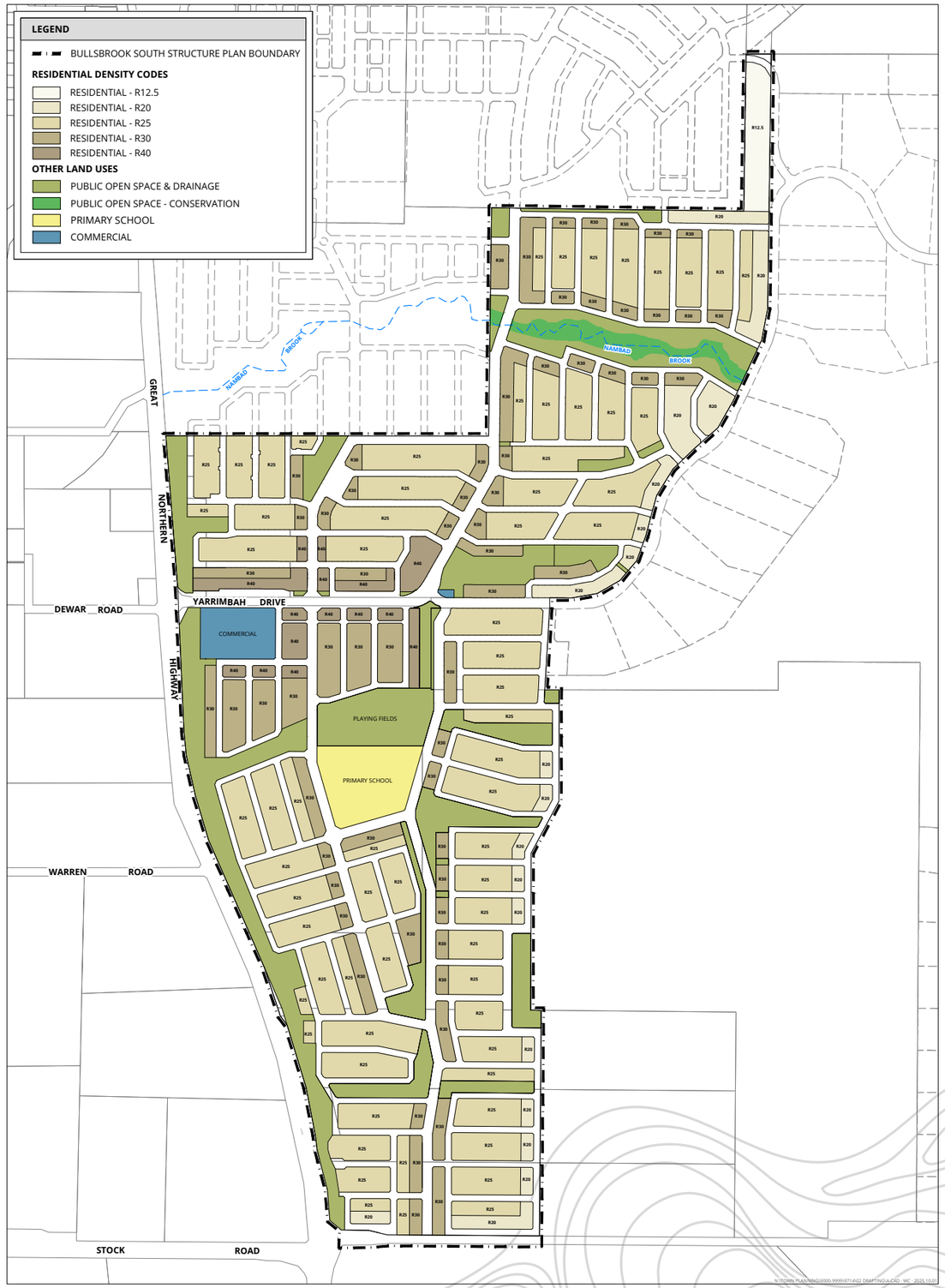


Figure 22. Indicative Residential Density Code Plan

5.3. Residential

An indicative street block layout has been prepared for the site, provided at **Figure 19**. This is provided for explanatory purposes only, and is subject to review and detailed design at subdivision stage.

Refer **Figure 19 – Indicative Subdivision Concept**.

5.3.1. Density Targets

Liveable Neighbourhoods and Directions 2031 set minimum average density targets for new residential areas, being 22 dwellings per residential site hectare and 15 dwellings per gross urban hectare, respectively.

- To achieve a minimum of 22 dwellings per residential site hectare, the Structure Plan would need to achieve a minimum yield of 2,186 dwellings, being an average lot size of approximately 455m².
- To achieve a minimum of 15 dwellings per gross urban hectare, the site would need to achieve a minimum yield of 2,803 dwellings being an average lot size of approximately 355m².

Whilst the Structure Plan is capable of achieving these targets, having regard to the locational context, working with the existing landform, the tree retention aspirations across the site, the retention of the Nambad Brook within a widened public open space reserve, the land take for the Neighbourhood Centre, and the need to manage the Rural-Urban interface and the interface with Great Northern Highway, whilst also working within the commercial realities of market demand for certain lot typologies, it is likely a lower density will be achieved.

Preliminary concept planning for the initial development stages, based on market demand for this location, contemplates an average lot size of approximately 576m². Assuming an average lot size of 576m² for the initial stages north of Yarrimbah Drive, and the likelihood of smaller lots being contemplated as development progresses south around the neighbourhood centre and primary school precincts, the Structure Plan is likely to achieve densities in the order of 20 dwellings per residential site hectare. This would translate to a density of approximately 11 dwellings per gross urban hectare.

Given the site context, as noted above, these densities are considered appropriate for the Structure Plan area. Notwithstanding, as development further progresses in this corridor, there may be opportunities to provide higher density outcomes. This will be subject to further review and consideration as part of detailed subdivision design for each stage of development.

Refer **Figure 19 – Indicative Residential Density Code Plan**.

5.3.2. Residential Density Codes

An indicative Residential Density Code Plan has been prepared for the site, based on the density code ranges designated on **Plan 1 – Structure Plan Map**, and having consideration for the site context and land use configuration.

Refer **Figure 22 – Indicative Residential Density Code Plan**.

The following density code ranges are designated across the Structure Plan:

- **Low Density:** comprises a range between 'R12.5 – R25'. A base code of R25 is applicable to majority of the Structure Plan area.
- **Medium Density:** comprises a range of 'R30 – R40', and is applicable to areas of high amenity and access.

A Residential Density Code Plan is required to be submitted at the time of application for subdivision to the WAPC. The Residential Density Code Plan will allocate specific Residential Density Codes to the proposed street block/lots (as the case requires). Once approved by the WAPC, the Residential Density Code Plan will form part of the Structure Plan.

The allocation of residential density codes within the Structure Plan area should generally be in accordance with the following locational criteria:

- **R12.5 – R20:** shall generally be applied to residential lots with one or more of the following characteristics:
  - Located along the eastern edge of the Structure Plan area, serving as a low-density interface to the adjacent rural residential area; and/or
  - Located where topography and/or other site considerations require larger lots.



- **R25:** shall generally apply as the base density code throughout the Structure Plan area.
- **R30 – R40:** may be applied to residential lots with one or more of the following characteristics:
    - Located within 400 metres of the Neighbourhood Centre;
    - Located within close proximity to public open space;
    - Located within close proximity of a Neighbourhood Connector (other such key distributor road); and/or
    - Located at the end of street blocks or other strategic locations to create a diverse streetscape and desired built-form character.

5.3.3. Lot Size and Variety

The density code ranges proposed on the Structure Plan will facilitate a diversity of lot product across the site, providing for a range of dwelling types, distributed in a site responsive manner.

Lots will range through easy care compact town lots in proximity to the Centre and areas of open space, to traditional suburban lots, to elevated lots with a westerly aspect and opportunities for views to Perth City and surrounds. In this regard, the Structure Plan proposes clusters of 'low density' and 'medium density' dwellings.

Larger lots are proposed along the interface with the rural land to the east of the site, in order to provide an appropriate land use transition. Larger lots will also provide an appropriate design response to the existing landform, having consideration for the slope of the land in the general north eastern portion of the site.

Smaller lot typologies are to be suitably located surrounding the neighbourhood centre, along the key distributor roads, in proximity to the primary school and within close proximity to high quality open space. These locations are afforded a higher degree of amenity and access, and therefore higher density outcomes are appropriate, providing for a range of sociodemographic opportunities.

The Structure Plan provides for relatively regular street blocks to facilitate the provision of standard lot typologies delivered across the residential project home builder industry. This provides for efficiencies in lot design, which translates to affordability in dwelling construction.

Lot typologies will be reviewed at each stage of subdivision, having consideration to density code allocations, site context and market demand.

Refer **Figure 19 – Indicative Subdivision Concept**.

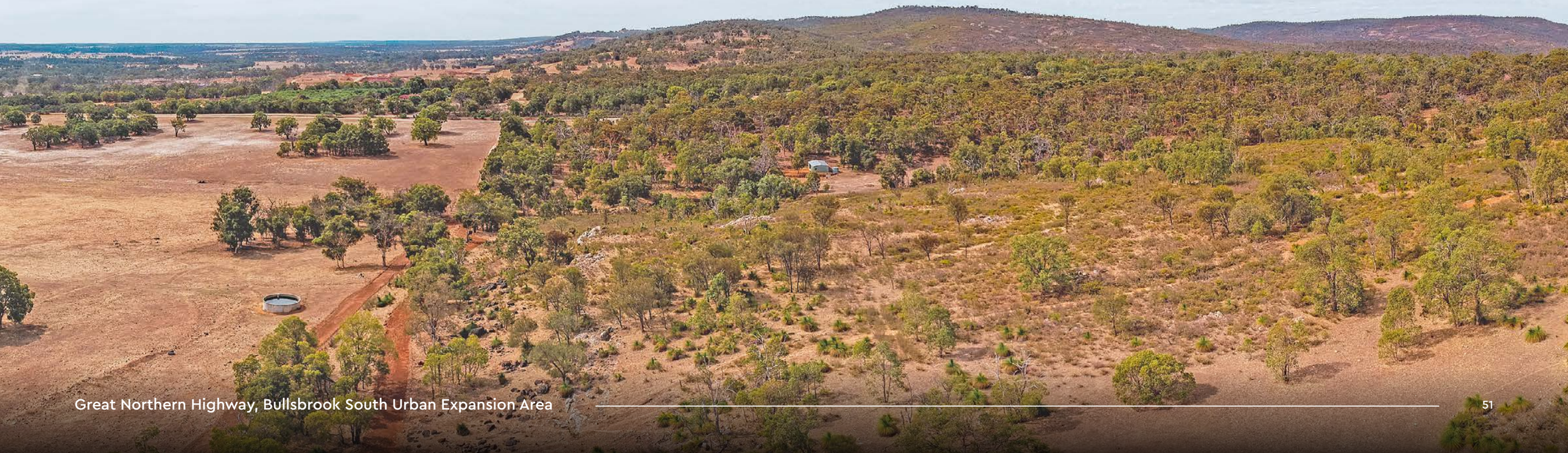
5.3.4. Local Development Plans

To provide for appropriate and site responsive built form outcomes, a Local Development Plan may be required, as a condition of subdivision approval, for any lots with one or more of the following attributes:

- Lots where specific vehicle access/egress control is required;
- Lots abutting public open space or foreshore reserve;
- Lots zoned 'Commercial'; and/or
- Lots where specific design considerations are required.

Where a Local Development Plan is required, a condition of subdivision approval should be imposed by the WAPC, requiring the preparation, approval and implementation of a Local Development Plan.

In preparing Local Development Plans, the design responses and interface treatments between the Structure Plan area and the adjoining Kingsford estate will need to be considered to ensure an effortless transition between the two developments, however noting the different design objectives of the two estates to create individual character and sense of place.



5.4. Public Open Space

The Structure Plan has been designed to maximise the retention of existing trees and vegetation within areas of public open space, where possible, as well taking advantage of existing drainage corridors through the site, serving as multi-functional areas that will ultimately play a stormwater conveyance role in the overall drainage strategy. This has resulted in an interconnected linear network of parkland, providing for a walkable community, and maximising exposure of future residential lots to areas of open space.

The supporting Landscape Master Plan and Public Open Space Strategy (**Appendix 8**) describes the overall landscape strategy for the site, providing for a range of landscaped areas to provide opportunities for active public open space (including playing fields), passive public open space (including walk trails, barbeque equipment and shelters), and conservation/ rehabilitation of the Nambad Brook within a foreshore reserve.

The Structure Plan provides for approximately 27.67 hectares of credited public open space, in accordance with Liveable Neighbourhoods classifications. This is comprised of approximately 26.63 hectares of unrestricted open space (15.25% of the gross subdivisible area), approximately 1.04 hectares of restricted open space (0.59% of the gross subdivisible area), and approximately 1.6 hectares (0.92%) deducted from the open space credits as dedicated drainage (first 15mm). In addition to the credited open space, the site provides approximately 2.62 hectares of conservation foreshore reserve, comprising the Nambad Brook. Including the Nambad Brook Reserve and the credited open space, as well as landscaped pedestrian access ways, the Structure Plan provides a total of approximately 32.09 hectares as green space.

Noting the above calculations, current concept planning provides well in excess of the minimum requirements for public open space provision across the Structure Plan area. This provides for flexibility in drainage and tree retention considerations as the structure plan is progressed. There are, however, opportunities for rationalisation of the open space provision across the site. This will be further refined at subdivision stage once detailed design is known.

Further, as a result of the public open space distribution across the site, based on site context, function and useability, there is somewhat of a disproportionate allocation of open space across landholdings. Where individual landowners are providing in excess of or are not achieving their minimum public open space requirement, cash in lieu arrangements may be explored with the City of Swan to reconcile any disproportion across the site. A breakdown of public open space provision by landholding is provided at **Figure 25**. This will be further refined at each stage of subdivision.

Refer **Figure 23 – Public Open Space Distribution Plan**.

Refer **Figure 24 – Public Open Space Schedule**.

Refer **Figure 25 – Public Open Space Provision by Landholding**.

Refer **Appendix 8 – Landscape Master Plan and Public Open Space Strategy**.

5.4.1. Tree Retention

One of the key design considerations for the Structure Plan has been premised on the retention of existing mature trees and vegetation. The Structure Plan seeks to retain some 449 existing black cockatoo habitat trees, in addition to other existing mature planted trees, through public open space distribution and configuration, and streetscape considerations, subject to detailed design. The retained trees on site comprise a range of species, including both local and introduced.

In addition to the trees proposed to be retained on site, additional trees and vegetation will be planted as part of parkland soft landscaping and street trees within road verges. These will comprise trees of local character, preferably being endemic and native to the site.

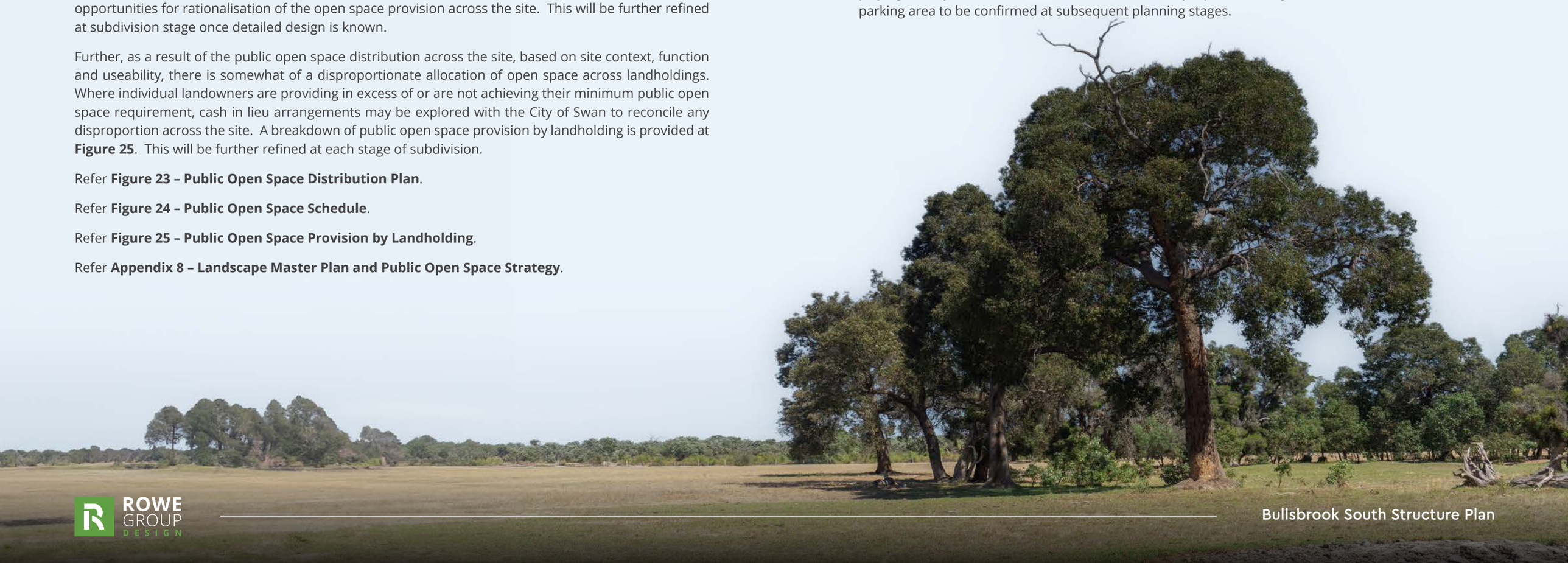
The retention and planting of a substantial number of mature trees and vegetation across the site not only has key environmental benefits, but also seeks to provide a strong sense of place and character, and soften the landscape within a new urban area, meeting established community expectations for the site.

5.4.2. Playing Fields

The Structure Plan provides for playing fields, generally in accordance with the District Structure Plan. The playing fields are included in the Bullsbrook Residential Townsite Development Contribution Plan, identified as neighbourhood open space.

As contemplated under the District Structure Plan, the playing fields are co-located with the proposed primary school.

Consistent with the requirements of the Development Contribution Plan, The Structure Plan allocates an area of 3.4 hectares for the playing fields. Also as required by the Development Contribution Plan, the playing fields precinct will include a co-located multi-purpose building (800m²) with the location and car parking area to be confirmed at subsequent planning stages.



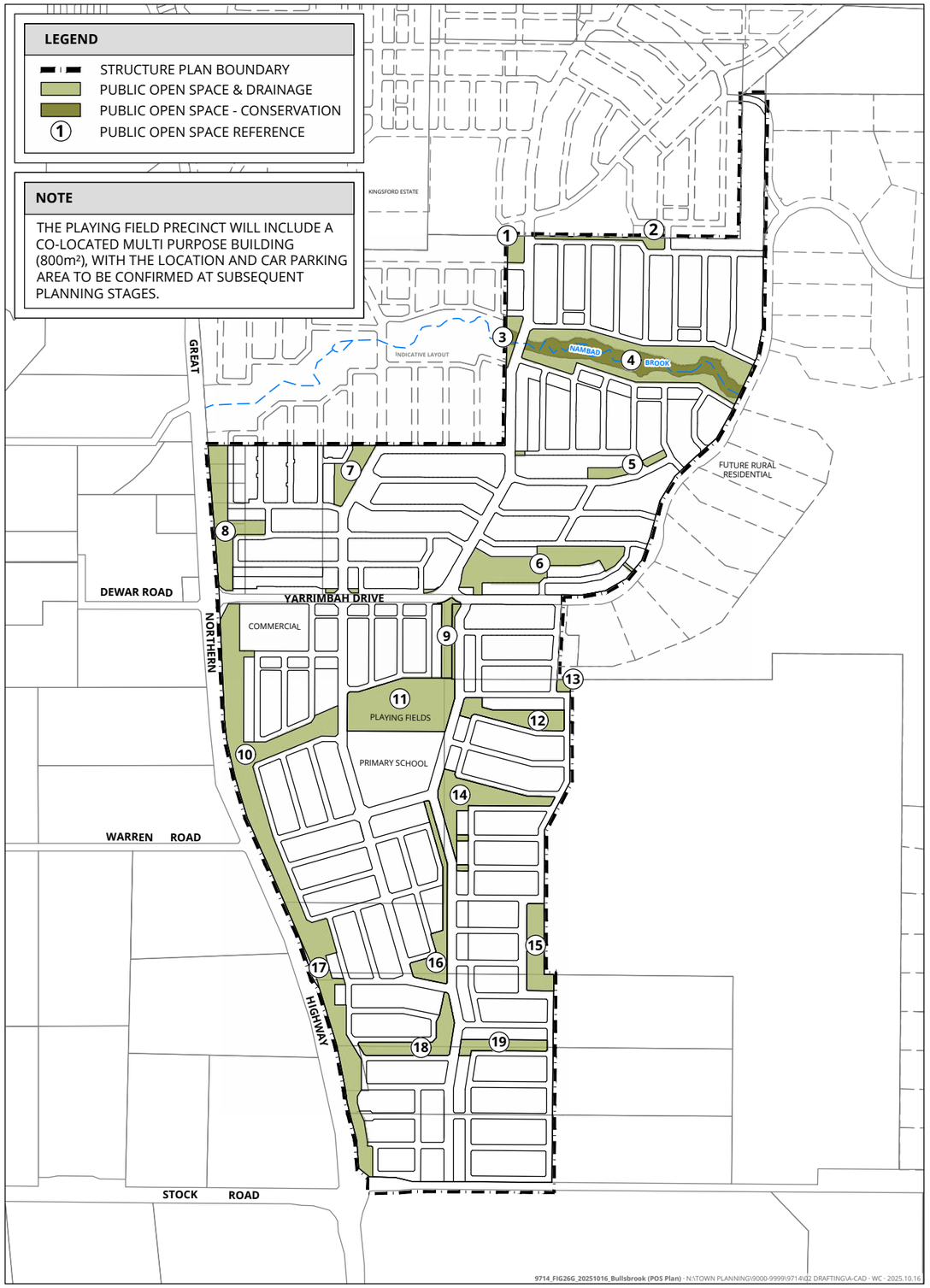


Figure 23. Public Open Space Distribution Plan

Bullsbrook South Urban Expansion Area (Local Structure Plan)

13.10.2025				
Site Area (Local Structure Plan Boundary)				186.69
Less				
Existing Yarrimbah Drive Reserve		1.64		
Total			1.64	
Net Site Area				**185.05**
Deductions				
Primary School		3.75		
Commercial 1		2.17		
Commercial 2		0.06		
Public Access Ways (PAW)		0.20		
Nambad Brook Conservation Reserve		2.62		
Dedicated Drainage (1:1yr ARI / First 15mm)		1.61		
Total			10.41	
Gross Subdivisible Area				**174.63**
POS @10%				17.46
Public Open Space Contribution				
May comprise:				
Min 80% unrestricted POS			13.97	
Min 20% restricted use POS			3.49	
Total Required POS				**17.46**
POS Reference Number (area within urban zone/LSP boundary only)		**1:1yr / First 15mm Drainage (m²)** *Deduction from Net Area*	**Unrestricted POS area (m²)**	**Credited Restricted POS area (m²)**
1	2969	0	2969	0
2	3578	0	3578	0
3 (excl Foreshore Reserve)	2119	58	2061	0
4 (excl Foreshore Reserve)	31003	4290	21831	4882
5	4757	135	4605	17
6	26293	952	24191	1150
7	7911	409	7452	50
8	19053	0	19053	0
9	7244	836	6115	293
10	51684	1990	49299	395
11 (playing fields)	33991	876	32810	305
12	11099	1034	9323	742
13	1114	0	1114	0
14	17929	865	16970	94
15	11109	0	11109	0
16	11747	632	10995	120
17	30173	660	28372	1141
18	12105	2807	8664	634
19	6834	532	5760	542
Total	**292711**	**16076**	**266270**	**10365**
	29.27	**1.61**	**26.63**	**1.04**
Percentage of gross subdivisible area		**0.92%**	**15.25%**	**0.59%**

Notes:

1. *This Public Open Space Schedule is based on the Subdivision Concept Plan prepared by Rowe Group (Plan ID: 9714 Fig 38 B).*
2. *This Public Open Space Schedule is based on the drainage assumptions as per the Local Water Management Strategy prepared by Pentium dated 10/5/24 (Pentium Ref: P011323).*
3. *Restricted Open Space credit based on 5 yr/ 20% drainage area less the 1yr / 15mm area. Therefore, Restricted Open Space actual land area equals Restricted open space credited area plus the 15mm area.*
4. *Restricted Open Space actual 'on the ground' land area equals Restricted open space credited area plus the 1 yr / 15mm area.*

Figure 24. Public Open Space Schedule

Public Open Space Provision by Landholding

Lot Number	Street Address	Total Lot Area within LSP Boundary	Deductions from Gross Subdivisible Area					Gross Subdivisible Area	Public Open Space Provision		
			Primary School	Commercial	PAW	Nambad Brook Conservation	Total Deductions		Required 10% of GSA	POS Provision as per LSP	Surplus/ Oversupply
900	61 Lage Road	74.62	0.00	0.62	0.10	2.62	3.34	71.28	7.13	8.02	0.89
4	Lot 4 Lage Road	7.67	0.00	0.00	0.00	0.00	0.00	7.67	0.77	0.19	-0.57
100	Lot 100 Great Northern Highway	1.31	0.00	0.00	0.00	0.00	0.00	1.31	0.13	0.81	0.67
6	2416 Great Northern Highway	0.44	0.00	0.00	0.00	0.00	0.00	0.44	0.04	0.24	0.20
5	2422 Great Northern Highway	0.45	0.00	0.00	0.00	0.00	0.00	0.45	0.05	0.21	0.17
2	2424 Great Northern Highway	0.44	0.00	0.00	0.00	0.00	0.00	0.44	0.04	0.22	0.18
400	2428 Great Northern Highway	0.45	0.00	0.00	0.00	0.00	0.00	0.45	0.05	0.23	0.19
61	2342 Great Northern Highway	41.26	3.75	2.17	0.00	0.00	5.92	35.34	3.53	8.61	5.08
201	2306 Great Northern Highway	28.60	0.00	0.00	0.09	0.00	0.09	28.51	2.85	5.90	3.05
100	2286 Great Northern Highway	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.01	0.10	0.09
Part Lot 1011	2274 Great Northern Highway	11.01	0.00	0.00	0.00	0.00	0.00	11.01	1.10	2.30	1.20
802	2258 Great Northern Highway	1.31	0.00	0.00	0.00	0.00	0.00	1.31	0.13	0.55	0.42
Part Lot 803	2242 Great Northern Highway	8.76	0.00	0.00	0.00	0.00	0.00	8.76	0.88	0.94	0.07
Part Lot 20	2234 Great Northern Highway	8.65	0.00	0.00	0.00	0.00	0.00	8.65	0.87	0.50	-0.36

Notes:

1. *This Schedule is based on the Subdivision Concept Plan prepared by Rowe Group (Plan ID: 9714 Fig 38 B).*
2. *Site area deductions exclude drainage calculations. To be confirmed at detailed design stage.*
3. *All areas are in hectares.*

Figure 25. Public Open Space Provision by Land Holding

5.5. Water Management

5.5.1. Local Water Management Strategy

A Local Water Management Strategy (LWMS) has been prepared by Pentium Water in support of this Structure Plan and is provided as **Appendix 4**.

The LWMS addresses the Structure Plan area and provides a refinement of flood modelling, the surface water management strategy and the groundwater management strategy to a local scale. The LWMS has been prepared in accordance with the Regional Water Management Strategy Report for Bullsbrook Townsite Area, the District Water Management Strategy for Marin Bullsbrook Urban, and the Addendum to the District Water Management Strategy for the Bullsbrook South Expansion Area.

In accordance with the processes defined under Better Urban Water Management, an Urban Water Management Plan (UWMP) will be required to be prepared and implemented at the time of subdivision. The UWMP will refine and implement the proposed drainage network/system, as identified under the LWMS.

Refer **Appendix 4 – Local Water Management Strategy**.

5.5.1.1. Stormwater Management

The following design objectives and criteria are adopted in the stormwater management strategy and preliminary drainage design for the Structure Plan area:

- Manage stormwater quantity and quality with a water sensitive urban design approach, which seeks to minimise drainage infrastructure and long-term maintenance requirements and incorporate stormwater management infrastructure within the urban form and landscaped areas.
- Maintain pre-development peak flow rates from the site, to protect downstream properties and receiving watercourses from increased flood risk.
- Manage, retain and/or detain, and treat stormwater run-off from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.
- Habitable floor levels to be at least 0.3 metres above the 1% AEP flood level of the urban drainage system and road reserve.
- Habitable floor levels to be at least 0.5 metres above the 1% AEP flood level of the Nambad Brook.

The preliminary stormwater drainage modelling demonstrates the land is capable of managing stormwater for all events up to 1% AEP event.

Stormwater run-off from constructed impervious surfaces generated by the first 15 mm of rainfall will be managed at-source as much as practical using soakwells (on lots) and bio-retention basins/swales located in public open space. Other, at-source infiltration mechanisms will be considered at detailed design stage and incorporated within road reserves where practical (such as the potential use of tree pits or roadside swales at locations where there is no crossover frontage for lots).

A pit-and-pipe drainage system will be designed to cater for flows up to 20% AEP. Where practical (such as adjacent to pervious public open space areas or open channel drainage systems), overland flow of stormwater rather than piped conveyance will be utilised to promote at-source infiltration and disconnection of impervious catchment areas. Rainfall events greater than 20% AEP will be conveyed via overland flow through the road network to flood detention basins or open channel conveyance systems.

Stormwater events greater than one year event will be allowed to overtop bioretention basins and be conveyed to the Nambad Brook, living streams and culverts along the Great Northern Highway. Flood storage for all rainfall events up to and including the 1% AEP will be provided by a combination of bioretention basins/swales, flood detention basins, the Nambad Brook and living streams. A preliminary design for these systems is presented in the LWMS, which manages flow rates discharging off-site through culverts along the Great Northern Highway in line with pre-development hydrological modelling and design criteria for the regional drainage system.

Structural and non-structural controls will be used to improve stormwater quality. The use of bio-retention basins and flood detention basins, native vegetation where possible, minimal fertiliser application, and soil amendment will assist with the management of groundwater and surface water quality. Native vegetation will be maintained in all suitable stormwater management areas to remove nutrient through plant uptake prior to infiltrating to the groundwater.

5.5.1.2. Groundwater Management

Underlying groundwater resources will be protected by minimising nutrient export to maintain or improve the quality of groundwater leaving the site through:

- Encouraging infiltration of stormwater as close to source as possible (such as through the use of soak wells, road run-off directed to bioretention areas within the streetscape or public open space) to prevent mobilisation of contaminants to downstream drainage / infiltration areas.
- All drainage areas will have significant separation to the superficial aquifer, given this is estimated to occur at a depth of at least several metres beneath the site. Separation from drainage areas to potential perched groundwater systems will be provided through the use of imported fill and subsoil drainage.
- Utilising waterwise gardening and landscaping practices to minimise fertiliser use and irrigation. Amended soil with a PRI >10 will be used beneath bioretention areas.
- Infrastructure will be protected from groundwater inundation through:
- Clay grading and/or subsoil drainage to provide a minimum of 1.2 metres between lot levels and the post-development controlled groundwater level (CGL).

5.5.1.3. Water Conservation and Non-Potable Water Supply

The use of water efficient fixtures and fittings within households will be promoted, to reduce household potable water use.

Public open space areas will be irrigated with groundwater abstracted from the aquifers underlying the subject area. Irrigation application rates will be tailored to suit the water requirements of the proposed landscaping (shrubs, turf, and littoral) used within public open space areas, to ensure efficient use of water for irrigation. Waterwise landscaping design will also incorporate waterwise native plants to reduce irrigation demand and turf will be limited to areas of active recreation.

There are currently four groundwater licences associated with the landholdings within the Structure Plan area, equating to a total volume allocation of 94,613kL/yr. This volume is sufficient to meet the permanent irrigation requirements of the Structure Plan area.

5.5.1.4. Monitoring

Pre-development surface water and groundwater monitoring was completed by Cardno over the subject site and a broader area in 2007-2009. The monitoring program included 6 bores within the Structure Plan area (and several others nearby) which were monitored monthly for levels and quarterly for quality over a period of 25 months.

Post-development surface water and groundwater monitoring is proposed to be undertaken for a period of two years, after which a decision will be made in consultation with the City of Swan and DWER as to whether subsequent monitoring is required.

The post-development monitoring program will involve quarterly analysis of groundwater levels and quality, and opportunistic monitoring of surface water levels and quality during the monitoring period.

5.5.1.5. Implementation

Consistent with the requirements of the LWMS and the Better Urban Water Management framework, a UWMP will be required as a condition of subdivision approval. While strategies have been provided within the LWMS that address planning for water management within the site, it is a logical progression that future subdivision designs and the supporting UWMP's clarify details not provided within the LWMS.

Details regarding the UWMP requirements, roles, and responsibilities related to water management have been provided in the LWMS.

5.6. Activity Centres and Employment

Taktics 4 were engaged to undertake a Retail Needs Assessment (**Appendix 6**) in support of the Structure Plan, specifically assessing the proposed Neighbourhood Centre. The findings of the Assessment are summarised in the sections below.

Refer **Appendix 6 – Retail Needs Assessment**.

5.6.1. Strategic Centre

The Midland Town Centre, an identified Strategic Metropolitan Centre under *State Planning Policy 4.2-Activity Centres* ('SPP 4.2') is located approximately 21 kilometres south of the Structure Plan Area. Strategic Metropolitan Centres typically service approximately 300,000-400,000 persons. The Bullsbrook South community will therefore expect to be serviced by the Midland Town Centre.

5.6.2. Secondary Centres

The closest Secondary Centre to Bullsbrook South is the Ellenbrook Regional Centre (Ellenbrook Central), an identified Secondary Centre under SPP 4.2, located approximately 13 kilometres southeast of the Structure Plan area.

Beside the Midland Strategic Centre, this centre comprises the main regional activity centre within relatively close proximity to the site. The Ellenbrook Centre will provide a diversity of uses, providing for a range of employment and services required to service the existing and future population.

5.6.3. District Centres

In accordance with SPP 4.2, District Centres have a primary indicative service area of 2,000-15,000 persons and are generally for the purpose of providing daily to weekly household shopping needs, community facilities and a small range of other convenience services.

In this regard, the Kingsford Town Centre, as identified in SPP 4.2 and the City of Swan *Local Commercial Activity Centres Strategy* ('LCACS'), services the subject land.

The Kingsford District Centre, situated to the immediate north of the Structure Plan area, will incorporate a small, limited line supermarket (IGA) and a single full-line supermarket (Woolworths). The Bullsbrook South community will therefore be serviced by the Kingsford Town Centre offering, albeit the centre is located on the fringe of the primary catchment, creating an opportunity for a small convenience-based retail offer to service the Bullsbrook South community.

The District Centre provides for a mix of smaller scale everyday uses, including food and beverage outlets and retail shops. The centre will support the larger scale Secondary Centres and provide further economic and employment opportunities for future residents.

5.6.4. Neighbourhood Centres

Consistent with the Bullsbrook Townsite District Structure Plan, the Structure Plan proposes an (approximate) two hectare Neighbourhood Centre site to service the future Bullsbrook South population. The Centre is located at the entrance to the subject land, on the intersection of Yarrimbah Drive and Great Northern Highway.

Consistent with the WAPC's *State Planning Policy 4.2 – Activity Centres*, Neighbourhood Centres may accommodate a range of retail land uses, including: shop, fast food outlet / lunch bar, restaurant/café, small bar, liquor store, market, restricted premises, amusement parlour, educational establishment, recreation – private, tavern, office – small, medical centre and art gallery.

The proposed centre is anticipated to accommodate a 3,500 sqm NLA supermarket and up to 10-15 shops (1,500 sqm NLA), creating a total retail floor space of approximately 5,000 sqm NLA. A single supermarket-based neighbourhood centre is typically capable of also supporting a range of non-retail activities including:

- Medical facilities;
- Service station;
- Childcare centre; and
- Fast food outlets.

The above uses may be accommodated within the proposed two hectare site, but will ultimately be determined at Development Application stage and ultimately, in accordance with the requirements of the Commercial Zone under the *City of Swan Local Planning Scheme No. 17*.

A Retail Needs Assessment was prepared in support of the proposed Neighbourhood Centre and the findings of the assessment concluded the following:

- The Bullsbrook trade area centres (Bullsbrook North, Bullsbrook Central, Bullsbrook South) can comfortably sustain three supermarket-based centres, and each of the three centres can be sustained by predominantly capturing spending from their immediate catchments, whilst also capturing additional sales from other trade areas;
- A single full line supermarket based Neighbourhood Centre at Bullsbrook South may be sustained by 2031; and
- The development of the planned Neighbourhood Centre in Bullsbrook South adheres to the policy objectives, principles, and centres framework/hierarchy for SPP 4.2 (2023) and the City of Swan LCACS (2017).

Refer **Appendix 6 – Retail Needs Assessment**.

5.7. Education Facilities

5.7.1. High Schools

The subject land is currently serviced by the existing Bullsbrook College, which is located within the existing Townsite. The Bullsbrook Townsite District Structure Plan contemplates the potential requirement for a second high school site, to service its future anticipated population growth (in the event the existing high school is not capable of expansion). In this regard, the District Structure Plan identifies a 'Preferred High School Site' should this be required, which is located to the east of the established Townsite, northeast of the Structure Plan area.

Consistent with the District Structure Plan, no high school sites are contemplated or required within the subject land.

5.7.2. Primary Schools

Consistent with the land use designation under the District Structure Plan, the Structure Plan is proposed to be serviced by one (1) new primary school. Having regard to the anticipated yield for the subject land, it is considered one primary school will appropriately service the population. The proposed primary school is generally centrally located and co-located with an area of public open space to provide shared public playing fields.

In accordance with Liveable Neighbourhoods, the primary school has been designed and located adjacent the Central Neighbourhood connector, providing access and connectivity from the school to the northern and southern precincts of the Structure Plan.

5.8. Infrastructure Coordination, Servicing and Staging

5.8.1. Infrastructure and Servicing Provision

A detailed outline of the existing and planned infrastructure network within the Structure Plan area has been provided in Engineering Services Report provided at **Appendix 1**. The key findings include:

- The subject land will require earthworks to facilitate residential development (to create flat building pads) and to create the appropriate drainage paths.
- For the development of the subject land, a high voltage connection under the Great Northern Highway will be required. This will need to be looped back to the distribution main in time to create a double source of supply. This could be done with a secondary connection to the existing aerials on Great Northern Highway or with connection to the high voltage infrastructure installed for the Centre to the north of the site.
- The Structure Plan area is not currently serviced by reticulated sewer. In terms of sewer catchment planning, the area north of Nambad Brook is accounted for as part of the Bullsbrook Central sewer catchment and may be utilised for the initial stages of development.
- Beyond the initial stages of development, the Water Corporation's planning and delivery timeframes for the progression of sewer infrastructure generally aligns with the planning approval timeframes and the anticipated market take up of currently serviced land. The Structure Plan area is therefore capable of being serviced with wastewater.

- As part of the future planning for water supply to the north of the site (in the Kingsford Estate) there is a diameter 250mm reticulation main proposed in Squadron Boulevard and a 150mm diameter main in Wylde Boulevard that could be extended to service the subject land.
- There is no reticulated gas supply in the proposed for the Structure Plan area, though as advised by ATCO, a 10 kilometre network mains extension would service the development if required. Reticulated gas supply is not an impediment to the Structure Plan.
- The land is currently serviced by multiple optic fibre in the Great Northern Highway Road reserve. It is expected expansion of this network along Lage and into the future subdivision will service the Structure Plan.

With continued emphasis by the Water Corporation on regional infrastructure planning for the Northeast Corridor, there should be no noted shortfall in infrastructure or constraints that would prevent development of this land for residential purposes in a staged and timely fashion.

Refer **Appendix 1 – Engineering Servicing Report**.

5.8.2. Subdivision Staging

The staging of the subdivision and development of the land will be primarily informed by the delivery and capacity of waste water infrastructure across the site.

Based on the current servicing strategy, the initial stages of development (approximately 560 lots) are anticipated to comprise the land north of Yarrimbah Drive, with the first stage (approximately 80 lots) intending to be delivered Q3, 2026 (subject to timing for the relevant approvals). Following the delivery of the first (approximate) 560 lots north of Yarrimbah Drive, development will then be progressed from Stock Road in the south and moving progressively north.

Subject to the provision of service infrastructure, development is anticipated to occur at a rate of approximately 100 lots per annum (subject to market forces) and be developed at a rate of approximately 30 – 50 lots per stage, in response to the market demand at the time of development.

Refer **Figure 26 – Indicative Staging Plan**.

5.8.3. Development Contributions

The Structure Plan area is included within the City of Swan's Developer Contribution Area No.7 (DCA7), and is subject to the applicable existing Development Contribution Plan (DCP). The DCP was gazetted in December 2020, and has been prepared to facilitate the orderly development of key infrastructure items.

The infrastructure and administrative items funded by this Development Contribution Plan are listed in the Local Planning Scheme – refer to the Scheme text and Development Contribution Plan for details. Infrastructure items within the Structure Plan boundary generally include:

- Local Transport Infrastructure, including upgrades associated with Yarrimbah Drive (Formerly Lage Road);
- Land for public open space and community infrastructure, including Neighbourhood Playing Fields identified for Bullsbrook South (as depicted on the Indicative Subdivision Concept);
- Community infrastructure; and

Sub-Regional Transport Infrastructure, including upgrades associated with Stock Road and selected intersections on Great Northern Highway (including but not limited to the Great Northern Highway-Yarrimbah Drive-Dewar Road intersection, and the Great Northern Highway-Stock Road intersection).

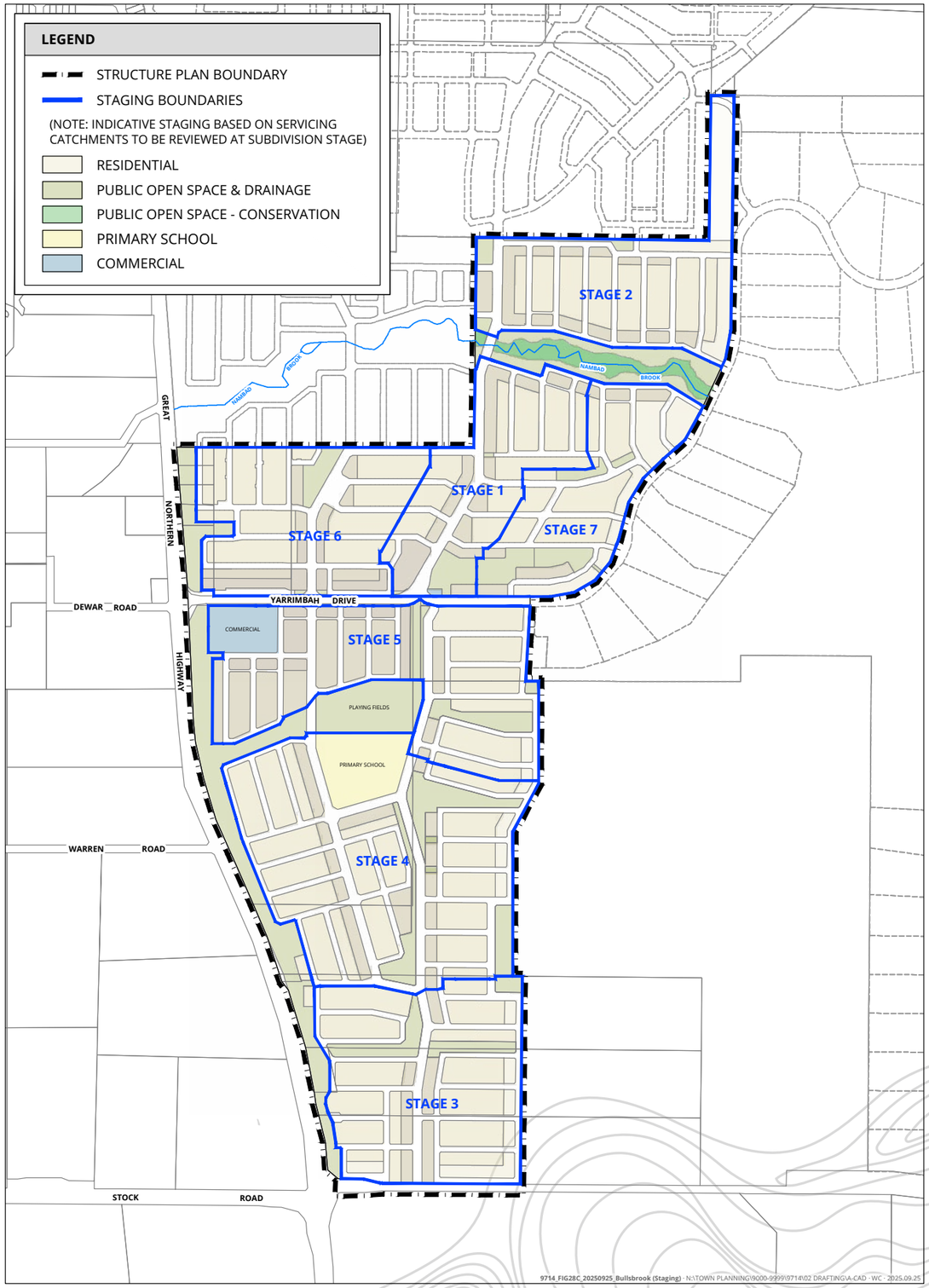


Figure 26. Indicative Development Staging

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Attachment 1

Engineering Servicing Report

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Bullsbrook South Land Holdings Local Structure Plan

Engineering Servicing Report

Project No: 22-063

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Appendix Two: Acid Sulphate Soil Risk Map

Appendix Three: Iron Staining Risk Map

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Appendix Eleven: North East Corridor Waste Water Concept Plan July 2023

Appendix Twelve: ATCO Gas Correspondence

Appendix Thirteen: Existing Western Power Infrastructure

Appendix Fourteen: Existing Communication and Fibre Infrastructure

Revision	Description	Author	Date
0	Issued for Local Structure Plan Submission	Mark Riddell	17 November 2023
1	Issued for Local Structure Plan Submission	Mark Riddell	12 December 2023
2	Issued for Final Submission	Mark Riddell	02 September 2025
3	Issued for Final Submission	Mark Riddell	26 September 2025

1 Introduction

This Engineering Servicing report has been prepared in support of a local structure plan over the Bullsbrook South Urban Expansion Area.

The report represents a summary of engineering services, both current and future planned, to facilitate the development of the proposed structure plan area. An aerial image of the site is shown below in Figure 1 and concept map of the local structure plan can be found in Appendix One as prepared by Rowe Group.

Information in this report is based on infrastructure planning currently available from relevant service authorities as well as their infrastructure mapping services. To complete this assessment, Pritchard Francis acquired specific advice for reticulated gas from ATCO, and underground power and communications servicing from Underground Power Development Pty Ltd (UPD).

2 Site Description

The site is located within the City of Swan, 5km southeast of the Bullsbrook townsite and about 40km northeast of the Perth central business district.

The site is bordered by Great Northern Highway on the western boundary, the Kingsford Estate currently being developed to the north (currently zoned urban), undeveloped land zoned rural to the east (Darling Scarp), and Stock Road to the south. Yarrimbah Driveand Nambad Brook intersect the site in the Northern third.



Figure 1 - Aerial Image – Subject Site courtesy Nearmap October 2023

3 Acid Sulphate Soils

The State Government has produced mapping identifying acid sulphate soils (ASS) highlighting any risk areas for ground excavation and development. From information obtained for this subject site, much of the developable area is shown to have low to no risk of actual acid sulphate soils present at depths less than 3 m. A portion of the site to the southeast is identified as having moderate to low risk of actual acid sulphate soils present at depths less than 3m. Please refer to **Appendix Two** for relevant mapping.

The consideration of ASS is not a hindrance to the rezoning of the land to urban and can be readily managed in line with the Department of Water and Environmental Regulation guidelines being incorporated into the civil engineering design. Along with ASS is the iron staining risk for the site. A significant portion of the site is not documented on the Iron Staining Risk Map. The land nearest Great Northern Highway has been documented as low possibility of iron staining from use of groundwater.

Refer Appendix Three – Iron Staining Risk Mapping

4 Topography

The 1:50,000 Environmental Geology Series Map has been obtained for Muchea which encompasses the subject landholding. An extract is attached in **Appendix Four** which highlights the development area.

Based on this mapping, it is anticipated that the soil profile is likely to consist of:

- SCHIST – grey to pale grey, highly schistose quartz mica schist. Located on the eastern portion of the site.
- GRANITE – mesocratic, fine to coarse-grained, ranges in composition from granodiorite to granite, adamellite being commonest variety. Located in the north-eastern corner of the site.
- SANDY SILT – strong brown, firm, friable, dispersive in part, occasional pebbly horizons with little matrix containing quartzite, quartz, granite, laterite of colluvial origin. Located across majority of the site.
- SAND – very pale brown, medium to coarse-grained, well sorted, little fines, sub-angular to rounded quartz and feldspar, of colluvial origin. Located in the northern portion of the site.
- SAND OVER PEBBLY SILT – sand very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin. Overlying strong brown silt with common fine to occasionally coarse grained, sub-rounded laterite, quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand of alluvial origin. Located across the north-western portion of the site.

Galt Geotechnics have also completed a preliminary geotechnical investigation of the site. This has been included in **Appendix Five**. Galt conclude their findings are broadly consistent with the geological mapping.

Subsoil surface conditions vary across the site, and typical soil profiles have been summarised as follows:

Parts of the northern end of site:

- Sandy GRAVEL/Silty GRAVEL (GP/GM): fine to coarse grained, angular to sub-rounded, brown, about 5% to 20% non-plastic fines extending from the surface to depths of typically between 0.3 m to 0.5 m; overlying
- Clayey SAND/ SAND (SC/SP): fine to coarse grained, orange brown, 5 – 15% low to medium plasticity fines extending to depths of between 0.9 m and 2.4 m;
- Extremely Weathered ROCK/ ROCK – possibly quartz rich, metamorphic rock present from depths of between 0.9 m and 2.8 m.

Central part of the site:

- Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 m.

Central and south of the site:

- Thin and irregular layer of granular gravel or sand, typically about 0.3m to 0.4m thick; overlying
- Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 m.

Land within the urban expansion area steadily climbs from west to east, from levels in the range of RL 37m to 42m AHD along Great Northern Highway. Nearing the eastern boundary, the land increases steeply from RL 60m AHD to levels in the order of RL 90m AHD.

Refer Appendix Six - for high level topography mapping.

We don't expect the topography of the site to be an impediment to the structure planning of the site.

5 Groundwater Level

Data for the historical maximum groundwater levels from the Perth Groundwater Map are unavailable for this site. The minimum groundwater contours are available for the western portion of the site and indicate that groundwater is present at RL 35m AHD in the south-western corner near where Stock Road intersects Great Northern Highway. Increasing to RL 40m AHD where Yarrimbah Drive intersects Great Northern Highway. Please refer **Appendix Seven** for available mapping.

Galt did not encounter any groundwater in test pits during their preliminary geotechnical investigation to a depth of 3.2m, however they expect shallow perched groundwater to develop on the clayey soils during winter. Groundwater levels should be verified in a full geotechnical investigation for detailed design. The stormwater strategy for the site, as outlined in the Local Water Management Strategy (LWMS) will collect the perched water table in sub soil drains that are treated either in bioretention areas or inline before discharge into the existing drainage tributaries.

Further detail on the stormwater strategy for the site can be found in the LWMS prepared by Pentium Water.

6 Earthworks Strategy

The urban expansion area will require earthworks to set up the site for residential development (flat pads) and to create the appropriate drainage paths from east to west where stormwater will be attenuated before using existing drainage outlets under Great Northern highway to move stormwater.

Galt's preliminary geotechnical investigation predicts on site infiltration in the insitu soils to be inappropriate due to clayey content and limited permeability. Stormwater should instead be diverted using drains or otherwise to a disposal area located away from structures. It is predicted importation of clean, inert fill will be required in part to produce a class A classification as a minimum in line with AS2870 and the residential slab and footing construction code. Galt's geotechnical reporting for the site requires 1.8 m of inert material under each structure to achieve this.

Opportunities for cut to fill will be investigated to shape the landform with consideration to the existing vegetation on site, requirements to obtain appropriate site classification for soils for all land uses, and requirements for best practise road design in line with Austroads and IPWEA guidelines. It is likely clay grading will take place in lower lying areas to facilitate run off moving towards subsoil drainage lines.

Refer **Figure 1B f**or preliminary drainage catchment planning including indicative subsoil drainage layout and Appendix 7B for preliminary earthwork design. Again, further detail on the stormwater strategy for the site can be found it the LWMS.

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- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- 15.0 EXISTING CONTOURS
- 15.0 PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
A	15/11/23	INITIAL ISSUE	A.D	M.R

pritchard francis
civil and structural engineering consultants

DRAWING STATUS: NOT FOR CONSTRUCTION

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: DESIGN CATCHMENT PLAN

DATE	GRID	DATUM
NOVEMBER 2023	PCG94	AHD

DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX .... / ....

W.A.P.C.	SCALE U.N.O.	SHEET SIZE	DRG No.	REVISION
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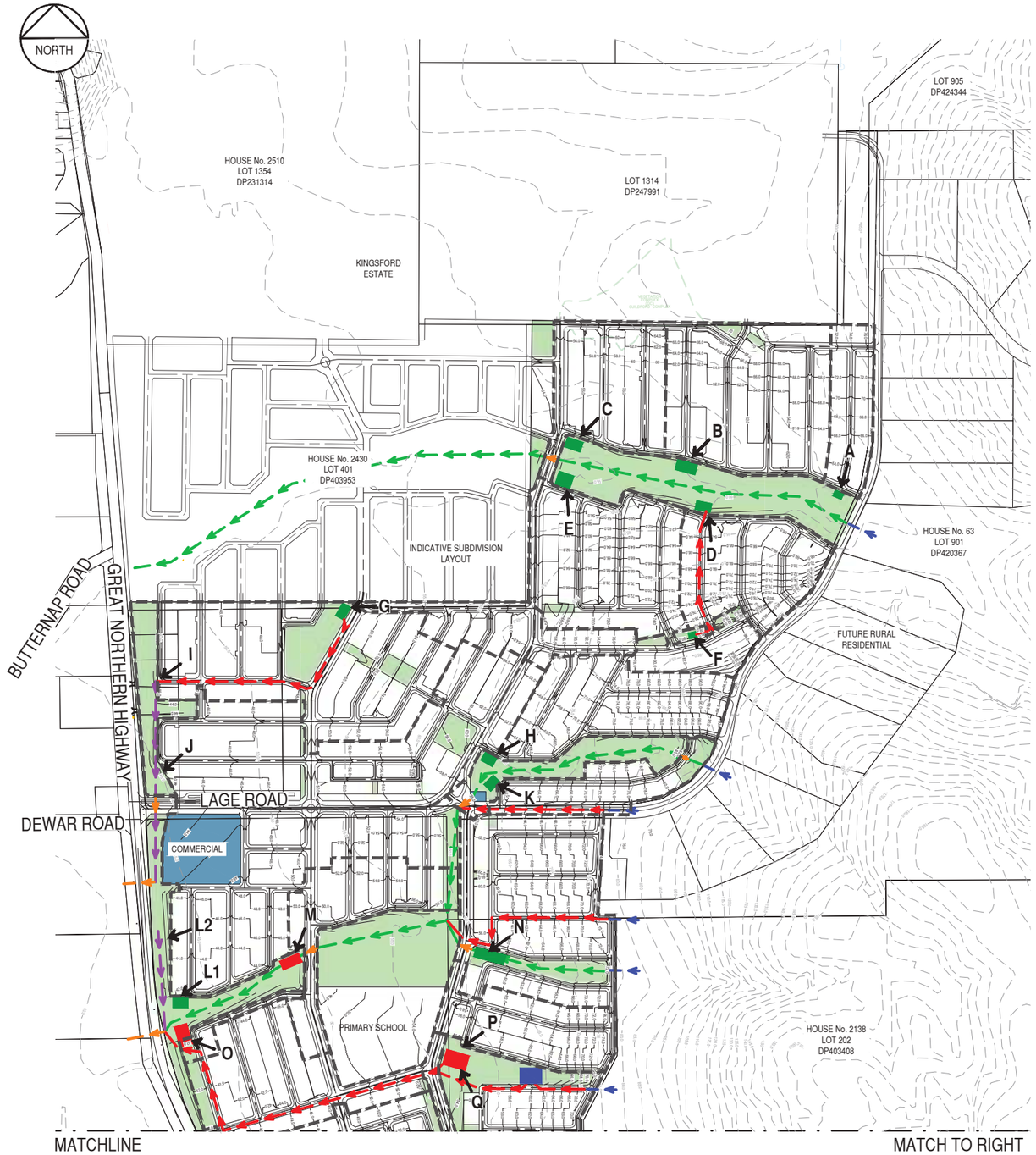



SCALE 1:5000 0m 100m 200m

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- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE
- LIVING STREAM
- TREATMENT / DETENTION SWALE
- CONVEYANCE SWALE
- STORMWATER CULVERT
- PIPED DRAINAGE
- INFLOWS
- BIOBASIN
- FLOOD DETENTION BASIN
- EXTERNAL CATCHMENTS BASIN

REV	DATE	DESCRIPTION	BY	CHKR
A	7/12/23	INITIAL ISSUE	N.S	M.R

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DRAWING STATUS: NOT FOR CONSTRUCTION

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: STORMWATER MANAGEMENT CONCEPT PLAN

DATE	GRID	DATUM
NOVEMBER 2023	PCG94	AHD

DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX .... / ....

W.A.P.C.	SCALE U.N.O.	SHEET SIZE	DRG No.	REVISION
N/A	1:5000 @	A1	22063-C1-SW-01	A

7 Utilities

7.1 Water Supply

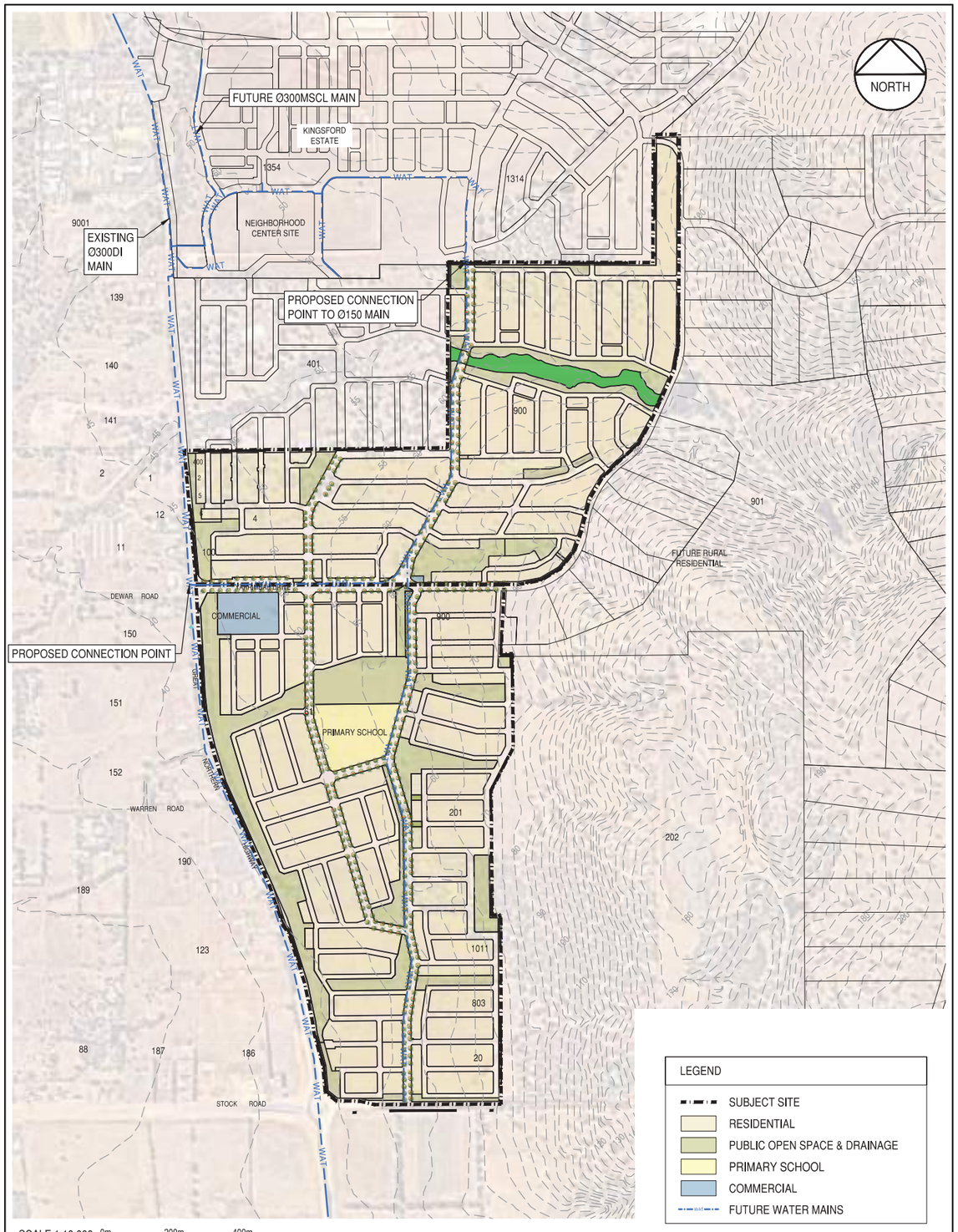
There is existing water supply infrastructure on the western side of the site located in the Great Northern Highway reserve. This includes a diameter 300 mm ductile iron (DI) main that feeds the Bullsbrook townsite district level supply tanks. It is unlikely this main would be used as a reticulation point for the proposed development.

We understand that as part of future planning for water supply to the north of the urban expansion area (in the Kingsford Estate) there is a diameter 250 mm reticulation main proposed in Squadron Boulevard and a 150 mm diameter main in Wylde Boulevard that could be extended to service the development. These reticulation mains are proposed to be reinforced with future diameter 300 mm MCSL pipe that runs through the Kingsford Estate and out to Great Northern Highway at an intersection just north of Nambad Brook. This is another option for future water supply. **Figure 2** highlights the proposed water connection points just north of the Bullsbrook South Urban Expansion Area.

In terms of water distribution infrastructure, the current Bullsbrook townsite supply tanks have a top water level of RL 120 m AHD and a maximum supply level of 112 m AHD which is above our nominated maximum levels of RL 90 m AHD on the Eastern side of the development. We understand from discussions with the Water Corporation a high-level water tank to help reinforce the existing supply tanks is due for construction in 2027/28. This will help further reinforce the current supply capacity and increase the maximum supply level above RL 140 m AHD.

We do not expect reticulated water supply to be an impediment to the local structure plan.

Figure 2 – Bullsbrook South Reticulated Water Connection Points and Water Concept.



7.2 Wastewater Servicing (Sewerage)

The reticulated sewer and wastewater outfall is one of the more complex issues for development of the proposed Bullsbrook South Local Structure Plan, however with consideration to the development staging and the timing of additional downstream infrastructure provided by the Water Corporation it shouldn't be an impediment to the acceptance of the local structure plan.

7.2.1 Existing Sewer Catchments

Currently the proposed local structure plan area isn't serviced by reticulated sewer. In terms of sewer catchment planning, the area north of Nambad Brook is accounted for as part of the Bullsbrook Central sewer catchment. This catchment grades to the future Type 90 Wastewater Pumping Station (WWPS) being built by the Water Corporation under project number CS03513. The catchment boundary relative to Bullsbrook South is shown in figure 3 with the full catchment plan found in **Appendix Eight**. The timing for completion of this WWPS is mid 2025 inline with the opening of the Neighbourhood Center Site adjacent. For the proposed Bullsbrook South Local Structure Plan Area this equates to approximately 560 lots under a residential density coding and approximately 8.6 l/sec of flow.

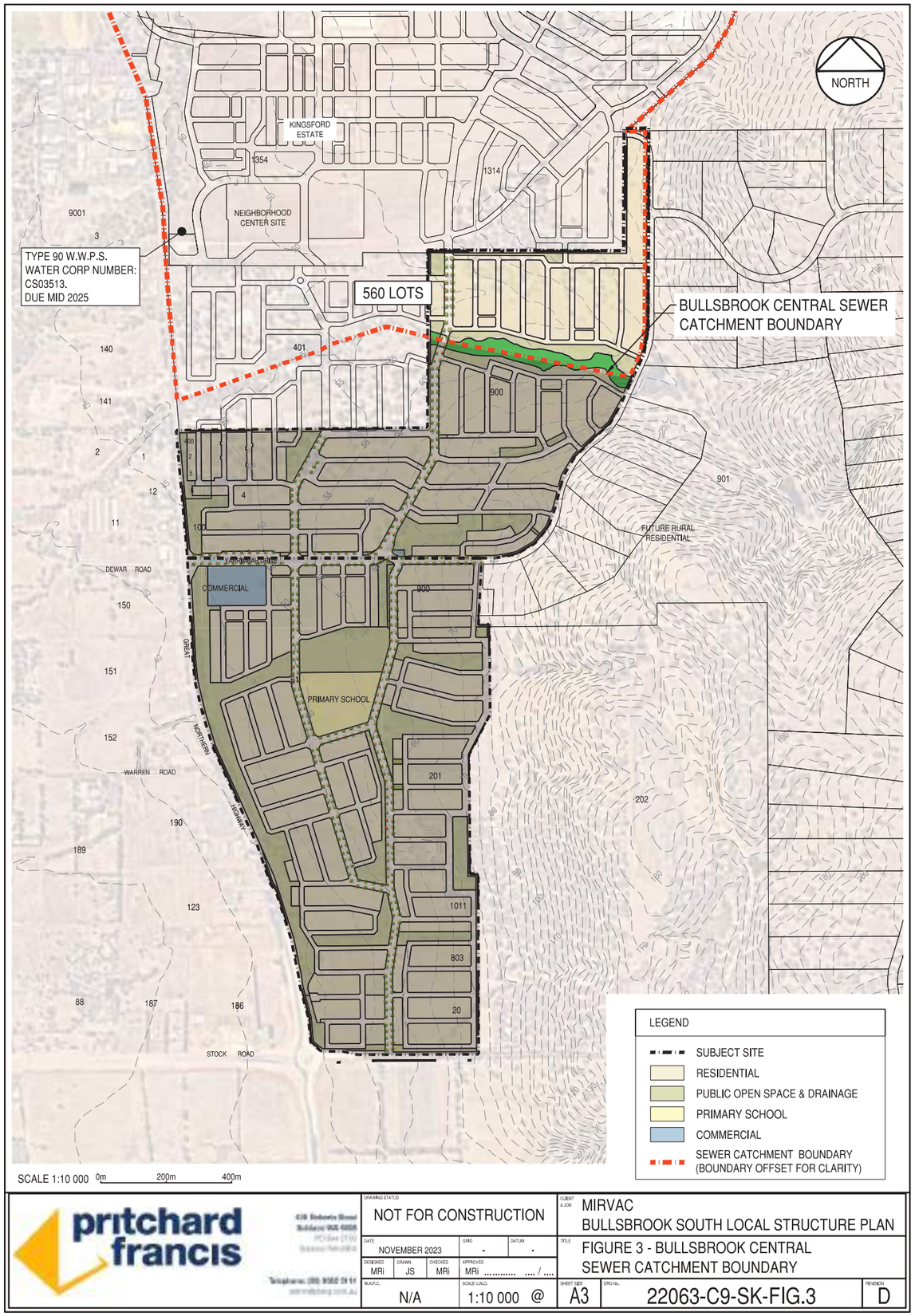
Figure 3 – Bullsbrook Central Sewer Catchment

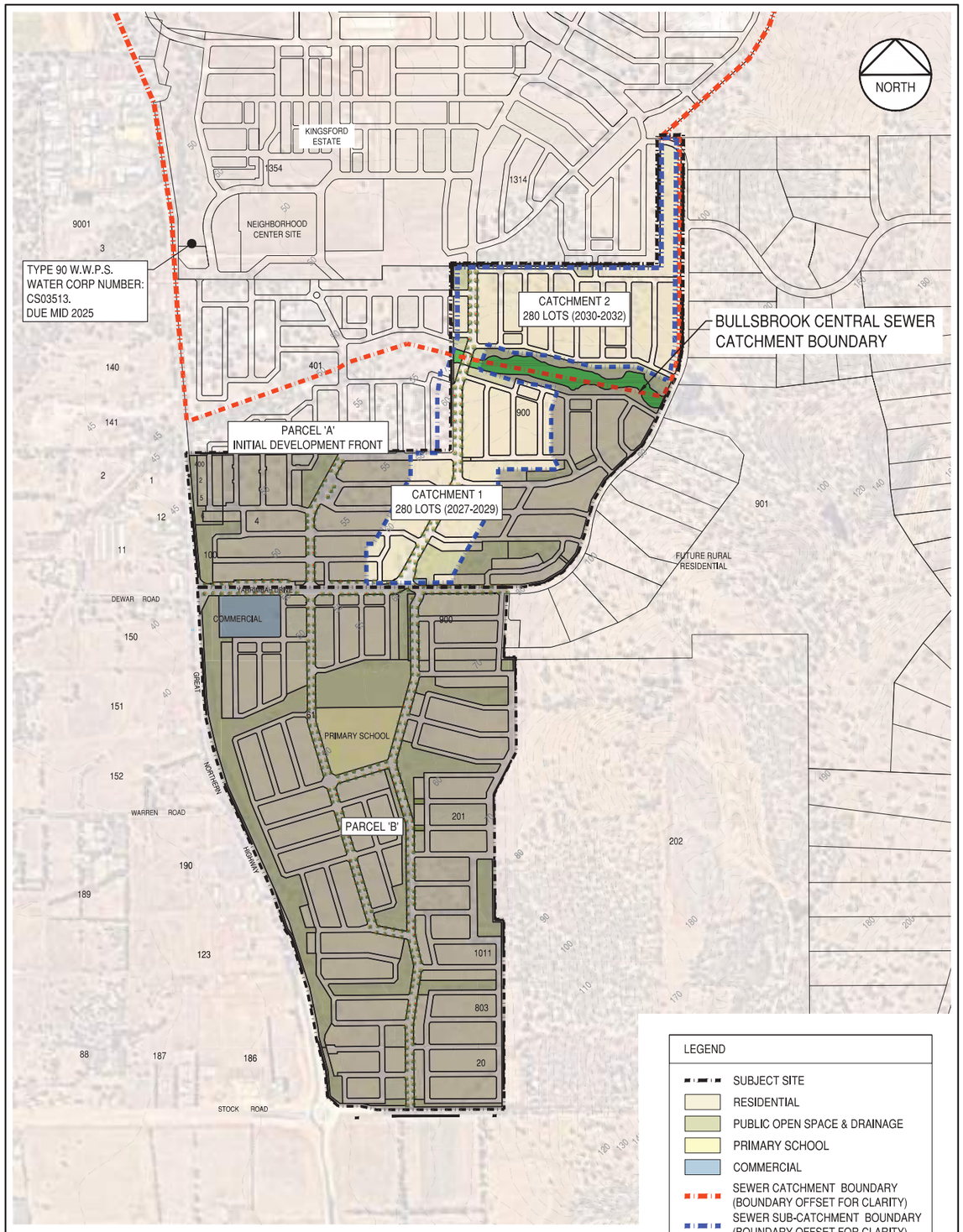
7.2.2 Development Staging

The initial focus of development within the urban expansion area will be the land immediately north of Yarrimbah Drive. This is known as "Parcel A" (with everything South of Yarrimbah Drive known as "Parcel B"). Part of Parcel A is currently not within the available sewer catchment as shown in figure 4. It is proposed to amend the Water Corporation catchment boundary temporarily to allow approximately half (560 Lots) of the approved area north of Nambad Brook to be reallocated south which will allow the initial stages of development near Yarrimbah Drive. A proposed catchment plan and indicative gravity sewer route to support this is shown in further detail in figure 5. This plan highlights that there is an option to redivert sewer flows in the future to the original catchment boundaries when the area north of Nambad Brook is proposed to be further developed, thus not impacting the ultimate flows allowed for in the Bullsbrook Central sewer catchment planning.

Figure 4 – Bullsbrook South Initial Development Areas

Figure 5 – Bullsbrook South Temporary Sewer Catchments – Parcel A



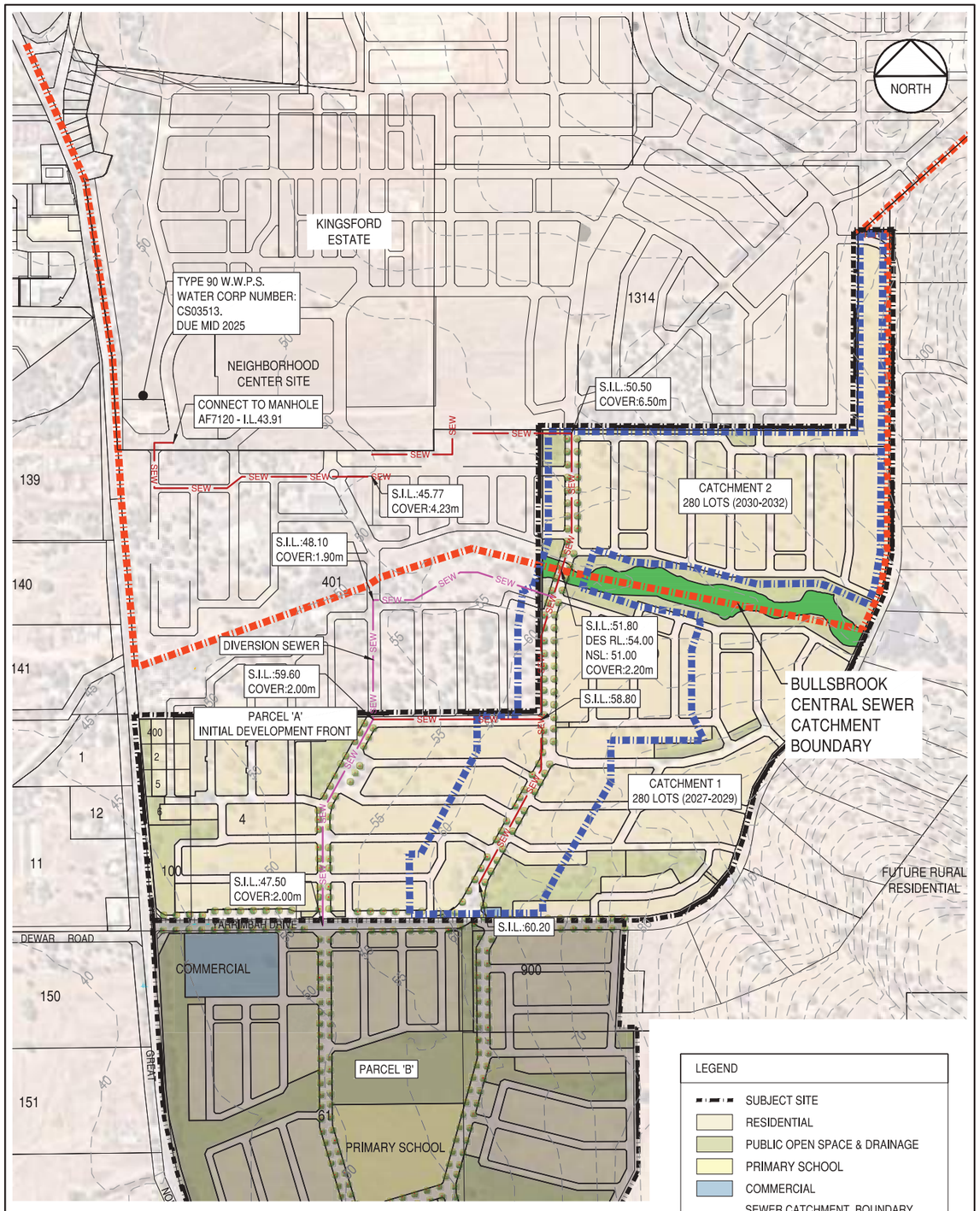


LEGEND

- SUBJECT SITE
- RESIDENTIAL
- PUBLIC OPEN SPACE & DRAINAGE
- PRIMARY SCHOOL
- COMMERCIAL
- SEWER CATCHMENT BOUNDARY (BOUNDARY OFFSET FOR CLARITY)
- SEWER SUB-CATCHMENT BOUNDARY (BOUNDARY OFFSET FOR CLARITY)

pritchard francis

DRAWING STATUS	NOT FOR CONSTRUCTION
CLIENT & JOB	MIRVAC BULLSBROOK SOUTH LOCAL STRUCTURE PLAN
DATE	NOVEMBER 2023
GRID	-
DATUM	-
DESIGNED	MRi
DRAWN	JS
CHECKED	MRi
APPROVED	MRi .... / ....
TITLE	FIGURE 4 - BULLSBROOK SOUTH INITIAL DEVELOPMENT AREAS
W.A.P.C.	N/A
SCALE U.N.O.	1:10 000 @
SHEET SIZE	A3
DRG No.	22063-C9-SK-FIG.4
REVISION	D



LEGEND

- SUBJECT SITE
- RESIDENTIAL
- PUBLIC OPEN SPACE & DRAINAGE
- PRIMARY SCHOOL
- COMMERCIAL
- SEWER CATCHMENT BOUNDARY (BOUNDARY OFFSET FOR CLARITY)
- SEWER SUB-CATCHMENT BOUNDARY (BOUNDARY OFFSET FOR CLARITY)

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DRAWING STATUS	NOT FOR CONSTRUCTION
CLIENT & JOB	MIRVAC BULLSBROOK SOUTH LOCAL STRUCTURE PLAN
DATE	NOVEMBER 2023
GRID	-
DATUM	-
DESIGNED	MRi
DRAWN	JS
CHECKED	MRi
APPROVED	MRi .... / ....
TITLE	FIGURE 5 - BULLSBROOK SOUTH TEMPORARY SEWER CATCHMENTS - PARCEL A
W.A.P.C.	N/A
SCALE U.N.O.	N.T.S. @
SHEET SIZE	A3
DRG No.	22063-C9-SK-FIG.5
REVISION	D

7.2.3 Development Timeframes

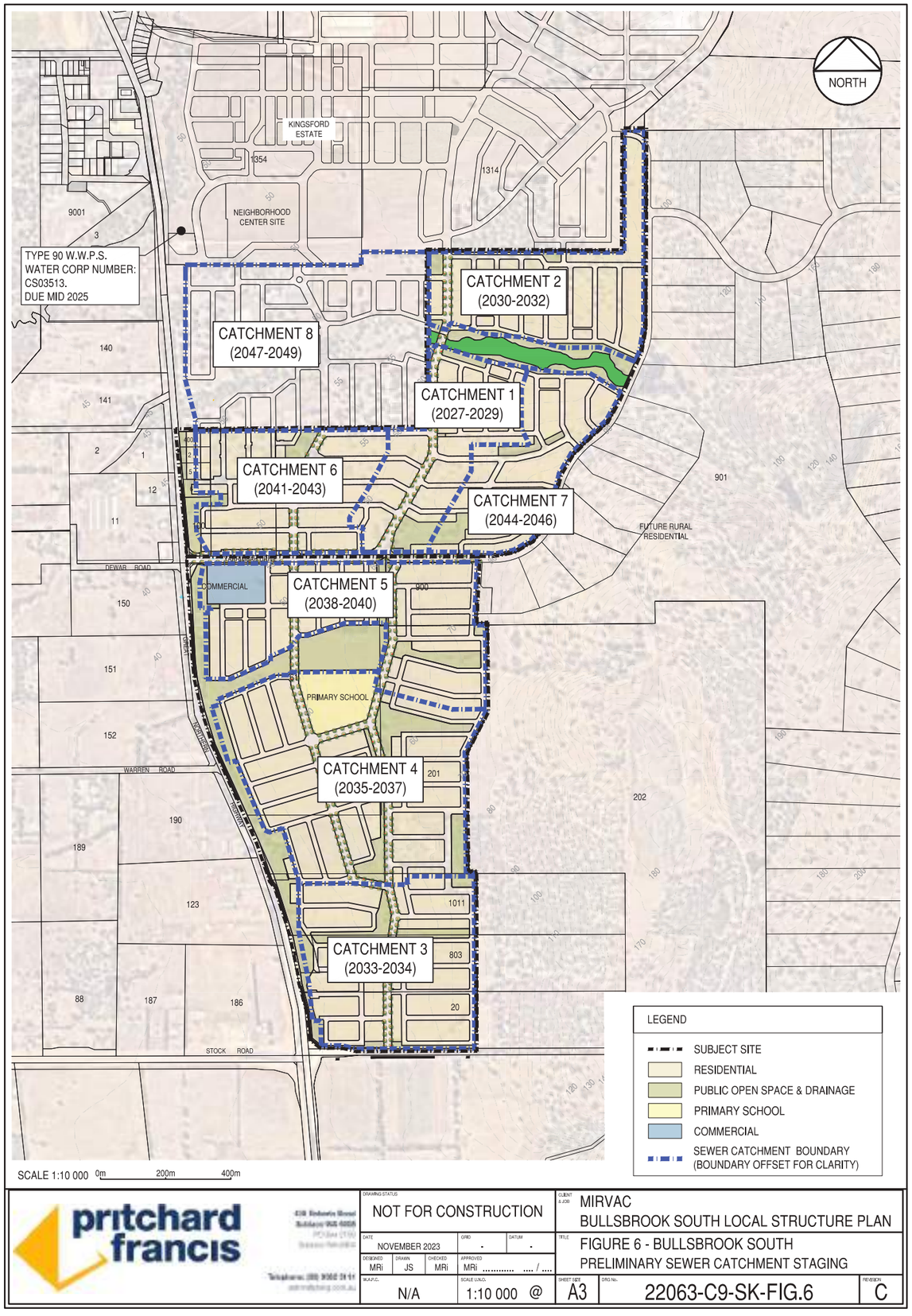
The estimated timeframe for development is important for assessing the local structure plan. A high-level program from lifting request through to possible sewer flow is shown in table 1. What this indicates is that the first 280 lots of sewer catchment south of Nambad Brook wouldn't contribute flow until 2027 and would be progressively developed until 2028. Another 280 lots North of Nambad Brook will take development through to the end of 2032. This indicates development of Parcel A would take place until the end 2032 (for 560 Lots total) before extra sewer outfall capacity is required.

Development Phase	Timeframe
Current Urban Zoning Request Approval	June 2024
Local Structure Plan Approval	July 2025
Subdivision Approval	October 2025
Construction Stage 1 (80 lots) completed	September 2026
Titles Stage 1	October 2026
Sewer flows (after housing construction) – Stage 1	October 2027
Build out of Catchment 1 – 280 lots	2027 to 2029
Build out of Catchment 2 – 280 lots	2030 to 2032

Table 1: Development Timing – Bullsbrook South Urban Expansion Area – First 560 Lots

The balance of this Parcel A landholding (approximately 350 lots) would need to gravitate south, through Parcel B to a sewer outfall on Stock Road, however this wouldn't be required until early 2033. Approximate staging and timing of sewer catchments through the urban expansion area is shown in figure 6. This is important when considering the development of regional wastewater infrastructure required to service Parcel B.

Figure 6 – Bullsbrook South Preliminary Sewer Catchment Staging



7.2.4 Regional Wastewater Infrastructure

We understand that the Kingsford Estate, directly to the north, has a further 1900 lots to be developed completing the build out of the Bullsbrook Central catchment in 2032. At this point a further sewer outfall option will be required by the Water Corporation as the existing infrastructure in Great Northern Highway will be at capacity. A schematic plan of the required infrastructure as provided by the Water Corporation is shown in figure 7. It highlights the key items relevant to the Bullsbrook South Urban Expansion Area but also the entire Northeast corridor encapsulating land in between Ellenbrook and Bullsbrook. There are several items included on this mapping with the main items as follows:

1. Stock Road Type 180 WWPS and Pressure Main to transfer flow from Bullsbrook to North Ellenbrook.
2. Additional Type 180 WWPS Transfer Station and Pressure Main to pump flow from North Ellenbrook to a gravity sewer discharge point within Ellenbrook.
3. Diameter 900 mm gravity sewer main within Ellenbrook to discharge at the existing Barrambie Way WWPS to transfer flows West.

Figure 7 – Northeast Corridor Wastewater Concept Plan – 10/7/2023

A high-level program for the planning and implementation of this infrastructure is shown in table 2. It is likely these infrastructure items will be staged in their construction and commissioning to meet development targets. We understand that a request has already been made to place the Diameter 900 mm gravity sewer on the Water Corporation's 5 year capital works funding allocation so this process is already underway.

Project Phase	Timeframe
Scoping and Land Acquisition	2024 to 2026
Detailed Design	2027 to 2028
Tender, Construction, Commissioning	2029 to 2032

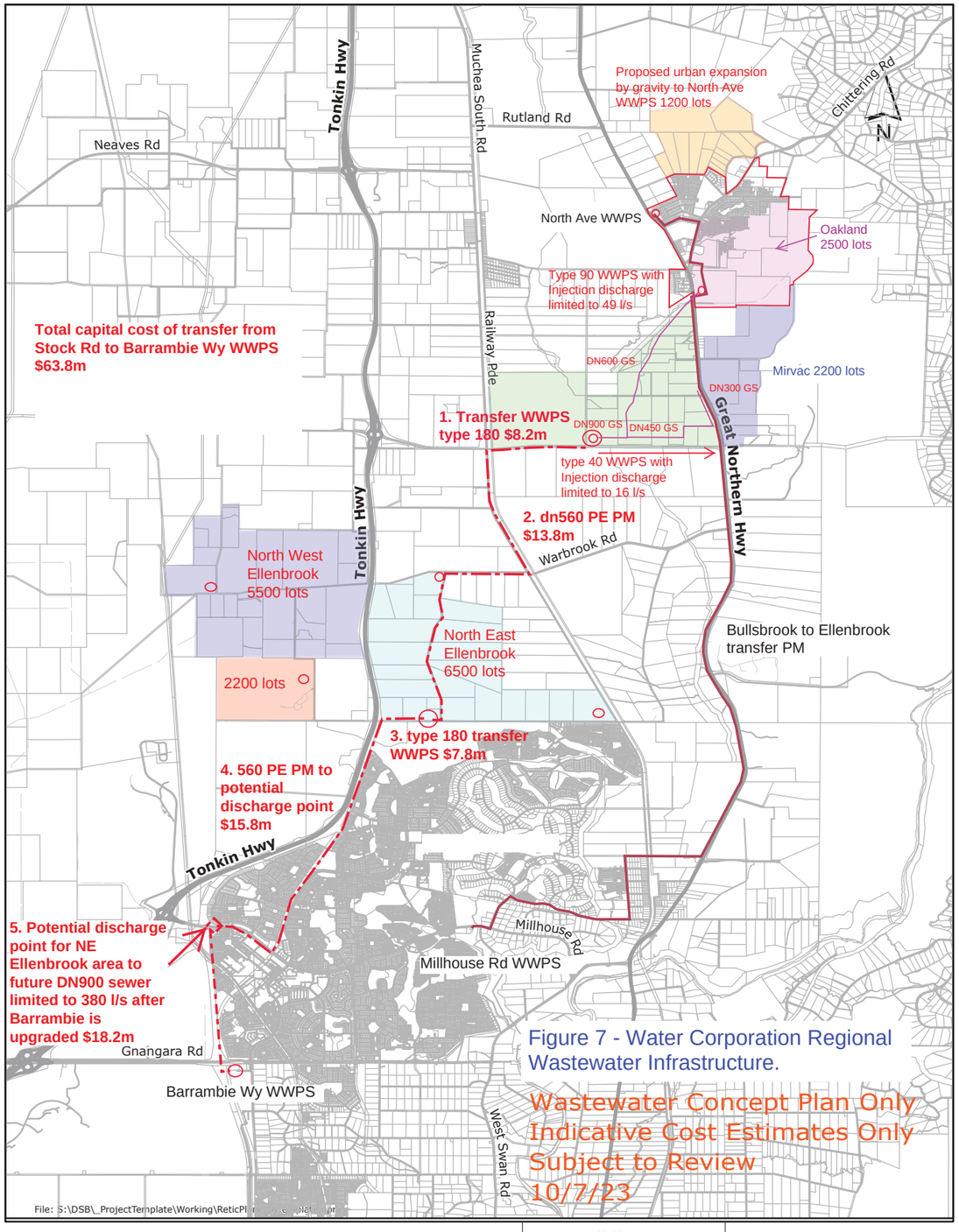
Table 2: Infrastructure Timing – Regional Wastewater – Northeast Corridor

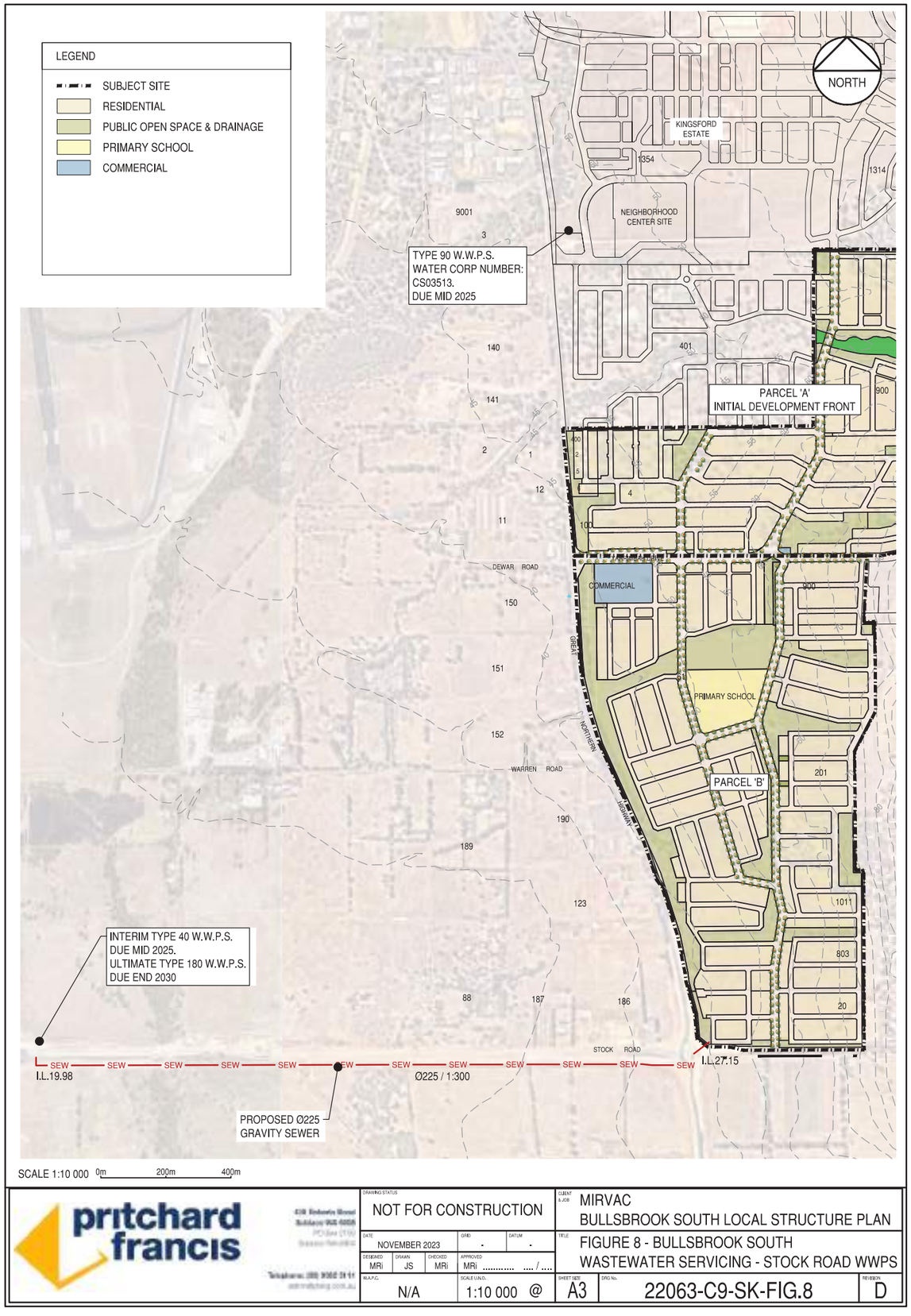
For Parcel B, approval of a scoping report for an interim Type 40 WWPS on Stock Road is due for completion imminently. The construction of this WWPS will allow limited flow (16 l/sec) to be pumped along Stock Road and discharge into the existing sewer transfer main in the Great Northern Highway reserve. This flow has initially been allocated to the Industrial land adjacent to Stock Road however the timing and flow rate required for this land is to be monitored with opportunity to create a sewer outfall for Parcel B. The construction of this interim Type 40 WWPS will allocate the future land requirements for the upgrade to the proposed type 180 WWPS that will be the ultimate sewer outfall for the greater Bullsbrook area (Item 1 above). Parcel B's sewer outfall will gravitate along Stock Road (or a similar alternative route) to this WWPS. An indicative sewer servicing alignment to the WWPS is shown in figure 8. It is anticipated the Type 180 WWPS will be available prior to 2032 to enable the development of Parcel B and the remainder of Parcel A thereafter with staged timing as indicated in figure 6. The development timeframes mapped against Regional Wastewater Infrastructure implementation is represented in figure 9.

Figure 8 – Parcel B Wastewater Servicing Alignment – Stock Road WWPS

Figure 9 – Bullsbrook South Urban Expansion Area / Regional Wastewater Implementation Timeframes

Considering all of the above, which highlights the staging of the Bullsbrook South Urban Expansion Area, temporarily altering the initial sewer catchment to allow development before 2032 and the expectation of continued timely development of regional wastewater infrastructure in the Northeast Corridor for access after 2032, we do not expect sewer reticulation and wastewater outfall to be an impediment to the acceptance of the local structure plan for Bullsbrook South.





pritchard francis

DRAWING STATUS: NOT FOR CONSTRUCTION

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH LOCAL STRUCTURE PLAN

TITLE: FIGURE 8 - BULLSBROOK SOUTH
WASTEWATER SERVICING - STOCK ROAD WWPS

DATE	GRID	DATUM
NOVEMBER 2023	-	-

DESIGNED	DRAWN	CHECKED	APPROVED
MRi	JS	MRi	MRi .... / ....

W.A.P.C.	SCALE (UNO)	SHEET SIZE	DRG No.	REVISION
N/A	1:10 000 @	A3	22063-C9-SK-FIG.8	D

Bullsbrook South Urban Expansion Area Timeframes

Colliers

Urban Expansion Area Project Timeframes		Water Corporation Regional Infrastructure Implementation
MRS Approval	2024	Scoping & Land Acquisition
Local Structure Plan Approval	2025 July	
Subdivision Approval	October	
Construction Stage 1 Completed	2026 September	
Titles Stage 1	October	
Sewer Flows (after housing construction) – Stage 1	2027 October	Detailed Design
Build out of Catchment 1 – 280 lots	2028	
	2029	
Build out of Catchment 2 – 280 lots	2030	Tender, Construction, Commissioning
	2031	
	2032	
Regional Waste Water Infrastructure Outfall Required	2033 January	

Figure 9: bullsbrook South Urban Expansion Area Timesframes

7.3 Gas Supply

There is no reticulated gas supply in the proposed urban expansion area or in the Bullsbrook townsite. ATCO has advised that a 10km network mains extension would service the development. The predicted scope of works is outlined below.

- Network tie-in at Apple Street, Upper Swan, and Rail Crossing (ARC)
- 850m of DN225PE Apple Street to Great Northern Highway
- 9,000m of DN225PE from the junction of Apple Street and Great Northern Highway and Yarrimbah Drive, Bullsbrook
- Installation methodology = Horizontal Directional Drilling (HDD)
- 500m x Open Cut in road reserve
- 500m x Open Cut in verge

We do not expect reticulated gas supply to be an impediment to the local structure planning of Bullsbrook South. Please refer to **Appendix Twelve** for more detail on the advice from ATCO.

7.4 Power Supply

7.4.1 Existing and Proposed UGP Network

The proposed structure plan area is currently bound by aerial power on the western side of Great North Highway and a high voltage spur line that runs along Yarrimbah Drive to service a RAAF radar and existing residents on the adjoining rural properties. This line has a 22 kV capacity of which there is about 500 kVA available. This is supplied from the Bullsbrook Zone substation which from current mapping shows 9 MVA available.

Whilst this load is likely sufficient for the initial stages of development it would be prudent for Western Power to continue future planning for the greater Bullsbrook area to confirm continuity of supply.

For the development of the subject site, a high voltage connection under the Great Northern Highway will be required and this will need to be looped back to the distribution main in time to create a double source of supply. This could be done with a secondary connection to the existing aerials on Great Northern Highway or with connection to the high voltage infrastructure installed for the Neighbourhood Center to the north of the urban expansion area.

Existing Western Power asset mapping can be found in **Appendix 13**.

We do not expect underground power supply to be an impediment to the local structure planning of Bullsbrook South.

7.5 Communication

7.5.1 Existing and Proposed Communications Network

The site is current serviced by multiple optic fibre in the Great Northern Highway Road reserve. It is expected expansion of this network along Yarrimbah Drive and into the future subdivision will service the urban expansion area.

There are many opportunities for residential suppliers in the area including NBN Co and Opticomm. NBN Co still have a standard $600 / lot backhaul fee to support the development of their infrastructure.

Optic Fibre mapping can be found in **Appendix 14**.

We do not expect communication infrastructure to be an impediment to the local structure planning of Bullsbrook South.

8 Conclusion

The subject site has future planning carried out by all service authorities and sits at the edge of the development front with required services found on Great Northern Highway and the edge of the Bullsbrook Central catchment which is the Kingsford Estate.

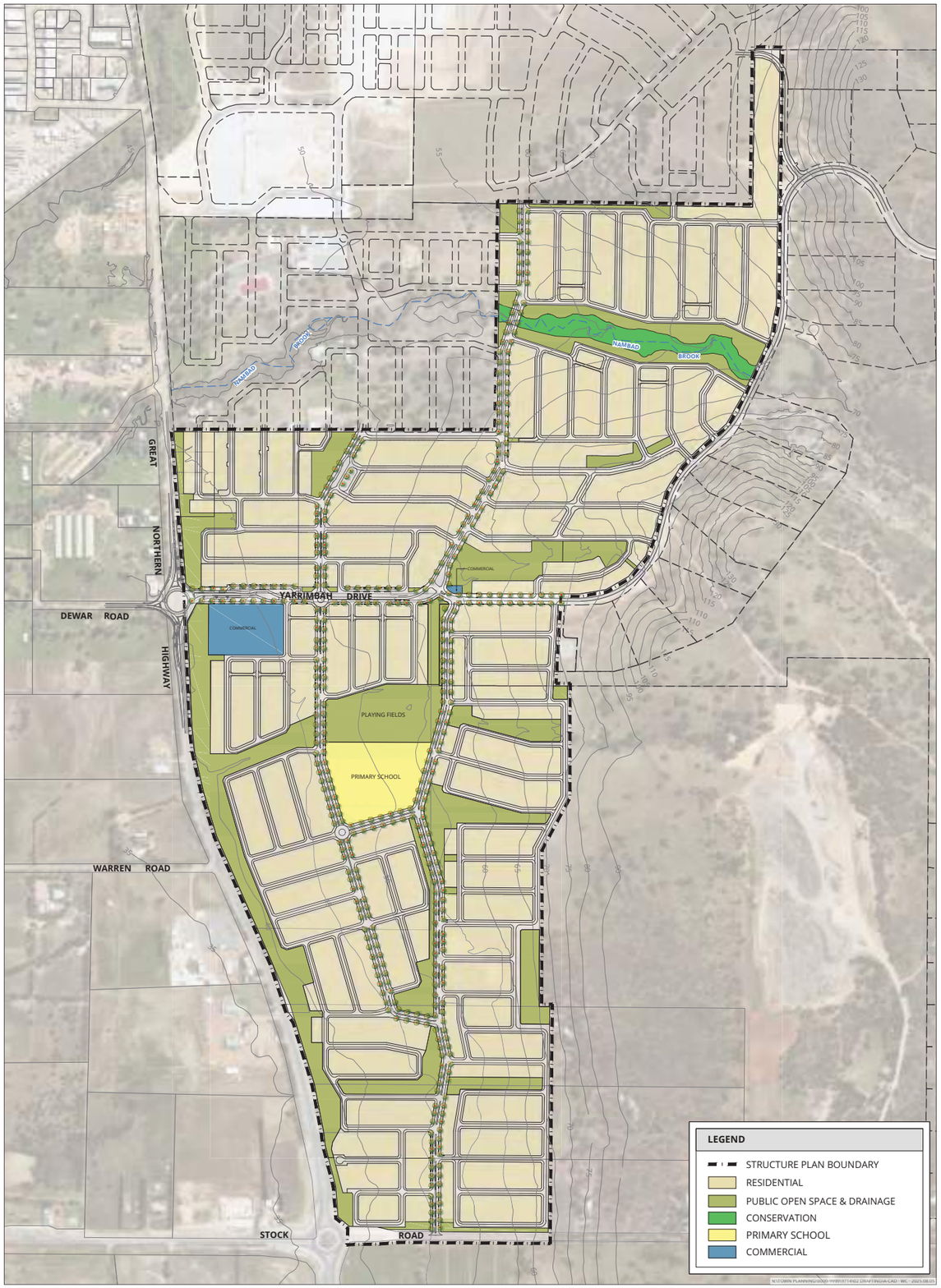
Based on the information available, the development of the Bullsbrook South Structure Plan Area should be from the north, moving in a southerly direction utilising access from Great Northern Highway.

With continued emphasis by the Water Corporation on regional infrastructure planning for the Northeast Corridor, there should be no noted shortfall in infrastructure or constraints that would prevent development of this land for residential development in a staged and timely fashion.

Appendices

Appendix One:	Bullsbrook South Expansion Area Concept Master Plan
Appendix Two:	Acid Sulphate Soil Risk Map
Appendix Three:	Iron Staining Risk Map
Appendix Four:	1:50,000 Environmental Geology Series Map – Muchea
Appendix Five:	Preliminary Geotechnical Investigation
Appendix Six:	Existing Ground Contours
Appendix Seven:	Perth Groundwater Map
Appendix Seven B:	Preliminary Earthwork and Drainage Design
Appendix Eight:	Bullsbrook Central Sewer Catchment
Appendix Nine:	Temporary Sewer Catchment Diversion
Appendix Ten:	Bullsbrook South Sewer Catchment Timing
Appendix Eleven:	North East Corridor Waste Water Concept Plan July 2023
Appendix Twelve:	ATCO Gas Correspondence
Appendix Thirteen:	Existing Western Power Infrastructure
Appendix Fourteen:	Existing Communication and Fibre Infrastructure

Appendix One: Bullsbrook South Expansion Area Concept Master Plan



INDICATIVE SUBDIVISION CONCEPT

VARIOUS LOTS - GREAT NORTHERN HIGHWAY
BULLSBROOK

N

0 200 m
SCALE @ A3: 1:8,000

9714-FIG-58-A

DRAWN: WC
DATE CREATED: 2025.08.05
PROJECTION: PCG94
CADASTRE: LANDGATE

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ROWE GROUP DESIGN

Appendix Two: **Acid Sulphate Soil Risk Map**

Superseded

The acid sulfate soils maps set out in Planning Bulletin No. 64 cover the Swan Coastal Plain and are provided as a guide to the location of acid sulfate soil layers occurring at different depths in this area. They have been prepared on the basis of geological origin, depth to groundwater, and partial 'ground-truthing'.

The maps have been prepared by the Department of Environment and the Department for Planning and Infrastructure on this basis in good faith, exercising all due care and attention. No representation or warranty, expressed or implied, is made as to the relevance, accuracy, completeness or fitness for purposes of these maps in respect of any particular user's circumstances. Users of these maps should satisfy themselves concerning their application to their situation, and where necessary seek expert advice.

The acid sulfate soils maps set out in Planning Bulletin No. 64 will be periodically updated as new information becomes available and the State Government's acid sulfate soil mapping program progresses.

Users should check the Policies and Planning Bulletins page on the Western Australian Planning Commission's website at www.wapc.wa.gov.au to ensure that they have the most up to date version of the mapping.

Alternative versions of this mapping and the associated digital data can be obtained from the Department for Planning and Infrastructure as follows:

Geographic Information Officer

Phone: 08 9264 7827
Fax: 08 9264 7838
Email: mapping@dpi.wa.gov.au

WESTERN AUSTRALIAN PLANNING COMMISSION

GDA

Two Rocks
WANNEROO ROAD
YANCHEP NATIONAL PARK
Yanchep
Eglinton
OLD YANCHEP ROAD
Carabooda
INDIAN OCEAN
Quinns Rock
WANNEROO ROAD
Neerabup
Mindarie
NEVES ROAD
Burns
Joondalup
Wanneroo
Ocean Reef
Craigee
GREAT NORTHERN HIGHWAY
BRAND HIGHWAY
Bulsbrook
Bullsbrook South Urban Expansion Area
WALYUNGA NATIONAL PARK
Ellenbrook
GNANGARA ROAD

N

0 2 4 6
Kilometres

Produced by Project Mapping Section, Planning Information - Mapping and Spatial, Department for Planning and Infrastructure, on behalf of the Department of Environment and the Western Australian Planning Commission, Perth, W. A. November 2003

ntw-map18\ \plan_imp\plan_reform\acid_sulphate\ maps\Review_Oct03\pmr_north_Oct03.dgn

Cadastral Data supplied by Department of Land Information, Western Australia

LEGEND

- High risk of actual acid sulfate soil (AASS) & potential acid sulfate soil (PASS) <3m from surface
- Moderate to low risk of AASS and PASS occuring generally at depths of >3m
- Low to no risk of AASS and PASS occuring generally at depths of >3m
- Local Government Boundary

Planning Bulletin Number 64

Figure 2: North Metropolitan Region Scheme Acid Sulfate Soils

Appendix Three: Iron Staining Risk Map

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Rutland Rd
Neaves Rd
Bullsbrook - West
East Bullsbrook
Bullsbrook
RAAF Base Pearce
Bonita
Veray
Killara
Chittering Rd
Lareema
Greenslopes
Yalliawirra
Killcodey
Great Northern Hwy
Lewoma
Shady Hills
Okaparinga
Woodsome Estate
Warbrook
Twin Swamps Nature Reserve
Walyunga National Park
Walyunga National Park

Appendix Two: Acid Sulphate Soil Risk Map

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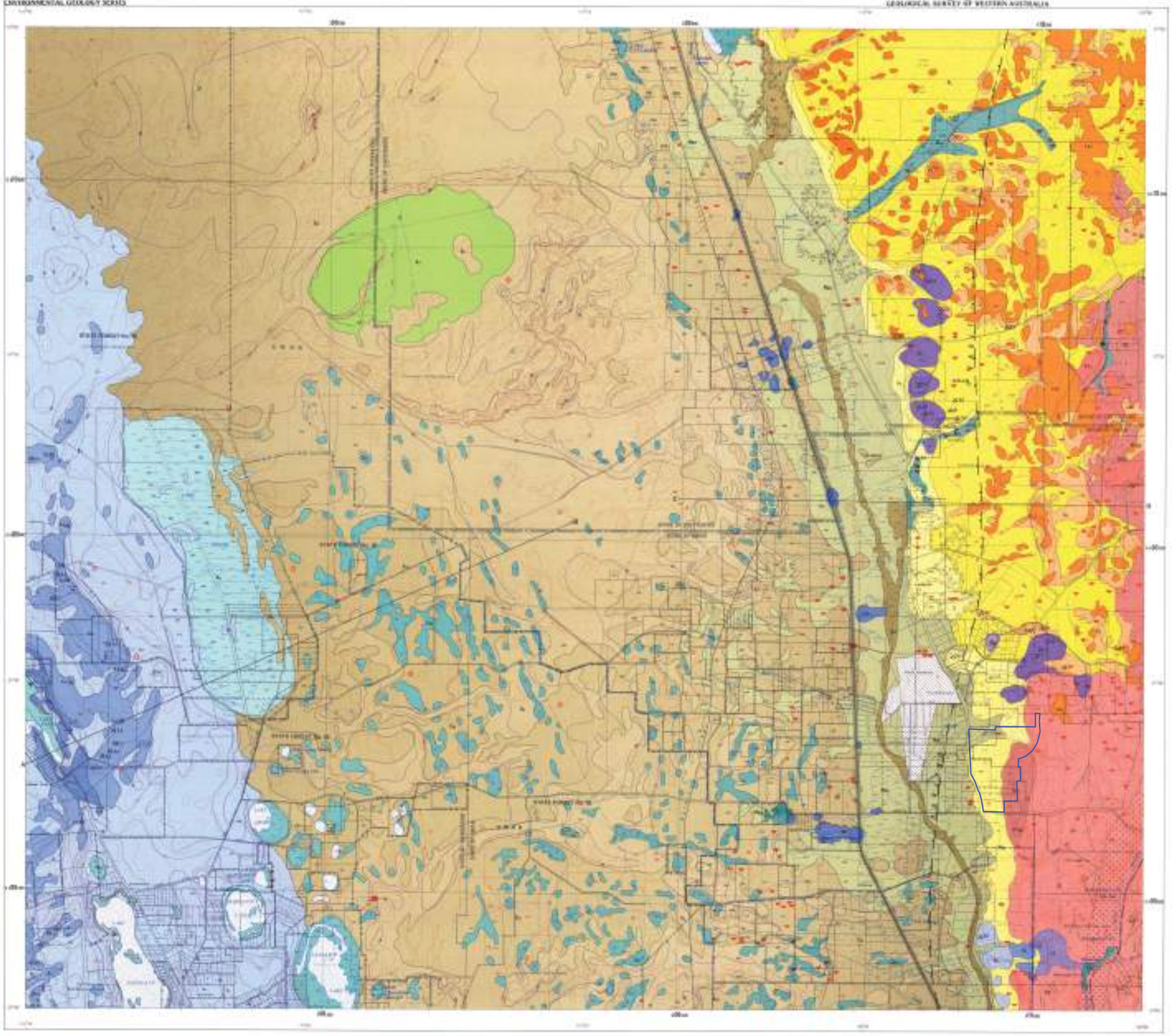
ENVIRONMENTAL GEOLOGY SERIES

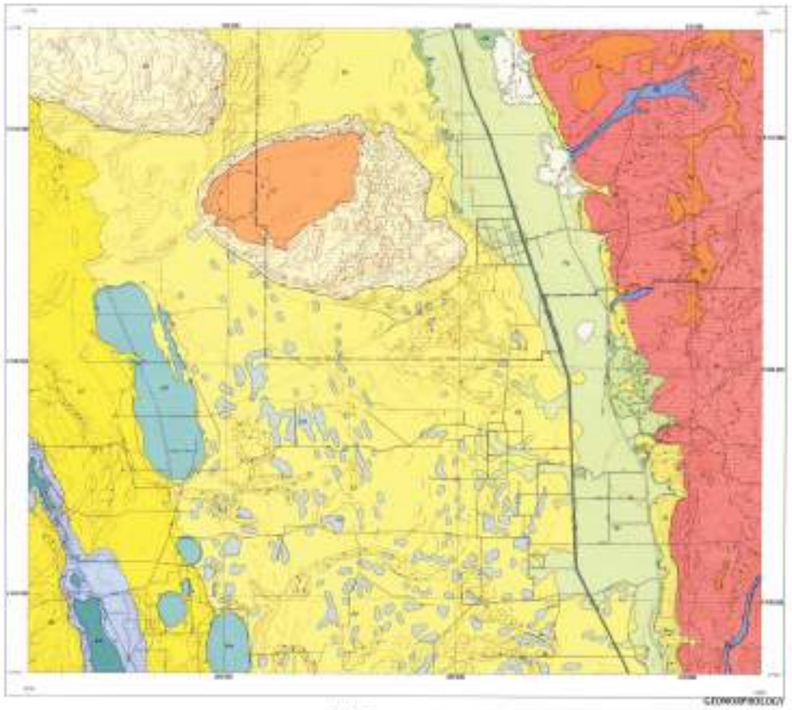
MUCHEA

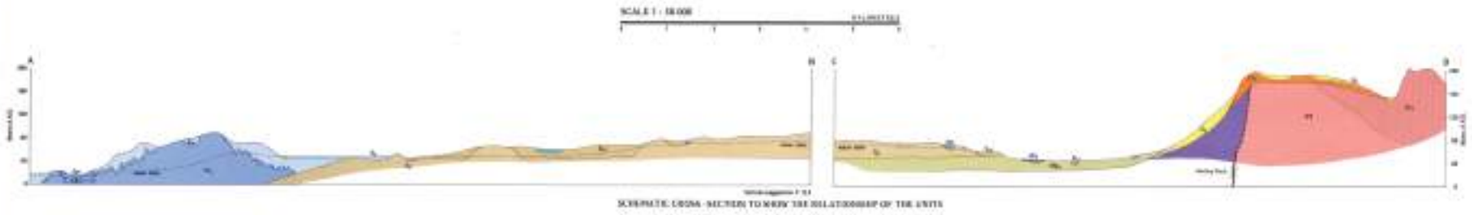
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET 2034 I AND PART OF 2134 IV



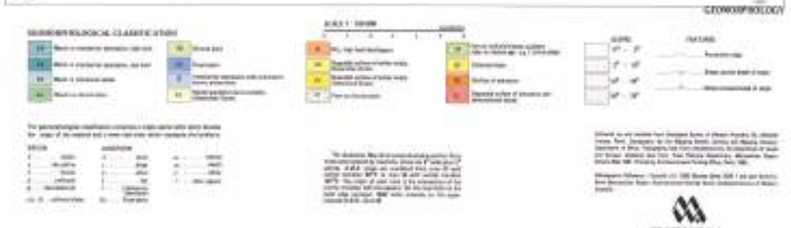






SCHEMATIC LOCAL SECTION TO SHOW THE RELATIONSHIP OF THE UNITS





GEOMORPHOLOGY

PERTH METROPOLITAN REGION
1 : 50 000 ENVIRONMENTAL GEOLOGY SERIES

MUCHEA

SHEET 2034 I AND PART OF 2134 IV

Appendix Five: **Preliminary Geotechnical Investigation**

Report on

PRELIMINARY GEOTECHNICAL STUDY
PROPOSED RESIDENTIAL SUBDIVISION
VARIOUS LOTS - GREAT NORTHERN HIGHWAY & LAGE ROAD, BULLSBROOK

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J2201093 001 R Rev0

16 May 2022

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2. Site Description and Proposed Development 1
3. Project Objectives 1
4. Fieldwork 1
5. Laboratory Test Results 2
6. Site Conditions 3
6.1 Geology 3
6.2 Subsurface Soil Conditions 3
6.3 Groundwater 4
7. Preliminary geotechnical assessment 4
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APPENDIX A: SUPPLIED DRAWINGS
APPENDIX B: SITE PHOTOGRAPHS
APPENDIX C: TEST PIT REPORTS
APPENDIX D: DYNAMIC CONE PENETROMETER TEST RESULTS
APPENDIX E: LABORATORY TEST RESULTS
APPENDIX F: UNDERSTANDING YOUR REPORT

1. INTRODUCTION

This report presents the outcomes of Galt Geotechnics Pty Ltd's (Galt's) preliminary geotechnical study for the proposed residential subdivision for Bullsbrook South covering various lots along Great Northern Highway and Lage Road, Bullsbrook ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

We note that the outcomes presented in this report should be used as a high-level assessment to guide future detailed investigations.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The site is irregular in shape, comprising multiple lots covering an area of over 187 ha (refer Figure 1). The site is mostly pastoral land, and is vegetated with grass and some mature trees scattered across parts of the site.

Publicly available survey information indicates the site slopes up from around RL 40 m AHD along the western boundary to around RL 80 m AHD along the eastern boundary.

A residential subdivision is proposed across the area. The proposed subdivision masterplan is presented in Appendix A, Supplied Drawings.

3. PROJECT OBJECTIVES

The objectives of the study were to:

broadly assess subsurface soil and groundwater conditions across the site;
provide a preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings"; and
assess key geotechnical issues relating to earthworks of the site.

This study was not intended for detailed design, but rather to inform the project team of broad geotechnical conditions and provide an appreciation of high-level planning for ground-related issues to inform detailed design.

4. FIELDWORK

Galt carried out the following fieldwork on 6 April 2022:

excavation of test pits at 18 locations, extending to depths of between 1.0 m and 3.2 m;
testing with a dynamic cone penetrometer (DCP) adjacent to each borehole, extending to refusal depths of between 0.1 m and 0.7 m; and
collection of samples for geotechnical laboratory testing.

General

BMD selected the location of the test pits and carried out the excavation of the test pits. Our geotechnical engineer observed the test pitting, logged the materials encountered in the test pits, performed the penetrometer testing and collected samples for laboratory testing.

The investigation was carried out in general accordance with AS1726-2017 "Geotechnical site investigations".

J2201093 001 R Rev0
16 May 2022

The approximate test locations are shown on Figure 1, Site and Location Plan. Photographs of the site are presented in Appendix B.

Details of the tests are presented below in Table 1.

Table 1: Summary of Tests

Test Name	Test Depth (m)	Reason for Termination	Stratigraphy
TP01/BH15	2.2	Target depth	Sandy GRAVEL overlying Clayey SAND/SAND
TP02/BH14	2.5		GRAVEL overlying Clayey SAND
TP03/BH13	2.5		Silty SAND overlying SAND/ Clayey SAND overlying Sandy CLAY
TP04/BH10	3.2		Silty GRAVEL overlying SAND/Clayey SAND overlying CLAY overlying ROCK
TP05/BH24	2.1	Refusal	Silty GRAVEL overlying SAND/Clayey SAND overlying Extremely Weathered ROCK overlying ROCK
TP06/BH09	1.0		GRAVEL overlying Sandy CLAY overlying ROCK
TP07/BH25	3.0	Target depth	Clayey Sandy GRAVEL overlying CLAY
TP08/BH08	1.5	Refusal	Sandy Silty GRAVEL overlying Sandy CLAY
TP09/BH07	1.0		GRAVEL overlying Sandy CLAY overlying possible SCHIST
TP10/BH06	2.5	Target depth	Sandy CLAY overlying CLAY overlying possible SCHIST
TP11/BH05	3.0		Sandy CLAY overlying CLAY overlying Sandy CLAY
TP12/BH04	2.7		Sandy CLAY overlying CLAY
TP13/BH18	3.0		Sandy CLAY overlying CLAY
TP14/BH19	3.0		Sandy CLAY overlying Clayey SAND
TP15/BH20	3.0		CLAY
TP16/BH21	3.0		Clayey GRAVEL overlying Sandy CLAY overlying Clayey SAND
TP17/BH16	2.8		Sandy CLAY overlying CLAY
TP18/BH01	2.5		GRAVEL overlying Clayey Gravelly SAND overlying Clayey SAND overlying Sandy CLAY

Notes: 1. GNE – Groundwater not encountered in any test pits

Test Pits

Test pits were excavated using a 33 tonne CAT330F excavator equipped with a 0.65 m wide rock bucket. The excavator was supplied and operated by BMD.

Test pit reports are presented in Appendix C, along with a method of soil and rock description and a list of explanatory notes and abbreviations used in the reports.

Dynamic Cone Penetrometer (DCP) Tests

DCP tests were carried out in accordance with AS 1289.6.3.2. Tests were carried out adjacent to each test pit and the results of the tests are presented in Appendix D.

5. LABORATORY TEST RESULTS

Laboratory testing was conducted by Western Geotechnical and Laboratory Services, a NATA accredited laboratory. The testing comprised determination of:

particle size distribution on 6 samples; and
Atterberg limits and linear shrinkage on 6 samples;

The laboratory test results are presented in Appendix E along with the test methods followed and a summary of the test results is presented in Table 2.

Table 2: Summary of Laboratory Test Results

Test Name	Sample Depth (m)	Soil Class (AS1726 2017)	% Gravel	% Sand	% Fines	LL (%)	PI (%)	LS (%)
TP01/BH15	1.5 to 2.0	SAND (SP) [2]	16	82	2	42	18	5.0
TP04/BH10	0.8 to 1.2	SAND (SP-SC) [2]	10	84	6	39	15	6.0
TP07/BH25	0.8 to 1.2	CLAY (CH)	16	17	67	59	38	8.0
TP11/BH05	0.7 to 1.1	CLAY (CH)	13	12	75	68	45	14.0
TP15/BH20	0.5 to 1.0	CLAY (CH)	16	13	71	66	43	12.0
TP17/BH16	2.2 to 2.7	Clayey GRAVEL (GC)	63	10	27	57	36	9.5

Notes **1.** LL – Liquid Limit PI – Plasticity Index LS – Linear Shrinkage

2. Despite the low fines content for TP01/BH15 and TP04/BH10, our tactile assessment of these sand samples displayed clayey properties. This sandy material must be assumed to have a low hydraulic conductivity when compacted (unless further testing can justify otherwise).

6. SITE CONDITIONS

6.1 Geology

The Muchea sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is underlain by predominantly Sandy SILT.

The findings of our investigation are broadly consistent with the geological mapping. Shallow clayey soils were predominantly present across the site with variable sand thicknesses in some areas. Rock (possibly granite or schist) was also noted along parts of the (more elevated) northeast corner of site.

6.2 Subsurface Soil Conditions

The subsurface soil conditions are somewhat variably across the site. Typical soil profiles have been broadly summarised as follows:

Parts of the northern end of site (typically Zone 1 – refer to Section 7)

Sandy GRAVEL/Silty GRAVEL (GP/GM): fine to coarse grained, angular to sub-rounded, brown, about 5% to 20% non-plastic fines extending from the surface to depths of typically between 0.3 m to 0.5 m; overlying
Clayey SAND/ SAND (SC/SP): fine to coarse grained, orange brown, 5-15% low to medium plasticity fines extending to depths of between 0.9 m and 2.4 m;

Extremely Weathered ROCK/ ROCK – possibly quartz rich, metamorphic rock present from depths of between 0.9 m and 2.8 m.

Central part of site (typically Zone 3 – refer to Section 7)

Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 m.

Central and south of the site (Zone 2 – refer to Section 7)

Zone 2 is as Zone 3 but with a thin and irregular overlay of granular material (gravel or sand), typically about 0.3 m to 0.4 m thick.

Note: 1. Subsurface conditions are variable. Reference should be made to the test pit reports for the specific soil conditions

6.3 Groundwater

The Perth Groundwater Atlas (2003) shows the end of summer level to be around RL 35 m to 45 m AHD. This is within about 5 m of the current ground surface near the western site boundary.

We did not encounter any groundwater in any of the test pits. However, we expect shallow perched groundwater to develop on the clayey soils during winter. Drainage designs must take this into account.

7. PRELIMINARY GEOTECHNICAL ASSESSMENT

Based on the findings of our investigation, we note that the following key geotechnical issues relating to this site and associated earthworks.

Preliminary Site Classification

We have assessed the site in accordance with AS 2870-2011 “Residential Slabs and Footings” which defines the site classes as summarised in Table 3.

Table 3 Summary of Site Classifications

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock site with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm

Class	Description	Characteristic Surface Movement (y_s)
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

Under current conditions, we consider the preliminary site classifications to be as follows:

Zone 1 – Class S (thick layers of inert granular material and/or low reactive clayey soils)

Zone 2: Class M (thin layer of inert granular material overlying shallow high plasticity clayey)

Zone 3 -Class H1/Class H2 (near surface high plasticity clay soils)

If required, the site classifications can be improved by placement and compaction of inert fill material. The thicknesses required in each zone are summarised in Table 4. The indicative soil zones are shown on Figure 1.

Table 4: Indicative Required Thickness of Inert Fill (m)

Zone	Current Site Class	Current nominal thickness of mostly granular surficial in-situ soil (m)	Improvement to Class M	Improvement to Class S	Improvement to Class A
Zone 1	S	0.9 to 2.4	-	-	1.8
Zone 2	M	0.3 to 0.4	-	0.5	1.8
Zone 3	H1/H2	0	0.4	0.9	1.8

We note the following:

- The delineation of the site classification zones is approximate only and based on very limited data. This will need to be supported by substantial additional testing on site for detailed design.
- Shrink-swell testing is required to better refine site classes.
- We note shallow rock was present in isolated areas within Zone 2. The site classification for areas underlain by shallow rock may be improved to Class S (these areas should be confirmed through further investigation).
- It is likely that the sand/clayey sand present in the north of the site (Zone 1) is very loose in situ (testing done to date has not proven this, however we have worked on nearby sites which had similar sand. This may require substantial earthworks to compact this material. Without such compaction, the sand/clayey sand may be collapsible (subject to consolidation under constant stress when inundated).
- The thicknesses of fill presented in Table 4 to improve the site classifications is in addition to the mostly granular surficial in-situ soil layer (nominal thickness also shown in Table 4).

Drainage Control and Construction Issues

Compaction and trafficking of the clayey areas of the site must NOT be attempted when the site is wet (i.e. following rainfall or if the site has been over-wetted during moisture conditioning). It will be necessary to let the site dry out or trim wet soil off to expose underlying drier material. Attempting to traffic or compact the wet clayey soils is likely to result in soil disturbance and significant softening of the clayey soils. Where shaping or grading of the underlying clay surface is carried out, the surface should be graded to divert rainfall and surface water away from any work areas and to avoid ponding.

Due to the low permeability of the clayey soils, storm water runoff is expected to pond on the clayey soils during the wetter months of the year. This may cause difficulties during construction including:

- heaving and rutting of saturated clayey soils when trafficked; and
- softening of clayey soils when water is allowed to pond at the base of excavations.

We recommend that earthworks are carried out in the summer months, even though earthworks conducted in summer can have their own issues such as dust control and rapid drying out of soils.

The moisture conditioning of the clayey soils is likely to be somewhat onerous (given that they are highly plastic, which tends to make them 'cloddy' and more difficult to moisten), however proper moisture conditioning is essential to successful compaction of clayey soils.

Compaction

No loose/soft soils, as inferred from DCP testing, were encountered during our investigation. As noted above, it is possible that the clayey sand may be very loose to loose in situ and collapsible.

Compaction control, on both in-situ sand and clayey soils, should be done with the nuclear density gauge in accordance with AS1289.5.8.1, to a depth of 0.3 m.

The use of penetrometers (either Perth sand or dynamic cone) would be limited to:

- spot checks of clayey fill for the contractor's satisfaction before undertaking NDG testing; and
- testing of clean sand fill (<5% fines, <5% gravel), which would be imported from off-site.

Stormwater Disposal

Based on the soil profile, we do not consider that disposal of stormwater by infiltration is appropriate for the site. Stormwater should instead be diverted using drains or otherwise to a disposal area or similar located away from structures.

8. CLOSURE

We draw your attention to Appendix F of this report, "Understanding your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD

Piravin Anandacoomaraswamy
Geotechnical Engineer

Owen Woodland CPEng
Geotechnical Engnieer

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Figures

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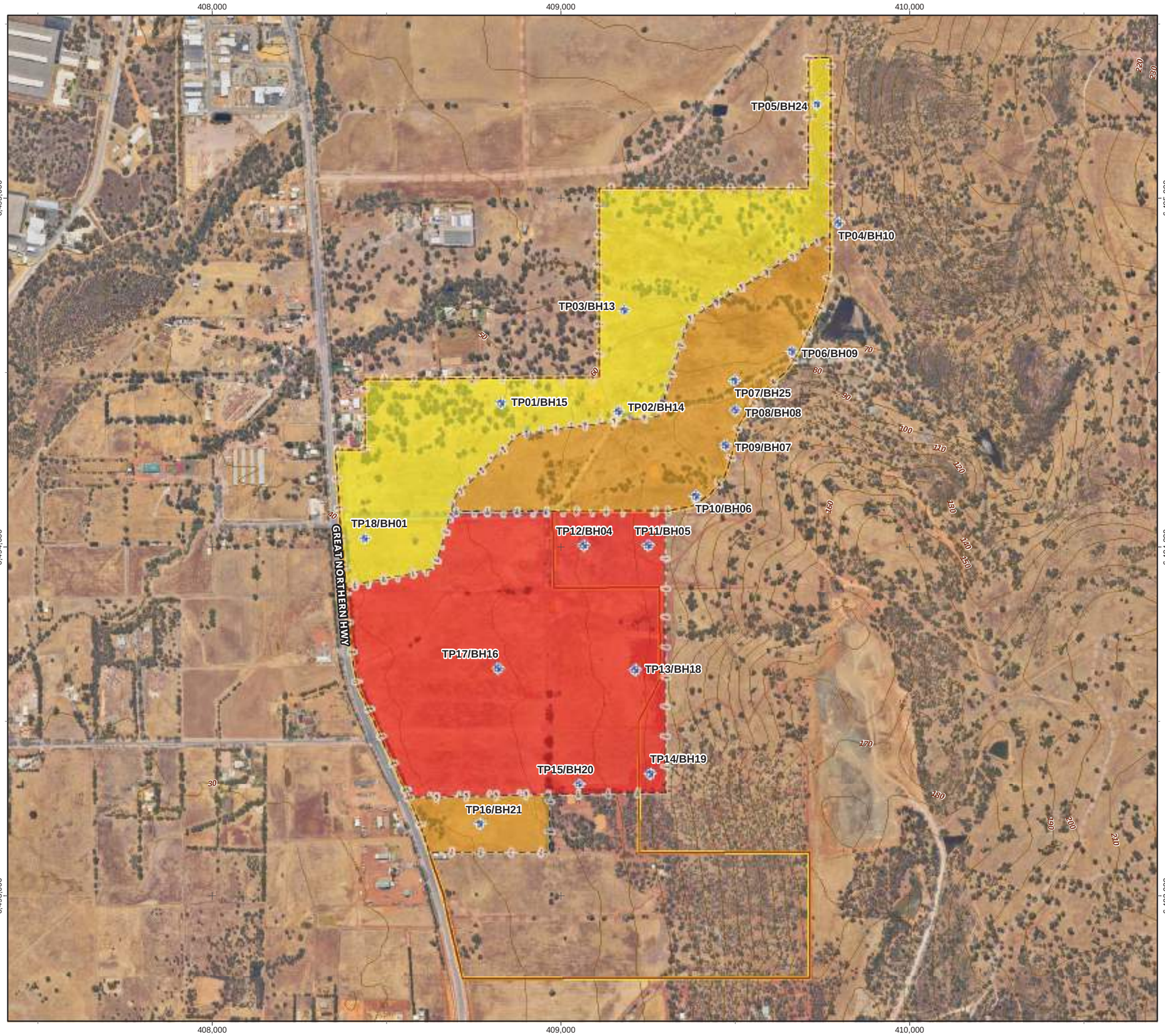



Legend

- Site Boundary

Preliminary Site Classifications (AS2870-2011)

- Possible Class H1/H2
- Possible Class M
- Possible Class S
- Test Pit

N

0 175 350 525 700 875

Meters

NOTES

Aerial Imagery and Cadastre sourced from Landgate/SLIP



SCALE	1:11,000	(A3)
DRAWN	CED	
DATE DRAWN	12/05/2022	
CHECKED	_	
DATE CHECKED	_	
PROJECTION	GDA 1994 MGA Zone 50	

Galt Geotechnics Pty Ltd
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CLIENT	**PRITCHARD FRANCIS**
PROJECT	DUE DILIGENCE
LOCATION	GREAT NORTHERN HIGHWAY BULLSBROOK
TITLE	SITE & LOCATION PLAN

Job No	Fig No	Rev
J2201093	FIGURE 1	**A**

Appendix A: Supplied Drawings

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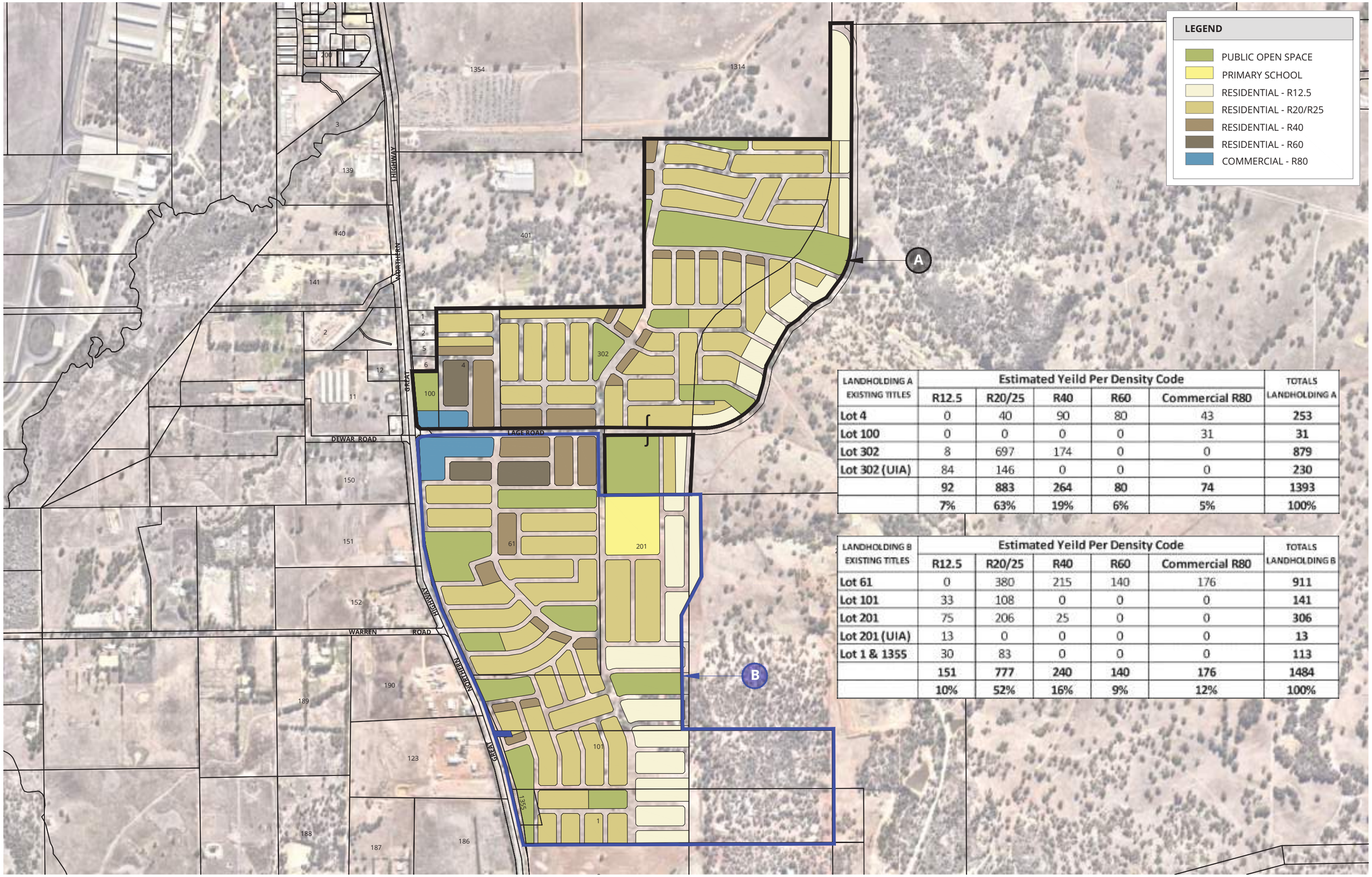

LANDHOLDING A EXISTING TITLES	Estimated Yeild Per Density Code					TOTALS LANDHOLDING A
	R12.5	R20/25	R40	R60	Commercial R80	
Lot 4	0	40	90	80	43	**253**
Lot 100	0	0	0	0	31	**31**
Lot 302	8	697	174	0	0	**879**
Lot 302 (UIA)	84	146	0	0	0	**230**
	92	**883**	**264**	**80**	**74**	**1393**
	7%	**63%**	**19%**	**6%**	**5%**	**100%**

LANDHOLDING B EXISTING TITLES	Estimated Yeild Per Density Code					TOTALS LANDHOLDING B
	R12.5	R20/25	R40	R60	Commercial R80	
Lot 61	0	380	215	140	176	**911**
Lot 101	33	108	0	0	0	**141**
Lot 201	75	206	25	0	0	**306**
Lot 201 (UIA)	13	0	0	0	0	**13**
Lot 1 & 1355	30	83	0	0	0	**113**
	151	**777**	**240**	**140**	**176**	**1484**
	10%	**52%**	**16%**	**9%**	**12%**	**100%**

BULLSBROOK SOUTHERN PRECINCT MAJOR LANDHOLDINGS A & B

CONCEPT STRUCTURE PLAN

LOTS 4, 61, 100 & PT 302 LAGE ROAD AND LOTS 1,101, 201 & 1355 GREAT NORTHERN HIGHWAY, BULLSBROOK

NORTH

0m 200m

SCALE @ A3: 1:11,000

4790-CON-12-E

ROWE GROUP

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Appendix B: Site Photographs



Photograph 1: View of site from near TP02/BH14



Photograph 2: View of rock recovered from TP05/BH24



Photograph 3: Excavator ripping through shallow rock present near TP06/BH09



Photograph 4:Rock recovered from TP09/BH07



Photograph 5: Looking west from near TP11/BH05



Photograph 6: Looking east at excavator positioned near TP14/BH19

Appendix C: Test Pit Reports

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

NOTE: Dual classification given for soils with a fines content between 5% and 12%.

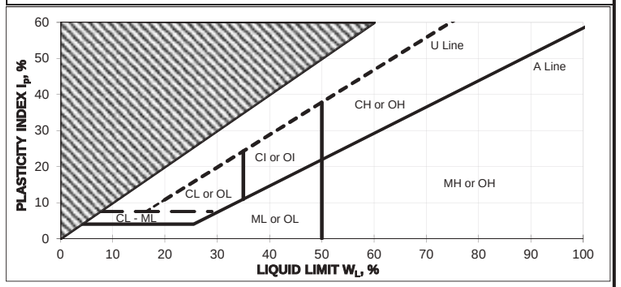
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).
NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION

Symbol	Term
D	Dry
M	Moist
W	Wet

CEMENTATION

Cementation	Description
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY

Symbol	Term	Undrained Shear Strength (kPa)
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS

Material	Organic Content % of dry mass
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY

Symbol	Term	Density Index (%)
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

TEST PIT: TP01/BH15

Job Number: J2201093
Client: Pritchard Francis
Project: Bullsbrook Southern Precinct Major
Location: Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook

Contractor: BMD
Machine: CAT 330F
Operator: JB
Bucket: 650 mm toothed

Date: 06/04/2022
Logged: PA
Checked Date: 13/05/2022
Checked By: ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP	Sandy GRAVEL: fine to coarse grained, angular to sub-rounded, brown, approximately 30% fine to coarse grained sand, trace fines	D	L D VD	Consistency/density assessed from DCP test adjacent to test pit.
			1.5		B(TP01-01)			SC / SP	Clayey SAND/SAND: fine to coarse grained, orange-brown, 5-15% low to medium plasticity fines			Ripper used at 1.2 m. Sand easily ripped.
			2.5						Hole terminated at 2.20 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP02/BH14

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					GP-GM	GRAVEL: fine to coarse grained, angular to sub-rounded, brown, with sand, with fines, trace organics in top 100 mm		L VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP02-01)			SC	Clayey SAND: fine to coarse grained, orange-brown, 15-25% low to medium plasticity fines, with gravel	D		
	E-F		1.0									
			1.5									
			2.0									
			2.5						Hole terminated at 2.50 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP03/BH13

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					SM	Silty SAND: fine to coarse grained, brown, 15-25% non-plastic fines, trace gravel		D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					SC / SP	SAND/Clayey SAND: fine to coarse grained, orange-brown, 5-20% low to medium plasticity fines, trace gravel	D	VD	
	E		1.0									
			1.5					CI	Sandy CLAY: medium plasticity, orange-brown, 30-50% fine to coarse grained sand, with gravel			
			2.0									
			2.5						Hole terminated at 2.50 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP04/BH10

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0		B(TP04-01)			GM	Silty GRAVEL: fine to coarse grained, angular to sub-rounded, pale brown, 15-25% non-plastic fines, with sand, trace organics in top 50 mm	D	MD / D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5									
			1.0		B(TP04-02)			SC / SP	SAND/Clayey SAND: fine to coarse grained, orange-brown, 5-15% low to medium plasticity fines, with gravel			
			1.5									
			2.0									
			2.5					CI-CH	CLAY: medium to high plasticity, grey, with fines			
H			3.0						ROCK, possible quartz-rich, metamorphic rock			Rock very slowly ripped with single tyne ripper with extreme difficulty.
			3.5						Hole terminated at 3.20 m Refusal on rock Groundwater not encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP05/BH24

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					GM	Silty GRAVEL: fine to coarse grained, angular to sub-rounded, pale brown, 15-25% non-plastic fines, with sand, trace organics in top 50 mm	D	VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP05-01)			SC / SP	SAND/Clayey SAND: fine to coarse grained, orange-brown, 5-15% low to medium plasticity fines, with gravel			
			1.0						Extremely Weathered ROCK, recovered as cobbles, gravel and boulder in a soil matrix			
			1.5									
			2.0						ROCK, possible quartz-rich, metamorphic rock			
			2.5						Hole terminated at 2.10 m Refusal on rock Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP06/BH09

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling	Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP-GM	GRAVEL: fine to coarse grained, angular to sub-angular, grey-brown, with sand, with fines		VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP06-01)			CI / SP	Sandy CLAY: medium to high plasticity, brown mottled grey, 30-50% fine to medium grained sand, trace gravel	D		
	H		1.0						Hole terminated at 1.00 m Refusal on rock Groundwater not encountered			
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP07/BH25

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling	Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP	Clayey Sandy GRAVEL: fine to coarse grained, brown, 30-40% fine to coarse grained sand, 15-30% low to medium plasticity fines		D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP07-01)			CH / SP	CLAY: high plasticity, orange-brown, with sand, with gravel	D		
	F-H		1.0									
			1.5									
	F		2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP08/BH08

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling	Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0					GM	Sandy Silty GRAVEL: fine to coarse grained, brown, fine to coarse grained sand, non-plastic fines, trace organics in top 50 mm		D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP08-01)			CH	Sandy CLAY: high plasticity, brown, 30-40% fine to coarse grained sand, trace gravel	D		
	H		1.0									
			1.5						Hole terminated at 1.50 m Refusal on rock Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP09/BH07

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling	Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0					GP-GM	GRAVEL: fine to coarse grained, pale brown, with sand, with fines, trace organics in top 50 mm		D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP09-01)			CI-CH	Sandy CLAY: medium to high plasticity, brown, 30-50% fine to coarse grained sand	D		
	H		1.0						Possible SCHIST, recovered as boulders, cobbles and gravel			Rock ripped with single tyne ripper attachments; moderately difficult ripping.
			1.5						Hole terminated at 1.00 m Refusal on rock Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP10/BH06

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E		0.0		B(TP10-01)			CL-CI	Sandy CLAY: low to medium plasticity, brown, 40-60% fine to coarse grained sand, trace gravel	D	D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CI	CLAY: medium to high plasticity, brown, with sand	D / M		
	F		1.5						Possible SCHIST, recovered as cobbles and gravel in a soil matrix	D		Rock easily broken up with single tyne ripper attachment
			2.0									
			2.5						Hole terminated at 2.60 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP11/BH05

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0									
			0.5		B(TP11-01)			CI	Sandy CLAY: medium plasticity, red-brown, 30-50% fine to medium grained sand	D	MD / D	Consistency/density assessed from DCP test adjacent to test pit.
	E		1.0					CH	CLAY: high plasticity, red-brown, trace sand, with gravel	D / M		
			1.5									
			2.0					CI	Sandy CLAY: medium plasticity, pale yellow, 35-45% fine to coarse grained sand			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP12/BH04

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					CI	Sandy CLAY: medium plasticity, red-brown, 30-50% fine to medium grained sand, trace gravel	D	VSt / H	Consistency/density assessed from DCP test adjacent to test pit.
	E		0.5					CH	CLAY: high plasticity, red-brown, with sand, trace gravel	D / M		
			1.0									
			1.5									
			2.0						Red-brown mottled white			
			2.5									
			3.0						Hole terminated at 2.70 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP13/BH18

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0					CI	Sandy CLAY: medium plasticity, red-brown, 40-50% fine to medium grained sand, trace organics in top 50 mm	D	VSt	Consistency/density assessed from DCP test adjacent to test pit.
	E		0.5					CH	CLAY: high plasticity, red-brown, with sand, trace gravel	D / M		
			1.0									
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01 GLB Log GG_EXCAVATION J2201093.GPJ <<DrawingFile>> 29/04/2022 13:13 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

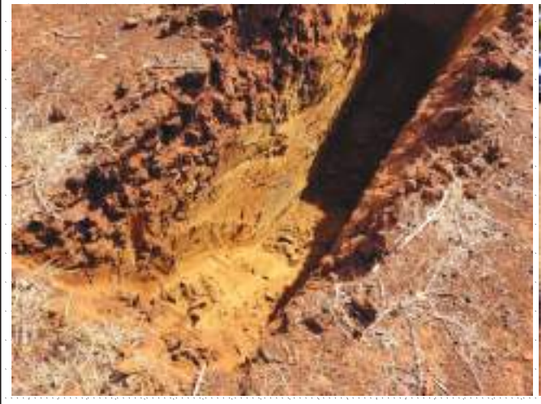
TEST PIT: TP14/BH19

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					CI	Sandy CLAY: medium plasticity, red-brown, 30-50% fine to coarse grained sand, trace gravel	D	VSt	Consistency/density assessed from DCP test adjacent to test pit.
			1.5		B(TP14-01)			SC	Clayey SAND: fine to coarse grained, orange-brown, 15-25% low plasticity fines			
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP15/BH20

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					CH	CLAY: high plasticity, brown, with sand, trace gravel	D		Consistency/density assessed from DCP test adjacent to test pit.
			1.5		B(TP15-01)					D / M		
			2.0						Grey			
			2.5							M		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP16/BH21

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					GC	Clayey GRAVEL: fine to medium grained, red-brown, 15-20% low plasticity fines, with sand	D	D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CI	Sandy CLAY: medium plasticity, brown, 40-60% fine to medium grained sand			
			1.0					SC	Clayey SAND: fine to coarse grained, orange-brown, 15-30% low plasticity fines			
			1.5		B(TP16-01)					D		
			2.0						With gravel			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J2201093.GPJ <<DrawingFile>> 29/04/2022 13:14 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP17/BH16

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					CI	Sandy CLAY: medium plasticity, brown, 40-50% fine to coarse grained sand, trace gravel	D	VSt	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP17-01)							
			1.0							D / M		
			1.5									
			2.0		B(TP17-02)			CH	CLAY: high plasticity, grey, with gravel, trace sand			
			2.5									
			3.0						Hole terminated at 2.80 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP18/BH01

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP	GRAVEL: fine to medium grained, rounded to sub-rounded, brown, with sand, trace fines		D / VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					SC	Clayey Gravelly SAND: fine to coarse grained, orange mottled red, approximately 30% fine to medium grained gravel, approximately 15-20% low plasticity fines	D		
	E		1.0		B(TP18-01)							
			1.5					SC	Clayey SAND: fine to coarse grained, orange-brown, 15-30% low plasticity fines			
			2.0					CI	Sandy CLAY: low to medium plasticity, grey mottled red, 40-60% fine to coarse grained sand			
			2.5						Hole terminated at 2.50 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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Appendix D: Dynamic Cone Penetrometer Test Results

Galt Geotechnics Pty Ltd

www.galtgeo.com.au
50 Edward Street OSBORNE PARK WA 6017

ABN: 64 625 054 729

DYNAMIC CONE PENETROMETER RECORD SHEET
AS 1298.6.3.2

Client: Pritchard Francis **Job No:** J2201093
Project: Proposed Residential Subdivision **Date:** 6-Apr-22
Location: Bullsbrook South **Engineer:** PA

Location:	TP01/BH15	TP02/BH14	TP03/BH13	TP04/BH10	TP05/BH24	TP06/BH09	TP07/BH25	TP08/BH08
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	1	1	1	2	1	7 HB	2	2
100-200	2	7 HB	5	3 HB	8		2 HB	5
200-300	4	10	4	5	6			7 HB
300-400	4	10+	6	9	10			
400-500	4		7	10	7 HB			
500-600	7		9	10+				
600-700	10+		10+					
700-800								
800-900								
900-1000								

Location:	TP09/BH07	TP10/BH06	TP11/BH05	TP12/BH04	TP13/BH18	TP14/BH19	TP15/BH20	TP16/BH21
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	2	4	3	5	3	2	-	2
100-200	5 HB	4 HB	9 HB	10+	10+	4		7 HB
200-300						3 HB		
300-400								
400-500								
500-600								
600-700								
700-800								
800-900								
900-1000								

Location:	TP17/BH16	TP18/BH01					
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**						
0-100	3	1					
100-200	8	5					
200-300	3 HB	10					
300-400		10					
400-500		7 HB					
500-600							
600-700							
700-800							
800-900							
900-1000							

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
0 = Penetration due to hammer weight only
R: Refusal

Appendix E: Laboratory Test Results

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

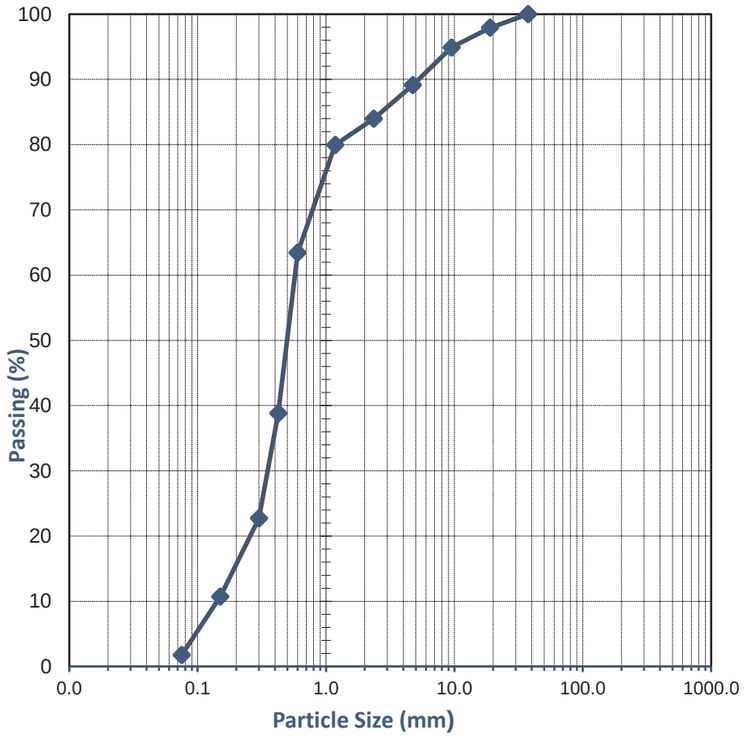
TEST REPORT - AS 1289.3.6.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5445_1_PSD
Project:	Bullsbrook South	*Sample No.*	WG22.5445
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP01/BH15 1.5-2.0m	*Date Tested:*	11/4/22-12/4/22

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	98
9.5	95
4.75	89
2.36	84
1.18	80
0.600	63
0.425	39
0.300	23
0.150	11
0.075	2



Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5445_1_PI
Project:	Bullsbrook South	*Sample No.*	WG22.5445
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP01/BH15 1.5-2.0m	*Date Tested:*	12/04/2022

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	42
AS 1289.3.2.1	Plastic Limit (%)	24
AS 1289.3.3.1	Plasticity Index (%)	18
AS 1289.3.4.1	Linear Shrinkage (%)	5.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Cracked

Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 13/April/2022

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SOIL | AGGREGATE | CONCRETE | CRUSHING

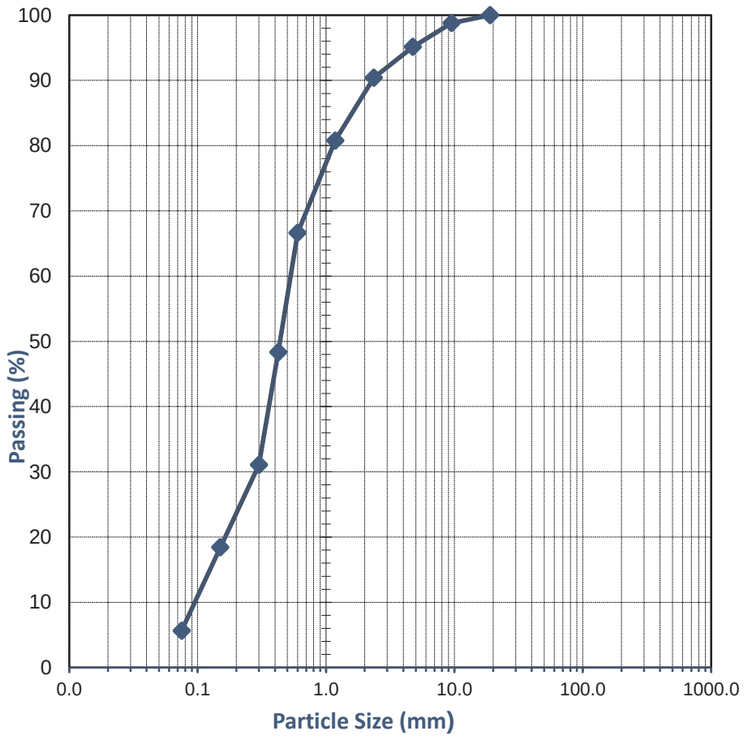
TEST REPORT - AS 1289.3.6.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5446_1_PSD
Project:	Bullsbrook South	*Sample No.*	WG22.5446
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP04/BH10 0.8-1.2m	*Date Tested:*	11/4/22-12/4/22

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	99
4.75	95
2.36	90
1.18	81
0.600	67
0.425	48
0.300	31
0.150	18
0.075	6



Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 12/April/2022

NATA **Accreditation No. 20599**
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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5446_1_PI
Project:	Bullsbrook South	*Sample No.*	WG22.5446
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP04/BH10 0.8-1.2m	*Date Tested:*	12/04/2022

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method: Sampled by Client, Tested as Received

History of Sample: Oven Dried <50°C

Method of Preparation: Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	39
AS 1289.3.2.1	Plastic Limit (%)	24
AS 1289.3.3.1	Plasticity Index (%)	15
AS 1289.3.4.1	Linear Shrinkage (%)	6.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Cracked

Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

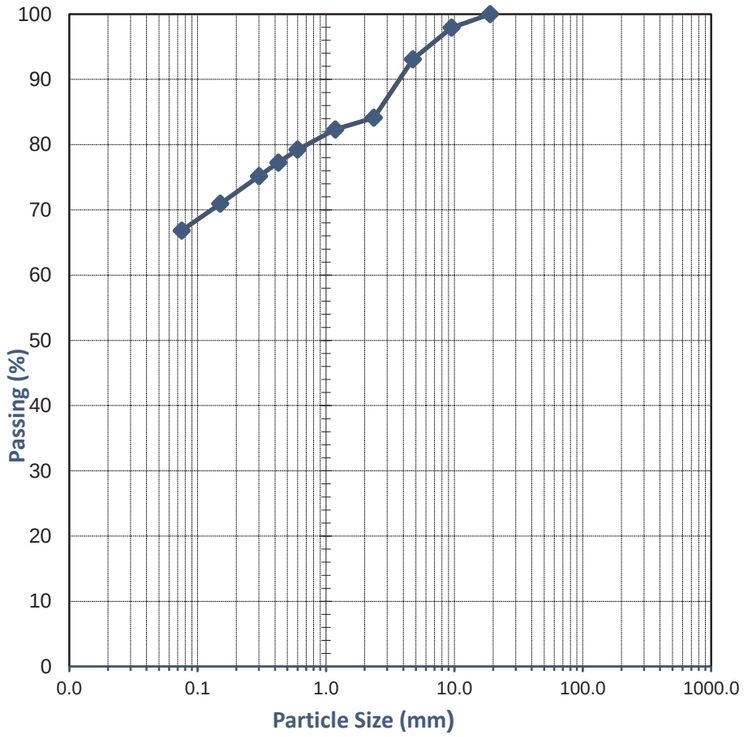
TEST REPORT - AS 1289.3.6.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5447_1_PSD
Project:	Bullsbrook South	*Sample No.*	WG22.5447
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP07/BH25 0.8-1.2m	*Date Tested:*	11/4/22-12/4/22

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	98
4.75	93
2.36	84
1.18	82
0.600	79
0.425	77
0.300	75
0.150	71
0.075	67



Comments:

Approved Signatory:

Name: Cody O'Neill

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5447_1_PI
Project:	Bullsbrook South	*Sample No.*	WG22.5447
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP07/BH25 0.8-1.2m	*Date Tested:*	12/04/2022

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	59
AS 1289.3.2.1	Plastic Limit (%)	21
AS 1289.3.3.1	Plasticity Index (%)	38
AS 1289.3.4.1	Linear Shrinkage (%)	8.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Curled

Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

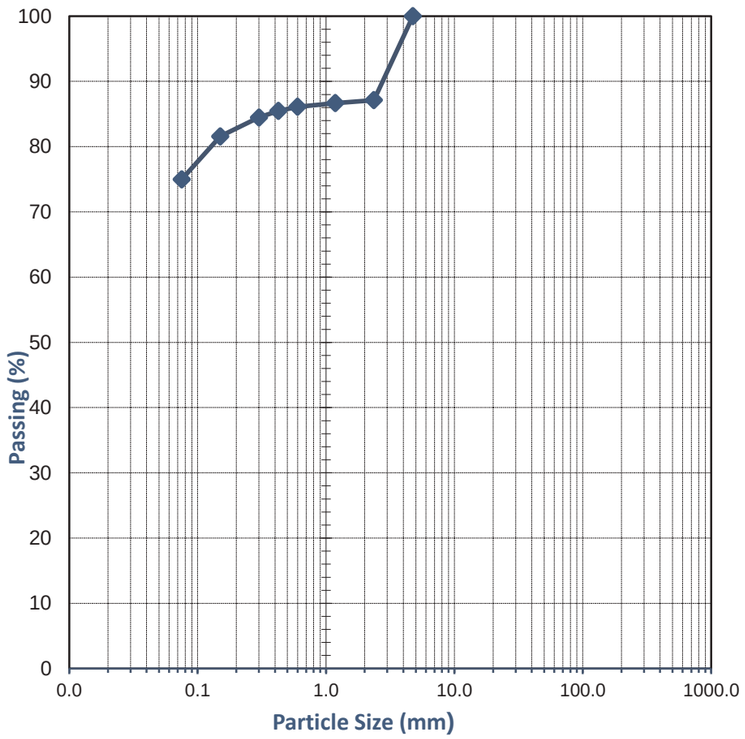
TEST REPORT - AS 1289.3.6.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5448_1_PSD
Project:	Bullsbrook South	*Sample No.*	WG22.5448
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP11/BH05 0.7-1.1m	*Date Tested:*	11/4/22-12/4/22

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	87
1.18	87
0.600	86
0.425	85
0.300	84
0.150	82
0.075	75



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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5448_1_PI
Project:	Bullsbrook South	*Sample No.*	WG22.5448
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP11/BH05 0.7-1.1m	*Date Tested:*	12/04/2022

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	68
AS 1289.3.2.1	Plastic Limit (%)	23
AS 1289.3.3.1	Plasticity Index (%)	45
AS 1289.3.4.1	Linear Shrinkage (%)	14.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Curled

Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 13/April/2022

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SOIL | AGGREGATE | CONCRETE | CRUSHING

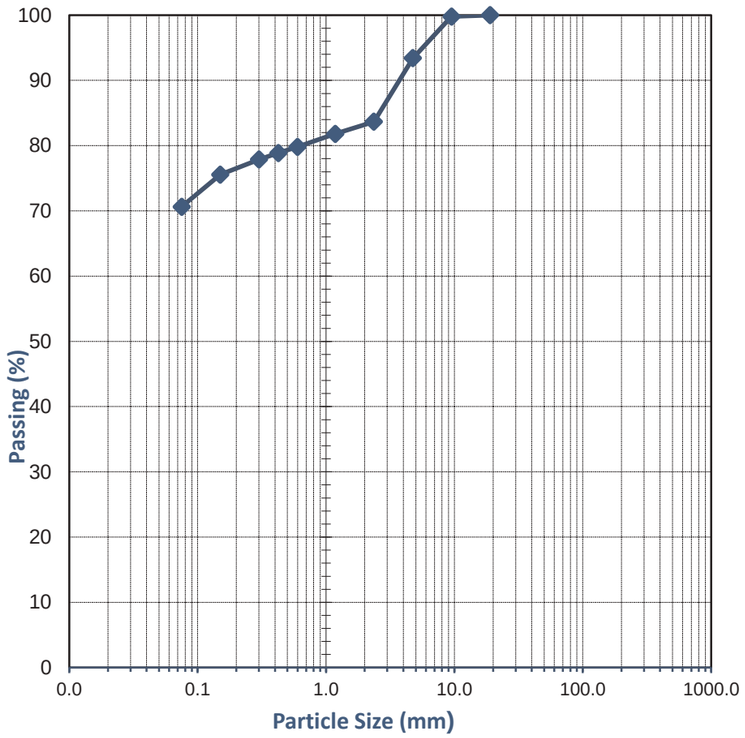
TEST REPORT - AS 1289.3.6.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5449_1_PSD
Project:	Bullsbrook South	*Sample No.*	WG22.5449
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP15/BH20 0.5-1.0m	*Date Tested:*	11/4/22-12/4/22

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	100
4.75	93
2.36	84
1.18	82
0.600	80
0.425	79
0.300	78
0.150	76
0.075	71



Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 12/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5449_1_PI
Project:	Bullsbrook South	*Sample No.*	WG22.5449
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP15/BH20 0.5-1.0m	*Date Tested:*	12/04/2022

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	66
AS 1289.3.2.1	Plastic Limit (%)	23
AS 1289.3.3.1	Plasticity Index (%)	43
AS 1289.3.4.1	Linear Shrinkage (%)	12.0
AS 1289.3.4.1	Length of Mould (mm)	250
AS 1289.3.4.1	Condition of Dry Specimen:	Curled

Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

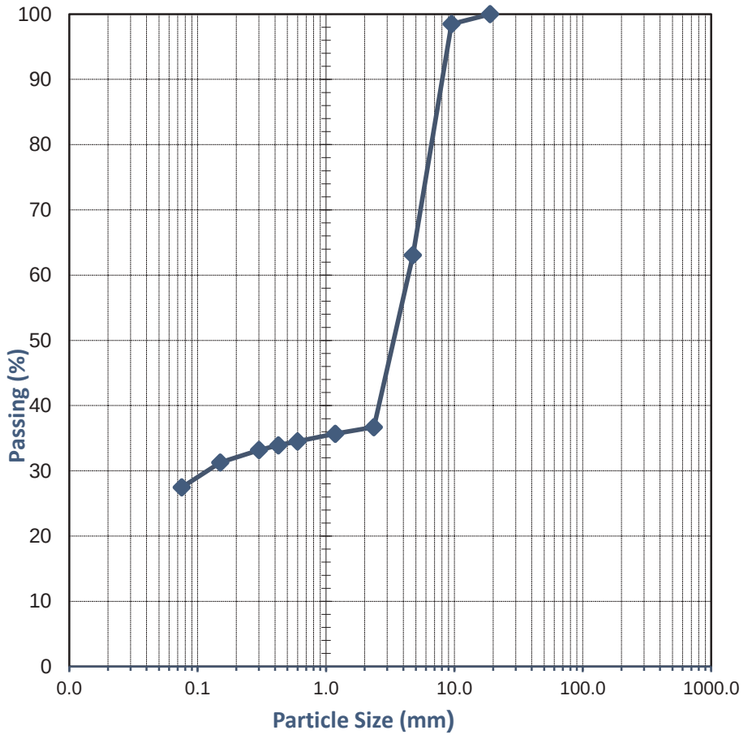
TEST REPORT - AS 1289.3.6.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5450_1_PSD
Project:	Bullsbrook South	*Sample No.*	WG22.5450
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP17/BH16 2.2-2.7m	*Date Tested:*	11/4/22-12/4/22

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	98
4.75	63
2.36	37
1.18	36
0.600	35
0.425	34
0.300	33
0.150	31
0.075	27



Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 12/April/2022

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	Pritchard Francis	*Ticket No.*	S6043
Client Address:	-	*Report No.*	WG22.5450_1_PI
Project:	Bullsbrook South	*Sample No.*	WG22.5450
Location:	Various Lots, Lage Road & Great Northern Highway, Bullsbrook	*Date Sampled:*	Not Specified
Sample Identification:	TP17/BH16 2.2-2.7m	*Date Tested:*	12/04/2022

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	Sampled by Client, Tested as Received
History of Sample:	Oven Dried <50°C
Method of Preparation:	Dry Sieved

AS 1289.3.1.1	Liquid Limit (%)	57
AS 1289.3.2.1	Plastic Limit (%)	21
AS 1289.3.3.1	Plasticity Index (%)	36
AS 1289.3.4.1	Linear Shrinkage (%)	9.5
AS 1289.3.4.1	Length of Mould (mm)	125
AS 1289.3.4.1	Condition of Dry Specimen:	Curled

Comments:

Approved Signatory:

Name: Cody O'Neill

Date: 13/April/2022

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Appendix F: Understanding Your Report

UNDERSTANDING YOUR REPORT

GALT FORM PMP11 Rev3

1. EXPECTATIONS OF THE REPORT

This document has been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

3. SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

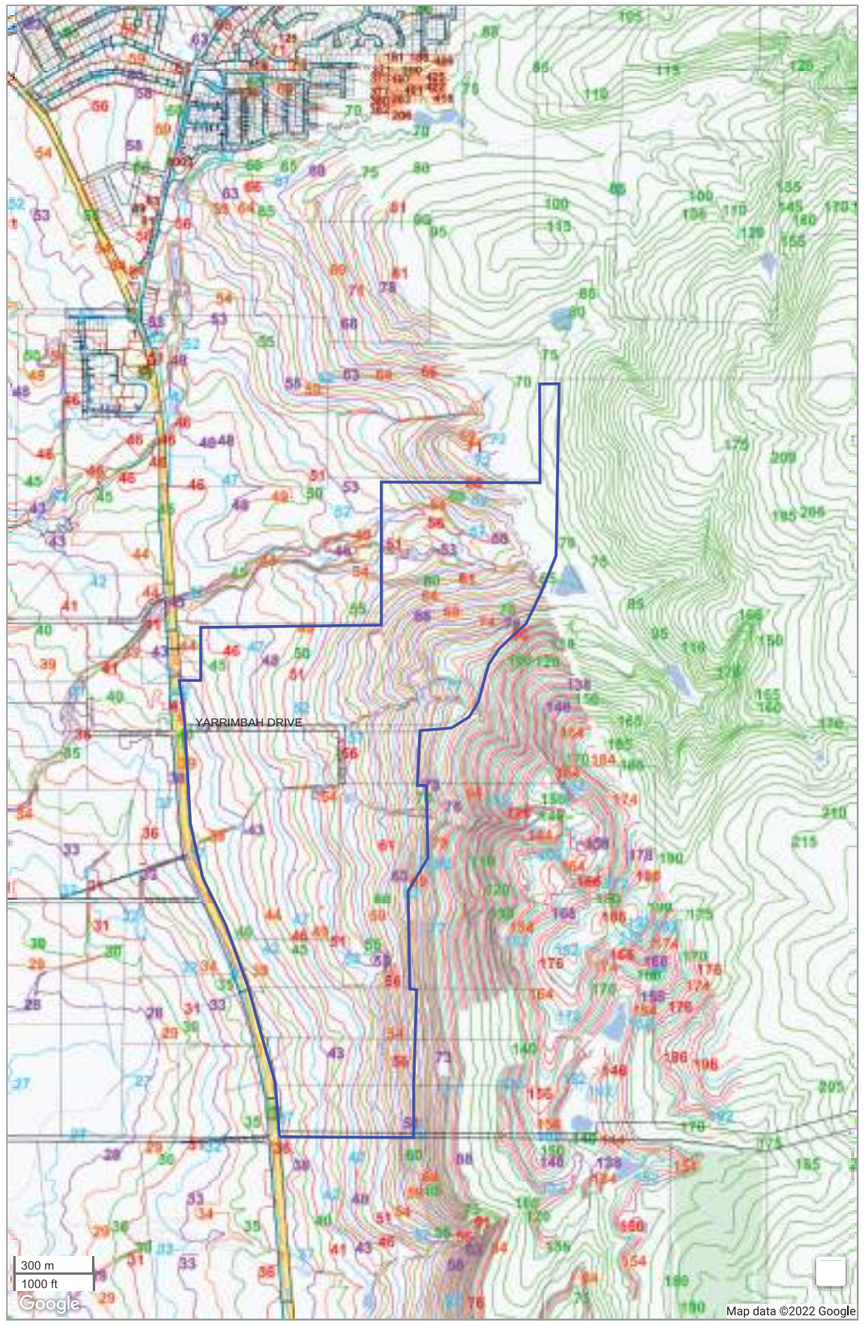
7. ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

Geotechnical advice presented in a Galt Environmental report has been provided by Galt Geotechnics under a sub-contract agreement. Similarly, environmental advice presented in a Galt Geotechnics report has been provided by Galt Environmental under a sub-contract agreement.

Unless specifically noted otherwise, no parties shall draw any inferences about the applicability of the Western Australian state government landfill levy from the contents of this document.

Appendix Six: Existing Ground Contours



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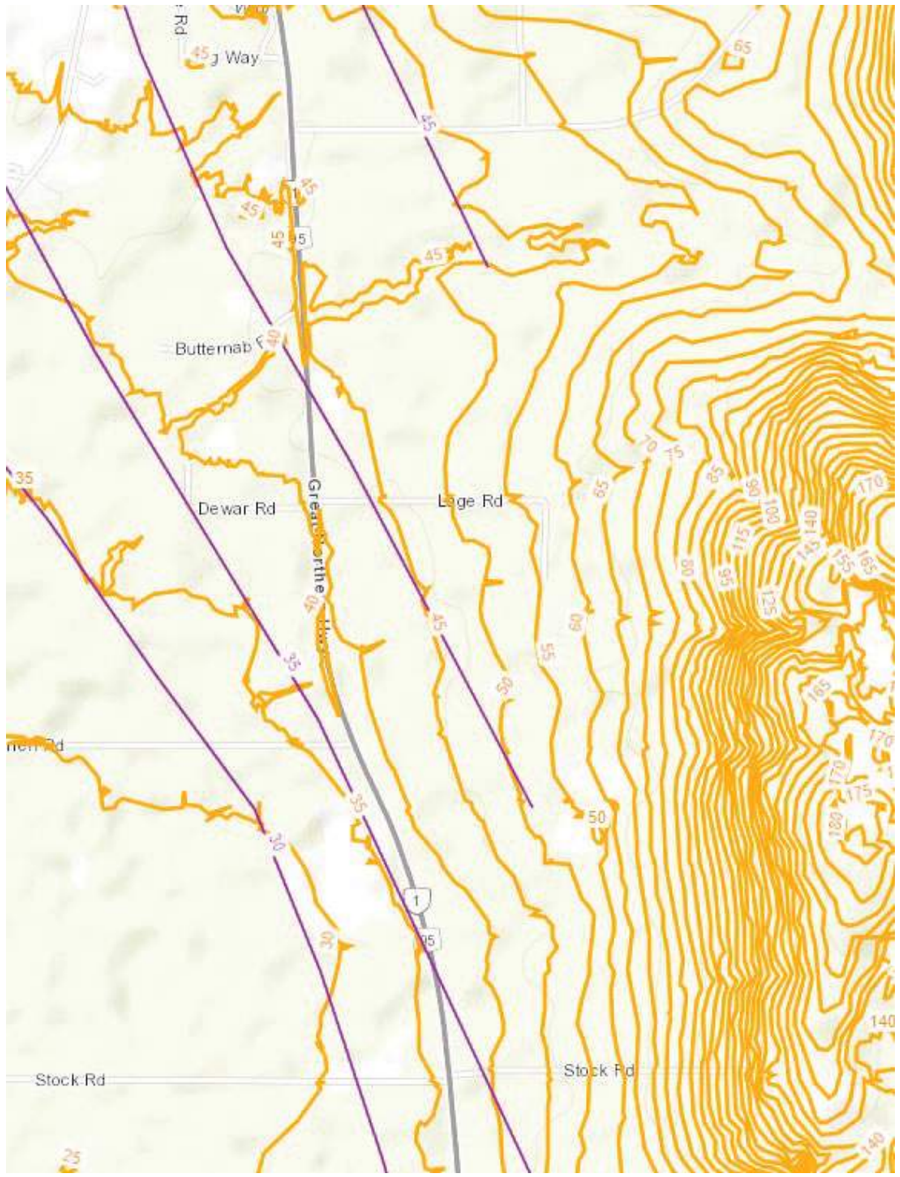
The Water Corporation has taken due care in the preparation of the data comprised on this map but accepts no responsibility for any inaccuracy of facility, cadastral or other information provided nor inappropriate use of this information. The user is reminded that under no circumstances can the information herewith displayed be copied, altered, modified or otherwise published in any form including the Internet without express permission of the Water Corporation. The Water Corporation should be advised of any intention to carry out any physical activities within proximity to facilities displayed on this map. If any inaccuracies are found with this information please contact the Help Desk on (08) 9420 3090.

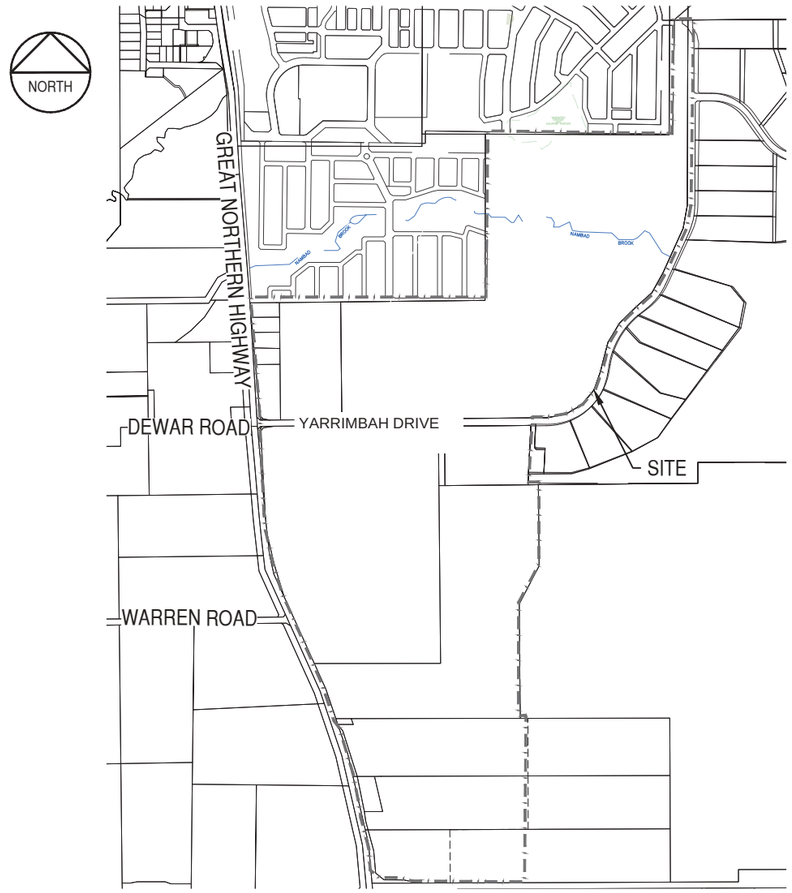
Appendix Seven: Perth Groundwater Map


Butternab
Dewar Rd
Stock Rd
Stock Rd

PROPOSED SUBDIVISION
2234 - 2342 GREAT NORTHERN HIGHWAY, BULLSBROOK
for
MIRVAC
NOVEMBER 2023

WAPC No: N/A

JOB No: 22-063



CIVIL DRAWING LIST

DRG No.	TITLE
22063-C1-CS-01	COVER SHEET
22063-C1-RL-01	ROAD LAYOUT
22063-C1-DC-01	DESIGN CONTOURS
22063-C1-EW-01	EARTHWORKS DEPTH PLAN
22063-C1-RW-01	RETAINING WALL LAYOUT & LEVELS
22063-C1-EC-01	EXISTING CATCHMENT PLAN SHEET 1 OF 2
22063-C1-EC-02	EXISTING CATCHMENT PLAN SHEET 2 OF 2
22063-C1-CA-01	DESIGN CATCHMENT PLAN
22063-C1-SW-01	STORMWATER MANAGEMENT CONCEPT PLAN

PRELIMINARY ROAD LEVELS, EARTHWORKS, CATCHMENTS & RETAINING WALLS

pritchard francis
civil and structural engineering consultants

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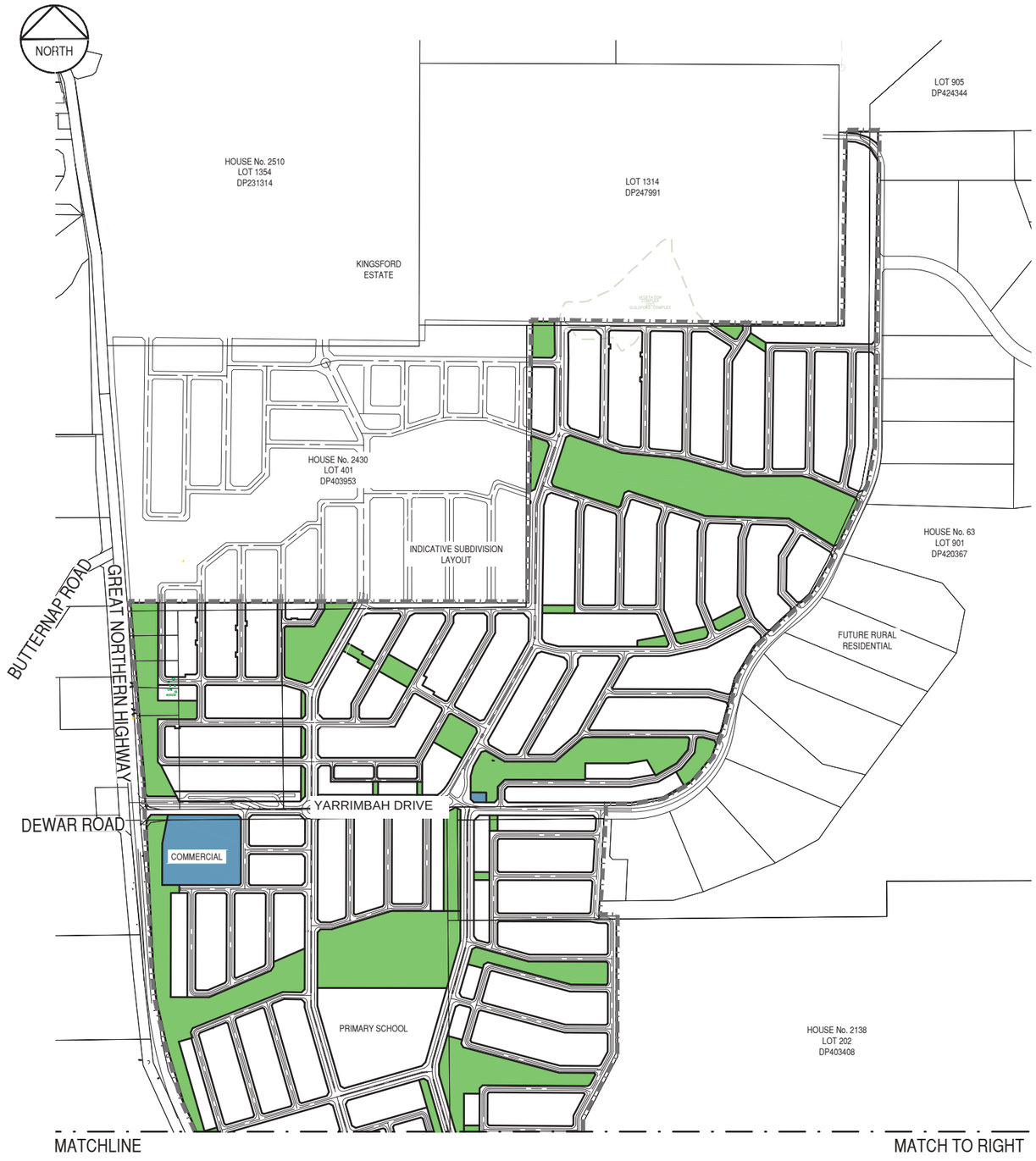
Subiaco WA 6008
PO Box 2150
Subiaco WA 6904

Telephone: (08) 9382 5111
admin@pfeng.com.au

DATE	DESIGNED	DRAWN	CHECKED	APPROVED
NOVEMBER 2023	A.D	N.S	M.R	XXX .... / ....

SHEET SIZE	DRG No.
A1	22063-C1-CS-01





SCALE 1:5000 0m 100m 200m

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- EXISTING CONTOURS (15.0)
- PROPOSED CONTOURS (15.0)
- PROPOSED PUBLIC OPEN SPACE

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REV	DATE	DESCRIPTION	BY	CHKR
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pritchard francis
civil and structural engineering consultants

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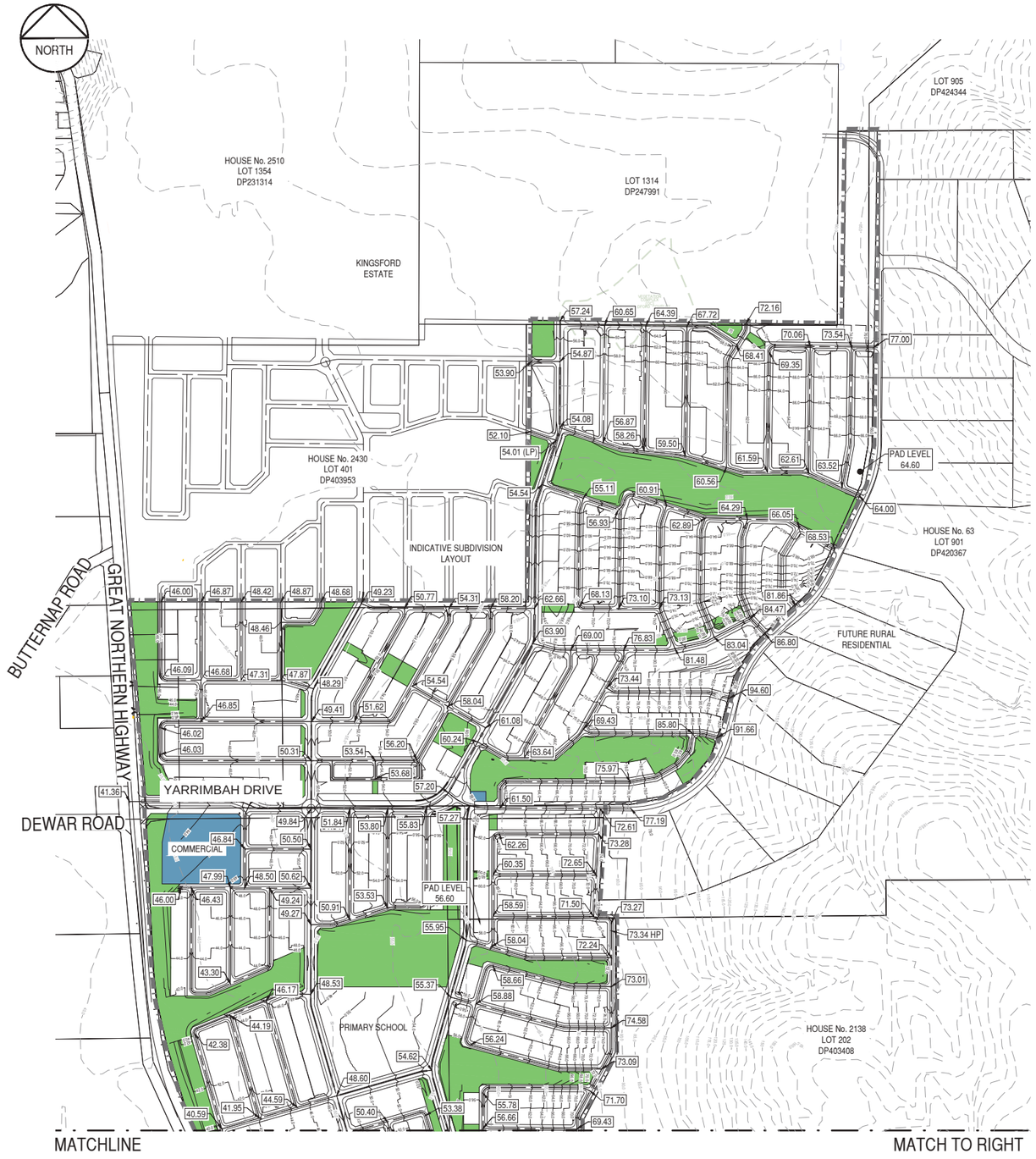
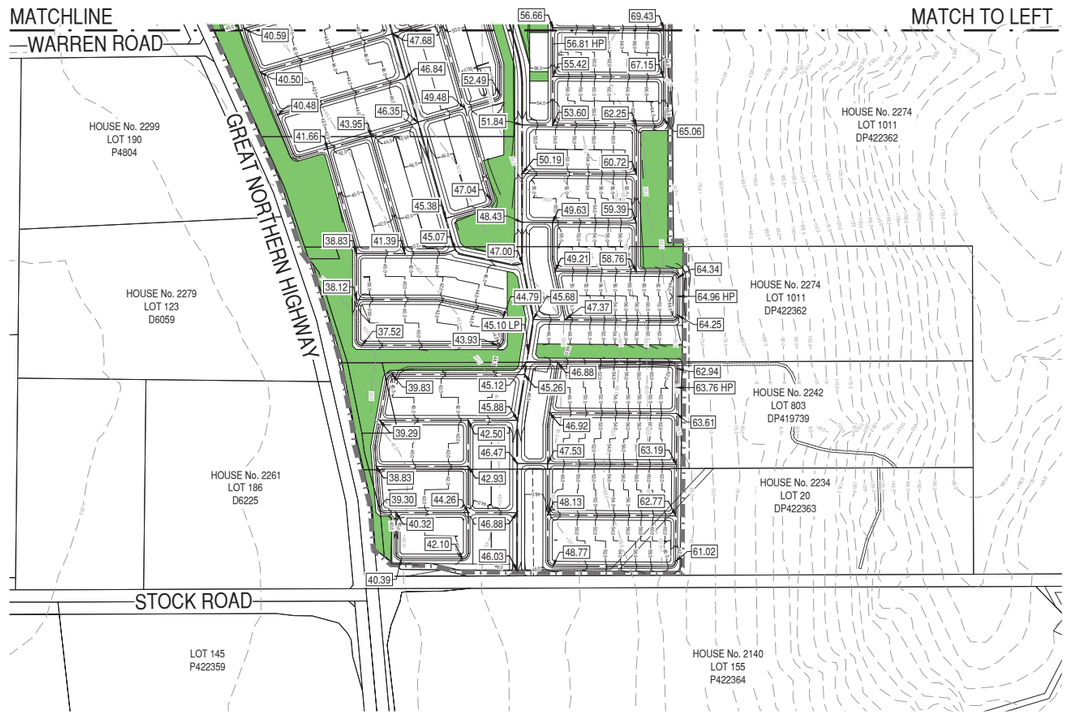
Ballarat VIC 3350
PO Box 1130
Ballarat VIC 3353
Telephone (03) 5332 1111

DRAWING STATUS	NOT FOR CONSTRUCTION
CLIENT & JOB	MIRVAC BULLSBROOK SOUTH URBAN EXPANSION AREA
DATE	NOVEMBER 2023
GRID	PCG94
DATUM	AHD
TITLE	ROAD LAYOUT
DESIGNED	A.D
DRAWN	N.S
CHECKED	M.R
APPROVED	XXX .... / ....
W.A.P.C.	N/A
SCALE U.N.O.	1:5000 @
SHEET SIZE	A1
DRG No.	22063-C1-RL-01
REVISION	A





SCALE 1:5000 0m 100m 200m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- 48.60 DESIGN LEVEL
- 15.0 EXISTING CONTOURS
- 15.0 PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
B	11/12/23	REVISED PAD LEVELS	N.S.	M.R.
A	15/11/23	INITIAL ISSUE	A.D	M.R

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DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

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W.A.P.C.: N/A | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1 | DRG No.: 22063-C1-DC-01 | REVISION: B

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: DESIGN CONTOURS



DEPTH OF CUT/FILL	
COLOUR	CUT AND FILL RANGE
	> 3.0m CUT
	3.0m - 2.0m CUT
	2.0m - 1.0m CUT
	1.0m -0.1m CUT
	0.1m CUT/FILL
	0.1m - 1.0m FILL
	1.0m - 2.0m FILL
	2.0m - 3.0m FILL
	3.0m - 4.0m FILL
	4.0m - 5.0m FILL
	> 5.0m FILL

SCALE 1:5000 0m 100m 200m

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- EXISTING CONTOURS (15.0)
- PROPOSED CONTOURS (15.0)

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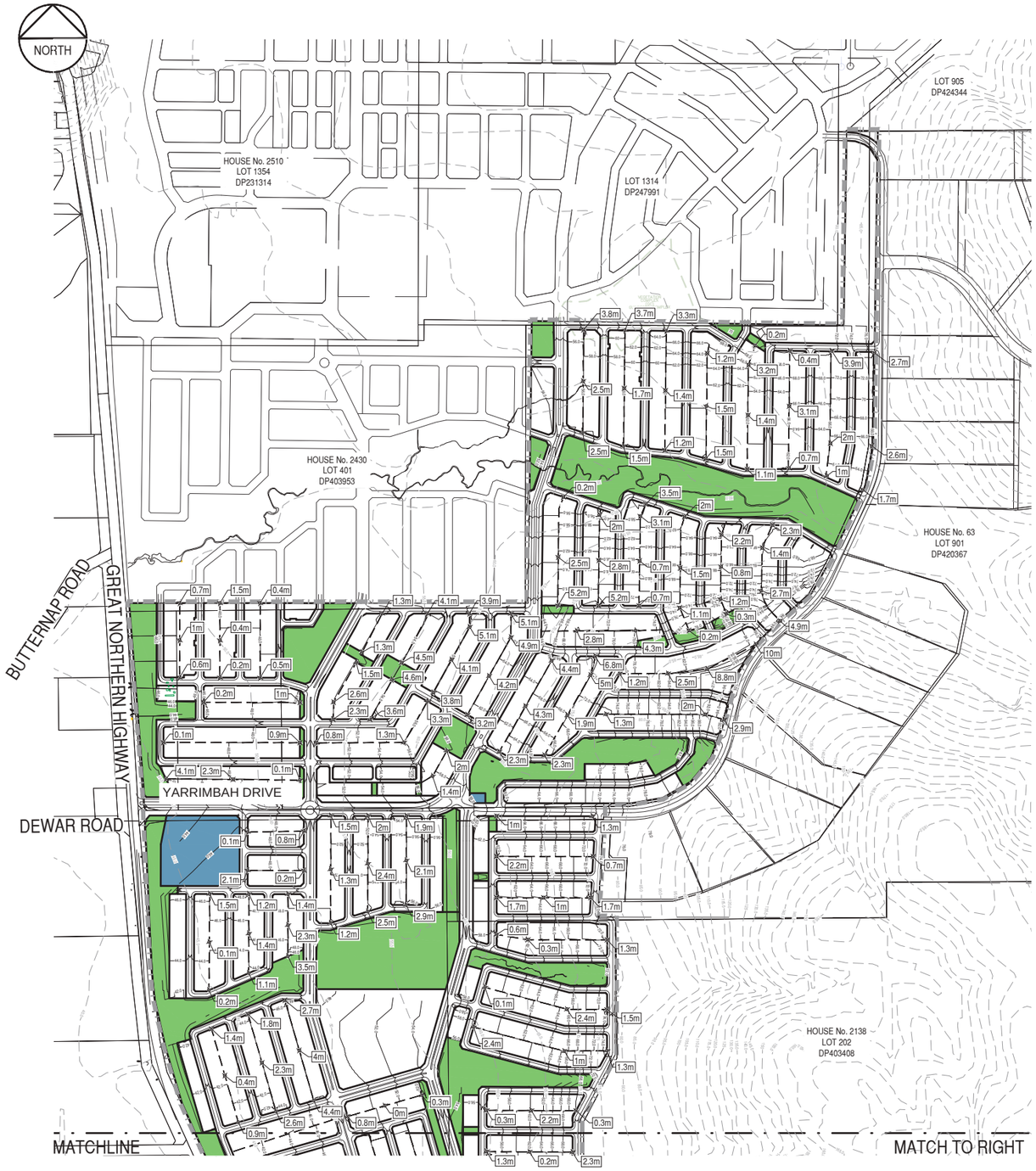
W.A.P.C.: N/A | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: EARTHWORKS DEPTH PLAN

DRG No.: 22063-C1-EW-01

REVISION: A





SCALE 1:500 0m 10m 20m

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- INDICATIVE WALL HEIGHT (3m)
- INDICATIVE RETAINING WALL
- PROPOSED CONTOURS (150)
- PROPOSED PUBLIC OPEN SPACE

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DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX .... / ....

W.A.P.C.: ????
SCALE U.N.O.: 1:5000 @

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: RETAINING WALL LAYOUT & LEVELS

SHEET SIZE: A1
DRG No.: 22063-C1-RW-01
REVISION: A

NORTH

HOUSE No. 2510
LOT 1354
DP231314

LOT 1314
DP247991

LOT 905
DP424344

CATCHMENT 1
AREA = 438.96ha

CATCHMENT 2
AREA = 57.94ha

CATCHMENT 3
AREA = 84.55ha

HOUSE No. 2430
LOT 401
DP403953

HOUSE No. 63
LOT 901
DP420367

HOUSE No. 2138
LOT 202
DP403408

BUTTERNAP ROAD

GREAT NORTHERN HIGHWAY

YARRIMBAH DRIVE

DEWAR ROAD

POS AREA = 2987.73m²
POS AREA = 1032.69m²
POS AREA = 2276.33m²
POS AREA = 52137.73m²
POS AREA = 18173.67m²
POS AREA = 10966.79m²
POS AREA = 954.86m²
POS AREA = 1435.083m²
POS AREA = 1362.77m²
POS AREA = 989.90m²
POS AREA = 1120.00m²
POS AREA = 2400.00m²
POS AREA = 391.53m²
POS AREA = 4097.76m²
POS AREA = 444.00m²
POS AREA = 488.33m²
POS AREA = 250.00m²
POS AREA = 250.00m²
POS AREA = 21552.86m²
POS AREA = 3118.41m²
POS AREA = 462.24m²
POS AREA = 462.00m²
POS AREA = 83713.93m²
POS AREA = 43053.17m²
POS AREA = 8774.68m²
POS AREA = 18541.37m²
POS AREA = 14615.75m²

MATCHLINE

MATCH 22063-C1-EC-02

SCALE 1:500 0m 10m 20m

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- EXISTING CATCHMENT BOUNDARY
- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

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CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: EXISTING CATCHMENT PLAN
SHEET 1 OF 2

DATE	GRID	DATUM
NOVEMBER 2023	PCG94	AHD

DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX .... / ....

W.A.P.C.	SCALE U.N.O.	SHEET SIZE	DRG No.	REVISION
????	1:5000 @	A1	22063-C1-EC-01	A

NORTH

COMMERCIAL

MATCHLINE

WARREN ROAD

MATCH 22063-C1-EC-01

GREAT NORTHERN HIGHWAY

STOCK ROAD

POS AREA = 462.00m²

POS AREA = 43053.17m²

POS AREA = 18541.37m²

POS AREA = 14615.75m²

POS AREA = 8774.68m²

POS AREA = 462.00m²

POS AREA = 83713.93m²

POS AREA = 11109.08m²

POS AREA = 5424.22m²

CATCHMENT 1
AREA = 438.96ha

CATCHMENT 3
AREA = 84.55ha

CATCHMENT 4
AREA = 101.70ha

HOUSE No. 2299
LOT 190
P4804

HOUSE No. 2279
LOT 123
D6059

HOUSE No. 2261
LOT 186
D6225

HOUSE No. 2274
LOT 1011
DP422362

HOUSE No. 2274
LOT 1011
DP422362

HOUSE No. 2242
LOT 803
DP419739

HOUSE No. 2234
LOT 20
DP422363

LOT 145
P422359

HOUSE No. 2140
LOT 155
P422364

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- EXISTING CATCHMENT BOUNDARY
- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- 15.0 EXISTING CONTOURS
- 15.0 PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

SCALE 1:500 0m 10m 20m

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PO Box 1150
Subiaco WA 6904
Telephone (08) 9382 2911

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DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

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W.A.P.C.: ???? | SCALE U.N.O.: 1:5000 @

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: EXISTING CATCHMENT PLAN
SHEET 2 OF 2

SHEET SIZE: A1 | DRG No.: 22063-C1-EC-02 | REVISION: A





MATCHLINE

SCALE 1:500 0m 10m 20m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- DESIGN CATCHMENT BOUNDARY
- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- 15.0 EXISTING CONTOURS
- 15.0 PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
A	15/11/23	INITIAL ISSUE	A.D	M.R

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Telephone (08) 9382 9111

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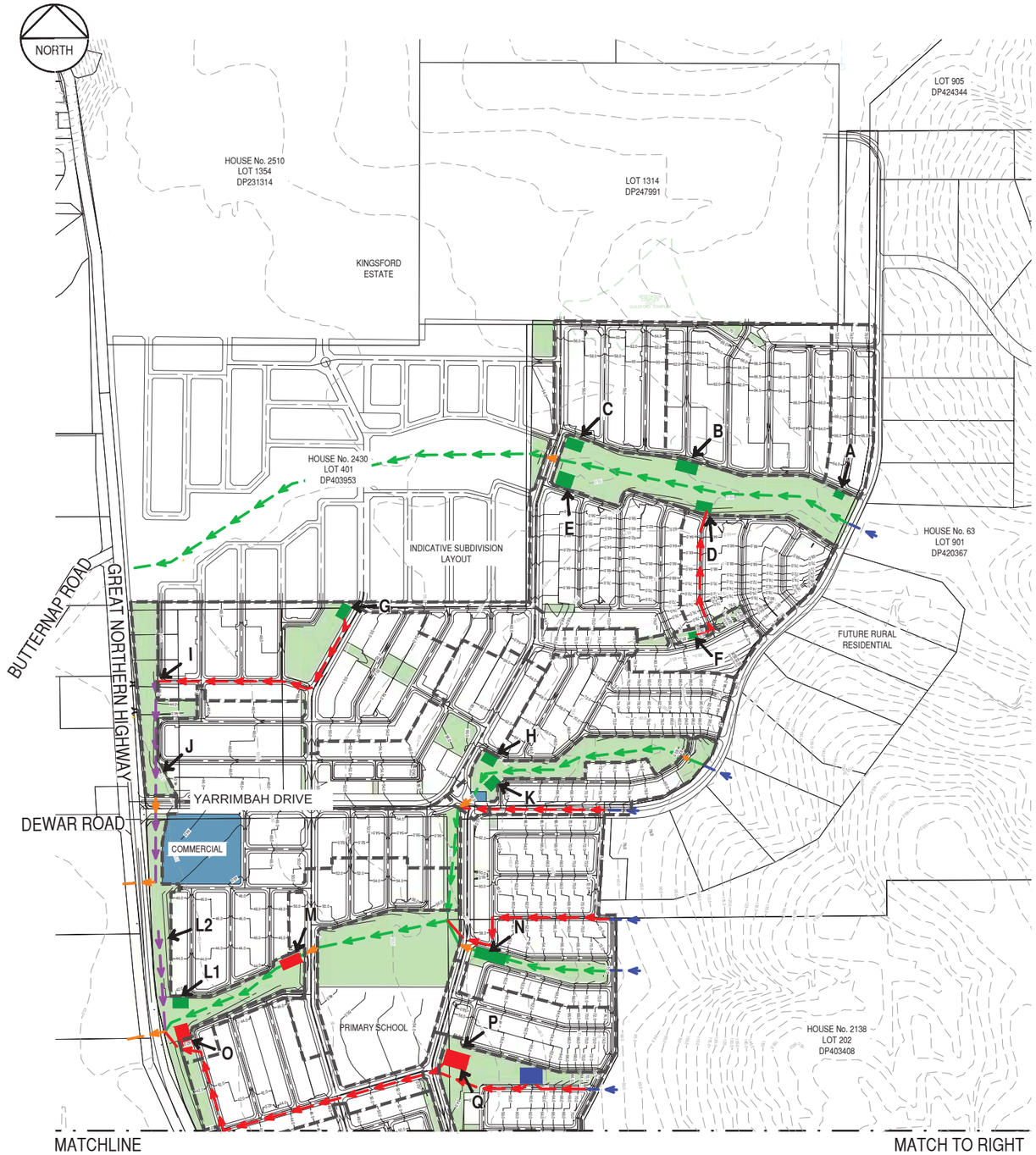
CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: DESIGN CATCHMENT PLAN

DATE	GRID	DATUM
NOVEMBER 2023	PCG94	AHD

DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX ...../....

W.A.P.C.	SCALE U.N.O.	SHEET SIZE	DRG No.	REVISION
????	1:5000 @	A1	22063-C1-CS-01	A





SCALE 1:5000 0m 100m 200m

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE
- LIVING STREAM
- TREATMENT / DETENTION SWALE
- CONVEYANCE SWALE
- STORMWATER CULVERT
- PIPED DRAINAGE
- INFLOWS
- BIOBASIN
- FLOOD DETENTION BASIN
- EXTERNAL CATCHMENTS BASIN

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DRAWING STATUS: NOT FOR CONSTRUCTION

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: STORMWATER MANAGEMENT CONCEPT PLAN

DATE	GRID	DATUM
NOVEMBER 2023	PCG94	AHD

DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX .... / ....

W.A.P.C.	SCALE U.N.O.	SHEET SIZE	DRG No.	REVISION
N/A	1:5000 @	A1	22063-C1-SW-01	A

Appendix Eight: Bullsbrook Central Sewer Catchment

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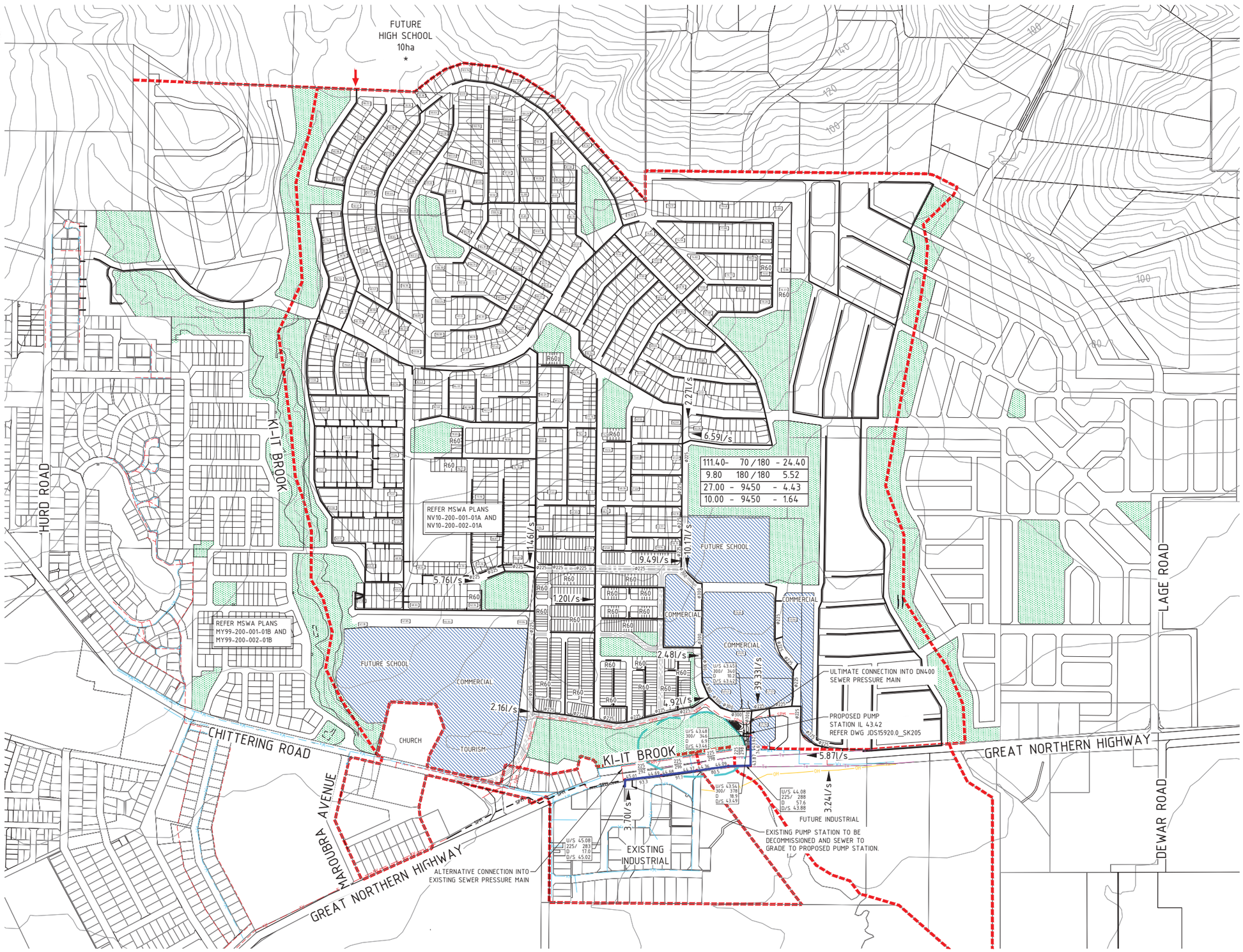

0 50 100 200 300m
SCALE 1:5000 @ ORIGINAL SHEET SIZE A1

PLAN
SCALE 1:5000

NOTES

1. ALL MAINS TO BE LAID ON THE STANDARD ALIGNMENTS UNLESS NOTED OTHERWISE.
2. SUBDIVISION CELLS ARE RESIDENTIAL R20 LAND USE UNLESS NOTED OTHERWISE.
3. ALL MAINS TO BE 150mm DIAMETER UNLESS NOTED OTHERWISE.
4. RESIDENTIAL ZONE HATCHING NOT SHOWN FOR CLARITY.
5. LOCAL AUTHORITY: CITY OF SWAN
6. ESTIMATED MAX. G.W.L. 45m (A.H.D.)
7. THIS RETICULATION AREA IS CLASSIFIED 'DRY' IN ACCORDANCE WITH THE WATER CORPORATION WASTEWATER MANUAL VOL. 1 UNLESS NOTED OTHERWISE.

LEGEND

- CATCHMENT BOUNDARIES
- PROPOSED CREEK AND P.O.S. AREAS
- PROPOSED COMMERCIAL/SCHOOL/TOURISM/CHURCH AREAS
- EXISTING CONTOURS (5m INTERVAL)
- SEWER CONTROL LINE
- EXISTING WATER MAINS
- R60 RESIDENTIAL FINISHED SURFACE LEVELS
- PRELIMINARY FINISHED SURFACE LEVELS

RESIDENTIAL

NET AREA (ha) — FLOW- LITRES/PERSON/DAY
1.00 - 52.5 / 230 - 0.21
PERSONS PER NET HECTARE — PEAK FLOW (l/s)

NON RESIDENTIAL

NET AREA (ha) — PEAK FLOW (l/s)
0.85 - 14976 - 0.22
FLOW- LITRES/NET HECTARE/DAY

WWPSL DESIGN CRITERIA

DESIGN INFLOW:	43.03L/s
PUMP RATE:	57.23L/s
MAX PUMP RATE:	90L/s
SEWER INVERT LEVEL:	43.42m
100 YEAR FLOOD LEVEL:	46.56m AHD
WWPS TOP SLAB LEVEL:	48.10m AHD
WWPS BASE LEVEL:	40.48m AHD
WWPS DEPTH:	7.62m

WARNING
BEWARE OF UNDERGROUND SERVICES
The location of underground cables are approximate only and their exact position should be checked on site. No guarantee is given that all existing cables and services are shown. Locate all underground cables and services before commencement of work. Refer to Worksafe Regulation 3.21.
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PRELIMINARY

REV	DATE	DRAWN	CHECKED	APPROVED

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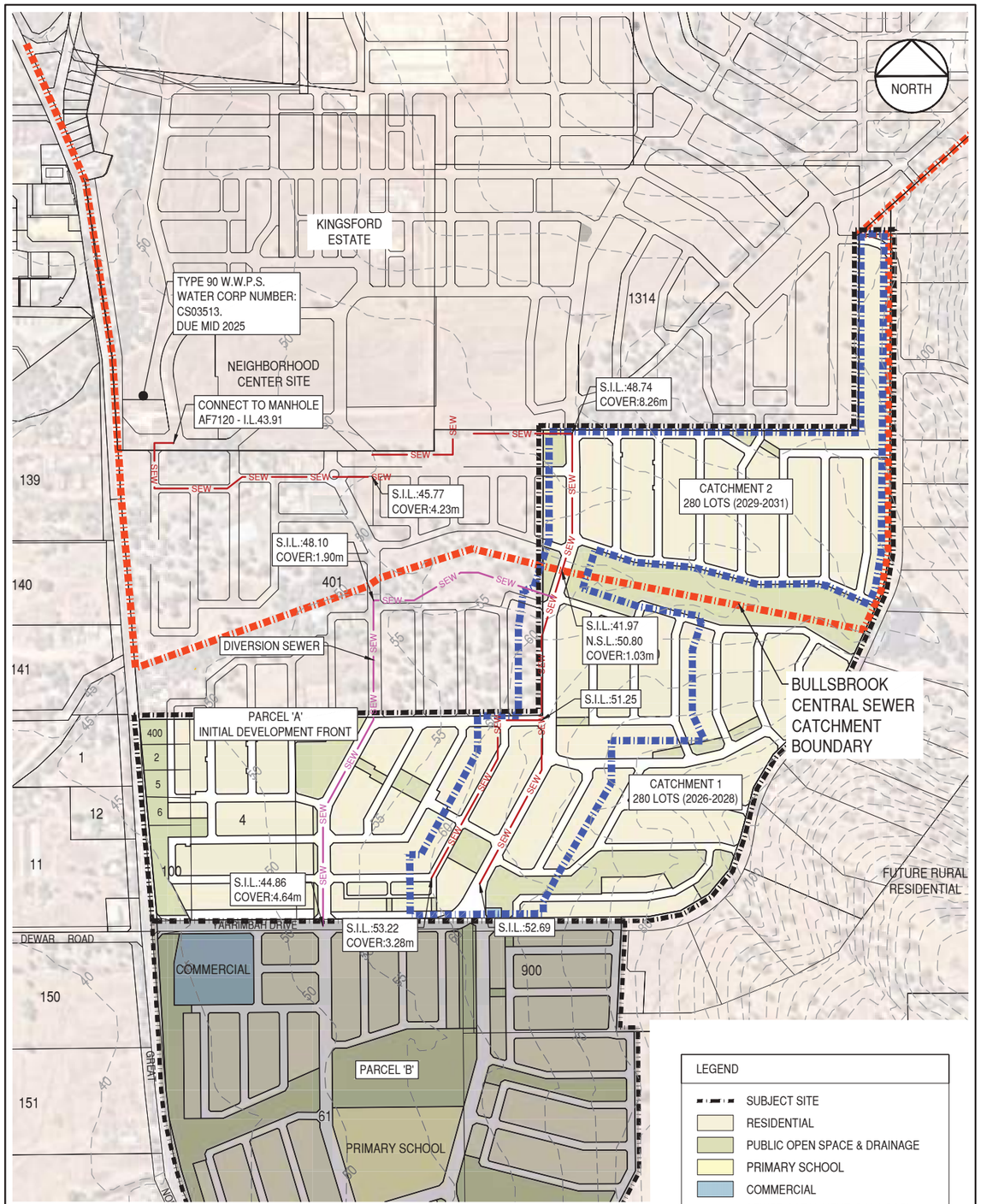
Level 1, 432 MURRAY STREET, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: okeland COMMUNITIES
PROJECT: KINGSFORD
STAGE: KINGSFORD - BULLSBROOK
DRAWING TITLE: BULLSBROOK OVERALL SEWER CATCHMENT PLAN

DRAWN: A. PANZICH	WAPC No.: 156769
DESIGNED: A. PANZICH	SCALE @ A1: 1:5000
PROJECT MANAGER: G. BOYD	DATUM: AHD; CO-ORDS: PCG94
JDSI PROJECT No.: JDS15920.0	DRAWING No.: SK203; REVISION: D

Plotted By: APanzich Plot Date: 08/07/22 - 08:54 Cad File: I:\JDS15920\JDS15920.W4\02 CIVIL\Drawings\XXXX-XXX-001-01A.dwg

Appendix Nine: Temporary Sewer Catchment Diversion



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DRAWING STATUS: NOT FOR CONSTRUCTION

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH LOCAL STRUCTURE PLAN

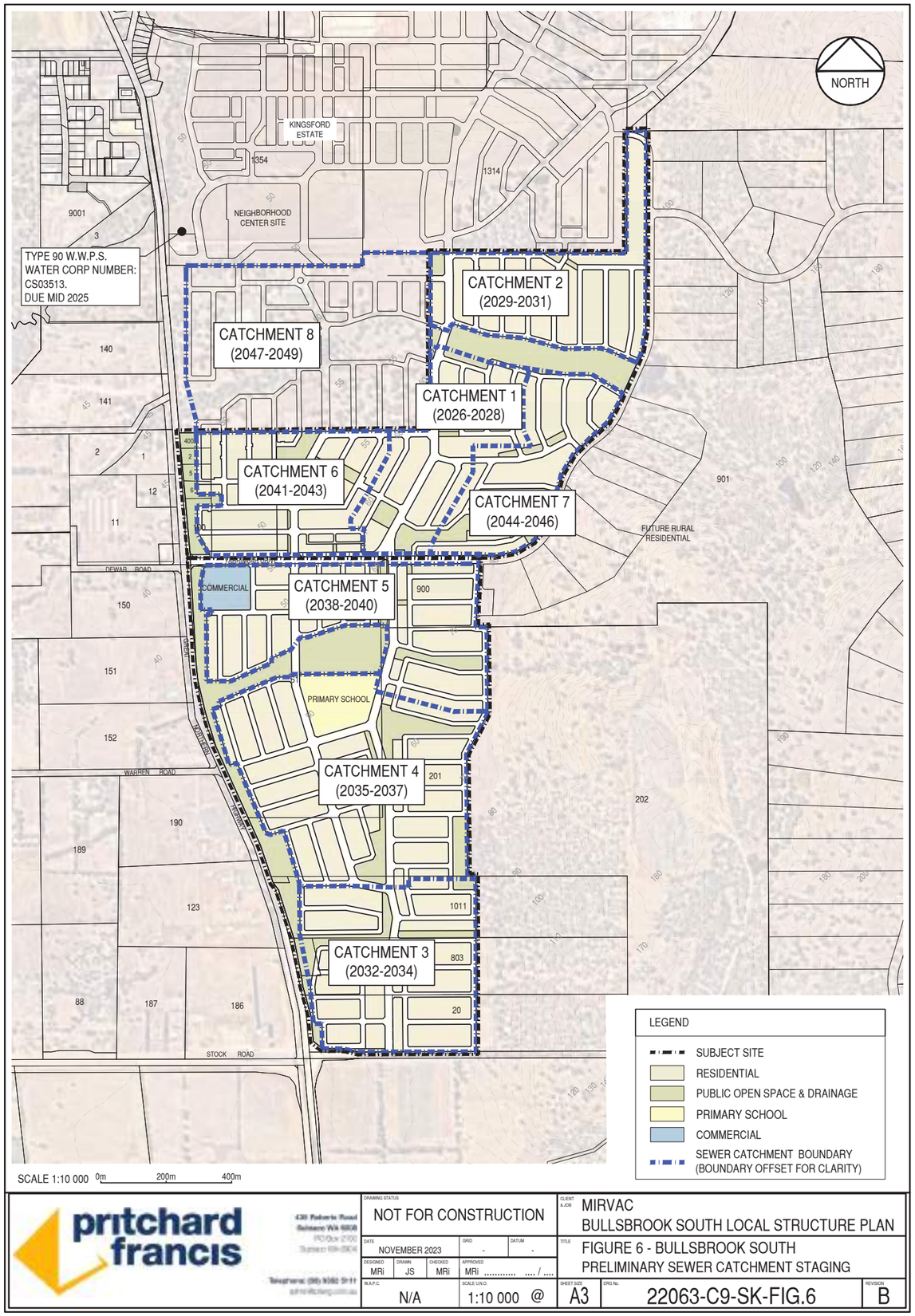
TITLE: FIGURE 5 - BULLSBROOK SOUTH
TEMPORARY SEWER CATCHMENTS - PARCEL A

DATE: NOVEMBER 2023 | GRID: - | DATUM: -

DESIGNED: MRi | DRAWN: JS | CHECKED: MRi | APPROVED: MRi .... / ....

W.A.P.C.: N/A | SCALE U.N.O.: N.T.S. @ | SHEET SIZE: A3 | DRG No.: 22063-C9-SK-FIG.5 | REVISION: C

Appendix Ten: Bullsbrook South Sewer Catchment Timing



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DRAWING STATUS: NOT FOR CONSTRUCTION

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH LOCAL STRUCTURE PLAN

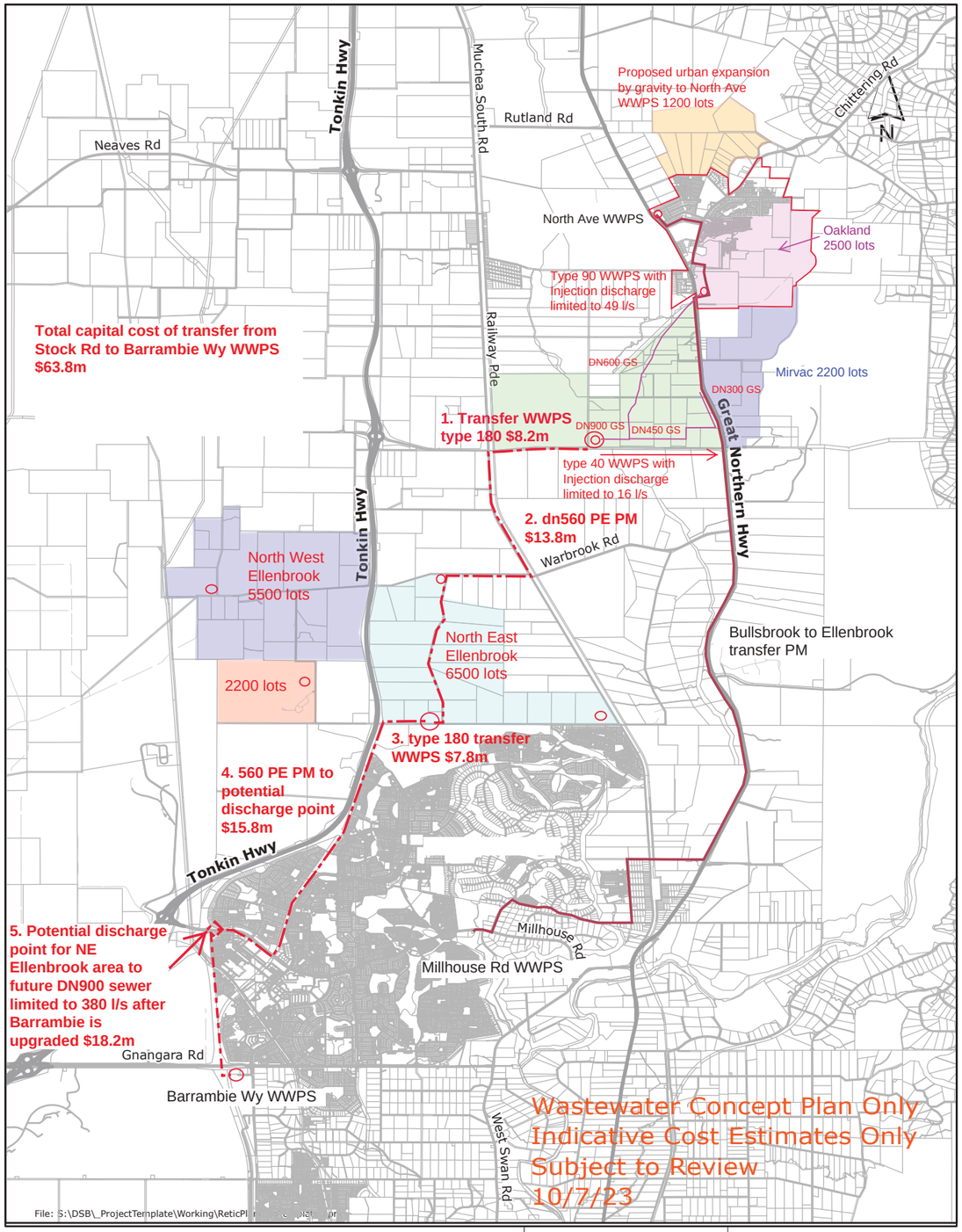
DATE: NOVEMBER 2023 | GRID: - | DATUM: -

DESIGNED: MRi | DRAWN: JS | CHECKED: MRi | APPROVED: MRi

TITLE: FIGURE 6 - BULLSBROOK SOUTH
PRELIMINARY SEWER CATCHMENT STAGING

W.A.P.C.: N/A | SCALE U.N.O.: 1:10 000 @ | SHEET SIZE: A3 | DRG No.: 22063-C9-SK-FIG.6 | REVISION: B

Appendix Eleven: **North East Corridor Waste Water Concept Plan July 2023**



Appendix Twelve: ATCO Gas Correspondence

Brianna Newnham

From: Hoyne, Ben <Ben.Hoyne@atco.com>
Sent: Tuesday, 3 May 2022 12:24 PM
To: Philip Patterson
Cc: Andrew Tucker; Mark Riddell; Cory Johnson; Maher, Lester
Subject: [External] ATCO Gas Australia - Cost Estimate - Bullsbrook South Precinct

CAUTION: This email originated from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Hi Philip

Once again, thank you for your enquiry in respect to reticulating gas at the proposed Bullsbrook South Precinct.

In order for the future development to have access to Natural Gas, an approx 10km network mains extension is required – high level details of which are listed below:

Scope of works

- Network tie-in at Apple Street, Upper Swan and, Rail Crossing (ARC)
- 850m x DN225PE Apple Street to Great Norther Hwy
- 9,000m x DN225PE from junction of Apple Street & Great Norther High Way to junction of Great Northern Hwy & Lage Road, Bullsbrook
- Installation methodology = Horizontal Directional Drilling (HDD)
- 500m x Open Cut in road reserve
- 500m x Open Cut in verge

Cost Estimate - - (*subject to ATCO Gas Australia Exec approval)

- *$4,300,000 exc GST

If you require any further information to support the projects feasibility study/ due diligence stage, please reach out.

Look forward to hearing back from you in due course.

Best regards,
Ben

Benjamin Hoyne
Business Development Manager
ATCO, Gas Division, Australia

P. +61 8 6163 5061 **M.** +61 419 787 599
A. 81 Prinsep Road, Jandakot, Western Australia, 6164
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We pay respect to their cultures, Elders past and present, and in the spirit of reconciliation, we commit to working together for our shared future.

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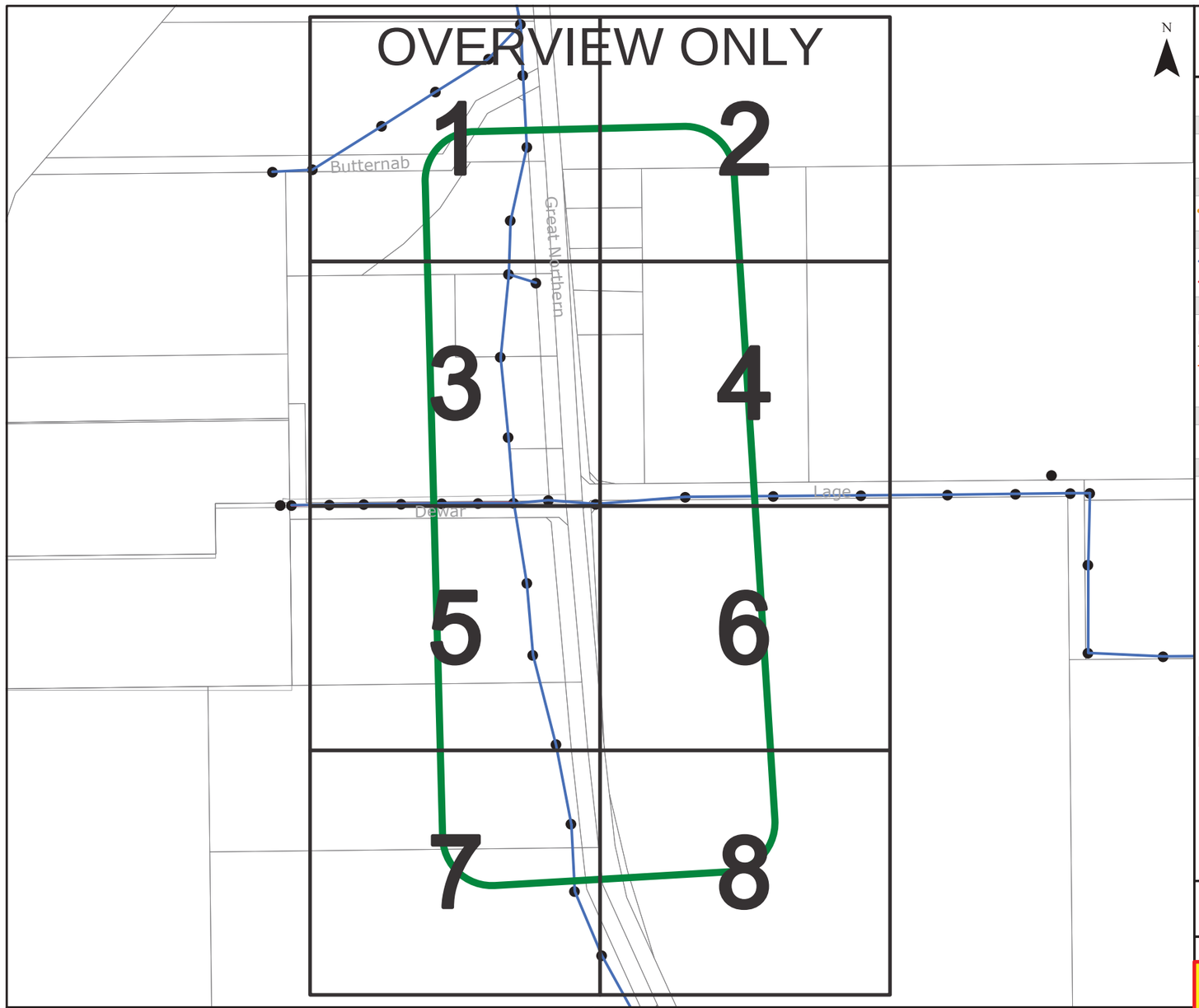
Appendix Thirteen: Existing Western Power Infrastructure



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Check that you have enough clearance from the DANGER ZONES near overhead powerlines.

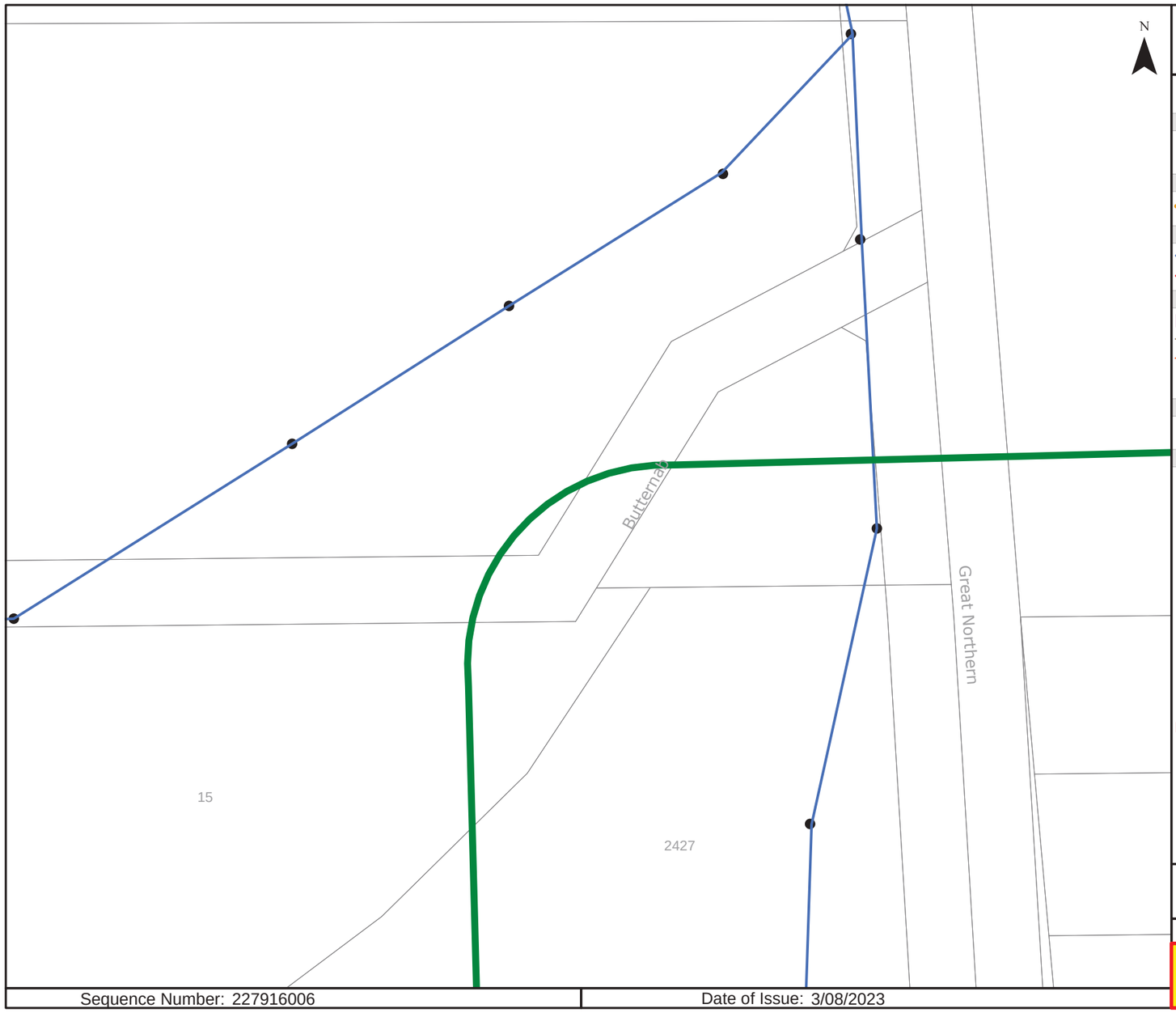
Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days from date of issue

A4 | Scale : 1:6150

WARNING! Look out for overhead power lines

Sequence Number: 227916006 | Date of Issue: 3/08/2023



westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

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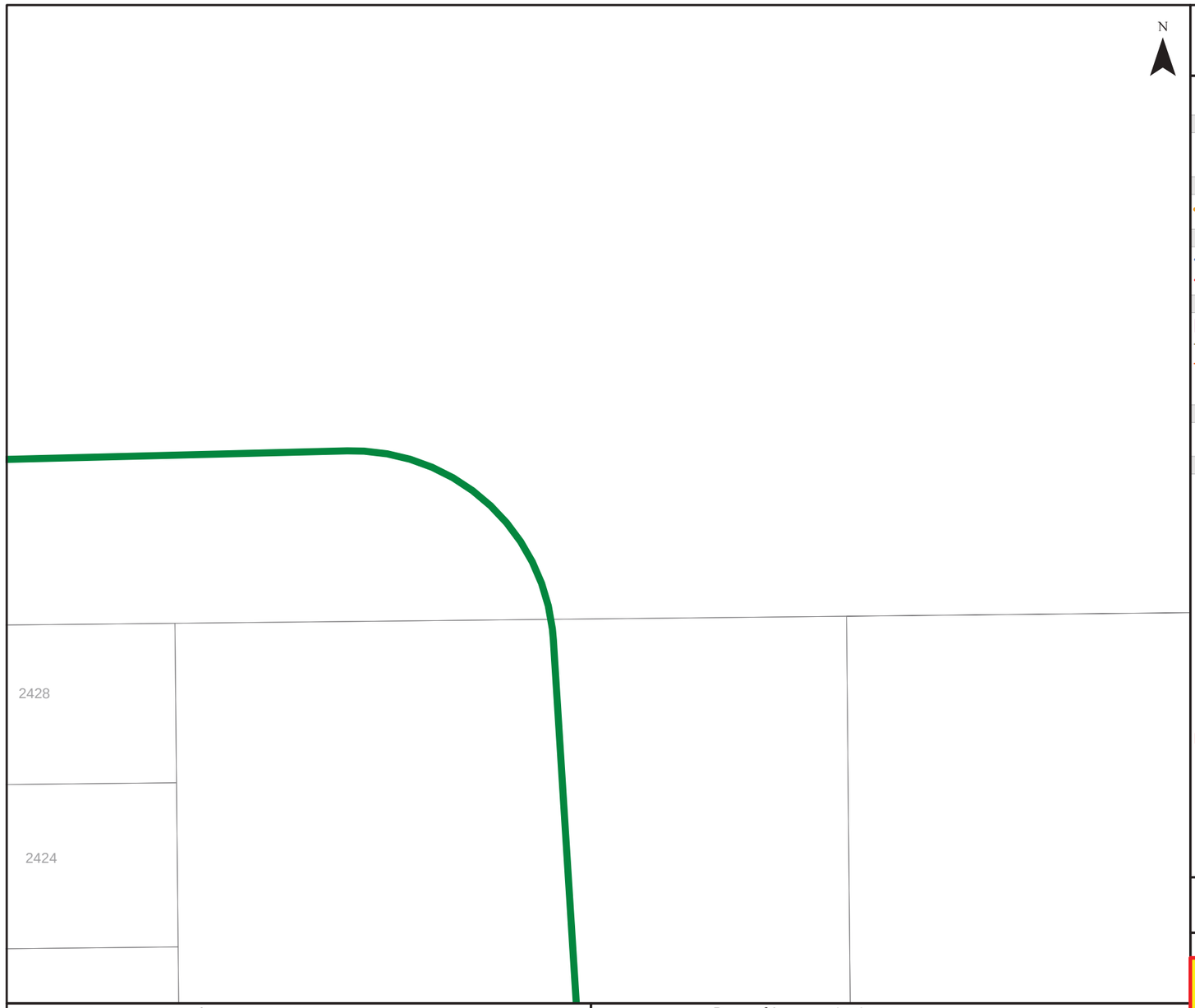

westernpower

OVERHEAD LEGEND

Structures

- Power Pole
- Transmission Poles

Transmission Overhead Powerline

- Transmission (33kV - 330kV)

Distribution Overhead Powerline

- High Voltage (1kV - 33kV)
- Low Voltage (< 1kV)

Proposed Construction Assets

- Design Area *
- High Voltage Overhead Powerline
- Low Voltage Overhead Powerline
- Power Pole

Communications Assets

- Overhead Pilot Cable

Feature

- Area of Interest

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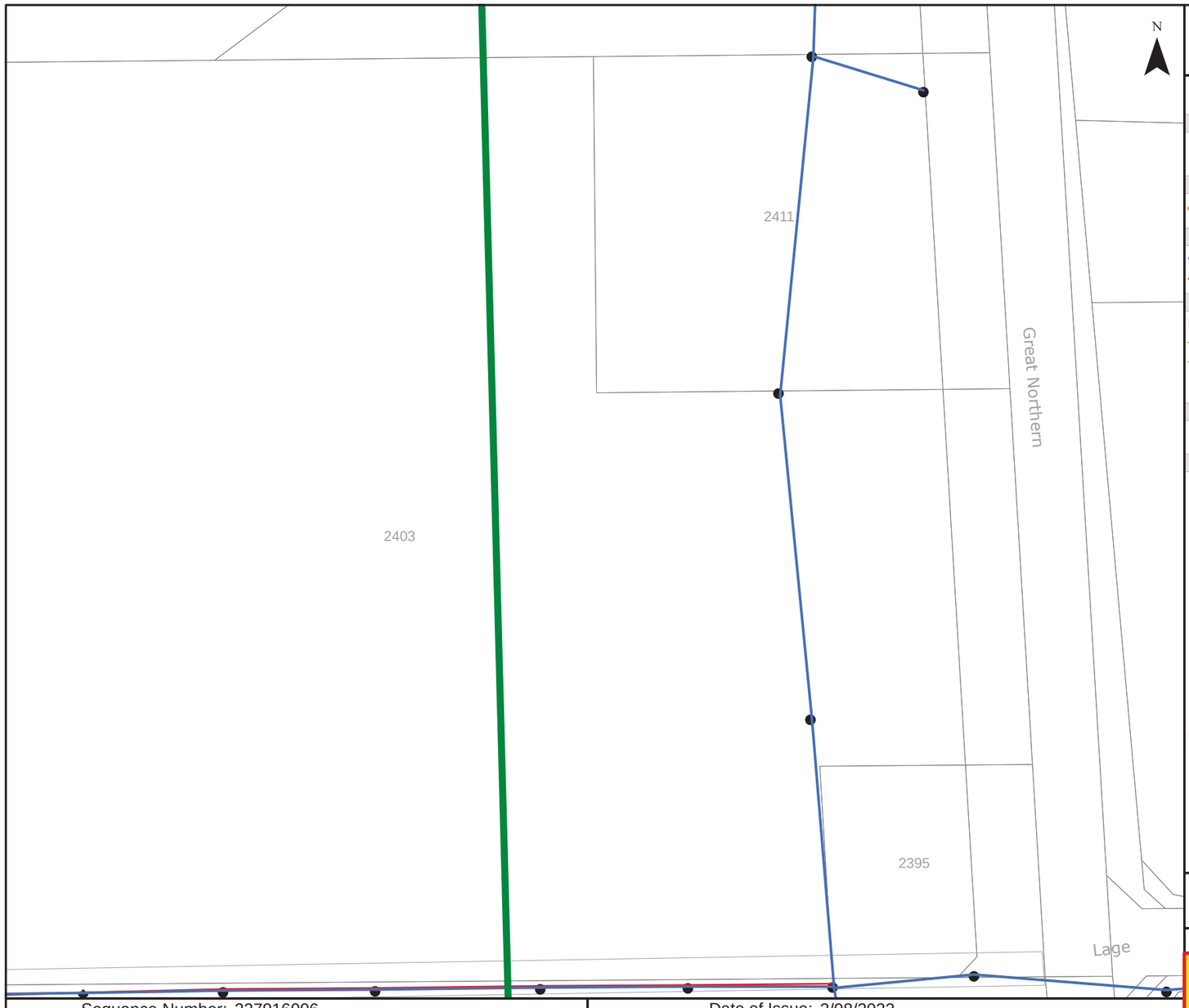

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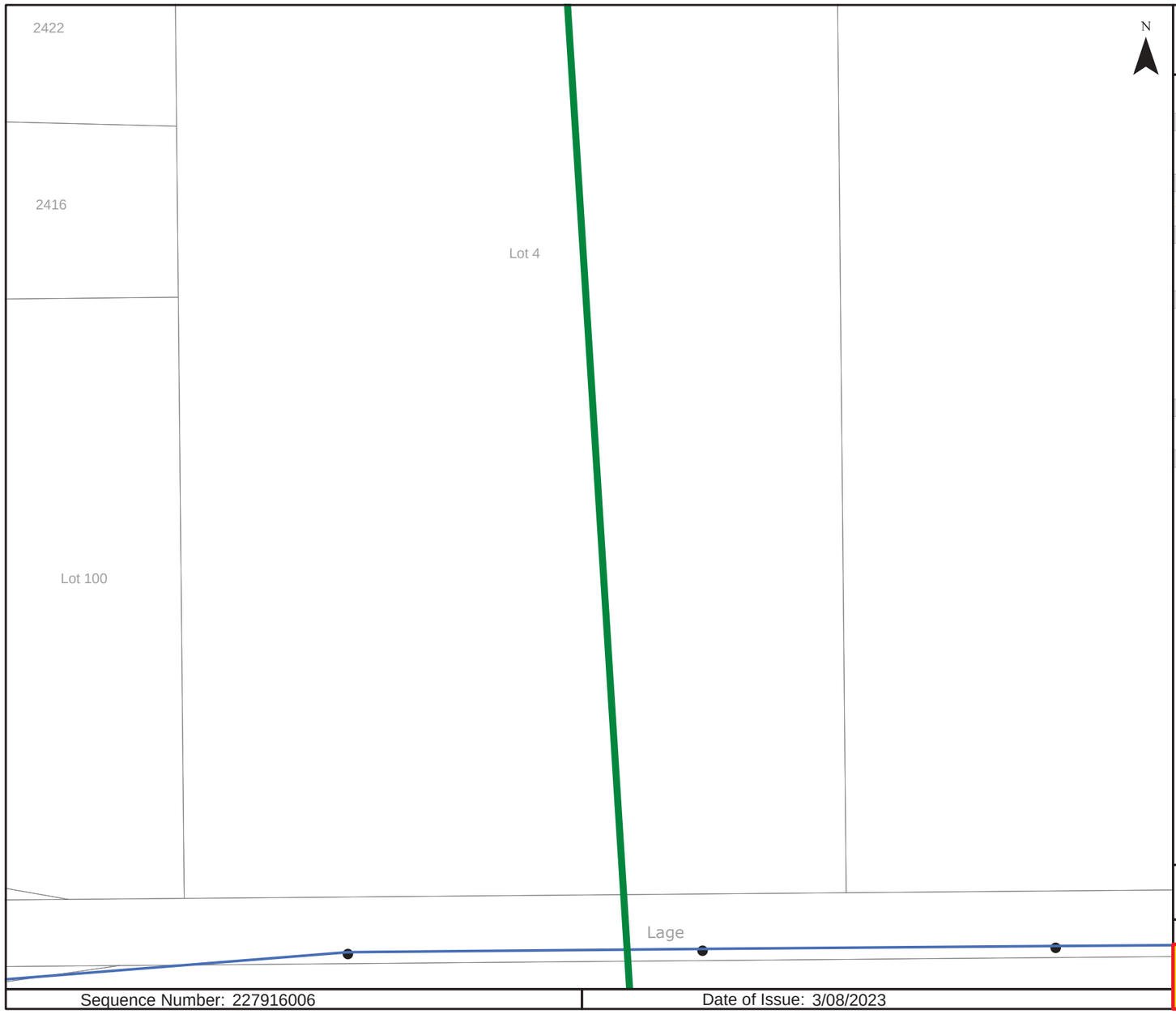

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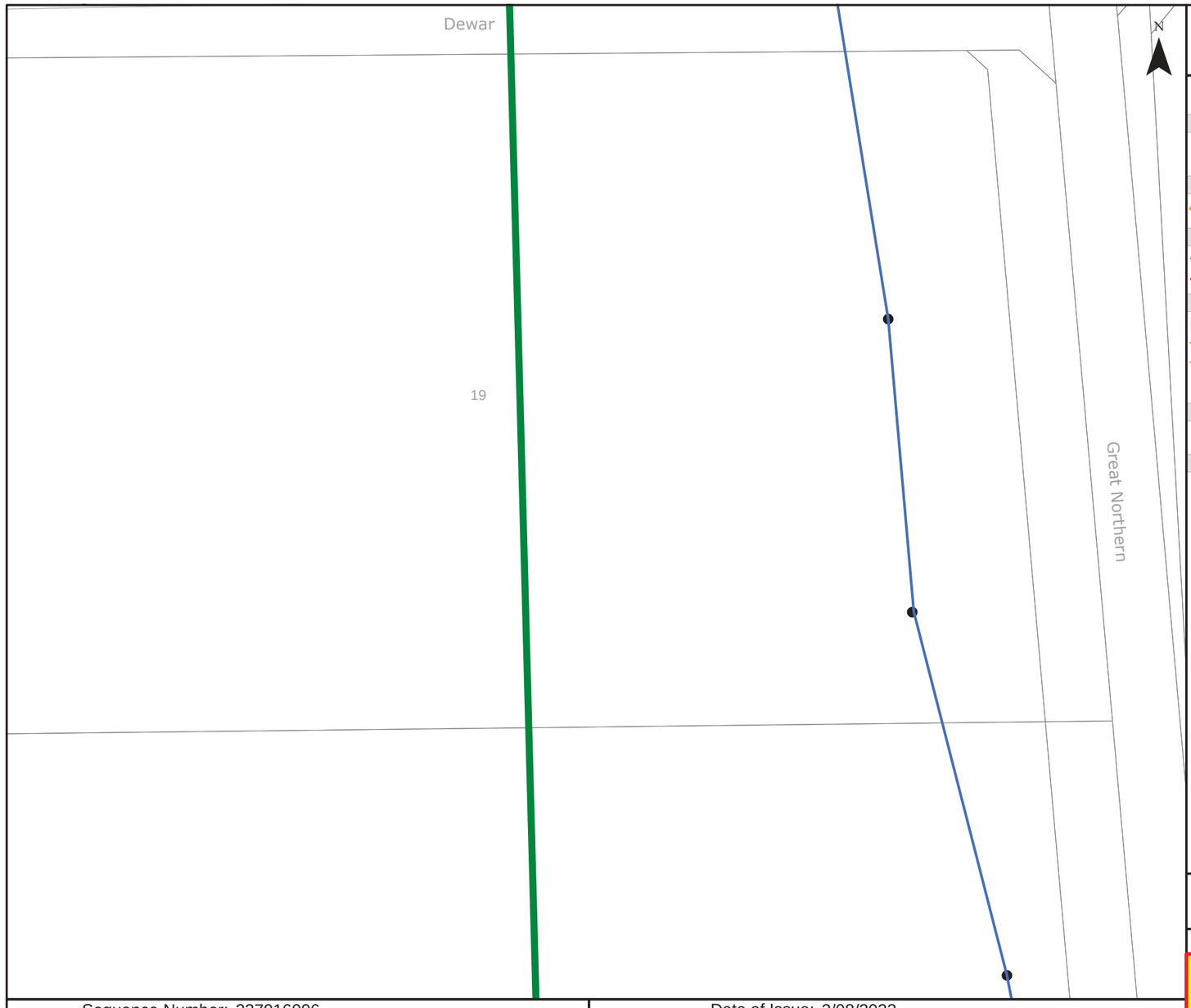

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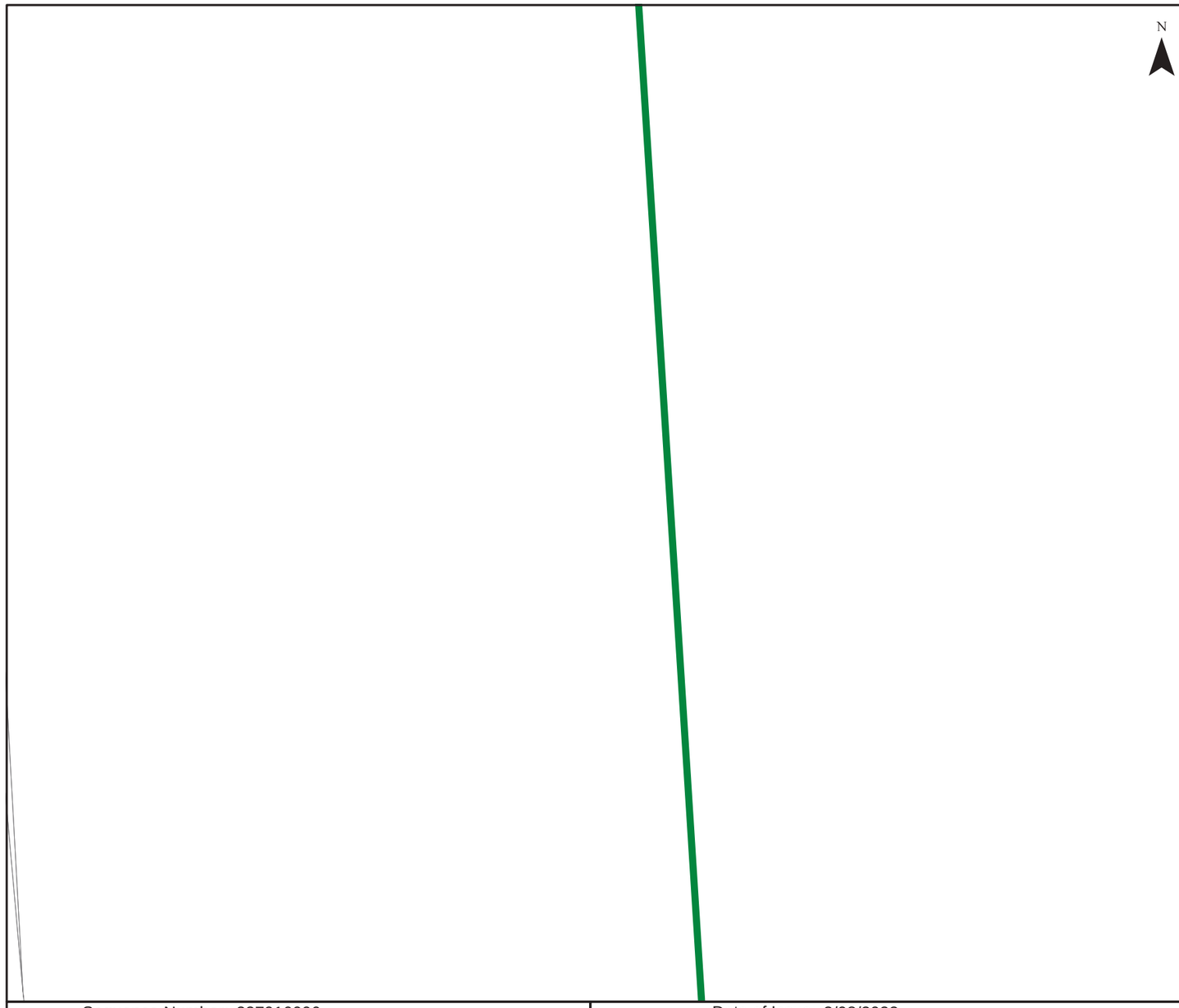

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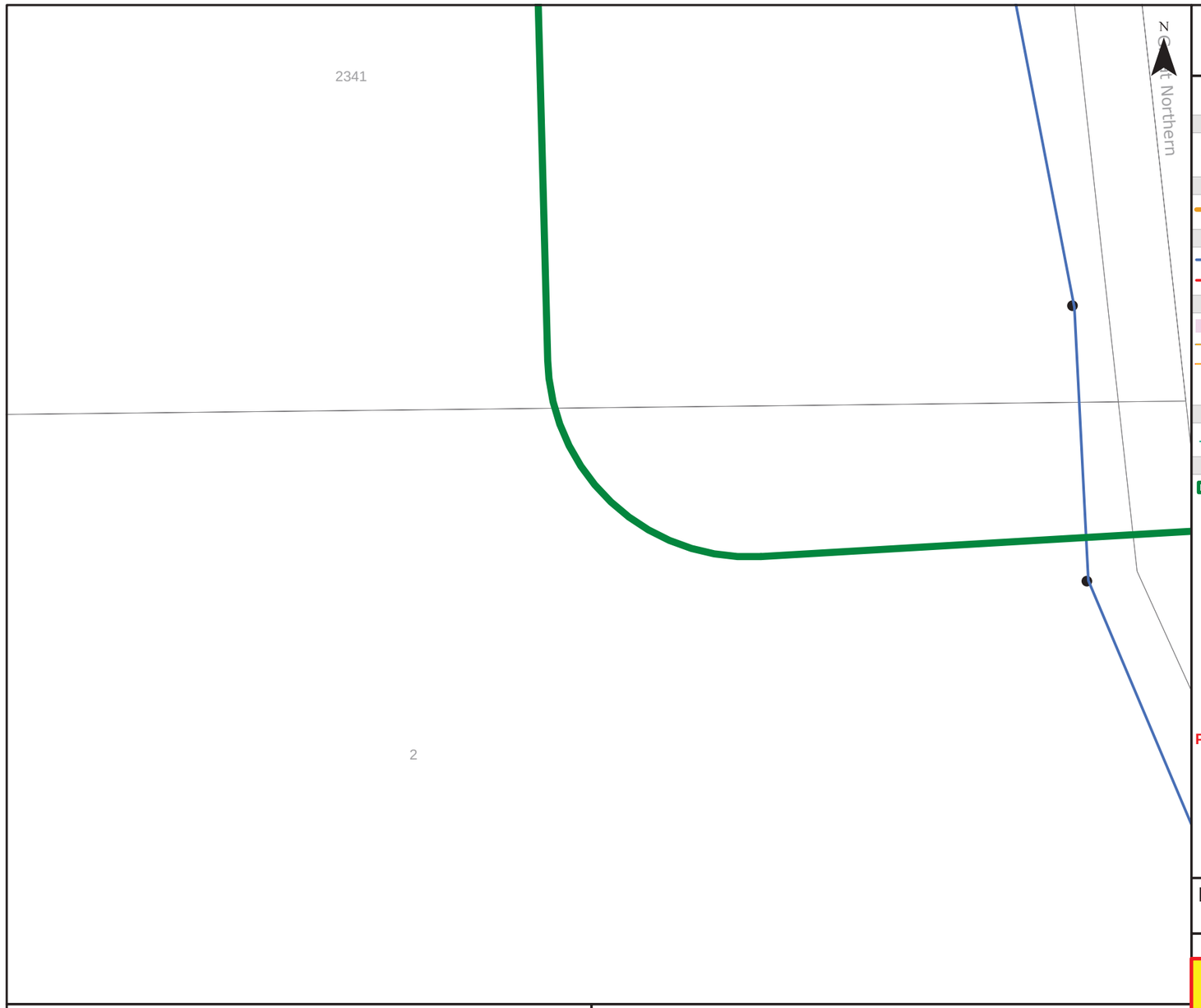

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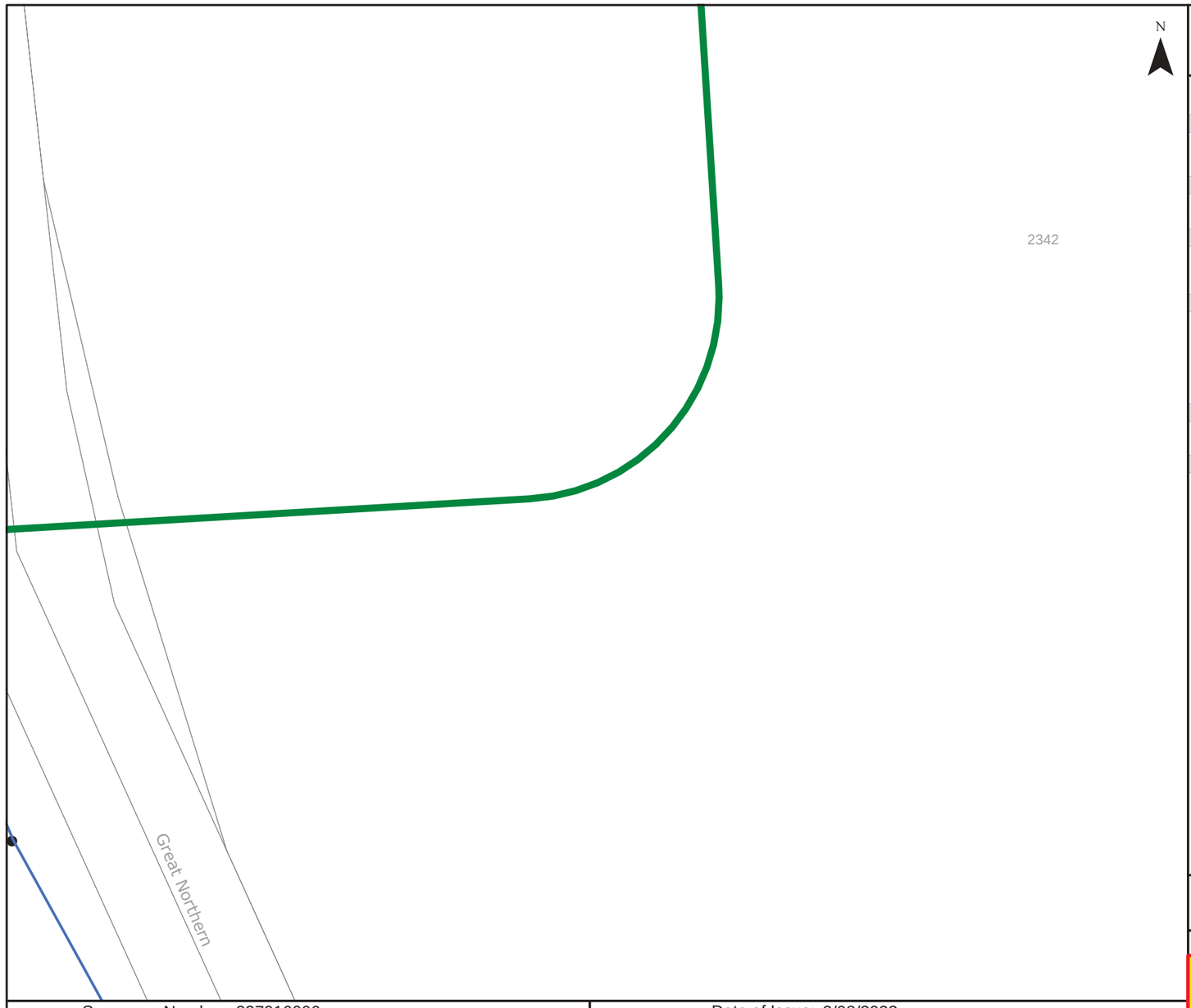

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Appendix Fourteen: Existing Communication and Fibre Infrastructure

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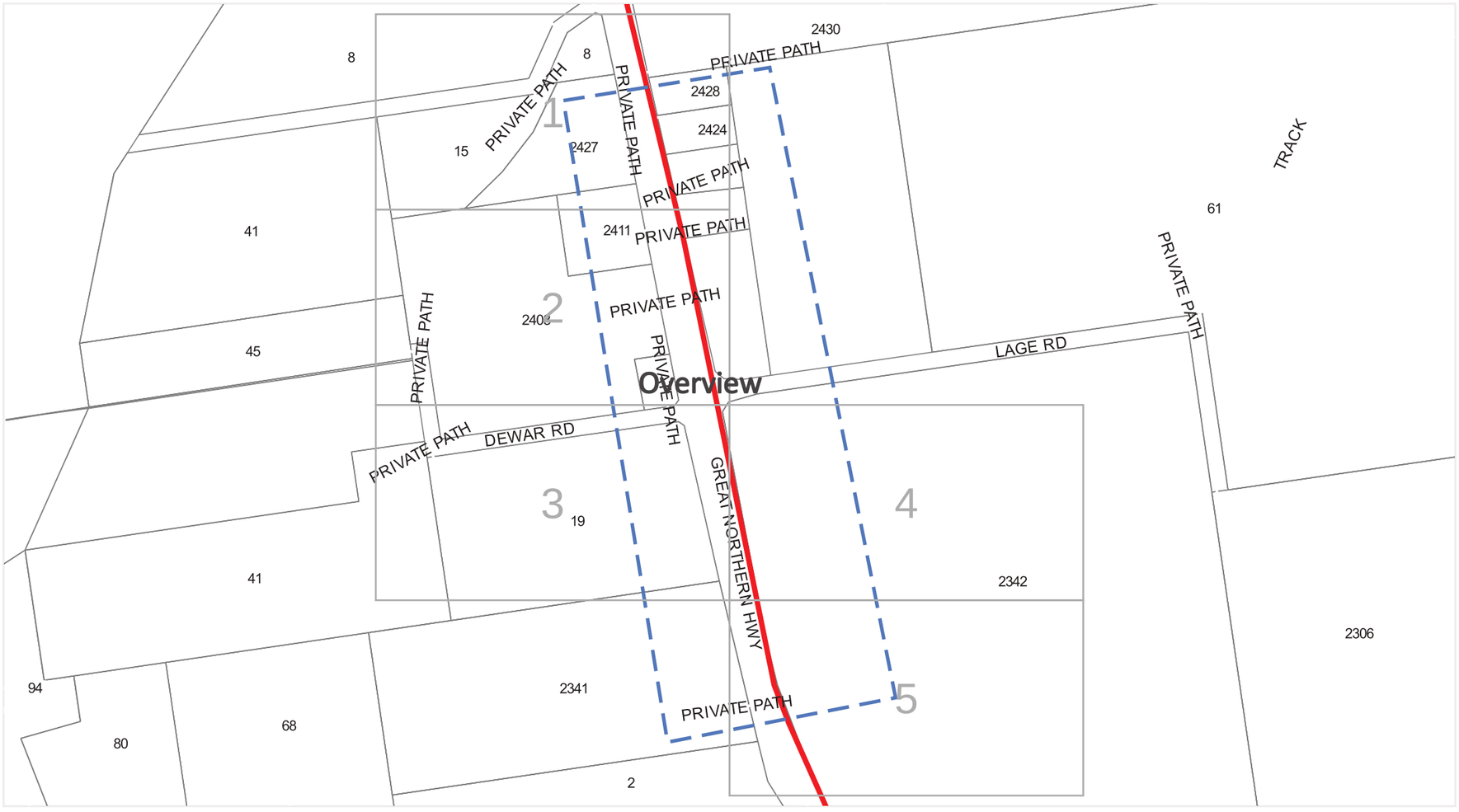

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- AARNet Power Assets
- Cadastre

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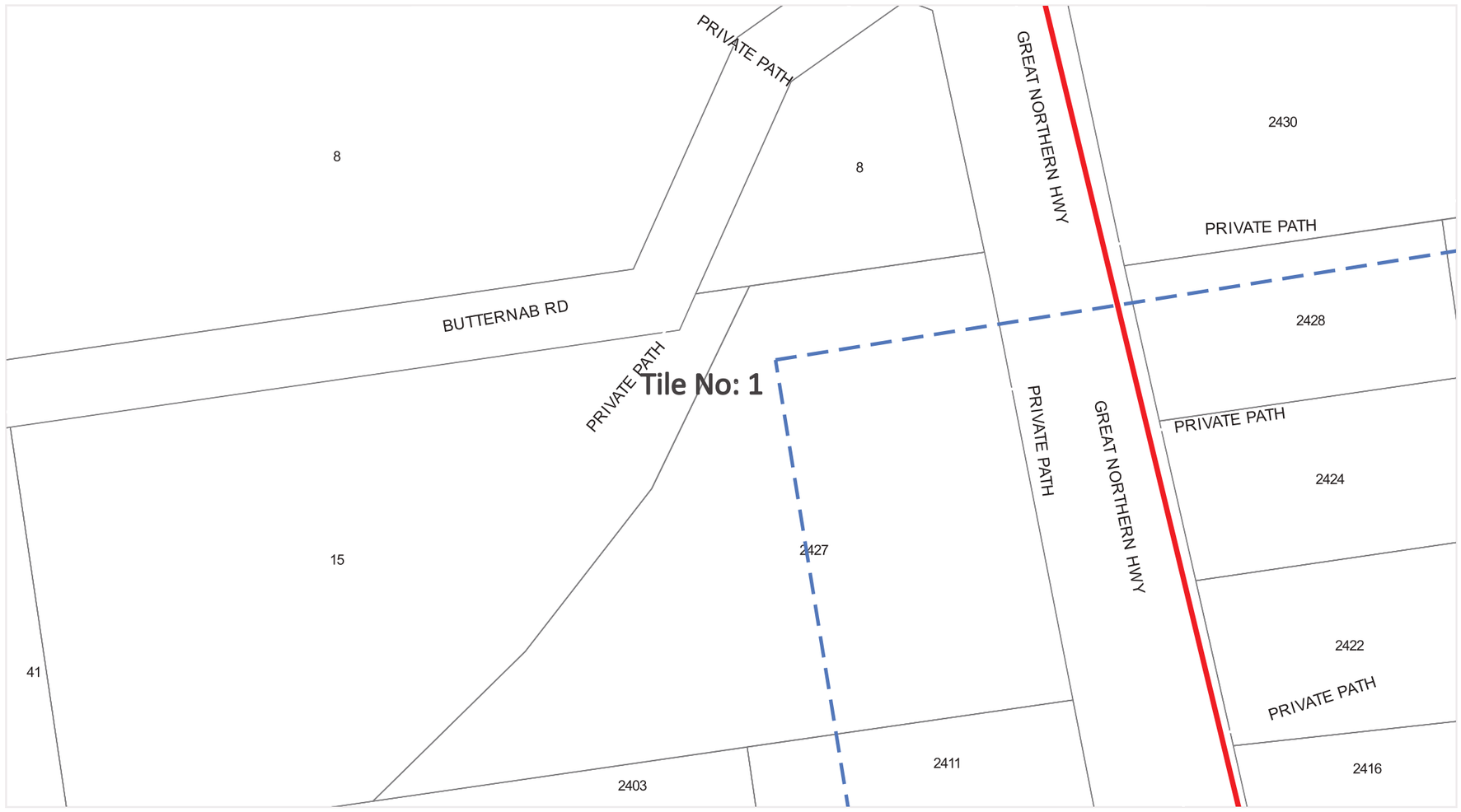

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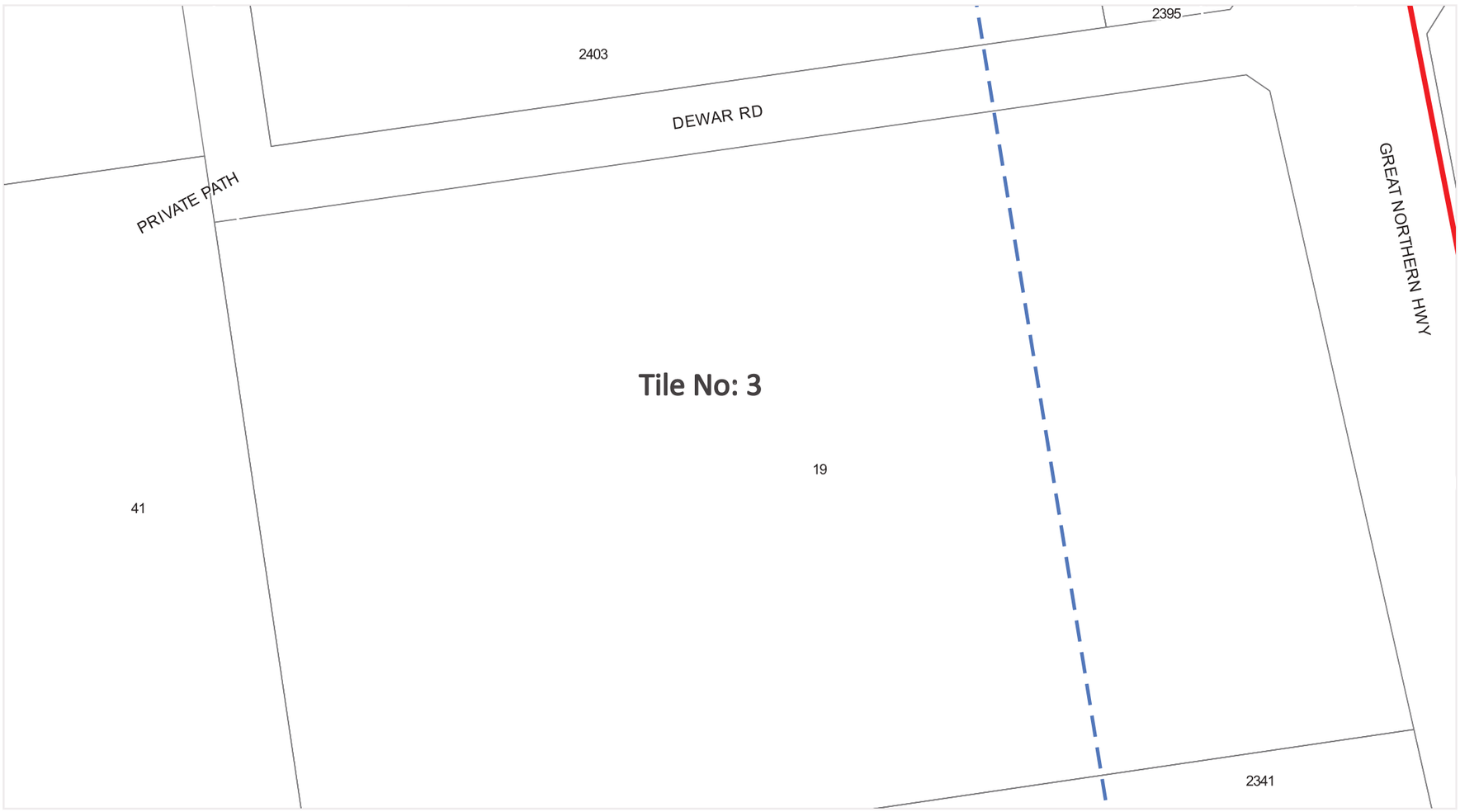

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Cadastre

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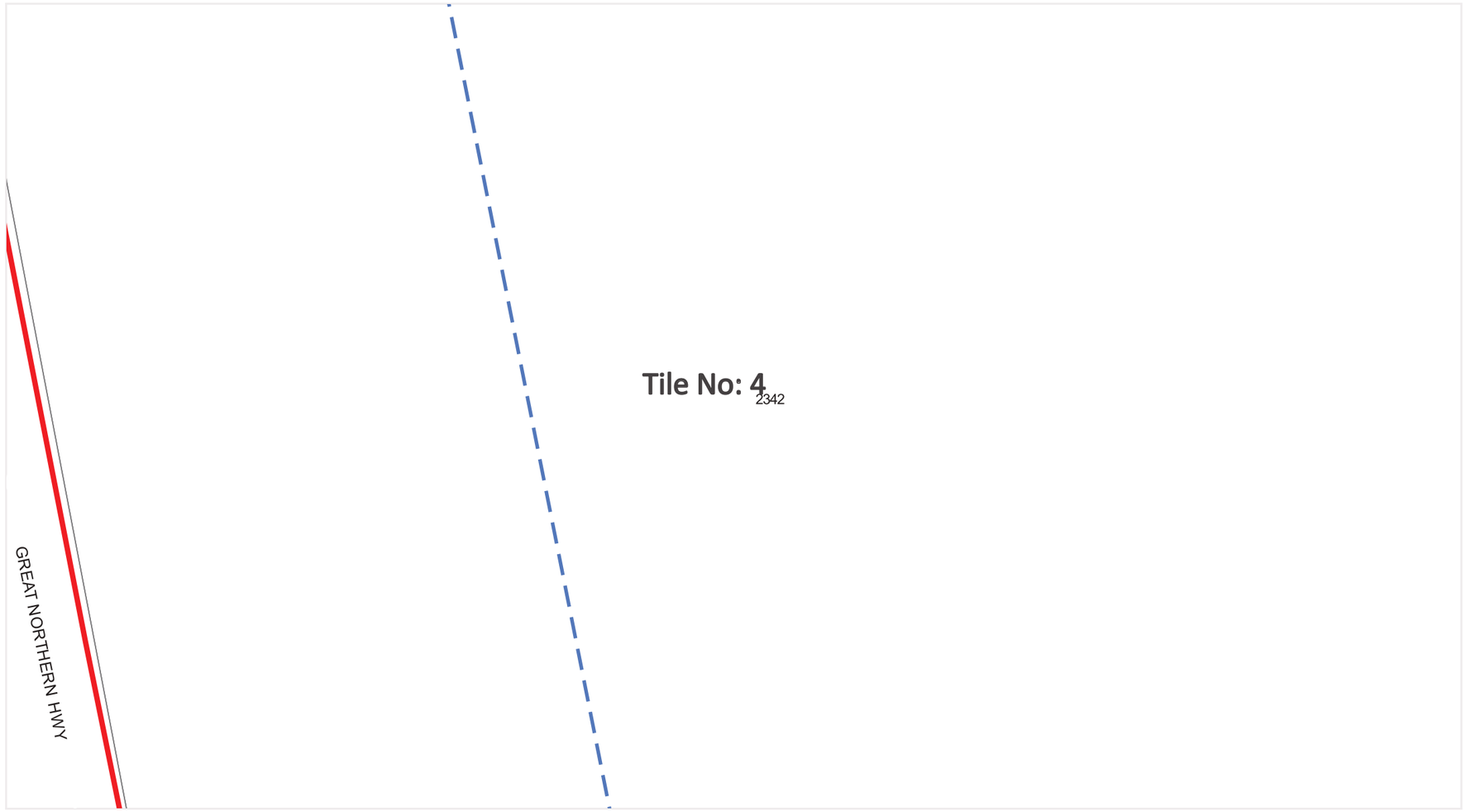

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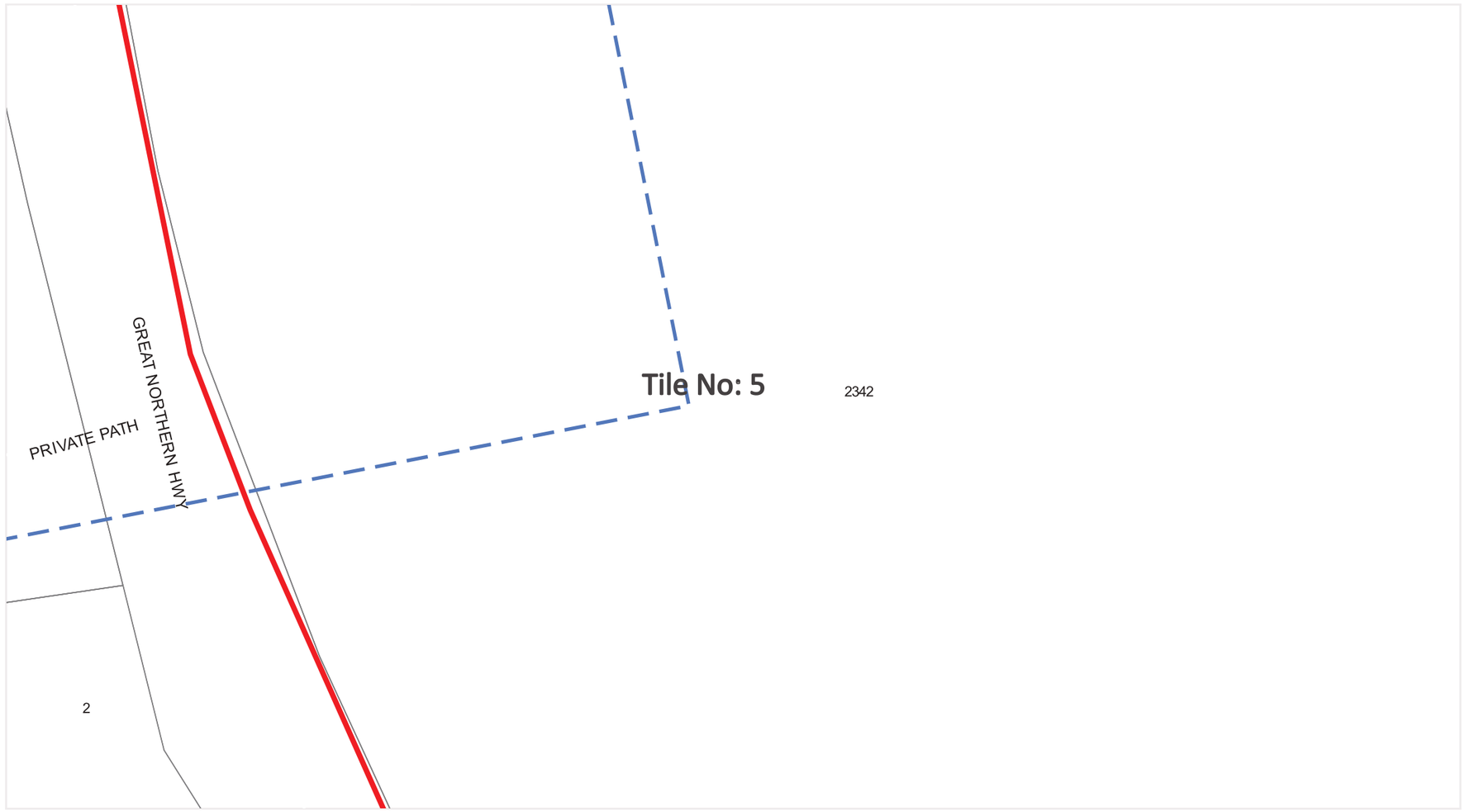

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Attachment 2

Transport Impact Assessment

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Bullsbrook South Urban Expansion Area

TRANSPORT IMPACT ASSESSMENT FOR PROPOSED LOCAL STRUCTURE PLAN

Updated 17 February 2025

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1. INTRODUCTION

A Local Structure Plan has been prepared by Rowe Group, on behalf of Mirvac, for the proposed development of the Bullsbrook South Urban Expansion Area, which is located on the eastern side of Great Northern Highway, north of Stock Road, as shown in the overall Locality Plan in Figure 1.

The subject site is currently zoned Urban Deferred within the Metropolitan Region Scheme. However, an application has been lodged to have urban deferment lifted, and the land transferred to the Urban zone.

Uloth and Associates was initially appointed to provide input to the proposed local structure plan (and supporting concept plan) and to prepare a Transport Impact Assessment in support of the proposal. The initial report (dated 15 December 2023) has now been updated in response to comments from City of Swan, Main Roads WA and Department of Transport.

1.1 BACKGROUND INFORMATION AND PREVIOUS STUDIES

The proposed Bullsbrook South Urban Expansion Area was initially identified for residential development as part of the Bullsbrook Townsite Land Use Master Plan report (October 2014), which provided a strategy for future development of the townsite, including future road network requirements, access arrangements and public transport provision. The overall plan was then incorporated into the approved Bullsbrook Townsite District Structure Plan (April 2018), which is described below in Section 2.2.

Traffic modelling for the overall District Structure Plan was documented in the Transcore report titled *Bullsbrook Townsite Land Use Master Plan - Precinct Traffic Contributions* (June 2018). The report includes detailed breakdowns of traffic flows generated by the various precincts within the overall District Structure Plan area, together with external traffic flow forecasts and future total traffic flows.

It is also important to note that the area immediately north of the Subject Site is part of the Kingsford Local Structure Plan (as referred to below in Section 2.3), which was approved and endorsed in November 2022. An additional local structure plan (*City of Swan Structure Plan No.11: Lot 301 Stock Road & Lot 302 Lage Road*) has also been approved and endorsed (in February 2020), for rural residential development to the east of the Subject Site, including the extension of the existing Lage Road (now Yarrimbah Drive) towards the east and north.

1.2 STUDY OBJECTIVES

The overall objective for this study is to prepare a Transport Impact Assessment for the proposed Local Structure Plan, and to confirm the suitability of the proposed overall road network.

Specific study objectives are therefore as follows:

- Identify and document the existing situation within and adjacent to the proposed structure plan area.
- Identify the future land use and traffic generation for the overall development area, together with additional background traffic flows to/from the surrounding areas.
- Prepare a future traffic model to identify future weekday traffic flows and the resulting recommended road hierarchy.
- Make recommendations regarding the required overall road network, road layouts, intersection treatments, pedestrian/cyclist facilities, and resulting road reserves.
- Review and identify the staging and construction of the proposed Great Northern Highway - Yarrimbah Drive - Dewar Road roundabout.



Locality Plan - Proposed Structure Plan

BULLSBROOK SOUTH URBAN EXPANSION AREA

FIG. 1

2. STUDY FINDINGS AND CONCLUSIONS

The study findings and conclusions regarding the existing situation and the proposed development are presented and discussed in this chapter, with additional information documented in Technical Appendix A.

2.1 EXISTING SITUATION

The existing situation for the proposed development area is shown in an aerial photograph in Figure A.1 in Chapter A.1 in Technical Appendix A, including the existing Lots within the proposed Local Structure Plan area, and the existing road network adjacent to the site.

- It can be seen in Figure 1 (in Chapter 1) and Figure A.1 that Great Northern Highway runs along the western boundary of the proposed local structure plan area, while Stock Road extends to the east of Great Northern Highway along the southern boundary. It can also be seen that Yarrimbah Drive (previously Lage Road) currently extends approximately 600 metres through the site from its intersection with Great Northern Highway, opposite Dewar Road; however, it has recently also been extended towards the north-east as a secondary access for the eastern rural residential area.

- Great Northern Highway is typically a 2-lane rural highway in the vicinity of the subject site, although with a painted median and right-turn auxiliary lanes at both Dewer Road and Warren Road, and a southbound overtaking lane between Yarrimbah Drive and Stock Road. It is identified as a Primary Distributor Road under the Main Roads WA functional road hierarchy, with a current speed limit of 100 kilometres per hour south of Yarrimbah Drive, decreasing to 80 and then 60 kilometres per hour north of Yarrimbah Drive, leading into the Bullsbrook townsite.

- It can also be seen in Figure A.1 that the Great Northern Highway - Stock Road intersection has recently been upgraded to a roundabout as part of the construction of Stock Road as a major east-west link west of Great Northern Highway to Tonkin Highway.

- Traffic counts obtained from the Main Roads WA Trafficmap website show that Great Northern Highway south of Warren Road carried 7,600 vehicles per day (in May 2022).

- The site is currently serviced by Transperth Bus Route 311, which travels from Midland Station to/from Bullsbrook via Great Northern Highway, with three bus stop locations on Great Northern Highway adjacent to the Subject Site.

- There is currently no pedestrian/cyclist path network available in the vicinity of the proposed development, except for paved shoulders along both sides of Great Northern Highway, which are available for cycling.

- Historical crash data was also obtained from Main Roads WA, indicating that there were 7 reported crashes along Great Northern Highway adjacent to the development site over the past 5 years to December 2023. One crash was 'hospital' in severity, which involved a motorcycle colliding with a vehicle that stopped to turn into a driveway, while two crashes were 'medical' in severity with both incidents caused by a driver trying to avoid a vehicle travelling in the opposite direction that veered into their lane. There were also two incidents that involved a vehicle hitting an object on the road, plus one rear end incident and a side-swipe crash.

2.2 BULLSBROOK TOWNSITE DISTRICT STRUCTURE PLAN

The Bullsbrook Townsite District Structure Plan is as shown in Figure A.2 in Chapter A.2 in Technical Appendix A.

- It can be seen in Figure A.2 that the approved Structure Plan identifies the currently proposed urban expansion area (in the south-east portion of the overall plan) as 'Future Residential' and includes a Neighbourhood Centre at Yarrimbah Drive plus a Primary School and Public Open Space just south of Yarrimbah Drive along a proposed north-south spine road extending south to Stock Road.

- The plan also includes a second north-south road extending north from Yarrimbah Drive (closer to Great Northern Highway) up to and beyond the proposed District Centre and Primary School (within Kingsford), with this road alignment also designated as an 'Activity Corridor' and the proposed alignment for future additional bus routes as well as a possible future rapid transit route.

- The proposed access arrangements, comprising a 4-way intersection at Great Northern Highway - Yarrimbah Drive - Dewer Road and a 4-way intersection at Great Northern Highway - Stock Road, are based on the Main Roads WA Ultimate Road Access Strategy for Great Northern Highway.

- It is important to note that the Great Northern Highway - Yarrimbah Drive - Dewar Road intersection was initially identified for upgrade to a 4-way signalised intersection. However, the City of Swan's *'Bullsbrook Residential Townsite - Development Contribution Plan'* (September 2021) shows that a roundabout is now proposed.

2.3 APPROVED LOCAL STRUCTURE PLANS

As noted above in Section 1.1, there are 2 approved local structure plans abutting the currently proposed development site, including the Kingsford Local Structure Plan (which is as shown in Figure A.3 in Chapter A.2 in Technical Appendix A), and City of Swan Structure Plan No. 11.

- It can be seen in Figure A.3 that the Kingsford Structure Plan identifies the two north-south spine roads as Neighbourhood Connector A roads, but with the eastern road identified as an Integrator B road as it extends south into the proposed Bullsbrook South development area. The plan also includes the proposed closure of the existing Chittering Road junction at Great Northern Highway, in favour of a new roundabout intersection at Great Northern Highway - Maroubra Avenue.

- City of Swan Structure Plan No. 11 (to the east of the site) is proposed for rural residential development, with access via the eastern extension of Yarrimbah Drive.

2.4 PROPOSED STRUCTURE PLAN

The proposed Bullsbrook South Local Structure Plan, as prepared by Rowe Group, is shown in Figure A.4 in Chapter A.3 in Technical Appendix A, while a corresponding development concept plan is shown in Figures A.5 and A.6.

- It can be seen in Figure A.4 that the proposed Structure Plan provides for predominantly residential development, together with a commercial site at the corner of Great Northern Highway and Yarrimbah Drive (previously Lage Road), a second (small) commercial site further east on Yarrimbah Drive, and a centrally located Primary School with adjacent Public Open Space.

- The plan also provides for 2 north-south spine roads extending north into the Kingsford Structure Plan area, in accordance with the Bullsbrook Townsite District Structure Plan. However, it is important to note that Yarrimbah Drive is proposed to deviate north and continue as the through route, to become the eastern spine road, with the recent extension of Yarrimbah Drive to/from the east now becoming the secondary route.

- Vehicular access is also proposed to/from Great Northern Highway via Yarrimbah Drive, as well as via Stock Road (as also indicated in Figures A.4 to A.6), with a large roundabout intersection proposed for the Great Northern Highway - Yarrimbah Drive - Dewar Road 4-way intersection, similar in size to the existing roundabout recently constructed at Stock Road.

- It can also be seen in Figure A.4 that there is a significant area at the north-west corner of the overall site (Lot 401) that is not included within the proposed structure plan. However, the corresponding concept plan (in Figures A.5) provides an indicative development layout for this area.

- On the basis of the proposed concept plan (in Figure A.5), it is estimated that the proposed Structure Plan area (in Figure A.4) will accommodate a total of 2,380 residential dwellings, while the additional development in Lot 401 could yield an further 420 dwellings.

- Table A.1 in Chapter A.3 therefore shows the proposed future land use and estimated trip generation for the overall development, while Figure A.7 shows the breakdown of the overall area into future Traffic Zones, for the preparation of the future traffic model, as discussed below in Section 2.5.

2.5 AIMSUN TRAFFIC MODEL AND FUTURE (2045) TRAFFIC FLOWS

In order to identify future traffic flows (and hence the recommended future road hierarchy) for the proposed Bullsbrook South Local Structure Plan, an AIMSUN traffic model has been developed, combining development traffic flows generated by the proposed structure plan with background traffic flows from the adjacent structure plan areas, as described in Chapter A.4 in Technical Appendix A, while resulting future traffic flows are then discussed in Chapter A.5.

- Figure A.8 in Chapter A.4 shows the proposed roads and intersections within and adjacent to the proposed Structure Plan area, based on the proposed overall concept plan in Figure A.6 (in Chapter A.3).

- Figures A.9 and A.10 then show the overall development area as represented within the AIMSUN traffic model, while the resulting future weekday traffic flows (for full development of the overall Structure Plan areas) are shown in Figure A.11 in Chapter A.5 in Technical Appendix A.

- It can be seen in Figure A.11 that Yarrimbah Drive is expected to carry 12,300 vehicles per day east of Great Northern Highway, reducing to 6,500 vehicles per day east of the western spine road. The eastern spine road carries between 5,800 and 6,800 vehicles per day, north of Yarrimbah Drive, but then varies between 2,700 vehicles per day and 4,700 vehicles per day south of Yarrimbah Drive.

- It can also be seen that the western spine road is expected to carry between 5,400 and 6,500 vehicles per day north of Yarrimbah Drive, but between 1,800 and 4,900 vehicles per day south of Yarrimbah Drive.

- Figure 2 in Chapter 3 Overall Conclusions and Recommendations shows the resulting recommended road hierarchy and road reserves, in accordance with Liveable Neighbourhoods, based on the forecast future traffic flows, noting that Yarrimbah Drive is recommended to be classified as an Integrator B road between Great Northern Highway and the eastern spine road, and then as a Neighbourhood Connector B road further east.

- It was initially recommended that the 2 north-south spine roads, north of Yarrimbah Drive, should be classified as Neighbourhood Connector A roads (with 24.4 metre road reserves), suitable for volumes up to 7,000 vehicles per day. However, it is possible that the northern part of the eastern spine road could carry higher traffic flows during an interim stage, if the northern part of the western spine road (within Lot 401) has not yet been constructed; it is therefore recommended to be classified as a 'Unique Transitional Neighbourhood Connector,' with an increased road reserve width of up to 26 metres.

- The remaining sections of the north-south spine roads, as well as both Stock Road and the east-west road immediately south of the proposed Primary School, should also be classified as Neighbourhood Connector A roads (as also shown in Figure 2), while all other roads within the Bullsbrook South Local Structure Plan area can be classified as various types of Access Streets or Laneways, as also shown.

2.6 YARRIMBAH DRIVE ALIGNMENT AND INTERNAL INTERSECTION SPACING

The recommended road alignments and intersection treatments for the overall structure plan area are shown in Figure 3 in Chapter 3 Overall Conclusions and Recommendations.

- It is important to note that the proposed alignment of Yarrimbah Drive between Great Northern Highway and the eastern spine road is designed to retain as many of the existing line of trees as possible. However, it is also proposed as a meandering alignment, such that the trees are within the proposed median at the western end, but then within the northern verge further east (on either side of the western spine road), and then again within the median as the road bends towards the north at the eastern spine road.

- It is also recommended that Yarrimbah Drive should have no direct lot access between Great Northern Highway and the eastern spine road, with recommended service roads or rear-lane access along this section, due to the high anticipated future traffic flows.

- Minimum intersection spacing for all-movement access along a Neighbourhood Connector road should be 40 metres, in accordance with Liveable Neighbourhoods.

- It is therefore important to ensure that the Yarrimbah Drive intersection with the southern part of the eastern spine road provides the minimum intersection spacing of 40 metres, as also noted in Figure 3, with the overall intersection design as shown in Figure 4 in Chapter 3.

2.7 GREAT NORTHERN HIGHWAY - YARRIMBAH DRIVE - DEWAR ROAD INTERSECTION

- As noted above in Section 2.1, the existing intersection at Great Northern Highway - Yarrimbah Drive - Dewar Road provides a right-turn auxiliary lane within the Highway for right turns into Dewar Road; however, due to the short left-right stagger distance between Dewar Road and Yarrimbah Drive there are no turn lane treatments for access into Yarrimbah Drive.

- Whilst this is acceptable for the currently low traffic flows on Yarrimbah Drive, it will not be possible to retain this configuration once development commences for the proposed Structure Plan. It is therefore important to note that the intersection has been identified as a future 4-way roundabout (as noted in Section 2.2) and it is expected to be constructed to a similar standard as the existing roundabout at the Great Northern Highway - Stock Road intersection.

- The indicative concept plan for the 'ultimate' future roundabout at Great Northern Highway - Yarrimbah Drive - Dewar Road is therefore as shown in Figure 5 in Chapter 3, based on the 15-percent 'Ultimate Design' drawings prepared by Pritchard Francis (after discussion with both Main Roads WA and City of Swan). The full set of 15-percent design drawings, including swept path diagrams for heavy vehicles, are also attached in Technical Appendix B.

- Intersection operational (SIDRA) analysis for the proposed ultimate roundabout is then shown in Table A.3 in Chapter A.6 in Technical Appendix A, based on the full-development intersection traffic flows in Figure A.12 in Chapter A.5 (which assumes the initial trip distribution scenario with 55 percent of trips travelling to/from the adjacent District Structure Plan areas).

- The analysis shows that the proposed 'ultimate' roundabout will operate at a high overall Level of Service A during both the long-term AM and PM peak hours, indicating very good operating

conditions with little or no traffic delays. However, the high proportion of trips assigned to/from the District Structure Plan has been questioned, since it reduces the amount of traffic accessing the area via the proposed roundabout.

- A sensitivity test has therefore also been carried out, with the proportion of trips allocated to the District Structure Plan area reduced from 55 percent to 40 percent, resulting in increased traffic flow along Yarrimbah Drive, as shown in the alternative peak hour intersection traffic flows in Figure A.13 in Chapter A.5.

- The resulting peak hour intersection operational analyses are then shown in Table A.4 in Chapter A.6, confirming that the roundabout will still operate at high Levels of Service A and B under this alternative scenario.

- The analysis therefore confirms the suitability of the proposed access arrangements for the overall structure plan; however, it is unclear whether the required land acquisition on the western side of the Highway will be possible in the short term, to allow the construction of the full-size roundabout in time for the proposed Stage 1 development.

- It is therefore necessary to also consider a possible interim design for the proposed 4-way intersection, as discussed below in Section 2.9.

2.8 PUBLIC TRANSPORT, PEDESTRIAN/CYCLIST FACILITIES AND SAFE ROUTES TO SCHOOL

With the recommended road hierarchy and road reserves as shown in Figure 2 in Chapter 3, it is now also necessary to consider the overall bus services and pedestrian/cyclist facilities within and adjacent to the proposed Bullsbrook South Local Structure Plan, which will also ensure provision for alternative transport modes and safe routes to school for the proposed new Primary School.

- It is important to note that future bus routes will be able to access the structure plan area via Yarrimbah Drive, and then travel north on either of the 2 spine roads (including the possible future 'rapid transit route' along the western spine road, as identified in the Bullsbrook Townsite District Structure Plan). Additional bus routes will also be able to access the overall site via Stock Road, and then via either of the 2 north-south spine roads, to best service the overall area.

- Figure 7 in Chapter 3 therefore identifies a series of possible future bus routes utilising Yarrimbah Drive and/or the various Neighbourhood Connector roads within the Bullsbrook South Local Structure Plan.

- It is also recommended to ensure that pedestrian/cyclist facilities are provided throughout the overall structure plan area, in accordance with Liveable Neighbourhoods. On-road cycle lanes plus a shared path on at least one side of the carriageway should be provided on Integrator and Neighbourhood Connector A roads, while a shared path on at least one side of the carriageway is also required on Neighbourhood Connector B roads. Additional shared paths are also proposed within the Bullsbrook South indicative concept plan.

- It is also important to note that the Department of Transport's interactive Long Term Cycle Network map for Perth and Peel identifies Great Northern Highway in the vicinity of the Bullsbrook South Structure Plan as a 'Secondary Route' (expected to have moderate levels of demand and provide connectivity between primary routes and major activity centres); it also shows Yarrimbah Drive and the western spine road north of Yarrimbah Drive as a 'Local Route' (with lower levels of demand but providing critical access to higher order routes, local amenities and recreational space).

- Figure 8 in Chapter 3 therefore shows the recommended pedestrian/cycle route network for the proposed structure plan, taking into account both the recommended road hierarchy, the proposed Development Concept Plan and the Long Term Cycle Network from Department of Transport.

- It can be seen in Figure 8 that the Liveable Neighbourhoods requirements for cycle lanes and shared paths, together with the additional shared paths proposed by the developer, results in a well-connected overall network to support the increased use of active transport modes.

- It is also important to note that the proposed ultimate roundabout design for the Great Northern Highway - Yarrimbah Drive - Dewar Road intersection provides path connections and crossing facilities across all 4 intersection legs, for safe pedestrian/cyclist routes and crossings, while the interim design (discussed below in Section 2.9) currently only shows crossings across the eastern and northern legs.

- The recommended 'Safe Routes to School' are then shown in Figure 9 in Chapter 3, confirming that direct, convenient and safe access routes will be available for pedestrians and cyclists accessing the new Primary School from the surrounding area.

2.9 PROPOSED INTERIM INTERSECTION DESIGN

- As noted above in Section 2.7, the proposed 'Ultimate Design' for the Great Northern Highway - Yarrimbah Drive - Dewar Road roundabout will be reliant on land acquisition from the western side of the Highway, which may not be available to construct the full-size roundabout in time for the proposed Stage 1 development of the Structure Plan.

- A possible interim road design was therefore initially considered, to construct a temporary deviation of Yarrimbah Drive approximately 150 metres to the north and therefore provide staggered T-Junctions for Dewar Road and Yarrimbah Drive. However, this was deemed to be less safe than an alternative (smaller) roundabout treatment; so, in collaboration with Main Roads WA, an interim roundabout design has been developed, providing 2 southbound lanes on Great Northern Highway but only 1 northbound lane, as shown in Figure 6 in Chapter 3 Overall Conclusions and Recommendations, based on the 15-percent design drawings from Pritchard Francis (which are attached in Technical Appendix C).

- It is important to note that the proposed interim design allows the eastern side of the roundabout to be constructed on its ultimate alignment, while the western side is modified to avoid any land acquisition from the adjacent Dewar Road properties. However, it is also important to confirm the future operation of this interim roundabout design, as development progresses within the proposed structure plan.

- Additional analyses have therefore also been carried out, based on interim future traffic flows identified and discussed in Chapter A.7 in Technical Appendix A.

- The analysis suggests that if development progresses at approximately 100 Lots per year from 2025, with access only via the interim roundabout at Great Northern Highway - Yarrimbah Drive, the proposed interim roundabout will reach the MRWA-preferred maximum degree of saturation of 0.85 by 2032 (with a maximum of 720 dwellings); alternatively, if the eastern spine road is also connected through into Kingsford, then the additional traffic route will reduce pressure on the interim roundabout, allowing it to continue operating at acceptable Levels of Service until approximately 2035 (with the construction of up to 1,050 Lots).

- However, if the allowable criteria is extended to a maximum degree of saturation of 0.95, then the interim roundabout will continue to operate until at least 2033 (with up to 880 dwellings), with access only via Yarrimbah Drive, or up to 2037 (with up to 1,210 dwellings) with the spine road extended north into Kingsford.

- It is therefore recommended that the eastern north-south spine road should be extended north into Kingsford by no later than 2032/33, and that the proposed interim roundabout at Great Northern Highway - Yarrimbah Drive will then be able to remain for at least 10 to 12 years (to 2037).

3. OVERALL CONCLUSIONS AND RECOMMENDATIONS

The overall conclusions and recommendations regarding the proposed Bullsbrook South Local Structure Plan are documented in this chapter, on the basis of the study findings and conclusions presented and discussed above in Chapter 2, and the additional information provided in the Technical Appendices.

- The proposed Local Structure Plan will accommodate an estimated 2,380 residential dwellings, a commercial area for a Local Centre, and a new Primary School, consistent with the proposed development identified under the Bullsbrook Townsite District Structure Plan.

- An additional development area in the north-west corner of the site (not part of the current structure plan) will accommodate a further 420 residential dwellings, bringing the total development (for traffic analysis purposes) to approximately 2,800 dwellings.

- Figure 2 shows the recommended road hierarchy and road reserves for the proposed development, based on future (full development) traffic forecasts identified in Figure A.11 in Chapter A.5 in Technical Appendix A, noting that Yarrimbah Drive should be classified as an Integrator B road between Great Northern Highway and the eastern spine road, but then as a Neighbourhood Connector B road further east.

- It can also be seen in Figure 2 that the eastern north-south spine road, north of Yarrimbah Drive is recommended as a 'Unique Transitional Neighbourhood Connector' road, with an increased road reserve of up to 26 metres to allow for the possibility of increased interim traffic flows if the northern part of the western spine road (within Lot 401) has not been constructed.

- The remaining sections of both north-south spine roads are then recommended as Neighbourhood Connector A roads, as also shown in Figure 2, together with both Stock Road and the east-west road immediately south of the proposed Primary School.

- Figure 3 then shows the recommended road alignments and intersection treatments for the overall structure plan, with reference to a more-detailed intersection layout for the Yarrimbah Drive intersection with the eastern spine road, as shown in Figure 4.

- It can be seen in Figure 4 that it is recommended to ensure that the Yarrimbah Drive intersection with the southern part of the eastern spine road provides a minimum intersection spacing of 40 metres, while the recommended intersection layout and pavement line markings for the intersection on the proposed bend in Yarrimbah Drive are also shown.

- Figure 5 shows the recommended 'ultimate' concept plan for the future roundabout at the Great Northern Highway - Yarrimbah Drive - Dewar Road 4-way intersection, as also shown in the 15-percent design drawings in Technical Appendix B, while Figure 6 then shows the recommended 'interim' concept plan, based on the 15-percent design drawings in Technical Appendix C.

- Figure 7 shows the possible future public bus routes within the proposed Structure Plan, including the future rapid transit route identified within the Bullsbrook Townsite District Structure Plan.

- Pedestrian/cyclist facilities should also be provided along all roads within the overall structure plan, in accordance with Liveable Neighbourhoods requirements. Figure 8 therefore shows the recommended pedestrian/cycle network within the proposed Structure Plan, including proposed on-road cycle lanes and roads with at least one shared path, plus additional (separate) shared paths already identified within the overall plans.

- Figure 9 then shows the resulting 'Safe Routes to School', confirming that direct, convenient and safe access routes will be available for pedestrians and cyclists accessing the new Primary School to/from the surrounding areas.

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LEGEND

- Primary Distributor
- Integrator B (29m)
- Unique Transitional Neighbourhood Connector (24 - 29m)
- Neighbourhood Connector A (24m)
- Neighbourhood Connector B (20m)
- Access Street B (17.9m)
- Access Street C (15.4m)
- Access Street D (15 - 15.4m)
- Laneway (6m) or Service Road

SOURCE: ULOTH & ASSOCIATES

Primary School

YARRIMBAH DRIVE

GREAT NORTHERN HIGHWAY

DEWAR ROAD

WARREN ROAD

STOCK ROAD

0 100 200

METRES

SCALE 1 : 7,500

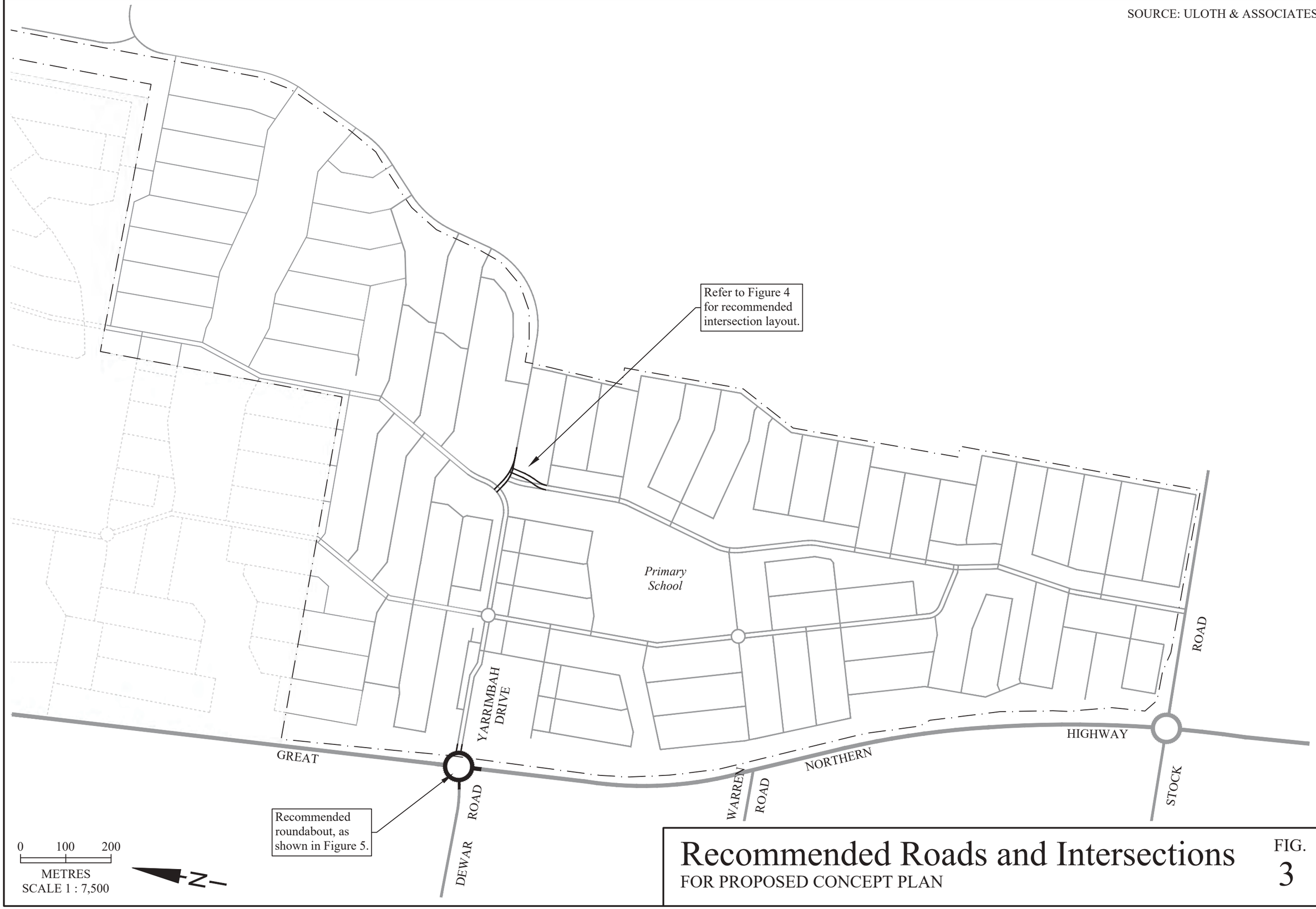
N

Recommended Road Hierarchy and Road Reserves

FOR OVERALL BULLSBROOK SOUTH URBAN EXPANSION AREA

FIG. 2

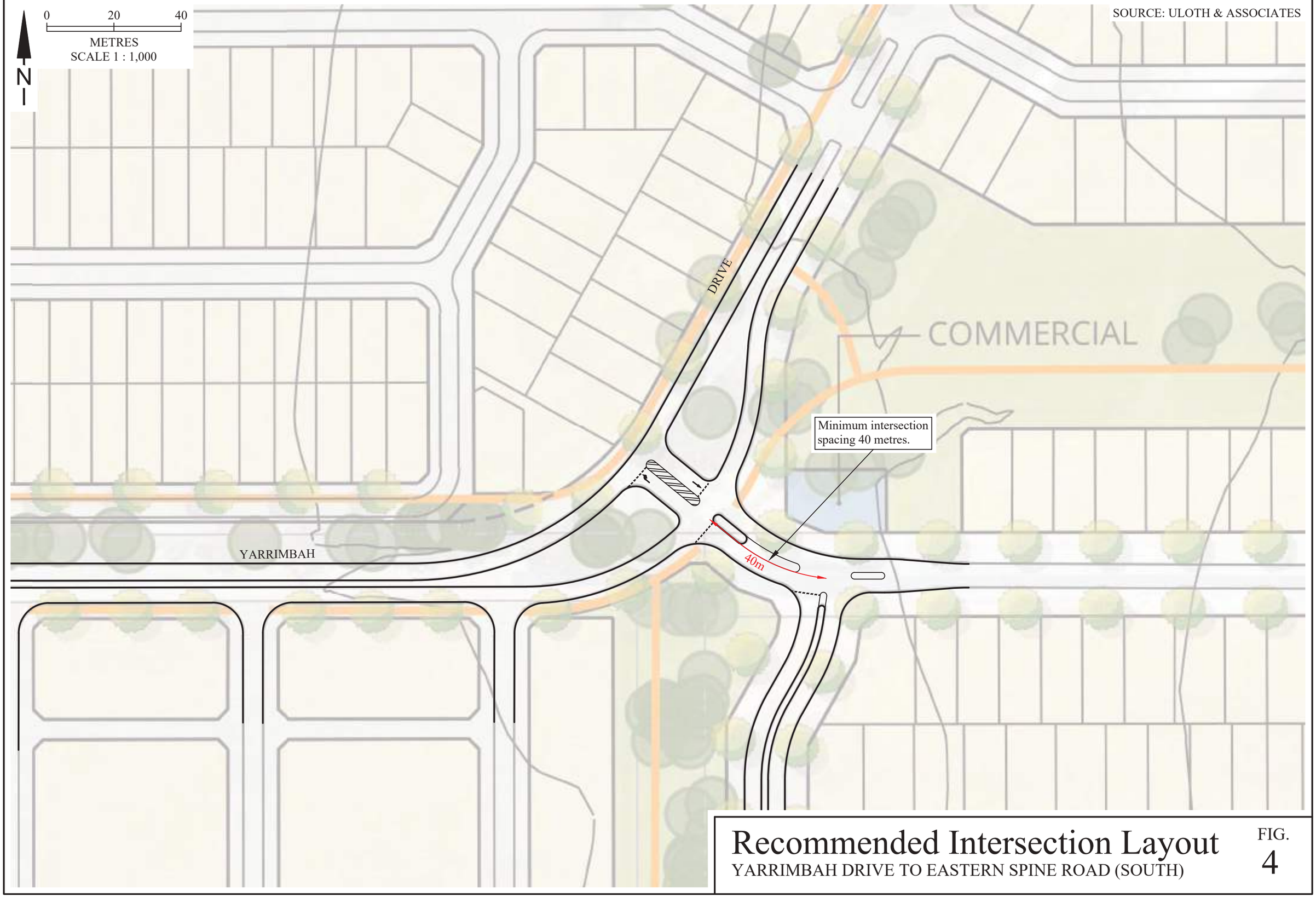
SOURCE: ULOTH & ASSOCIATES



Recommended Roads and Intersections

FOR PROPOSED CONCEPT PLAN

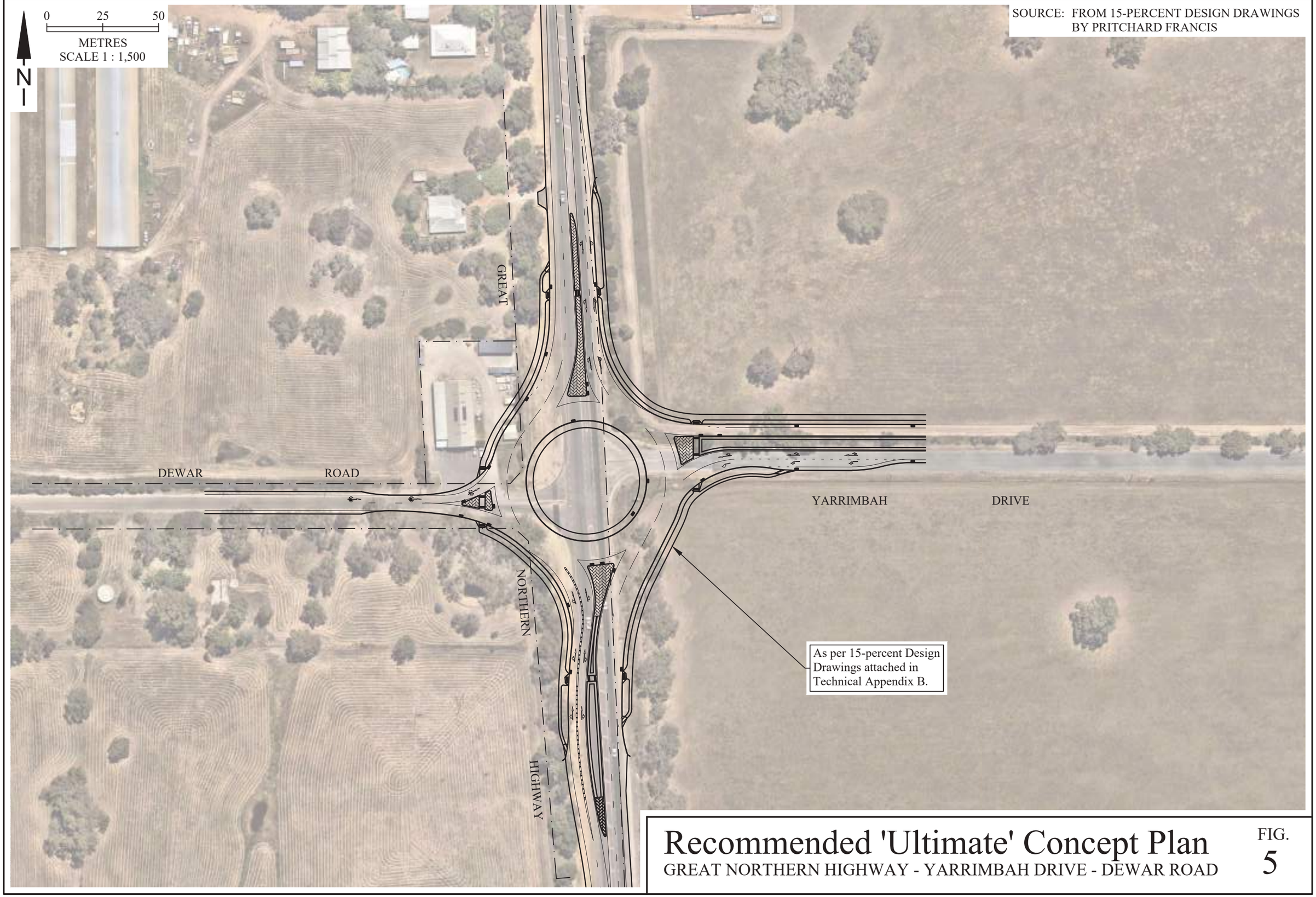
FIG. 3



Recommended Intersection Layout

YARRIMBAH DRIVE TO EASTERN SPINE ROAD (SOUTH)

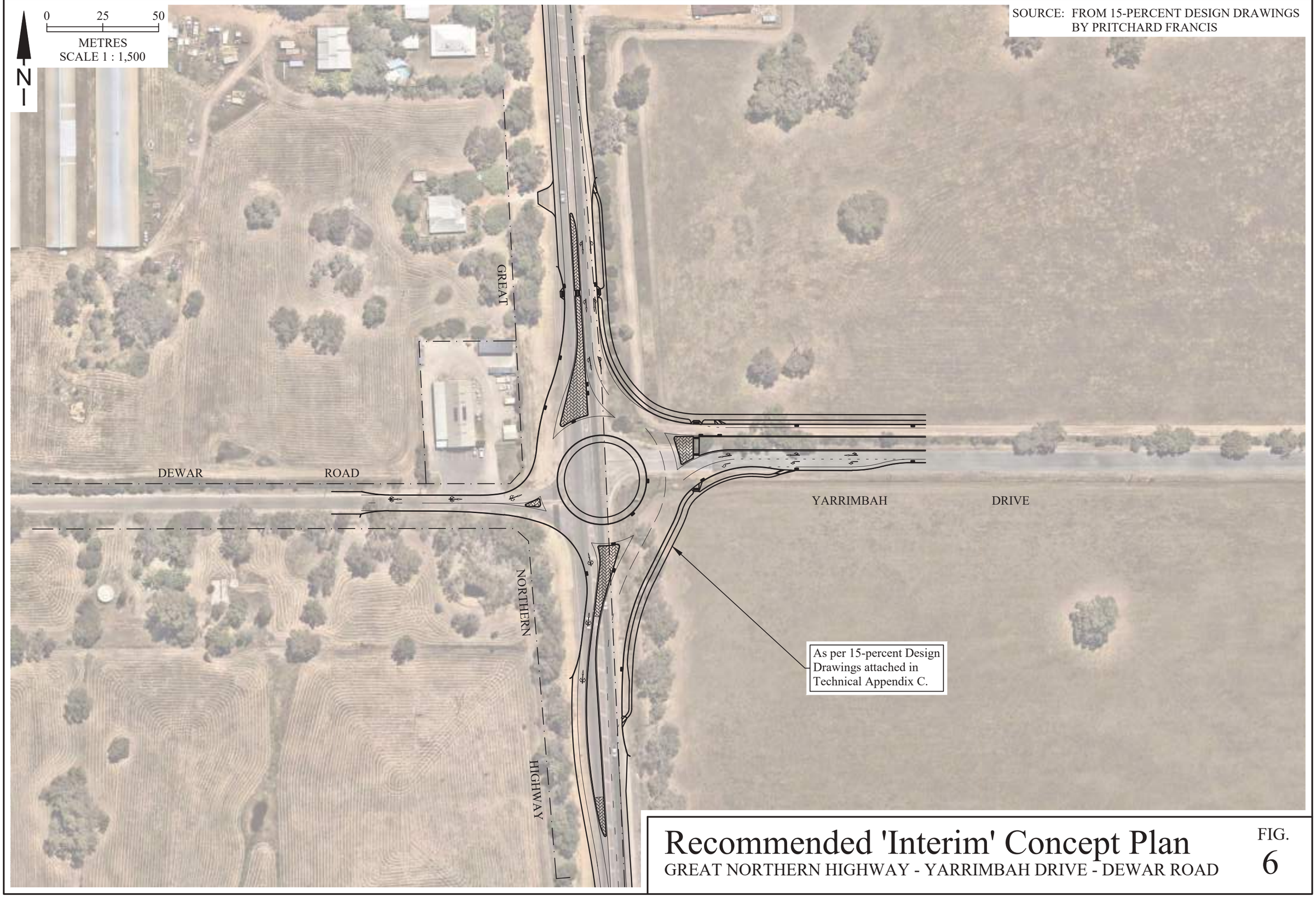
FIG. 4



Recommended 'Ultimate' Concept Plan

GREAT NORTHERN HIGHWAY - YARRIMBAH DRIVE - DEWAR ROAD

FIG. 5



Recommended 'Interim' Concept Plan

GREAT NORTHERN HIGHWAY - YARRIMBAH DRIVE - DEWAR ROAD

FIG. 6

LEGEND

Future Rapid Transit Route

Possible Additional Bus Routes:

Route 1

Route 2

Route 3

Ⓣ Terminus

SOURCE: ULOTH & ASSOCIATES

GREAT NORTHERN HIGHWAY

YARRIMBAH DRIVE

DEWAR ROAD

WARREN ROAD

STOCK ROAD

0 100 200

METRES

SCALE 1 : 7,500

N

Possible Future Bus Routes

BULLSBROOK SOUTH STRUCTURE PLAN

FIG. 7

LEGEND

- Connector roads with On-Road Cycle Lanes and Shared Paths on at least one side
- Connector roads with no On-Road Cycle Lanes but a Shared Path on at least one side
- Local Roads with proposed Shared path on one side
- Additional separate shared path

SOURCE: ULOTH & ASSOCIATES

GREAT NORTHERN HIGHWAY

YARRIMBAH DRIVE

DEWAR ROAD

WARREN ROAD

STOCK ROAD

0 100 200

METRES

SCALE 1 : 7,500

N

Recommended Cycle Route Network

BULLSBROOK SOUTH STRUCTURE PLAN

FIG. 8

LEGEND

Safe Routes to/from Schools

SOURCE: ULOTH & ASSOCIATES

Note: Refer to Figure 8 for Recommended Pedestrian/Cyclist Facilities

Future Primary School

YARRIMBAH DRIVE

GREAT NORTHERN HIGHWAY

DEWAR ROAD

WARREN ROAD

STOCK ROAD

0 100 200

METRES

SCALE 1 : 7,500

N

Recommended Safe Routes to School

BULLSBROOK SOUTH STRUCTURE PLAN

FIG. 9

TECHNICAL APPENDIX A

Technical Appendix A documents the existing situation within and adjacent to the proposed development, together with future land use and trip generation for the proposed Local Structure Plan area, and the development of the AIMSUN traffic model for the identification of total future traffic flows.

A.1 EXISTING ROADS AND INTERSECTIONS

Figure A.1 shows the existing situation in the vicinity of the proposed development.

A.2 APPROVED STRUCTURE PLANS

Figure A.2 shows the Bullsbrook Townsite District Structure Plan (April 2018), which includes the currently proposed development area in the south-east corner of the overall plan.

Figure A.3 shows the Kingsford Local Structure Plan (November 2022), which is located immediately north of the currently proposed Bullsbrook South Local Structure Plan.

SOURCE: NEARMAP PTY LTD

Proposed
Local Structure
Plan Area

Lot 900

Part of
Lot 901

Lot 201

Lot 401
(not part of
proposed
Structure Plan)

Lot 61

Lot 4

Lot 1011

Lot 803

Lot 20

Lot 802

Lot 100

Lot 400

Lot 2

Lot 5

Lot 6

Lot 100

DRIVE

YARRIMBAH

ROAD

GREAT

NORTHERN

HIGHWAY

DEWAR ROAD

WARREN ROAD

STOCK ROAD

0 100 200
METRES
SCALE 1 : 7,500

N

Existing Situation

BULLSBROOK SOUTH URBAN EXPANSION AREA

FIG.
A.1

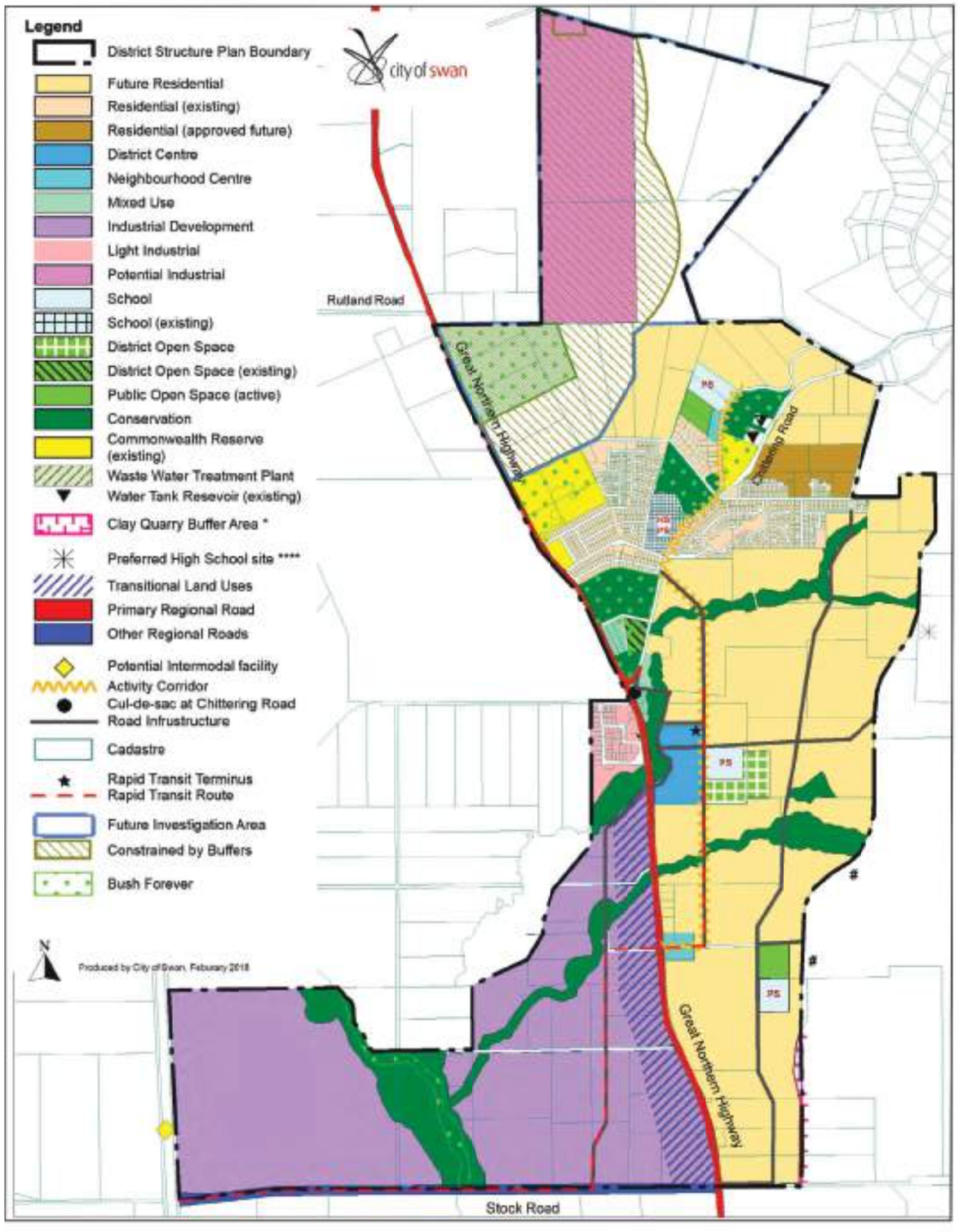


Figure 18. Bullsbrook Townsite District Structure Plan

* The existing 500 metre clay quarry buffer may be reduced in the future, upon agreement of all relevant parties. This buffer is subject to detailed mapping.

** Transitional land uses are required along the western edge of the Great Northern Highway (refer Section 3.1.2 of the Bullsbrook Townsite District Structure Plan report).

*** The location, design and size of the DOS is to be refined through the local structure planning stage.

**** In the event that an additional high school site is required, its siting and location should be determined prior to supporting the first major structure plan. Refer to Section 3.6.1 of the Bullsbrook Townsite District Structure Plan report.

\# It is noted that an existing approved rural local structure plan overlaps in this area. This issue needs to be adressed in future local structure plans.

FIG.
A.2

N

CHITTERING ROAD TO BE IN ACCORDANCE WITH APPENDIX B OF TRANSPORT IMPACT ASSESSMENT, TO ENABLE PROTECTION OF EXISTING TREES ALONG LSP BOUNDARY.

R20

R20 - R30

R20 - R30

R5 - R15

500m LANDFILL BUFFER

R20 - R40

R10 - R30

CHURCH

R20 - R40

R20 - R40

R10 - R30

LANDFILL SITE

R40 - R60

R40 - R60

R20 - R40

R10 - R30

PS

R20 - R40

500m LANDFILL BUFFER

LEGEND

LOCAL STRUCTURE PLAN BOUNDARY (254.61ha)

AREA SUBJECT TO PRECINCT PLAN

ZONES

RESIDENTIAL (R5-R15)

RESIDENTIAL (R20)

RESIDENTIAL (R10-R30)

RESIDENTIAL (R20-R30)

RESIDENTIAL (R20-R40)

RESIDENTIAL (R40-R60)

GENERAL COMMERCIAL

PUBLIC PURPOSE - PS PRIMARY SCHOOL
WC WATER CORPORATION

RECREATION

DISTRICT OPEN SPACE

PRIVATE CLUBS AND INSTUTIONS

PRIMARY REGIONAL ROAD

A68 ADDITIONAL USES - SERVICE STATION

RESERVES

PRIMARY DISTRIBUTOR

INTEGRATOR B

NEIGHBOURHOOD CONNECTOR A

NEIGHBOURHOOD CONNECTOR B

R20 - R40

R20 - R40

GREAT NORTHERN HWY

ENLARGEMENT

FIG.
A.3

okeland COMMUNITIES

KINGSFORD

HATCH | RobertsDay

CADASTRAL INFORMATION
SOURCE: MNG
YYMMDD: 220520
DWG REF: 97797bls-9999bl-PCDP4
PROJECTION: PCDP4

1:10,000 SIZE A3 0 metres 100 200 300 400 500

REV	DESCRIPTION	YYMMDD	DRAWN	APPVD
Z	ADJUST LANDFILL BUFFER	221007	TG	TT
Y	MODIFY DENSITIES	220803	SB	TT
X	MODIFY DENSITIES	210930	SB	TT
W	ADD PROPOSED URBAN AREA	210811	SB	TT

KINGSFORD LOCAL STRUCTURE PLAN
Bullsbrook
City of Swan

REF NO.	DRAW NO.	REV.
AMX BUL	**RD1 107**	**Z**

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

A.3 PROPOSED DEVELOPMENT

Figure A.4 shows the Bullsbrook South Local Structure Plan, while Figure A.5 shows the corresponding concept plan for the proposed development, including an indicative layout for the additional future development area within Lot 401, at the north-west corner of the overall site.

Figure A.6 then shows the proposed concept plan superimposed on an aerial photograph, identifying the proposed development in the context of the adjacent roads and intersections.

Table A.1 shows a summary of the future land use and estimated trip generation for the overall Bullsbrook South Urban Expansion Area, including both the proposed Local Structure Plan area (with 2,380 dwellings) and the additional development area in Lot 401 (with 420 dwellings), while Figure A.7 shows the future Traffic Zones for the development of the future traffic model (which is discussed below in Chapter A.4).

It can be seen in Table A.1 that the proposed Local Structure Plan area is estimated to generate a total of 28,900 vehicle trips per day, with 2,567 trips during the AM peak hour and 3,213 trips during the PM peak hour.

It can also be seen that this increases to a total of 32,860 vehicle trips per day with the inclusion of the additional development area in the north-west corner of the site, before reducing again to a total of 27,640 vehicle trips per day of external traffic flows in and out of the overall study area, including 1,817 trips and 2,668 trips during the AM and PM peak hours, respectively.

TABLE A.1
FUTURE LAND USE AND ESTIMATED TRIP GENERATION
FOR OVERALL BULLSBROOK SOUTH URBAN EXPANSION AREA

PROPOSED LAND USE	TRIP GENERATION		
	AM Peak Hour (vph)	PM Peak Hour (vph)	Weekday (vpd)
• Proposed Local Structure Plan			
- Residential (2,380 dwellings) [1)]	1,666	2,237	22,440
- Primary School (800 students) [2)]	704	568	2,860
- Commercial (2 ha) [3)]	187	385	3,320
- Cafe (500m^2) [4)]	10	23	280
- Sub-Total	2,567	3,213	28,900
• Additional Development (NW Corner)			
- Residential (420 dwellings) [1)]	294	395	3,960
• Total Development	2,861	3,608	32,860
• Less Internal Trips [5)]	- 1,044	- 920	- 5,220
• Total External Trips	1,817	2,668	27,640

Notes:
1) Based on ITE Trip Generation for 'Single Family Detached Housing (#210)'.
2) Based on NSW RMS Trip Generation Surveys Schools Analysis Report for Primary School.
3) Assumes Land Use and trip generation rates:
   - 1,600m^2 Supermarket (Based on NSW RMS 'Shopping Centre').
   - 3,400m^2 Bulky Retail (Based on a range of trip generation rates for NSW RMS 'Bulky Retail and Hardware Store' and ITE 'Hardware (#816)' / 'Home Improvement (#862)).
   - Child Care Centre for 92 children (Based on Uloth and Associates Surveys).
4) Based on NSW RMS Trip Generation rate for 'Speciality Shop'.
5) Internal Trips (Remaining within Structure Plan area):
   - 100 percent Cafe trips linked with residential development.
   - 20 percent Commercial trips linked with residential and school development.
   - 70 percent School trips linked with residential and commercial development.

Source: Uloth and Associates

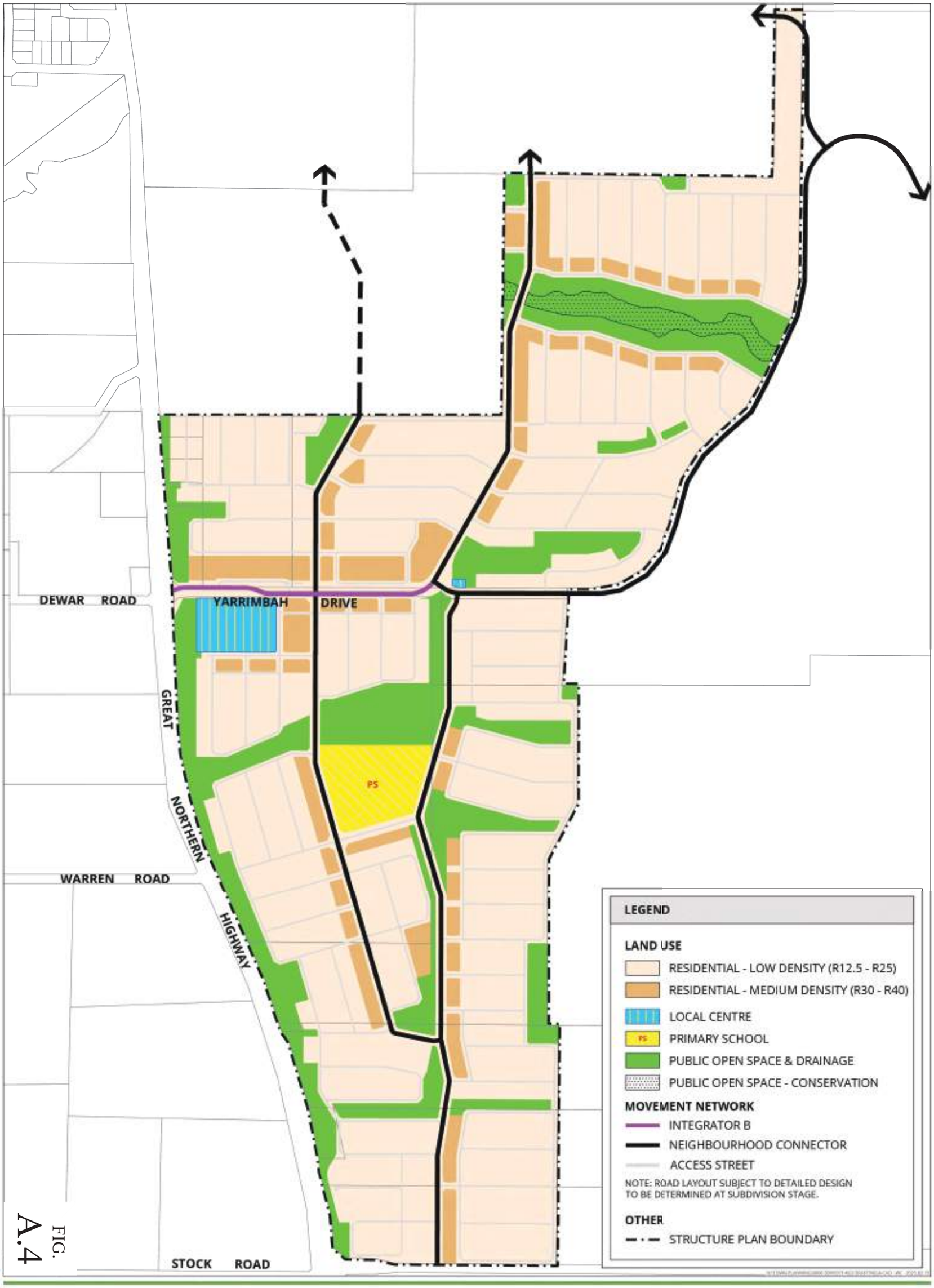


FIG. A.4

PLAN 1 - LOCAL STRUCTURE PLAN

VARIOUS LOTS - GREAT NORTHERN HIGHWAY
BULLSBROOK

N

0 200 m
SCALE @ A3: 1:7500

9714-LSP-01-E

ROWE GROUP DESIGN



FIG. A.5

INDICATIVE SUBDIVISION CONCEPT

VARIOUS LOTS - GREAT NORTHERN HIGHWAY
BULLSBROOK

9714-CON-22-C

ROWE GROUP DESIGN

SOURCE: ULOTH & ASSOCIATES

Proposed access via Stock Road

Proposed Roundabout.

YARRIMBAH DRIVE

GREAT NORTHERN HIGHWAY

DEWAR ROAD

WARREN ROAD

STOCK ROAD

0 100 200

METRES

SCALE 1 : 7,500

N

Overall Development Concept Plan

BULLSBROOK SOUTH URBAN EXPANSION AREA

FIG. A.6

SOURCE: ULOTH & ASSOCIATES

1
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10-1
10-2
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20
21

DRIVE
YARRIMBAH
GREAT
NORTHERN
HIGHWAY
ROAD
DEWAR
ROAD
WARREN
ROAD
STOCK
ROAD

0 100 200
METRES
SCALE 1 : 7,500

N

Traffic Model Zones

OVERALL BULLSBROOK SOUTH URBAN EXPANSION AREA

FIG.
A.7

A.4 TRAFFIC MODEL DEVELOPMENT

Figure A.8 shows the future roads and intersections within and adjacent to the proposed Structure Plan area, as identified from the proposed concept plan in Figure A.6 in Chapter A.3.

Figure A.9 then shows the corresponding area, as represented within the AIMSUN traffic model (with internal zone 'centroids' representing each of the Traffic Zones from Figure A.7 in Chapter A.3), while Figure A.10 shows the modelled road network and centroids for the broader area (representing the overall District Structure Plan areas), for trip distribution purposes.

Internal trips identified in Table A.1 are initially linked between the residential developments and the various Commercial, Cafe and Primary School zones, leaving external trips to be allocated firstly to the nearby District Structure Plan area (Zones 200 to 207), and then to the external roads (Zones 100 to 106), as shown in Table A.2, based on a detailed review of the previous traffic modelling for the overall District Structure Plan.

It is important to note that the Kingsford structure plan proposes a Primary School and District Centre, just north of the proposed local structure plan. Therefore, to ensure that traffic demand on roads north of the development is realistically reflected in the traffic model, it was necessary to split the Kingsford Structure Plan into five smaller zones, as also shown in Table A.2.

It is also important to note that some of the trips generated by the primary school in Kingsford may come from residential development at the northern end of the proposed local structure plan area. The modelling therefore assumes some of the external flows from the northern end of Bullsbrook South to go to Kingsford primary school.

Background traffic flows passing through the development area have also been identified, as discussed below in Chapter A.5, to reflect future traffic flows to/from the north using the local road network as an alternative parallel route to Great Northern Highway, in addition to future traffic flows on Yarrimbah Drive to/from the rural residential development (in Structure Plan No. 11).

TABLE A.2
EXTERNAL TRIP DISTRIBUTION
BULLSBROOK SOUTH URBAN EXPANSION AREA

LOCATION	DISTRIBUTION (PERCENT)
District Structure Plan	
• Bullsbrook North (Zone 203)	6
• Kingsford Structure Plan	
- District Centre (Zone 200)	7
- Primary School (Zone 201)	2
- Eastern Area (Zone 206)	7
- Central Area (Zone 205)	6
- Western Area (Zone 204)	9
• Bullsbrook Town (Zone 202)	8
• Industrial Precinct (Zone 207)	10
• Total District Structure Plan	55
External Zones	
• Great Northern Highway, north (Zone 100)	3
• Chittering Road, north-east (Zone 101)	4
• Approved Structure Plan No. 11, east (Zones 102 & 103)	8
• Great Northern Highway, south (Zone 105)	23
• Stock Road, west (Zone 106)	7
• Total External Zones	45
• Grand Total	100

Notes: 1) External Zones as shown in Figure A.10.

Source: Uloth and Associates

SOURCE: ULOTH & ASSOCIATES

GREAT NORTHERN HIGHWAY

YARRIMBAH DRIVE ROAD

DEWAR ROAD

WARREN ROAD

STOCK ROAD

0 100 200

METRES

SCALE 1 : 7,500

N

Proposed Roads and Intersections

BULLSBROOK SOUTH URBAN EXPANSION AREA

FIG. A.8

SOURCE: ULOTH & ASSOCIATES

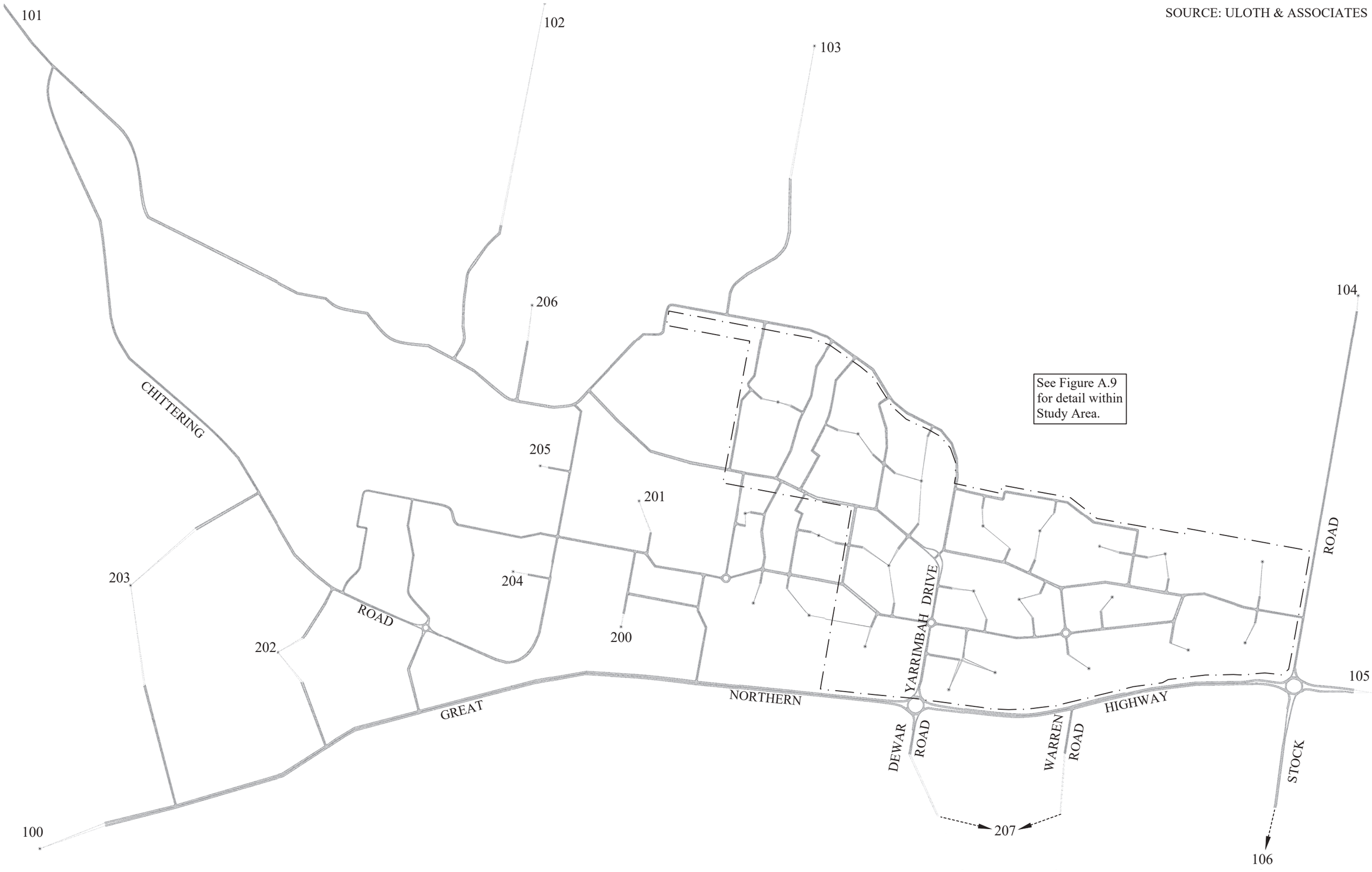


Aimsun Road Network and Centroids

PROPOSED LOCAL STRUCTURE PLAN AREA

FIG. A.9

SOURCE: ULOTH & ASSOCIATES



0 250 500
METRES
SCALE 1 : 15,000

N

Aimsun Road Network and Centroids

FOR OVERALL TRAFFIC MODEL AREA

FIG. A.10

A.5 BACKGROUND TRAFFIC FLOWS AND RESULTING TOTAL TRAFFIC

Background traffic flows for the AIMSUN traffic model were derived from traffic forecasts (for 2045) published in the *'Bullsbrook Townsite Land Use Masterplan – Precinct Traffic Contributions'* report for each of the surrounding District Structure Plan areas (or precincts).

This includes an estimated 3,100 vehicles per day travelling from the northern precincts to/from Yarrimbah Drive (via the 2 spine roads north of Yarrimbah Drive), including 2,020 vehicles per day accessing Great Northern Highway via Yarrimbah Drive west and 1,080 vehicles per day accessing the Structure Plan No. 11 development via Yarrimbah Drive east. A further 840 vehicles per day also travel east-west along Yarrimbah Drive across the proposed structure plan area to/from Great Northern Highway.

The forecast daily traffic flows were then also converted to PM peak hour flows based on an assumed factor of 10 percent, together with an assumed directional split percentage based on standard residential trip generation data, and the resulting traffic movements were allocated to selected external traffic zones to reflect the identified traffic patterns.

PM peak hour Background traffic flows were then combined with Development traffic flows generated within the proposed Structure Plan area, for assignment within the AIMSUN traffic model.

Figure A.11 shows the future daily traffic flows derived from the resulting PM peak hour traffic flow outputs, while Figure A.12 shows the future AM and PM peak hour traffic flows for the Great Northern Highway - Yarrimbah Drive - Dewar Road intersection, with additional background traffic flows on Great Northern Highway and Dewar Road also determined from additional information within the previous traffic reports.

An alternative traffic forecast scenario was then also developed, as a sensitivity test, with the distribution percentage to/from the District Structure Plan areas reduced from 55 percent to 40 percent, as discussed above in Section 2.7, with resulting AM and PM peak hour traffic flows as shown in Figure A.13.

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LEGEND

below 1,500 vehicles per day

1,500 - 3,000 vehicles per day

3,000 - 6,000 vehicles per day

6,000 - 12,000 vehicles per day

12,000 - 18,000 vehicles per day

18,000 - 24,000 vehicles per day

above 24,000 vehicles per day

Traffic not shown

SOURCE: ULOTH & ASSOCIATES

1,740
5,830
820
5,800
1,620
660
1,450
1,400
500
098
570
1,360
3,590
6,730
2,950
1,180
5,390
1,210
2,700
2,360
3,660
4,680
2,430
6,470
6,490
4,940
096
1,800
12,330
YARRIMBAH DRIVE
GREAT NORTHERN HIGHWAY
DEWAR ROAD
WARREN ROAD
STOCK ROAD

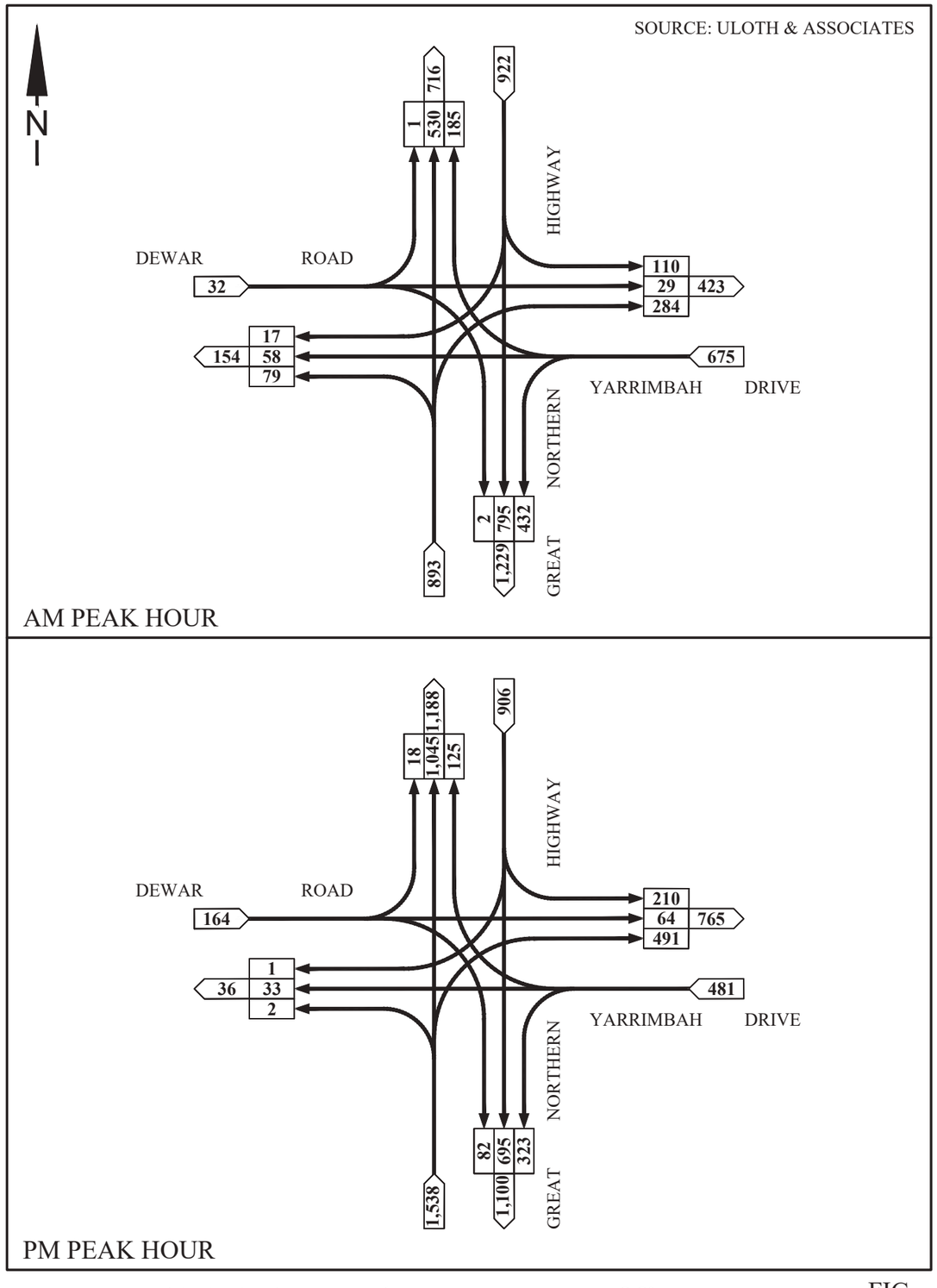
0 100 200
METRES
SCALE 1 : 7,500

N

Future Daily Traffic Flows

PROPOSED LOCAL STRUCTURE PLAN

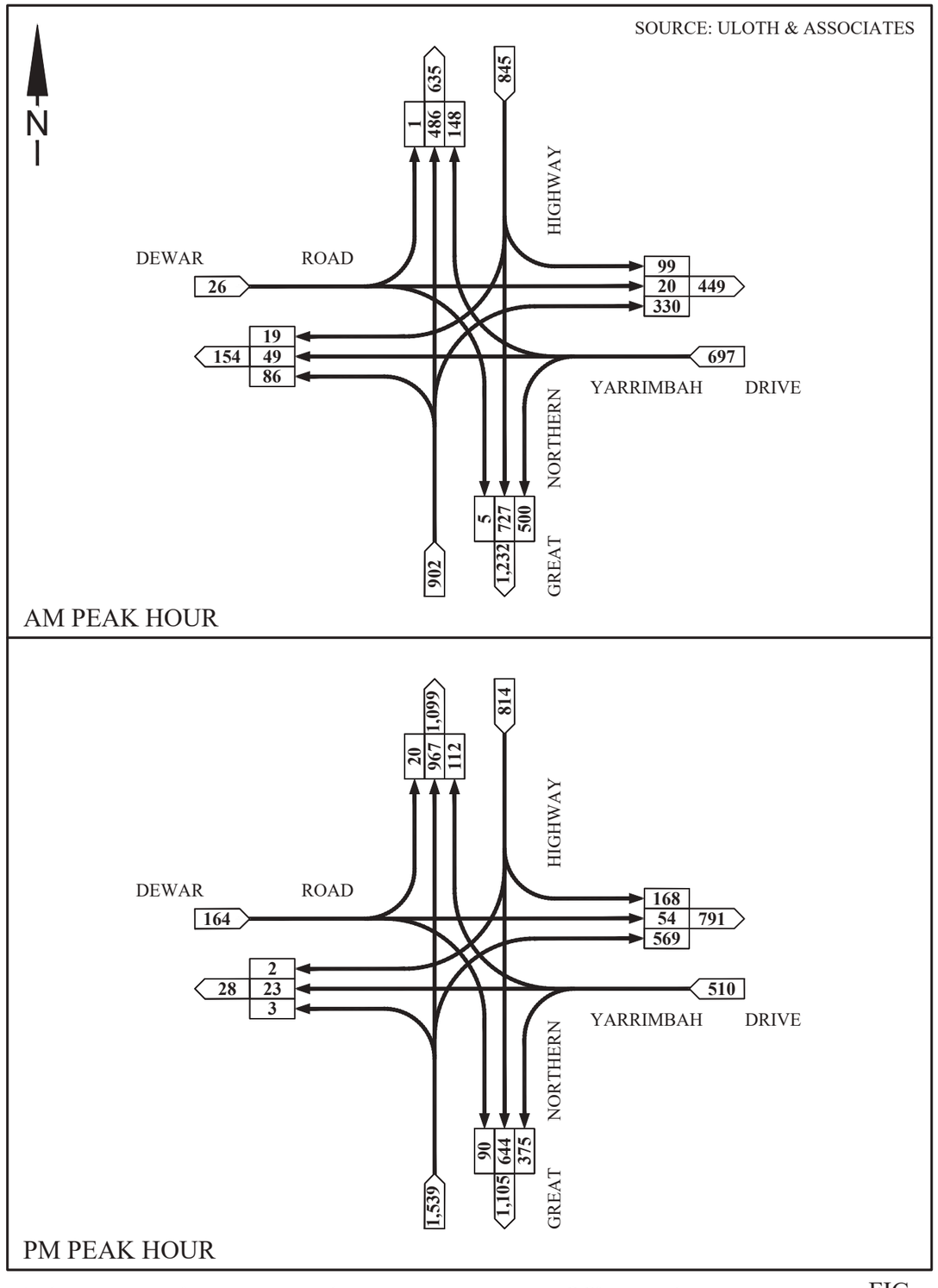
FIG. A.11



Future (2045) Peak Hour Traffic

GREAT NORTHERN HWY - YARRIMBAH DR - DEWAR RD

FIG. A.12



Alternative Peak Hour Traffic Flows

WITH TRIPS TO/FROM DSP AREAS REDUCED

FIG. A.13

A.6 GREAT NORTHERN HWY - YARRIMBAH DVE ULTIMATE ROUNDABOUT

Table A.3 shows the long-term future AM and PM peak hour intersection operational characteristics for the Great Northern Highway - Yarrimbah Drive - Dewar Road intersection, with full development of the proposed structure plan and surrounding areas, based on the ultimate roundabout layout in Figure 4 in Chapter 3, and with future peak hour traffic flows as identified in Figure A.12 in Chapter A.5.

Table A.4 then shows the alternative long term future AM and PM peak hour intersection operational characteristics for the ultimate roundabout layout based on the proposed sensitivity test, with the proportion of trips allocated to the District Structure Plan area reduced from 55 percent to 40 percent, and hence future peak hour traffic flows in Figure A.13 in Chapter A.5.

TABLE A.3
OPERATIONAL CHARACTERISTICS FOR PROPOSED GREAT NORTHERN HIGHWAY - YARRIMBAH DVE ULTIMATE ROUNDABOUT – FUTURE (2045) AM AND PM PEAK HOURS WITH 55 PERCENT OF TOTAL TRAFFIC TO/FROM DISTRICT STRUCTURE PLAN AREAS

ITEMS	OPERATIONAL CHARACTERISTICS											
	Future AM Peak Hour						Future PM Peak Hour					
No. of Approach Lanes: N E S W	2 2 2 1						2 2 2 1					
Max X Value	0.570						0.673					
Avrge Delay (sec)	9.4						12.2					
Level of Service	A						B					
Approach	Move-ment	X-Value	Max. Queue Veh.	Max. Queue m	Avrge Delay (sec)	Level of Serv.	Move-ment	X-Value	Max. Queue Veh.	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Great Northern Hwy - north	LT	0.481	3.9	33	8.8	A	LT	0.673	8.2	68	16.5	B
	TR	0.481	3.7	32	9.7	A	TR	0.673	7.4	64	19.7	B
Yarrimbah Dr - east	L	0.570	4.0	31	7.9	A	L	0.447	2.9	22	6.9	A
	TR	0.426	2.4	18	11.4	B	TR	0.298	1.5	12	10.6	B
Great Northern Hwy - south	LT	0.430	3.4	29	8.2	A	LT	0.652	7.2	62	8.0	A
	TR	0.430	3.3	27	11.5	B	TR	0.652	7.0	57	11.2	B
Industrial Access - west	LTR	0.063	0.3	2	7.6	A	LTR	0.530	2.9	23	18.2	B

Notes: Level of Service calculations are based on Average Delay.
Underlined X-values denote maximum values.

Source: Uloth and Associates

TABLE A.4
OPERATIONAL CHARACTERISTICS FOR PROPOSED GREAT NORTHERN HIGHWAY - YARRIMBAH DRIVE ULTIMATE ROUNDABOUT – FUTURE (2045) AM AND PM PEAK HOURS SENSITIVITY TEST - WITH TRAFFIC TO/FROM DSP AREAS REDUCED TO 40 PERCENT

ITEMS	OPERATIONAL CHARACTERISTICS											
	Future AM Peak Hour						Future PM Peak Hour					
No. of Approach Lanes: N E S W	2 2 2 1						2 2 2 1					
Max X Value	0.636						0.661					
Avrge Delay (sec)	9.4						12.4					
Level of Service	A						B					
Approach	Move-ment	X-Value	Max. Queue Veh.	Max. Queue m	Avrge Delay (sec)	Level of Serv.	Move-ment	X-Value	Max. Queue Veh.	Max. Queue m	Avrge Delay (sec)	Level of Serv.
Great Northern Hwy - north	LT	0.460	3.6	31	9.1	A	LT	0.661	7.9	66	18.0	B
	TR	0.460	3.4	30	10.1	B	TR	0.661	7.0	61	21.5	C
Yarrimbah Dr - east	L	0.636	5.0	38	8.4	A	L	0.501	3.4	27	7.1	A
	TR	0.363	1.8	14	11.0	B	TR	0.267	1.3	10	11.0	B
Great Northern Hwy - south	LT	0.410	3.2	28	7.9	A	LT	0.632	6.9	60	7.8	A
	TR	0.410	3.1	25	11.5	B	TR	0.632	6.8	54	11.4	B
Industrial Access - west	LTR	0.050	0.2	2	8.0	A	LTR	0.510	2.7	22	17.8	B

Notes: Level of Service calculations are based on Average Delay.
Underlined X-values denote maximum values.

Source: Uloth and Associates

A.7 INTERIM SCENARIO TRAFFIC FLOWS AND ANALYSES

In order to confirm the suitable intersection operations of the proposed interim roundabout at the Great Eastern Highway - Yarrimbah Drive intersection, interim traffic flows for the likely Stage 1 development of the proposed structure plan have been identified.

Traffic generation for the proposed Stage 1 development has been calculated using the ITE trip generation rate for 'Single Family Detached Housing (#210)', together with an assumption that the commercial/retail development and the primary school will not yet be constructed.

Two scenarios have then been identified, based on access opportunities to/from the proposed Structure Plan: firstly, with access only off Great Northern Highway via Yarrimbah Drive, but then also with a north-south road connection into Kingsford.

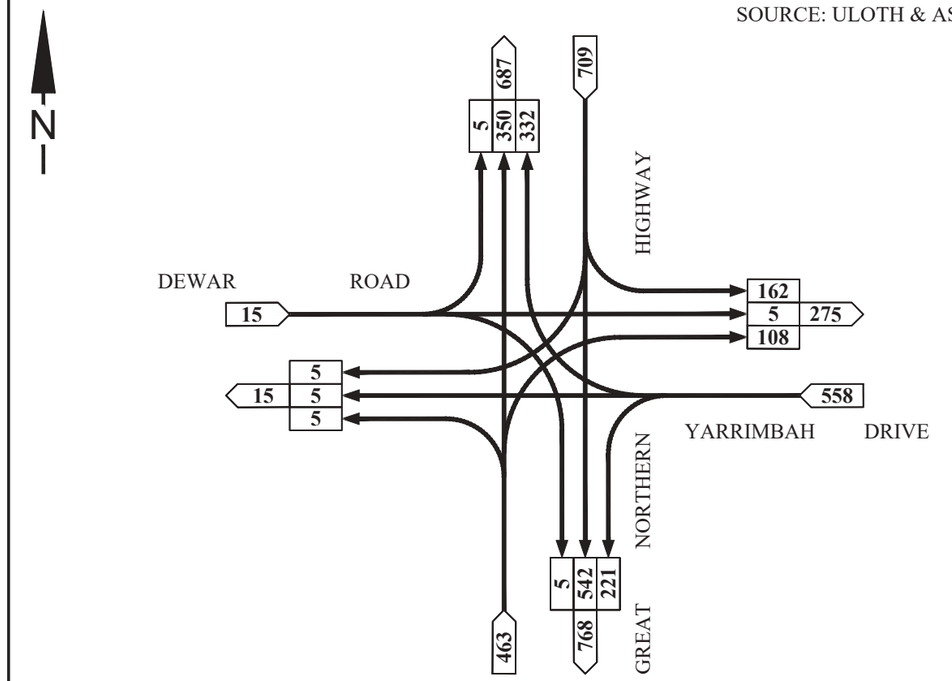
For Scenario 1, with access only via Yarrimbah Drive, it is assumed that 60 percent of development trips will turn to/from the north, with 40 percent to/from the south, as a worst-case scenario. Traffic to/from the rural residential development to the east (from Structure Plan No.11) has also been included, together with background traffic growth of 3.5 percent per annum along Great Northern Highway.

When the road connection to Kingsford is constructed, it is assumed that 50 percent of traffic travelling from the proposed structure plan to/from the north will now use this connection instead using Great Northern Highway, together with 75 percent of traffic travelling from the eastern development to/from the north.

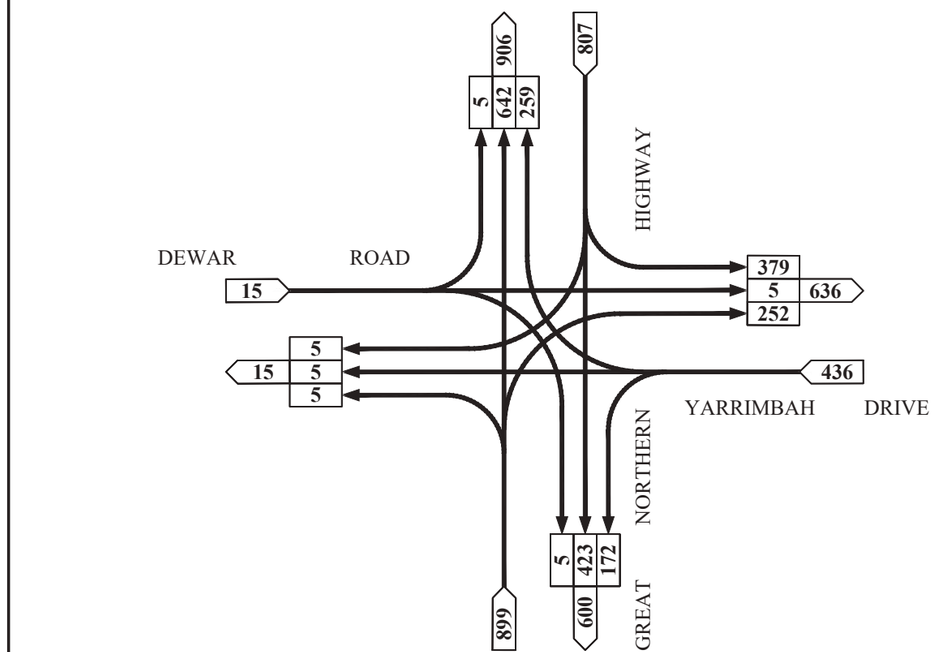
The analysis then shows that if development progresses at approximately 100 Lots per year from 2025, with access only via Yarrimbah Drive, then the proposed interim roundabout will operate at acceptable Levels of Service until 2033, based on the future traffic flows in Figure A.14 (with the construction of approximately 880 Lots).

However, if the north-south spine road is extended into Kingsford, then traffic flows on Yarrimbah Drive will reduce, allowing the interim roundabout to operate at acceptable Levels of Service until approximately 2037, based on the alternative future traffic flows in Figure A.15 (with construction of up to 1,210 Lots).

SOURCE: ULOTH & ASSOCIATES



AM PEAK HOUR

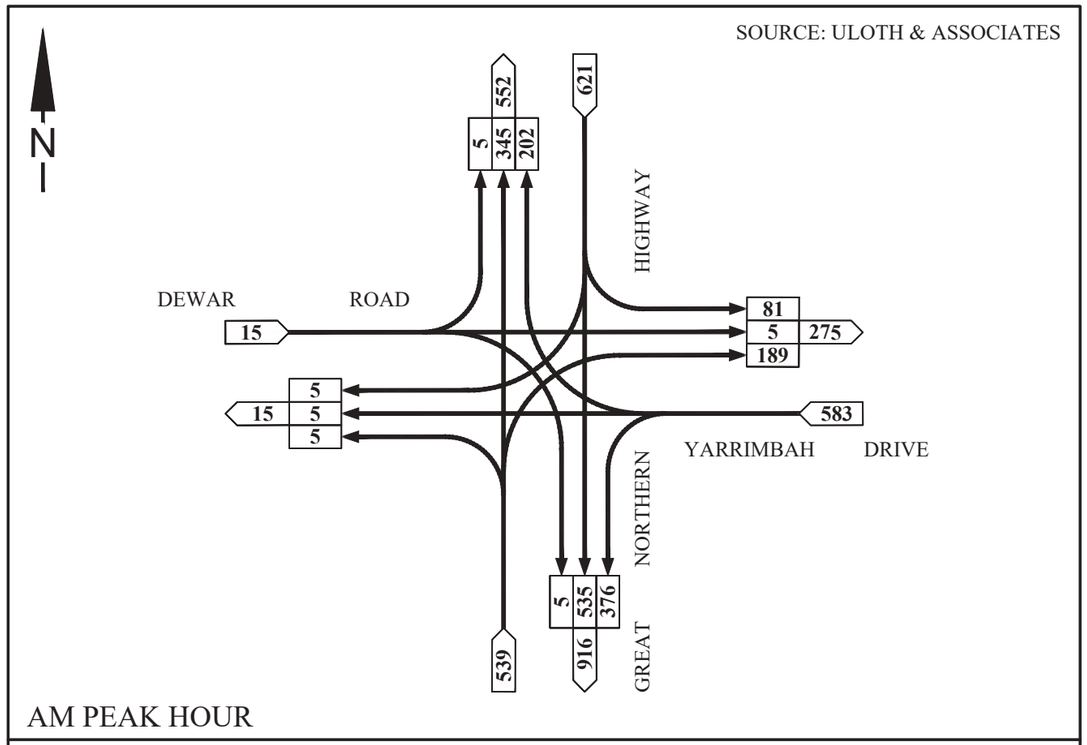


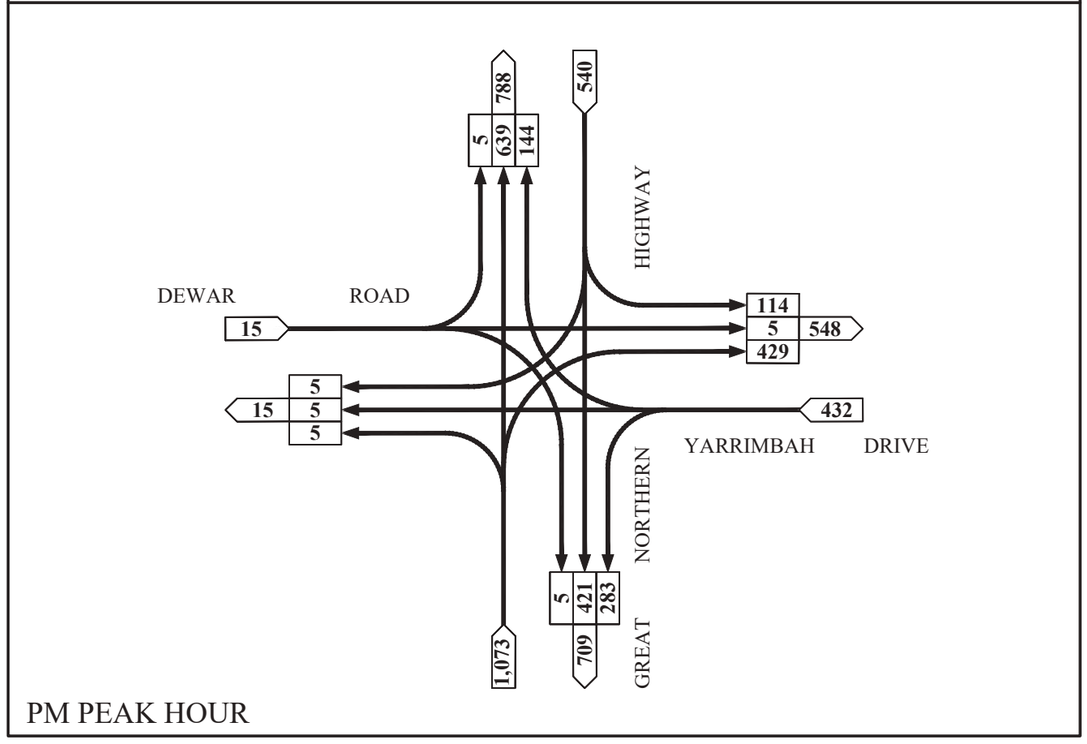
PM PEAK HOUR

Interim (2033) Peak Hour Traffic

WITH ACCESS ONLY VIA YARRIMBAH DRIVE

FIG. A.14





Interim (2037) Peak Hour Traffic

WITH ADDITIONAL NORTHERN ACCESS INTO KINGSFORD

FIG. A.15

APPENDIX B: 15-PERCENT DESIGN FOR ULTIMATE ROUNDABOUT

Technical Appendix B provides the 15-percent drawings for the 'Ultimate Design' of the proposed roundabout at the Great Northern Highway - Yarrimbah Drive - Dewar Road intersection, together with swept path diagrams for Heavy Vehicles, as prepared by Pritchard Francis.

METROPOLITAN REGION

ROUNDABOUT CONSTRUCTION (ULTIMATE DESIGN)

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05

YARRIMBAH DRIVE (0077) AND DEWAR ROAD (0041) INTERSECTION
CITY OF SWAN (109)

DRAWINGS - ROADWORKS

NOT FOR CONSTRUCTION

SCALES A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C0-CS-01

DRAWN	B. POCSIDIO
DESIGNED	T. McFARLANE
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.
RECOMMENDED
APPROVED
DRAWING STATUS

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
COVER SHEET

LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C0-CS-01-A

DRAWING INDEX

GENERAL DRAWINGS

22063-1-C0-CS-01	COVER SHEET
22063-1-C0-IN-01	DRAWING INDEX
22063-1-C0-LP-01	KEY, LOCALITY AND SITE PLAN

TYPICAL DRAWINGS

22063-1-C1-TD-01	TYPICAL CROSS SECTIONS - REFERENCE LINE MCNB - CHA. 23480 TO CHA. 23770
22063-1-C1-TD-02	TYPICAL CROSS SECTIONS - REFERENCE LINE MCNB - CHA. 23860 TO CHA. 24065
22063-1-C1-TD-03	TYPICAL CROSS SECTIONS - REFERENCE LINE MCDW - CHA. 0 TO CHA. 110
22063-1-C1-TD-04	TYPICAL CROSS SECTIONS - REFERENCE LINE MCYE - CHA. 70 TO CHA. 120
22063-1-C1-TD-05	TYPICAL DETAILS - ROADWORKS
22063-1-C1-TD-11	TYPICAL DETAILS - PAVEMENT

PLAN AND PROFILE DRAWINGS

~~22063-1-C5-RP-01 PLAN AND PROFILE MCN1 - CHA 23530 TO 23880~~
~~22063-1-C5-RP-02 PLAN AND PROFILE MCN1 - CHA 23880 TO 24247~~
~~22063-1-C5-RP-03 PLAN AND PROFILE MCD0~~
~~22063-1-C5-RP-04 PLAN AND PROFILE MCLA~~

ROLL PLOT DRAWINGS

22063-1-C5-RPLT-01	ROLL PLOT - ROUNDABOUT LAYOUT
22063-1-C5-RPLT-02	ROLL PLOT - PLAN AND PROFILE - REFERENCE LINE MCNB - CHA. 23475 TO CHA. 24180
22063-1-C5-RPLT-03	ROLL PLOT - PLAN AND PROFILE - REFERENCE LINE MCSB - CHA. 23476 TO CHA. 24180
22063-1-C5-RPLT-04	ROLL PLOT - PLAN AND PROFILE - REFERENCE LINES MCDW, MCYE AND MCYW
22063-1-C5-RPLT-05	ROLL PLOT - SCHEME PLAN

LAYOUT DRAWINGS

~~22063-1-C5-RL-01 ROAD LAYOUT PLAN - CHA 23530 TO 23720~~
~~22063-1-C5-RL-02 ROAD LAYOUT PLAN - CHA 23720 TO 23920~~
~~22063-1-C5-RL-03 ROAD LAYOUT PLAN - CHA 23920 TO 24120~~
~~22063-1-C5-RL-04 ROAD LAYOUT PLAN - CHA 24120 TO 24247.293~~

VEHICLE MOVEMENT DRAWINGS

22063-1-C5-TT-01	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 1 OF 5
22063-1-C5-TT-02	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 2 OF 5
22063-1-C5-TT-03	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 3 OF 5
22063-1-C5-TT-04	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 4 OF 5
22063-1-C5-TT-05	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 5 OF 5
22063-1-C5-TT-06	VEHICLE MOVEMENT PLAN - DEWAR ROAD
22063-1-C5-TT-07	VEHICLE MOVEMENT PLAN - YARRIMBAH DRIVE

DRAINAGE AND SERVICES DRAWINGS

22063-1-C3-DC-01 DRAINAGE STRATEGY PLAN
~~22063-1-C3-DP-01 DRAINAGE AND SERVICES PLAN~~

CROSS SECTION DRAWINGS

~~22063-1-C5-XS-01 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-02 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-03 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-04 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-05 MCN1 CROSS SECTIONS~~

PAVEMENT AND SURFACING DRAWINGS

~~22063-1-C5-SP-01 PAVEMENT AND SURFACING PLAN~~
~~22063-1-C5-SP-02 PAVEMENT AND SURFACING PLAN~~
~~22063-1-C5-SP-03 PAVEMENT AND SURFACING PLAN~~
~~22063-1-C5-SP-04 PAVEMENT AND SURFACING PLAN~~

PAVEMENT MARKING DRAWINGS

~~22063-1-C5-PM-01 SIGNS AND PAVEMENT MARKING PLAN~~
~~22063-1-C5-PM-02 SIGNS AND PAVEMENT MARKING PLAN~~
~~22063-1-C5-PM-03 SIGNS AND PAVEMENT MARKING PLAN~~
~~22063-1-C5-PM-04 SIGNS AND PAVEMENT MARKING PLAN~~

MAIN ROADS STANDARD DRAWINGS

9331-0376	KERB TYPES
9331-0377	KERB TREATMENTS
201131-0069	KERBED BATTER DRAINS
201331-0032	TYPICAL DETAILS - GRANULAR TRAVERSE JOINTS
201331-0036	TYPICAL DETAILS - DGA TRAVERSE JOINTS
201331-0038	TYPICAL DETAILS - LONGITUDINAL JOINTS
201631-0083	TYPICAL DETAILS - GRANULAR LONGITUDINAL JOINTS
200331-0154	SEGMENTAL PAVING DETAILS - ISLANDS AND MEDIANS
200331-0155	SEGMENTAL PAVING DETAILS - AROUND OBJECTS
200331-0156	SEGMENTAL PAVING DETAILS - EDGE TREATMENTS
8720-0762	TWO AND THREE POST SIGN - LOCATION DETAILS
9531-2010	PAVEMENT ARROWS DIMENSIONS
9531-2011	PAVEMENT ARROWS POSITIONING DETAILS
9548-0106	LOCATION DETAILS FOR ONE POST SIGNS
9648-176	FIXING AND INSTALLATION DETAILS FOR SINGLE HAZARD MARKERS
9648-0438	ONE WAY ARROW DIRECTION SIGNS - FIXING AND INSTALLATION DETAILS
9931-0198	PAVEMENT MARKING LINE TYPES
200031-0015	TYPICAL CORNER TREATMENT ON HEAVY COMBINATION VEHICLE ROUTE
200331-0091	"D" BULLNOSE, MEDIAN TREATMENTS AND DIAGONAL MARKINGS
200331-191	PAVEMENT MARKINGS AND RRPM'S AT RAISED MEDIANS
200431-002	STOP AND GIVE WAY LINES
201031-0027	RAISED PAVEMENT MARKERS - GENERAL APPLICATIONS - FREEWAYS, HIGHWAYS, MAIN ROADS AND ARTERIAL ROADS IN RURAL AND OUTER METROPOLITAN AREAS
201631-0003	LAYOUT FOR TURNING GUIDE LINES

NOT FOR CONSTRUCTION

SCALES
A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C0-IN-01

DRAWN	B. POCSIDIO
DESIGNED	T. McFARLANE
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

mainroads WESTERN AUSTRALIA
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METROPOLITAN REGION
WATERLOO CRESENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

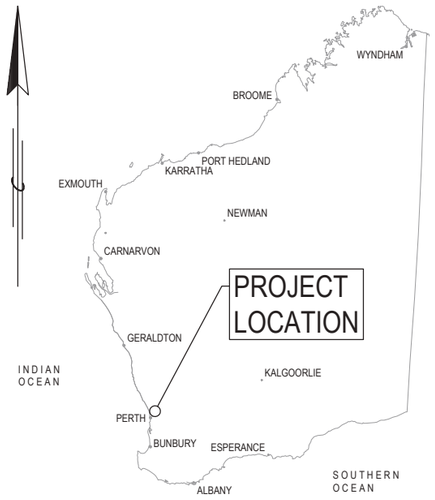
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
DRAWING INDEX

LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C0-IN-01-A



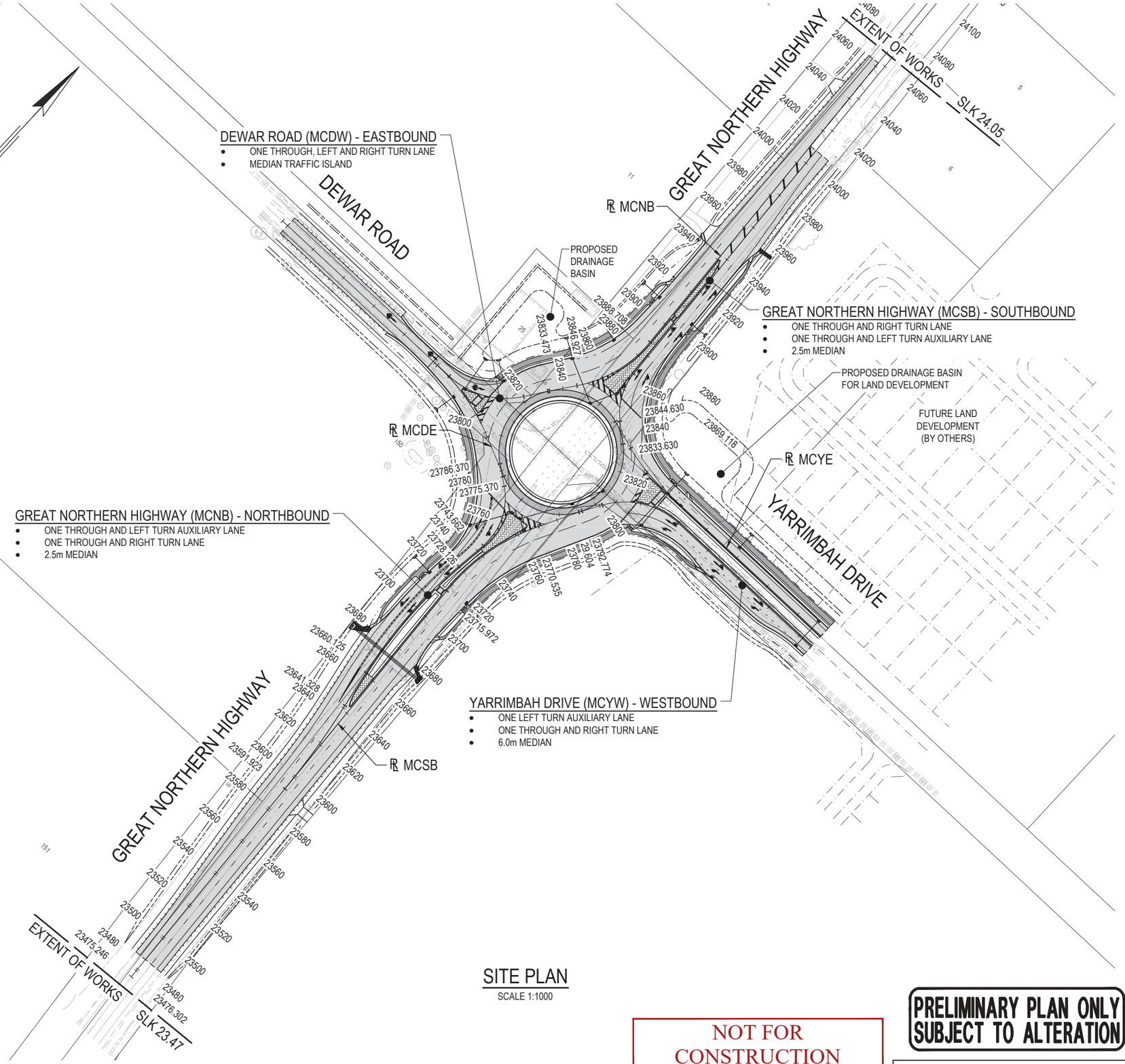
LOCALITY PLAN

N.T.S.



KEY PLAN

N.T.S.



SITE PLAN

SCALE 1:1000

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:1000

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA	
GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C0-LP-01

DRAWN	B. POCSIDIO
DESIGNED	T. McFARLANE
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

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OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
KEY, LOCALITY AND SITE PLAN

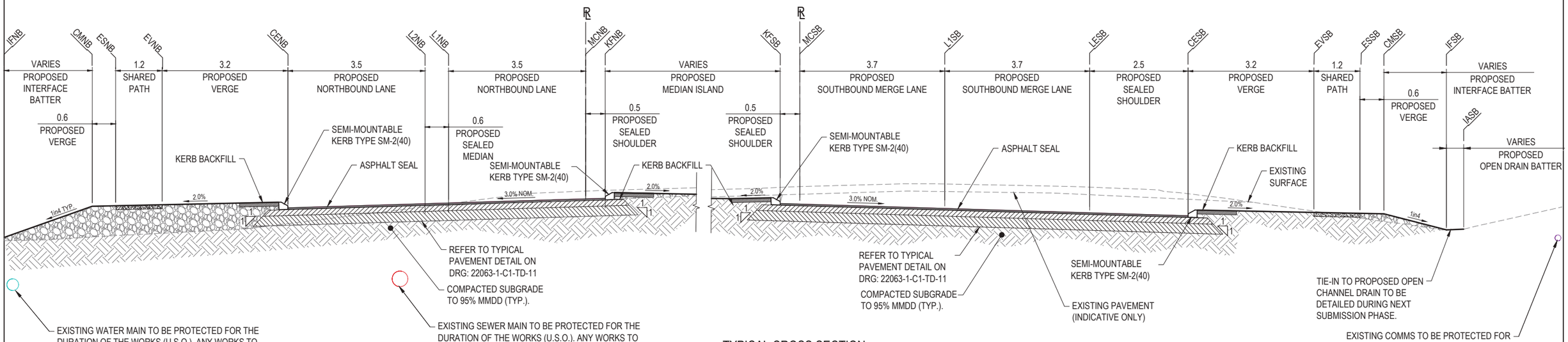
LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER

22063-1-C0-LP-01-A

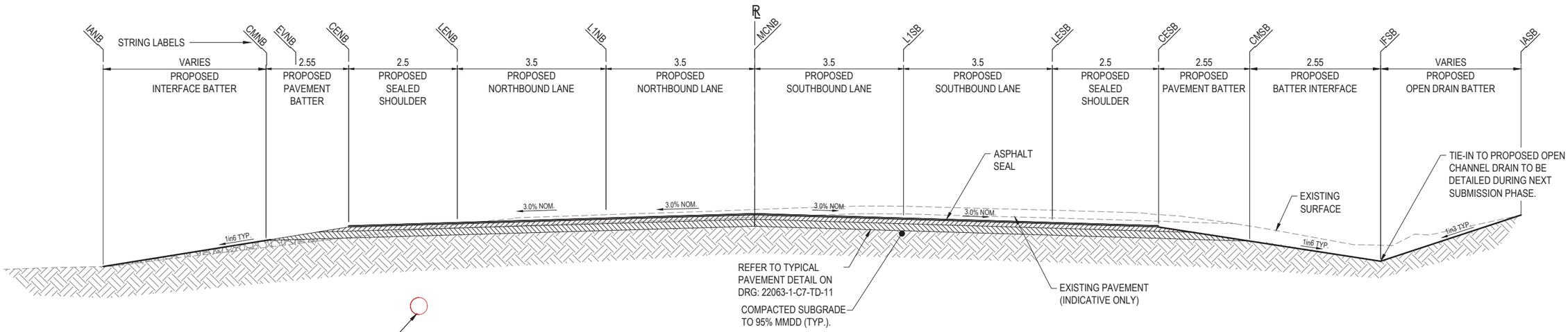
NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE MAIN ROADS WA SPECIFICATIONS.
2. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
3. DESIGN LEVELS ARE TO FINISHED TOP OF PAVEMENT SURFACE.
4. FOR TYPICAL PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-05.
5. FOR CUT EDGE DETAILS REFER TO DRG 22063-1-C1-TD-11.
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-11.



TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23700 TO CHA. 23770

SCALE 1:50



TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23480 TO CHA. 23680

SCALE 1:50

NOT FOR CONSTRUCTION

SCALES 1:50 — A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C1-TD-01

DRAWN	W. BRIERS
DESIGNED	T. McFARLANE
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

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OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
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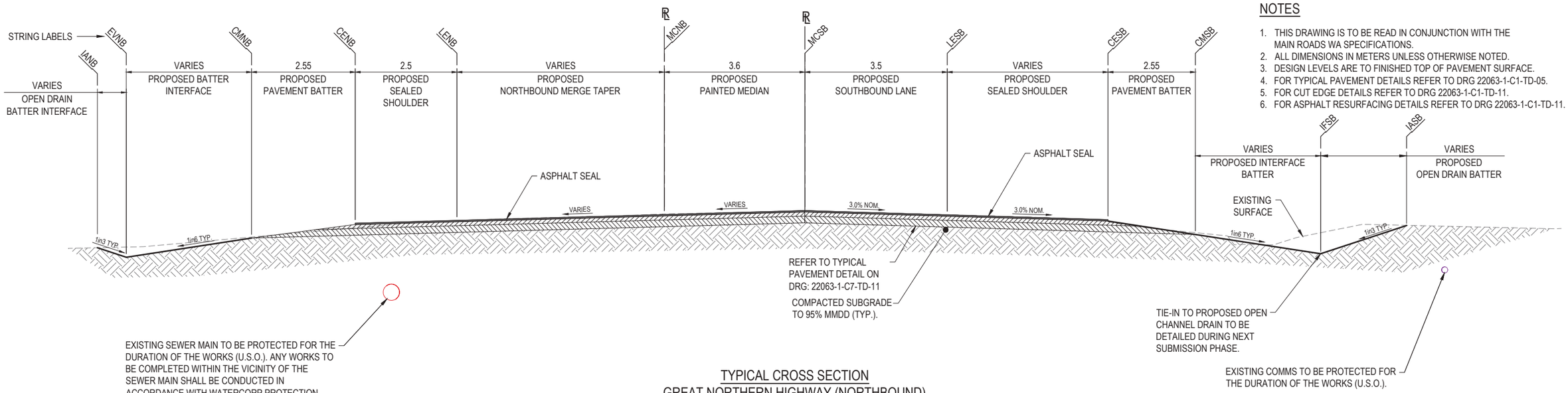
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCNB - CHA. 23480 TO CHA. 23770
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-01-A

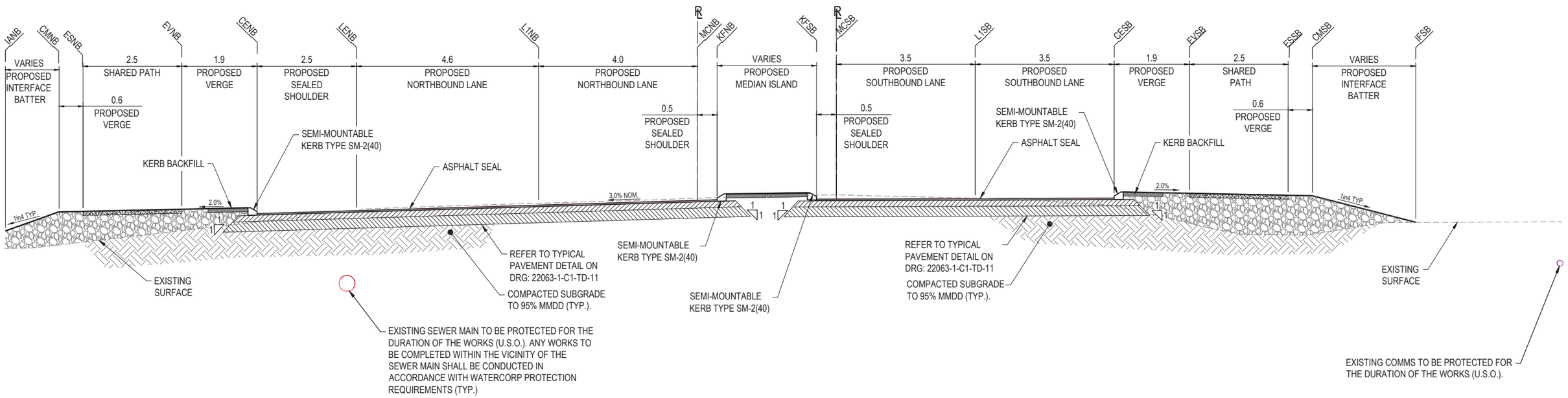


NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE MAIN ROADS WA SPECIFICATIONS.
2. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
3. DESIGN LEVELS ARE TO FINISHED TOP OF PAVEMENT SURFACE.
4. FOR TYPICAL PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-05.
5. FOR CUT EDGE DETAILS REFER TO DRG 22063-1-C1-TD-11.
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-11.

TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23960 TO CHA. 24065

SCALE 1:50



TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23860 TO CHA. 23940

SCALE 1:50

NOT FOR CONSTRUCTION

A 1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA	
GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER 22063-1-C1-TD-02

DRAWN	W. BRIERS
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VERIFIED	T. McFARLANE
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Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCNB - CHA. 23860 TO CHA. 24065
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-02-A

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE MAIN ROADS WA SPECIFICATIONS.
2. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
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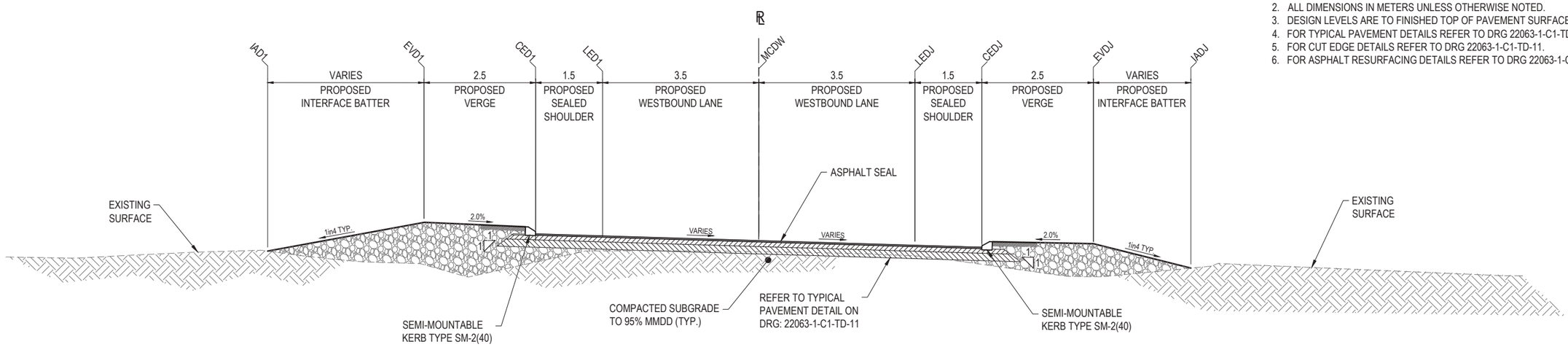
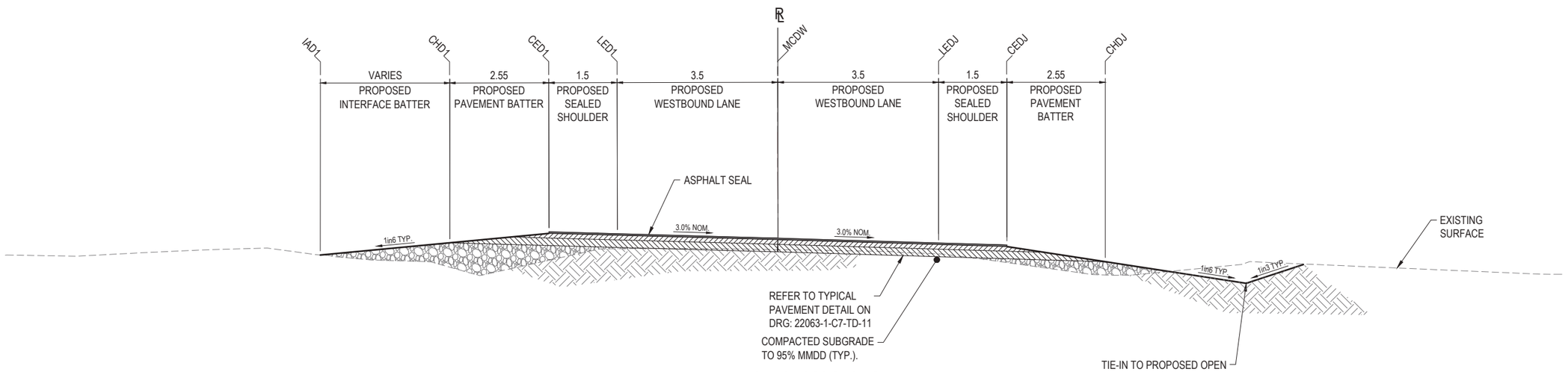
4. FOR TYPICAL PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-05.
5. FOR CUT EDGE DETAILS REFER TO DRG 22063-1-C1-TD-11.
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-11.



TYPICAL CROSS SECTION
DEWAR ROAD (EASTBOUND)
REFERENCE LINE MCDW - CHA. 80 TO CHA. 110

SCALE: 1:50



TYPICAL CROSS SECTION
DEWAR ROAD (EASTBOUND)
REFERENCE LINE MCDW - CHA. 0 TO CHA. 70

SCALE: 1:50

SCALES 1:50 0 0.5m 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5

A1

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER 22063-1-C1-TD-03

DRAWN W. BRIERS
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VERIFIED T. McFARLANE
DIRECTOR M. RIDDELL

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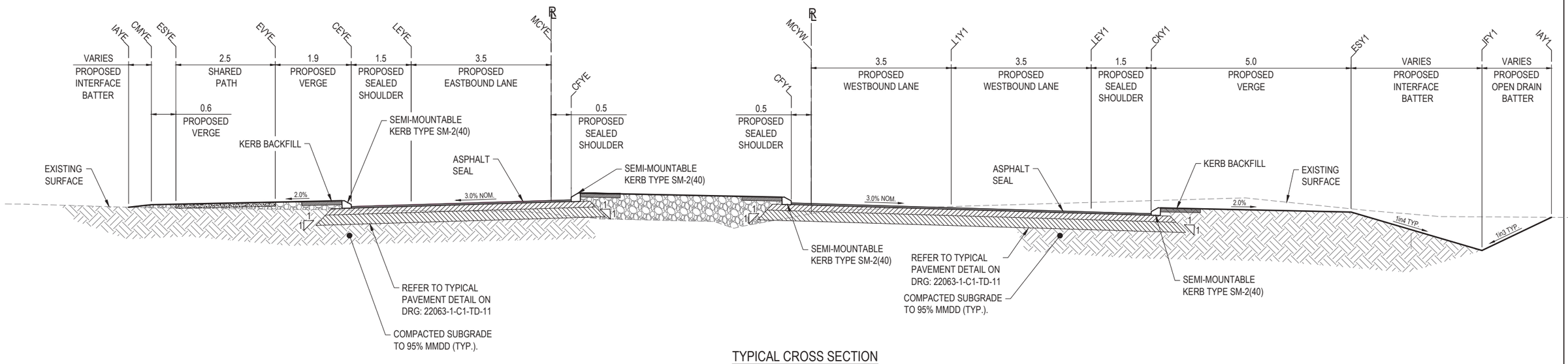
CLIENT FILE No.
RECOMMENDED
APPROVED
DRAWING STATUS

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCDW - CHA. 0 TO CHA. 110
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-03-A

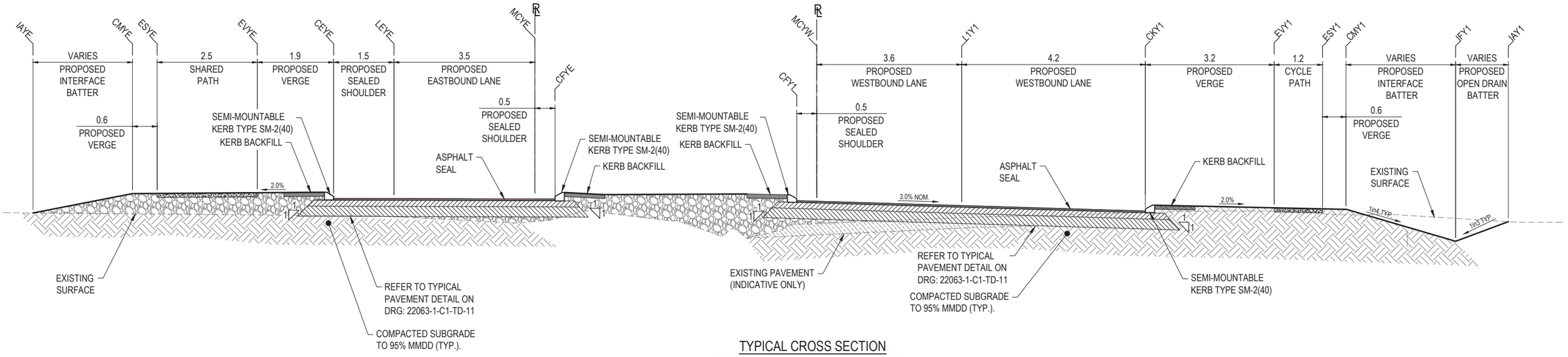
NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE MAIN ROADS WA SPECIFICATIONS.
2. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
3. DESIGN LEVELS ARE TO FINISHED TOP OF PAVEMENT SURFACE.
4. FOR TYPICAL PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-05.
5. FOR CUT EDGE DETAILS REFER TO DRG 22063-1-C1-TD-11.
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-11.



TYPICAL CROSS SECTION YARRIMBAH DRIVE (EASTBOUND) REFERENCE LINE MCYE - CHA.120

SCALE 1:50



TYPICAL CROSS SECTION YARRIMBAH DRIVE (EASTBOUND) REFERENCE LINE MCYE - CHA. 70

SCALE 1:50

NOT FOR CONSTRUCTION

SCALES 1:50

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER 22063-1-C1-TD-04

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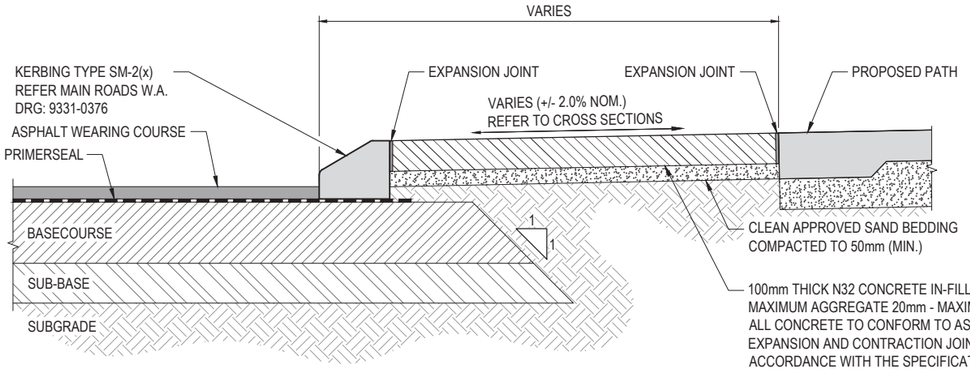
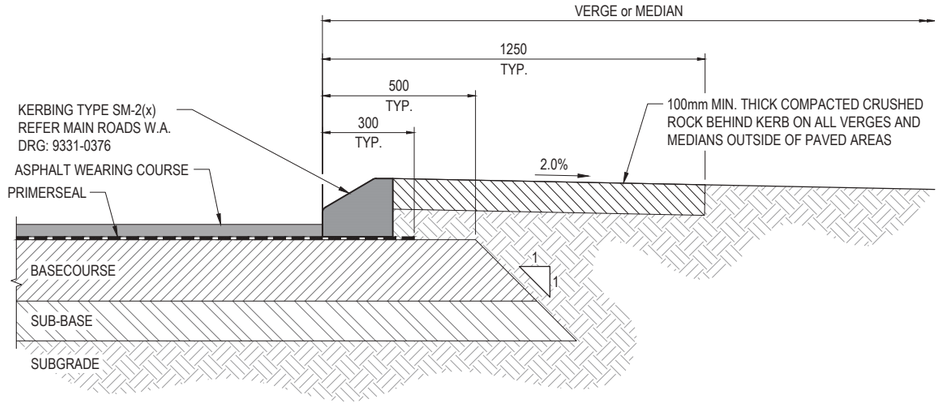
CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCYE - CHA. 70 TO CHA. 120
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-04-A



TYPICAL CONCRETE INFILL TREATMENT DETAIL

SCALE 1:10 0m 200mm 400mm

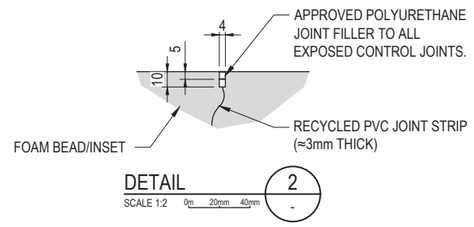


TYPICAL KERB AND PAVEMENT TREATMENT DETAIL

SCALE 1:10 0m 200mm 400mm

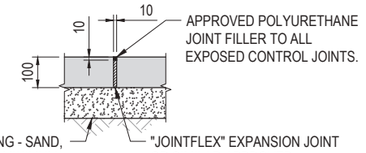
NOTES

1. ALL CONCRETE TO BE A MINIMUM OF 25MPa, 20mm AGGREGATE AND A MAXIMUM SLUMP OF 80mm, FROM AN APPROVED PRE-MIX BATCH PLANT
2. MINIMUM THICKNESS - 100mm.
3. BEDDING - SAND, 50mm MINIMUM.
4. FINISH - BROOMED TO NON-SKID FINISH PARALLEL TO LINE OF KERB WITH TOOLED EDGES
5. EXPANSION JOINTS - APPROVED MATERIAL SHALL BE EXPANDITE-FLEXICELL.
6. TACTILE GROUND SURFACE INDICATORS (T.G.S.I.'s) SHALL BE IN ACCORDANCE WITH AS1428.1 AND AS1428.4.
7. CONTRACTOR TO INSTALL STAINLESS STEEL WARNING T.G.S.I.'s FOR FULL WIDTH OF CONCRETE KERB RAMP. REFER TO ARCHITECTURAL FINISHES SCHEDULE FOR DETAILS.
8. WARNING TGSI's ARE NOT TO BE CUT. CONTRACTOR SHALL SELECT SUITABLE SIZE TO EXTEND ACROSS FULL WIDTH OF KERB RAMP (EXCLUDING SPLAYS).
9. WHERE THE KERB RAMP IS CONSTRUCTED USING BLOCK PAVERS, THE CONTRACTOR SHALL INSTALL TGSI PAVERS IN A CONTRASTING COLOUR CONFORMING WITH AS1428.4 LUMINANCE REQUIREMENTS.



DETAIL 2

SCALE 1:2 0m 20mm 40mm



EXPANSION JOINT

SCALE 1:10 0m 200mm 400mm

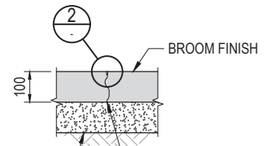
TYPICAL KERB TAPER AND ROCK PITCHING END TREATMENT DETAIL

SCALE 1:50 0m 1m 2m

ALL CONCRETE TO CONFORM TO AS 1379.
ALL CONCRETE FOR PATH CONSTRUCTION
SHALL BE A MINIMUM OF N32 WITH A
MAXIMUM AGGREGATE OF 20mm AND A
MAXIMUM SLUMP OF 80mm
FINISH - BROOMED TO NON-SKID FINISH.

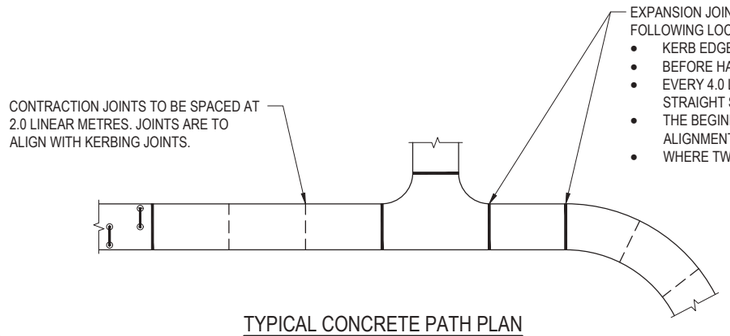
CONCRETE PATH SECTION

SCALE 1:25 0m 0.5m 1.0m



CONTRACTION JOINT

SCALE 1:10 0m 200mm 400mm



TYPICAL CONCRETE PATH PLAN

SCALE 1:100 0m 2m 4m

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C1-TD-05

DRAWN	W. BRIERS
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DIRECTOR	M. RIDDELL

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CLIENT FILE No.	
RECOMMENDED	
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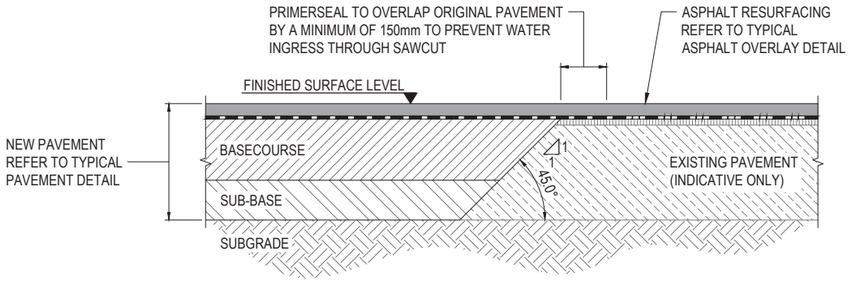
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
TYPICAL DETAILS
ROADWORKS
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-05-A

SCALES 1:100 1:25 1:2

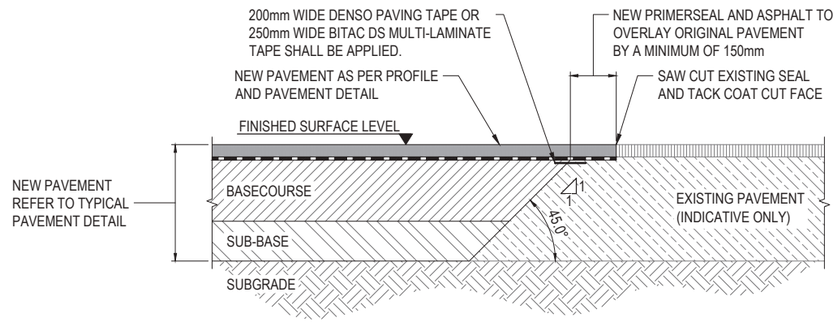
A1



TYPICAL SAW CUT DETAIL - ASPHALT OVERLAY

SCALE 1:10 0m 200mm 400mm

NOTE: FOR FURTHER DETAIL REFER TO MAIN ROADS W.A. STD DRG 201331-0038



TYPICAL SAW CUT DETAIL

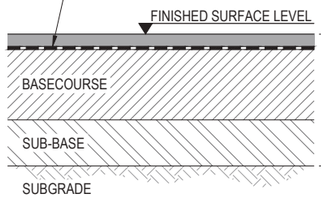
SCALE 1:10 0m 200mm 400mm

NOTE: FOR FURTHER DETAIL REFER TO MAIN ROADS W.A. STD DRG 201331-0038

NOTES

1. ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE NOTED.
2. FOR PAVEMENT PLAN REFER TO DRG. 22063-1-C5-RPLT-01.
3. IF TOTAL CRUSHED ROCK THICKNESS IS LESS THAN 250mm, PLACE IN SINGLE LAYER. MINIMUM LAYER THICKNESS IS 100mm.
4. PAVEMENT TRANSITION RAMPS TO BE 15.0m MINIMUM IN ACCORDANCE WITH MAIN ROADS W.A. DRG 201331-0035.
5. LONGITUDINAL JOINTS TO BE IN ACCORDANCE WITH MAIN ROADS W.A. DRG 201331-0038.
6. TRANSVERSE JOINTS TO BE IN ACCORDANCE WITH MAIN ROADS W.A. DRG 201331-0032.
7. ASPHALT OVERLAY TO BE APPLIED WHERE LEVEL CHANGE CAN BE ACCOMMODATED.
8. FOR CUT EDGE LOCATIONS REFER TO INTERSECTION DETAILS DRG'S 22063-1-C5-RPLT-01.

PRIMERSEAL
40/60 BITUMEN (C170)/MEDIUM CURING CUTTER BLEND APPLIED AT 0.6 L/m².
DOUBLE COAT 10/5mm EMULSION SEAL
FIRST COAT RESIDUAL BINDER (CRS-170/60) APPLICATION RATE 0.9 L/m²
FIRST COAT 10mm AGGREGATE APPLICATION RATE 120-140 m²/m³
SECOND COAT RESIDUAL BINDER (CRS-170/60) APPLICATION RATE 1.1 L/m²
SECOND COAT 5mm AGGREGATE APPLICATION RATE 200-250 m²/m³



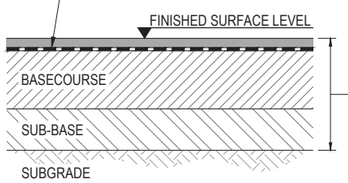
- 40mm MRWA INTERSECTION MIX (AC14 - A15E BINDER)
- PRIME PRIMERSEAL
- 230mm CRUSHED ROCK BASE
- 145mm CRUSHED LIMESTONE

TYPICAL ROAD PAVEMENT DETAIL - TYPE 1

SCALE 1:10 0m 200mm 400mm

NOTE:
THE CONTRACTOR SHALL CONSTRUCT PAVEMENT IN ACCORDANCE WITH AS2150 AND CIVIL SPECIFICATIONS AND DETAILS

PRIME
40/60 BITUMEN (C170)/MEDIUM CURING CUTTER BLEND APPLIED AT 0.6 L/m².
DOUBLE COAT 10/5mm EMULSION SEAL
FIRST COAT RESIDUAL BINDER (CRS-170/60) APPLICATION RATE 0.9 L/m²
FIRST COAT 10mm AGGREGATE APPLICATION RATE 120-140 m²/m³
SECOND COAT RESIDUAL BINDER (CRS-170/60) APPLICATION RATE 1.1 L/m²
SECOND COAT 5mm AGGREGATE APPLICATION RATE 200-250 m²/m³



- 30mm DENSE GRADE ASPHALT (AC10 - A15E BINDER)
- PRIME (SEE NOTE)
- 230mm CRUSHED ROCK BASE
- 145mm CRUSHED LIMESTONE

TYPICAL ROAD PAVEMENT DETAIL - TYPE 2

SCALE 1:10 0m 200mm 400mm

NOTE:
THE CONTRACTOR SHALL CONSTRUCT PAVEMENT IN ACCORDANCE WITH AS2150 AND CIVIL SPECIFICATIONS AND DETAILS

NOT FOR CONSTRUCTION

SCALES 1:10

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

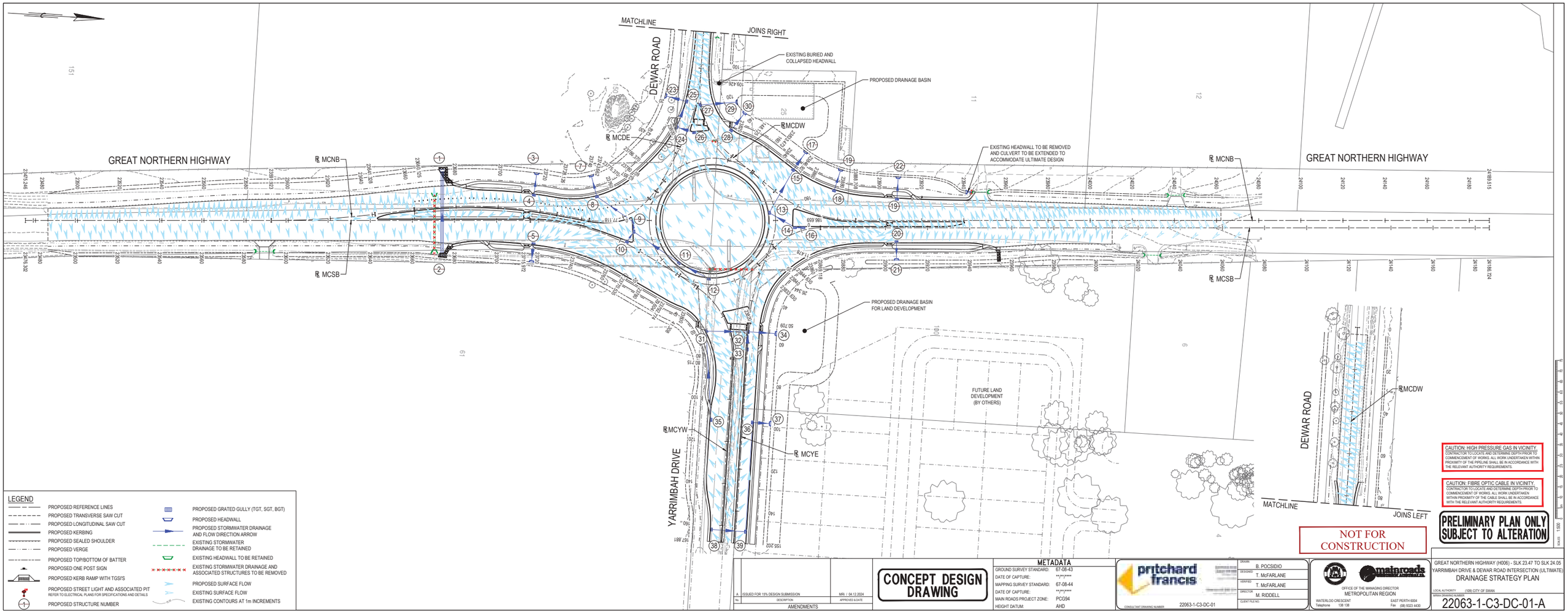
pritchard francis
CONSULTANT DRAWING NUMBER 22063-1-C1-TD-11

DRAWN W. BRIERS
DESIGNED T. McFARLANE
VERIFIED T. McFARLANE
DIRECTOR M. RIDDELL

mainroads WESTERN AUSTRALIA
OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.
RECOMMENDED
APPROVED
DRAWING STATUS

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
TYPICAL DETAILS
PAVEMENT
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-11-A



LEGEND

- PROPOSED REFERENCE LINES
- PROPOSED TRANSVERSE SAW CUT
- PROPOSED LONGITUDINAL SAW CUT
- PROPOSED KERBING
- PROPOSED SEALED SHOULDER
- PROPOSED VERGE
- PROPOSED TOP/BOTTOM OF BATTER
- PROPOSED ONE POST SIGN
- PROPOSED KERB RAMP WITH TGSI'S
- PROPOSED STREET LIGHT AND ASSOCIATED PIT (REFER TO ELECTRICAL PLANS FOR SPECIFICATIONS AND DETAILS)
- PROPOSED STRUCTURE NUMBER
- PROPOSED GRATED GULLY (TGT, SGT, BGT)
- PROPOSED HEADWALL
- PROPOSED STORMWATER DRAINAGE AND FLOW DIRECTION ARROW
- EXISTING STORMWATER DRAINAGE TO BE RETAINED
- EXISTING HEADWALL TO BE RETAINED
- EXISTING STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES TO BE REMOVED
- PROPOSED SURFACE FLOW
- EXISTING SURFACE FLOW
- EXISTING CONTOURS AT 1m INCREMENTS

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MR / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER: 22063-1-C3-DC-01

DRAWN	B. POCSIDIO
DESIGNED	T. McFARLANE
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL
CLIENT FILE NO.	

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
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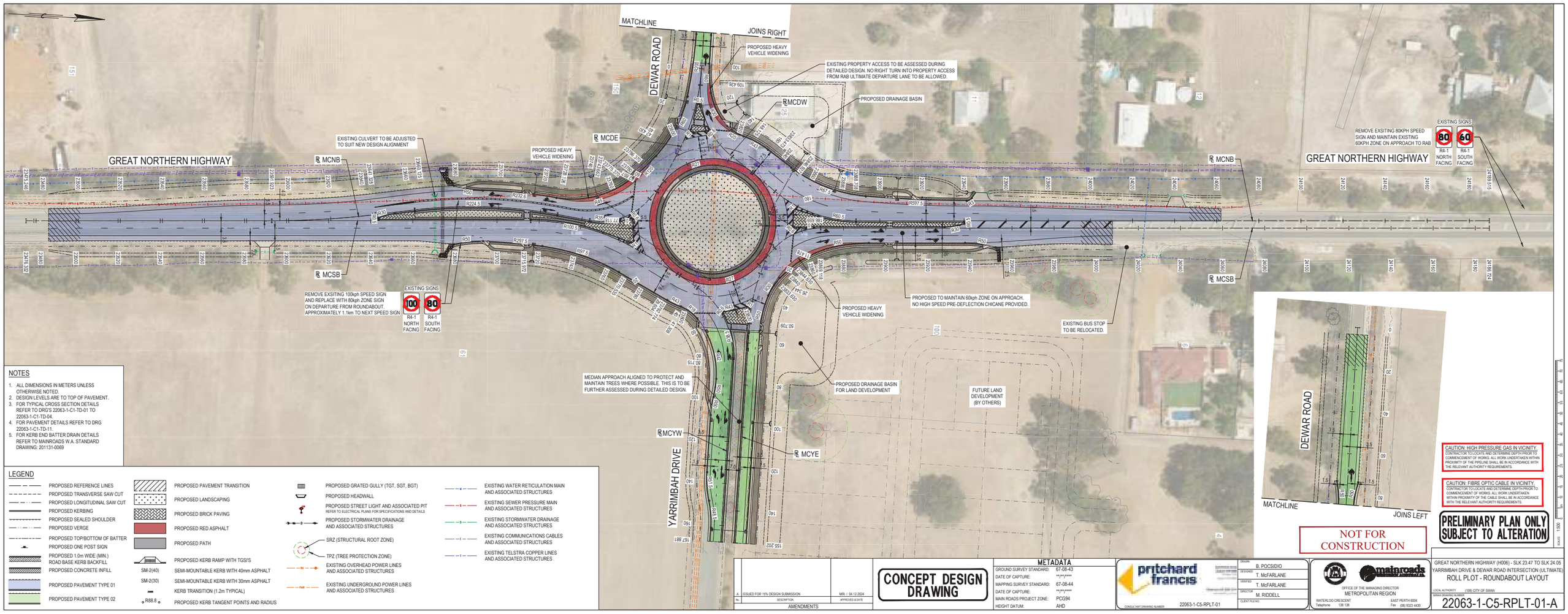
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
DRAINAGE STRATEGY PLAN

LOCAL AUTHORITY: (109) CITY OF SWAN
MRWA DRAWING NUMBER: 22063-1-C3-DC-01-A

DWG SIZE: A1 1:500



NOTES

1. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
2. DESIGN LEVELS ARE TO TOP OF PAVEMENT.
3. FOR TYPICAL CROSS SECTION DETAILS REFER TO DRG'S 22063-1-C1-TD-01 TO 22063-1-C1-TD-04.
4. FOR PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-11.
5. FOR KERB END BATTER DRAIN DETAILS REFER TO MAINROADS W.A. STANDARD DRAWING: 201131-0069

LEGEND

- PROPOSED REFERENCE LINES
- PROPOSED TRANSVERSE SAW CUT
- PROPOSED LONGITUDINAL SAW CUT
- PROPOSED KERBING
- PROPOSED SEALED SHOULDER
- PROPOSED VERGE
- PROPOSED TOP/BOTTOM OF BATTER
- PROPOSED ONE POST SIGN
- PROPOSED 1.0m WIDE (MIN.) ROAD BASE KERB BACKFILL
- PROPOSED CONCRETE INFILL
- PROPOSED PAVEMENT TYPE 01
- PROPOSED PAVEMENT TYPE 02
- PROPOSED PAVEMENT TRANSITION
- PROPOSED LANDSCAPING
- PROPOSED BRICK PAVING
- PROPOSED RED ASPHALT
- PROPOSED PATH
- PROPOSED KERB RAMP WITH TGSI'S
- SM-2(40) SEMI-MOUNTABLE KERB WITH 40mm ASPHALT
- SM-2(30) SEMI-MOUNTABLE KERB WITH 30mm ASPHALT
- KERB TRANSITION (1.2m TYPICAL)
- R88.8 PROPOSED KERB TANGENT POINTS AND RADIUS
- PROPOSED GRATED GULLY (TGT, SGT, BGT)
- PROPOSED HEADWALL
- PROPOSED STREET LIGHT AND ASSOCIATED PIT (REFER TO ELECTRICAL PLANS FOR SPECIFICATIONS AND DETAILS)
- PROPOSED STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES
- SRZ (STRUCTURAL ROOT ZONE)
- TPZ (TREE PROTECTION ZONE)
- EXISTING OVERHEAD POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING UNDERGROUND POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING WATER RETICULATION MAIN AND ASSOCIATED STRUCTURES
- EXISTING SEWER PRESSURE MAIN AND ASSOCIATED STRUCTURES
- EXISTING STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES
- EXISTING COMMUNICATIONS CABLES AND ASSOCIATED STRUCTURES
- EXISTING TELSTRA COPPER LINES AND ASSOCIATED STRUCTURES

CAUTION: HIGH PRESSURE GAS IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE PIPELINE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

CAUTION: FIBRE OPTIC CABLE IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE CABLE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MR / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER: 22063-1-C5-RPLT-01

DRAWN:	B. POCSIDIO
DESIGNED:	T. McFARLANE
VERIFIED:	T. McFARLANE
DIRECTOR:	M. RIDDELL
CLIENT FILE NO:	

OFFICE OF THE MANAGING DIRECTOR
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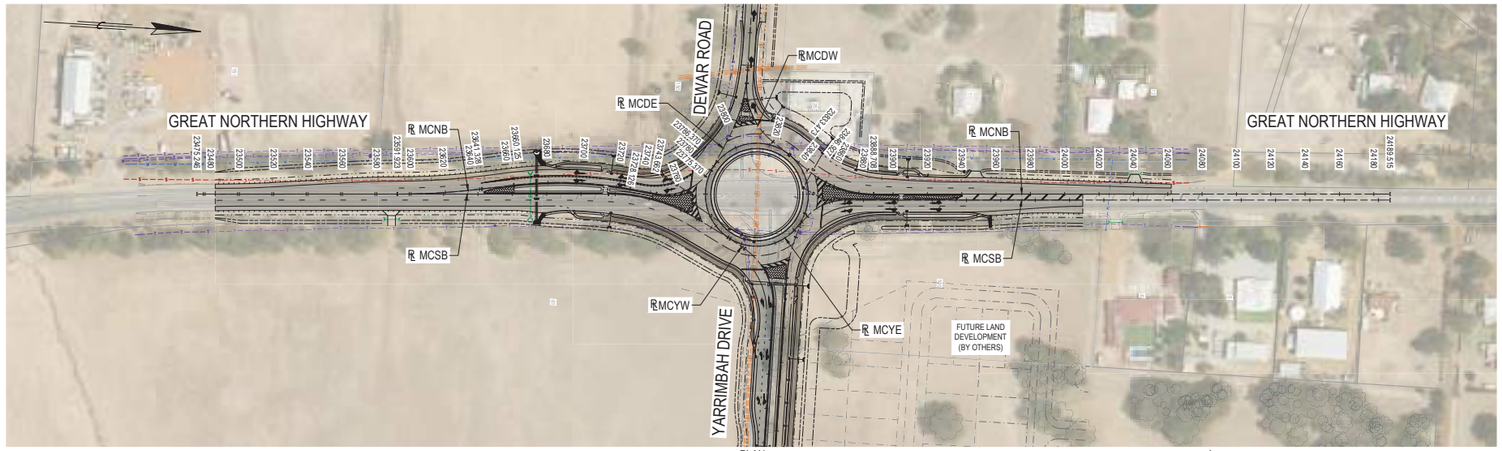
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
ROLL PLOT - ROUNDABOUT LAYOUT

LOCAL AUTHORITY (109) CITY OF SWAN
MAIN ROADS DRAWING NUMBER
22063-1-C5-RPLT-01-A



PLAN
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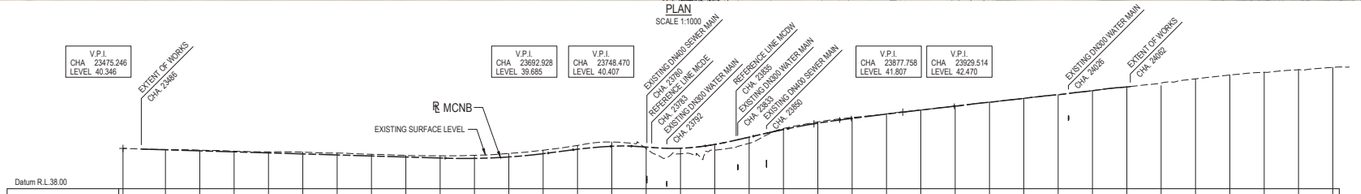

Datum R.L.38.00

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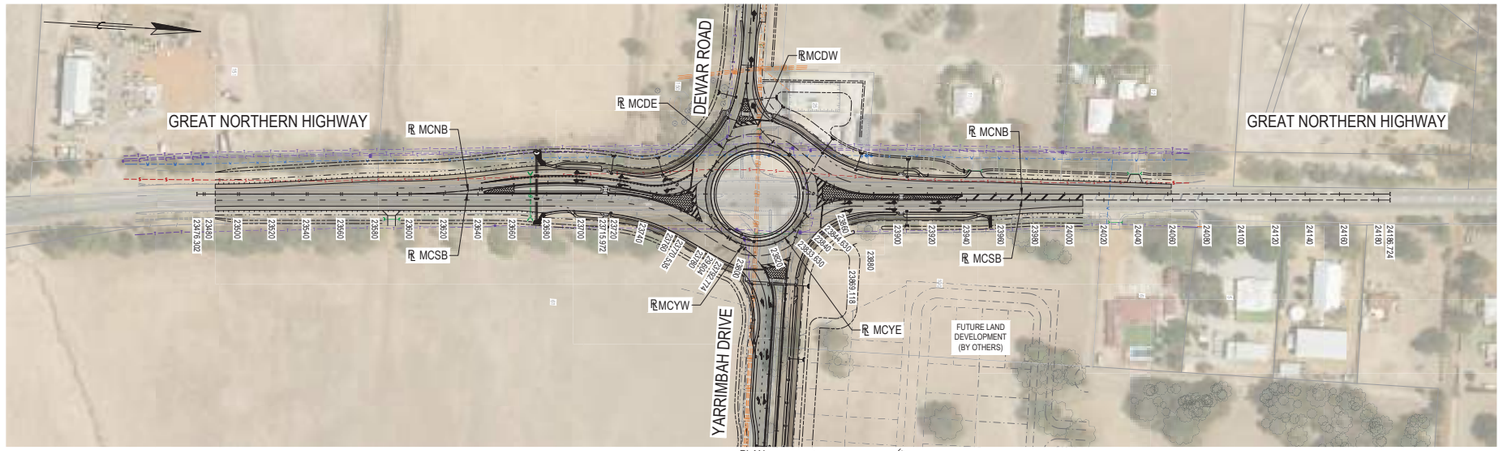

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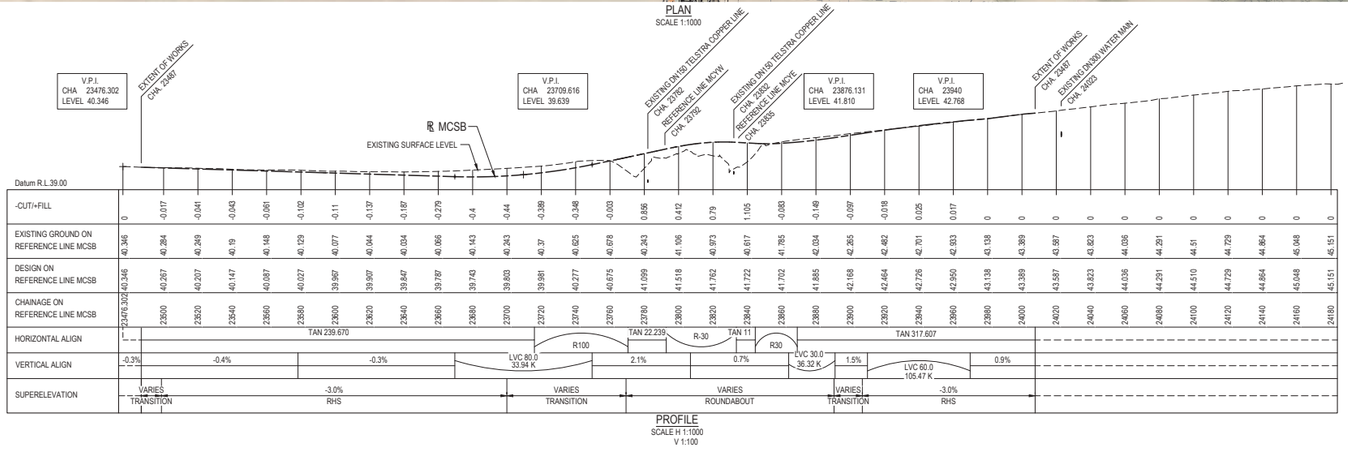

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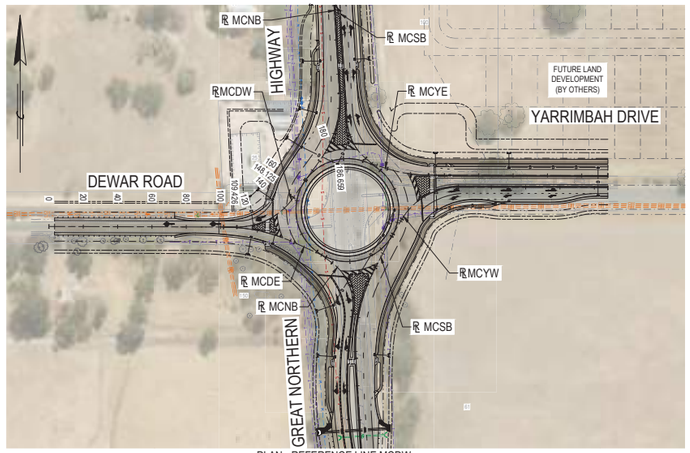
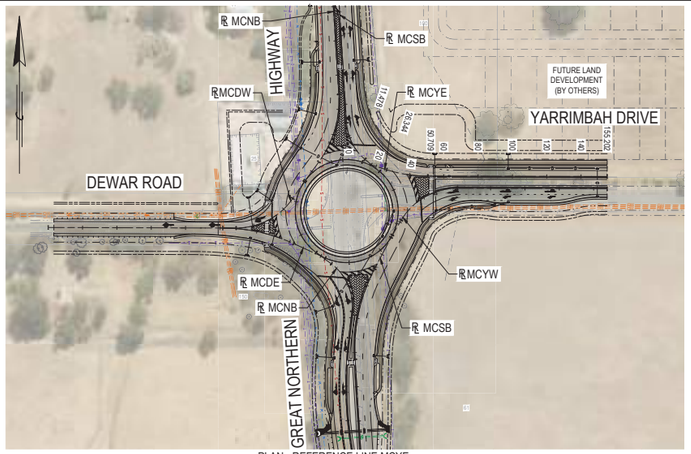
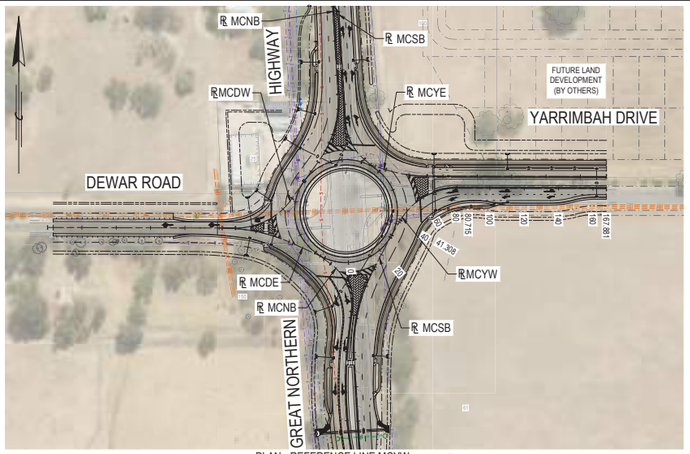


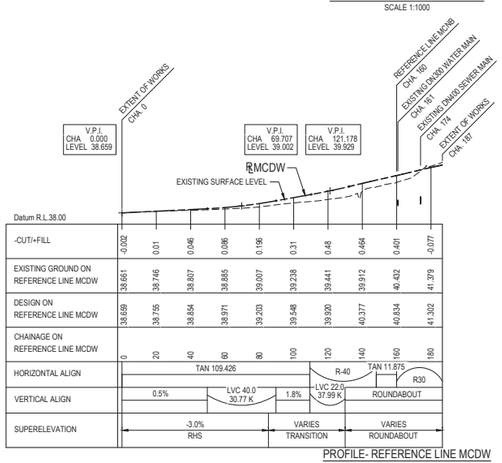
PLAN - REFERENCE LINE MCDW
SCALE 1:1000



PLAN - REFERENCE LINE MCYE
SCALE 1:1000



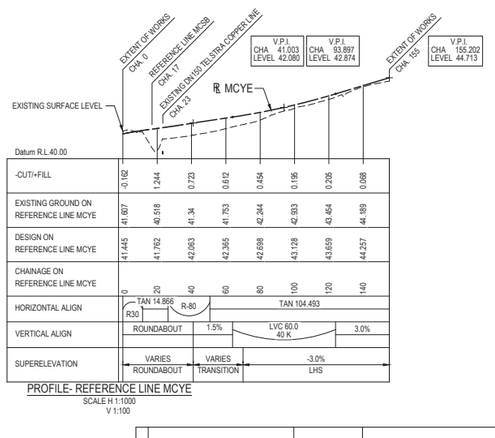
PLAN - REFERENCE LINE MCYW
SCALE 1:1000



Datum R.L.38.00

-CUT/+FILL	-0.002	0.01	0.046	0.086	0.195	0.31	0.48	0.464	0.401	-0.077
EXISTING GROUND ON REFERENCE LINE MCDW	38.661	38.746	38.807	38.885	39.007	39.238	39.441	39.912	40.432	41.379
DESIGN ON REFERENCE LINE MCDW	38.659	38.755	38.854	38.971	39.203	39.548	39.920	40.377	40.834	41.302
CHAINAGE ON REFERENCE LINE MCDW	0	20	40	60	80	100	120	140	160	180
HORIZONTAL ALIGN	TAN 109.426						R-40		TAN 11.875	R30
VERTICAL ALIGN	0.5%		LVC 40.0 30.77 K		1.8%		LVC 22.0 37.99 K		ROUNDABOUT	
SUPERELEVATION	-3.0% RHS				VARIES TRANSITION		VARIES ROUNDABOUT			

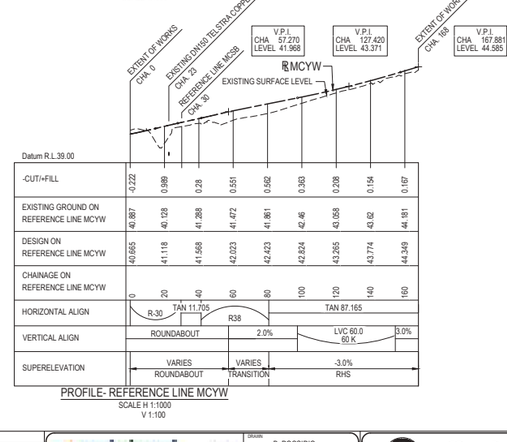
PROFILE- REFERENCE LINE MCDW
SCALE H 1:1000
V 1:100



Datum R.L.40.00

-CUT/+FILL	-0.162	1.244	0.723	0.612	0.454	0.195	0.205	0.068	
EXISTING GROUND ON REFERENCE LINE MCYE	41.607	40.518	41.34	41.753	42.244	42.933	43.454	44.189	
DESIGN ON REFERENCE LINE MCYE	41.445	41.762	42.063	42.365	42.698	43.128	43.659	44.257	
CHAINAGE ON REFERENCE LINE MCYE	0	20	40	60	80	100	120	140	
HORIZONTAL ALIGN	TAN 14.866 R30		R-80		TAN 104.493				
VERTICAL ALIGN	ROUNDABOUT		1.5%		LVC 60.0 40 K		3.0%		
SUPERELEVATION	VARIES ROUNDABOUT		VARIES TRANSITION		-3.0% LHS				

PROFILE- REFERENCE LINE MCYE
SCALE H 1:1000
V 1:100



Datum R.L.39.00

-CUT/+FILL	-0.222	0.989	0.28	0.551	0.562	0.393	0.208	0.154	0.167
EXISTING GROUND ON REFERENCE LINE MCYW	40.887	40.128	41.268	41.472	41.861	42.46	43.058	43.82	44.181
DESIGN ON REFERENCE LINE MCYW	40.665	41.118	41.568	42.023	42.423	42.824	43.265	43.774	44.349
CHAINAGE ON REFERENCE LINE MCYW	0	20	40	60	80	100	120	140	160
HORIZONTAL ALIGN	R-30	TAN 11.705		R38		TAN 87.165			
VERTICAL ALIGN	ROUNDABOUT		2.0%		LVC 60.0 60 K		3.0%		
SUPERELEVATION	VARIES ROUNDABOUT		VARIES TRANSITION		-3.0% RHS				

PROFILE- REFERENCE LINE MCYW
SCALE H 1:1000
V 1:100

NOTES

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED.
2. DESIGN LEVELS ARE TO TOP OF PAVEMENT.
3. FOR TYPICAL CROSS SECTION DETAILS REFER TO DRG'S 22063-1-C1-TD-01 TO 22063-1-C1-TD-04.
4. FOR PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-11.
5. FOR KERB END BATTER DRAIN DETAILS REFER TO MAIN ROADS W.A. STANDARD DRAWING: 201131-0069.
6. ROCK PITCHING SHALL COMPLY WITH MAIN ROADS WA STANDARDS AND SPECIFICATIONS, AS 1141.22, AS 1726 AND AS 2758.4 LATEST EDITIONS.
7. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH MAIN ROADS WA DRAWING NO. 9331-0376, 9331-0377, 201131-0069, 201331-0032, 201331-0035, 201331-0038, 201348-2734, 201348-2736, 201631-0083 AND 9831-5649.
8. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH MAIN ROADS WA TECHNICAL SPECIFICATIONS "301", "302", "407", "501", "503", "504", "505", "509", "511", "604", "606" AND "901".
9. FOR CONSTRUCTION SETOUT REFER TO STRING MODEL.

LEGEND

- PROPOSED REFERENCE LINES
- PROPOSED KERBING
- PROPOSED SEALED SHOULDER
- PROPOSED VERGE
- PROPOSED BRICK PAVING
- PROPOSED ASPHALT PAVEMENT
- PROPOSED PATH
- PROPOSED TOP/BOTTOM OF BATTER
- PROPOSED STORMWATER DRAINAGE PIPE AND ASSOCIATED PITS
- PROPOSED STREET LIGHT AND ASSOCIATED PIT (REFER TO ELECTRICAL PLANS FOR SPECIFICATIONS AND DETAILS)
- EXISTING OVERHEAD POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING UNDERGROUND POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING WATER RETICULATION MAIN AND ASSOCIATED STRUCTURES
- EXISTING SEWER PRESSURE MAIN AND ASSOCIATED STRUCTURES
- EXISTING STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES
- EXISTING COMMUNICATIONS CABLES AND ASSOCIATED STRUCTURES
- EXISTING TELSTRA COPPER LINES AND ASSOCIATED STRUCTURES

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

CAUTION: HIGH PRESSURE GAS IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE PIPELINE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

CAUTION: FIBRE OPTIC CABLE IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE CABLE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRI / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER: 22063-1-C5-RPLT-04

DRAWN	B. POCSIDIO
DESIGNED	T. McFARLANE
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL
CLIENT FILE NO.	

OFFICE OF THE MANAGING DIRECTOR
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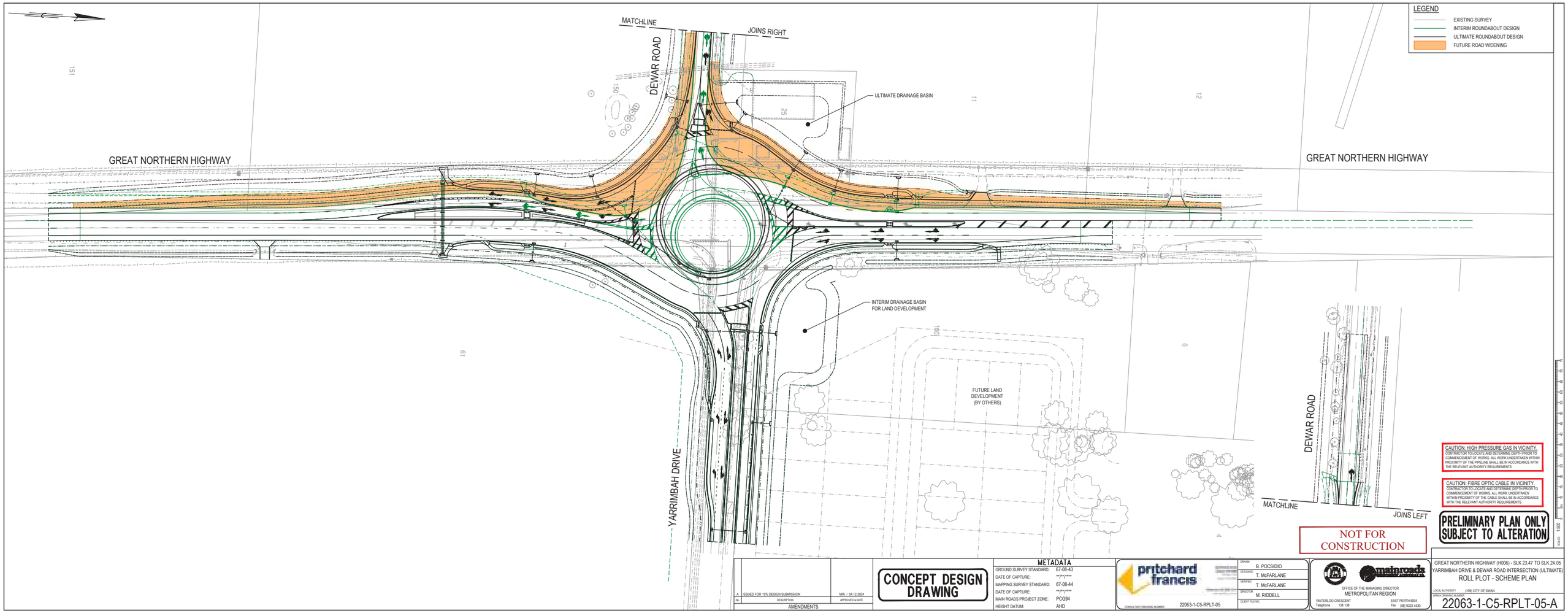
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
ROLL PLOT - PLAN AND PROFILE
REFERENCE LINES MCDW, MCYE AND MCYW

LOCAL AUTHORITY: (109) CITY OF SWAN
MRWA DRAWING NUMBER:

22063-1-C5-RPLT-04-A



No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MR / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER: 22063-1-C5-RPLT-05

DRAWN	B. POCSIDIO
DESIGNED	T. McFARLANE
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL
CLIENT FILE NO.	

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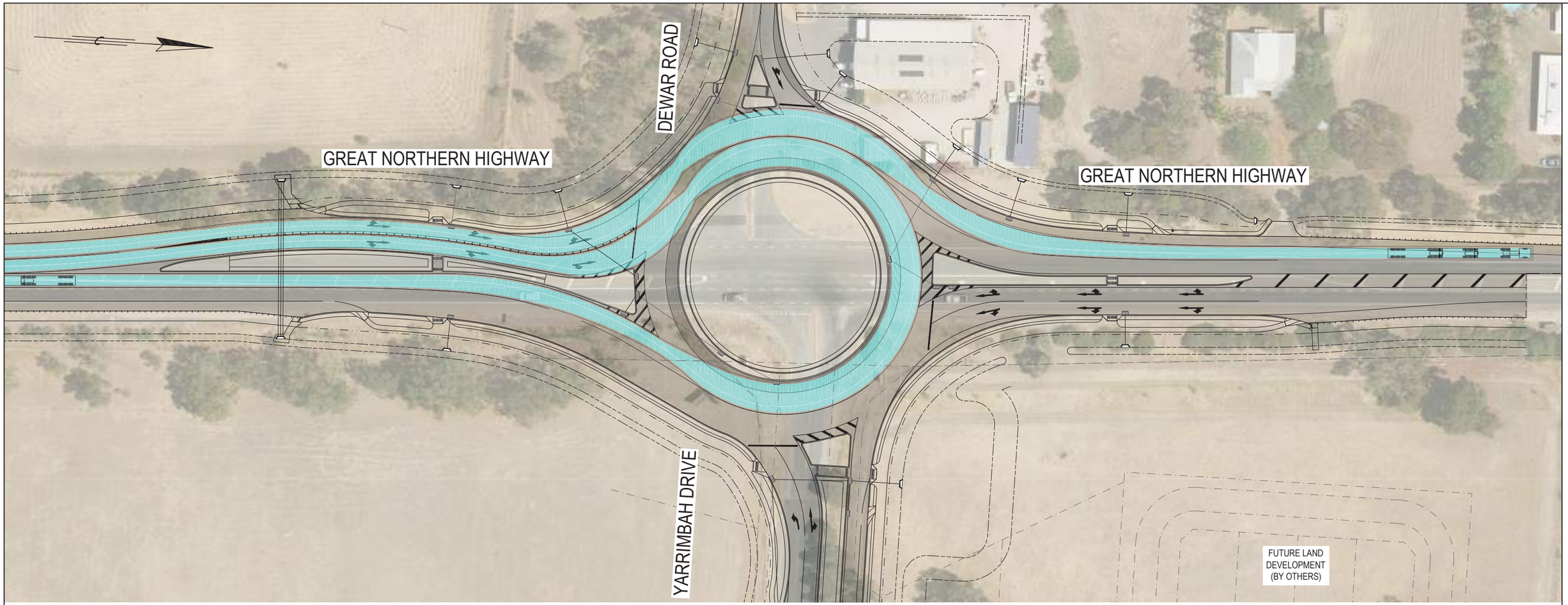
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

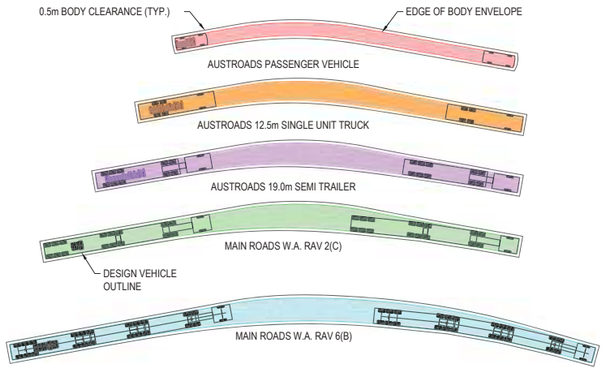
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
ROLL PLOT - SCHEME PLAN

LOCAL AUTHORITY: (109) CITY OF SWAN
MRWA DRAWING NUMBER: 22063-1-C5-RPLT-05-A



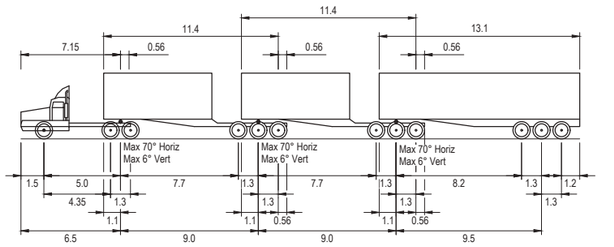
VEHICLE MOVEMENT PLAN

SCALE 1:500



TURNING TEMPLATE DIAGRAM

PRODUCED BY VEHICLE TRACKER



MAIN ROADS W.A. - RAV 6(B) B-TRIPLE (36.5m)

Overall Length	36.500m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	15.000m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA	
GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C5-TT-01

DRAWN	B. POCSIDIO
DESIGNED	T. McFARLANE
VERIFIED	T.McFARLANE
DIRECTOR	M.RIDDELL

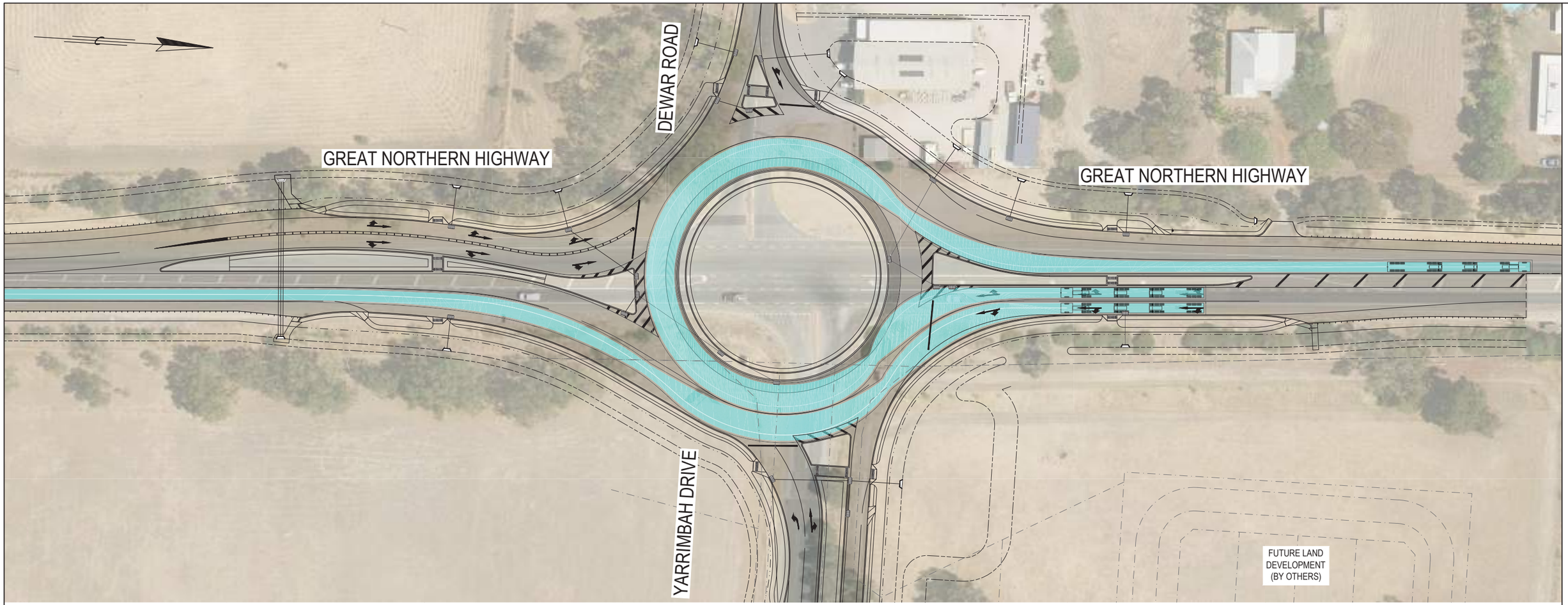
mainroads WESTERN AUSTRALIA

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.	
RECOMMENDED	
APPROVED	

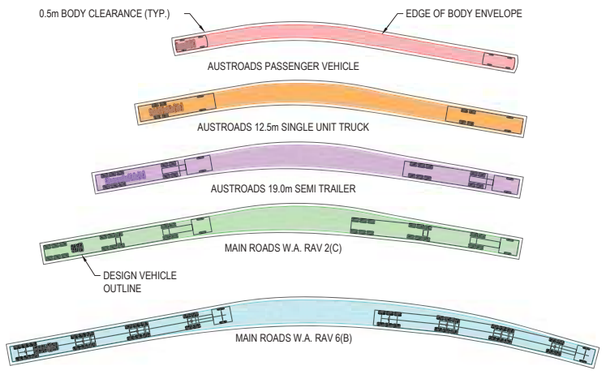
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 1 OF 5
LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER
22063-1-C5-TT-01-A



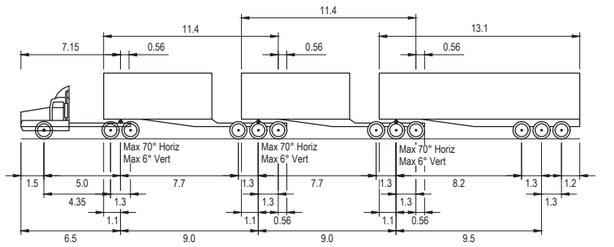
VEHICLE MOVEMENT PLAN

SCALE 1:500



TURNING TEMPLATE DIAGRAM

PRODUCED BY VEHICLE TRACKER



MAIN ROADS W.A. - RAV 6(B) B-TRIPLE (36.5m)

Overall Length	36.500m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	15.000m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C5-TT-02

DRAWN	B. POCSIDIO
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VERIFIED	T.McFARLANE
DIRECTOR	M.RIDDELL

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METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

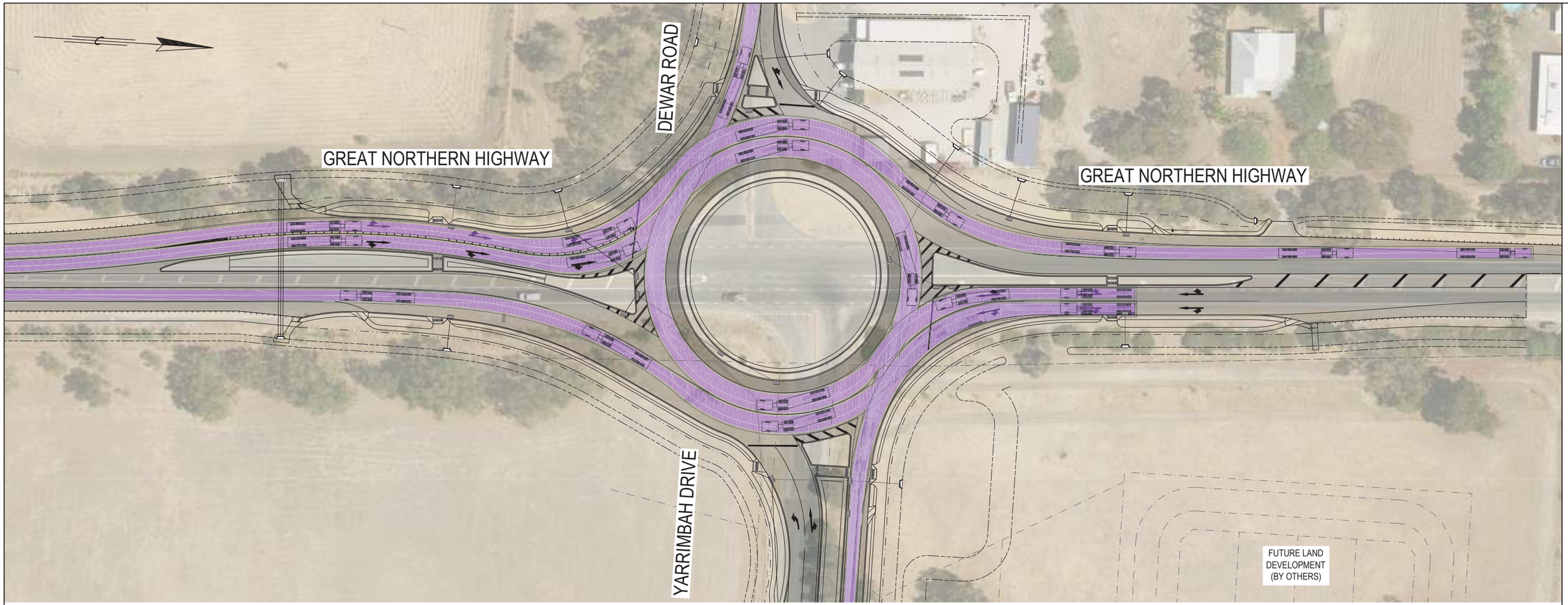
CLIENT FILE No.

RECOMMENDED

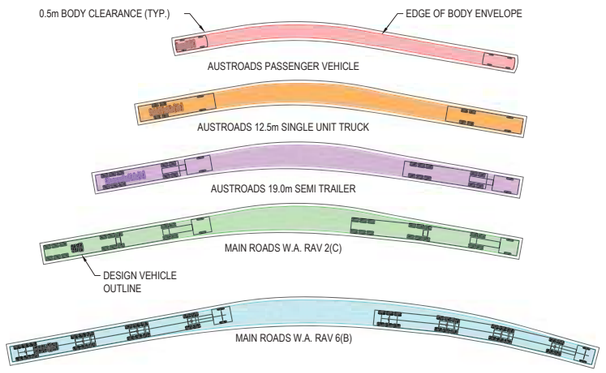
APPROVED

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 2 OF 5
LOCAL AUTHORITY (109) CITY OF SWAN

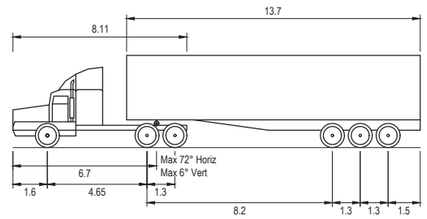
MRWA DRAWING NUMBER
22063-1-C5-TT-02-A



VEHICLE MOVEMENT PLAN
SCALE 1:500



TURNING TEMPLATE DIAGRAM
PRODUCED BY VEHICLE TRACKER



AUSTROADS PRIME MOVER AND SEMI-TRAILER (19.0m)

Overall Length	19.000m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	12.500m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A 1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C5-TT-03

DRAWN	B. POCSIDIO
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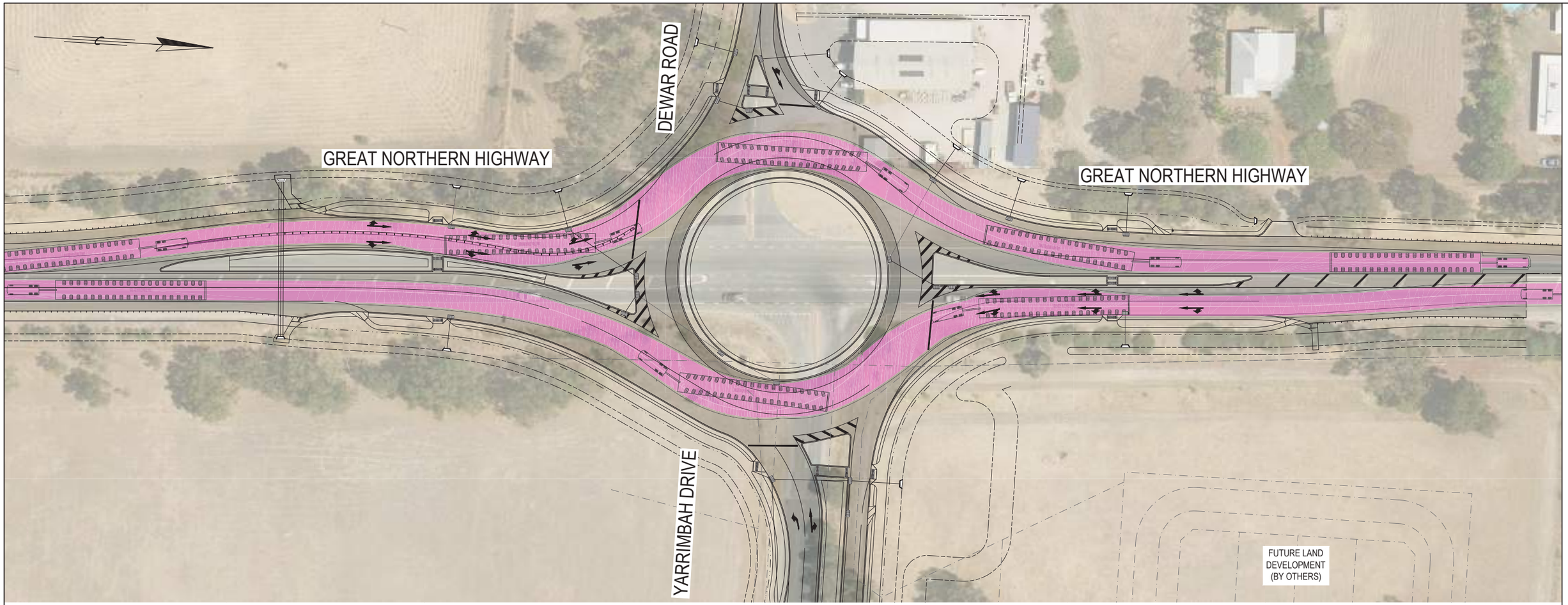
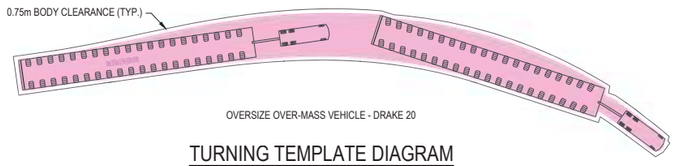
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.
RECOMMENDED
APPROVED

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 3 OF 5
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C5-TT-03-A



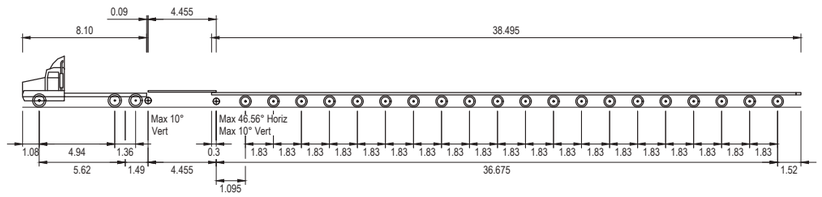
VEHICLE MOVEMENT PLAN
SCALE 1:500



OVERSIZE OVER-MASS VEHICLE - DRAKE 20

TURNING TEMPLATE DIAGRAM

PRODUCED BY VEHICLE TRACKER



MAIN ROADS W.A. O.S.O.M. - DRAKE 20 ROW (2 File) (4.88m Width)

Overall Length	50.840m
Overall Width	4.880m
Overall Body Height	3.341m
Min Body Ground Clearance	0.417m
Max Track Width	4.880m
Lock-to-lock time	6.00s
Wall to Wall Turning Radius	28.865m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A 1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C5-TT-04

DRAWN	B. POCSIDIO
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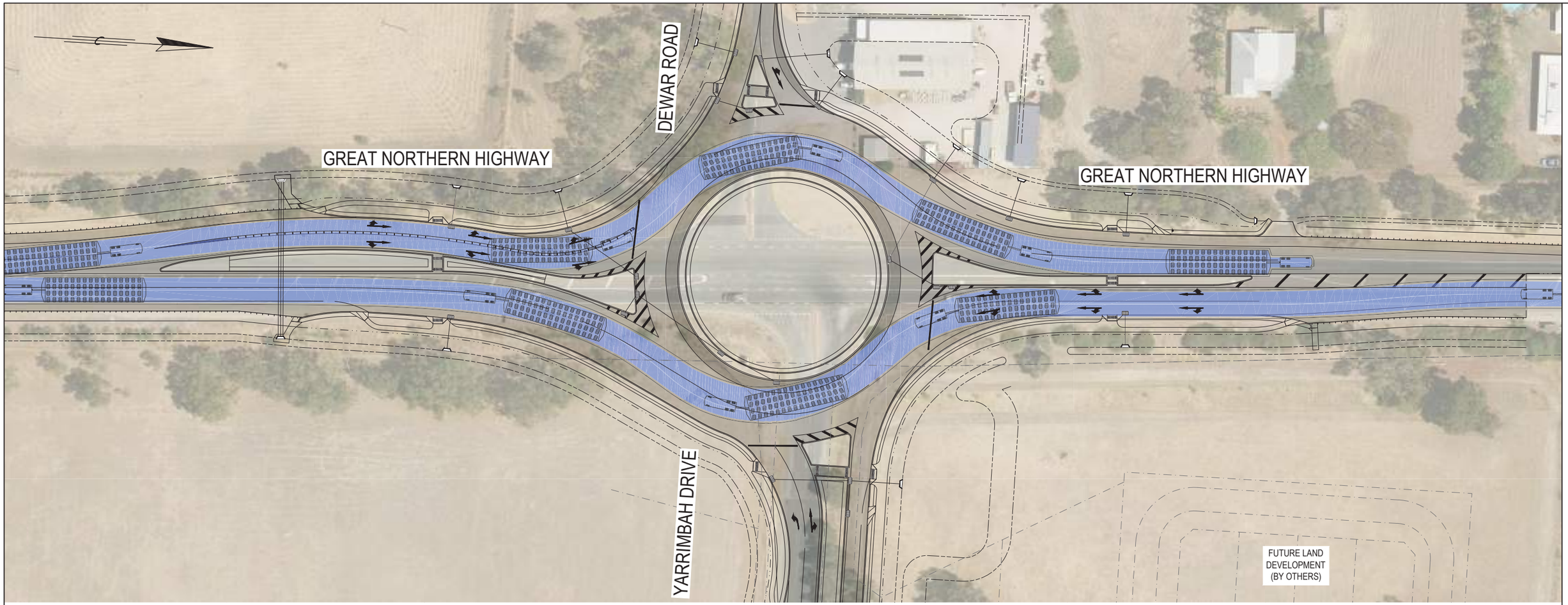
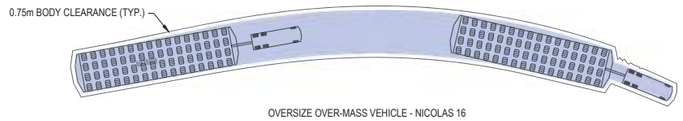
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.
RECOMMENDED
APPROVED

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 4 OF 5
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C5-TT-04-A

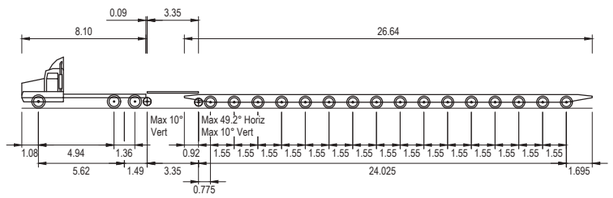


VEHICLE MOVEMENT PLAN
SCALE 1:500



OVERSIZE OVER-MASS VEHICLE - NICOLAS 16

TURNING TEMPLATE DIAGRAM
PRODUCED BY VEHICLE TRACKER



MAIN ROADS W.A. O.S.O.M. - NICOLAS 16 ROW (4 File)

Overall Length	37.260m
Overall Width	6.220m
Overall Body Height	3.341m
Min Body Ground Clearance	0.390m
Max Track Width	6.220m
Lock-to-lock time	6.00s
Wall to Wall Turning Radius	18.925m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A 1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C5-TT-05

DRAWN	B. POCSIDIO
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METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
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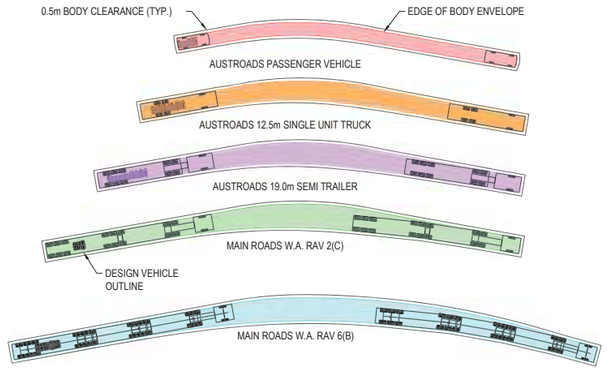
CLIENT FILE No.	
RECOMMENDED	
APPROVED	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 5 OF 5
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C5-TT-05-A

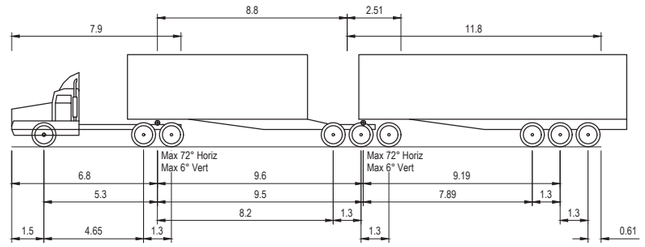


VEHICLE MOVEMENT PLAN
SCALE 1:500



TURNING TEMPLATE DIAGRAM

PRODUCED BY VEHICLE TRACKER



MAIN ROADS W.A. - RAV 2(C) B-DOUBLE (27.5m)

Overall Length	27.500m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	18.000m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
[redacted]
CONSULTANT DRAWING NUMBER 22063-1-C5-TT-06

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DIRECTOR	M.RIDDELL

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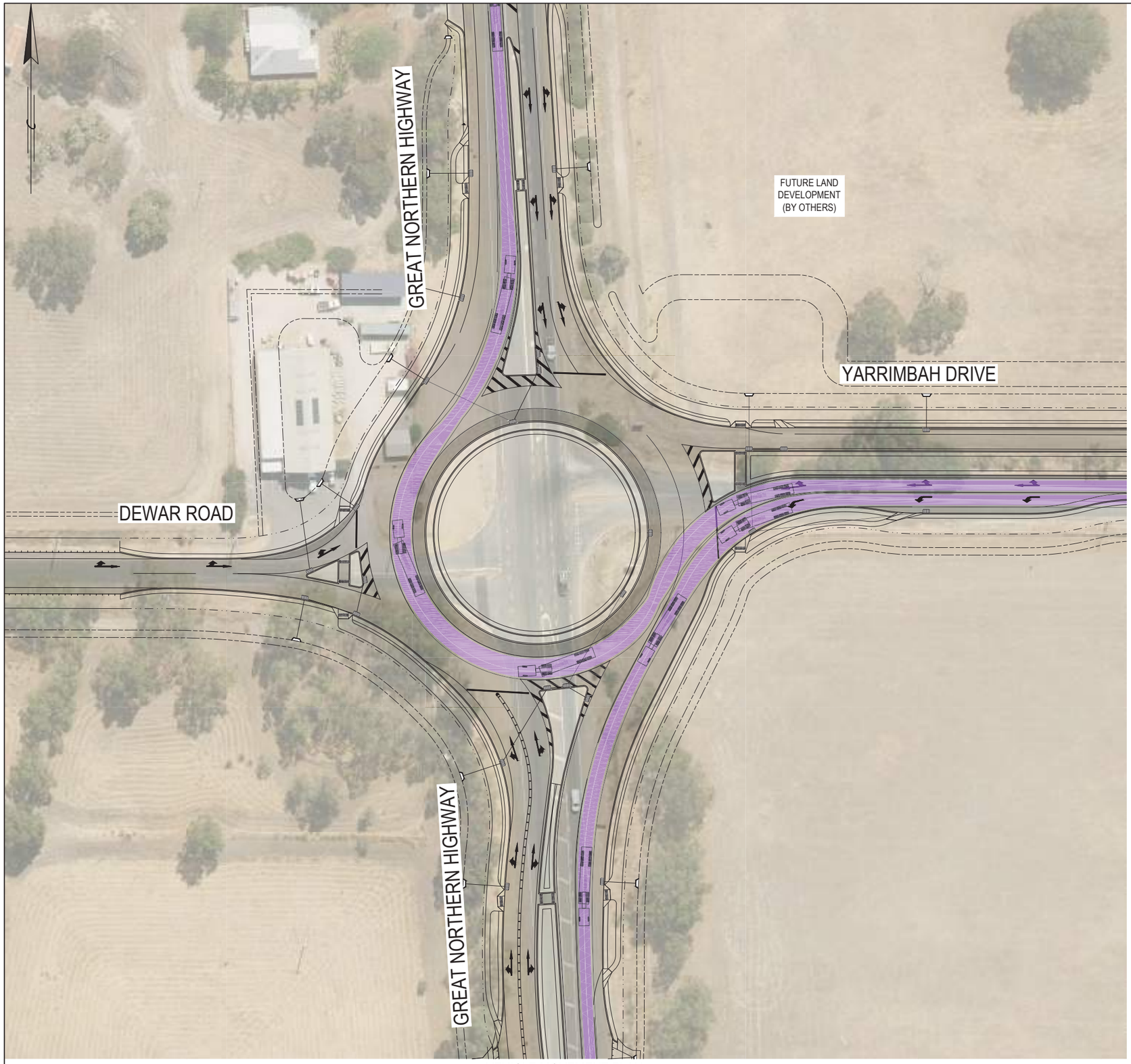
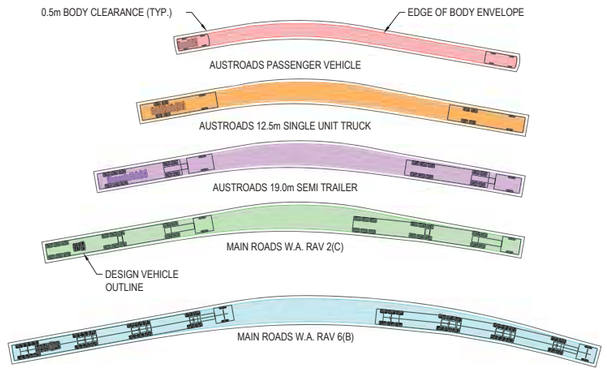
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.	
RECOMMENDED	
APPROVED	

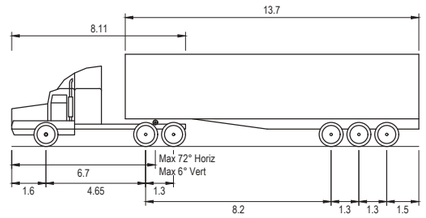
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
VEHICLE MOVEMENT PLAN
DEWAR ROAD
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C5-TT-06-A



VEHICLE MOVEMENT PLAN
SCALE 1:500



TURNING TEMPLATE DIAGRAM
PRODUCED BY VEHICLE TRACKER



AUSTROADS PRIME MOVER AND SEMI-TRAILER (19.0m)

Overall Length	19.000m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	12.500m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C5-TT-07

DRAWN B. POCSIDIO
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DIRECTOR M.RIDDELL

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CLIENT FILE No.
RECOMMENDED
APPROVED

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (ULTIMATE)
VEHICLE MOVEMENT PLAN
YARRIMBAH DRIVE
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C5-TT-07-A

APPENDIX C: 15-PERCENT DESIGN FOR INTERIM ROUNDABOUT

Technical Appendix C provides the 15-percent drawings for the 'Interim Design' of the proposed roundabout at the Great Northern Highway - Yarrimbah Drive - Dewar Road intersection, together with swept path diagrams for Heavy Vehicles, as prepared by Pritchard Francis.

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METROPOLITAN REGION

ROUNDABOUT CONSTRUCTION (INTERIM DESIGN)

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05

YARRIMBAH DRIVE (0077) AND DEWAR ROAD (0041) INTERSECTION
CITY OF SWAN (109)

DRAWINGS - ROADWORKS

NOT FOR CONSTRUCTION

SCALES
A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA	
GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C0-CS-21

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CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
COVER SHEET

LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C0-CS-21-A

DRAWING INDEX

GENERAL DRAWINGS

22063-1-C0-CS-21	COVER SHEET
22063-1-C0-IN-21	DRAWING INDEX
22063-1-C0-LP-21	KEY, LOCALITY AND SITE PLAN

TYPICAL DRAWINGS

22063-1-C1-TD-21	TYPICAL CROSS SECTIONS - REFERENCE LINE MCNB - CHA. 23480 TO CHA. 23790
22063-1-C1-TD-22	TYPICAL CROSS SECTIONS - REFERENCE LINE MCNB - CHA. 23860 TO CHA. 24065
22063-1-C1-TD-23	TYPICAL CROSS SECTIONS - REFERENCE LINE MCDW - CHA. 80 TO CHA. 110
22063-1-C1-TD-24	TYPICAL CROSS SECTIONS - REFERENCE LINE MCYE - CHA. 70 TO CHA. 120
22063-1-C1-TD-25	TYPICAL DETAILS - ROADWORKS
22063-1-C1-TD-27	TYPICAL DETAILS - PAVEMENT

PLAN AND PROFILE DRAWINGS

~~22063-1-C5-RP-21 PLAN AND PROFILE MCN1 - CHA 23530 TO 23880~~
~~22063-1-C5-RP-22 PLAN AND PROFILE MCN1 - CHA 23880 TO 24247~~
~~22063-1-C5-RP-23 PLAN AND PROFILE MCD0~~
~~22063-1-C5-RP-24 PLAN AND PROFILE MCLA~~

ROLL PLOT DRAWINGS

22063-1-C5-RPLT-21	ROLL PLOT - ROUNDABOUT LAYOUT
22063-1-C5-RPLT-22	ROLL PLOT - PLAN PROFILE - REFERENCE LINE MCNB - CHA. 23496 TO CHA. 24200
22063-1-C5-RPLT-23	ROLL PLOT - PLAN PROFILE - REFERENCE LINE MCSB - CHA. 23476 TO CHA. 24180
22063-1-C5-RPLT-24	ROLL PLOT - PLAN PROFILE - REFERENCE LINES MCDW, MCYE AND MCYW
22063-1-C5-RPLT-25	ROLL PLOT - SCHEME PLAN

LAYOUT DRAWINGS

~~22063-1-C5-RL-21 ROAD LAYOUT PLAN - CHA 23530 TO 23720~~
~~22063-1-C5-RL-22 ROAD LAYOUT PLAN - CHA 23720 TO 23920~~
~~22063-1-C5-RL-23 ROAD LAYOUT PLAN - CHA 23920 TO 24120~~
~~22063-1-C5-RL-24 ROAD LAYOUT PLAN - CHA 24120 TO 24247.293~~

VEHICLE MOVEMENT DRAWINGS

22063-1-C5-TT-21	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 1 OF 3
22063-1-C5-TT-22	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 2 OF 3
22063-1-C5-TT-23	VEHICLE MOVEMENT PLAN - GREAT NORTHERN HIGHWAY - SHEET 3 OF 3
22063-1-C5-TT-24	VEHICLE MOVEMENT PLAN - DEWAR ROAD
22063-1-C5-TT-25	VEHICLE MOVEMENT PLAN - YARRIMBAH DRIVE

DRAINAGE AND SERVICES DRAWINGS

22063-1-C3-DC-21 DRAINAGE STRATEGY PLAN
~~22063-1-C3-DP-21 DRAINAGE AND SERVICES PLAN~~

CROSS SECTION DRAWINGS

~~22063-1-C5-XS-21 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-22 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-23 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-24 MCN1 CROSS SECTIONS~~
~~22063-1-C5-XS-25 MCN1 CROSS SECTIONS~~

PAVEMENT AND SURFACING DRAWINGS

~~22063-1-C5-SP-21 PAVEMENT AND SURFACING PLAN~~
~~22063-1-C5-SP-22 PAVEMENT AND SURFACING PLAN~~
~~22063-1-C5-SP-23 PAVEMENT AND SURFACING PLAN~~
~~22063-1-C5-SP-24 PAVEMENT AND SURFACING PLAN~~

PAVEMENT MARKING DRAWINGS

~~22063-1-C5-PM-21 SIGNS AND PAVEMENT MARKING PLAN~~
~~22063-1-C5-PM-22 SIGNS AND PAVEMENT MARKING PLAN~~
~~22063-1-C5-PM-23 SIGNS AND PAVEMENT MARKING PLAN~~
~~22063-1-C5-PM-24 SIGNS AND PAVEMENT MARKING PLAN~~

MAIN ROADS STANDARD DRAWINGS

9331-0376	KERB TYPES
9331-0377	KERB TREATMENTS
201131-0069	KERBED BATTER DRAINS
201331-0032	TYPICAL DETAILS - GRANULAR TRAVERSE JOINTS
201331-0036	TYPICAL DETAILS - DGA TRAVERSE JOINTS
201331-0038	TYPICAL DETAILS - LONGITUDINAL JOINTS
201631-0083	TYPICAL DETAILS - GRANULAR LONGITUDINAL JOINTS
200331-0154	SEGMENTAL PAVING DETAILS - ISLANDS AND MEDIANS
200331-0155	SEGMENTAL PAVING DETAILS - AROUND OBJECTS
200331-0156	SEGMENTAL PAVING DETAILS - EDGE TREATMENTS
8720-0762	TWO AND THREE POST SIGN - LOCATION DETAILS
9531-2010	PAVEMENT ARROWS DIMENSIONS
9531-2011	PAVEMENT ARROWS POSITIONING DETAILS
9548-0106	LOCATION DETAILS FOR ONE POST SIGNS
9648-176	FIXING AND INSTALLATION DETAILS FOR SINGLE HAZARD MARKERS
9648-0438	ONE WAY ARROW DIRECTION SIGNS - FIXING AND INSTALLATION DETAILS
9931-0198	PAVEMENT MARKING LINE TYPES
200031-0015	TYPICAL CORNER TREATMENT ON HEAVY COMBINATION VEHICLE ROUTE
200331-0091	"D" BULLNOSE, MEDIAN TREATMENTS AND DIAGONAL MARKINGS
200331-191	PAVEMENT MARKINGS AND RRPM'S AT RAISED MEDIANS
200431-002	STOP AND GIVE WAY LINES
201031-0027	RAISED PAVEMENT MARKERS - GENERAL APPLICATIONS - FREEWAYS, HIGHWAYS, MAIN ROADS AND ARTERIAL ROADS IN RURAL AND OUTER METROPOLITAN AREAS
201631-0003	LAYOUT FOR TURNING GUIDE LINES

NOT FOR CONSTRUCTION

SCALES
A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
[redacted]
CONSULTANT DRAWING NUMBER 22063-1-C0-IN-21

DRAWN	B. POCSIDIO
DESIGNED	W. BRIERS
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

mainroads WESTERN AUSTRALIA
OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

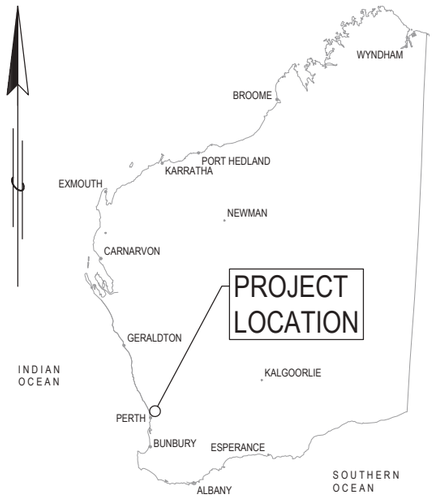
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
DRAWING INDEX

LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C0-IN-21-A



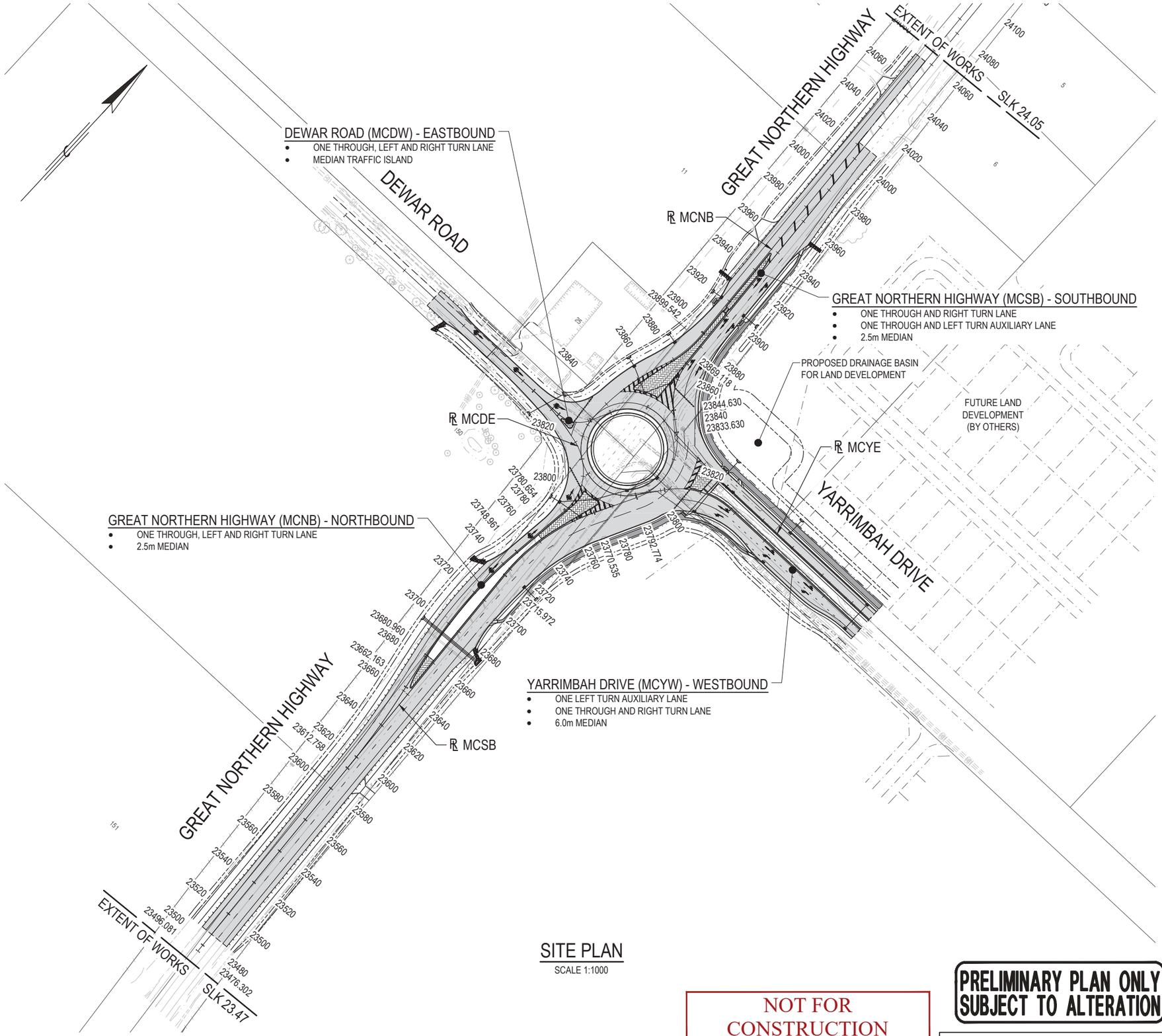
LOCALITY PLAN

N.T.S.



KEY PLAN

N.T.S.



SITE PLAN

SCALE 1:1000

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:1000

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA	
GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C0-LP-21

DRAWN	B. POCSIDIO
DESIGNED	W. BRIERS
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

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CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
KEY, LOCALITY AND SITE PLAN

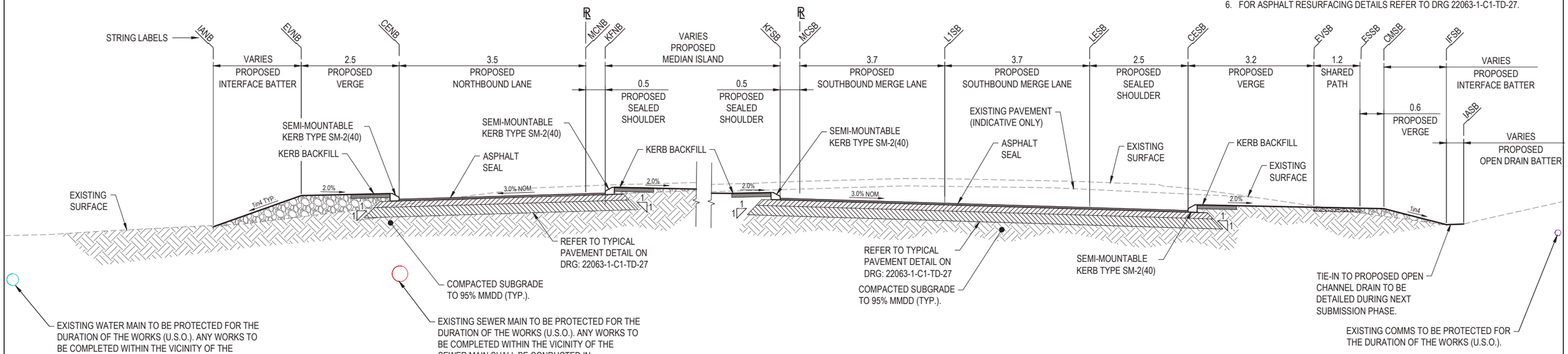
LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER

22063-1-C0-LP-21-A

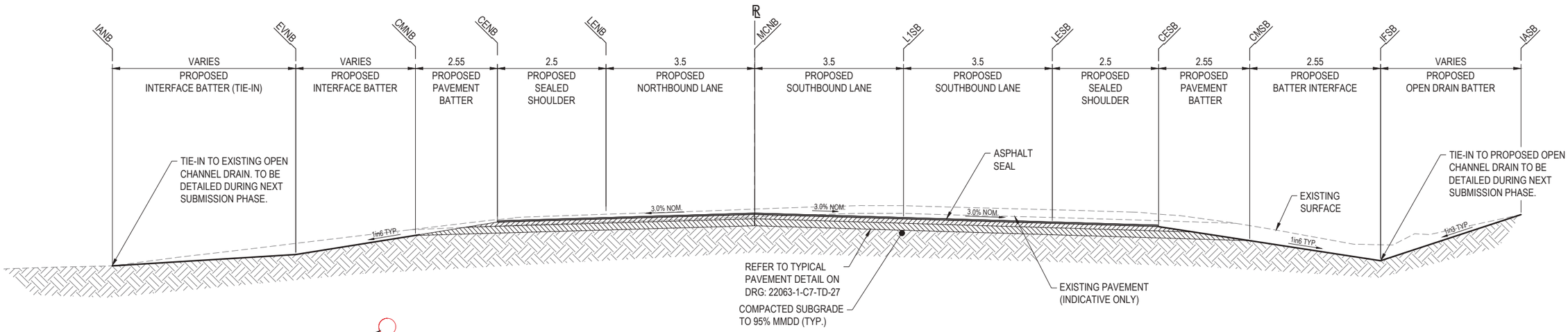
NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE MAIN ROADS WA SPECIFICATIONS.
2. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
3. DESIGN LEVELS ARE TO FINISHED TOP OF PAVEMENT SURFACE.
4. FOR TYPICAL PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-25.
5. FOR CUT EDGE DETAILS REFER TO DRG 22063-1-C1-TD-27.
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-27.



TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23700 TO CHA. 23790

SCALE 1:50



TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23480 TO CHA. 23680

SCALE 1:50

SCALES 1:50 — 0 0.5m 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5

A1

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C1-TD-21

DRAWN	W. BRIERS
DESIGNED	W. BRIERS
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DIRECTOR	M. RIDDELL

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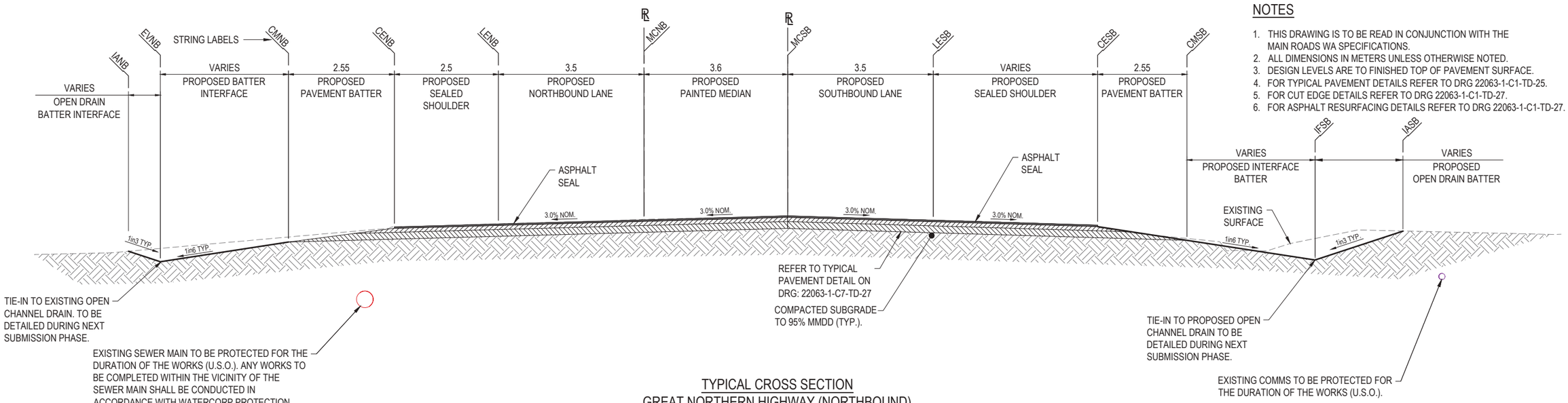
CLIENT FILE No.	
RECOMMENDED	
APPROVED	
DRAWING STATUS	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCNB - CHA. 23480 TO CHA. 23790
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-21-A

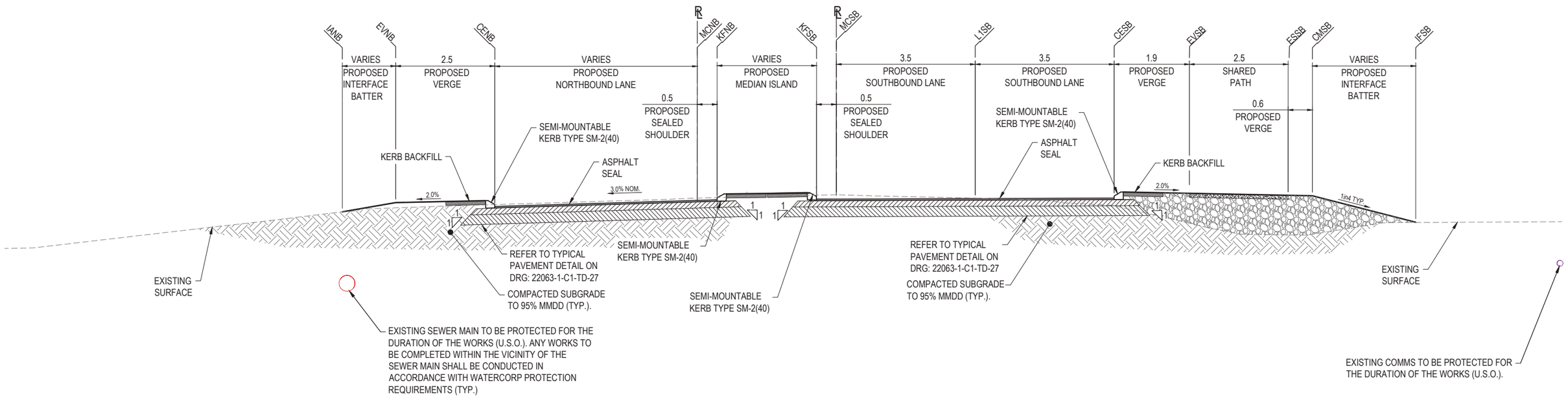
NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE MAIN ROADS WA SPECIFICATIONS.
2. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
3. DESIGN LEVELS ARE TO FINISHED TOP OF PAVEMENT SURFACE.
4. FOR TYPICAL PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-25.
5. FOR CUT EDGE DETAILS REFER TO DRG 22063-1-C1-TD-27.
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-27.



TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23960 TO CHA. 24065

SCALE 1:50



TYPICAL CROSS SECTION
GREAT NORTHERN HIGHWAY (NORTHBOUND)
REFERENCE LINE MCNB - CHA. 23860 TO CHA. 23940

SCALE 1:50

NOT FOR CONSTRUCTION

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA	
GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C1-TD-22

DRAWN	W. BRIERS
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CLIENT FILE No.	
RECOMMENDED	
APPROVED	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCNB - CHA. 23860 TO CHA. 24065
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-22-A

NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH THE MAIN ROADS WA SPECIFICATIONS.
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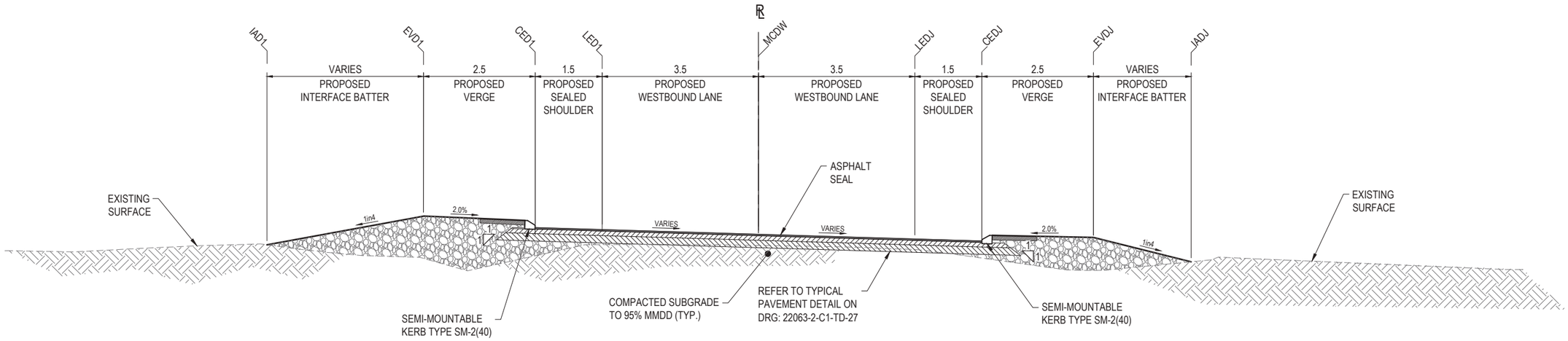
4. FOR TYPICAL PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-25.
5. FOR CUT EDGE DETAILS REFER TO DRG 22063-1-C1-TD-27.
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-27.



TYPICAL CROSS SECTION
DEWAR ROAD (EASTBOUND)
REFERENCE LINE MCDW - CHA. 80 TO CHA. 110

SCALE: 1:50

NOT FOR CONSTRUCTION

SCALES 1:50 0 0.5m 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER 22063-1-C1-TD-23

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CLIENT FILE No.	
RECOMMENDED	
APPROVED	

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCDW - CHA. 80 TO CHA. 110
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C1-TD-23-A

NOTES

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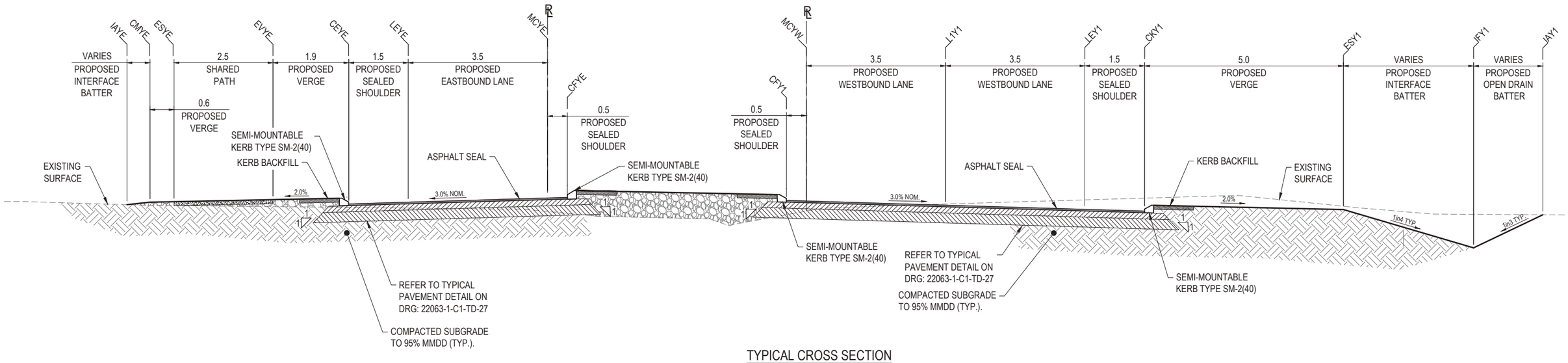
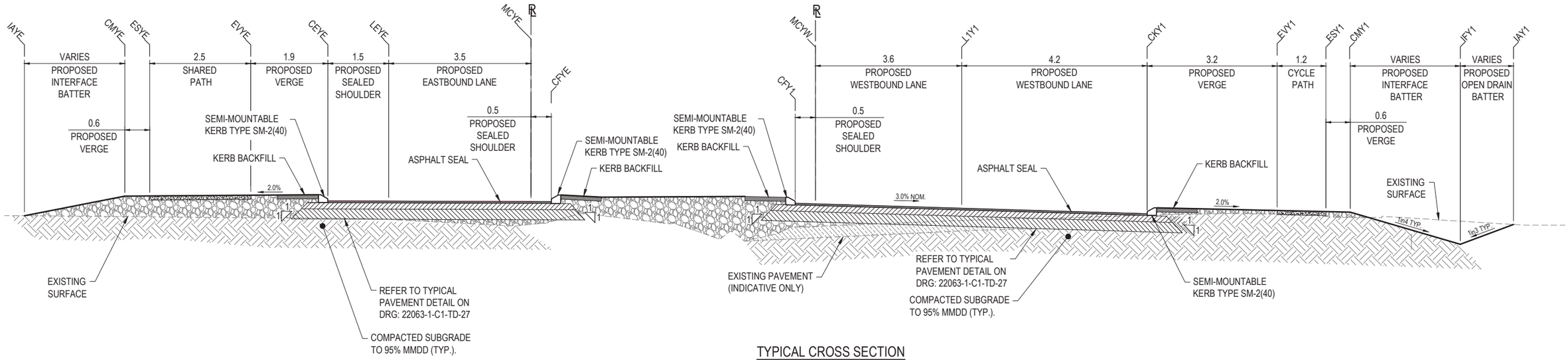
6. FOR ASPHALT RESURFACING DETAILS REFER TO DRG 22063-1-C1-TD-27.



TYPICAL CROSS SECTION
YARRIMBAH DRIVE (EASTBOUND)
REFERENCE LINE MCYE - CHA.120

SCALE 1:50



TYPICAL CROSS SECTION
YARRIMBAH DRIVE (EASTBOUND)
REFERENCE LINE MCYE - CHA. 70

SCALE 1:50

NOT FOR CONSTRUCTION

SCALES 1:50

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C1-TD-24

DRAWN	W. BRIERS
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WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

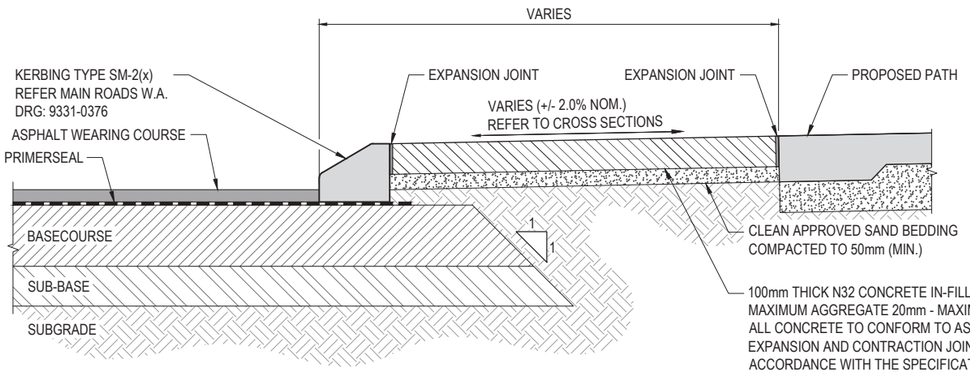
CLIENT FILE No.

RECOMMENDED

APPROVED

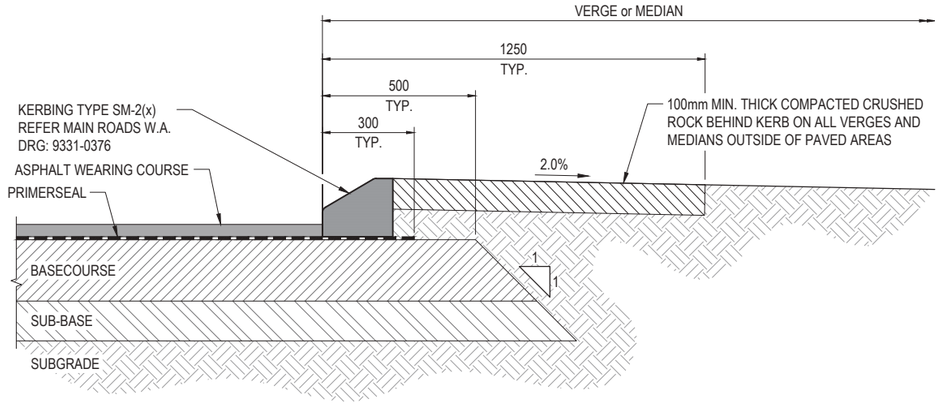
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
TYPICAL CROSS SECTIONS
REFERENCE LINE MCYE - CHA. 70 TO CHA. 120
LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER
22063-1-C1-TD-24-A



TYPICAL CONCRETE INFILL TREATMENT DETAIL

SCALE 1:10 0m 200mm 400mm

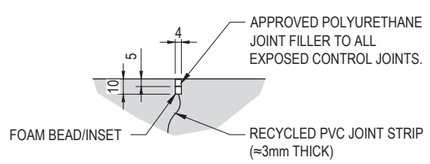


TYPICAL KERB AND PAVEMENT TREATMENT DETAIL

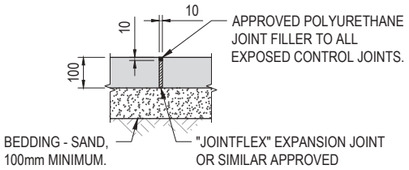
SCALE 1:10 0m 200mm 400mm

NOTES

1. ALL CONCRETE TO BE A MINIMUM OF 25MPa, 20mm AGGREGATE AND A MAXIMUM SLUMP OF 80mm, FROM AN APPROVED PRE-MIX BATCH PLANT
2. MINIMUM THICKNESS - 100mm.
3. BEDDING - SAND, 50mm MINIMUM.
4. FINISH - BROOMED TO NON-SKID FINISH PARALLEL TO LINE OF KERB WITH TOOLED EDGES
5. EXPANSION JOINTS - APPROVED MATERIAL SHALL BE EXPANDITE-FLEXICELL.
6. TACTILE GROUND SURFACE INDICATORS (T.G.S.I.'s) SHALL BE IN ACCORDANCE WITH AS1428.1 AND AS1428.4.
7. CONTRACTOR TO INSTALL STAINLESS STEEL WARNING T.G.S.I.'s FOR FULL WIDTH OF CONCRETE KERB RAMP. REFER TO ARCHITECTURAL FINISHES SCHEDULE FOR DETAILS.
8. WARNING TGSI's ARE NOT TO BE CUT. CONTRACTOR SHALL SELECT SUITABLE SIZE TO EXTEND ACROSS FULL WIDTH OF KERB RAMP (EXCLUDING SPLAYS).
9. WHERE THE KERB RAMP IS CONSTRUCTED USING BLOCK PAVERS, THE CONTRACTOR SHALL INSTALL TGSI PAVERS IN A CONTRASTING COLOUR CONFORMING WITH AS1428.4 LUMINANCE REQUIREMENTS.

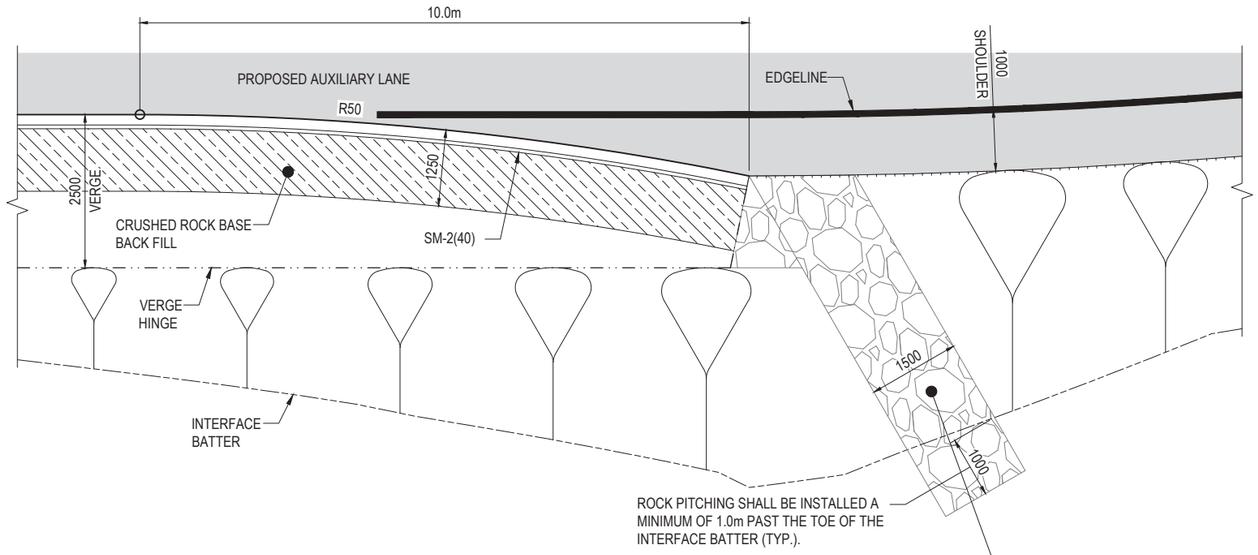


DETAIL 2 / - SCALE 1:2 0m 20mm 40mm



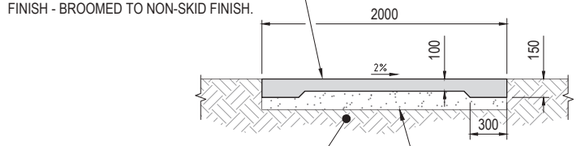
EXPANSION JOINT

SCALE 1:10 0m 200mm 400mm



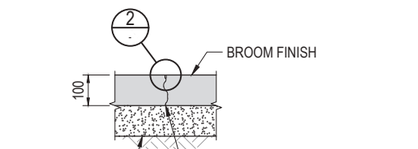
TYPICAL KERB TAPER AND ROCK PITCHING END TREATMENT DETAIL

SCALE 1:50 0m 1m 2m



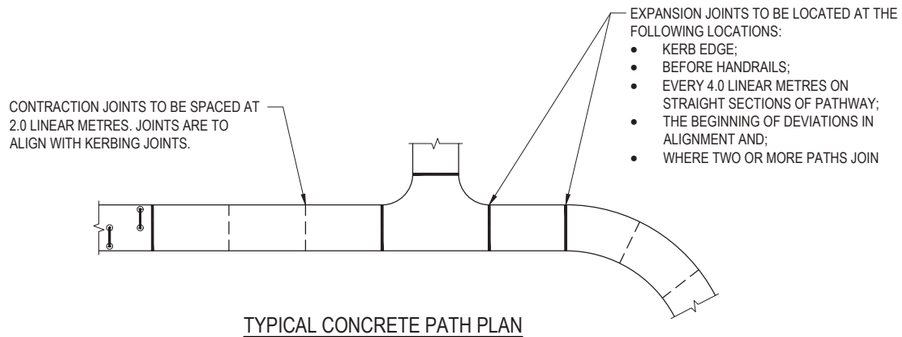
CONCRETE PATH SECTION

SCALE 1:25 0m 0.5m 1.0m



CONTRACTION JOINT

SCALE 1:10 0m 200mm 400mm



TYPICAL CONCRETE PATH PLAN

SCALE 1:100 0m 2m 4m

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER 22063-1-C1-TD-25

DRAWN W. BRIERS
DESIGNED W. BRIERS
VERIFIED T. McFARLANE
DIRECTOR M. RIDDELL

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METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
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CLIENT FILE No.
RECOMMENDED
APPROVED

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)

TYPICAL DETAILS

ROADWORKS

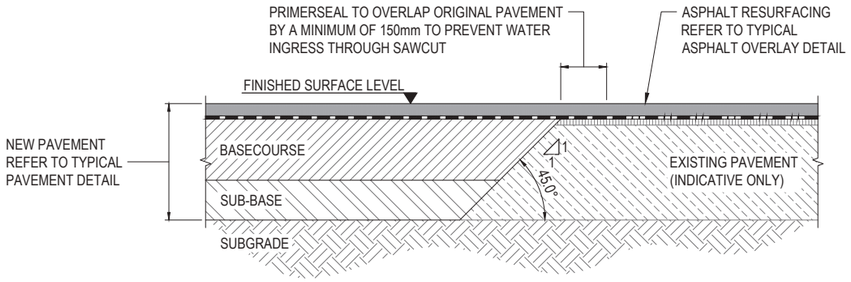
LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER

22063-1-C1-TD-25-A

SCALES 1:100 1:25 1:2

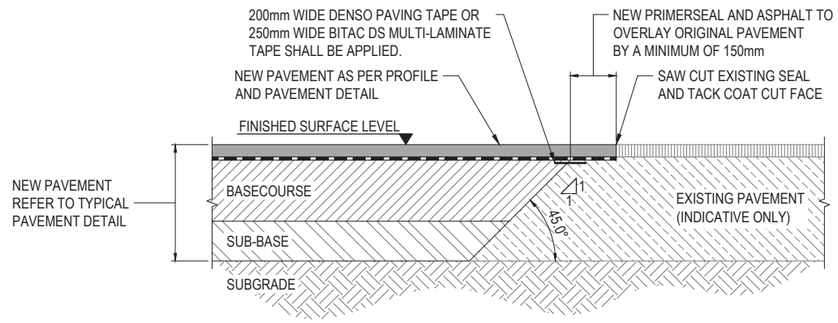
A1



TYPICAL SAW CUT DETAIL - ASPHALT OVERLAY

SCALE 1:10 0m 200mm 400mm

NOTE: FOR FURTHER DETAIL REFER TO MAIN ROADS W.A. STD DRG 201331-0038



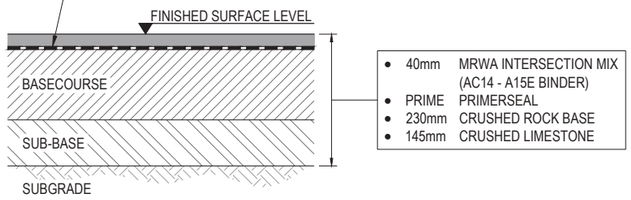
TYPICAL SAW CUT DETAIL

SCALE 1:10 0m 200mm 400mm

NOTE: FOR FURTHER DETAIL REFER TO MAIN ROADS W.A. STD DRG 201331-0038

NOTES

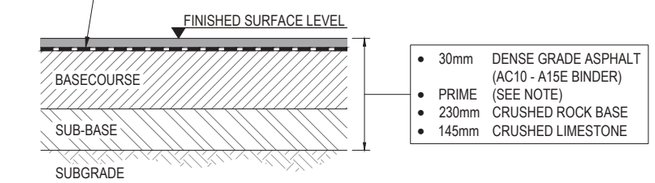
1. ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE NOTED.
2. FOR PAVEMENT PLAN REFER TO DRG. 22063-1-C5-RPLT-21
3. IF TOTAL CRUSHED ROCK THICKNESS IS LESS THAN 250mm, PLACE IN SINGLE LAYER. MINIMUM LAYER THICKNESS IS 100mm.
4. PAVEMENT TRANSITION RAMPS TO BE 15.0m MINIMUM IN ACCORDANCE WITH MAIN ROADS W.A. DRG 201331-0035.
5. LONGITUDINAL JOINTS TO BE IN ACCORDANCE WITH MAIN ROADS W.A. DRG 201331-0038.
6. TRANSVERSE JOINTS TO BE IN ACCORDANCE WITH MAIN ROADS W.A. DRG 201331-0032.
7. ASPHALT OVERLAY TO BE APPLIED WHERE LEVEL CHANGE CAN BE ACCOMMODATED.
8. FOR CUT EDGE LOCATIONS REFER TO INTERSECTION DETAILS DRG'S 22063-1-C5-RPLT-21.



TYPICAL ROAD PAVEMENT DETAIL - TYPE 1

SCALE 1:10 0m 200mm 400mm

NOTE:
THE CONTRACTOR SHALL CONSTRUCT PAVEMENT IN ACCORDANCE WITH AS2150 AND CIVIL SPECIFICATIONS AND DETAILS



TYPICAL ROAD PAVEMENT DETAIL - TYPE 2

SCALE 1:10 0m 200mm 400mm

NOTE:
THE CONTRACTOR SHALL CONSTRUCT PAVEMENT IN ACCORDANCE WITH AS2150 AND CIVIL SPECIFICATIONS AND DETAILS

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis
CONSULTANT DRAWING NUMBER 22063-1-C1-TD-27

DRAWN	W. BRIERS
DESIGNED	W. BRIERS
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

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METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

CLIENT FILE No.

RECOMMENDED

APPROVED

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)

TYPICAL DETAILS
PAVEMENT

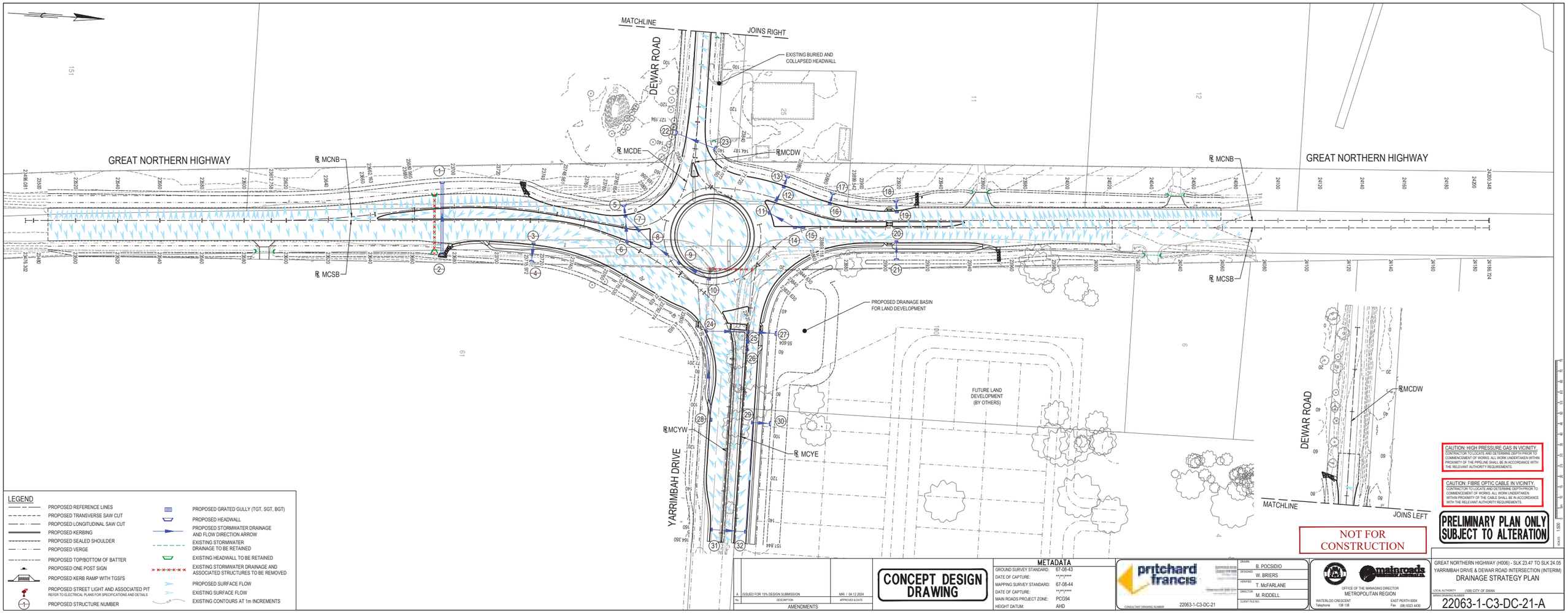
LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER

22063-1-C1-TD-27-A

SCALES 1:10

A1



CAUTION: HIGH PRESSURE GAS IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE PIPELINE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

CAUTION: FIBRE OPTIC CABLE IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE CABLE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

NOT FOR CONSTRUCTION

LEGEND

- PROPOSED REFERENCE LINES
- PROPOSED TRANSVERSE SAW CUT
- PROPOSED LONGITUDINAL SAW CUT
- PROPOSED KERBING
- PROPOSED SEALED SHOULDER
- PROPOSED VERGE
- PROPOSED TOP/BOTTOM OF BATTER
- PROPOSED ONE POST SIGN
- PROPOSED KERB RAMP WITH TGS/'S
- PROPOSED STREET LIGHT AND ASSOCIATED PIT REFER TO ELECTRICAL PLANS FOR SPECIFICATIONS AND DETAILS
- PROPOSED STRUCTURE NUMBER
- PROPOSED GRATED GULLY (TGT, SGT, BGT)
- PROPOSED HEADWALL
- PROPOSED STORMWATER DRAINAGE AND FLOW DIRECTION ARROW
- EXISTING STORMWATER DRAINAGE TO BE RETAINED
- EXISTING HEADWALL TO BE RETAINED
- EXISTING STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES TO BE REMOVED
- PROPOSED SURFACE FLOW
- EXISTING SURFACE FLOW
- EXISTING CONTOURS AT 1m INCREMENTS

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MR / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

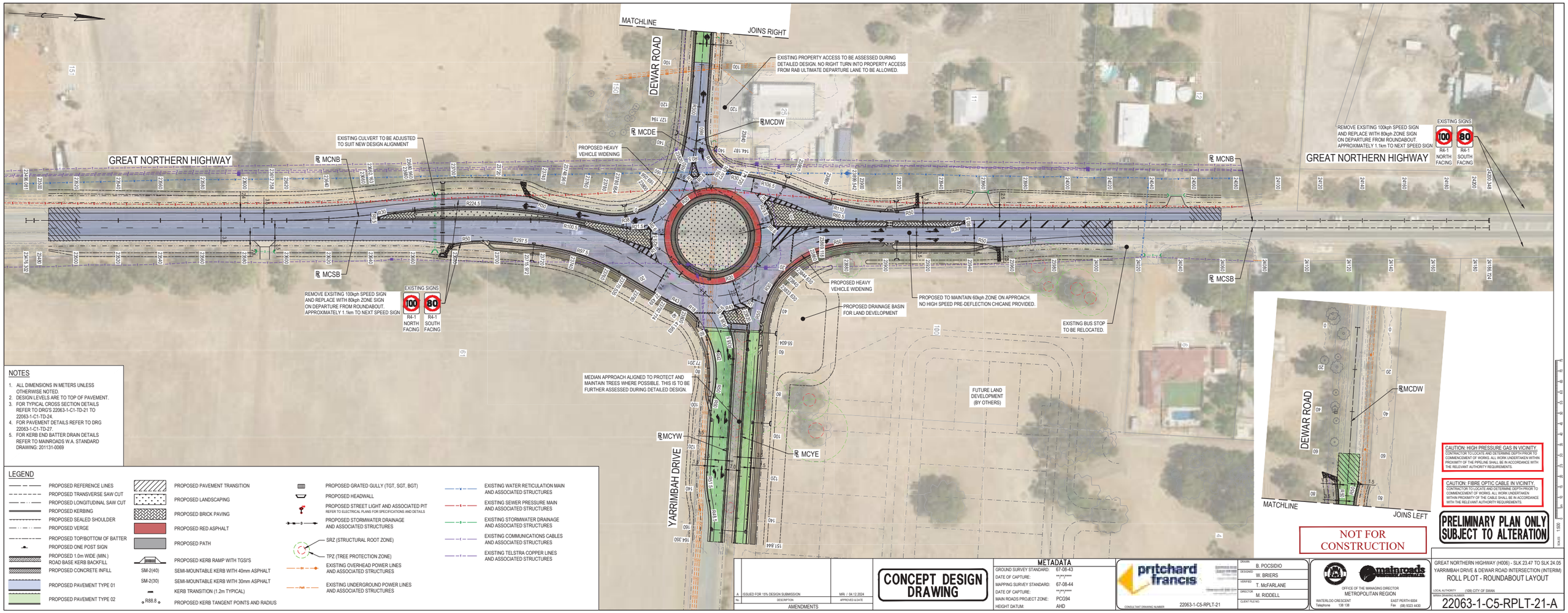
CONSULTANT DRAWING NUMBER 22063-1-C3-DC-21

DRAWN	B. POCSIDIO
DESIGNED	W. BRIERS
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL
CLIENT FILE NO.	

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
DRAINAGE STRATEGY PLAN

LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C3-DC-21-A



NOTES

1. ALL DIMENSIONS IN METERS UNLESS OTHERWISE NOTED.
2. DESIGN LEVELS ARE TO TOP OF PAVEMENT.
3. FOR TYPICAL CROSS SECTION DETAILS REFER TO DRG'S 22063-1-C1-TD-21 TO 22063-1-C1-TD-24.
4. FOR PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-27.
5. FOR KERB END BATTER DRAIN DETAILS REFER TO MAINROADS W.A. STANDARD DRAWING: 201131-0069

LEGEND

- PROPOSED REFERENCE LINES
- PROPOSED TRANSVERSE SAW CUT
- PROPOSED LONGITUDINAL SAW CUT
- PROPOSED KERBING
- PROPOSED SEALED SHOULDER
- PROPOSED VERGE
- PROPOSED TOP/BOTTOM OF BATTER
- PROPOSED ONE POST SIGN
- PROPOSED 1.0m WIDE (MIN.) ROAD BASE KERB BACKFILL
- PROPOSED CONCRETE INFILL
- PROPOSED PAVEMENT TYPE 01
- PROPOSED PAVEMENT TYPE 02
- PROPOSED PAVEMENT TRANSITION
- PROPOSED LANDSCAPING
- PROPOSED BRICK PAVING
- PROPOSED RED ASPHALT
- PROPOSED PATH
- PROPOSED KERB RAMP WITH TGSI'S
- SM-2(40) SEMI-MOUNTABLE KERB WITH 40mm ASPHALT
- SM-2(30) SEMI-MOUNTABLE KERB WITH 30mm ASPHALT
- KERB TRANSITION (1.2m TYPICAL)
- R88.8 PROPOSED KERB TANGENT POINTS AND RADIUS
- PROPOSED GRATED GULLY (TGT, SGT, BGT)
- PROPOSED HEADWALL
- PROPOSED STREET LIGHT AND ASSOCIATED PIT (REFER TO ELECTRICAL PLANS FOR SPECIFICATIONS AND DETAILS)
- PROPOSED STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES
- SRZ (STRUCTURAL ROOT ZONE)
- TPZ (TREE PROTECTION ZONE)
- EXISTING OVERHEAD POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING UNDERGROUND POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING WATER RETICULATION MAIN AND ASSOCIATED STRUCTURES
- EXISTING SEWER PRESSURE MAIN AND ASSOCIATED STRUCTURES
- EXISTING STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES
- EXISTING COMMUNICATIONS CABLES AND ASSOCIATED STRUCTURES
- EXISTING TELSTRA COPPER LINES AND ASSOCIATED STRUCTURES

CAUTION: HIGH PRESSURE GAS IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE PIPELINE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

CAUTION: FIBRE OPTIC CABLE IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE CABLE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MR / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

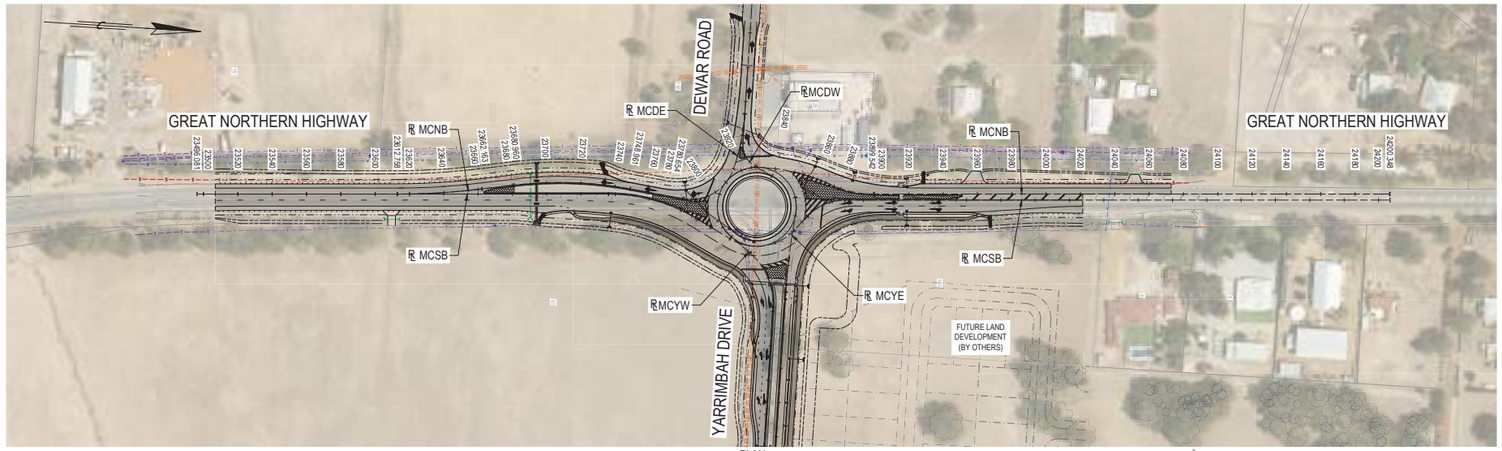
pritchard francis
CONSULTANT DRAWING NUMBER: 22063-1-C5-RPLT-21

DRAWN:	B. POCSIDIO
DESIGNED:	W. BRIERS
VERIFIED:	T. McFARLANE
DIRECTOR:	M. RIDDELL
CLIENT FILE NO:	

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
ROLL PLOT - ROUNDABOUT LAYOUT

LOCAL AUTHORITY (109) CITY OF SWAN
MAIN ROADS DRAWING NUMBER
22063-1-C5-RPLT-21-A



PLAN
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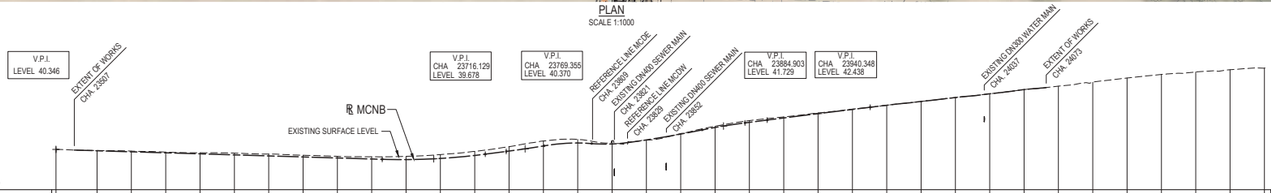
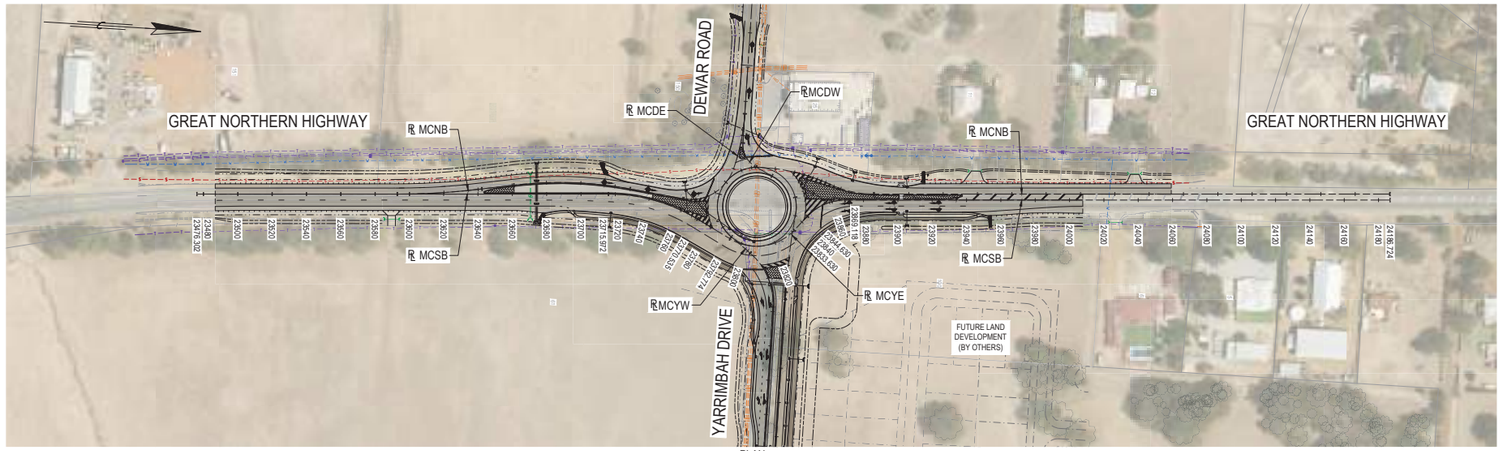


Datum R.L.38.00

| | | |



PLAN
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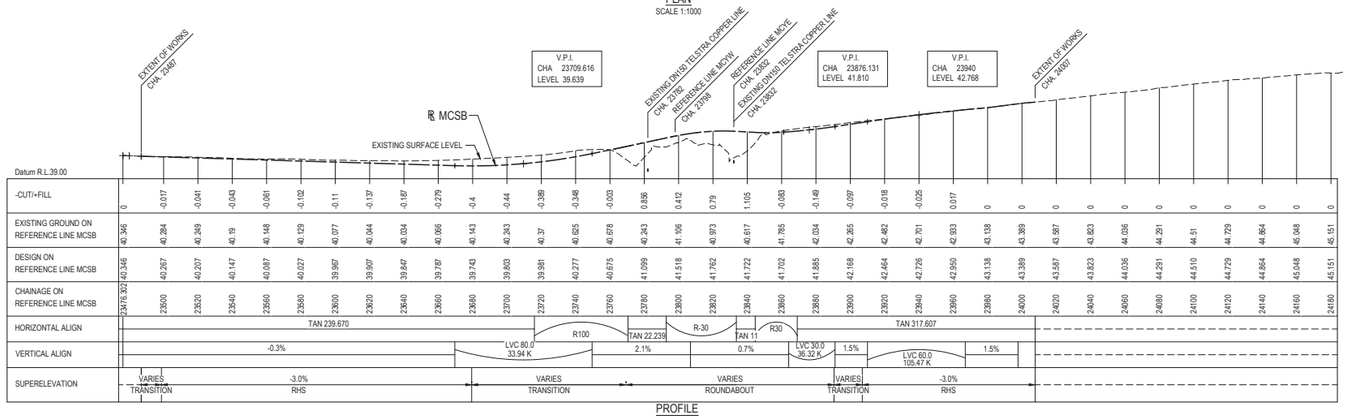

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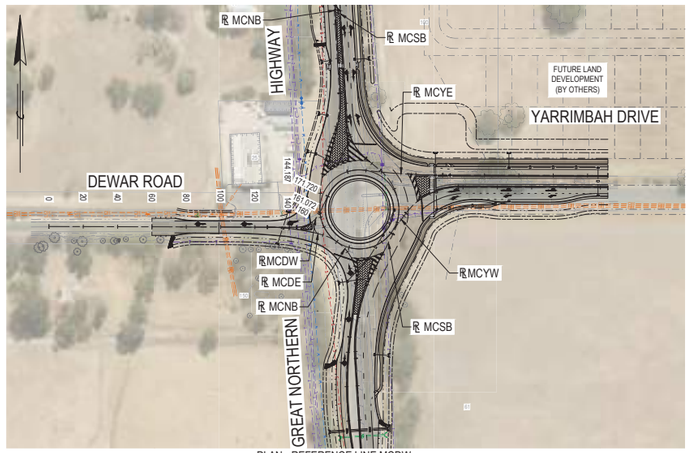
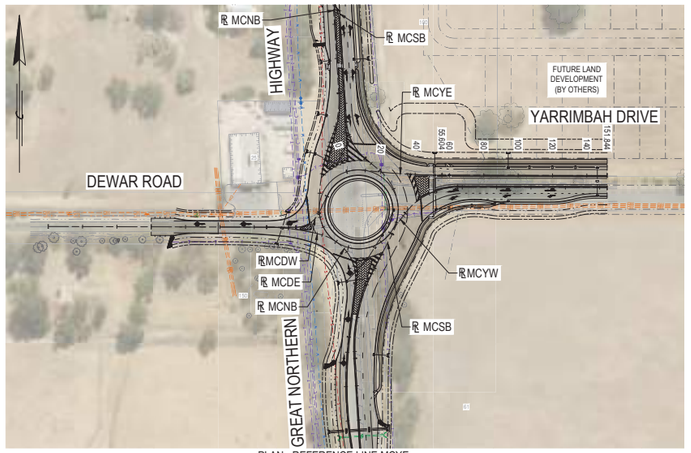
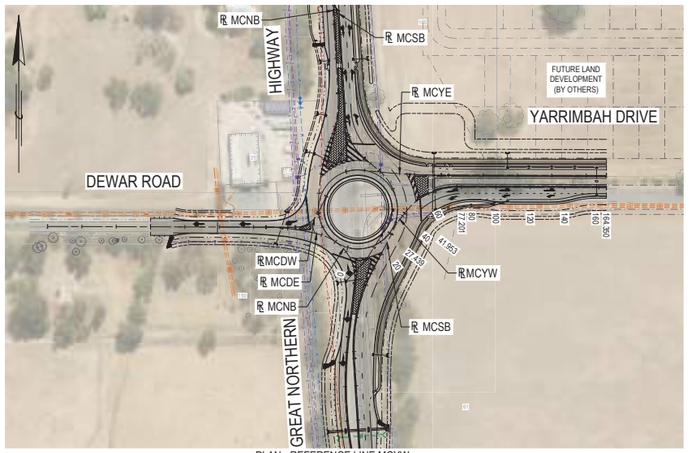


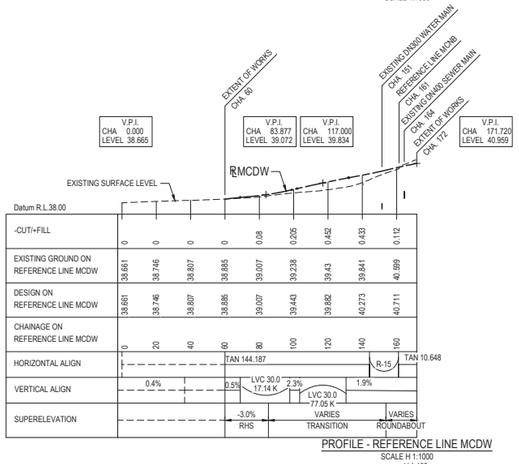
PLAN - REFERENCE LINE MCDW
SCALE 1:1000



PLAN - REFERENCE LINE MCYE
SCALE 1:1000

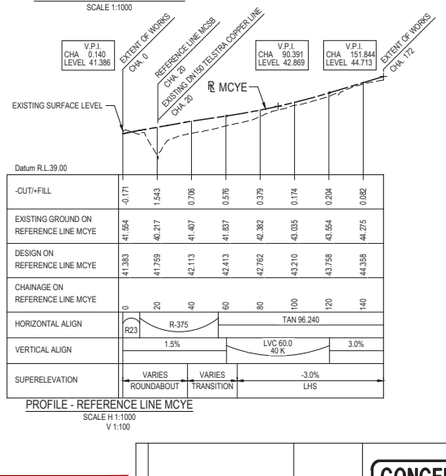


PLAN - REFERENCE LINE MCYW
SCALE 1:1000



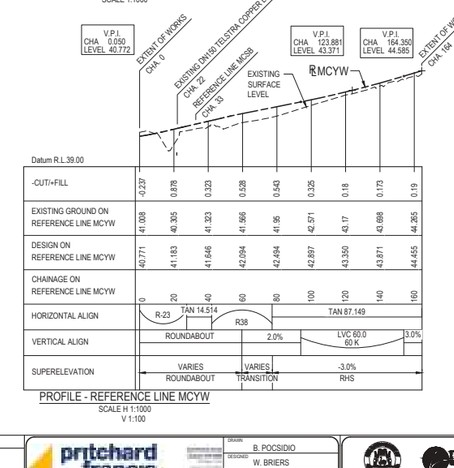
Datum R.L.38.00									
-CUT/+FILL	0	0	0	0	0.08	0.205	0.452	0.433	0.112
EXISTING GROUND ON REFERENCE LINE MCDW	38.661	38.746	38.807	38.885	39.007	39.238	39.43	39.841	40.999
DESIGN ON REFERENCE LINE MCDW	38.661	38.746	38.807	38.885	39.007	39.443	39.882	40.273	40.711
CHAINAGE ON REFERENCE LINE MCDW	0	20	40	60	80	100	120	140	160
HORIZONTAL ALIGN	TAN 144.187						R-15		TAN 10.648
VERTICAL ALIGN	0.4%	0.5%	LVC 30.0 17.14 K		2.3%	LVC 30.0 77.05 K		1.9%	
SUPERELEVATION			-3.0% RHS		VARIES TRANSITION			VARIES ROUNDABOUT	

PROFILE - REFERENCE LINE MCDW
SCALE H 1:1000
V 1:100



Datum R.L.39.00									
-CUT/+FILL	-0.171	1.543	0.706	0.576	0.379	0.174	0.204	0.082	
EXISTING GROUND ON REFERENCE LINE MCYE	41.564	40.217	41.407	41.837	42.382	43.035	43.564	44.275	
DESIGN ON REFERENCE LINE MCYE	41.383	41.759	42.113	42.413	42.762	43.210	43.758	44.358	
CHAINAGE ON REFERENCE LINE MCYE	0	20	40	60	80	100	120	140	
HORIZONTAL ALIGN	R23	R-375			TAN 96.240				
VERTICAL ALIGN	1.5%			LVC 60.0 40 K			3.0%		
SUPERELEVATION	VARIES ROUNDABOUT		VARIES TRANSITION		-3.0% LHS				

PROFILE - REFERENCE LINE MCYE
SCALE H 1:1000
V 1:100



Datum R.L.39.00									
-CUT/+FILL	-0.237	0.878	0.323	0.528	0.543	0.325	0.18	0.173	0.19
EXISTING GROUND ON REFERENCE LINE MCYW	41.008	40.305	41.323	41.566	41.95	42.571	43.17	43.688	44.265
DESIGN ON REFERENCE LINE MCYW	40.771	41.183	41.646	42.094	42.494	42.897	43.350	43.871	44.455
CHAINAGE ON REFERENCE LINE MCYW	0	20	40	60	80	100	120	140	160
HORIZONTAL ALIGN	R-23	TAN 14.514		R38		TAN 87.149			
VERTICAL ALIGN	ROUNDABOUT		2.0%		LVC 60.0 60 K		3.0%		
SUPERELEVATION	VARIES ROUNDABOUT		VARIES TRANSITION		-3.0% RHS				

PROFILE - REFERENCE LINE MCYW
SCALE H 1:1000
V 1:100

NOTES

1. ALL DIMENSIONS IN METRES UNLESS OTHERWISE NOTED.
2. DESIGN LEVELS ARE TO TOP OF PAVEMENT.
3. FOR TYPICAL CROSS SECTION DETAILS REFER TO 22063-1-C1-TD-21 TO 22063-1-C1-TD-27.
4. FOR PAVEMENT DETAILS REFER TO DRG 22063-1-C1-TD-27.
5. FOR KERB END BATTER DRAIN DETAILS REFER TO MAIN ROADS W.A. STANDARD DRAWING: 201131-0069.
6. ROCK PITCHING SHALL COMPLY WITH MAIN ROADS WA STANDARDS AND SPECIFICATIONS, AS 1141.22, AS 1726 AND AS 2758.4 LATEST EDITIONS.
7. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH MAIN ROADS WA DRAWING No. 9331-0376, 9331-0377, 201131-0069, 201331-0032, 201331-0035, 201331-0038, 201348-2734, 201348-2736, 201631-0083 AND 9831-5649.
8. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH MAIN ROADS WA TECHNICAL SPECIFICATIONS "301", "302", "407", "501", "503", "504", "505", "509", "511", "604", "606" AND "901".
9. FOR CONSTRUCTION SETOUT REFER TO STRING MODEL.

LEGEND

- PROPOSED REFERENCE LINES
- PROPOSED KERBING
- PROPOSED SEALED SHOULDER
- PROPOSED VERGE
- PROPOSED BRICK PAVING
- PROPOSED ASPHALT PAVEMENT
- PROPOSED PATH
- PROPOSED TOP/BOTTOM OF BATTER
- PROPOSED STORMWATER DRAINAGE PIPE AND ASSOCIATED PITS
- PROPOSED STREET LIGHT AND ASSOCIATED PIT (REFER TO ELECTRICAL PLANS FOR SPECIFICATIONS AND DETAILS)
- EXISTING OVERHEAD POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING UNDERGROUND POWER LINES AND ASSOCIATED STRUCTURES
- EXISTING WATER RETICULATION MAIN AND ASSOCIATED STRUCTURES
- EXISTING SEWER PRESSURE MAIN AND ASSOCIATED STRUCTURES
- EXISTING STORMWATER DRAINAGE AND ASSOCIATED STRUCTURES
- EXISTING COMMUNICATIONS CABLES AND ASSOCIATED STRUCTURES
- EXISTING TELSTRA COPPER LINES AND ASSOCIATED STRUCTURES

CAUTION: HIGH PRESSURE GAS IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE PIPELINE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

CAUTION: FIBRE OPTIC CABLE IN VICINITY.
CONTRACTOR TO LOCATE AND DETERMINE DEPTH PRIOR TO COMMENCEMENT OF WORKS. ALL WORK UNDERTAKEN WITHIN PROXIMITY OF THE CABLE SHALL BE IN ACCORDANCE WITH THE RELEVANT AUTHORITY REQUIREMENTS.

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

NOT FOR CONSTRUCTION

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRL / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

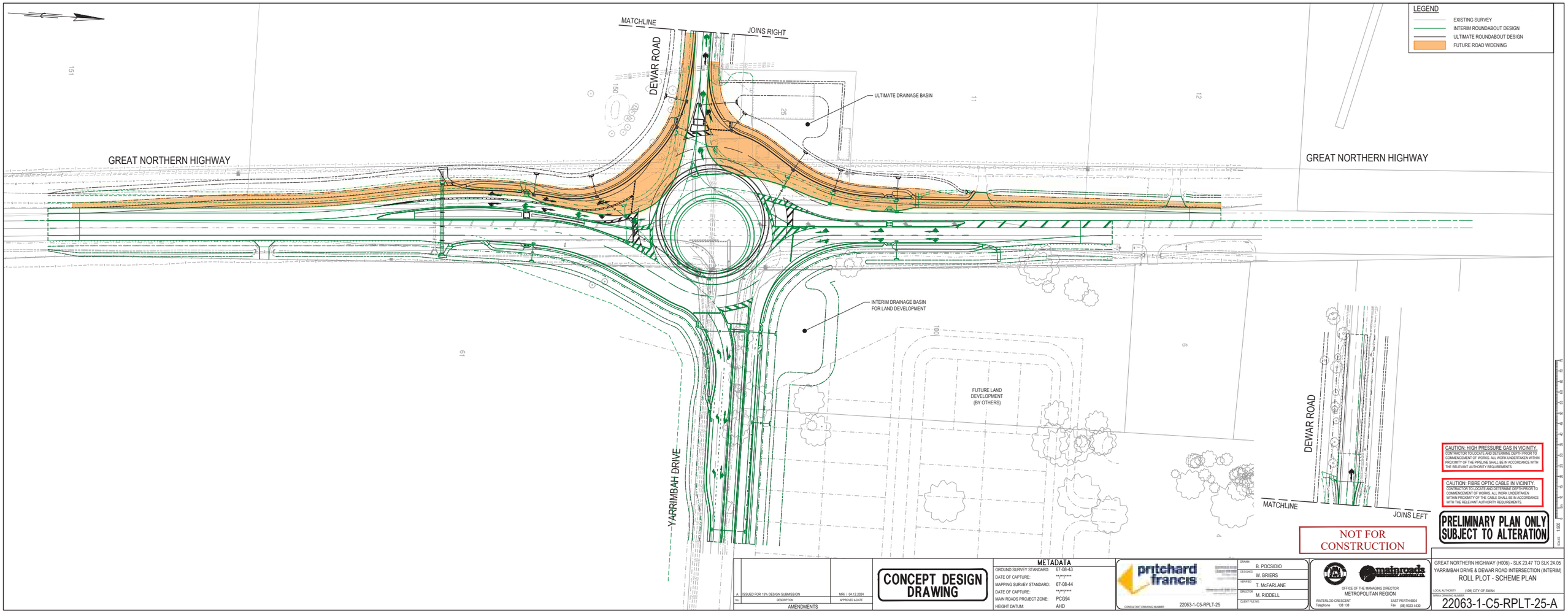
pritchard francis
CONSULTANT DRAWING NUMBER: 22063-1-C5-RPLT-24

DRAWN:	B. POCSIDIO
DESIGNED:	W. BRIERS
VERIFIED:	T. McFARLANE
DIRECTOR:	M. RIDDELL
CLIENT FILE NO.	

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
ROLL PLOT - PLAN AND PROFILE
REFERENCE LINES MCDW, MCYE AND MCYW

LOCAL AUTHORITY: CITY OF SWAN
MRWA DRAWING NUMBER: 22063-1-C5-RPLT-24-A



No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MR / 04.12.2024

AMENDMENTS

CONCEPT DESIGN DRAWING

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

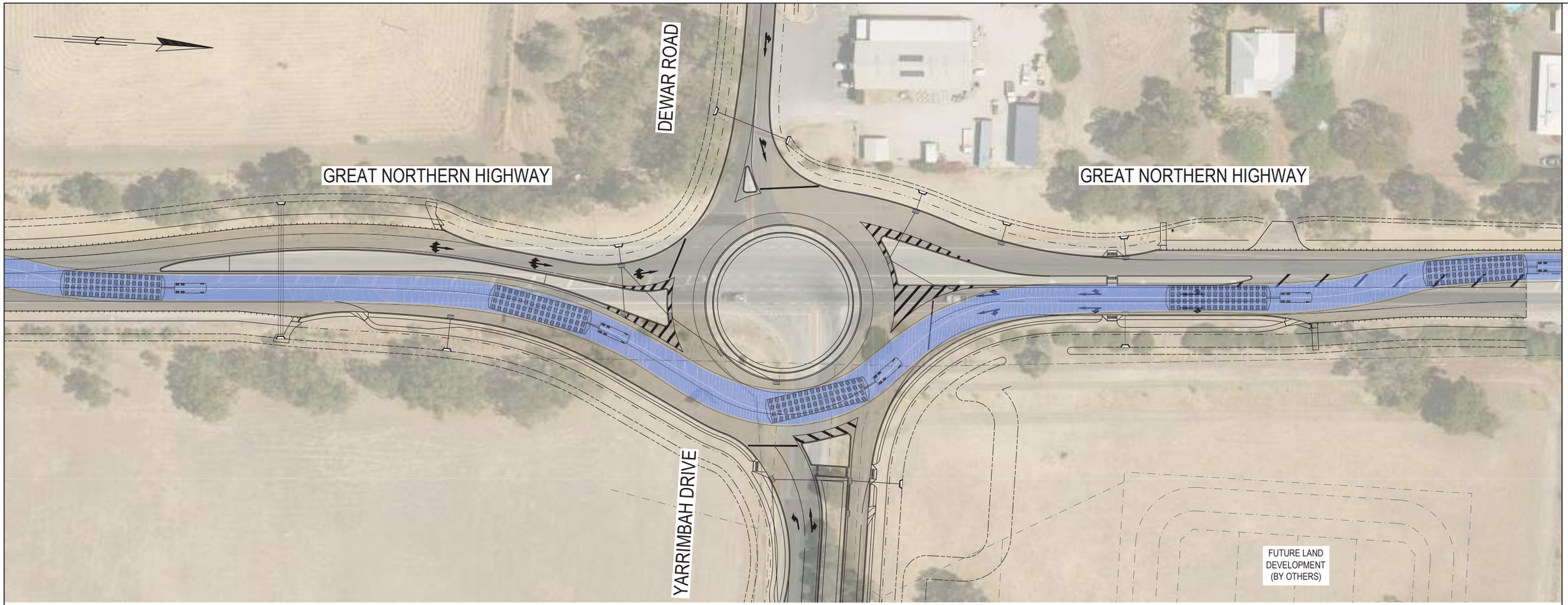
CONSULTANT DRAWING NUMBER: 22063-1-C5-RPLT-25

DRAWN:	B. POCSIDIO
DESIGNED:	W. BRIERS
VERIFIED:	T. McFARLANE
DIRECTOR:	M. RIDDELL
CLIENT FILE NO:	

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

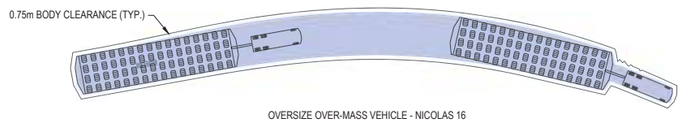
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
ROLL PLOT - SCHEME PLAN

LOCAL AUTHORITY: (108) CITY OF SWAN
MRWA DRAWING NUMBER: 22063-1-C5-RPLT-25-A



VEHICLE MOVEMENT PLAN

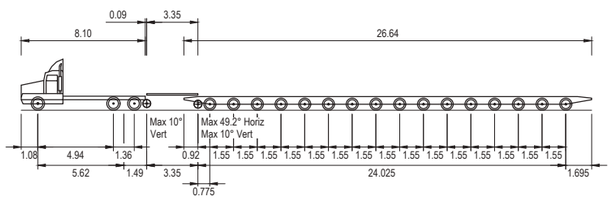
SCALE 1:500



OVERSIZE OVER-MASS VEHICLE - NICOLAS 16

TURNING TEMPLATE DIAGRAM

PRODUCED BY VEHICLE TRACKER



MAIN ROADS W.A. O.S.O.M. - NICOLAS 16 ROW (4 File)

Overall Length	37.260m
Overall Width	6.220m
Overall Body Height	3.341m
Min Body Ground Clearance	0.390m
Max Track Width	6.220m
Lock-to-lock time	6.00s
Wall to Wall Turning Radius	18.925m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A 1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

pritchard francis

CONSULTANT DRAWING NUMBER 22063-1-C5-TT-21

DRAWN	B. POCSIDIO
DESIGNED	W.BRIERS
VERIFIED	T. McFARLANE
DIRECTOR	M. RIDDELL

mainroads WESTERN AUSTRALIA

OFFICE OF THE MANAGING DIRECTOR
METROPOLITAN REGION
WATERLOO CRESCENT EAST PERTH 6004
Telephone 138 138 Fax (08) 9323 4430

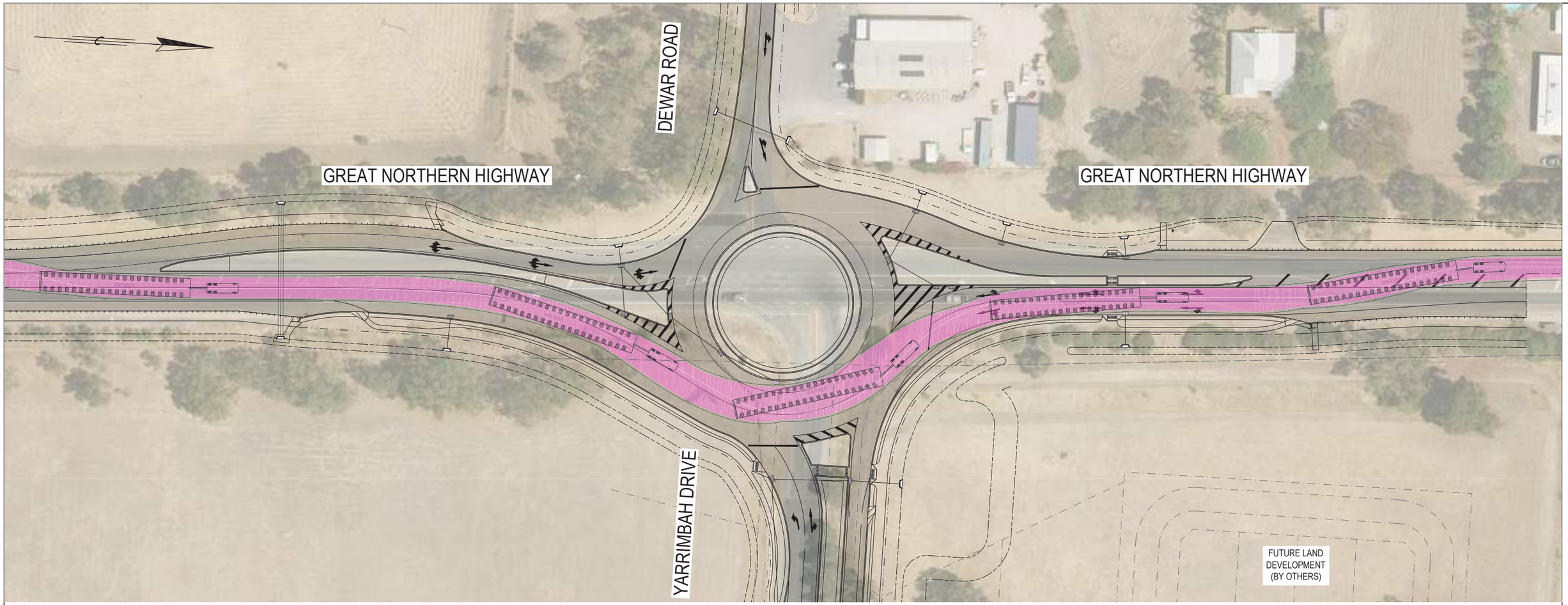
CLIENT FILE No.

RECOMMENDED

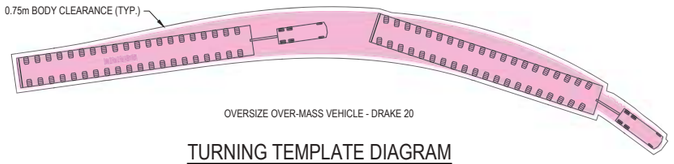
APPROVED

GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 1 OF 3
LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER
22063-1-C5-TT-21-A

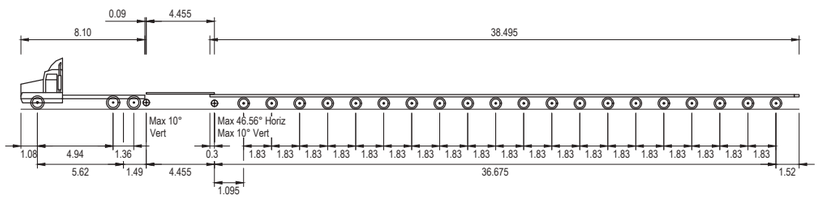


VEHICLE MOVEMENT PLAN
SCALE 1:500



OVERSIZE OVER-MASS VEHICLE - DRAKE 20

TURNING TEMPLATE DIAGRAM
PRODUCED BY VEHICLE TRACKER



MAIN ROADS W.A. O.S.O.M. - DRAKE 20 ROW (2 File) (4.88m Width)

Overall Length	50.840m
Overall Width	4.880m
Overall Body Height	3.341m
Min Body Ground Clearance	0.417m
Max Track Width	4.880m
Lock-to-lock time	6.00s
Wall to Wall Turning Radius	28.865m

NOT FOR CONSTRUCTION

PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500

A 1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

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CONSULTANT DRAWING NUMBER 22063-1-C5-TT-22

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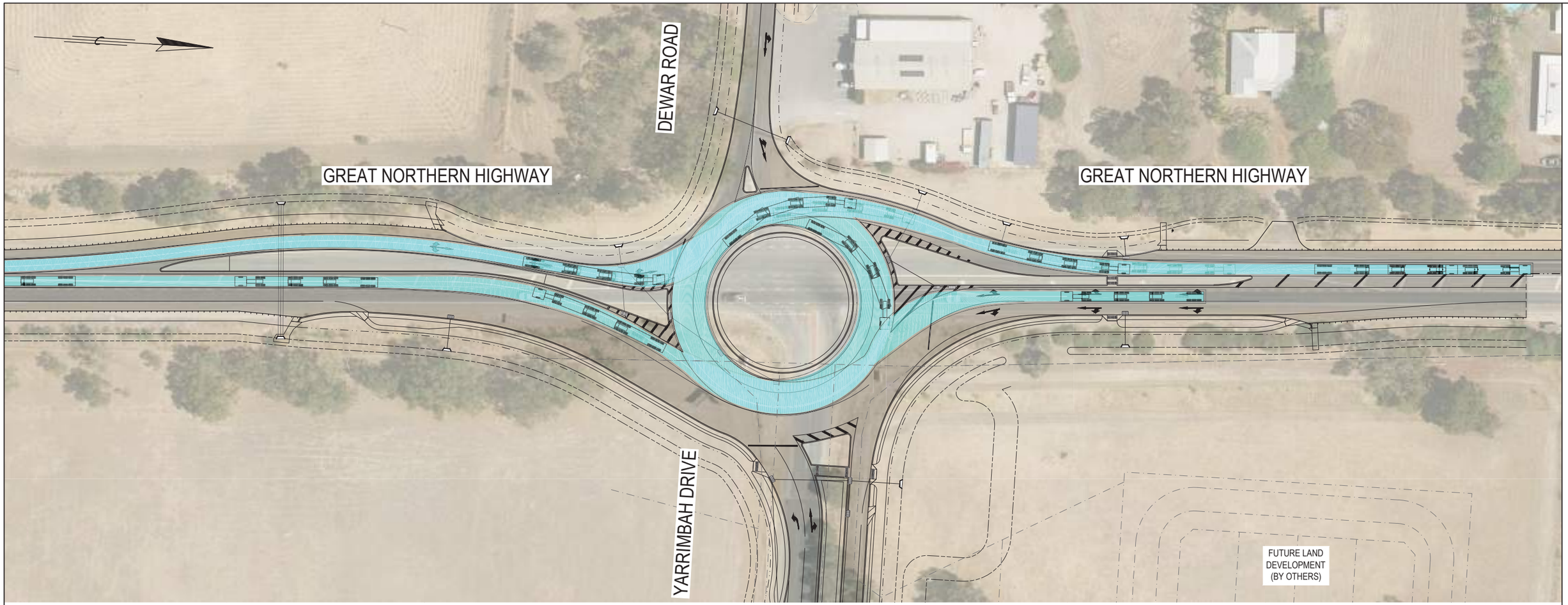
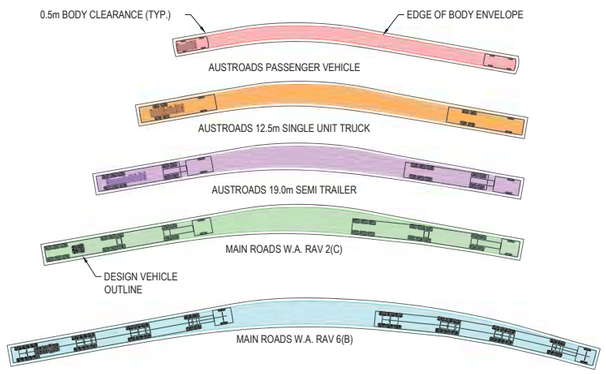
GREAT NORTHERN HIGHWAY (H006) - SLK 23.47 TO SLK 24.05
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 2 OF 3
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C5-TT-22-A



VEHICLE MOVEMENT PLAN
SCALE 1:500



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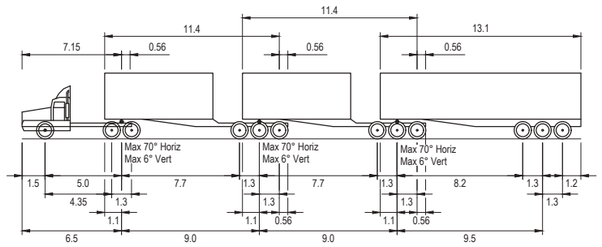

MAIN ROADS W.A. - RAV 6(B) B-TRIPLE (36.5m)

Overall Length	36.500m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	15.000m

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PRELIMINARY PLAN ONLY SUBJECT TO ALTERATION

SCALES 1:500
A1

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GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

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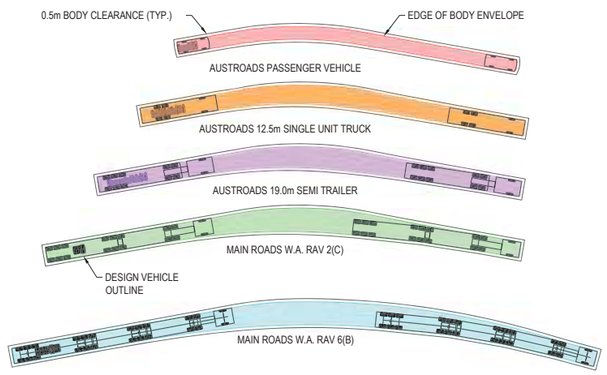
YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
VEHICLE MOVEMENT PLAN
GREAT NORTHERN HIGHWAY - SHEET 3 OF 3
LOCAL AUTHORITY (109) CITY OF SWAN
MRWA DRAWING NUMBER
22063-1-C5-TT-23-A



VEHICLE MOVEMENT PLAN

SCALE 1:500



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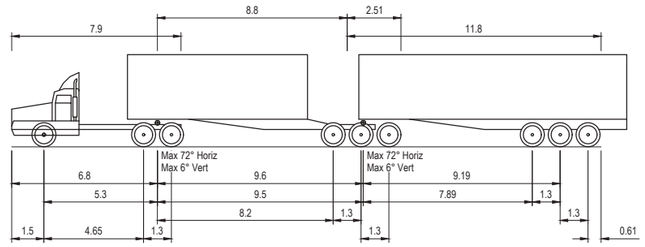

MAIN ROADS W.A. - RAV 2(C) B-DOUBLE (27.5m)

Overall Length	27.500m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	18.000m

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SCALES 1:500

A1

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A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

METADATA

GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

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CONSULTANT DRAWING NUMBER 22063-1-C5-TT-24

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YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
VEHICLE MOVEMENT PLAN
DEWAR ROAD
LOCAL AUTHORITY (109) CITY OF SWAN
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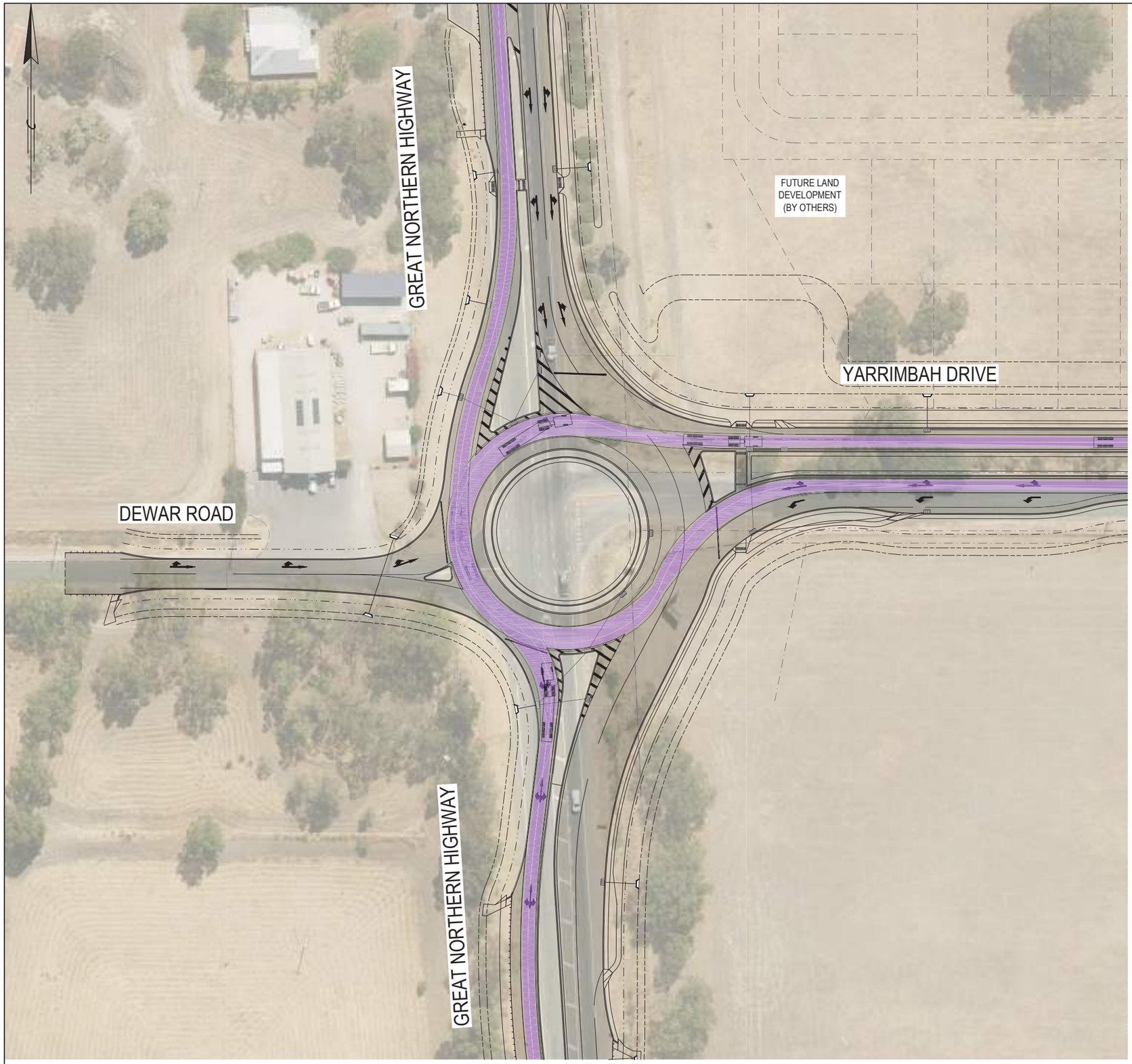
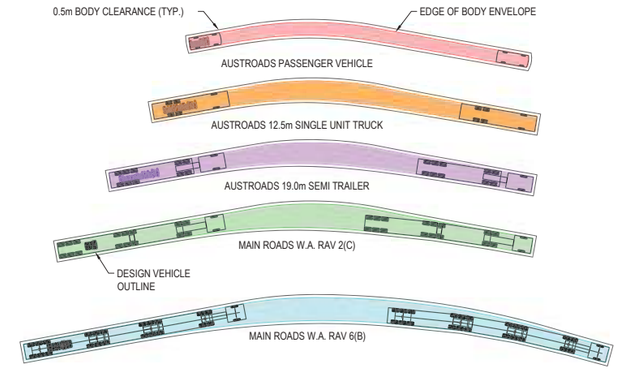
22063-1-C5-TT-24-A



VEHICLE MOVEMENT PLAN

SCALE 1:500



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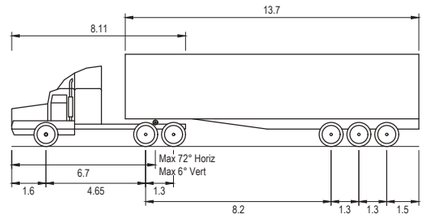

AUSTROADS PRIME MOVER AND SEMI-TRAILER (19.0m)

Overall Length	19.000m
Overall Width	2.500m
Overall Body Height	4.300m
Min Body Ground Clearance	0.540m
Track Width	2.500m
Lock-to-lock time	6.00s
Curb to Curb Turning Radius	12.500m

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SCALES 1:500

A1

No.	DESCRIPTION	APPROVED & DATE
A	ISSUED FOR 15% DESIGN SUBMISSION	MRi / 04.12.2024

AMENDMENTS

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GROUND SURVEY STANDARD:	67-08-43
DATE OF CAPTURE:	**/**/****
MAPPING SURVEY STANDARD:	67-08-44
DATE OF CAPTURE:	**/**/****
MAIN ROADS PROJECT ZONE:	PCG94
HEIGHT DATUM:	AHD

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CONSULTANT DRAWING NUMBER 22063-1-C5-TT-25

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YARRIMBAH DRIVE & DEWAR ROAD INTERSECTION (INTERIM)
VEHICLE MOVEMENT PLAN
YARRIMBAH DRIVE

LOCAL AUTHORITY (109) CITY OF SWAN

MRWA DRAWING NUMBER
22063-1-C5-TT-25-A

Attachment 3

Environmental Assessment Report

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Bullsbrook South Urban Expansion Area

Environmental Assessment Report

Western Environmental Pty Ltd
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Bullsbrook South Urban Expansion Area

Environmental Assessment Report

Report No:
23.028-SPEAR
Issue Date:
3-Sep-2025
Status
FINAL

Prepared for:
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Northbridge WA 6003

Prepared by
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3-Sep-2025	**3-Sep-2025**	**3-Sep-2025**

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Environmental Conclusions

In accordance with the scope of services, WEPL has conducted environmental field monitoring and/or testing in the preparation of this report. The nature and extent of monitoring and/or testing conducted is described in this report.

On all sites, varying degrees of non-uniformity of vertical and horizontal conditions in media (soil, water, air, waste or other media as described in the report) are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of media conditions encountered. The conclusions are based on the data and the environmental field monitoring and/or testing actually undertaken, and are therefore merely indicative of the environmental condition of the site at the time of preparing this report, including the presence or otherwise of contaminants or emissions. It should be recognised that site conditions, including the extent and concentration of contaminants, can change.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. To the maximum extent permitted by law, no other warranty, express or implied, is made.

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This report is intended to be read in its entirety, and sections or parts of this report should therefore not be read and relied on out of context.

WEPL will not be liable to update or revise this report to take into account any events or circumstances or facts becoming apparent after the date of this report.

Executive Summary

Western Environmental Pty Ltd (WEPL) present this Environmental Assessment Report (EAR) to provide support to the Structure Plan for multiple lots in Bullsbrook South, comprising approximately 180 ha (the Site).

In consideration of the former MRS Amendment of the Site from Rural to Urban Deferred, the former Office of the Environmental Protection Authority (OEPA) raised no objections to the proposed amendment, subject to the retention of remnant vegetation consistent with work undertaken for the draft Perth and Peel Green Growth Plan for 3.5 Million. The Office of the EPA determined that the Amendment was not assessed, advice given. The EPA has advised that for the purposes of Part IV of the *Environmental Protection Act 1986*, the scheme is defined as an assessed scheme. That is, no assessment can be expected at subsequent rezoning phases.

The EPA advice included the following:

- Where possible, remnant vegetation should be retained, particularly remnant vegetation along the Nambad Brook, which provides potential habitat for Carnaby's Black Cockatoos. This species is listed as 'Endangered' under the *Environment Protection and Biodiversity Conservation Act 1999*. The OEPA acknowledges that further consultation and investigations will be required in the subsequent local structure plan, subdivision or at development application stages.

The Site's biological values are generally degraded due to agricultural activity with remnant vegetation along the Nambad Brook. The following characteristics are noted with regard to the Site:

- There are no Commonwealth listed Threatened Ecological Communities (TEC) or State listed Priority Ecological Communities (PECs) identified in the flora and vegetation surveys, and much of the vegetation on the Site is considered to be Completely Degraded.
- The Site is not registered as a contaminated site and there are no registered contaminated sites within 1 km of the Site.
- No risk of Acid Sulfate Soils (ASS) has been identified on the Site.
- No Environmentally Sensitive Areas have been identified on the Site.

A summary of the potential impacts of development of the Site are listed below, along with management measures, where relevant:

- The Landfill Facility to the north of the Site has been closed with the last waste received in November 2018. It is considered that the Landfill Facility does not pose a constraint to the lifting of the Urban Deferred zoning of the South Bullsbrook Urban Expansion Area as part of the MRS Amendment or to the development of the Structure Plan and future development of the land. The Landfill Closure and Post-Closure Management Plans were submitted to DWER in October 2023. The licence has been amended to reflect these reports and the footprint of the prescribed premises reduced.
- Clay extraction to the east of the Site with development falling inside the 500m buffer. It is presented that the 435 m separation between the for Clay extraction Mine (S000545) and the proposed residential development provides appropriate separation distance to future residents.
- Hydrogeology and foreshore reserve of Nambad Brook, including retention of vegetation to support black cockatoos. Nambad Brook foreshore reserve is completely contained within proposed Public Open Space and serves to retain vegetation in line with recommendations made by the EPA and the City of Swan Local Biodiversity Strategy (2015). A Foreshore Management Plan will be developed to guide the rehabilitation of the degraded Nambad Brook foreshore.
- Pest management for declared Pest and Weed of National Significance (WoNs) species *Asparagus asparagoides* (bridal creeper) and declared Pest *Gomphocarpus fruticosus* (cotton bush) to control the populations and soil movement from the affected areas is limited to prevent spread of seed stored in the soil.
- Management of potential breeding trees and foraging habitat for black cockatoo species.
- Consideration of EPBC obligations will be made at future planning and development stages.

The concept plan for the development has been informed by environmental values of the Site and these are reflected in the retention of vegetation and high value black cockatoo foraging and breeding trees within the Nambad Brook foreshore reserve, Public Open Space (POS) and Yarrimbah Drive Reserve. A total of 449 black cockatoo habitat trees are proposed to be retained within POS and Yarrimbah Drive Reserve and there is a potential loss of 435 black cockatoo habitat trees.

Measures to mitigate impacts associated with the proposed development, beyond retention of habitat as POS and the Yarrimbah Drive Reserve, include:

- the implementation of the foreshore management plan of the Nambad Brook.
- the development committing to a revegetation strategy of replanting at a 1:1 ratio.
- Street trees planted at an average density at 1 per lot, if 25% of street trees are black cockatoo trees this will increase the ratio of replantation to 2:1.

A Local Water Management Strategy has been developed by Pentium Water which outlines best management practices approach to water management that will be undertaken for this development. This will include managing, protecting, and conserving the total water cycle of the local environment and the greater catchment.

A Bushfire Management Plan (BMP) has been prepared by Bushfire Prone Planning (2023) to address requirements under Policy Measure 6.3 of State Planning Policy 3.7 Planning in Bushfire-Prone Areas (SPP 3.7; WAPC 2015) and Guidelines for Planning in Bushfire-Prone Areas (the Guidelines; WAPC 2021).

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1. Introduction

1.1 Background

This Environmental Assessment Report (EAR) is to provide support to the Structure Plan to inform an amendment to the City of Swan Local Planning Scheme no. 17, for multiple lots in Bullsbrook South, comprising approximately 180 ha (the Site) (Figure 1):

The subject sites are zoned Urban under the Metropolitan Region Scheme (MRS). Urban Deferred zone was achieved in 2018, when the land was amended from Rural Zone (MRS 1323/41). The WAPC Amendment Report (MRS 1323/41) noted the following requirements that are to be addressed prior to lifting of the subject site's Urban Deferment status:

- A District Structure Plan (DSP) or the Bullsbrook Townsite Landuse Masterplan (BTLUMP) has been prepared to guide the development of the Bullsbrook townsite.
- The DSP or BTLUMP should consider matters such as: a spatial staging plan, district developer contribution plan, MRS reservations (e.g., High Schools, Other or Primary Regional Roads etc.), buffers (e.g., landfill and extractive industries etc.), environmental constraints, transport modelling and traffic analysis (amongst other matters) in consultation with relevant State Government agencies and the City of Swan (CoS).
- Confirmation of water and wastewater infrastructure.
- Confirmation on the location of a High School site.
- Confirmation of road upgrading requirements to support the proposed scale of development.
- Confirmation that the existing landfill operations and associated buffer has ceased.
- The eastern portion of the site is partly within a 500 metre separation buffer for clay resources. The clay extraction is to be completed, prior to the transfer of this land to the Urban zone.

In consideration of the Amendment, the former Office of the Environmental Protection Authority (OEPA) raised no objections to the proposed amendment, subject to the retention of remnant vegetation consistent with work undertaken for the draft Perth and Peel Green Growth Plan for 3.5 Million. The Office of the EPA determined that the Amendment was not assessed, advice given. The EPA have advised that for the purposes of Part IV of the EP Act, the scheme is defined as an assessed scheme. That is, no assessment can be expected at subsequent rezoning phases.

The EPA advice included the following:

- Where possible, remnant vegetation should be retained, particularly remnant vegetation along the Nambad Brook, which provides potential habitat for Carnaby's Black Cockatoos. This species is listed as 'Endangered' under the Environment Protection and Biodiversity Conservation Act 1999. The OEPA acknowledges that further consultation and investigations will be required in the subsequent local structure plan, subdivision or a development application stages.

The Urban Deferred Lifting (Urban Zoning) was Gazetted on 16 May 2025 (WAPC decision 30 April 2025 Amendment number 1440/23). This Amendment also included a concurrent rezoning under the CoS Local Planning Scheme No 17 to 'Development' zone.

This zoning amendment and will facilitate future residential development, a neighbourhood centre, areas of public open space, a primary school and associated playing fields and conservation area.



Figure 1: Site Location

N 0 75 150 225 300 m	PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook		
SCALE: 1:9,500	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD / PN	DATE: 4/4/2024

Legend

Site Location

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	4/4/2024

NOTES:

Cadastral boundary (LGATE-002)

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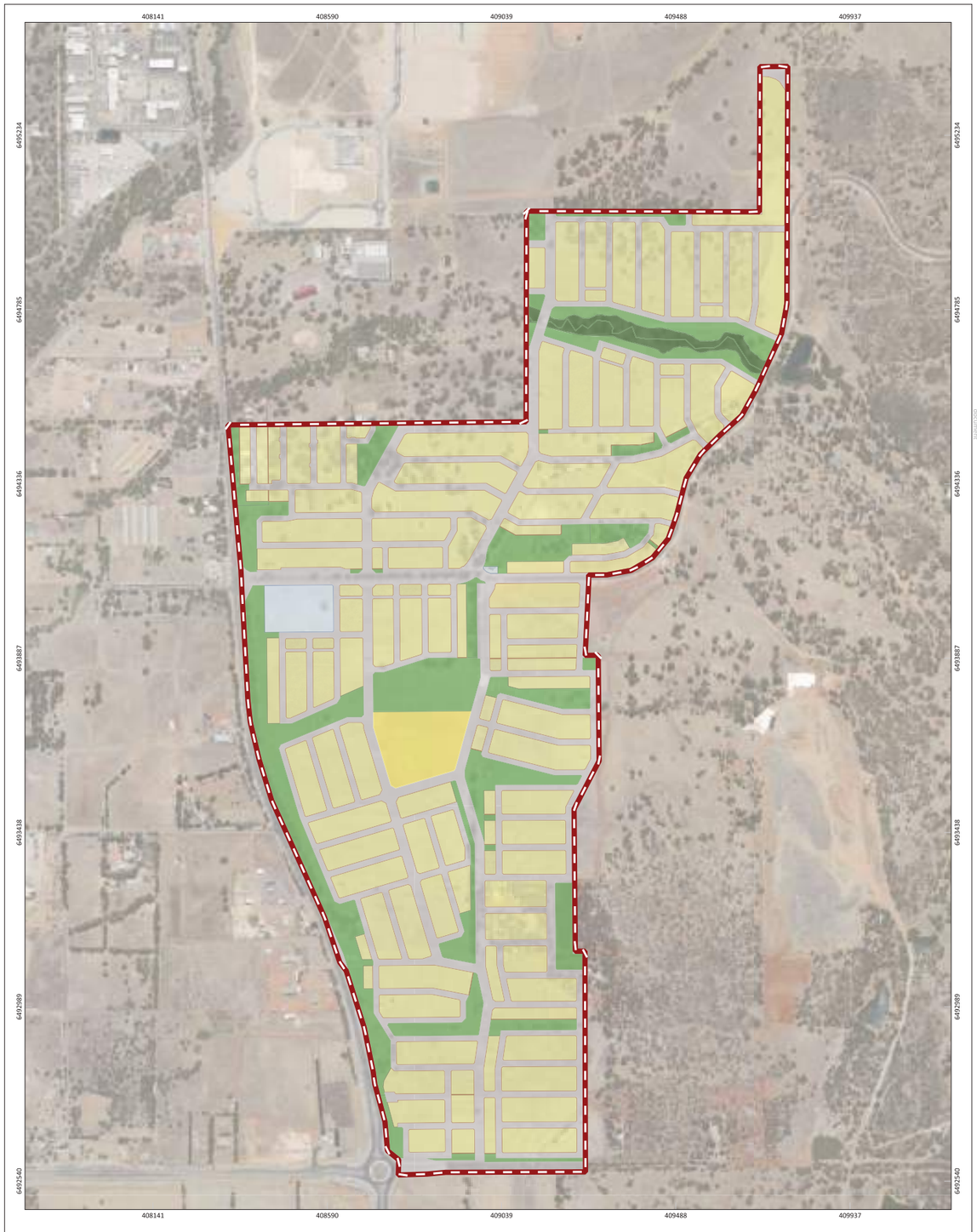

Figure 2: Bullsbrook South Urban Expansion Area - Concept Plan

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1.2 Purpose and Scope

This EAR will be responsive to, and will inform the Structure Plan describing potential impacts, mitigation and management measures, such as the treatment of Nambad Brook. It will be informed by and provide summary information on the Local Water Management Strategy and Environmental Assessment Report - Eastern Edge and will be descriptive of any buffer management zones that may be in place for adjacent land uses.

For all stages of work, the following aspects will be addressed:

- Surrounding land uses and appropriate buffers - clay extraction, landfill, agriculture etc.
- Soil and surface geology, including potential contamination (historical land use) and acid sulphate soils.
- Hydrology and drainage - surface water and groundwater.
- Wetlands.
- Flora, vegetation and fauna.
- Heritage – Aboriginal and European.

For all aspects above, identification of opportunities and constraints in an urban development context, management and timing implications will be articulated.

1.3 Consultation

The proposed development was referred to the Environmental Protection Authority (EPA) in 2017 and the Metropolitan Region Scheme Amendment (MRS 1323/41) was advertised for public submissions in March 2018. Nineteen submissions were received comprising one supporting submission, two objecting submissions and 16 submissions containing neutral comments or otherwise not objecting to the amendment. Details of the submissions are included in Metropolitan Region Scheme Amendment 1323/41 (Appendix A).

2. Identification and General Information

A summary of the site identification details is presented below in Table 1.

Table 1: Site Identification

Identifier	Details
Street Number, Street Name and Suburb	Lot 4 Yarrimbah Drive, Bullsbrook. 61 Yarrimbah Drive, Bullsbrook. 2428 Great Northern Highway, Bullsbrook. 2424 Great Northern Highway, Bullsbrook. 2422 Great Northern Highway, Bullsbrook. 2416 Great Northern Highway, Bullsbrook. Lot 100 Great Northern Highway, Bullsbrook. 2342 Great Northern Highway, Bullsbrook. 2306 Great Northern Highway, Bullsbrook. 2286 Great Northern Highway, Bullsbrook. 2274 Great Northern Highway, Bullsbrook. 2258 Great Northern Highway, Bullsbrook. 2242 Great Northern Highway, Bullsbrook. 2234 Great Northern Highway, Bullsbrook.
Lot ID	Lot 4 on Diagram 59157. Lot 900 on Plan 420367. Lot 400 on Plan 403953. Lot 2 on Plan 22890. Lot 5 on Plan 31211. Lot 6 on Plan 31211. Lot 100 on Diagram 6254. Lot 61 on Plan 42250. Lot 201 on Plan 403408. Lot 100 on Plan 27953. Lot 1011 on Plan 422362. Lot 802 on Plan 419739 Lot 803 on Plan 419739. Lot 20 on Plan 422363.
Local Government Authority	City of Swan.
Zoning	Urban under the Metropolitan Region Scheme.
Current Land Use	Rural.
Proposed Future Land Use	Urban.
Site Coordinates	31.68834°S, 116.03700°E.
Site Area	Approximately 180 ha.

3. Planning Context

3.1 Planning Schemes and zoning

The Site is located in the City of Swan with all lots zoned Rural under the CoS Local Planning Scheme No 17 and as Urban under the Metropolitan Region Scheme (MRS) (Figure 3).

The Urban Deferred Lifting (Urban Zoning) was Gazetted on 16 May 2025 (WAPC decision 30 April 2025 Amendment number 1440/23). This Amendment also included a concurrent rezoning under the CoS Local Planning Scheme No 17 to 'Development' zone.

This zoning amendment and will facilitate future residential development, a neighbourhood centre, areas of public open space, a primary school and associated playing fields and conservation area.

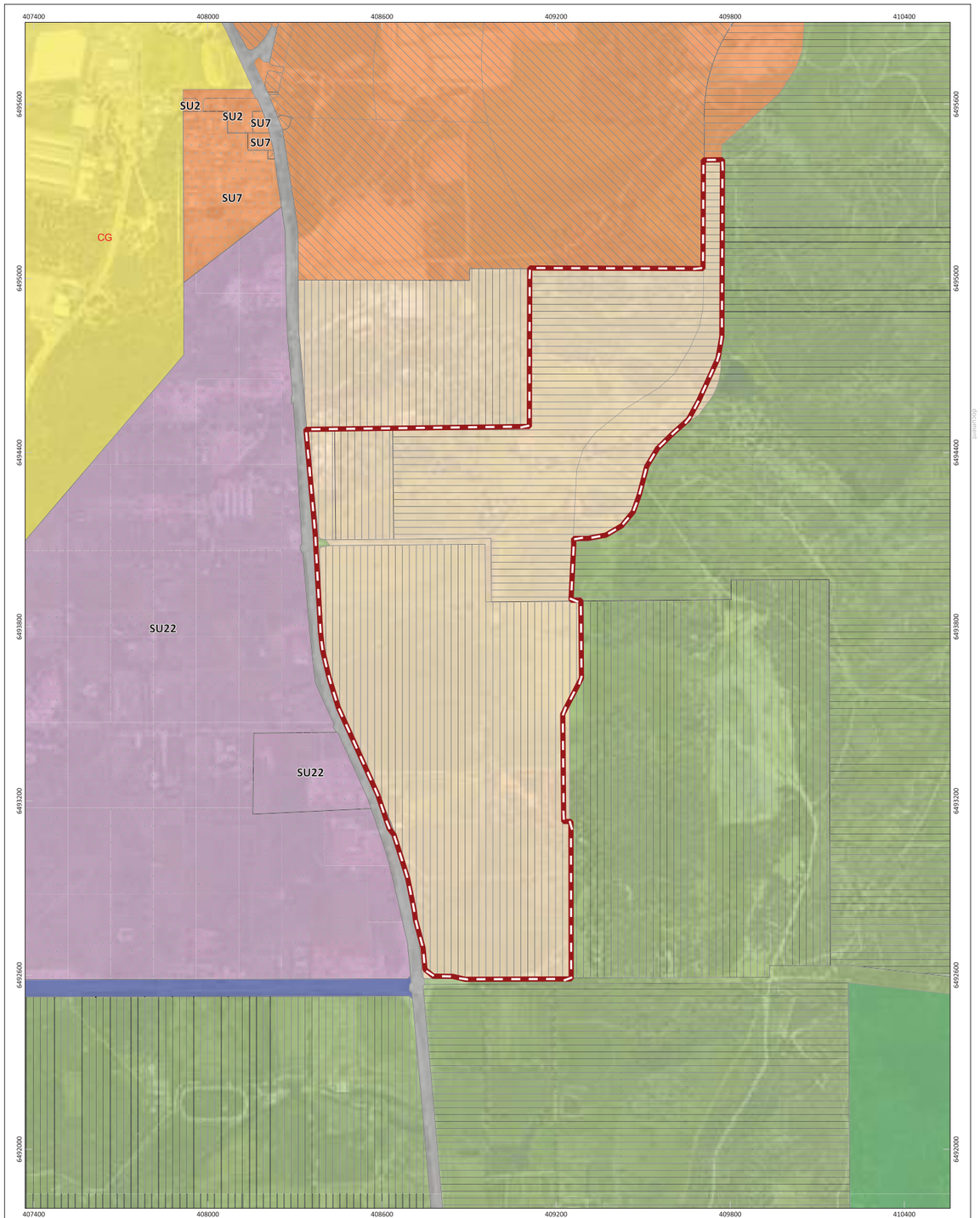
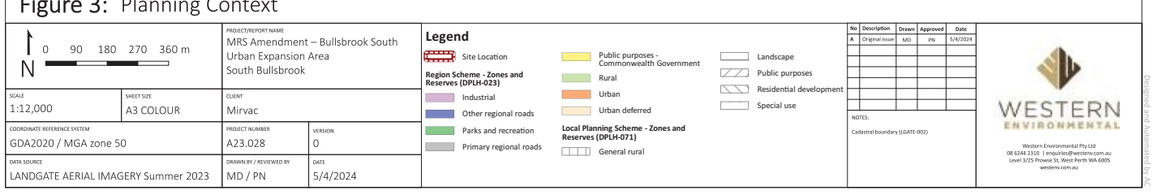


Figure 3: Planning Context



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4. Environmental Legislation, Policy and Guidelines

Key statutory and policy documents are listed below, and where specifically relevant to the Site are discussed in detail below.

4.1 Commonwealth Legislation and Guidelines

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Department of the Environment Water Heritage and the Arts (DEWHA). (2010). Survey Guidelines for Australia's Threatened Birds.
- Department of Sustainability Environment Water Population and Communities (DSEWPaC). (2011). Survey Guidelines for Australia's Threatened Mammals.
- Department of the Environment (DoE). (2013). Matters of National Environmental Significance. Significant Impact Guidelines 1.1 - Environment Protection.
- Department of the Environment, Water, Heritage and the Arts (DEWHA). (2009). EPBC Act Policy Statement 3.10: Significant impact guidelines for the vulnerable western ringtail possum (*Pseudocheirus occidentalis*) in the southern Swan Coastal Plain, Western Australia.
- Department of Climate Change, Energy, Environment and Water (DCCEEW). (2022). Referral Guidelines for 3 WA threatened black cockatoo species: Carnaby's Cockatoo, Baudin's Cockatoo and the Forest Red-tailed Black-cockatoo.

4.2 State Government Legislation

All assessments have been conducted with reference to the following State legislation, which provides for the environmental values and contamination risks addressed within this document:

- *Environmental Protection Act 1986* (EP Act).
- *Contaminated Sites Act 2003* (CS Act).
- *Planning and Development Act 2005* (PD Act).
- Contaminated Sites Regulations 2006 (CS regulations).
- *Biosecurity and Agriculture Management Act 2007* (BAM Act).
- *Biodiversity Conservation Act 2016* (BC Act).
- *Heritage Act 2018*.

- Western Australian Biodiversity Conservation Regulations (2018).
- *Aboriginal Heritage Act 1972*.
- *Aboriginal Cultural Heritage Act 2021*.

4.3 Environmental Protection Authority (EPA) Guidance

This assessment has given consideration to the recommendations of EPA regulatory guidance as listed below:

- Environmental Factor Guideline- Flora and Vegetation.
- Environmental Factor Guideline- Terrestrial Fauna.
- Environmental Factor Guideline- Social Surroundings.
- Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016).
- Technical Guidance - Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA, 2020).
- Environmental Protection Bulletin No. 20 - Protection of naturally vegetated areas through planning and development (EPA, 2013).

4.4 State Government Agency Guidance

The assessment has given consideration to the recommendations of State government agency guidance as listed below:

- Aboriginal Heritage Due Diligence Guidelines (DAA 2013).
- inHerit (State Heritage Office).
- Environmentally Sensitive Areas: Clearing Regulation Fact Sheet 24 (Department of Environment Regulation).

4.5 Local Government Policies, Strategies and Guidance

- City of Swan Local Planning Scheme No. 17.
- Bullsbrook District Structure Plan.

5. Existing Environment

5.1 Site Description

5.1.1 Historical Aerial

Historical aerial photographs were reviewed online using Landgate Mapviewer (Landgate, 2022). WEPL note that the lot numbers listed below relate to the lot numbers which comprise the Site (as listed in Table 1).

- The earliest available aerial (1965) indicates that the Site is cleared and is likely used for agricultural purposes (paddocks inferred for livestock and/or crops). Small patches of remnant bushland are evident in the south-eastern and north-eastern portions of the Site. There are approximately five to ten rural residential properties evident in the central and southern section of the Site (overlaying Lots 803, 802, 201 and 900).
- An inferred rural residential property on Lot 201 has had a small extension added between the 1965 and 1974 aerial, this property is demolished between the 1985 and 1989 aerial.

  A cleared patch of sand is evident in the 1974 aerial (over Lot 201), and additional rural residential houses are evident in the northern/central portion of Lot 61 and the south-eastern corner of Lot 802.
- By 1977 a possible quarry and associated dam is evident on the south-eastern portion of Lot 201, an additional dam is evident on the western portion of Lot 201 (1977 aerial) and on the south- eastern portion of Lot 900 (1981 aerial).
- A cleared sandy area is also evident on the southern portion of Lot 900 in the 1983 aerial. A dam has been construction on Lot 61 by the 1985 aerial. The quarry in the south-eastern portion of Lot 201 has expanded to the east and north by the 1985 aerial. Agricultural land uses (inferred cropping) are evident on the southern portion of Lot 900 in the 1985 and 1989 aerials respectively.
- By the 2000 aerial the quarry on Lot 201 appears to be decommissioned and revegetated. Two dams are now evident in this area. A small amount of agricultural cropping is evident on the western side of Lot 803 in this aerial (2000). Brown structures (possible laydown areas or dams) are evident north and east of the structures on Lot 61 in the 2000 aerial, these are no longer evident in the 2004 aerial. A laydown area (comprising pipes, drums and tyres) within the southern/central portion of Lot 900 is now evident.
- By the 2015 aerial, the inferred rural residential structures on Lot 802 appear to be in a dilapidated condition (with only the footprint of the central structure still evident). The structure located on Lot 61 appears dilapidated in the 2018 aerial.
- Site surrounds have predominantly comprised rural residential and agricultural land uses on all sides. A quarry is evident bounding the Site to the east (i.e. present day Lot 202 on Plan 403408), first evident in the 1979 aerial ~200 m south-east of the Site, this area used as the quarry moves to the

northern portion of Lot 202 on Plan 403408 and expands in size to the current location. Commercial/industrial land uses were first evident in the 1981 aerial approximately 250 m north-west of Lot 100 on Diagram 6254. RAAF Base Pearce is first evident approximately 800 m north-west of the Site in the 1983 aerial (this area had been redacted from earlier available aerials). The commercial/industrial land uses ~200 m west of the Site have expanded to the north and south between 1981 and 2000.

5.2 Surrounding Land Use

Adjacent land uses have been identified based on the review of available mapping and current aerial images and are presented on Figure 4. A summary of these adjacent land uses has been provided below:

- North - Immediately north of the northern extremity of Lot 900 is the landfill operated by the City of Swan. The distance between the boundary of the subject land and closest point of the landfill operations is 270 m. The Valley Bullsbrook Landfill Facility is located in an area comprising of part of Lot 834, Lot 1288 and Lot 2792 and sits approximately 350 m north of the northernmost tip of the Site.

- North-west - North-west of the Site is the Swan Valley Nursery, zoned as Urban (DPLH, 2021b). Further north (<1 km) are residential properties zoned Urban (DPLH, 2021b).

- East - Immediately east of the Site is an area zoned Rural (DPLH, 2021b). A quarry is also evident bounding the Site to the east (on Lot 202 on Plan 4034080), which is also zoned Rural (DPLH, 2021b). The Walyunga National Park is located approximately 550 m south-east of the Site, zoned Regional Open Space (DPLH, 2021b).

- South - Bounding the Site to the south is Lot 2 on Diagram 61074, understood to comprise the Lynward Park Horse Stud, which is also zoned Urban Deferred (DPLH, 2021b). Further south (~200 m) is an unnamed private road reserve. South of this private road reserve comprises agricultural land (Taylors Alpacas) zoned Rural (DPLH, 2021b).

- West - Immediately to the west of the Site is the Great Northern Highway. To the west of the Great Northern Highway (< 1 km) are a mix of commercial/industrial and agricultural land uses, including TGA pallets (pallet manufacturer), produce suppliers (livestock producer), Allwood Stud Farm, Tannamurra bed and breakfast, Kalgrain Weighbridge and Glomax Riding Pony Stud, the land to the west of the Great Northern Highway is zoned Industrial (DPLH, 2021b). RAAF Base Pearce is located approximately 800 m north-west and is zoned Public Purposes - Commonwealth Government (DPLH, 2021b).

- West - Poultry farm on Dewar Road approximately 200 m west of Lot 100 Gt Northern Hwy.

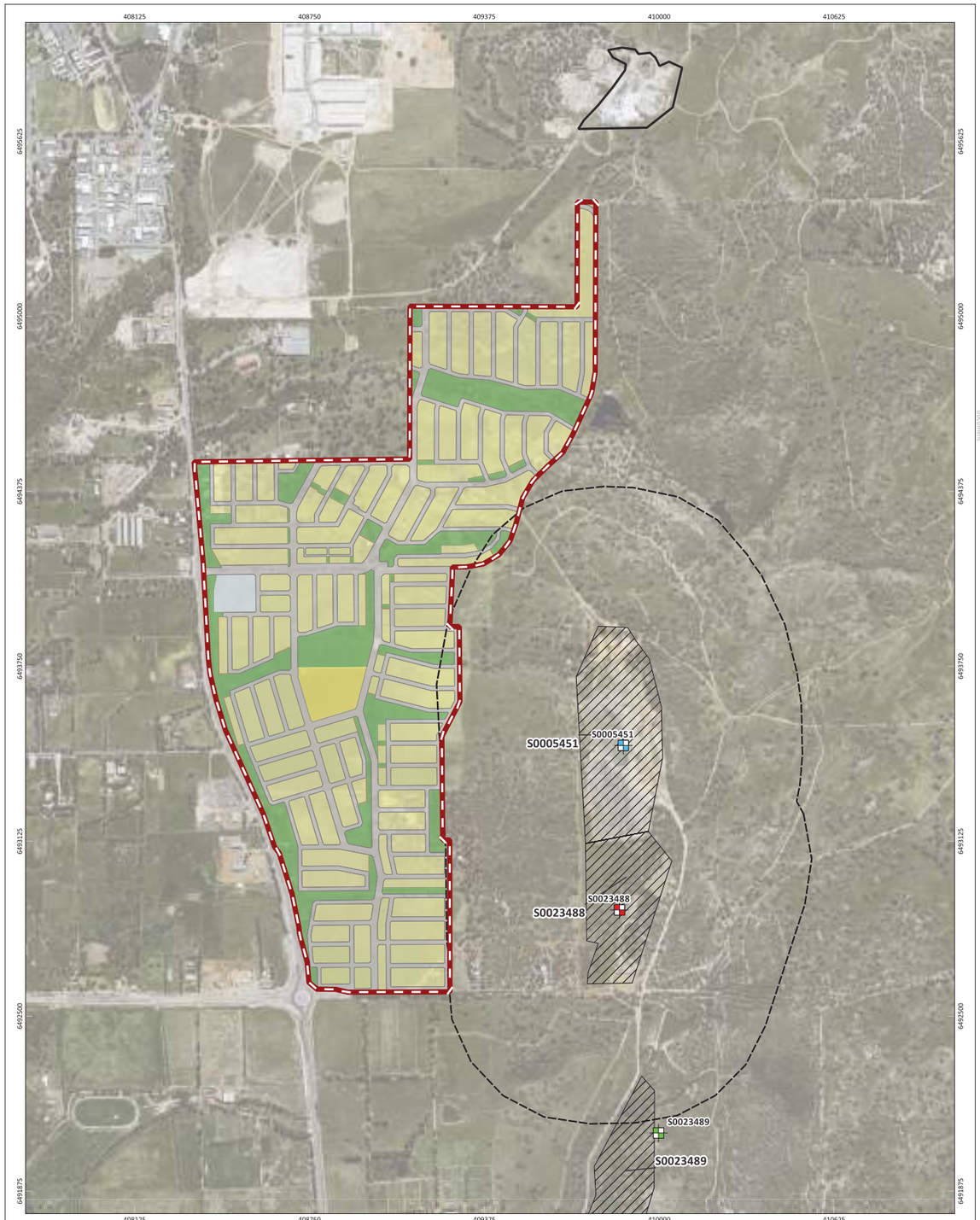

Figure 4: Surrounding Land use

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5.2.1 Landfill Facility

The Valley Bullsbrook Landfill Facility (Landfill Facility) is located on Part Lot 834 on Deposited Plan 246328, Part Lot 1288 on Deposited Plan 247994 and Part Lot 2792 on Deposited Plan 253699 and sits approximately 350 m north of the northernmost tip of Lot 900 Yarrimbah Drive, Bullsbrook. (Figure 4). The Landfill Facility is licenced under the Environmental Protection Act 1986 (EP Act) as a Prescribed Premises Licence Number L9162/2018/1 (Appendix B) under the following category:

- 63 - Class I inert landfill site (More than 50,000, but not more than 500,000 tonnes per year).

The original Licence for the prescribed premises was issued on 23 October 2018, with amendments submitted in 2022 and 2023. The amendments were sought to facilitate the closure phase of the premises. Waste acceptance has been ceased for a number of years, with the last load of waste being received in November 2018. Crushing of building material has also ceased at the premises, with the only remaining operations required to be done at the premises being the final cover and capping of the landfill.

On 19 July 2022, the Licence Holder submitted an application to the Department of Water and Environmental Regulation (DWER) to amend Licence L9162/2018/1 under section 59B of the EP Act. The amendment was limited only to extending the licence expiry date, extending the submission date for a Landfill Closure and Post-Closure Management Plan (Appendix C).

On 31 August 2023, the licence holder submitted an application to DWER to amend Licence L9162/2018/1 under section 59 and 59B of the EP Act (Appendix D). The following amendments were sought:

- Redescribe the purpose of the premises licence by removing categories 13 and 62 as permitted activities, as the related activities are no longer undertaken.
- Redescribe the boundary of the premises to cover the landfill area only.
- Correct the description of the premises to the new lot number and title particulars, to reflect changes made by Landgate on 10 March 2023.
- Removing or varying the condition for waste acceptance so that no more waste may be accepted at the premises.

DWER assessed the risks of emissions from the prescribed premises and determined that a revised licence would be granted. The Landfill closure and Post-Closure Management Plans were submitted to DWER as part of this amendment, and as such those conditions were removed from the licence. There remain some uncertainties regarding the presence of residual waste material or contaminants that may pose an emission risk in the previous operational areas removed from the premises boundary, to address this, conditions requiring validation inspections to be performed and reported to DWER. A report on the validation inspections is required in order to surrender the licence or prior to the expiry of the licence. The licence expiry date was extended to 22 October 2026.

5.2.2 Clay Extraction

The eastern edge of the Site lies approximately 500 m from an active clay extraction facility. The clay extraction facility is operated by Midland Brick. The active pit is Stage 1 of the three stage Bullsbrook South Development. The three-stage development was initiated in 2014 and is expected to extract up to 125 000 tonnes schist - clay per year, with a project life of 20 plus years across the three stages. The approved mining stages are shown in Figure 4:

- Stage 1 (S0005451) located on Lot 202 (No. 2138) Great Northern Highway is currently operating with a lifespan of 1-10 years, operations commenced in 2014. The area of active mining is consistent with the Stage 1 boundary and operations have extended as far west as is approved.
- Stage 2 (S0023488) located on Lot 202 (No. 2138) Great Northern Highway is a proposed clay mine that is not operational and has a lifespan of 5-20 years. Midland Brick have confirmed that Stage 2 will commence operation in 2024 with mining of Stages 1 and 2 to be concurrent.
- Stage 3 (S002389) located on Lot 202 (No. 2138) Great Northern Highway is a proposed clay mine that is not operational and has a lifespan of 10 years once operational.

As shown in Figure 4, a 500 m buffer for Clay extraction Mines (S0005451, S0023488 and S002389) intersects approximately 4.02 ha of the Site.

The EPA's Guidance Statement No. 3 (GS 3) provides guidance on the generic separation distances and buffers for a range of industrial land uses to sensitive land uses such as residential dwellings. It should be noted that the GS 3 states that these distances can be reduced if the need for the deviation can be justified. Buffers are considered useful to achieve an acceptable environmental outcome. The operations at the mine site fit into the category "clay extraction or processing". The potential impacts are listed as "noise" and "dust". GS 3 provides a generic separation distance of "500-1000 metres, depending on size and processing. The Midland Brick operations do not include any processing.

The EPA's Draft Environmental Assessment Guideline for Separation Distances between Industrial and Sensitive Land Uses (2015) identifies clay extraction as an Extractive Industry. The recommended separation distance for clay extraction with no grinding or milling works is 300 – 500 m. Like GS 3, the emission risks are identified as noise and dust.

A review of decisions relevant to similar clay extraction operations has identified that a buffer of 500m or less is acceptable to the EPA and has not resulted in an assessment by the EPA. The EPA has previously approved proposals for clay extraction operations in 2016 (CMS15304) and 2019 (CMS17634), where the separation buffer to sensitive receptors (in both cases, residential dwellings) was 450 m and 200 m respectively, and the overall environmental impact was assessed as not significant.

The Midland Brick Clay extraction Mines were approved with exiting sensitive receptors at 120 m and 460 m. Agreements have been made with landowners to the east of the extraction site that fall within the 500m buffer. A Blast Hazard Assessment and Management Plan concluded that the predicted effects from flyrock

and vibration are low due to the extent of the charge mass and the design of the blast. Air blast overpressure will not exceed statutory limits and will be at levels that should not cause damage to residential structures. A distance of 63 metres for flyrock discharge was calculated although distances exceeding this could occur. Midland Brick will give advance notice to all residents within the buffer area of the date, time and duration of blasting operations so that those residents may take appropriate action (leave the property or remain indoors).

It is presented that the 400 - 500 m separation distance to the proposed residential development is appropriate, provides sufficient separation to future residents and falls within the 300 - 500 m separation distance recommended by the EPA.

5.3 Surface Geology and Topography

The Site slopes from east to west, with a peak elevation of around 160 m Australian Height Datum (mAHD) noted within the eastern most side of Lot 101 and 803, to a minimum elevation of around 40 mAHD reported at the western boundary of the Site (along the Great Northern Highway). Site topographic contours are provided in Figure 5.

The surface geology of the Site is classified as Guildford Formation Pebbly Silt, with a small portion of the south-eastern and north-eastern sections of the Site overlaying Schist. These are described below:

- Mgs1: GUILDFORD FORMATION PEBBLY SILT - Mainly alluvial sandy clay, strong brown silt with common fine to occasionally coarse grained sub-rounded laterite quarts heavily weathered granite pebbles some fine to medium grained.
- SC1: SCHIST - metallic grey quartz mica schist pronounced schistosity relative amount of biotite to muscovite varies biotite often altered to chlorite.

5.4 Contamination

A search of publicly available online government databases was undertaken in June 2023. The Site is not registered as a contaminated site and there no registered contaminated sites within 1 km of the Site.

5.5 Government Databases

A search of publicly available online government databases was undertaken. The findings are summarised in Table 2 below.

Table 2: Public Government Database Search

Database	Search Result
DWER Contaminated Sites Database	The DWER online Contaminated Sites Database was accessed in June 2023 and search results reported that the Site is not currently registered as a known contaminated site. A search within a 1 km radius of the Site did not show any other registered contaminated sites in the area.
DMIRS Dangerous Goods Register	A search of the DMIRS Dangerous Goods Storage Register online database was undertaken in June 2023. Search results reported NO DANGEROUS goods for the Site and its surroundings within a radius of 1 km.
DWER Water Information Reporting	The DWER Water Information Reporting (WIR) database lists registered groundwater abstraction bores in WA. A database search was conducted in June 2023 to determine the occurrence of wells within 1000 m radius of the Site. Two groundwater wells were reported to be present within the Site. Fourteen groundwater wells were reported within 1000 m of the Site's centre.

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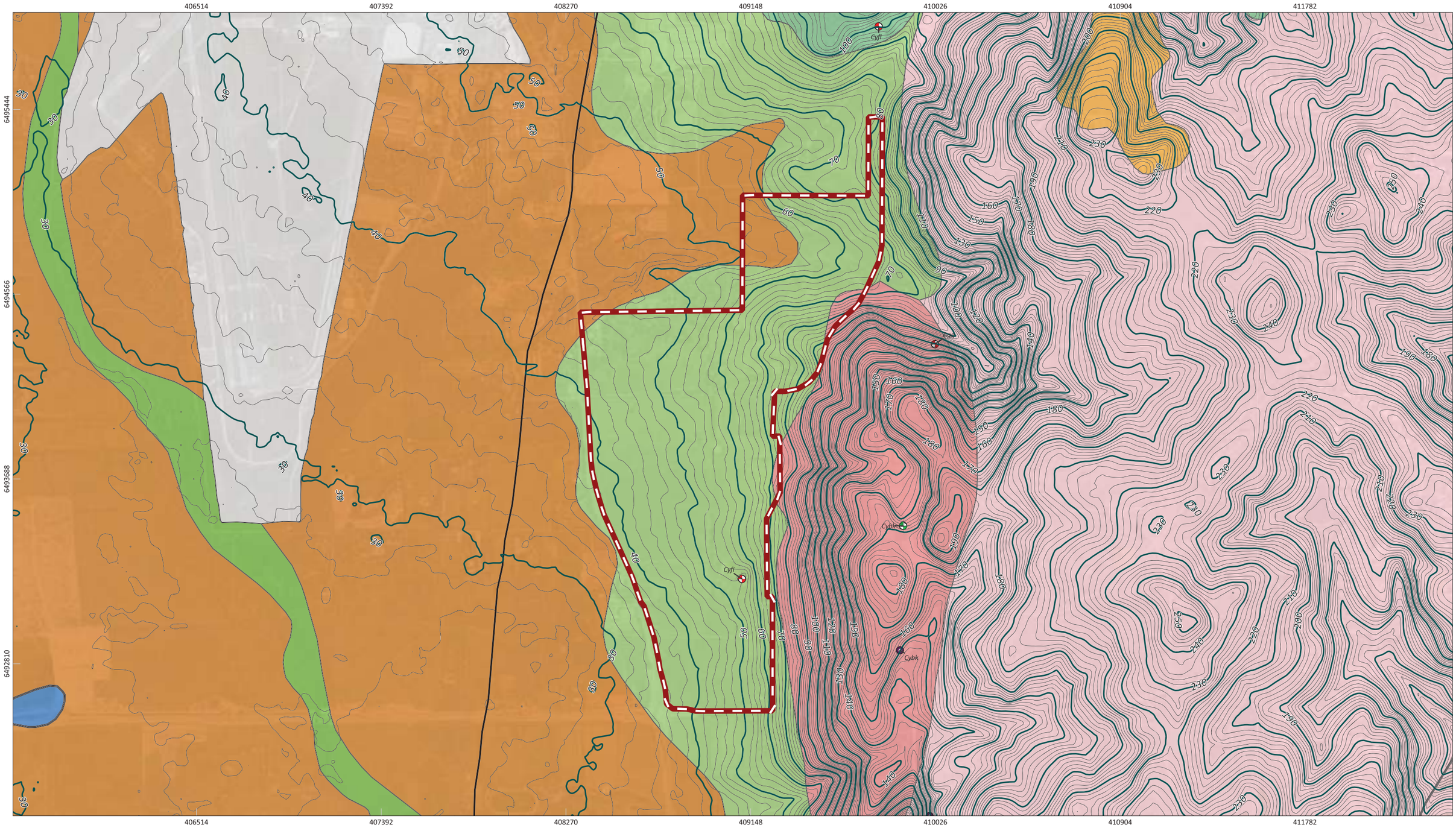

Figure 5: Surface Geology (Soils) and Topography

N

0 260 520 780 1,040 m

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook			
SCALE: 1:17,569	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD / PN	DATE: 4/4/2024

Legend

- Survey Area
- **GSWA - Code**
  - Aerodrome
  - GR
  - GR-GN
  - LA1
  - LS5
  - Mgs1
  - Msg
  - S11
  - SC2
  - ST1
- **2m contours (DPIRD_072)**
  - Each 5m
  - Each 1m
- **Minedex (DMIRS-001)**
  - Operating
  - Proposed
  - Shut
- **1:500 000 State linear structures layer (DMIRS-015)**
  - Fault or shear zone, major; normal, exposed, tick on downthrown side

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	4/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022

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Geology and Topograghy Figure - Legend and Details

CODE	SoilType
Aerodrome	NULL
GR	GRANITE - fine to coarse-grained mesocratic rocks of granite granodiorite and adamellite composition even-grained or porphyritic
GR-GN	GRANITES AND GNEISSES - intimate association of coarse-grained granites (GR) and gneisses (GN) and fine-grained dolerites (DO)
LA1	LATERITE - massive and vuggy to cemented pisolites up to 4m thick associated loose sandy pisolite gravel (G2) of residual origin
LS5	MUCHEA LIMESTONE - white to cream fine-grained algal lamination common
Mgs1	GUILDFORD FORMATION PEBBLY SILT - mainly alluvial sandy clay, strong brown silt with common fine to occasionally coarse grained sub-rounded laterite quartz heavily weathered granite pebbles some fine to medium-grai
Msg	SANDY SILT - strong brown firm friable dispersive in part occasional pebbly horizons with little matrix containing quartzite, quartz granite laterite of colluvial or
S11	SAND - light grey to yellowish grey medium-grained sub-angular to rounded quartz with some feldspar moderately sorted of alluvial origin
SC2	NULL
ST1	SILTSTONE - white thinly bedded well laminated fine-grained some large ferruginous concretions and laminae occasionally micaceous

Reference

Department of Mines, Industry Regulation and Safety (DMIRS). (1984). 1:50 000 environmental map – MUCHEA (2034-I, 2134-IV). Accessed on 3/2/2022 from https://dasc.dmp.wa.gov.au/dasc/

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5.6 Acid Sulfate Soils

Acid Sulfate Soil (ASS) is naturally occurring soil containing iron sulphides, which when oxidised, can lead to acidification of soils and groundwater and, consequently, extensive environmental damage. According to the DWER (2017) Acid Sulphate Soil Risk Map - Swan Coastal Plain (DWER-055), the Site is not in an area which may pose an ASS risk. Two areas were identified to have a moderate to low risk of ASS occurring within 3 m of the natural soil surface but high to moderate risk of ASS beyond 3 m of the natural soil surface, these comprise an area immediately (<10 m) east of the Site, and Ellen Brook (located ~ 1.6 km west of the Site) (Figure 6).

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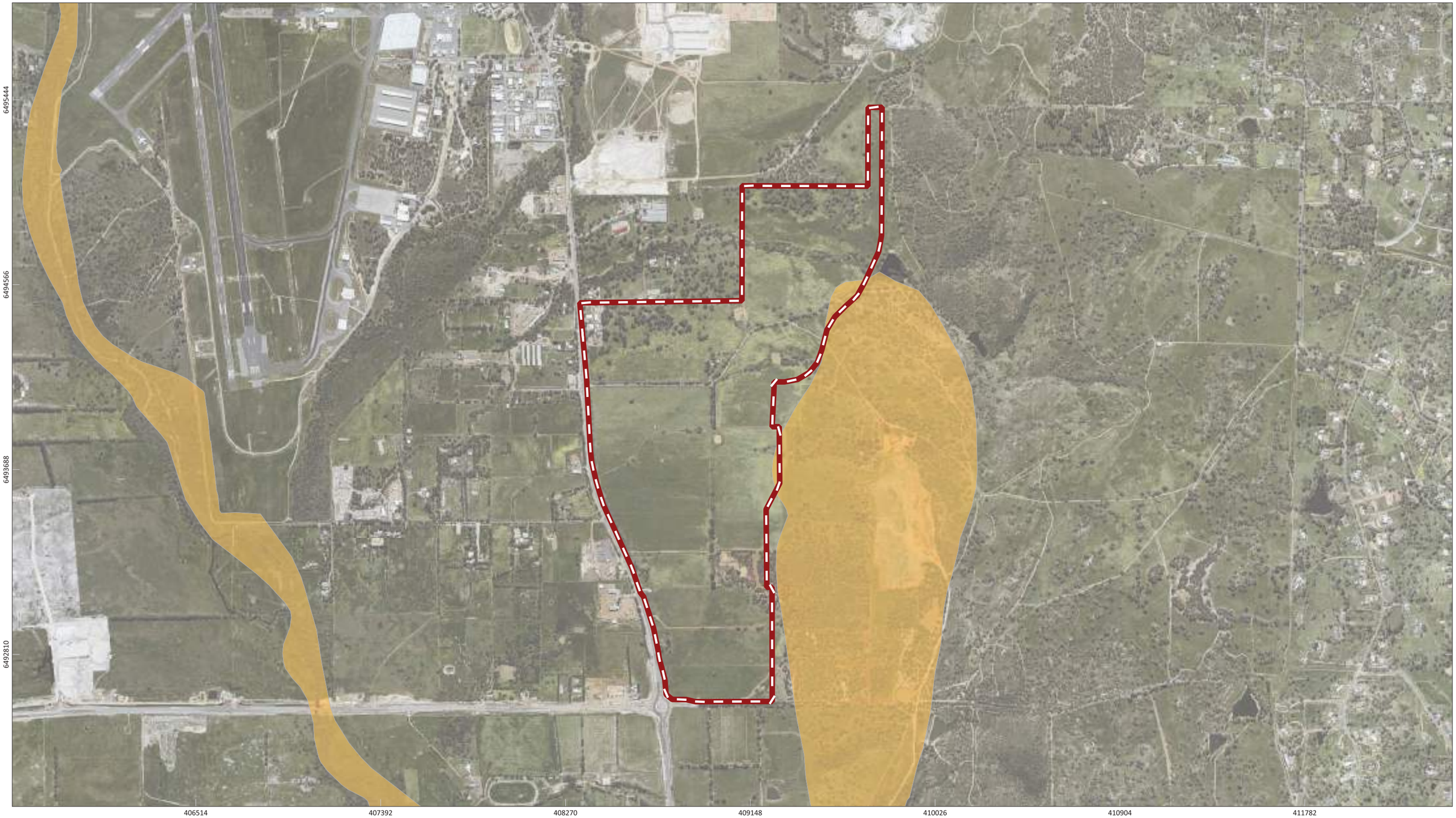

Figure 6: Acid Sulfate Soils Risk

N

0 260 520 780 1,040 m

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE	1:17,569
SHEET SIZE	A3 COLOUR
CLIENT	Mirvac
COORDINATE REFERENCE SYSTEM	GDA2020 / MGA zone 50
PROJECT NUMBER	A23.028
VERSION	0
DATA SOURCE	LANDGATE AERIAL IMAGERY Summer 2023
DRAWN BY / REVIEWED BY	MD / PN
DATE	4/4/2024

Legend

Site Location

Acid Sulfate Soil Risk Map, Estuaries (DWER-050)

2 – Moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	4/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022

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5.7 Hydrology

5.7.1 Groundwater

The Hydrological Zones of Western Australia (Department of Primary Industries and Regional Development [DPIRD]-069) Coastal Plain dataset, indicates that the Site is located within the western portion of the Perth Basin, overlying the Leederville, Yarragadee and Cockleshell Gully Formations. The Perth Basin sediments range from highly permeable to impermeable, with superficial deposits generally consisting of highly permeable sands (Western Australian Agriculture Authority [WAAA], 2014). Major aquifers are located in the sandstones of the Leederville, Yaragadee and Cockelshell Gully formations with deposits of clay and shale acting as confining (or semi-confining layers) (WAAA, 2014). The Yoganup Formation lies along the inland (eastern) boundary of these formations and is the major recharge area for the Perth Basin, with groundwater subsequently discharging to the Indian Ocean in the west (WAAA, 2014).

5.7.2 Irrigation Water Supply

The DWER Water Register (DWER, 2021d) provides information about water availability and licences in WA. The Register indicated that there are two groundwater abstraction licences which currently overlap the Site boundary. These licence details are as follows:

- Lot 61 - Gt Northern Hwy - Licence ID: 180972. Allocation allowance 27,800 kilolitres (kL). Expiry date 2 August 2025.
- Lot 803 Gt Northern Hwy - License ID: 166199. Allocation allowance 1500 kL. Expiry date 28 October 2028.

There are an additional fourteen groundwater abstraction licences within a 1 km radius of the Site centre. These licences appear to be used for irrigation, commercial and domestic purposes.

The DWER Water Licencing Branch were engaged to identify whether any groundwater allocations were available for the subject land. DWER advised that the superficial and deeper Leederville aquifers were both fully subscribed and that no allocations were available. DWER identified that allocations appeared to be available on the western side of Gt Northern Hwy in an aquifer that does not extend onto the subject land.

DWER advised that water trading in the area was a common and sophisticated market.

Irrigation water will be supplied by a combination of existing groundwater licences and trading of groundwater allocation from the Leederville Aquifer in the groundwater subarea.

5.7.3 Surface Water

Approximately four tributaries of Ellen Brook (including Nambad Brook) extend on-site (passing through Lot 900 and Lot 61), however based on available aerial imagery these appear to be dry the majority of the year (Landgate Mapviewer - Landgate, 2021a). There are also five dams on-site. Ellen Brook is located approximately 1.6 km west of the Site. Multiple tributaries extend off Ellen Brook in the north, including Nambad Brook (on-site) and Ki-it Monger Brook (located ~1 km west of the Site). The Avon River is located approximately 5 km south-east of the Site.

5.7.4 Biophysical Assessment

A biophysical assessment of the Site was undertaken via a desktop analysis of existing data as well as through a site assessment in May 2023 to delineate the foreshore reserve of any waterways on the Site. Biophysical criteria are the factors used in determining the extent of a foreshore reserve. The biophysical assessment was undertaken as per *River Restoration No 16 Determining Foreshore Reserves* (2001), this includes the criteria listed below in Table 3, some of which may not be present or relevant to the Site.

Table 3: Biophysical Assessment

Biophysical Assessment Criteria	Assessment Findings
Hydrology, topography and geology	There is one mapped linear surface water hydrological feature on the Site, with the Nambad Brook running east west through the northern portion (Figure 7). There is no mapped floodplain for this waterway. Geomorphic wetland mapping indicates that there is one mapped Multiple Use Wetland (UFID 15282-Palusplain) present covering much of the southern and western portions of the Site (Figure 8). The mapped Multiple Use Wetland does not intersect with the Nambad Brook and was not used in discerning waterway features extent. Mapped topography of the Site indicates a clearly defined valley feature running east to west associated with the Nambad Brook and a more weakly defined broad feature running in parallel 100-150m north of the Nambad Brook. In the central portion of the Site a broad drainage feature is present with two branches originating in the east and joining in the centre of the Site before heading west. Topography was used to provide an indicative centre to the unmodified waterway courses (Figure 7). The site assessment identified a clearly defined channel for the Nambad Brook with an approximate incised flowing channel of a depth of between 1 to 1.5 meters and between 2 and 10 meters wide. Fringing this is a waterway platform of between 5-25 meters width either side. Sections of this platform which may experience flow during peak events however specific hydrology is required to understand extent. The broad feature running in parallel 100-150m north of the Nambad Brook did not have a clearly defined channel and comprises a broad low lying valley floor. The central feature has a clearly defined channel with an approximate incised flowing channel of a depth of between 0.5 to 1 meter and between 1 and 3 meters wide. This feature appears to have been subject to several course modification having been straightened from the original course in sections, particularly following the north south running section of Large Rd and running west from Large Rd. Several dams are also present. Geology mapping indicates the surface geology of the Site is classified as Guildford Formation Pebbly Silt with a small portion of the south-eastern and north-eastern sections of the Site overlaying Schist and provides no discerning water way features (Figure 4).

Biophysical Assessment Criteria	Assessment Findings
	Soil landscape system mapping identifies that two of the systems intersecting the Site are associated with waterways these being: • Forrestfield F4 phase-Incised stream channels within gentle slopes with deep acidic yellow soils and sandy alluvial gradational brown earths. • Pinjarra phase Gf5-Incised drainage channels with poorly drained gradational mottled yellow brown earths, shrublands of Melaleucas and other low shrubs.
Soil type and flood risk	The three drainage features discussed above intersect with these two soil landscape systems (Figure 7). Drainage features also associated with soil landscape flood risk (DPIRD-007) class: • H1- 50-70% of the map unit has a moderate to high flood risk. • H2- >70% of the map unit has a moderate to high flood risk. Site is outside of the FMP 1 in 100 (1%) Floodplain Development Control Area (DWER- 003).
Heritage	There are no heritage features that assist with the identification of the waterway, however the whole Site is mapped as part of the Ellenbrook 'Mythological', Place ID:3525.
Land use	Land use across the entire Site is currently grazing agriculture. No areas have a specific land use which would assist in identifying the waterway or which are at a higher risk from land use modification.
Vegetation and Habitat	A vegetation and habitat site assessment has been undertaken and focused on the extent of riparian vegetation to assist in defining the waterway. Riparian vegetation was defined by the presence of species known to occur within or directly adjacent to waterways. Due to the mainly cleared nature of the site limited plant species were present to assist in defining waterways. In the Nambad Brook a small number of plants of riparian associated species *Melaleuca rhaphiophylla* and *Taxandria linearifolia* were present. Mature flooded gum (*Eucalyptus rudis*) trees are present within the channel feature. Flooded gum occurs within riparian zones, but also occurs in seasonally damp situations outside of these however was used as an indicator species in this assessment. Riparian vegetation although severely degraded is considered present within the Nambad Brook, this vegetation type is mapped as Creek (Figure 9). The drainage feature running parallel 100m to the north of the Nambad Brook did not have any native vegetation present, or non-native vegetation indicating a riparian zone. The central drainage feature has scattered native species wandoo (*Eucalyptus wandoo*) present. Wandoo is not associated with riparian vegetation. No riparian vegetation is considered present associated with this feature.

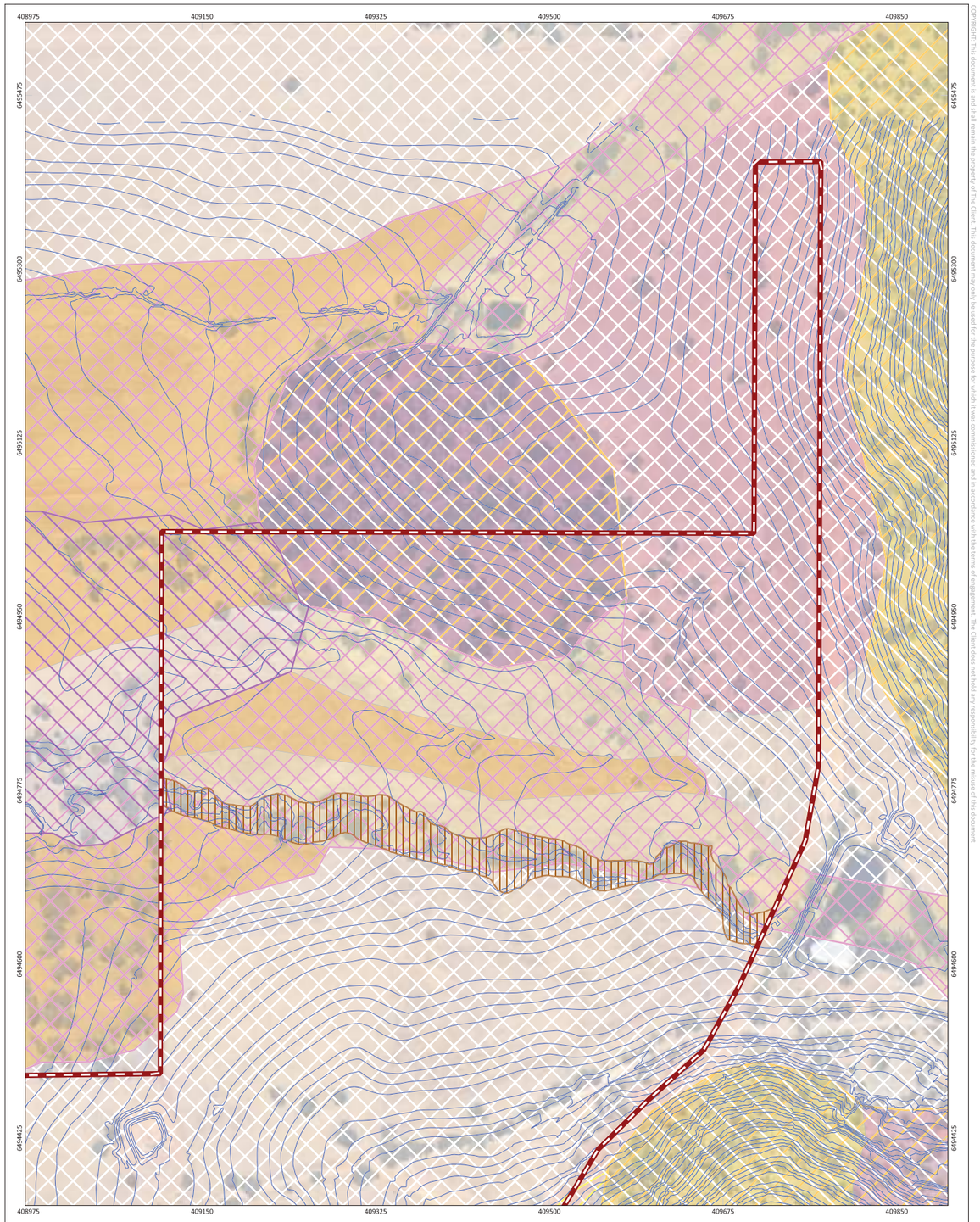

Figure 7: Biophysical Assessment

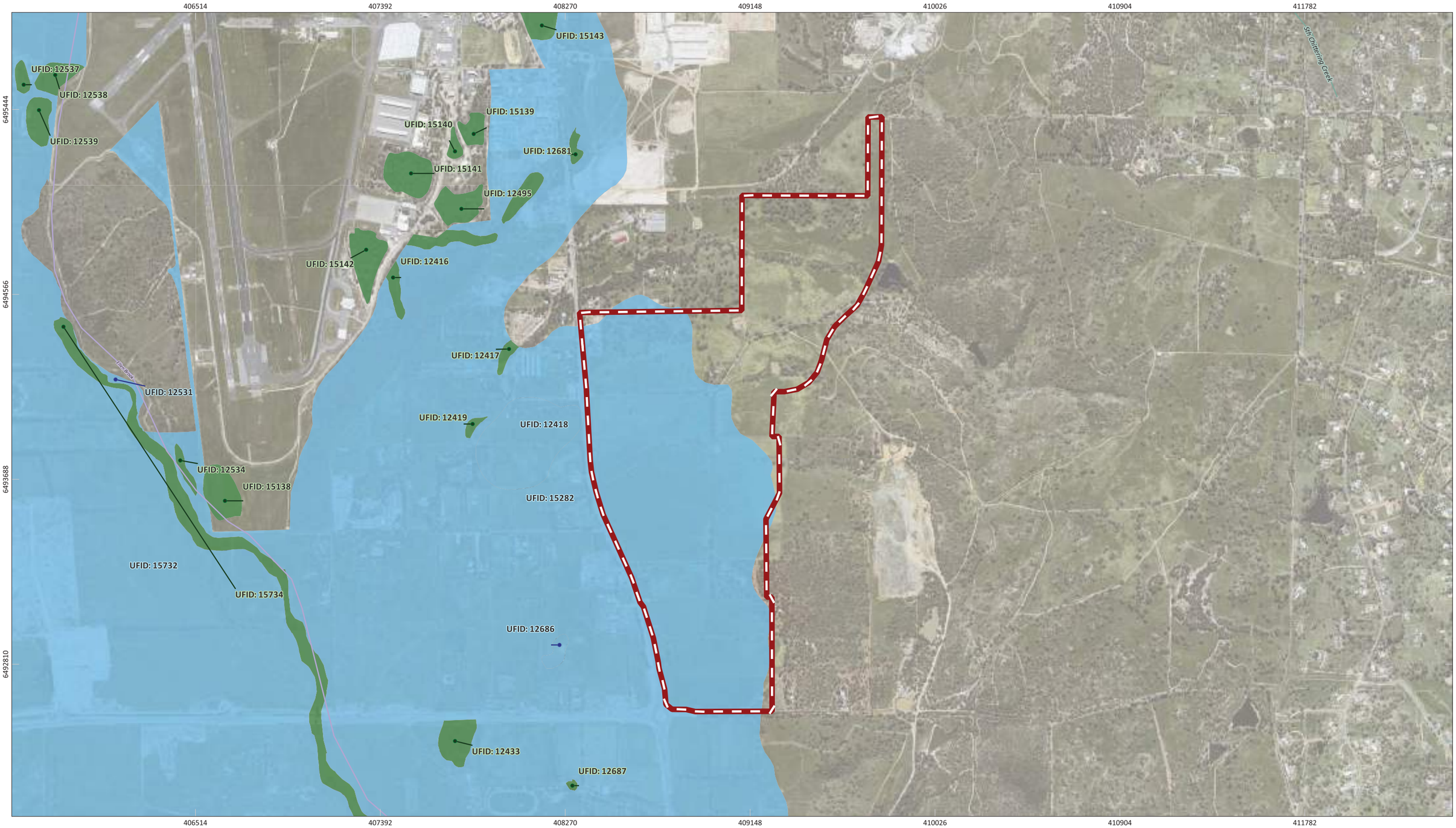

Figure 8: Surface Water Features and Geomorphic Wetlands

N

0 250 500 750 1,000 m

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE	1:17,569
SHEET SIZE	A3 COLOUR
CLIENT	Mirvac
COORDINATE REFERENCE SYSTEM	GDA2020 / MGA zone 50
PROJECT NUMBER	A23.028
VERSION	0
DATA SOURCE	LANDGATE AERIAL IMAGERY Summer 2023
DRAWN BY / REVIEWED BY	MD / PN
DATE	4/4/2024

Legend

Site Location

Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)

Conservation

Multiple Use

Hydrography Linear (Hierarchy) (DWER-031)

Minor River

Significant Stream

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	4/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022. UFID stands for Unique Identifier

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Geomorphic Wetlands Swan Coastal Plain (DBCA-019) - Legend and Details

Sites within the map extent

objectid	Unique_Feature_ID	Wetland_Name	Landform	Wetland_Type	Management_Category	Area__Ha_	st_area_shape_	st_perimeter_shape_

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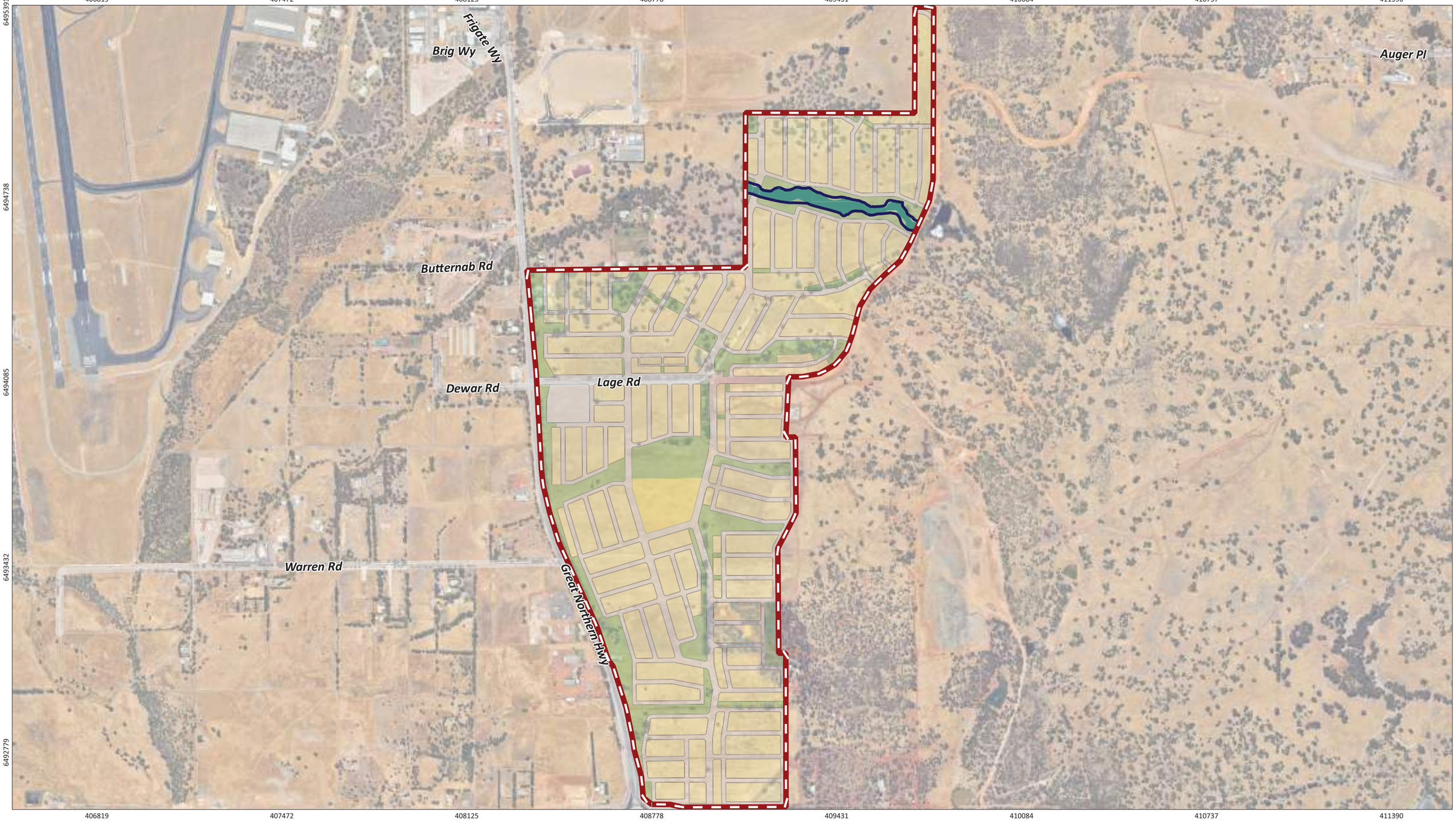

Figure 9: Riparian Zone and Foreshore Zone

N

0 190 380 570 760 m

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE	1:13,058
SHEET SIZE	A3 COLOUR
CLIENT	Mirvac
COORDINATE REFERENCE SYSTEM	GDA2020 / MGA zone 50
PROJECT NUMBER	A23.028
VERSION	0
DATA SOURCE	LANDGATE AERIAL IMAGERY Summer 2023
DRAWN BY / REVIEWED BY	MD/PN
DATE	3/5/2024

Legend

- Site Location
- Riparian Zone Vegetation
- ForeshoreZone
- Commerical
- Roads
- School
- Public Open Space
- Residential

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	3/5/2024

NOTES:

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The biophysical assessment considered an overlay of the following features:

- Surface water features.
- Topography.
- Mapping of incised drainage lines
- Soil landscape.
- Flood risk.
- Heritage.
- Riparian associated vegetation identified as part of the field survey.

The assessed values were confined to the area mapped as a defined waterway and the riparian vegetation identified during the site assessment, no other biophysical elements specifically contribute to the definition of the Nambad Brook and it is not identified as a wetland, a minor river or significant steam (Figure 8). As such the foreshore reserve can be denoted by drainage channel and the riparian vegetation as mapped (Figure 7).

The urban design concept plan has been informed by the proposed foreshore reserve and the City of Swan Local Biodiversity Strategy (2015) and allows for the Nambad Brook to be completely contained within the Public Open Space on the development concept plan (Figure 9).

The drainage feature running parallel 100m to the north of the Nambad Brook is not considered to comprises a riparian zone, although it has topography and soil landscape/flood risk mapping indicating a feature is present.

The central feature demonstrates a draining line is present through topography, mapping of incised drainage lines, soil landscape/flood risk. No riparian vegetation is present, and it does not comprise a riparian zone. The history of modification to the course of this feature and clearing has resulted in it being more representative of a farm drain than a natural watercourse.

See representative images below.



Photo 1: Nambad Brook east end.



Photo 2: Typical Nambad Brook channel with flooded gum.



Photo 3: Central Nambad Brook with channel in centre and platform extending 25 m each side.



Photo 4: Western Nambad Brook looking west into non accessible lot.



Photo 5: Typical central drainage feature.



Photo 6: Western end of central draining feature with drain having been reshaped.

5.7.5 Wetlands

Wetlands were identified using the Geomorphic Wetland, Swan Coastal Plain (DBCA-019) dataset (DBCA, 2021a) (Figure 8). A multiple use wetland overlapped the majority (>90%) of the Site (Unique Feature ID [UFI]: 15282). The landform is listed as 'flat' and wetland type is a 'palusplain'. Three other wetlands were identified proximally (< 1km) to the Site as follows (Figure 7):

- UFI: 12417. Located approximately 400 m west of the Site, conservation category, flat, plausplain.
- UFI: 12419. Located approximately 500 m west of the Site, conservation category, flat, palusplain.
- UFI: 12433. Located approximately 900 m south-west of the Site, conservation category, flat, palusplain.

5.7.6 Public Drinking Water Source Area

The Site is not located in a Public Drinking Water Source Area (PDWSA).

5.8 Flora and Vegetation

5.8.1 Desktop Assessment

Database searches were undertaken to compile a list of potential conservation significant flora and ecological communities within or surrounding the Survey Area (Table 4). In addition, an EPBC Protected Matters Search Tool (PMST) was undertaken to identify the potential for Matters of National Environmental Significance (MNES) to occur within or surrounding the Survey Area (DEECCW, 2022).

Table 4: Database searches of the survey area

Database Name	Date Received and Reference Number	Search Type	Search Area
Threatened and Priority Ecological Communities database search (Department of Biodiversity Conservation and Attractions)	10/08/2022 38-0822C	TECs and PECs	20 km buffer around the Survey Area
Threatened and Priority Flora (TPFL) database search (Department of Biodiversity Conservation and Attractions)	10/08/2022 60-0822FL	Threatened and Priority Flora	20 km buffer around the Survey Area
Western Australian Herbarium (WAHerb) flora database search (Department of Biodiversity Conservation and Attractions)	10/08/2022 60-0822FL	Threatened and Priority Flora	20 km buffer around the Survey Area
DBCA Threatened and Priority Fauna database search (Department of Biodiversity Conservation and Attractions)	06/06/2023 FAUNA#7742	Threatened and Priority Fauna	10 km buffer around the Survey Area
Protected Matters Search Tool Department of Agriculture Water and the Environment, 2022a)	06/06/2023	Commonwealth listed Threatened Flora and fauna and TECs	10 km buffer around the Survey Area

5.8.2 Likelihood of Occurrence

Conservation listed flora communities identified from the desktop assessment were assessed to determine the likelihood of their occurrence within the Survey Area, both prior to and post field survey. The assessment was completed based on the likelihood of occurrence criteria presented in Table 5. Only species either recorded within the Survey Area or considered as having a high likelihood of occurrence in post field survey assessment will be discussed in detail. Species classified as having a low likelihood of occurrence will not be discussed unless a justification for this classification is required.

Table 5: Likelihood of Occurrence Criteria

Likelihood	Criteria
Recorded	Recorded in the Survey Area from database searches, previous survey by others or by current survey.
High	Records of flora species <1 km from the Survey Area. With record <20 years old. Records of fauna species <5 km from the Survey Area. With record <20 years old; or For species with well understood and specific habitat preference/ requirements, when specific habitat is present in the Survey Area, and records present <10 km from the Survey Area. Species with general habitat preference, which is present in the Survey Area, and records present <5 km from the Survey Area.
Medium	There are records <10 km from the Survey Area, however: The species is strongly linked to a specific habitat, which is marginally suitable or small in extent in the Survey Area; or Species has a general habitat preference, but small extent of suitable habitat is present. There is suitable habitat in the Survey Area, but records are >10 km from Survey Area.
Low	Records are historical only, or are pre mapping procedures (e.g., records assigned to towns or place names). The species has a well understood and specific habitat preference/ requirements, which is absent from the Survey Area; or Suitable habitat is present, however there are no existing records of the species from the region despite reasonable previous search effort; or There is some suitable habitat in the Survey Area, however the species is very infrequently recorded in the locality (e.g., migratory bird species).

5.8.3 Pre European Vegetation

During the 1970s, John Beard and associates conducted a systematic survey of native vegetation, describing the vegetation systems in Western Australia at a scale of 1:250 000 in the south-west and at a scale of 1:1,000,000 in less developed areas (Beard, 1976) (Figure 10).

Beard's mapping attempted to depict the native vegetation as it was presumed to be at the time of settlement and is known as the pre-European vegetation type and extent. Beard's vegetation maps are maintained in digital form by DPIRD (2019). Extents are updated periodically by Department of Biodiversity, Conservation and Attractions (DBCA) (GoWA, 2018). This mapping indicates that the Survey Area intersects three pre-European vegetation associations:

- Pinjarra_3: Forest - Medium forest; jarrah-marri
- Pinjarra_4: Woodland Southwest - Medium woodland; marri & wandoo
- East Darling_4: Woodland Southwest - Medium woodland; marri & wandoo

The pre-European vegetation association identified from the Survey Area (DPIRD-006) and its pre-European and current extents are listed in Table 6. (GoWA, 2018).

Table 6: Pre European Vegetation Association Representation

Vegetation Association	Original Extent (ha)	Current Extent (ha)	% Remaining	% Managed for Conservation
Pinjarra_3	13,738.98	1,586.73	11.55	1.53
Pinjarra_4	10,632.64	1,237.66	11.64	1.17
East Darling_4	47,288.88	31,180.33	65.94	16.99

Regional vegetation for the Swan Coastal Plain (at vegetation complex level) was mapped by Heddle et al. (1980) and are maintained in digital form by DBCA (2018). The mapping indicates that the Survey Area intersects mainly one pre-European regional vegetation complex, but slightly intersects two other vegetation complexes:

- Guildford Complex (32): A mixture of open forest to tall open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) and woodland of *Eucalyptus wandoo* (Wandoo) (with rare occurrences of *Eucalyptus lane-poolei* (Salmon White Gum)). Minor components include *Eucalyptus rudis* (Flooded Gum) - *Melaleuca rhaphiophylla* (Swamp Paperbark).
- Forrestfield complex (29): Vegetation ranges from open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) to open forest of *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) - *Allocasuarina fraseriana* (Sheoak) - Banksia species. Fringing woodland of *Eucalyptus rudis* (Flooded Gum) in the gullies that dissect this landform.
- Darling Scarp (DS2): Mosaic of open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla*, with some admixtures with *Eucalyptus laeliae* in the north (subhumid zone), with occasional *Eucalyptus marginata* subsp. *elegantella* (mainly in subhumid zone) and *Corymbia haematoxylon* in the south (humid zone) on deeper soils adjacent to outcrops, woodland of *Eucalyptus wandoo* (subhumid and semiarid zones), low woodland of *Allocasuarina huegeliana* on shallow soils over granite outcrops, closed heath of *Myrtaceae-Proteaceae* species and lithic complex on or near granite outcrops in all climate zones.

The pre-European regional vegetation complex identified from the Survey Area (DBCA-046; DBCA-047) and its' pre-European and current extents are listed in Table 7 (GoWA, 2017).

Table 7: Pre European Regional Vegetation Complexes

Vegetation Complex Name	System 6 Mapping Unit Number	Original Extent (ha)	Current Extent (ha)	% Remaining	% Managed for Conservation
Guildford Complex	32	90,513.13	4,522.01	5.00	0.26
Forrestfield Complex	29	22,812.92	2,804.97	12.30	1.37
Darling Scarp	DS2	32,448.29	13,536.76	41.72	7.67

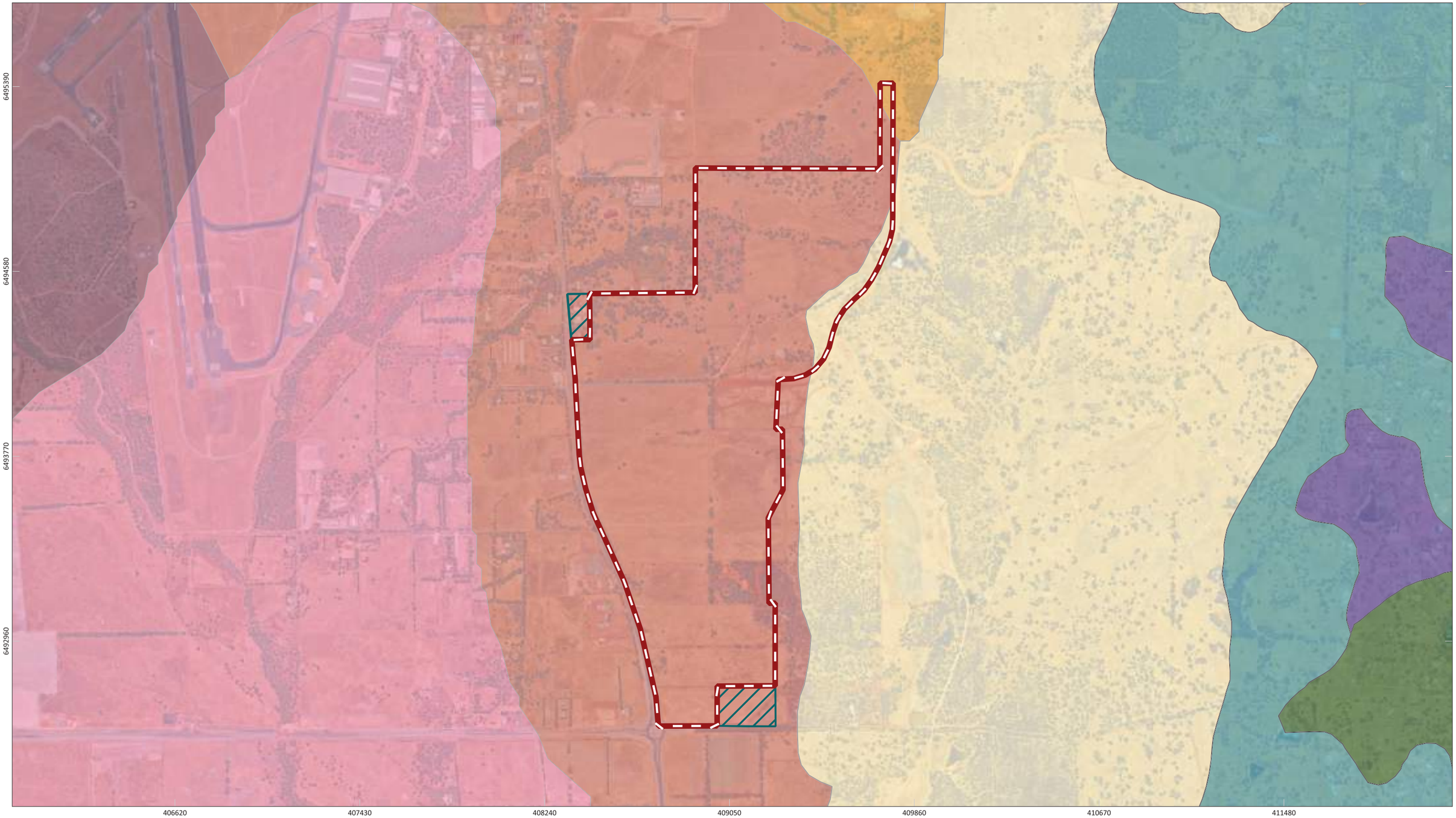

Figure 10: Pre-European Vegetation Type

N

0 240 480 720 960 m

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook			
SCALE: 1:16,208	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD / PN	DATE: 19/4/2024

Legend

- SurveyArea
- Not assessed

Vegetation Complexes - South West forest region of Western Australia (DBCA-047)

- Darling Scarp, DS2
- Murray 2, My2
- Pindalup, Pn
- Yalanbee, Y6

Vegetation Complexes - Swan Coastal Plain (DBCA-046)

- Mogumber Complex-South
- Guildford Complex
- Beermullah Complex
- Yanga Complex
- Forrestfield Complex

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022. Label corresponds to the vegetation association number.

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5.8.4 Site Assessment

A broad scale reconnaissance level flora and vegetation survey and a targeted priority and threatened flora search was undertaken the Site on 23-25 May 2023. A portion of the Site, Lot 400, Lot 2, Lot 5 and Lot 6 Great Northern Highway and the eastern portion of Lot 20 Great Northern Highway (Figure 11) were not assessed as part of this survey. The survey was conducted by suitably qualified ecologists according to standards set out in the Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016). A summary of the results of these surveys is provided in the following sections. See Appendix B for full biological survey report.

Vegetation Types

The vegetation present throughout the Survey Area was considered not to be representative of intact remnant native vegetation and was described from observations while traversing Survey Area. Due to the Completely Degraded condition and highly depauperate nature of the vegetation a traverse sampling method considered suitable. Additionally, due to the degraded condition and low native species abundance Floristic Community Type (FCT) analysis was not suitable to be undertaken to assist in defining broad vegetation types. The vegetation present within the Survey Area is described below Table 8 and shown in Figure 12.

Table 8: Vegetation Present in Survey Area

Vegetation Unit	Description	Total Area, Proportion (%) of the Survey Area	Vegetation Condition
VT01-Marri and Wandoo over Paddocks	Scattered paddock trees and denser groves of *Corymbia calophylla* and *Eucalyptus wandoo* over pasture grassland. Mid and ground stratum absent. Occurring on flats and lower hillslopes. Soil a clay loam with limited laterite influence on higher parts	32.69 ha 16.96%	Completely Degraded.
VT02 Wandoo Over Paddocks	Stands of *Eucalyptus wando*o. Trees have been previously cleared and are coppicing as multi stem mallee forms. Vegetation is subject to ongoing sheep grazing which has supressed/ removed the ground and mid stratum. Occurring at base of hills with a mixed clay loam and light laterite soil. Heavily compacted by sheep.	2.26 ha 1.17%	Completely Degraded.
Creek-Creek with Flooded Gum	Open woodland of *Eucalyptus rudis, Corymbia calophylla* and scattered *Eucalyptus wandoo*. Very occasional *Melaleuca rhaphiophylla* and *Taxandria linearifolia*. Ground stratum pasture grasses. Occurring along the Nambad Brook. Soil clay with alluvial river stone. Comprises highly degraded riparian vegetation zone.	3.13 ha 1.62%	Completely Degraded.
Drain-Minor Drainage Line	Minor drainage line with *Eucalyptus wandoo* over pasture grass. Soil clayey. Drainage line has been modified in several sections. No riparian associated species present.	3.18 ha 1.65%	Completely Degraded.
Planted Trees-Windbreaks, Gardens, Revegetation	Planted areas. Species typically non endemic including *Eucalyptus camaldulensis, Eucalyptus grandis, Corymbia citriodora* and endemic *Casuarina obesa*.	7.68 ha 3.98%	Completely Degraded.
Paddocks-Paddock with Isolated Trees	Paddock with very isolated *Corymbia calophylla* and *Eucalyptus wandoo* over pasture grasses.	143.81 ha 74.61%	Completely Degraded.
Total	192.75 ha		

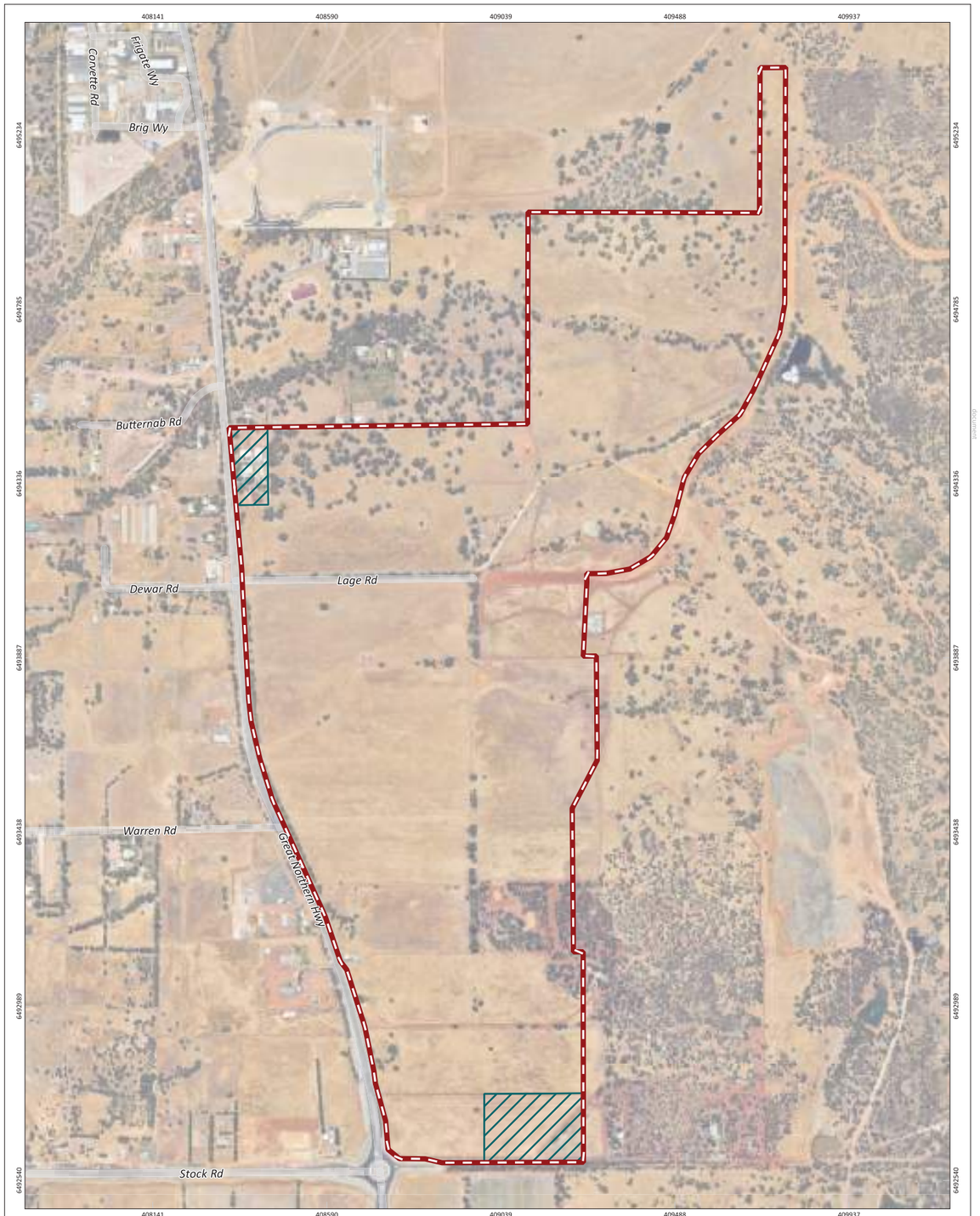

Figure 11: Survey Area

N 0 75 150 225 300 m

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook			
SCALE: 1:8,983	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD / PN	DATE: 19/4/2024

Legend

- Survey Area
- Not assessed

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

NOTES:

Cadastral boundary (LGATE-002)

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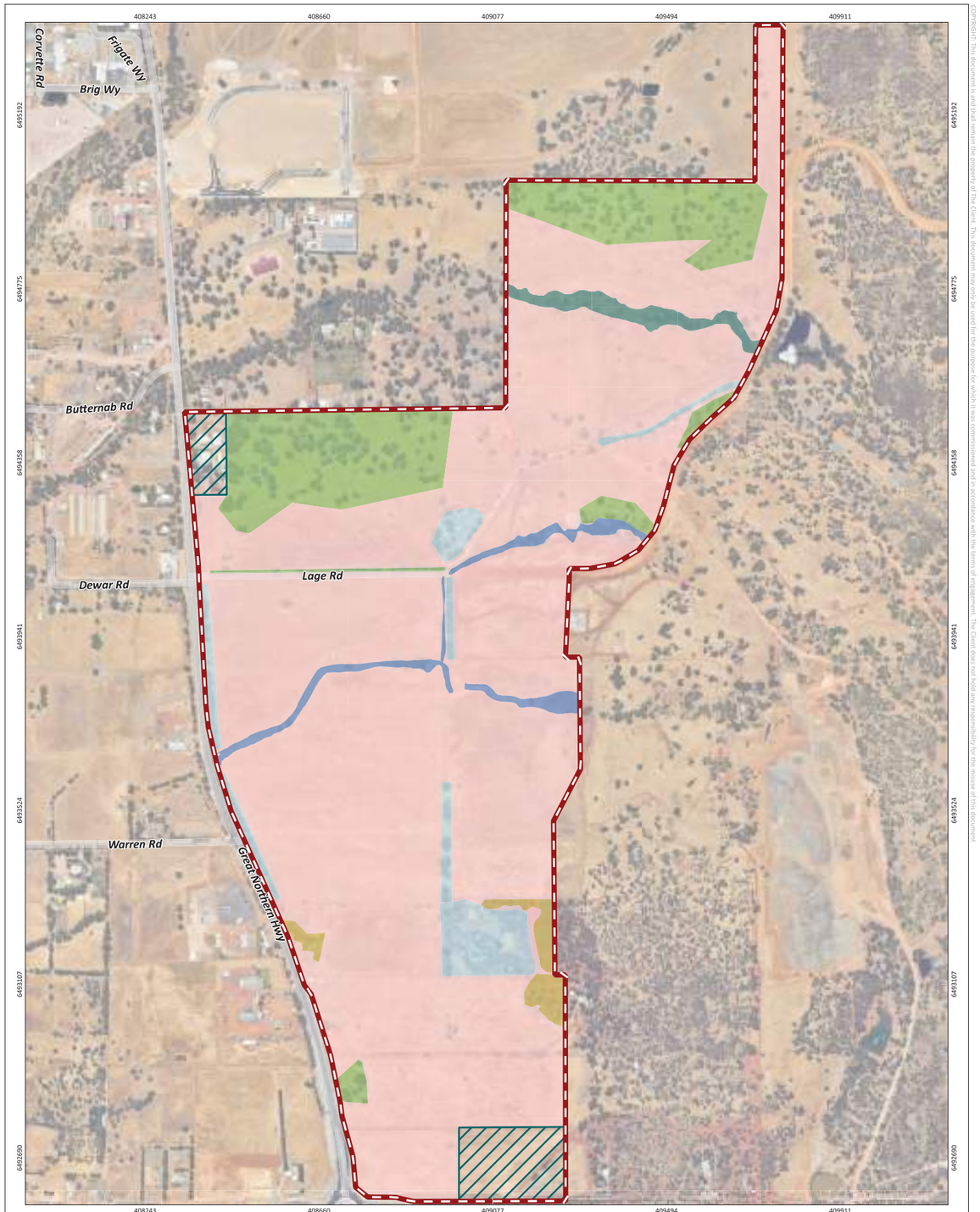

Figure 12: Vegetation Types

N 0 70 140 210 280 m

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook			
SCALE: 1:8,334	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD/PN	DATE: 19/4/2024

Legend

- Survey Area
- Not assessed

Vegetation Type

- VT01 - Marri and Wandoo over paddock
- VT02 - Wandoo over paddock
- Creek - Creek with Flooded Gum
- Drain - Minor drainage line
- Paddock - Paddock with isolated trees
- Planted Trees - Windbreaks, gardens, revegetation

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

NOTES:

Cadastral boundary (LGATE-002) Label corresponds to the vegetation association number.

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Vegetation Condition

All areas of the Survey Area are in Completely Degraded condition (Table 9). The vegetation of the Survey Area has been degraded as a result of historic clearing for agriculture and ongoing grazing.

Table 9: Vegetation Condition Extents (as per EPA, 2016 Condition Scale)

Vegetation Condition	Extent (ha)	Extent (%)
Excellent		
Very Good		
Good		
Degraded		
Completely Degraded	192.75	100
Total	**192.75**	**100**

Threatened Priority Flora

No Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act listed or State BC Act Listed Threatened Flora were recorded in the survey area or were assessed as having a high-medium post survey likelihood of occurrence.

The historical clearing, soil structural breakdown and ongoing grazing leading to removal of the mid and ground stratums have rendered the habitat unsuitable for most native species.

The only portion of the survey area which possessed any ground or mid stratum species is the narrow (3-5m) verge on the northern side of Yarrimbah Drive. The vegetation is in Completely Degraded condition with sparse native plants present. This vegetation was traversed in more detail to identify potential Threatened or Priority Species. The desktop assessment identified that Threatened Species *Grevillea curviloba* is present in the area and that the species can persist in highly degraded road/rail corridors. The species is perennial and grows to 2m tall with distinctive leave characteristics. No *Grevilia sp.* were recorded. Additionally, the typical vegetation soil association (peaty grey sand over limestone) does not match that which is present in the survey area (TSSC, 2016). Based on these factors the species was assessed as having a low likelihood of occurrence.

Due to the season of survey (May) some species identified in the desktop assessment would not have been present/identifiable, however based on assessment of habitat type and quality, is not considered that they are likely to occur.

Flora of other significance

Flora may be considered of other conservation significance if it is considered a novel taxon or represents a range extension. None of the recorded taxa may be considered flora of other conservation significance.

Introduced Flora

As per requirements for a Reconnaissance level survey and considering the survey area comprised entirely of farmland a comprehensive weed list was not prepared. Key observations regarding weeds were:

- Declared Pest and Weed of National Significance (WoNs) species *Asparagus asparagoides* (bridal creeper) is common along the verges of Yarrimbah Drive.
- Declared Pest *Gomphocarpus fruticosus* (cotton bush) was recorded from three large occurrences in open paddocks and drainage lines.

Under the Declared Pest listing by DPIRD these species are required to have some form of management applied by the land holder that will reduce the numbers or distribution of the organism or prevent or contain the spread of the organism. It is recommended that the populations are controlled and soil movement from the affected areas is limited to prevent spread of seed stored in the soil.

5.9 Threatened Ecological Communities

5.9.1 Threatened and Priority Ecological Communities

One State or Commonwealth listed Threatened Ecological Community (TEC) or DBCA listed PEC was identified as potentially occurring.

Potential presence identified for one of three associated TECs occurring on heavy soils on the eastern part of the Swan Coastal Plain (FCT 3a, 3b, 3c as originally described in Gibson et al. 1994). Communities listed as Critically Endangered by State and Endangered by Commonwealth. The potential occurrence comprises of Marri and Wandoo over Paddock running along the narrow (3-5 m) verge on the northern side of Yarrimbah Drive. Potential occurrence covers 0.43 ha.

The site visit assessed this vegetation as Completely Degraded with scattered *Corymbia calophylla* and *Eucalyptus wandoo* over very sparse mid and ground stratum species. Due to time of survey (May) annual species were not present and detectability of perennial species was reduced.

Vegetation is considered potentially not comprising an occurrence of the TEC due to the Completely Degraded condition and having lost most understorey and mid-storey taxa typical of the TEC. A follow up survey during the primary spring season to identify a more comprehensive flora list may be suitable to refine assessment of TEC presence.

5.10 Fauna

5.10.1 Desktop Assessment

Database searches identified 23 conservation listed fauna species potentially occurring within the Survey Area, comprising:

- Seven bird species.
- Nine mammal species.
- Two reptile species.
- Five invertebrate species.

The results of the DBCA Threatened and Priority Fauna database search are shown in Figure 13.

5.10.2 Likelihood of Occurrence

Species listed as Marine only under the EPBC Act, as well as marine dependent bird species have been excluded from the likelihood of occurrence list as there is no marine habitat present.

The likelihood of occurrence for conservation listed fauna species found that:

- Two species had a high likelihood of occurrence.
- One species had a medium likelihood of occurrence.
- Twenty species had a low likelihood of occurrence.

The two species that had a high likelihood of occurrence were:

- *Calyptorhynchus banksii naso* (Forest red-tailed black cockatoo) - Vulnerable.
- *Zanda latirostris* ([Carnaby's black cockatoo] previously *Calyptorhynchus latirostris*) – Endangered.

The one species that had a medium likelihood of occurrence was:

- *Falco peregrinus* (peregrine falcon) - Other Specially Protected Species (OS).

5.10.3 Fauna Habitat Types

Four habitat types were described. These broadly align with the mapped vegetation type boundaries. Fauna habitat types were primarily defined to focus on black cockatoo foraging habitat values. The fauna habitat types are described below in Table 10 and shown in Figure 14.

For possibly occurring conservation listed fauna species, habitat types are assessed as either core, supporting or non-significant habitat. As per Commonwealth Matters of National Environmental Significance – Significant Impact Guidelines 1.1 "core" habitat is defined as that critical to the survival of the species and considered to contain denning/ breeding sites, primary foraging areas and refuge from drought, fire and other stresses (DofE, 2013). "Supporting" habitat is defined as that which is likely used for foraging and dispersing/ connective purposes but is not essential habitat for the continuation of a local population. "Non-significant" habitat is that which would be used only very infrequently for foraging or dispersing. Discussion of habitat type suitability for species identified as having a high or medium likelihood of occurrence is provided in Table 10.

Table 10: Fauna Habitat Type Descriptions within the Survey Area

Fauna Habitat Type	Habitat Description	Area (ha) and % of Survey Area
FHT-01 Isolated Paddock Trees	Scattered paddock trees and denser groves of *Corymbia calophylla* and *Eucalyptus wandoo* over pasture. Lack of mid and ground layer greatly reduces habitat quality. Large mature paddock trees present forming hollows. Foraging evidence from black cockatoo species recorded in several locations from chewed marri nuts. Supporting habitat for: Black cockatoo species (high value foraging trees) Peregrine falcon (foraging)	185.64 ha 96.25%
FHT-02 Planted Eucalypts	Planted areas. Species typically non endemic including Eucalyptus camaldulensis, *Eucalyptus grandis, Corymbia citriodora* and a mix of other small fruited eucalyptus species. Supporting habitat for: Peregrine falcon (foraging).	5.17 ha 2.68%
FHT-03 Sheoak Windbreaks	Dense planted windbreaks of *Casuarina obesa*. Supporting habitat for: Forest red-tailed black cockatoo (high value foraging) Peregrine falcon (foraging)	0.39 ha 0.20%

Fauna Habitat Type	Habitat Description	Area (ha) and % of Survey Area
FHT-04 Wandoo Regrowth	Stands of *Eucalyptus wandoo*. Trees have been previously cleared and are coppicing as multi stem mallee forms. Supporting habitat for: Black cockatoo species (high value foraging) Peregrine falcon (foraging)	1.66 ha 0.86%
Total		192.86 ha

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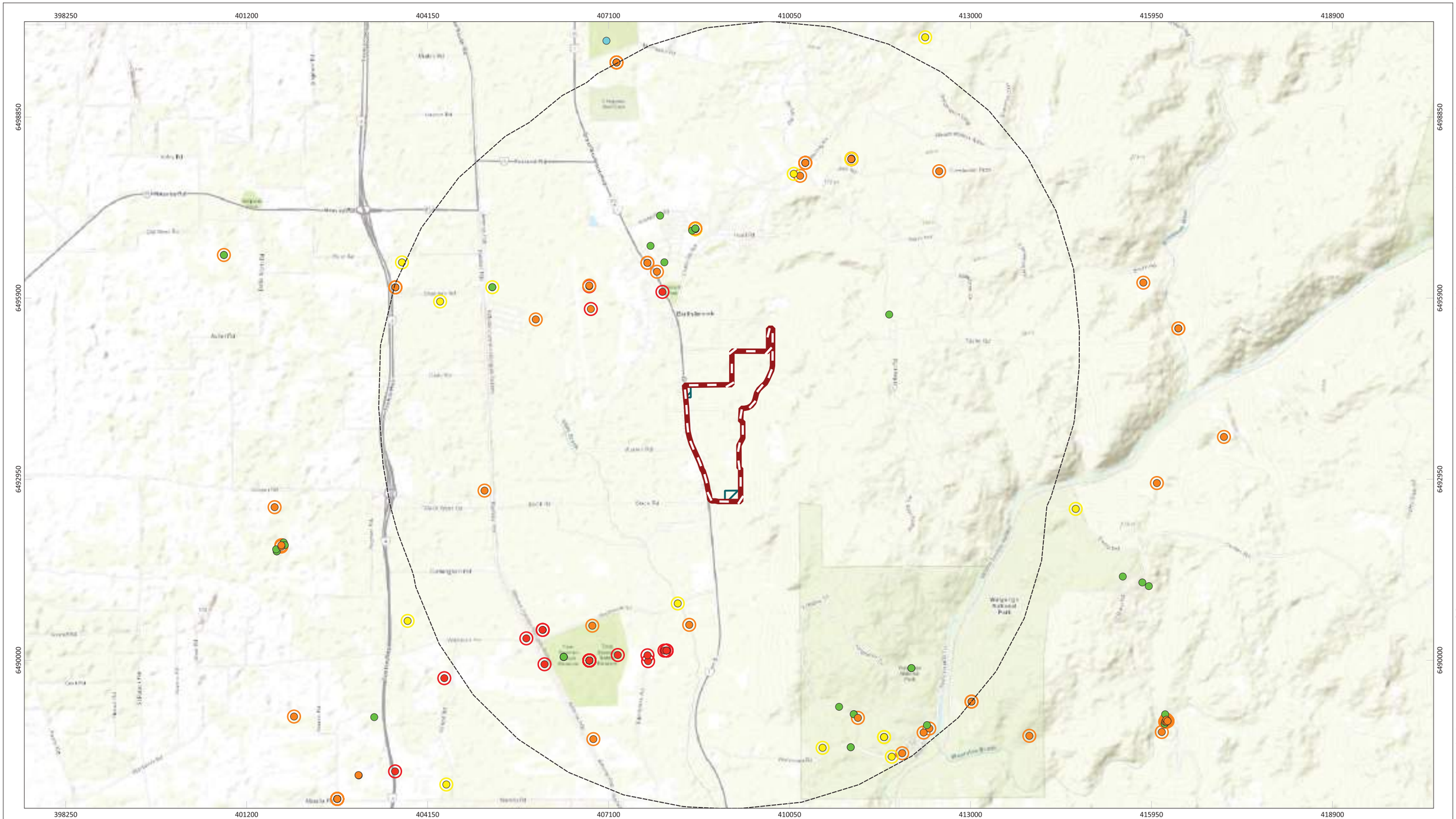

Figure 13: DBCA Database Search Results Fauna

N

0 800 1,600 2,400 3,200 m

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook		
SCALE: 1:58,992	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50	PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023	DRAWN BY / REVIEWED BY: MD/PN	DATE: 19/4/2024

Legend

- Survey Area
- Not assessed

DBCA Fauna Database - WA Status

- Critically endangered species
- Endangered species
- Vulnerable species
- Priority 4
- Other specially protected species

DBCA Fauna Database - EPBC Status

- Critically endangered species
- Endangered species
- Vulnerable species

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

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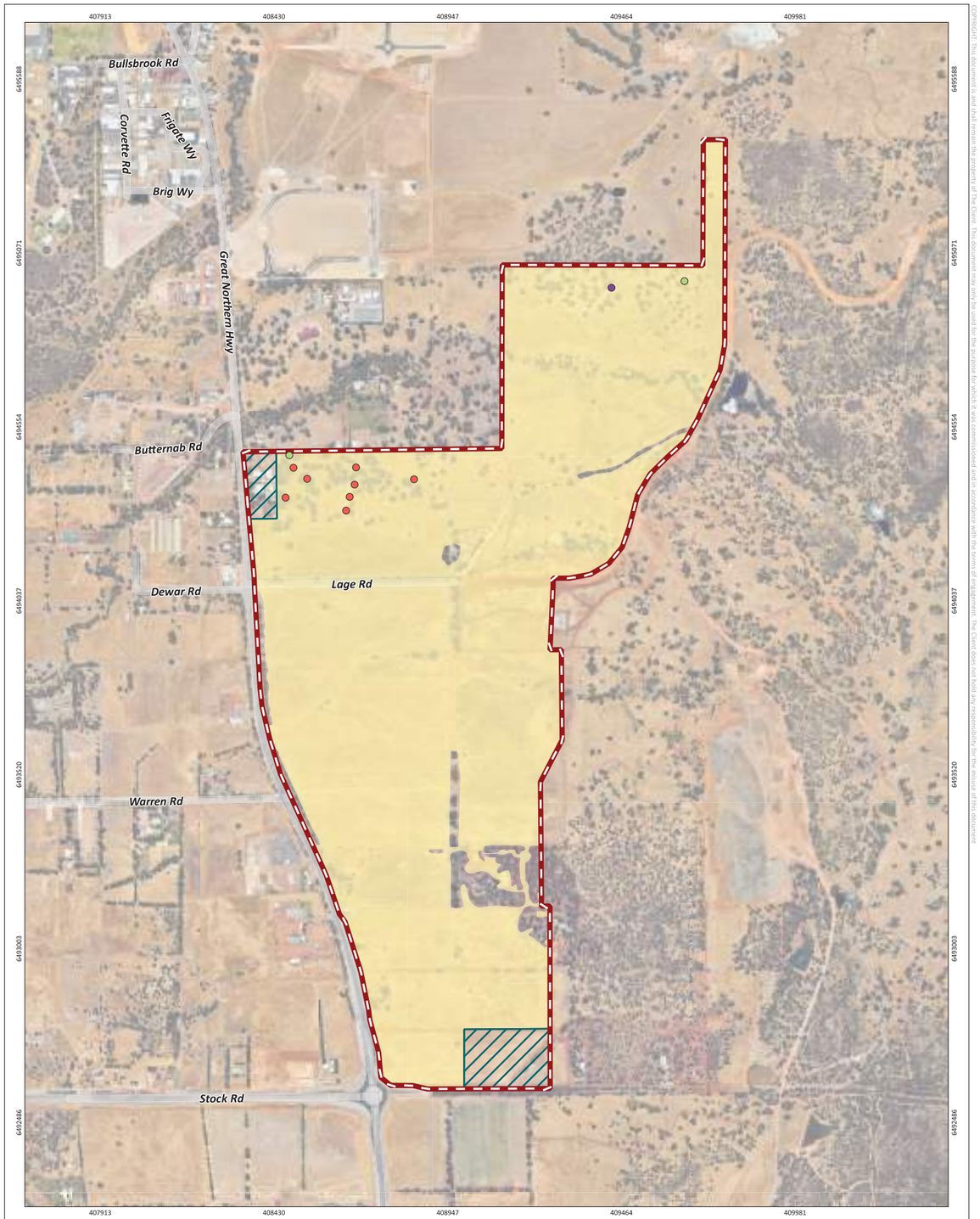

Figure 14: Fauna Habitat Types And Conservation Significant Fauna Observations

5.10.4 Site Assessment

A basic level fauna habitat survey and targeted black cockatoo assessment was undertaken across the Site 23-25 May 2023. A portion of the Site, Lot 400, Lot 2, Lot 5 and Lot 6 Great Northern Highway and the eastern portion of Lot 20 Great Northern Highway (Figure 11) were not assessed as part of this survey. The survey was conducted by suitably qualified ecologists according to standards set out in the Technical Guidance – Terrestrial Fauna Surveys for Environmental Impact Assessment (EPA 2016). A summary of the results of these surveys is provided in the following sections. See Appendix D for full biological survey report.

5.10.5 Observations and Previous Records

The Survey Area falls outside the modelled distribution for Baudin's black cockatoo, within the breeding range for Carnaby's black cockatoo and in the Likely to Occur range for Forest Red-tailed black cockatoo (DCCEEW, 2022). Numerous records for Carnaby's black cockatoo and forest red-tailed black cockatoo were present in DBCA database search results within 5 km of the Survey Area.

A confirmed Carnaby's black cockatoo breeding location is present approximately 13 km northeast of the Survey Area in the Muchea area (DBCA-054). The Survey Area does not overlap with the (12 km) key foraging area buffer of this confirmed breeding location. Three mapped black cockatoo roosting sites are present within 3-5 km to the northeast of the Survey Area (DBCA-64; DBCA-50). All are confirmed Carnaby's black cockatoo roost sites (Roost Code XK27, Bullsbrook, no specific ID code supplied for other two) (DBCA- 64; DBCA-50). (Figure 13).

Foraging evidence (chewed marri nuts) from both Carnaby's and Forest red-tailed black cockatoos were opportunistically recorded during the field survey, with evidence from Carnaby's at eight locations and evidence from Forest red-tailed at three locations. Additionally, calls were heard, and individuals of Forest Red-tailed Black cockatoo were seen flying adjacent to the Survey Area. (Figure 15).

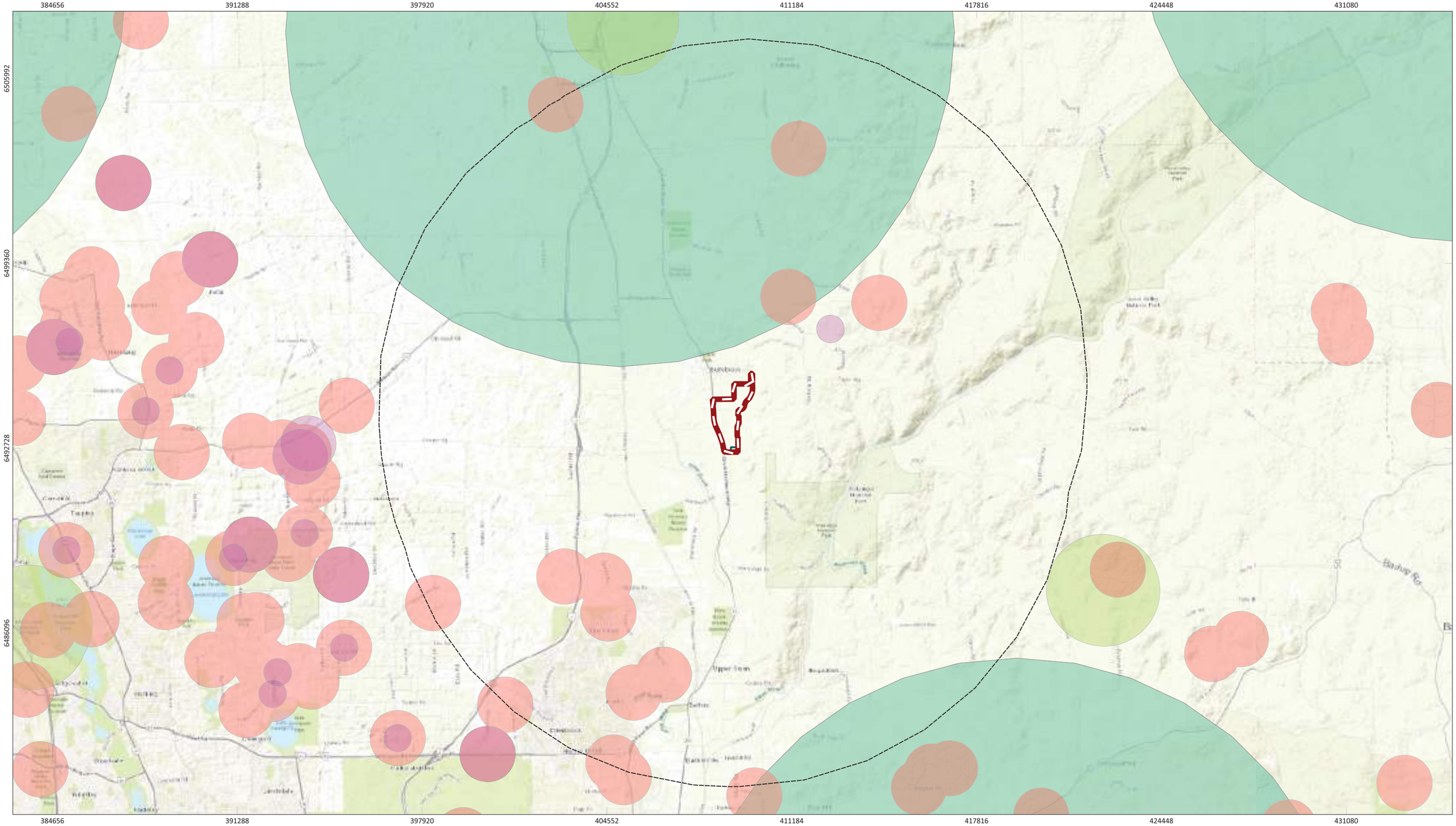

Figure 15: Known Black Cockatoo Roosting and Breeding Sites within 12 km Buffer

N

0 2 4 6 km

SCALE: 1:132,634	SHEET SIZE: A3 COLOUR
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50	
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023	

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook	
CLIENT: Mirvac	
PROJECT NUMBER: A23.028	VERSION: 0
DRAWN BY / REVIEWED BY: MD/PN	DATE: 19/4/2024

Legend

- Survey Area
- Not assessed
- Black Cockatoo Breeding Sites - Buffered (DBCA-063)
- Black Cockatoo Roosting Sites - Buffered (DBCA-064)
- Carnabys Cockatoo Confirmed Breeding Areas within the Swan Coastal Plain and Jarrah Forest IBRA Regions (DBCA-054)
- Carnabys Cockatoo Confirmed Roost Sites (DBCA-050)

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Breeding Habitat Assessment

Potential black cockatoo breeding trees are defined as those which either have a suitable nest hollow or are of a suitable DBH (> 500 mm for most species, >300mm for wandoo and salmon gum) to develop a hollow (DEECCW 2022). Breeding typically occurs in native eucalypt species particularly marri, jarrah, wandoo and tuart however many species of eucalypt including non-endemic species may develop suitable hollows for breeding (DEECCW 2022). A summary of understood suitable nesting hollow characteristics for the three species is provided below in Table 11.

Table 11: Black Cockatoo Nesting Hollow Characteristics

Species	Baudin's Black Cockatoo	Carnaby's Black Cockatoo	Forest Red-tailed Black Cockatoo
Tree species and hollow characteristic	Nesting mainly in karri, marri, jarrah, wandoo, bullich, and tuart. Preferred hollow dimensions have not been specifically studied but are considered likely to be similar to that of the Carnaby's Black cockatoo.	Nesting mainly in salmon gum, wandoo, tuart, jarrah, flooded gum, karri and marri. Utilise hollows from 10-65 cm diameter (average 26 cm) and >1 m deep.	Nesting mainly in jarrah, marri, karri, wandoo, bullich, blackbutt and tuart. Utilise hollow from 12-150 cm diameter (average 34 cm) and >1 m depth.
Sources	DCCEEW, 2022.	DCCEEW, 2022, Saunders et al., 2014a, Saunders et al., 2014b.	DCCEEW, 2022, Johnstone et al., 2013.

A total of 572 potential breeding trees were recorded (Table 12). No evidence of current or previous nesting behaviour such as chew marks at the hollow entrance attributed to black cockatoo of flushed individuals were recorded.

The large majority of potential breeding trees (536 trees) did not show signs of potential nesting hollow development (Class 5 trees). Thirty five trees were reassessed as possessing small hollows which are of an insufficient size to support nesting (<10 cm entrance) or which have an entrance of >10 cm but the internal dimensions are not suitable or the hollow is not accessible (Class 4 trees). These Class 4 trees are however of sufficient age and growth to form breeding hollows.

One marri tree (tree number 551) was assessed as possessing a hollow with sufficient entry diameter to potentially support a suitable nesting hollow (Class 3 trees), the tree is located in the northwest corner of the Survey Area. A detailed inspection of internal dimensions via pole camera was not possible because the hollow was too high up (15m+) to reach with the pole camera. Drone operation is also not permitted in the location due to the very close proximity to RAAF Pearce Airbase runways. The tree has one upwards opening knot type hollow mid trunk with a slit type entrance of 15x 20 cm diameter. The hollow faces south and is accessible to black cockatoos. A nesting galah pair was observed and there is chew markings around entrance to hollow and on trunk attributed to galah. Galah are a recognised nest competitor for black cockatoo with Johnstone and Kirkby (Cataby research project 2004 – 2008) having reported numerous instances of failed breeding attempts attributed to corellas or galahs (Groom, 2010). The presence of galah makes usage by black cockatoo unlikely at the time of survey however the potential suitability of the hollow to support black cockatoo breeding cannot be excluded. A follow up inspection of internal dimensions may be required to allow more detailed understanding of actual suitability (Figure 16).

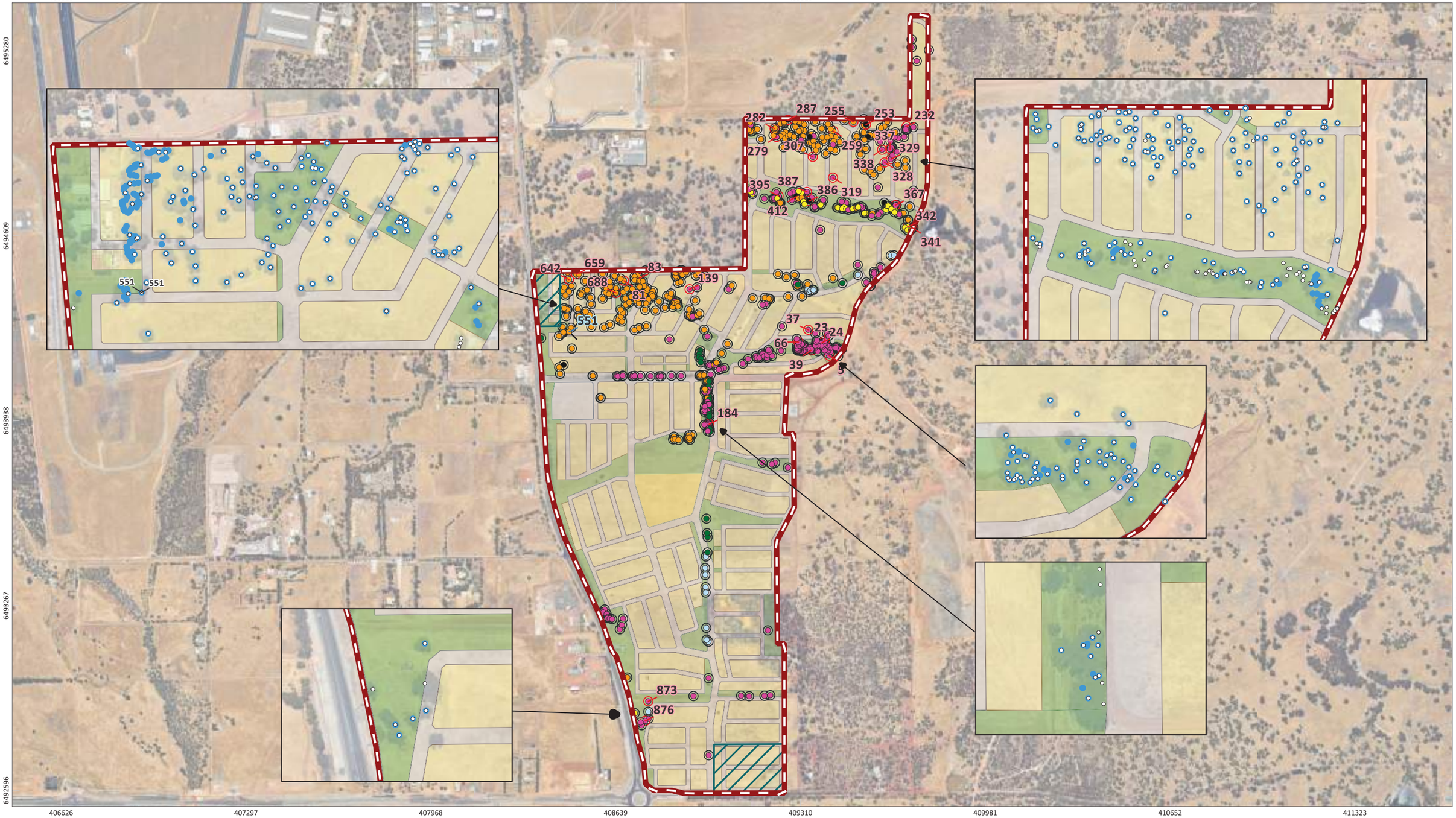

Figure 16: Black Cockatoo Potential Breeding Habitat

N

0 200 400 600 800 m

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook			
SCALE: 1:13,426	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD/PN	DATE: 19/4/2024

Legend

- Survey Area
- Not assessed

Tree Species

- Dead
- Eucalyptus
- Flooded Gum
- Marri
- River Red Gum
- Wandoo

Bamford Tree Class

- 3
- 5
- 4

- Commerical
- Roads
- School
- Public Open Space
- Residential

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

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Table 12: Black Cockatoo Potential Breeding Tree Summary

Tree Species	Class 3	Class 4	Class 5	Total
Dead		4	6	10
Eucalyptus sp. (planted)			26	26
Flooded Gum		2	40	42
Marri	1	8	248	257
River Red Gum (planted)			17	17
Wandoo		21	199	220
Total	1	35	536	572

Foraging Habitat Assessment

The majority of the Survey Area has been historically cleared for pasture. Some areas of remnant isolated trees are present interspersed with paddocks and groves of native or planted non endemic eucalypts. Areas of intact remnant native vegetation habitat are not present.

Foraging habitat comprises primarily marri and wandoo trees with scattered sheoak, pines and a range of small-fruited eucalypts. Marri, pines and to a lesser extent wandoo are high value foraging species for Carnaby's black cockatoo (DCCEEW, 2022; Groom, 2011). Marri, wandoo and sheoak are high value foraging for Forest red-tail black cockatoo (DCCEEW, 2022). Other small-fruited eucalypt species including flooded gum, planted river red gum, rose gum and lemon scented gum are considered species which may be foraged on occasion but are not assessed as high value foraging species.

Where occurring as consistent groves of a tree species foraging habitat was mapped as polygons and is expressed in hectares. Where trees are occurring as scattered paddock trees, individual trees of high value foraging species were recorded and are expressed as individual trees. See Figure 17and Figure 18for foraging habitat extent.

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406626 407297 407968 408639 409310 409981 410652 411323

6495280 6494609 6493938 6493267 6492596

551 551 551

Figure 17: Carnaby's Black Cockatoo Foraging Habitat

N

0 200 400 600 800 m

SCALE	1:13,426
SHEET SIZE	A3 COLOUR
COORDINATE REFERENCE SYSTEM	GDA2020 / MGA zone 50
DATA SOURCE	LANDGATE AERIAL IMAGERY Summer 2023

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook

CLIENT: Mirvac

PROJECT NUMBER: A23.028

VERSION: 0

DRAWN BY / REVIEWED BY: MD/PN

DATE: 19/4/2024

Legend

- Survey Area
- Not assessed

Tree Species

- Dead
- Eucalyptus
- Flooded Gum
- Marri
- Pines
- River Red Gum
- Sheoak
- Wandoo

Tree Species Foraging Value

- High
- Low

- Commerical
- Roads
- School
- Public Open Space
- Residential

No	Description	Drawn	Approved	Date
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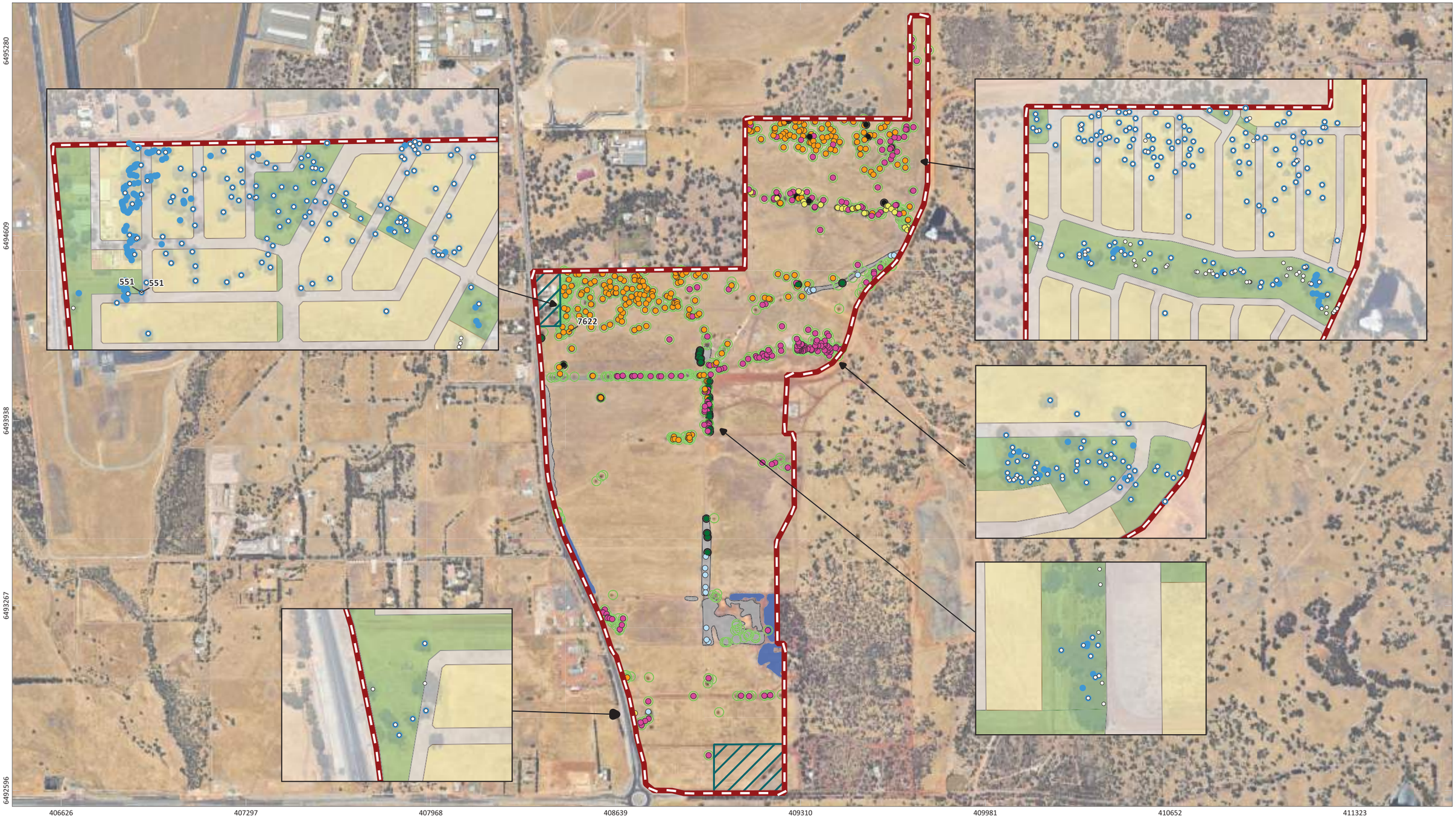

Figure 18: Forest Red-tailed Black Cockatoo Foraging Habitat

N

0 200 400 600 800 m

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE	1:13,426
SHEET SIZE	A3 COLOUR
CLIENT	Mirvac
COORDINATE REFERENCE SYSTEM	GDA2020 / MGA zone 50
PROJECT NUMBER	A23.028
VERSION	0
DATA SOURCE	LANDGATE AERIAL IMAGERY Summer 2023
DRAWN BY / REVIEWED BY	MD/PN
DATE	19/4/2024

Legend

- Survey Area
- Not assessed

Foraging Habitat Score (Bamford, 2018 Scale)

- 2 - Low
- 4 - Moderate

Tree Species Foraging Value

- High
- Low

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

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The Commonwealth referral guidelines provides a foraging quality scoring tool to guide referral information (DCCEEW, 2022). The tool advises that if the Survey Area contains native vegetation used for foraging at any time by a black cockatoo species and is >1 ha in size, that it is considered at face value to be of very high quality and assigned a starting score of 10. The tool then allows for subtractions if attributes are present which reduce the functionality of the foraging habitat. The Commonwealth referral guidelines specify that the tool is to be applied once to the entire impact area even if there is more than one type of foraging habitat present. The calculated foraging habitat quality score is shown below in Table 13. Scores of 5-10 are identified as representing high value foraging habitat.

Table 13: Foraging Quality Scoring Tool (DCCEEW, 2022)

Attribute	Baudin's Black cockatoo	Carnaby's Black cockatoo	Forest Red-tailed Black cockatoo
Starting score	Not in mapped distribution	10- eucalypt woodland/ paddock trees with marri and wandoo	10- eucalypt woodland/ paddock trees with marri and wandoo
Foraging potential (-2 if no foraging evidence)	-	No change, foraging evidence present	No change, foraging evidence present
Connectivity (-2 if no other foraging habitat in 12km)	-	No change, other foraging habitat <12 km away	No change, other foraging habitat <12 km away
Proximity to breeding habitat (-2 if no breeding habitat in 12km)	-	-2 No recorded breeding habitat within 12 km	-2, No recorded breeding habitat within 12 km
Proximity to roosting (-1 if >20km from known night roost)	-	No change, known roosting site <20 km distant	No change, known roosting site <20 km distant
Impact from significant plant disease (-1 if >50% impact)	-	No change, impact from plant disease affecting <50% of foraging plants	No change, impact from plant disease affecting <50% of foraging plants
Total score	NA	8	8

The Black cockatoo referral guidance allows for the inclusion of additional information for foraging habitat which may be considered during an assessment, such as the extent and density of recognised foraging plants within a Survey Area. As an additional source of information, WEPL provides an assessment of foraging habitat quality using a scoring tool developed by Dr Mike Bamford in 2018 to produce a numerical foraging habitat score value for each identified habitat type. For fauna habitat type FHT_01 Isolated Paddock Trees and FHT_02 Planted Eucalypts it was considered more appropriate to mark individual high value foraging trees and present the foraging habitat score as a number of trees within the extent The WEPL foraging habitat score and tree counts are summarised below in Table 14 and Table 15.

Table 14: High Value Foraging Tree Count

Tree Species	Count	Carnaby's High Value Foraging Trees	Forest Red-Tailed High Value Foraging Trees
Marri	459	Y	Y
Pines	5	Y	-
Sheoak	18	-	Y
Wandoo	307	Y (lower value than marri)	Y
Total	789	771	784

Table 15: Combined Foraging Habitat Score

Habitat Type	Carnaby's Foraging Habitat Score	Forest Red-Tailed Foraging Habitat Score	Justification	Area (ha) and % of Survey Area
FHT_01	See individual high value tree counts.		Isolated paddock trees with high value trees individually marked and counted	185.64 96.25%
FHT_02	Low-2 (both species) Individually marked DBH trees are captured in tree counts		Planted small fruit eucalypts, mainly river red gum. High value trees (DBH trees) individually marked and counted	5.17 2.68%
FHT_03	Low-2	Moderate-4	Sheoak windbreak	0.39 0.20%
FHT_04	Low-Moderate- 3	Moderate-4	Wandoo regrowth woodland	1.66 0.86%
Total	Low=5.56 ha Low-Moderate=1.66 ha 771 high value trees	Low=5.17 ha Moderate=2.06 784 high value trees		192.86 100%

*Application of foraging habitat quality scoring: 0- None; 1-2-Low; 3-Low Moderate; 4- Moderate; 5-Moderate to High; 6- High; 7-10 Very High.

For the purpose of quantifying quality black cockatoo foraging habitat, Low quality habitat is excluded from further consideration of black cockatoo foraging values.

Within the Survey Area there is 1.66 ha of Low-Moderate quality Carnaby's Black Cockatoo foraging habitat and 2.06 ha of Moderate quality Forest Red-tailed Black Cockatoo foraging habitat (FHT_02, 03, and 04) mapped as polygons. In addition, there are 789 individually marked high value foraging paddock trees. Based on area mapped, this represents approximately 0.008 % of the estimated regional habitat extent. The habitat quality within the Survey Area is considered likely to be of similar quality than much of the regional foraging

habitat, which includes high quality banksia woodlands of the Bassendean Complex sandplains and the jarrah and marri forests of the Darling Scarp.

Analysis of estimated foraging habitat extent within the local area was also undertaken to provide further context. The estimated extent of foraging habitat is calculated for a buffer of 12 km around and including the Survey Area. This buffer is selected as recommended in the Commonwealth referral guidelines due to black cockatoos mainly foraging within 12 km of their nest site during the breeding season and their reliance on this proximity of foraging resources to successfully raise chicks (DCCEEW, 2022).

Analysis considers Remnant Native Vegetation Extent mapping (DPIRD-005) and Vegetation Complexes-Swan Coastal Plain and South West forest region (DBCA-046 and DBCA-047). See summary of regional vegetation complexes and extents in Table 16.

Analysis indicates there is 23,338 ha of remnant native vegetation mapped within a 12 km buffer of the Survey Area. It is expected that the majority of this vegetation would contain suitable foraging species at the same or greater rate than that present within the Survey Area. Much of this regional remnant native vegetation occurs within the Jarrah Forest to the east and regional park and nature reserves.

Table 16 Regional Foraging Habitat Extent

Vegetation Complex	Remnant Extent (ha)
Bassendean Complex-Central and South	0.43
Bassendean Complex-North	5763.44
Bassendean Complex-North Transition	703.36
Beermullah Complex	371.09
Coolakin, Ck	354.15
Coonambidgee Complex	6.70
Darling Scarp, DS2	1013.53
Dwellingup, D2	1391.51
Dwellingup, D3	551.30
Dwellingup, D4	607.66
Forrestfield Complex	131.68
Guildford Complex	227.43
Helena 2, He2	6807.51
Mogumber Complex-South	950.36
Murray 2, My2	1530.15
Pindalup, Pn	121.63
Reagan Complex	545.38
Southern River Complex	87.80
Swan Complex	128.12
Williams, Wi	0.09
Yalanbee, Y6	1018.04
Yanga Complex	883.47
Yarragil 1, Yg1	144.03
Grand Total	23,338.85

Roosting Habitat Assessment

Known roost sites are present 3.5 km northeast and 6.7 km southwest of the Survey Area (DBCA-064). No evidence of night roosting (e.g. piles of scats, feeding debris or chewed trees) were recorded within the Survey Area.

Night roosting locations are typically in proximity to foraging habitat (Black cockatoos mainly foraging within 20km of night roosts) and with access to water points <2km from roosting location (DCCEEW, 2022). Any groups of tall trees, particularly large native eucalypts in proximity to water sources may provide night roosting habitat (DCCEEW, 2022). Throughout the Survey Area, isolated stands of tall (> 10 m) eucalypts are

scattered which may provide suitable roosting habitat. Adjacent bush lands with foraging potential were located < 4 km from the Survey Area and access to permanent water was present from farm dams and the Ellen Brook (DWER-031) that flows 2 km west of the Survey Area.

5.10.6 Total Black Cockatoo habitat

As described in Section 5.10.5, there is an overlap between the potential breeding (DBH>500mm) and high quality foraging habitat. This is shown in Table 17.

Table 17: Black cockatoo trees within the Survey Area.

Black Cockatoo Trees	Count
High Value Forage Tree (only)	312
Potential Breeding Tree (only)	95
Both High Value Forage and Potential Breeding Tree	477
Total	884

5.10.7 Threatened and Priority Fauna

Black cockatoo species were subject to a specific habitat assessment as per the Commonwealth referral guidelines (DCCEEW, 2022) which is presented below. Foraging evidence (chewed marri nuts) from both Carnaby's and Forest red-tailed black cockatoo were recorded from several locations. A group of forest red-tailed black cockatoo was also observed flying over the Survey Area.

There were no other observations of, or secondary evidence recorded for Threatened or Priority fauna within the Survey Area and no core or supporting habitat is present. The degraded condition and lack of a shrub or ground layer results in the Survey Area providing limited habitat value to most species.

Fauna species of conservation significance which were recorded or assessed as having a high or medium likelihood of occurrence are discussed in detail below:

- *Falco peregrinus* (peregrine falcon) – Other Specially Protected Species (OS)

  This species is uncommon but wide-ranging across Australia. Habitat is extremely diverse, comprising most dryland habitats of Australia. The peregrine falcon nests primarily on ledges of cliffs, shallow tree hollows, and ledges of buildings or antennas. No breeding or core habitat is present, but all habitat types of the Survey Area may be used as supporting habitat for foraging on occasion with the species an infrequent visitor.

5.11 Conservation Areas

5.11.1 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are declared by the Department of Water and Environmental Regulation (DWER) to prevent the degradation of important environmental values such as Threatened Flora, Threatened Ecological Communities (TECs) or significant wetlands.

No ESAs intersects with the Survey Area (DWER-046). The closest ESA is 890 m northwest of the Survey Area (ID 10109) and is associated with a TEC (Figure 19)

The Survey Area is not identified as intersecting a Conservation Area (DBCA-011). The nearest conservation area is:

- Walyunga National Park (R 2065) located approximately 2.6 km to the southeast.

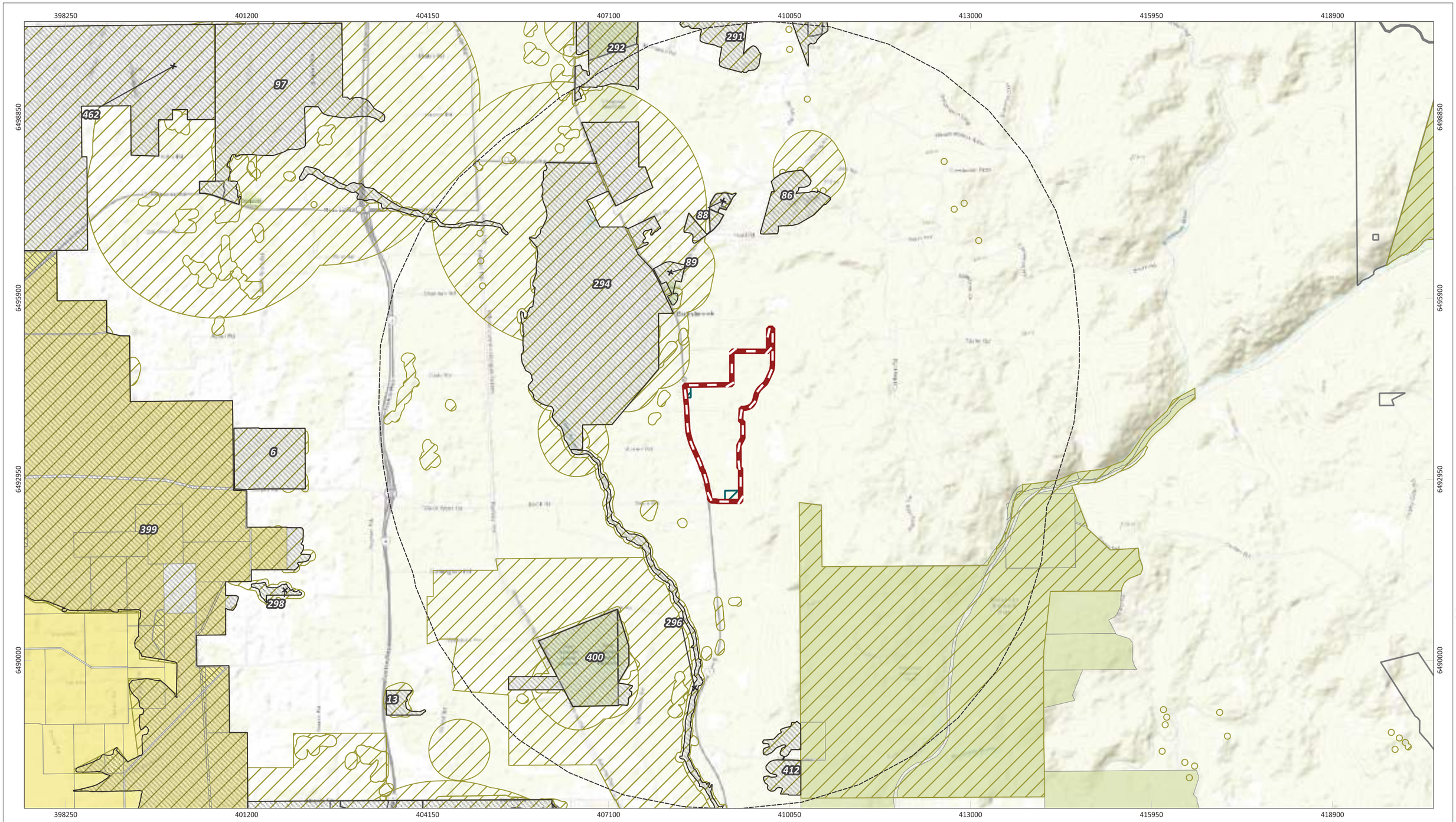

Figure 19: Environmentally Sensitive Areas, Conservation Estate and Bush Forever

N

0 800 1,600 2,400 3,200 m

SCALE: 1:58,992	SHEET SIZE: A3 COLOUR	PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook	
		CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD/PN	DATE: 19/4/2024

Legend

- Site Location
- Not assessed
- Bush Forever Areas - 2000 (DPLH-019)
- Clearing Regulations - Environmentally Sensitive Areas (DWER-046)

DBCA - Legislated Lands and Waters (DBCA-011)

- National Park
- Nature Reserve
- State Forest

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022. Label corresponds to the Bush Forever Areas Site ID

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5.12 Bushfire Risk

The Department of Fire and Emergency Services, Map of Bushfire Prone Areas (2021) indicates that portions of the Site are mapped as 'Bush Fire Prone' (Figure 20).

A Bushfire Management Plan (BMP) has been prepared by Bushfire Prone Planning (2023) to address requirements under Policy Measure 6.3 of State Planning Policy 3.7 Planning in Bushfire-Prone Areas (SPP 3.7; WAPC 2015) and Guidelines for Planning in Bushfire-Prone Areas (the Guidelines; WAPC 2021).

Recommendations made in the BMP include the following:

Developer

- A notification, pursuant to Section 165 of the Planning and Development Act 2005, is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows:

  "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". (Western Australian Planning Commission)

- Construct the public roads, including any no through roads and perimeter roads, to comply with the technical requirements referenced in the BMP.

- Construct emergency access ways, fire service access routes and associated signs and gates to comply with the technical requirements referenced in the BMP.

- Install the reticulated firefighting water supply and hydrants to comply with the technical requirements referenced in the BMP.

Developer/Landowner

- Prior to relevant building work, inform the builder of the existence of this approved Bushfire Management Plan (BMP). The plan identifies that the development site is within a designated bushfire prone area and states the indicative (or determined) BAL rating(s) that may (or will) be applied to buildings/structures. A BAL assessment report may be required to confirm determined ratings and will be required when ratings are indicative. BAL certificates will need to be issued to accompany building applications.

  The BMP may also establish, as an additional bushfire protection measure, that construction requirements to be applied will be those corresponding to a specified higher BAL rating. Compliance with the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), will require certain bushfire resistant construction requirements be applied to residential buildings in bushfire prone areas (i.e., Class 1, 2 and 3 and associated Class 10a buildings and decks). Other classes of buildings may also be required to comply with these construction requirements when established by the relevant authority or if identified as an additional bushfire protection measure within the BMP.

  The deemed to satisfy solutions that will meet the relevant bushfire performance requirements are found in AS 3959 – Construction of Building in Bushfire Prone Areas (as amended) and the NASH Standard - Steel Framed Construction in Bushfire Areas (as amended).

- Prior to sale of the subject lots, each individual lot is to be compliant with current version of the City of Swan Fire Hazard Reduction Notice issued under s33 of the Bushfires Act 1954.

This may include standards for asset protection zones that differ from Schedule 1 in the Guidelines DPLH, 2021 v1.4, with the intent to better satisfy local conditions.

- There is an outstanding obligation, created by this Bushfire Management Plan, for a site-specific Bushfire Management Plan at the future subdivision or development stage/s for the land use, at the subsequent subdivision/development application stage.

Landowner

- Maintain the 'Required' Asset Protection Zone (APZ) around habitable buildings (and other structures as required) to satisfy:
    - The minimum required dimensions established in Appendix B1.
    - The standards established by the Guidelines DPLH, 2021 v1.4, Schedule 1, or as varied by the local government through their annually issued firebreak / hazard reduction notice when the variations have been endorsed by the WAPC and DFES as per s4.5.3 of the Guidelines.
- Comply with the City of Swan Fire Hazard Reduction Notice issued under s33 of the Bush Fires Act 1954. Check the notice annually for any changes.
- Maintain vehicular access routes within the lot to comply with the technical requirements referenced in the BMP and the relevant local government's annual firebreak / hazard reduction notice.
- Ensure that builders engaged to construct dwellings/additions and/or other relevant structures on the lot, are aware of the existence of this approved Bushfire Management Plan (BMP). The plan identifies that the development site is within a designated bushfire prone area and states the indicative (or determined) BAL rating(s) that may (or will) be applied to buildings/structures.

  A BAL assessment report may be required to confirm determined ratings and will be required when ratings are indicative. BAL certificates will need to be issued to accompany building applications.

  Compliance with the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), will require certain bushfire resistant construction requirements be applied to residential buildings in bushfire prone areas (i.e., Class 1, 2 and 3 and associated Class 10a buildings and decks). The deemed to satisfy solutions that will meet the relevant bushfire performance requirements are found in AS 3959 – Construction of Building in Bushfire Prone Areas (as amended) and the NASH Standard - Steel Framed Construction in Bushfire Areas (as amended).

  As an additional bushfire protection measure, other classes of buildings may also be required to comply with these construction requirements when established by the relevant authority or if identified as an additional bushfire protection measure within the BMP. The BMP may also establish that construction requirements to be applied will be those corresponding to a specified higher BAL rating.

- Ensure all future buildings the landowner has responsibility for, are designed and constructed in full compliance with:
    - The bushfire resistant construction requirements of the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), as established by the Building Regulations 2012 (WA Building Act 2011).
    - Any additional bushfire protection measures this Bushfire Management Plan has established are to be implemented.

Local Government

- Monitor landowner compliance with the annual Fire Hazard Reduction Notice and with any bushfire protection measures that are:
    - Established by this BMP.
    - Are required to be maintained by the landowner/occupier.
    - Are relevant to local government operations.

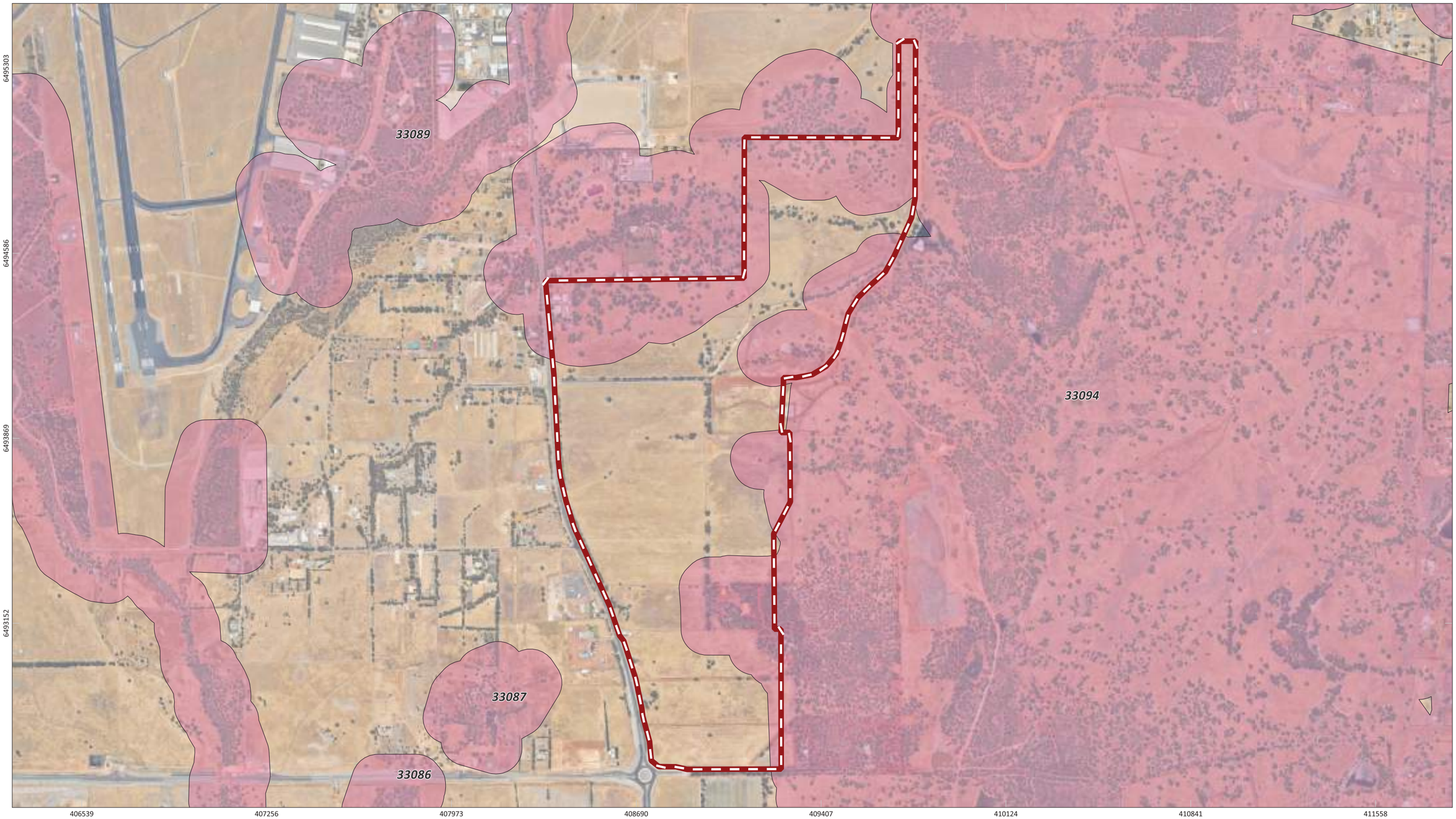

Figure 20: Bush Fire Prone Areas

N

0 200 400 600 800 m

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE: 1:14,347	SHEET SIZE: A3 COLOUR
CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50	PROJECT NUMBER: A23.028 / VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023	DRAWN BY / REVIEWED BY: MD / PN / DATE: 19/4/2024

Legend

- Site Location
- Bush Fire Prone Areas 2021 (OBRM-019)

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022

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5.13 Heritage

A search on the Department of Planning, Lands and Heritage, Aboriginal Heritage Places (DPLH) (2023) shows that the entire Site is mapped as 'Mythological', Place ID:3525, the northern edge is mapped as 'Ceremonial/Modified Tree/Mythological', Place ID:3583 and the central area is mapped as 'Artefacts/Scatter', Place ID:4362. (Figure 21).

The Site has been pre-referred to the South West Aboriginal Land and Sea Council (SWALSC) as part of the MRS Amendment process and no comment has been received to date.

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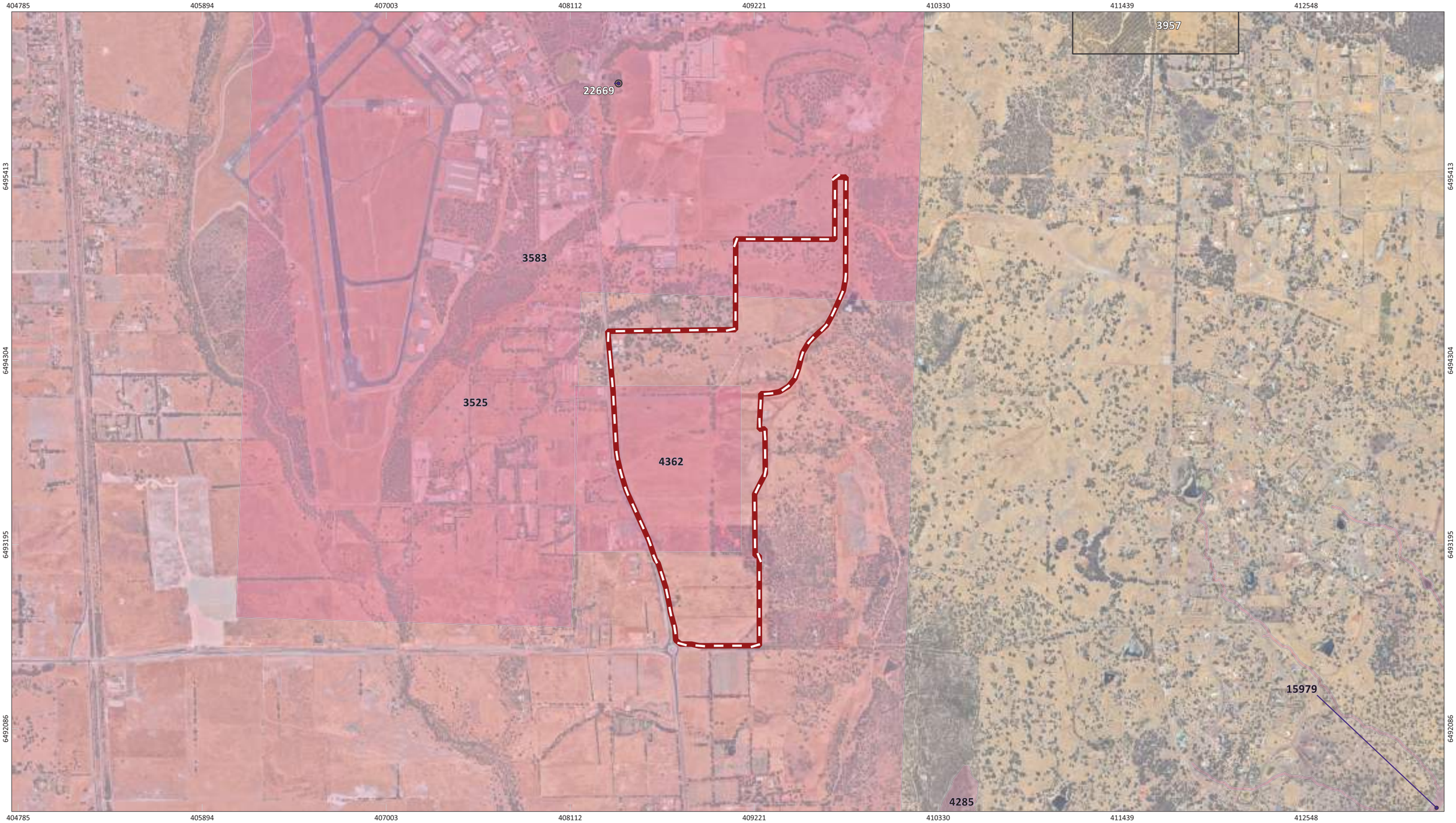

Figure 21: Aboriginal Heritage

N

0 300 600 900 1,200 m

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE: 1:22,171	SHEET SIZE: A3 COLOUR
CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50	PROJECT NUMBER: A23.028 / VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023	DRAWN BY / REVIEWED BY: MD / PN / DATE: 19/4/2024

Legend

- Site Location
- Aboriginal Cultural Heritage - Register (DPLH-099)
- Aboriginal Cultural Heritage - Lodged (DPLH-100)

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	19/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022. UFID stands for Unique Identifier

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6. Potential Impacts, Mitigation, Management and Recommendations

Potential impacts of mitigation and management approaches identified for the proposal are summarised below.

6.1 Surrounding Land use

6.1.1 Landfill Facility

The Landfill Facility to the north of the Site has been closed with the last waste received in November 2018. It is considered that the Landfill Facility does not pose a constraint to the lifting of the Urban Deferred zoning of the South Bullsbrook Urban Expansion Area as part of the MRS Amendment or to the development of the Structure Plan and future development of the land. The Landfill Closure and Post-Closure Management Plans were submitted to DWER in October 2023. The licence has been amended to reflect these reports and the footprint of the prescribed premises reduced.

6.1.2 Clay Extraction

The approved Midland Brick Clay extraction Mines operate, or are proposed to operate with existing sensitive land uses within 500 m. The current operational Mine S0005451 (Stage 1), has a residence 460 m from the boundary of approved mining operations. Stage 2, Mine S0023488 has a residence 120 m from the boundary of approved mining operations.

A review of decisions relevant to similar clay extraction operations has identified that a buffer of 500m or less is acceptable to the EPA and has not resulted in an assessment by the EPA. The EPA has previously approved proposals for clay extraction operations in 2016 (CMS15304) and 2019 (CMS17634), where the separation buffer was less than 500 m and the overall environmental impact was assessed as not significant.

As shown in Figure 4, a 500 m buffer for Clay extraction Mines (S0005451, S0023488 and S002389) intersects approximately 4.02 ha of the Site.

It is presented that the separation distance is appropriate and provides sufficient separation to future development. The buffer intersects with proposed Public Open Space and road reserves with the closest separation distance from Residential zoned land being 435 m. The Midland Brick Clay extraction Mines were approved with exiting sensitive receptors at 120 m and 460 m, which is less than the separation distance of the proposed residential lots. Management measures implemented by Midland Brick in the operation of the Mines are established to achieve acceptable outcomes for those sensitive receptors and will therefore act to manage risks for the proposed future development.

6.2 Hydrology

The proposed foreshore reserve of the Nambad Brook (Figure 9) takes into account the biophysical features of the watercourse. The assessed values were confined to the area mapped as a defined waterway and the riparian vegetation identified during the site assessment, no other biophysical elements specifically contribute to the definition of the Nambad Brook and it is not identified as a wetland, a minor river or significant steam. As such the foreshore reserve has been denoted by drainage channel and the riparian vegetation and provides for the retention of vegetation as per the EPA advice given in 2017, which states the following:

- Where possible, remnant vegetation should be retained, particularly remnant vegetation along the Nambad Brook which provides potential habitat for Carnaby's Black Cockatoos.

The urban design concept plan has been informed by the proposed foreshore reserve and the City of Swan Local Biodiversity Strategy (2015) and allows for the Nambad Brook to be completely contained within the Public Open Space on the development concept plan, as shown in Figure 9.

A Foreshore Management Plan will be developed for the portion of Nambad Brook within the Site. The Foreshore Management Plan will describe rehabilitation of the highly degraded foreshore area. Whist ensuring the foreshore area adequately supports urban water management for the Site and does not exacerbate bushfire risk, the revegetation of the foreshore will include a significant number of trees that will partially address the loss of Black Cockatoo habitat trees on the Site.

6.3 Flora Vegetation and Fauna

6.3.1 Flora and vegetation

The vegetation is not sufficiently intact for the flora and vegetation values being sufficient to inform urban design for avoidance, mitigation and management purposes. The key matters relevant to the Site are the presence of a declared weed and the fauna value of the vegetation present.

Pest Management for Declared Pest and Weed of National Significance (WoNs) species Asparagus asparagoides (bridal creeper) is common along the verges of Yarrimbah Drive and declared Pest *Gomphocarpus fruticosus* (cotton bush) was recorded from three large occurrences in open paddocks and drainage lines.

Under the Declared Pest listing by DPIRD these species are required to have some form of management applied by the land holder that will reduce the numbers or distribution of the organism or prevent or contain the spread of the organism. It is recommended that the populations are controlled and soil movement from the affected areas is limited to prevent spread of seed stored in the soil.

6.3.2 Fauna

A total of 572 potential breeding trees were recorded, the large majority of black cockatoo potential breeding trees (536 trees) did not show signs of potential nesting hollow development (Class 5 trees). No evidence of current or previous nesting behaviour such as chew marks at hollow entrance attributed to black cockatoos, or flushed individuals was recorded.

The Thirty-five trees were assessed as possessing small hollows which are of an insufficient size to support nesting (<10cm entrance); or which have an entrance of >10cm but the internal dimensions are not suitable, or the hollow is not accessible (Class 4 trees). These Class 4 trees are however of sufficient age and growth form to be developing hollows.

One marri tree (tree number 551) was assessed as possessing a hollow with sufficient entry diameter to potentially support a suitable nesting hollow (Class 3 trees). A follow up inspection of internal dimensions may be required to allow more detailed understanding of actual suitability.

The concept plan for the development has sought to retain potential black cockatoo breeding trees and high quality black cockatoo foraging habitat located on the site within the foreshore reserve of the Nambad Brook, public open space and Yarrimbah Drive Reserve, including tree number 551 (Figure 22). Future engineering works will take this into consideration as part of the planning process.

The placement of the POS in the concept plan has been designed to retain the maximum extent of high quality black cockatoo habitat within the Site. Based on the concept plan presented in Figure 22, the following habitat values are proposed to be avoided:

- 449 trees retained within POS and Yarrimbah Drive Reserve, as shown in Table 19, including:
    - 232 trees identified as both high value foraging and potential breeding trees.
    - 148 identified as high value foraging trees only.
    - 69 trees identified as potential breeding trees only.

The residual impact of black cockatoo habitat after avoidance is:

- Potential loss of 435 trees, including:
    - 245 trees identified as both high value foraging and potential breeding trees.
    - 164 trees identified as high value foraging trees only.
    - 26 trees identified as potential breeding trees only.

Measures to mitigate impacts associated with the proposed development, beyond retention of habitat as POS and the Yarrimbah Drive Reserve, include:

- the implementation of the foreshore management plan of the Nambad Brook.
- the development committing to a revegetation strategy of replanting at a 1:1 ratio.
- Street trees planted at an average density at one per lot, if 25% of street trees are black cockatoo trees this will increase the replantation ratio to 2:1.

Table 18: Black cockatoo trees within the Concept Plan

Black Cockatoo Trees	POS	Yarrimbah Drive Reserve	Residential	Road	Total
High Value Forage Tree (only)	107	41	124	40	**312**
Potential Breeding Tree (only)	68	1	14	12	**95**
Both High Value Forage and Potential Breeding Tree	210	22	150	95	**477**
Total	**385**	**64**	**288**	**147**	**884**

The impacts associated with the proposed development and due to black cockatoos being listed under the EPBC Act, black cockatoo habitat present within the Site is considered a Matter of National Environmental Significance (MNES) under the Act. Consideration of EPBC obligations will be made at future planning and development stages.

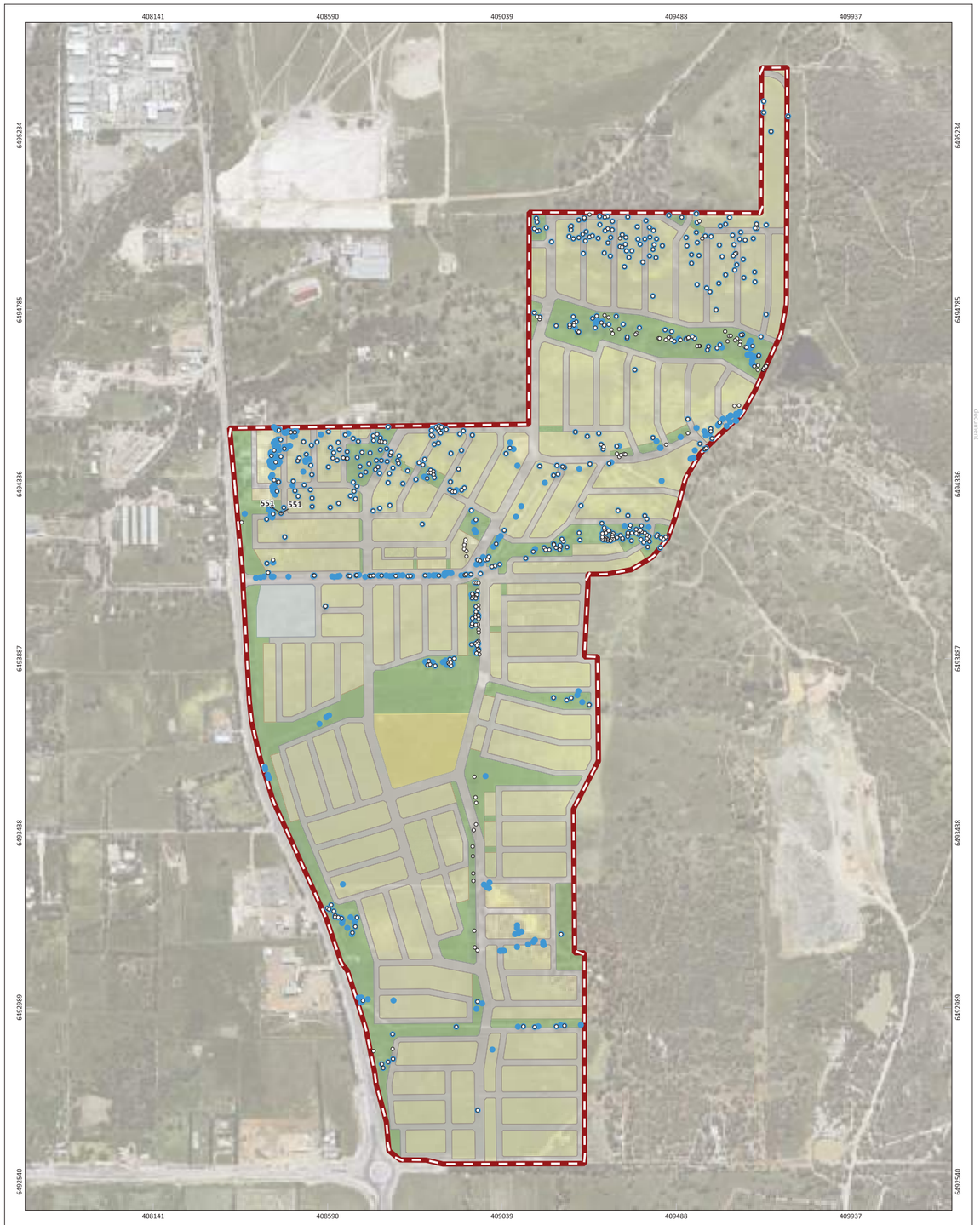

Figure 28: Black Cockatoo Habitat

0 75 150 225 300 m
N

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE	1:8,983
SHEET SIZE	A3 COLOUR
CLIENT	Mirvac
COORDINATE REFERENCE SYSTEM	GDA2020 / MGA zone 50
PROJECT NUMBER	A23.028
VERSION	0
DATA SOURCE	LANDGATE AERIAL IMAGERY Summer 2023
DRAWN BY / REVIEWED BY	MD / PN
DATE	5/4/2024

Legend

- Survey Area
- Potential Breeeding Trees
- High Value Forage Trees
- Commerical
- Roads
- School
- Public Open Space
- Residential

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	5/4/2024

NOTES:
Cadastral boundary (LGATE-002)

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7. Recommendations and Conclusions

This environmental assessment has identified environmental values on the Site and potential constraints to future development, which may require further investigation or management. Recommendations and conclusions are provided below.

- Further investigation into additional groundwater resources that will be needed to service irrigation needs. This will be addressed as under the Local Water Management Strategy.
- It is presented that the 435 m buffer and management measures implemented by Midland Brick will achieve acceptable outcomes for those sensitive receptors within the 500 m buffer. The 435m buffer for Clay extraction Mine (S000545) provides appropriate separation distance to future residents.
- Pest management for declared Pest and Weed of National Significance (WoNs) species *Asparagus asparagoides* (bridal creeper) and declared Pest *Gomphocarpus fruticosus* (cotton bush) to control the populations and soil movement from the affected areas is limited to prevent spread of seed stored in the soil.
- A follow up inspection of one marri tree (tree number 551) for internal dimensions of may be required to allow more detailed understanding of actual suitability.
- Nambad Brook foreshore reserve is completely contained within Public Open Space and serves to retain vegetation in line with recommendations made by the EPA and the City of Swan Local Biodiversity Strategy.
- The concept plan for the development has been informed by environmental values of Site and these are reflected in the retention of vegetation within the Nambad Brook foreshore reserve, Public Open Space and road reserves.
- Measures to mitigate impacts associated with the proposed development, beyond retention of habitat as POS and the Yarrimbah Drive Reserve, include:
    - the implementation of the foreshore management plan of the Nambad Brook.
    - the development committing to a revegetation strategy of replanting at a 1:1 ratio.
    - Street trees planted at an average density at one per lot, if 25% of street trees are black cockatoo trees this will increase the replantation ratio to 2:1.
- Consideration of EPBC obligations to be made at future planning and development stages that are assessed to likely significantly impact black cockatoo species.

8. References

Beard, J. S. (1976). Vegetation Survey of Western Australia. Western Australia 1: 1 000 000 Vegetation Series. Design and cartography by Dept. of Geography, University of W.A.

Bushfire Prone Planning. (2023). Bushfire Management Plan (BMP) - Bullsbrook South.

City of Swan. (2015). Local Biodiversity Strategy.

Department of Agriculture Water and the Environment. (2022b). Weeds of National Significance. https://weeds.org.au/.

Department of Biodiversity Conservation and Attractions (DBCA). (2023a). Methods for survey and identification of Western Australian threatened ecological communities.

Department of Biodiversity Conservation and Attractions (DBCA). (2023b). Threatened and Priority Fauna List. Retrieved on 5 September 2022 from https://www.dpaw.wa.gov.au/plants-and-animals/Threatened-species-and-communities/Threatened-animals.

Department of Climate Change, Energy, the Environment and Water (DCCEEW). (2022). Referral Guidelines for 3 Threatened Black Cockatoo Species.

Department of Climate Change, Energy, the Environment and Water (DCCEEW). (2022a). Protected Matters Search Tool. Retrieved on 13 February 2023 from http://www.environment.gov.au/webgisframework/apps/pmst/pmst.jsf.

Department of Primary Industries and Regional Development (DPIRD). (2022). Declared Plants. https://www.agric.wa.gov.au/organisms.

Department of the Environment (DotE). (2013). Matters of National Environmental Significance: Significant Impact Guidelines 1.1. Canberra, Australia.

Department of the Environment and Energy. (DotEE). (2016). Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community. Canberra, Australia.

Department of the Environment Water Heritage and the Arts (DEWHA). (2010). Survey Guidelines for Australia's Threatened Birds: Guidelines for Detecting Birds Listed as Threatened under the EPBC Act. Canberra, Australia.

Department of Sustainability Environment Population and Communities (DSEWPaC). (2011). Survey

Guidelines for Australia's Threatened Mammals. Canberra, Australia.

Environmental Protection Authority (EPA). (2016). Technical Guidance - Flora and Vegetation surveys for Environmental Impact Assessment.

Environmental Protection Authority (EPA). (2020). Technical Guidance - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment.

Environmental Protection Authority (EPA). (2021). Statement of Environmental Principles, Factors and Objectives.

Government of Western Australia (GoWA). (2018). 2018 Statewide Vegetation Statistics - Full Report. https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetationstatistics/resource/b7bd60c2-bff6-4637-b213-aee4706412c7.

Groom, C. (2011) Plants Used by Carnaby's Black Cockatoo. Department of Environment and Conservation.

Heddle, E.M., Loneragan, O.W. & Havel, J.J. (1980). Vegetation Complexes of the Darling System, WA, in Atlas of Natural Resources, Darling System WA, Department of Conservation and Environment

Johnstone, R. E., Kirkby T. & Sarti K. (2013). The Breeding Biology of the Forest Red-tailed Black Cockatoo Calyptorhynchus banksii naso Gould in South-Western Australia. I. Characteristics of Nest Trees and Nest Hollows. Pacific Conservation Biology, 19(2), 121–142.

Johnstone, R. E. & Storr, G. M. (1998). Handbook of Western Australian Birds – Non-passerines (Emu to Dollarbird). (Volume 1, pp. 278–280) Western Australian Museum.

NVIS Technical Working Group. (2017). Australian Vegetation Attribute Manual Version 7.0. Commonwealth of Australia.

Saunders, D. A., P.R. Mawson, and P.R. Dawson. (2014b). Use of tree hollows by Carnaby's Cockatoo and the fate of large hollow-bearing trees at Coomallo Creek, Western Australia 1969- 2013. Biological Conservation 177:185-193

Threatened Species Scientific Committee. (2016). Conservation Advice Grevillea curviloba subsp. curviloba curved-leaf grevillea. Canberra: Department of the Environment. Canberra, Australia.

Western Australian Herbarium. (2022). FloraBase - The Western Australian Flora. Perth, Australia. Retrieved on 5 September 2022 from https://florabase.dpaw.wa.gov.au.

Western Australian Museum. (2022). Checklist of the Terrestrial Vertebrate Fauna of Western Australia. Retrieved on 5 September 2022 from http://museum.wa.gov.au/research/departments/terrestrialzoology/checklist-terrestrial-vertebrate-fauna-western-australia.

8.1.1 Databases used

Department of Biodiversity Conservation and Attractions (DBCA). (2017). RAMSAR Sites (DBCA-010). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/ramsar-sites.

Department of Biodiversity Conservation and Attractions (DBCA). (2018). Vegetation Complexes-Swan Coastal Plain (DBCA-046). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/vegetation-complexes-swan-coastal-plain.

Department of Biodiversity, Conservation and Attractions (DBCA). (2018) Vegetation Complexes – South West Forest Region of Western Australia (DBCA-047). Accessed on 18 April 2023 from https://catalogue.data.wa.gov.au/dataset/vegetation-complexes-swf-50k.

Department of Biodiversity, Conservation and Attractions (DBCA). (2022). Geomorphic Wetlands, Swan Coastal Plan (DBCA-019). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/geomorphic-wetlands-swan-coastal-plain.

Department of Biodiversity, Conservation and Attractions (DBCA), (2018) Carnaby's Cockatoo Confirmed Breeding Areas within the Swan Coastal Plain and Jarrah Forest IBRA Regions (DBCA-054). Accessed on 10 September 2022 from https://catalogue.data.wa.gov.au/dataset/carnabys-cockatoo-confirmed-breeding-area.

Department of Biodiversity, Conservation and Attractions (DBCA). (2018) Carnaby's Cockatoo Confirmed Roost Sites (DBCA-050). Accessed on 18 April 2023 from https://catalogue.data.wa.gov.au/dataset/black-cockatoo-roosting-sites-buffered.

Department of Biodiversity, Conservation and Attractions (DBCA). (2019) Black Cockatoo Roosting Sites - Buffered (DBCA-064). Accessed on 18 April 2023 from https://catalogue.data.wa.gov.au/dataset/black-cockatoo-roosting-sites-buffered.

Department of Biodiversity Conservation and Attractions (DBCA). (2023). DBCA - Legislated Lands and Waters (DBCA-011). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/dbca- legislated-lands-and-waters.

Department of Water and Environmental Regulation (DWER). (2018). Hydrography, Linear (Hierarchy) (DWER-031). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/hydrography-linear-hierarchy.

Department of Water and Environmental Regulation (DWER). (2021). Clearing Regulations - Environmentally Sensitive Areas (DWER-046). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/clearing-regulations-environmentally-sensitive-areas-dwer-046.

Department of Primary Industries and Regional Development (DPIRD). (2019). Pre-European Vegetation (DPIRD-006). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006.

Department of Primary Industries and Regional Development (DPIRD). (2022). Soil Landscape Mapping – Systems (DPIRD-064). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/soil-landscape-mapping-systems.

Appendix A

Metropolitan Region Scheme Amendment 1323/41

GOVERNMENT OF WESTERN AUSTRALIA

Western Australian Planning Commission

March 2018

Metropolitan Region Scheme Amendments 1323/41, 1324/41, 1325/41



Amendments in the Bullsbrook Urban Precinct (South, Central, North)

Amendment Report

City of Swan

Metropolitan Region Scheme
Amendments 1323/41, 1324/41, 1325/41

Amendments in the
Bullsbrook Urban Precinct (South, Central, North)

1323/41 South Bullsbrook Urban Precinct

1324/41 Bullsbrook Central Urban Precinct

1325/41 North Bullsbrook Urban Precinct

City of Swan

GOVERNMENT OF WESTERN AUSTRALIA

Western Australian Planning Commission

March 2018

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MRS Amendments 1323/41, 1324/41, 1325/41 Amendment Report
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North Bullsbrook Urban Precinct

Appendix I Your property and the planning system – region schemes

Appendix II Preparing a submission and hearings committees

The Metropolitan Region Scheme
What it is and how it is amended

Planning Perth's future

Perth is currently home to more than 2 million people and this is anticipated to grow to 3.5 million by 2050.

Provision must be made for future housing, employment opportunities and transport needs to meet this growth. It is also necessary to set aside land for conservation and recreation.

The Metropolitan Region Scheme (MRS) provides for this growth, and the means by which affected landowners can be compensated for land acquired for public purposes.

The role of the WAPC?

The Western Australian Planning Commission (WAPC) has statewide responsibility for planning how land in metropolitan and regional areas can be used and developed. The WAPC comprises a Chair and 16 members, representing industry, government and the community.

The WAPC is a statutory authority and operates in accordance with the *Planning and Development Act 2005*. It is supported by the Department of Planning, Lands and Heritage, which provides professional and technical expertise, administrative services and corporate resources.

What is the Metropolitan Region Scheme?

The MRS is a large town planning scheme which defines how land can be used in the Perth metropolitan area, dividing it into broad zones and reservations. The metropolitan area stretches from south of Rockingham to north of Yanchep and east of Mundaring.

The MRS uses a set of maps and a scheme text to set the planning rules and identify the various zones and reservations.

This plan has been in operation since 1963 and provides the legal basis for planning in the Perth metropolitan area.

The MRS is amended frequently as the region grows and changes.

What is an amendment?

An amendment to the MRS changes the zoning or reservation of land to allow for a different land use.

When a rezoning or a new reservation is considered, an amendment to the MRS is advertised to seek comment from landowners, the broader community and all levels of government.

This process allows for extensive community consultation and discussion in Parliament, prior to a final decision being made.

How is the Metropolitan Region Scheme amended?

The WAPC is responsible for maintaining the MRS, including reviewing and initiating changes where necessary.

The amendment process is regulated by the *Planning and Development Act 2005*. The Act requires an amendment to be consistent with both the *Swan River Trust Act 1988* and the *Heritage of Western Australia Act 1990* and does not allow for an amendment to occur within the defined area of which a redevelopment scheme applies.

The amendment proposed in this report is being made under the provisions of section 41 (often referred to as a major amendment).

The amendment process includes (also see the diagram on page ix):

- Request submitted and considered by the WAPC.
- WAPC determines to either progress or reject application.
- If progressed, the application is referred to the Environmental Protection Authority (EPA) to set the level of environmental assessment. If the EPA requires an environmental review, this is carried out before the amendment is advertised.
- Consent by the Minister for Planning to call for submissions.
- Proposed amendment is advertised for public comment. Advertisements are placed in local and statewide newspapers and the information is made available on www.planning.wa.gov.au/public-comment. Landowners directly affected by a proposed amendment are contacted in writing. Where there is an environmental review, this is also made available for comment.
- WAPC receives public submissions over a period of three months.
- WAPC considers submissions. Everyone who made a submission may also choose to present to a hearings committee appointed by the WAPC to consider and report on these submissions.
- WAPC reviews the proposed amendment in light of both the submissions and planning advice provided by the Department of Planning, Lands and Heritage.
- The WAPC provides a recommendation to the Minister whether to accept, reject or modify the proposed amendment.
- Proposed amendment may be required by the Minister for Planning to be readvertised if the amendment is substantially modified as a result of submissions and planning advice.
- Minister presents the proposed amendment with the WAPC's recommendations to the Governor for approval.
- The proposed amendment, as approved by the Governor, is tabled before each House of State Parliament, where it must remain for 12 sitting days. During this time, the amendment is again on public display.
- In Parliament, a member may introduce a motion to disallow the amendment. If this motion succeeds, the MRS will not be amended. Otherwise, the amendment becomes legally effective in the MRS after 12 sitting days.
- Within three months of an MRS amendment being finalised, all affected local governments must initiate an amendment to its local planning scheme to match the new zonings.

Zones and reservations

Zones and reservations in the MRS are broad categories to define how land can be used and developed. The following descriptions are a guide only.

Zones

Urban: areas in which a range of activities are undertaken including residential, commercial, recreational and light industry.

Urban deferred: land identified for future urban uses following the extension of urban services, the progressive development of adjacent urban areas, and resolution of any environmental and planning requirements relating to development.

The WAPC must be satisfied that these issues have been addressed before rezoning to urban.

Central city area: strategic regional centres for major retail, commercial and office facilities as well as employment, civic, business and residential uses.

Industrial and special industrial: land on which manufacturing, processing, warehousing and related activities are undertaken.

Rural: land on which a range of agricultural, extractive and conservation uses is undertaken.

Private recreation: areas of significance to the region's recreation resource, which are (or are proposed to be) managed by the private sector.

Rural - water protection: rural land over public groundwater areas where land use is controlled to avoid contamination.

Reservations

Land reserved for community purposes. It may be reserved to protect a resource or to provide areas for infrastructure.

Parks and recreation: land of regional significance for ecological, recreation or landscape purposes.

Railways: provides for public transit routes, freight rail lines and associated facilities such as marshalling yards, maintenance depots and park n' ride stations.

Port installations: regional maritime shipping facilities.

State forests: areas of woodland located on Crown land and managed under the *Conservation and Land Management Act 1984*.

Water catchments: water sources protected for high quality public water supply. These areas have strict controls on land use to avoid pollution of the water resource.

Civic and cultural: significant civic precincts and buildings.

Waterways: permanent inland and coastal waters including many rivers and reservoirs.

Public purposes: land for public facilities such as hospitals, high schools, universities, prisons, utilities for electricity, water and treatment of wastewater, commonwealth government and other special uses.

Primary regional roads: important regionally significant roads as part of the planned road network that are currently, or proposed to be declared, under the *Main Roads Act 1930*.

Other regional roads: roads of regional significance in the planned road network for which the planning responsibilities are shared by the WAPC and local governments.

What if my land is rezoned?

Landowners may find that an amendment seeks to rezone their property, for example from rural to urban or urban deferred.

If the zoning is changed, landowners do not have to change their lifestyle or the way they use the land. However, depending on the new zone, there may be opportunities to change the land use, such as seek approval to subdivide or apply to develop it in some way that suits the new zoning.

The WAPC realises that many people choose their properties because they like them as they are and may not want to change from, for example, a rural-residential lifestyle to an urban area. Others are keen to change the land use.

For these reasons, amendments to the MRS are advertised so that all affected landowners and the broader community have time to examine the proposal and provide their comment.

What if my land is reserved?

Land is reserved because it will eventually be needed for a public purpose such as parks and recreation or other regional roads.

If your land is proposed to be reserved in an advertised amendment, you can continue to use and enjoy your property. Generally, reserved land can remain in private ownership until it is needed for the purpose for which it is reserved.

To protect landowners, there are procedures for acquisition or compensation by the WAPC. These are outlined in *Your property and the planning system – region schemes*, a leaflet reproduced at the back of this report and online at www.planning.wa.gov.au/regionschemes.

How can my views be heard?

You can lodge a submission to the proposed amendment during the advertised period:

- online at www.planning.wa.gov.au/public-comment
- in writing to Western Australian Planning Commission, Level 2, 140 William Street, Perth 6000 (a submission form is included at the back of this report).

The WAPC will try and make contact with everyone who nominated to attend a hearings committee following the advertised period.

Publications

In the course of each amendment to the MRS, information is published under the following titles:

Amendment report
This document is available from the start of the public submission period of the proposed amendment. It sets out the purpose and scope of the amendment, explains why the proposal is considered necessary and informs people how they can comment.

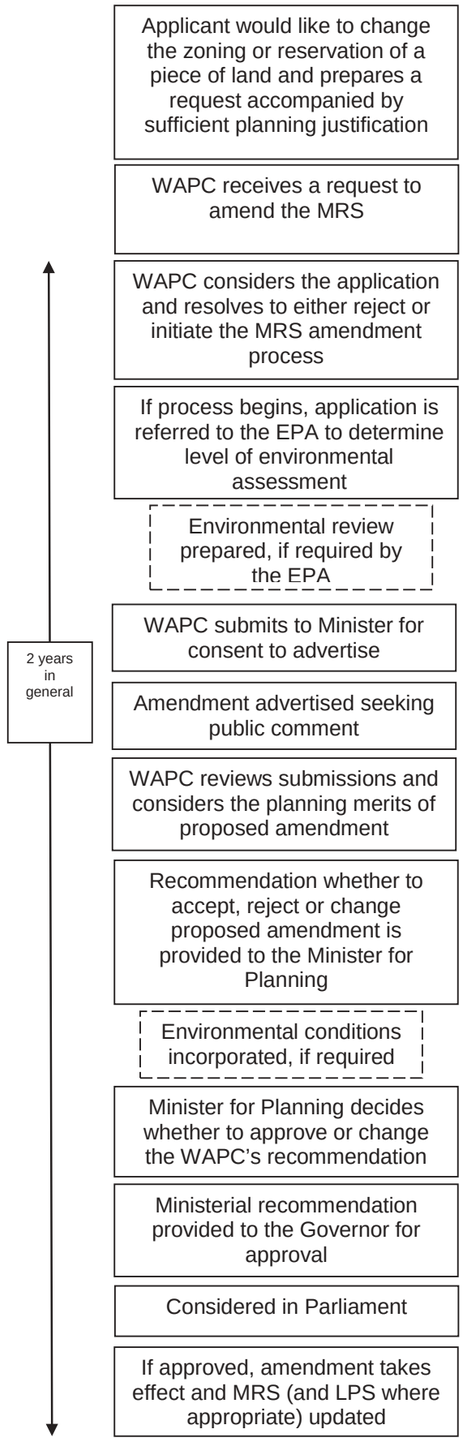
Environmental review report
The EPA considers the environmental impact of an amendment to the MRS before it is advertised. Should the EPA require formal assessment, an environmental review is undertaken and that information is made available for comment at the same time as the amendment report.

Report on submissions
This publication documents the submissions received, the minutes of the hearings and the Hearings committee summary of the proceedings

All the written submissions received on the proposed amendment are reproduced as a public record.

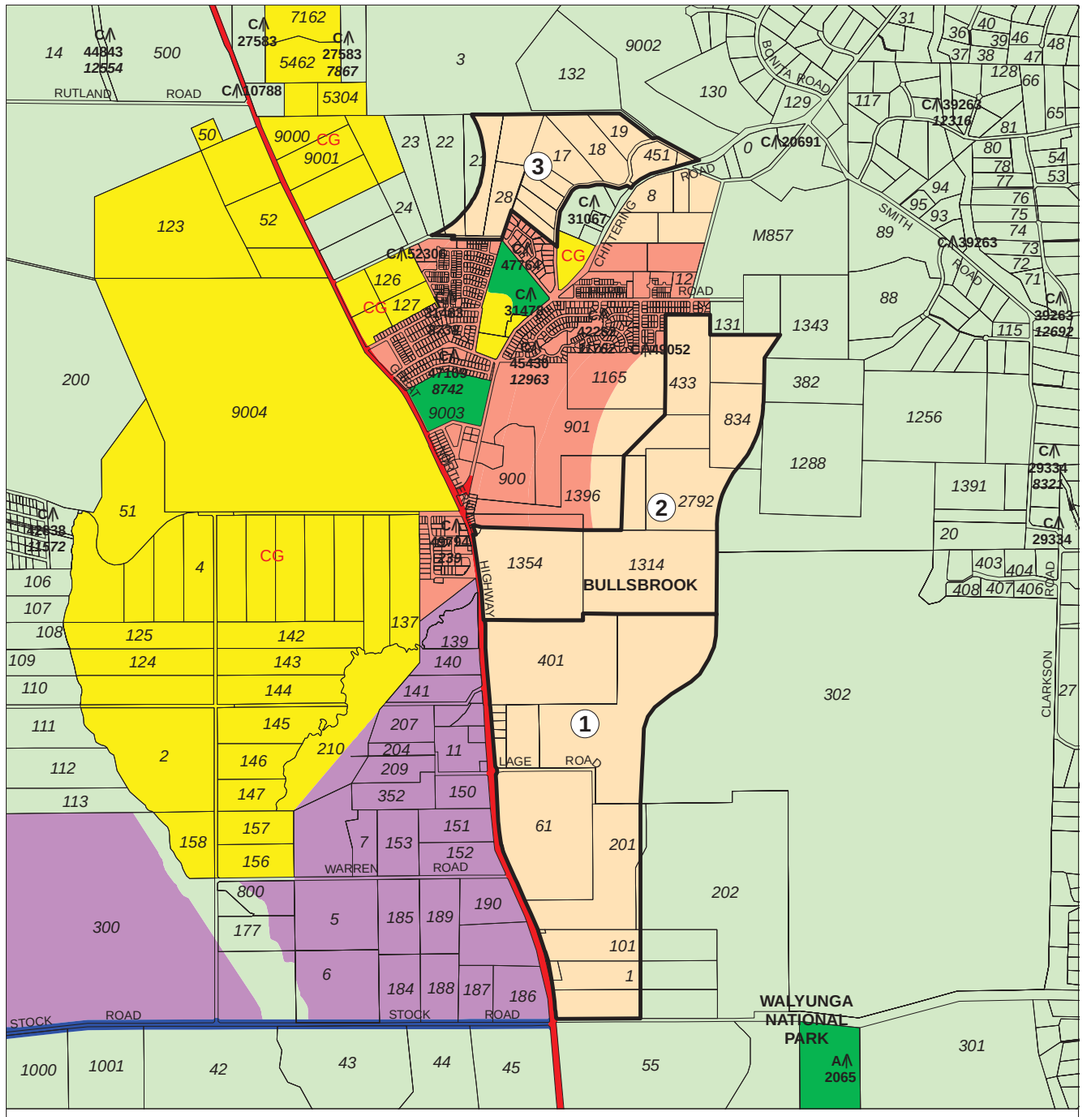
The final scheme or amendment
This publication documents the planning rationale for the amendment or scheme and the WAPC's recommendation to the Minister for Planning.

A simple diagram of the amendment process.



Abbreviations

AHA	Aboriginal Heritage Act
AHD	Australian Height Datum
BTLUMP	Bullsbrook Townsite Landuse Masterplan
CBD	Central Business District
DAA	Department of Aboriginal Affairs
DIA	Department of Indigenous Affairs
DWER	Department of Water and Environmental Regulation
DPLH	Department of Planning, Lands and Heritage
DSP	District Structure Plan
DWMS	District Water Management Strategy
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
GGP	Green Growth Plan
LPS	Local Planning Scheme
MRS	Metropolitan Region Scheme
MRWA	Main Roads Western Australia
OEPA	Office of the Environmental Protection Authority
POS	Public Open Space
RAAF	Royal Australian Air Force
SPP	State Planning Policy
WAPC	Western Australian Planning Commission
WWTP	Wastewater Treatment Plant



Metropolitan Region Scheme Amendment Nos. 1323/41, 1324/41 & 1325/41

Proposed:

1. amendment 1323/41
2. amendment 1324/41
3. amendment 1325/41

Metropolitan Region Scheme Legend

Reserved Lands
- Parks and recreation
- Restricted public access
- Railways
- Port installations
- State forests
- Water catchments
- Civic and cultural
- Waterways

Roads:
- 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

Bush forever area

Zones
- Urban
- Urban deferred
- Central city area
- Industrial
- Special industrial
- Rural
- Rural - water protection
- Private recreation

Western Australian Planning Commission

Created on date: Thursday, 27 July 2017
Document Name: MRS_2865_v2_locality plan
Produced by Geospatial Research and Modelling, Department of Planning, Lands and Heritage, Perth WA
Base information supplied by Western Australian Land Information Authority LI 862-2016-1

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Section 1

Amendment 1323/41

South Bullsbrook Urban Precinct

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Appendix A Notice of environmental assessment

Appendix B List of detail plans supporting the amendment

Appendix C Submission form for this amendment (form 41)

1 Purpose

The purpose of the amendment is to transfer approximately 210.7 ha of Rural zoned land to the Urban Deferred zone in the Metropolitan Region Scheme (MRS), as shown on the ***Amendment Figure – Proposal 1***.

The proposed amendment will facilitate future residential development, a neighbourhood centre, areas of public open space, a primary school and associated playing fields and conservation areas.

Requirements to lift the Urban Deferment

The subject land is being zoned Urban Deferred, as the following requirements are to be addressed prior to lifting of Urban Deferment:

- A District Structure Plan (DSP) or the *Bullsbrook Townsite Landuse Masterplan* (BTLUMP) being approved by the Western Australian Planning Commission (WAPC) to guide the development of the Bullsbrook townsite.

  The DSP or BTLUMP should consider matters such as: a spatial staging plan, district developer contribution plan, MRS reservations (e.g. High Schools, Other or Primary Regional Roads etc), buffers (e.g. landfill and extractive industries etc), environmental constraints, transport modelling and traffic analysis (amongst other matters) in consultation with relevant State Government agencies and the City of Swan;

- Confirmation of water and wastewater infrastructure;

- Confirmation on the location of a High School site;

- Confirmation of road upgrading requirements to support the proposed scale of development;

- Confirmation that the existing landfill operations and associated buffer has ceased; and

- The eastern portion of the site is partly within a 500 metre separation buffer for clay resources. The clay extraction is to be completed, prior to the transfer of this land to the Urban zone.

2 Background

The subject land is located within the City of Swan and is approximately 32 km north-east of the Perth CBD and is 21 km north-east of the Midland strategic centre. The land has access to Great Northern Highway and existing local roads in the locality. The Bullsbrook townsite and RAAF Pearce Airbase are to the north-west and the Perth-Geraldton railway and Perth-Darwin Highway are further to the west of the site.

The site has historically been used for agricultural pursuits, including land uses such as cropping and grazing, and is therefore degraded state and cleared of any significant vegetation. There are some areas of remnant vegetation associated with existing creek lines, however these areas are generally devoid of understorey. There are existing dwellings and other farming related structures within the site.

An operational Class I inert landfill (includes crushing of building materials and a solid waste depot) is located to the east of the subject land. Once closed, the landfill is proposed to be rehabilitated in accordance with Department of Water and Environment Regulation (DWER) requirements.

Vegetation across the site ranges from "Completely Degraded" to "Degraded" condition. "Completely Degraded" areas occur across the vast majority of the site, consisting of cleared and grazed paddocks, dominated by pasture weeds. The small pockets of remnant plant communities were in "Degraded" condition, and contained an intact over-storey and a limited native understorey.

No Threatened or Priority flora has been identified within the subject site. No Threatened Ecological Communities or Priority Ecological Communities have been identified. There are no Bush Forever sites within or abutting the site.

Land use and development within the amendment area is generally controlled by the City of Swan Local Planning Scheme No. 17 (LPS 17). The subject is currently zoned Rural in the MRS and "General Rural", "Landscape" and "Recreation" under LPS 17.

3 Scope and content of the amendment

The amendment proposes to rezone approximately 16 properties and road reserves bounded by Stock Road to the south, Great Northern Highway to the west and existing Rural zoned properties to the north and east.

The total area subject of this amendment is approximately 210.7 ha.

4 Discussion

STRATEGIC CONTEXT

Draft *Perth and Peel @ 3.5 Million* / Draft *North-East Sub-regional Planning Framework*

The draft *Perth and Peel @ 3.5 Million* document provides a snapshot of the Perth and Peel regions in the future. It makes the case for change from a "business-as-usual" perspective to a more considered, connected, consolidated urban form. It links four draft Frameworks and encourages the consideration of new urban growth opportunities.

Future areas for urban development have been determined in conjunction with the State Government's draft *Perth and Peel Green Growth Plan for 3.5 Million*, in order to avoid and protect areas which have significant regional environmental value. The draft *North-East Sub-Regional Planning Framework* identifies the subject land as "*Urban Expansion*", with a "*Medium-Long Term (2022+)*" timeframe.

The WAPC considers that the amendment contributes to the implementation of the draft Frameworks' recommendations and generally meets the criteria outlined for consideration ahead of its urban staging timeframe.

Bullsbrook Townsite Land Use Master Plan

In 2014, the City of Swan adopted the BTLUMP in response to the targets identified under *Directions 2031 and Beyond*. The BTLUMP provides guidance for the growth and development of the Bullsbrook town site, with population forecasts to increase from 5,614 to 26,483 people by 2036.

The subject site is identified under the BTLUMP for future residential development. The BTLUMP allocates a primary school and local playing fields within the subject site, as well as a Neighbourhood Centre generally at the intersection of Lage Road and the Great Northern Highway. There is also a conservation area identified traversing the site along the existing creek line. The proposed amendment request is generally in accordance with the BTLUMP.

State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning

State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning addresses transport noise from within major transport corridors, including primary freight routes, and its impact on nearby noise-sensitive land uses.

As the Great Northern Highway abuts the western boundary of the subject land, there is the potential for noise attenuation to be required. The exact nature of these measures will be determined at the detailed structure planning stage. Noise reduction strategies will be designed and implemented in conjunction with local government recommendations and government agency guidelines.

In subsequent planning stages, management measures will be incorporated into the future development to minimise the impacts of noise and may also be subject to subdivision and development approval conditions.

State Planning Policy 2.4 - Basic Raw Materials

State Planning Policy 2.4 - Basic Raw Materials sets out the matters which are to be taken into account by the WAPC and local governments in considering zoning, subdivision and development applications for extractive industries zoning, subdivision and development applications in the vicinity of identified basic raw material resource areas.

The former Department of Mines and Petroleum advises that the eastern portion of the amendment area is partly located within the 500 metre separation buffer from clay resources. The clay extraction is required to be completed, prior to the transfer of this land to the Urban zone.

State Planning Policy 4.1 - State Industrial Buffer Policy

State Planning Policy 4.1 - State Industrial Buffer Policy (SPP 4.1) applies statewide, to planning decision-making, and proposals which seek to provide for new industrial areas and uses, and essential infrastructure, sensitive land uses in proximity to existing industrial areas. The objectives of the policy are to:

- avoid conflict between industry and/or essential infrastructure and sensitive land uses;

- protect industry and/or essential infrastructure from encroachment by those land uses that would be sensitive to impacts and adversely impact the efficient operations;
- provide for the development of industry and/or the provision of essential infrastructure in a way that maximises amenity, minimises environmental and health impacts and takes account of risk to nearby sensitive land uses; and
- promote compatible uses in areas affected by off-site impacts of industry and/or essential infrastructure.

The proposed amendment is in accordance with SPP 4.1 as the subject land is being zoned Urban Deferred, and will require that the landfill operations have ceased, prior to the land being transferred to the Urban zone.

State Planning Policy 3.7 – Planning in Bushfire Prone Areas

State Planning Policy 3.7 – Planning in Bushfire Prone Areas (SPP 3.7) seeks to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. It applies to all higher order strategic planning documents, strategic planning proposals, subdivision and development applications located in designated bushfire prone areas (unless exemptions apply).

The accompanying *Guidelines for Planning in Bushfire Prone Areas* provide supporting information to assist in the interpretation of the objectives and policy measures outlined in SPP 3.7. They provide advice on how bushfire risk is to be addressed when planning, designing or assessing a planning proposal within a designated bushfire prone area. A Bushfire Management Plan has been approved for the site by the Department of Fire and Emergency Services.

STATUTORY CONTEXT

Environment

The former Office of the Environmental Protection Authority (OEPA) raises no objections to the proposed amendment, subject to the retention of remnant vegetation consistent with work undertaken for the draft *Perth and Peel Green Growth Plan for 3.5 Million.*

Where possible, remnant vegetation should be retained, particularly remnant vegetation along the Nambad Brook which provides potential habitat for Carnaby's Black Cockatoos. This species is listed as 'Endangered' under the *Environment Protection and Biodiversity Conservation Act 1999*. The OEPA acknowledges that further consultation and investigations will be required in the subsequent local structure plan, subdivision or a development application stages.

Urban Water Management

A District Water Management Strategy is required to be approved by the DWER prior to the WAPC's consideration of the amendment for a final determination.

Infrastructure

Water & Wastewater

The Water Corporation has adopted long-term, conceptual water and wastewater planning that provides for the ultimate urban expansion of the Bullsbrook townsite. This infrastructure planning may be varied by the developers in consultation with the Corporation in the subsequent structure planning stage, when more detailed land use, lot yield and timing information becomes available.

The subject land is physically separated from the current townsite and is not serviced with water or sewerage, and extensions will be needed. The Corporation's infrastructure planning for new water storages, distribution mains, permanent wastewater pumping stations, large gravity sewers etc, is premised on a logical and orderly progression of the development front.

If the proponent wishes to develop this land ahead of the Corporation's planned capital expenditure program, the developers may be required to fund some headworks infrastructure. Developers may also need to build temporary water and wastewater infrastructure to service the land. A temporary servicing solution may be acceptable to the Corporation, provided it does not compromise the Corporation's long-term planning.

Transportation

Main Roads WA (MRWA) advises as follows.

- The proposed concept plan (for the eastern portion of Great Northern Highway) should align with the various structure plans on the western side of the Highway;
- The concept plan shows a Neighbourhood Centre at the intersection of Great Northern Highway/Lage Road. No direct vehicle access will be provided to Great Northern Highway, therefore the neighbourhood centre should be relocated further eastward; and
- The City of Swan, former Department of Planning, Department of Transport and MRWA endorsed an access strategy for Great Northern Highway. Further detail of the preferred treatment for the Dewar Road/Lage Road intersection potentially being relocated south has been provided.

This information has been provided to the proponent as it relates to the subsequent stages of the planning and development process.

5 Aboriginal heritage

The *Aboriginal Heritage Act 1972* (AHA) provides for the protection and preservation of Aboriginal heritage and culture throughout Western Australia, including places and objects that are of significance to Aboriginal people. Aboriginal sites and materials are protected whether or not they have been previously recorded or reported.

The process of rezoning or reservation of land in a region scheme is not in itself directly affected by the AHA. Proposed changes to land-use are broad by nature and do not physically interfere with the land. Consideration of any protection that may be required is

addressed more specifically at later stages of the planning process, typically being a local planning scheme amendment and when preparing a local structure plan.

Nevertheless, in recognising the importance of having reliable Aboriginal information on land and the values attached to it, the WAPC / Department of Planning, Lands and Heritage has entered into a Memorandum of Understanding with the South West Aboriginal Land and Sea Council (SWALSC) for the provision of Aboriginal consultative services. All MRS amendment proposals likely to have Aboriginal interest are now referred to SWALSC for comment before being released for public submission. SWALSC is the recognised Native Title Representative Body for Western Australia's south west region, and as such is also well placed to provide advice on Aboriginal heritage.

This amendment has been pre-referred to the SWALSC but no response was received. However, it will be referred to SWALSC during the advertising period for the amendment.

6 Coordination of local and region scheme amendments

Under section 126(3) of the *Planning and Development Act 2005* the WAPC has the option to concurrently rezone land being zoned Urban under the MRS to a "Development" zone (or similar) in the Local Planning Scheme. As no land is being zoned Urban, section 126(3) of the *Planning and Development Act 2005* is not applicable.

7 Substantiality

The *Planning and Development Act 2005* allows for amendments to the MRS to be processed as either "minor" or "major" amendments depending on whether they are considered to constitute a substantial alteration to the MRS or not. WAPC Policy *DC 1.9 Amendment to Region Schemes* sets out the criteria for deciding whether the major or minor process should be followed. In this regard, the amendment is proposed to be processed as a "major" amendment given it seeks to zone a new urban area which is considered to be a substantial/regional change in the MRS and in the general Bullsbrook locality.

8 Sustainability

The proposed amendment will facilitate the future urban development of the site in accordance with the BTLUMP and will complement the existing Industrial zoned areas in Bullsbrook, has regard to the protection of the environment and has access to the regional road network e.g. Great Northern Highway.

9 Environmental Protection Authority advice

The proposed amendment was referred to the Environmental Protection Authority (EPA) for advice on whether environmental assessment would be required.

The EPA has advised that the proposed amendment does not require formal assessment under Part IV of the *Environmental Protection Act 1986*. However, it has provided advice on the key environmental factors for the amendment. A copy of the notice from the EPA is included at appendix A.

10 The amendment process

The procedures for amending the MRS are prescribed by the *Planning and Development Act 2005.* The amendment proposed in this report is being made under the provisions of Section 41 of that act.

In essence, this procedure for a substantial alteration to the MRS (often referred to as a 'major' amendment) involves:

- formulation of the amendment by the WAPC;
- referral to the EPA for environmental assessment;
- completion of an Environmental Review (if required) to EPA instructions;
- public submissions being sought on the proposed amendment (including the Environmental Review if it was required);
- consideration of submissions (including hearings where requested);
- referral of WAPC recommendations, with or without any modifications to the amendment in response to submissions, to the Minister for Planning;
- approval by the Governor;
- consideration by both Houses of Parliament, which can disallow the amendment;
- amendment takes legal effect when no longer subject to disallowance after 12 sitting days; and
- where the WAPC has agreed to the parallel amendment of a local planning scheme under section 126(3) of the *Planning and Development Act 2005*, the local planning scheme amendment becomes effective upon gazettal of the MRS amendment.

An explanation of this process can also be found in the front of this report, entitled *'The Metropolitan Region Scheme, what it is and how it is amended'*.

11 Submissions on the amendment

The WAPC invites people to comment on this proposed amendment to the MRS.

The amendment is being advertised for public submissions for a period of three months from Friday 2 March 2018 to Friday 8 June 2018.

Copies of the amendment will be available for public inspection at:

i) Western Australian Planning Commission, 140 William Street, Perth

ii) City of Perth

ii) City of Fremantle

ii) City of Swan

ii) City of Kalamunda

iii) the State Reference Library, Northbridge.

Online submissions are encouraged via: *www.planning.wa.gov.au/public-comment.*

Written submissions on the amendment should be sent to:

The Secretary
Western Australian Planning Commission
Locked Bag 2506
PERTH WA 6001

and **must be received by Friday 8 June 2018.**

All submissions received by the WAPC will be acknowledged.

For your convenience a submission form (Form 41) for this amendment 1323/41 is attached to this report (Appendix C). Additional copies of this form are available from the display locations listed above and from the PlanningWA website *www.dplh.wa.gov.au.*

You should be aware that the calling for submissions is a public process, and all submissions lodged will together become a public document. It will be published and made available when the amendment is presented to both Houses of Parliament. Advice of disclosure and access requirements is shown on side two of the submission form.

Before making your submission, it is recommended that you read the information in Appendix II of this report regarding preparing a submission.

12 Hearings

Any person making a written submission also has the opportunity to personally present the basis of their submission to a sub-committee of the WAPC. Details required for attending the hearings are on side two of the submission form.

Presentations made to the hearings committee are an extension of the submission process, and the minutes of all hearings will become a public document. The minutes will be published and made available when the amendment is presented to both Houses of Parliament.

Before completing your submission form, please refer to the information regarding hearings in Appendix II of this report.

13 Modifications to the amendment

After considering any comments received from the public and Government agencies, the WAPC may make modifications to the amendment.

The recommendations of the WAPC, including any modifications, are published in a report on submissions. Anyone who has made a submission will receive a copy of this document when the amendment is tabled in Parliament. The report will also be available on the PlanningWA website *www.dplh.wa.gov.au*.

14 Final outcome

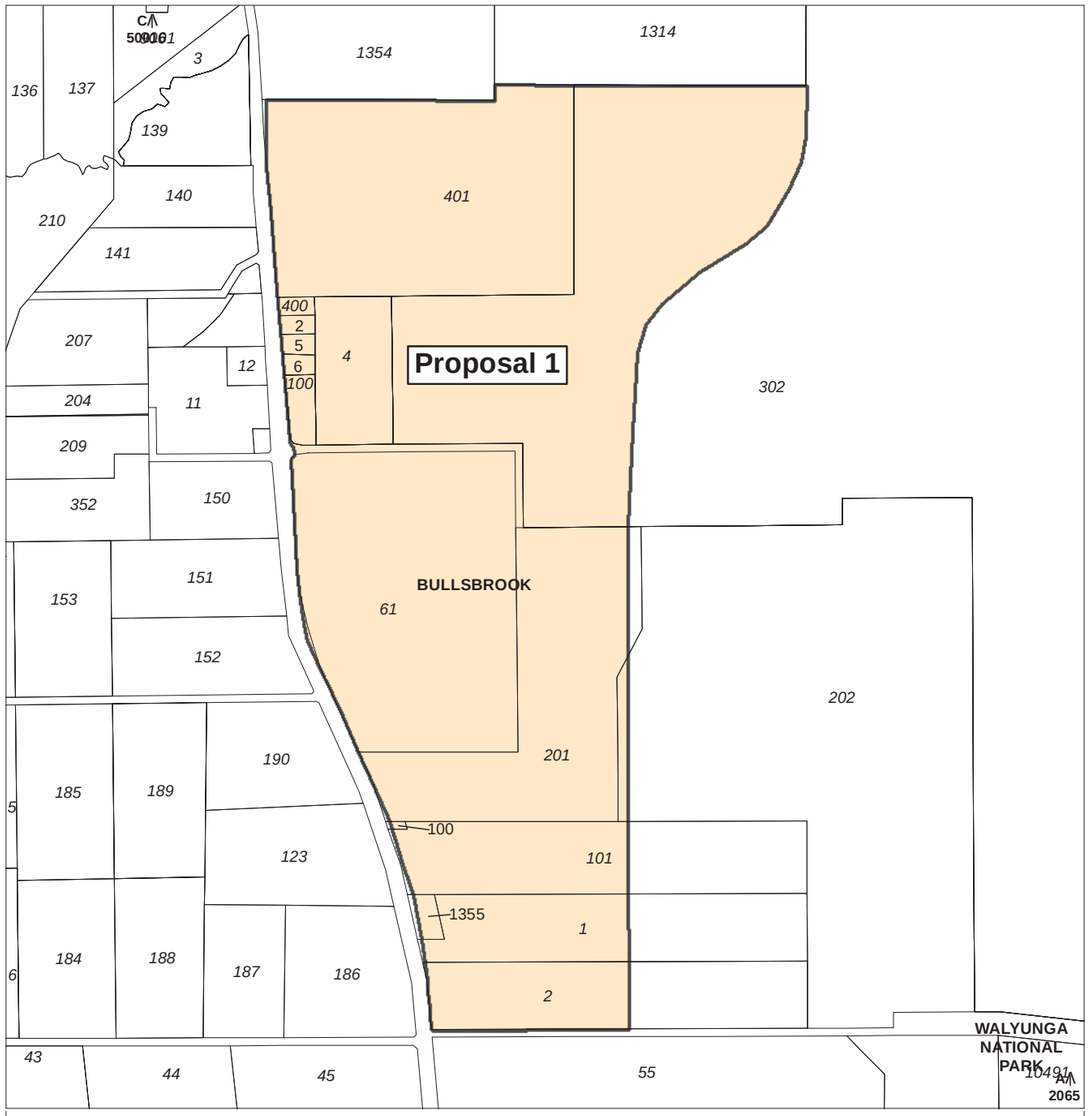
After considering the submissions, the WAPC may make modifications to the amendment. The WAPC will then submit the amendment plans, together with a *Report on Submissions* and a copy of all written submissions, to the Minister for Planning for presentation to the Governor.

If the Governor approves, a copy of the plans of the amendment together with the *Report on Submissions* will be laid before each House of Parliament for twelve sitting days. Either House may, by resolution, disallow an amendment within that time. As soon as the amendment is no longer subject to disallowance it becomes legally effective in the MRS.

People who have made submissions will be kept advised on the progress of the amendment, and along with all affected landowners, will be notified of the final outcome.

MRS Amendment 1323/41
South Bullsbrook Urban Precinct

Amendment Figure
Proposal 1



South Bullsbrook Urban Precinct
Proposed major amendment
as advertised

27 April 2017

Proposal 1

Proposed Amendment:

Urban deferred zone

Oracle reference no: 2908
File number: 809/02/21/0039P V
Version number: 2

Western Australian Planning Commission

Date: 10/10/2017
Produced by Geospatial Research and Modelling, Department of Planning, Lands and Heritage, Perth WA
Base information supplied by Western Australian Land Information Authority LI 862-2016-1

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Appendix A

Notice of environmental assessment

Environmental Protection Authority

GOVERNMENT OF WESTERN AUSTRALIA

DEPARTMENT OF PLANNING
19 JUL 2017
FILE A15/c693

The Secretary
Western Australian Planning Commission
Locked Bag 2506
PERTH WA 6001

Your Ref:
Our Ref: CMS15321
Enquiries: Billie-J Hughes, 6364 7600
Email: Billie-J.Hughes@dwer.wa.gov.au

Dear Sir/Madam

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

SCHEME:	**Metropolitan Region Scheme - Amendment 1323/41 South Bullsbrook Urban Precinct**
LOCATION:	**Various properties and road reserves bounded by Stock Road to the south, Great Northern Highway to the west and existing Rural zoned properties to the north and east**
RESPONSIBLE AUTHORITY:	**Western Australian Planning Commission**
DECISION:	**Referral Examined, Preliminary Investigations and Inquiries Conducted. Scheme Amendment Not to be Assessed Under Part IV of EP Act. Advice Given. (Not Appealable)**

Thank you for referring the above proposed scheme to the Environmental Protection Authority (EPA).

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

Please note the following:

- For the purposes of Part IV of the EP Act, the scheme is defined as an assessed scheme. In relation to the implementation of the scheme, please note the requirements of Part IV Division 4 of the EP Act.

- There is no appeal right in respect of the EPA's decision to not assess the scheme.

A copy of this letter and the attached advice and recommendations will be made available to the public via the EPA website.

Yours sincerely

Robert Harvey
DEPUTY CHAIRMAN

Delegate of the Chairman of the Environmental Protection Authority
Under Notice of Delegation No. 40 published 7 March 2017

17 July 2017

Encl. Scheme Advice and Recommendations

ADVICE UNDER SECTION 48A(1)(a) ENVIRONMENTAL PROTECTION ACT 1986

Metropolitan Region Scheme Amendment 1323/41 South Bullsbrook Urban Precinct

Location: Various properties and road reserves bounded by Stock Road to the south, Great Northern Highway to the west and existing Rural zoned properties to the north and east

Determination: Scheme Not Assessed – Advice Given (no appeals)

Determination Published: 17 July 2017

Summary

The Western Australian Planning Commission (WAPC) has resolved to proceed with Metropolitan Region Scheme Amendment 1323/41 South Bullsbrook Urban Precinct. The purpose of the amendment is to transfer approximately 210.7 hectares of Rural zoned land to Urban Deferred.

The Environmental Protection Authority (EPA) has considered the scheme amendment in accordance with the requirements of the *Environmental Protection Act 1986* (EP Act). The EPA considers that the scheme amendment, as set out, is unlikely to have a significant effect on the environment and does not warrant formal assessment under Part IV of the EP Act. Having considered this matter the following advice is provided.

1. Environmental Factors

Having regard to EPA's *Statement of Environmental Principles, Factors and Objectives*, the EPA has identified the following preliminary environmental factors relevant to this scheme amendment:

a) Flora and Vegetation;
b) Terrestrial Fauna;
c) Hydrological Processes;
d) Inland Water Environmental Quality;
e) Social Surroundings; and
f) Human Health

Advice and Recommendations regarding Environmental Factors

The EPA has based its decision on the documentation provided by the WAPC.

a. Flora and Vegetation, Terrestrial Fauna, Hydrological Processes and Inland Waters Environmental Quality

The remnant native vegetation within the amendment area is mapped as Guildford Complex, which only has 5.3% of its original extent remaining. The vegetation ranges in condition from Degraded to Completely Degraded. Within the amendment area, this vegetation occurs along Nambad Brook and a small pocket of vegetation in the south east.

The vegetation associated with the Nambad Brook is identified as Carnaby's Black Cockatoo foraging habitat. The EPA notes an environmental assessment did not identify the presence of Black Cockatoos or evidence to suggest it is habitat. All species of Black Cockatoos are protected under both the *Wildlife Conservation Act 1950* and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any proposed development may require referral to the Commonwealth Department of the Environment and Energy under the EPBC Act due to impacts to Black Cockatoo habitat.

The EPA supports the retention of Nambad Brook and associated vegetation in public open space as depicted in concept planning for the future urban development. The retention of other areas of vegetation that provides habitat for Black Cockatoo would also be supported.

b. Social Surroundings and Human Health

An operational Class I inert landfill is located to north east of the subject land and a clay schist quarry to the east.

The separation distance between the landfill and proposed amendment area is approximately 500 metres (m). The EPA notes the generic separation distance exceeds the 150m recommended for inert landfills in the EPA's Guidance Statement No. 3 *Separation Distances between Industrial and Sensitive Land Uses* (EPA GS 3) (EPA 2005).

A buffer of 500m has been provided between the quarry and the proposed amendment area. EPA GS 3 also advises 500 to 1000m depending on the size of the operation. The EPA supports the requirement for the land to not be transferred to the Urban zone until clay extraction has ceased.

Recommendation

The EPA concludes that the amendment can be managed to meet the EPA's environmental objectives through the requirements identified to lift Urban Deferment in the amendment report, preparation of future local planning scheme provisions and/or structure planning to manage and protect the identified environmental factors above.

Appendix B

List of detail plans supporting the amendment

South Bullsbrook Urban Precinct

Proposed Major Amendment

Amendment 1323/41

as advertised

Amending Plan 3.2701
Detail Plans
1.5866 & 1.5870

Appendix C

Submission form for this amendment
(form 41)

Planning and Development Act 2005
Section 41 Amendment (Substantial)
Form 41

Submission

Metropolitan Region Scheme Amendment 1323/41

South Bullsbrook Urban Precinct

OFFICE USE ONLY

SUBMISSION NUMBER

RLS/0728

To: Secretary
Western Australian Planning Commission
Locked Bag 2506
Perth WA 6001

Title *(Mr, Mrs, Miss, Ms)* ..... First Name .....

Surname ..... (PLEASE PRINT CLEARLY)

Address ..... Postcode .....

Contact phone number ..... Email address .....

Submission (Please attach additional pages if required. It is preferred that any additional information be loose rather than bound)

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turn over to complete your submission

Hearing of submissions

Anyone who has made a written submission on the amendment has the opportunity to personally present the basis of their submission to a sub-committee of the WAPC. **You do not have to attend a hearing.** The comments presented by you in this written submission will be considered in determining the recommendation for the proposed amendment.

For information about the submission and hearings process, please refer to the amendment report and in particular appendix D.

Please choose one of the following:

☐ **No**, I do not wish to speak at the hearings. (Please go to the bottom of the form and sign)

OR

☐ **Yes**, I wish to speak at the hearings. (Please complete the following details)

I will be represented by:

☐ Myself – My telephone number (business hours): .....

or

☐ A spokesperson

Name of spokesperson: .....
Contact telephone number (business hours): .....
Postal address: .....

I would prefer my hearing to be conducted in:

☐ Public (members from the general public may attend your presentation)

OR

☐ Private (only the people nominated by you or the hearings committee will be permitted to attend)

You should be aware that:

- The WAPC is subject to the *Freedom of Information Act 1992* and as such, submissions made to the WAPC may be subject to applications for access under the act.
- In the course of the WAPC assessing submissions, or making its report on these submissions, copies of your submission or the substance of that submission, may be disclosed to third parties.
- Hearings may be recorded and transcribed. The minutes of all hearings, along with all written submissions, are tabled in Parliament and published as public records should the Governor approve the proposed amendment. The WAPC recommendations are similarly published in a report on submissions and tabled in Parliament.

To be signed by person(s) making the submission

Signature ..... Date .....

Note: Submissions MUST be received by the advertised closing date, being close of business (5pm) on 8 JUNE 2018. Late submissions will NOT be considered.

Contacts: Telephone - (08) 6551 8002 Fax - (08) 6551 9001 Website - http://www.planning.wa.gov.au/public-comment

Section 2

Amendment 1324/41

Central Bullsbrook Urban Precinct

Contents

1 Purpose....1

2 Background....1

3 Scope and content of the amendment....2

4 Discussion....2

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6 Coordination of local and region scheme amendments....6

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10 The amendment process....7

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Amendment Figure – Proposal 1....13

Appendix A Notice of environmental assessment

Appendix B List of detail plans supporting the amendment

Appendix C Submission form for this amendment (form 41)

1 Purpose

The purpose of the amendment is to rezone approximately 153.17 ha of Rural zoned land to the Urban Deferred zone in the Metropolitan Region Scheme (MRS), as shown on the ***Amendment Figure – Proposal 1***.

The proposed amendment will facilitate future residential development, a district centre, a primary school, conservation and public open space areas.

Requirements to Lift the Urban Deferment

The subject land is being zoned Urban Deferred, as the following requirements are to be addressed prior to lifting of Urban Deferment:

- A District Structure Plan (DSP) or the *Bullsbrook Townsite Landuse Masterplan* (BTLMP) being approved by the Western Australian Planning Commission (WAPC) to guide the development of the Bullsbrook townsite.

  The DSP or BTLUMP should consider matters such as: a spatial staging plan, district developer contribution plan, MRS reservations (e.g. High Schools, Other or Primary Regional Roads etc), buffers (e.g. landfill and extractive industries etc), environmental constraints, transport modelling and traffic analysis (amongst other matters) in consultation with relevant State Government agencies and the City of Swan;

- Confirmation of water and wastewater infrastructure;

- Confirmation on the location of a High School site;

- Confirmation of road upgrading requirements to support the proposed scale of development; and

- Confirmation that the existing landfill operations and associated buffer has ceased.

2 Background

The subject land is located within the City of Swan and is approximately 35 km north-east of the Perth CBD and is 21 km north-east of the Midland strategic centre. The Bullsbrook townsite is to the north and west, the RAAF Pearce Airbase, the Perth-Geraldton railway and Perth-Darwin Highway are further to the west. The site is located at the foothills of the Darling Scarp.

Historically, the subject land has been extensively cleared for agricultural purposes, and is predominantly characterised by large, grassed paddocks. Remnant native vegetation within the subject land is restricted to the Ki-It Monger Brook and pockets of vegetation across the subject land.

An operational Class I inert landfill (includes crushing of building materials and a solid waste depot) is located to the east of the subject land. Once closed, the landfill is proposed to be rehabilitated in accordance with Department of Water and Environment Regulation (DWER) requirements.

Vegetation across the site ranges from "Completely Degraded" to "Degraded" condition. Stands of remnant vegetation associated with Ki-It Monger Brook are proposed to be retained, as they are a potential habitat for black cockatoo species. The banks of the seasonal creek line may also support the migratory Rainbow Bee-eater.

No Threatened or Priority Flora has been identified within the site. No Threatened Ecological Communities or Priority Ecological Communities are within the site.

Land use and development within the amendment area is generally controlled by the City of Swan Local Planning Scheme No. 17 (LPS 17). The subject is currently zoned Rural in the MRS and "General Rural", "Landscape" and "Additional Uses (A46) & (A68)" in the LPS 17.

3 Scope and content of the amendment

The amendment proposes to rezone approximately five properties bounded by Great Northern Highway and a mix of Urban, Urban Deferred and Rural zoned land.

The total area subject of this amendment is approximately 106.25 ha.

4 Discussion

STRATEGIC CONTEXT

Draft *Perth and Peel @ 3.5 Million* / Draft *North-East Sub-regional Planning Framework*

The draft *Perth and Peel @ 3.5 Million* document provides a snapshot of the Perth and Peel regions in the future. It makes the case for change from a "business-as-usual" perspective to a more considered, connected, consolidated urban form. It links four draft Frameworks and encourages the consideration of new urban growth opportunities.

Future areas for urban development have been determined in conjunction with the State Government's draft *Perth and Peel Green Growth Plan for 3.5 Million*, in order to avoid and protect areas which have significant regional environmental value. The draft *North-East Sub-Regional Planning Framework* identifies the subject land as "*Urban Expansion*", with a "*Medium-Long Term (2022+)*" timeframe.

The WAPC considers that the amendment contributes to the implementation of the draft Frameworks' recommendations and generally meets the criteria outlined for consideration ahead of its urban staging timeframe.

Bullsbrook Townsite Land Use Master Plan

In 2014, the City of Swan adopted the BTLUMP in response to the targets identified under *Directions 2031 and Beyond*. The BTLUMP provides guidance for the growth and development of the Bullsbrook town site, with population forecasts to increase from 5,614 to 26,483 people by 2036.

The BTLUMP proposes the subject land be developed for urban purposes as a mix of district centre, future residential, conservation, mixed use, public open space and primary school, as well as a rapid transit route and rapid transit route terminus.

State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning

State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning (SPP 5.4) addresses transport noise from within major transport corridors, including primary freight routes, and its impact on nearby noise-sensitive land uses.

As Great Northern Highway abuts the western boundary of the subject land, there is the potential for noise attenuation to be required. The exact nature of these measures will be determined at the detailed structure planning stage. Noise reduction strategies will be designed and implemented in conjunction with local government recommendations and government agency guidelines.

State Planning Policy 4.1 - State Industrial Buffer Policy

State Planning Policy 4.1 - State Industrial Buffer Policy (SPP 4.1) applies statewide, to planning decision-making, and proposals which seek to provide for new industrial areas and uses, and essential infrastructure, sensitive land uses in proximity to existing industrial areas. The objectives of the policy are to:

- avoid conflict between industry and/or essential infrastructure and sensitive land uses;
- protect industry and/or essential infrastructure from encroachment by those land uses that would be sensitive to impacts and adversely impact the efficient operations;
- provide for the development of industry and/or the provision of essential infrastructure in a way that maximises amenity, minimises environmental and health impacts and takes account of risk to nearby sensitive land uses; and
- promote compatible uses in areas affected by off-site impacts of industry and/or essential infrastructure.

The proposed amendment is in accordance with SPP 4.1 as the subject land is being zoned Urban Deferred, and will require that the landfill operations have ceased prior to being transferred to the Urban zone.

State Planning Policy 3.7 – Planning in Bushfire Prone Areas

State Planning Policy 3.7 – Planning in Bushfire Prone Areas (SPP 3.7) seeks to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. It applies to all higher order strategic planning documents, strategic planning proposals, subdivision and development applications located in designated bushfire prone areas (unless exemptions apply).

The accompanying *Guidelines for Planning in Bushfire Prone Areas* provide supporting information to assist in the interpretation of the objectives and policy measures outlined in SPP 3.7. They provide advice on how bushfire risk is to be addressed when planning, designing or assessing a planning proposal within a designated bushfire prone area.

STATUTORY CONTEXT

Environment

The former Office of the Environmental Protection Authority (OEPA) notes that it has considered the BTLUMP in 2014. The subject land has been extensively cleared for agricultural purposes, and as a result is predominantly characterised by large, grassed paddocks. Remnant native vegetation is restricted to the Ki-It Monger Brook and pockets of vegetation within the proposed amendment area. The OEPA notes the following in relation to the proposed amendment:

- A Ki-It Monger Brook Management plan will be prepared and implemented to mitigate potential impacts to the native vegetation and fauna habitat retained within the brook;
- A Wetland Management plan for the portion of the Conservation Category Wetland within the Ki-It Monger Brook will be prepared prior to subdivision; and
- Road noise associated with heavy haulage from the Great Northern Highway will be considered at the structure planning stage in accordance with SPP 5.4.

At a regional level, the majority of the remnant vegetation on the subject land is mapped as Guildford Complex, which is below 10% of the pre-European extent. From the information provided, the Guildford Complex is mostly associated with the Ki-It Monger Brook and is to be retained. The OEPA supports the retention of the remnant vegetation within the Ki-It Monger Brook, through the establishment of buffer areas, development setbacks, drainage retention and open space areas consistent with the BTLUMP.

The other pockets of remnant vegetation outside of the Ki-It Monger Brook, will be considered for retention through the local structure plan and Remnant Vegetation Management Plan. The OEPA supports the retention of the portions of remnant vegetation and recommends that these areas are prioritised for retention in the structure planning process.

A pocket of remnant Guildford Complex occurs within Lot 1314 Chittering Road, Bullsbrook, which has been identified as active Public Open Space (POS) associated with a Primary School in the BTLUMP. This vegetation should be prioritised as POS and not result in the clearing of the vegetation for a school oval.

The OEPA is of the view that the proposed MRS amendment does not raise any environmental issues that are likely to be significant in terms of the Environmental Protection Authority's (EPA) environmental objectives. However, all amendments to the MRS still require referral to the EPA in accordance with Section 38 of the *Planning and Development Act 2005* for a decision on whether or not the amendment requires formal environmental assessment.

Urban Water Management

A District Water Management Strategy for the site has been approved by former Department of Water.

Infrastructure

Water and Wastewater

The Water Corporation has prepared long-term, conceptual water and wastewater planning that provides for the ultimate urban expansion of the Bullsbrook townsite. This conceptual infrastructure planning may be staged and varied in consultation with the Corporation.

The Corporation's role in the ongoing planning for Bullsbrook is to prepare, maintain and review its long term water and wastewater system planning for the town at the headworks level. The Corporation's adopted infrastructure planning for new water storages, water distribution mains, permanent wastewater pumping stations and large gravity sewers is premised on the logical and orderly spatial progression of the townsite development front.

The water and wastewater planning for the town and environs is subject to ongoing review and the Corporation will continue to adjust the planning and timing on capital upgrades as needed to meet the proposed townsite growth. Depending on location and hydraulic considerations, opportunities may exist for developers to prefund some Corporation permanent works to align better with their development timeframes. The option also exists for developers to request the Corporation to adjust the timing of capital project/s to an earlier delivery date to suit their development timeframe.

The north-eastern corner of the subject land, north of the Ki-It Monger Brook is readily serviceable by extensions of mains from the existing water and wastewater systems. The balance of the amendment area is spatially separated from the current town development front. If subdivision and development of the land to the south occurs ahead of the Corporation's planned capital expenditure on headworks infrastructure, the developers may be required to fund the headworks to the serve the area.

"Leap-frogging" ahead of the logical development front would require developers to individually or jointly investigate the feasibility of installing temporary wastewater pump stations and long water main extensions from the town. Temporary servicing arrangements may be considered, provided that they do not detract from or compromise the Corporation's long-term planning and the hydraulic capacity exists in the town's systems to support long reticulation water mains extensions to accept pumped wastewater flows.

Transportation

Main Roads WA (MRWA) acknowledges that the Perth-Darwin National Highway will attract and divert some freight traffic away from Great Northern Highway. However, the Great Northern Highway will remain a major freight route and distributor road from these precincts.

It is likely that Great Northern Highway will need to be upgraded through the Bullsbrook area in order to cater for the proposed increased traffic volumes. Future planning work for this has not yet commenced.

Access to the Perth-Darwin National Highway will be via Stock Road to the south or via Rutland Road to Neaves Road to the north. These roads will need to be upgraded to highway standard or possibly four lane dual carriageways.

MRWA supports the BTLUMP to guide the development of the area. However, it is necessary to have some foundation infrastructure in place to support the development. The connection of Stock Road to the Perth-Darwin National Highway is important. Prior to the transfer of the land to the Urban zone, confirmation is required on the upgrading requirements to support the proposed scale of development.

5 Aboriginal heritage

The *Aboriginal Heritage Act 1972* (AHA) provides for the protection and preservation of Aboriginal heritage and culture throughout Western Australia, including places and objects that are of significance to Aboriginal people. Aboriginal sites and materials are protected whether or not they have been previously recorded or reported.

The process of rezoning or reservation of land in a region scheme is not in itself directly affected by the AHA. Proposed changes to land-use are broad by nature and do not physically interfere with the land. Consideration of any protection that may be required is addressed more specifically at later stages of the planning process, typically being a local planning scheme amendment and when preparing a local structure plan.

Nevertheless, in recognising the importance of having reliable Aboriginal information on land and the values attached to it, the WAPC / Department of Planning, Lands and Heritage has entered into a Memorandum of Understanding with the South West Aboriginal Land and Sea Council (SWALSC) for the provision of Aboriginal consultative services. All MRS amendment proposals likely to have Aboriginal interest are now referred to SWALSC for comment before being released for public submission. SWALSC is the recognised Native Title Representative Body for Western Australia's south west region, and as such is also well placed to provide advice on Aboriginal heritage.

This amendment has been pre-referred to the SWALSC but no response was received. However, it will be referred to SWALSC during the advertising period for the amendment.

6 Coordination of local and region scheme amendments

Under section 126(3) of the *Planning and Development Act 2005* the WAPC has the option to concurrently rezone land being zoned Urban under the MRS to a "Development" zone (or similar) in the Local Planning Scheme. As no land is being zoned Urban, section 126(3) of the *Planning and Development Act 2005* is not applicable.

7 Substantiality

The *Planning and Development Act 2005* allows for amendments to the MRS to be processed as either "minor" or "major" amendments depending on whether they are considered to constitute a substantial alteration to the MRS or not. WAPC Policy *DC 1.9 Amendment to Region Schemes* sets out the criteria for deciding whether the major or minor process should be followed. In this regard, the amendment is proposed to be processed as a "major" amendment given it seeks to zone a new urban area which is considered to be a substantial/regional change in the MRS and in the general Bullsbrook locality.

8 Sustainability

The proposed amendment will facilitate the future urban development of the site in accordance with the BTLUMP and will complement the existing Industrial zoned areas in Bullsbrook, has regard to the protection of the environment and has access to the regional road network e.g. Great Northern Highway.

9 Environmental Protection Authority advice

The proposed amendment was referred to the Environmental Protection Authority (EPA) for advice on whether environmental assessment would be required.

The EPA has advised that the proposed amendment does not require formal assessment under Part IV of the *Environmental Protection Act 1986*. However, it has provided advice on the key environmental factors for the amendment. A copy of the notice from the EPA is included at appendix A.

10 The amendment process

The procedures for amending the MRS are prescribed by the *Planning and Development Act 2005.* The amendment proposed in this report is being made under the provisions of Section 41 of that act.

In essence, this procedure for a substantial alteration to the MRS (often referred to as a 'major' amendment) involves:

- formulation of the amendment by the WAPC;
- referral to the EPA for environmental assessment;
- completion of an Environmental Review (if required) to EPA instructions;
- public submissions being sought on the proposed amendment (including the Environmental Review if it was required);
- consideration of submissions (including hearings where requested);
- referral of WAPC recommendations, with or without any modifications to the amendment in response to submissions, to the Minister for Planning;
- approval by the Governor;
- consideration by both Houses of Parliament, which can disallow the amendment;
- amendment takes legal effect when no longer subject to disallowance after 12 sitting days; and
- where the WAPC has agreed to the parallel amendment of a local planning scheme under section 126(3) of the *Planning and Development Act 2005*, the local planning scheme amendment becomes effective upon gazettal of the MRS amendment.

An explanation of this process can also be found in the front of this report, entitled *'The Metropolitan Region Scheme, what it is and how it is amended'*.

11 Submissions on the amendment

The WAPC invites people to comment on this proposed amendment to the MRS.

The amendment is being advertised for public submissions for a period of three months from Friday 2 March 2018 to Friday 8 June 2018.

Copies of the amendment will be available for public inspection at:

i) Western Australian Planning Commission, 140 William Street, Perth

ii) City of Perth

ii) City of Fremantle

ii) City of Swan

ii) City of Kalamunda

iii) the State Reference Library, Northbridge.

Online submissions are encouraged via: *www.planning.wa.gov.au/public-comment.*

Written submissions on the amendment should be sent to:

The Secretary
Western Australian Planning Commission
Locked Bag 2506
PERTH WA 6001

and **must be received by Friday 8 June 2018.**

All submissions received by the WAPC will be acknowledged.

For your convenience a submission form (Form 41) for this amendment 1324/41 is attached to this report (Appendix C). Additional copies of this form are available from the display locations listed above and from the PlanningWA website *www.dplh.wa.gov.au.*

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Before completing your submission form, please refer to the information regarding hearings in Appendix II of this report.

13 Modifications to the amendment

After considering any comments received from the public and Government agencies, the WAPC may make modifications to the amendment.

The recommendations of the WAPC, including any modifications, are published in a report on submissions. Anyone who has made a submission will receive a copy of this document when the amendment is tabled in Parliament. The report will also be available on the PlanningWA website *www.dplh.wa.gov.au*.

14 Final outcome

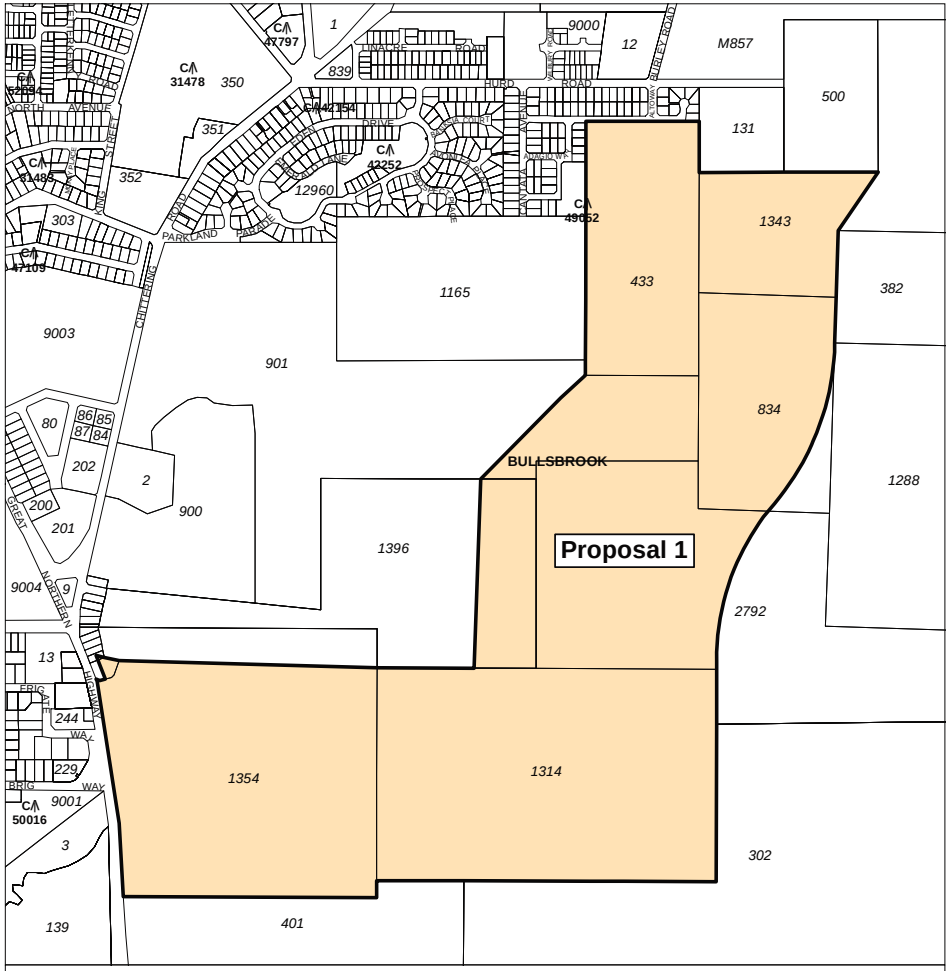
After considering the submissions, the WAPC may make modifications to the amendment. The WAPC will then submit the amendment plans, together with a *Report on Submissions* and a copy of all written submissions, to the Minister for Planning for presentation to the Governor.

If the Governor approves, a copy of the plans of the amendment together with the *Report on Submissions* will be laid before each House of Parliament for twelve sitting days. Either House may, by resolution, disallow an amendment within that time. As soon as the amendment is no longer subject to disallowance it becomes legally effective in the MRS.

People who have made submissions will be kept advised on the progress of the amendment, and along with all affected landowners, will be notified of the final outcome.

MRS Amendment 1324/41
Central Bullsbrook Urban Precinct

Amendment Figure
Proposal 1



Central Bullsbrook Urban Precinct
Proposed major amendment
as advertised

27th April 2017 — Proposal 1

Proposed Amendment:

Urban deferred zone

Oracle reference no: 2907
File number: 809/02/21/0041
Version number: 4

Western Australian Planning Commission

Date: 10/10/2017
Produced by Geospatial Research and Modelling, Department of Planning, Lands and Heritage, Perth WA
Base information supplied by Western Australian Land Information Authority LI 862-2016-1

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Appendix A

Notice of environmental assessment

GOVERNMENT OF WESTERN AUSTRALIA

Environmental Protection Authority

DEPARTMENT OF PLANNING
19 JUL 2017
FILE RLS/0696

The Secretary
Western Australian Planning Commission
Locked Bag 2506
PERTH WA 6001

Your Ref:
Our Ref: CMS16275
Enquiries: Billie-J Hughes, 6364 7600
Email: Billie-J.Hughes@dwer.wa.gov.au

Dear Sir/Madam

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

SCHEME:	**Metropolitan Region Scheme – Amendment 1324/41 Bullsbrook Central Urban Precinct**
LOCATION:	**Various properties bounded by Great Northern Highway and a mix of Urban, Urban Deferred and Rural zoned land**
RESPONSIBLE AUTHORITY:	**Western Australian Planning Commission**
DECISION:	**Referral Examined, Preliminary Investigations and Inquiries Conducted. Scheme Amendment Not to be Assessed Under Part IV of EP Act. Advice Given. (Not Appealable)**

Thank you for referring the above proposed scheme to the Environmental Protection Authority (EPA).

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

Please note the following:

- For the purposes of Part IV of the EP Act, the scheme is defined as an assessed scheme. In relation to the implementation of the scheme, please note the requirements of Part IV Division 4 of the EP Act.

- There is no appeal right in respect of the EPA's decision to not assess the scheme.

A copy of this letter and the attached advice and recommendations will be made available to the public via the EPA website.

Yours sincerely

Robert Harvey
DEPUTY CHAIRMAN

Delegate of the Chairman of the Environmental Protection Authority
Under Notice of Delegation No. 40 published 7 March 2017

17 July 2017

Encl. Scheme Advice and Recommendations

ADVICE UNDER SECTION 48A(1)(a)
ENVIRONMENTAL PROTECTION ACT 1986

Metropolitan Region Scheme Amendment 1324/41 Bullsbrook Central Urban Precinct

Location: Approximately 5 properties bounded by Great Northern Highway and a mix of Urban, Urban Deferred and Rural zoned land

Determination: Scheme Not Assessed – Advice Given (no appeals)

Determination Published: 17 July 2017

Summary

The Western Australian Planning Commission (WAPC) has resolved to proceed with Metropolitan Region Scheme Amendment 1324/41 Bullsbrook Central Urban Precinct. The purpose of the scheme amendment is to transfer approximately 153.17 hectares of Rural zoned land to Urban Deferred.

The Environmental Protection Authority (EPA) has considered the scheme amendment in accordance with the requirements of the *Environmental Protection Act 1986* (EP Act). The EPA considers that the scheme amendment, as set out, is unlikely to have a significant effect on the environment and does not warrant formal assessment under Part IV of the EP Act. Having considered this matter the following advice is provided.

1. Environmental Factors

Having regard to EPA's *Statement of Environmental Principles, Factors and Objectives*, the EPA has identified the following preliminary environmental factors relevant to this scheme amendment:

a) Flora and Vegetation;
b) Terrestrial Fauna;
c) Hydrological Processes;
d) Inland Water Environmental Quality;
e) Social Surroundings; and
f) Human Health

Advice and Recommendations regarding Environmental Factors

The EPA has based its decision on the documentation provided by the WAPC.

a. Flora and Vegetation, Terrestrial fauna

The remnant native vegetation within the amendment area is mapped as Guildford Complex, which only has 5.3% of its original extent remaining. The occurrence of Guildford Complex is mostly associated with the Ki-it Monger Brook. The vegetation ranges in condition from Degraded to Completely Degraded with the better quality along the Ki-it Monger Brook, the associated Conservation Category Wetland (CCW) and in Lot 1314.

The vegetation along the Ki-it Monger Brook and in the southern portion of Lot 1314 is also potential Carnaby's Black Cockatoo habitat. All species of Black Cockatoos are protected

under both the *Wildlife Conservation Act 1950* and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any proposed development may require referral to the Commonwealth Department of the Environment and Energy under the EPBC Act due to impacts to Black Cockatoo habitat.

The EPA supports the retention of the remnant vegetation associated with the Ki-it Monger Brook as proposed in the scheme amendment documentation and concept planning. The EPA would also support the conservation of remnant vegetation mapped as Guildford Complex, which are specific commitments for retention under the Strategic Assessment of the Perth and Peel regions. The EPA notes the vegetated area within Lot 1314, proposed for active Public Open Space is Guildford Complex, and recommends this vegetation is prioritised for retention in the structure planning process.

b. Hydrological Processes and Inland Water Environmental Quality

Two wetland areas are associated with the Ki-it Monger Brook, with one identified as a Conservation Category Wetland (CCW). Other minor drainage lines also traverse the area.

The EPA considers CCWs to be of high conservation value that require a high level of protection. EPA Guidance Statement No. 33 *Environmental Guidance for Planning and Development* (GS 33) states that CCWs are wetlands which support a high level of attributes and functions, with the EPA urging that all CCWs and appropriate buffers are fully protected. The retention and management of the Ki-it Monger Brook, other drainage lines and the CCW with a buffer is recommended and supported. GS 33 recommends a 50 metre buffer for CCWs from the geomorphic wetland boundary to ensure wetland values are protected. Alternatively a site specific buffer requirement may be determined.

It is noted a District Water Management Strategy has been approved by the Department of Water. The Ki-it Monger Brook flows to Ellen Brook and therefore management and maintenance of water quality and quantity is an important component of the future development of the site.

c. Social Surroundings and Human Health

An Aboriginal heritage site, mythological site 3583, is registered over the scheme amendment area. The EPA recommends consultation with the Traditional Owner group and investigations into the extent of the mythological site be undertaken prior to structure planning.

An operational Class 1 inert landfill is located in the eastern portion of the Amendment area. The separation distance between the landfill and proposed amendment area is approximately 500 metres (m). The generic separation distance recommended for inert landfills in the EPA's *Guidance for the Assessment of Environmental Factors No. 3: Separation Distances between Industrial and Sensitive Land Uses* (EPA 2005) is 150m.

The EPA supports the requirement for the land to not be transferred to the Urban zone until operations have ceased and the proposed rehabilitation of the landfill site once closed.

Recommendation

The EPA concludes that the scheme amendment can be managed to meet the EPA's environmental objectives through the requirements to lift Urban Deferment, preparation of

future local planning scheme provisions and/or structure planning to further and identify, manage and protect the above environmental values.

The EPA does not consider it appropriate for a concurrent amendment to the region and local planning schemes under section 126 of the *Planning and Development Act 2005* to be undertaken.

Bullsbrook Central Urban Precinct

Proposed Major Amendment

Amendment 1324/41

as advertised

Appendix B

List of detail plans supporting the amendment

Amending Plan 3.2700
Detail Plans
1.5826, 1.5827, 1.5830 & 1.5866

Appendix C

Submission form for this amendment (form 41)

Planning and Development Act 2005
Section 41 Amendment (Substantial)
Form 41

Submission

Metropolitan Region Scheme Amendment 1324/41

Central Bullsbrook Urban Precinct

OFFICE USE ONLY

SUBMISSION NUMBER

RLS/0729

To: Secretary
Western Australian Planning Commission
Locked Bag 2506
Perth WA 6001

Title *(Mr, Mrs, Miss, Ms)* ..... First Name .....

Surname ..... (PLEASE PRINT CLEARLY)

Address ..... Postcode .....

Contact phone number ..... Email address .....

Submission (Please attach additional pages if required. It is preferred that any additional information be loose rather than bound)

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turn over to complete your submission

Hearing of submissions

Anyone who has made a written submission on the amendment has the opportunity to personally present the basis of their submission to a sub-committee of the WAPC. **You do not have to attend a hearing.** The comments presented by you in this written submission will be considered in determining the recommendation for the proposed amendment.

For information about the submission and hearings process, please refer to the amendment report and in particular appendix D.

Please choose one of the following:

☐ **No**, I do not wish to speak at the hearings. (Please go to the bottom of the form and sign)

OR

☐ **Yes**, I wish to speak at the hearings. (Please complete the following details)

I will be represented by:

☐ Myself – My telephone number (business hours): ……

or

☐ A spokesperson

Name of spokesperson: ……
Contact telephone number (business hours): ……
Postal address: ……

I would prefer my hearing to be conducted in:

☐ Public (members from the general public may attend your presentation)

OR

☐ Private (only the people nominated by you or the hearings committee will be permitted to attend)

You should be aware that:

- The WAPC is subject to the *Freedom of Information Act 1992* and as such, submissions made to the WAPC may be subject to applications for access under the act.
- In the course of the WAPC assessing submissions, or making its report on these submissions, copies of your submission or the substance of that submission, may be disclosed to third parties.
- Hearings may be recorded and transcribed. The minutes of all hearings, along with all written submissions, are tabled in Parliament and published as public records should the Governor approve the proposed amendment. The WAPC recommendations are similarly published in a report on submissions and tabled in Parliament.

To be signed by person(s) making the submission

Signature …… Date ……

Note: Submissions MUST be received by the advertised closing date, being close of business (5pm) on 8 JUNE 2018. Late submissions will NOT be considered.

Contacts: Telephone - (08) 6551 8002 Fax - (08) 6551 9001 Website - http://www.planning.wa.gov.au/public-comment

Section 3

Amendment 1325/41

North Bullsbrook Urban Precinct

Contents

1 Purpose....1
2 Background....1
3 Scope and content of the amendment....2
4 Discussion....2
5 Aboriginal Heritage....4
6 Coordination of local and region scheme amendments....5
7 Substantiality....5
8 Sustainability Appraisal....5
9 Environmental Protection Authority advice....5
10 The amendment process....5
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Appendix A Notice of environmental assessment
Appendix B List of detail plans supporting the amendment
Appendix C Submission form for this amendment (form 41)

Metropolitan Region Scheme Amendment 1325/41

North Bullsbrook Urban Precinct

1 Purpose

The purpose of the amendment is to rezone approximately 63.75 ha in Bullsbrook from the Rural zone to the Urban Deferred zone in the Metropolitan Region Scheme (MRS), as shown on ***Amendment Figure – Proposal 1***.

The proposed amendment will facilitate future residential development, areas of public open space, a primary school and associated playing fields.

Requirements to lift the Urban Deferment

The subject land is being zoned Urban Deferred, as the following requirements are to be addressed prior to lifting of Urban Deferment:

- A District Structure Plan (DSP) or the *Bullsbrook Townsite Land Use Masterplan* (BTLUMP) being approved by the Western Australian Planning Commission (WAPC) to guide the development of the Bullsbrook townsite.

  The DSP or BTLUMP should consider matters such as: a spatial staging plan, district developer contribution plan, MRS reservations (e.g. High Schools, Other or Primary Regional Roads etc), buffers (e.g. landfill and extractive industries etc), environmental constraints, transport modelling and traffic analysis (amongst other matters) in consultation with relevant State Government agencies and the City of Swan;

- Confirmation of water and wastewater infrastructure;

- Confirmation on the location of a High School site; and

- Confirmation of road upgrading requirements to support the proposed scale of development.

2 Background

The subject land is located within the City of Swan and is approximately 36 km north-east of the Perth CBD and is 23 km north-east of the Midland strategic centre. The land has access to Great Northern Highway and existing local roads in the locality. The Bullsbrook townsite and RAAF Pearce Airbase are to the south and the Perth-Geraldton railway and Perth-Darwin Highway are further to the west of the site.

The land has been used for a range of rural uses such as cropping and grazing and rural-residential uses. A number of existing dwellings and (associated outbuildings and infrastructure) are located within the land. The elevation of the site ranges from 56 m Australian Height Datum (AHD) in the west to 143 m AHD in the east.

The Bullsbrook Wastewater Treatment Plant (WWTP) and associated 500 m buffer is located to the west of the site. The proposed amendment area is located outside the 500 m WWTP buffer area.

Vegetation across the site ranges from "Completely Degraded" to "Very Good" condition. "Completely Degraded" areas dominate the majority of the site, consisting of cleared and grazed paddocks dominated by pasture weeds and developed areas. The pockets of remnant plant communities vary from "Degraded" to "Very Good" condition depending on the level of previous disturbance, extent of weed invasion and loss of native species. Areas of vegetation in "Good" or better condition are limited to Lots 17 and 18 Ashton Road, Bullsbrook.

A Threatened Ecological Community or Priority Ecological Community (SCP 3c) may be present within the site. Therefore a future detailed spring survey is proposed to be undertaken to inform a local structure plan. There are no Bush Forever sites within the site.

There is potential fauna habitat for three threatened species of Black Cockatoo and the Chuditch occurs within the site, primarily within Lots 17 and 18 Ashton Road. The proposal must comply with State and Federal environmental legislative requirements.

Land use and development within the amendment area is generally controlled by the City of Swan Local Planning Scheme No. 17 (LPS 17). The subject is currently zoned "General Rural" in LPS 17.

3 Scope and content of the amendment

The amendment proposes to rezone approximately 14 properties and road reserves to the east of Great Northern Highway, generally bound by Ashton Road and Chittering Road to north-east, Kimberley Road and residential lots to the south and Rural zoned lots to the north and west.

The total area subject of this amendment is approximately 63.75 ha.

4 Discussion

STRATEGIC CONTEXT

Draft *Perth and Peel @ 3.5 Million* / Draft *North-East Sub-regional Planning Framework*

The draft *Perth and Peel @ 3.5 Million* document provides a snapshot of the Perth and Peel regions in the future. It makes the case for change from a "business-as-usual" perspective to a more considered, connected, consolidated urban form. It links four draft Frameworks and encourages the consideration of new urban growth opportunities.

Future areas for urban development have been determined in conjunction with the State Government's draft *Perth and Peel Green Growth Plan for 3.5 Million*, in order to avoid and protect areas which have significant regional environmental value. The draft *North-East Sub-Regional Planning Framework* identifies the subject land as "*Urban Expansion*", with a "*Medium-Long Term (2022+)*" timeframe.

The WAPC considers that the amendment contributes to the implementation of the draft Frameworks' recommendations and generally meets the criteria outlined for consideration ahead of its urban staging timeframe.

Bullsbrook Townsite Land Use Master Plan

In 2014, the City of Swan adopted the BTLUMP in response to the targets identified under *Directions 2031 and Beyond*. The BTLUMP provides guidance for the growth and development of the Bullsbrook town site, with population forecasts to increase from 5,614 to 26,483 people by 2036.

The subject site forms part of the Bullsbrook townsite and is identified for future residential development. The BTLUMP shows the location of a new primary school and adjacent playing fields. The BTLUMP also shows a portion of Ashton Road adjoining the subject site as an activity corridor which connects south to Chittering Road and a new north-south arterial route.

A neighbourhood centre node is identified along Ashton Road, adjacent to the Primary School site. However, the proponent considers a more suitable location for the neighbourhood centre node along Kimberley Street, which acts as a neighbourhood connector with linkages to the existing road network. The proposed amendment is generally in accordance with the BTLUMP.

State Planning Policy 3.7 – Planning in Bushfire Prone Areas

State Planning Policy 3.7 – Planning in Bushfire Prone Areas (SPP 3.7) seeks to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. It applies to all higher order strategic planning documents, strategic planning proposals, subdivision and development applications located in designated bushfire prone areas (unless exemptions apply).

The accompanying *Guidelines for Planning in Bushfire Prone Areas* provide supporting information to assist in the interpretation of the objectives and policy measures outlined in SPP 3.7. They provide advice on how bushfire risk is to be addressed when planning, designing or assessing a planning proposal within a designated bushfire prone area. A Bushfire Management Plan has been approved for the site by the Department of Fire and Emergency Services.

STATUTORY CONTEXT

Environment

The former Office of the Environmental Protection Authority (OEPA) advises that remnant vegetation within the subject area may have potential habitat for Carnaby's Cockatoos. All species of Cockatoos are protected under both the *Wildlife Conservation Act 1950* and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The former OEPA has no objection to the WAPC initiating the proposed amendment, subject to the retention of remnant vegetation consistent with work undertaken for the draft Green Growth Plan (GGP). The former OEPA notes that the associated concept plan does not protect the areas identified for retention in the draft GGP.

The former OEPA acknowledges that further consultation and investigations will be required in the preparation of relevant management plans as a condition of a local structure plan, subdivision or a development application with relevant agencies.

All amendments to the MRS require referral to the Environmental Protection Authority (EPA) in accordance with Section 38 of the *Planning and Development Act 2005* for a decision on whether or not the amendment requires formal environmental assessment.

Urban Water Management

A District Water Management Strategy is required to be approved by the Department of Water and Environmental Regulation prior to the WAPC's consideration of the amendment for a final determination.

Infrastructure

Water & Wastewater

The Water Corporation advises as follows:

Water: There is water planning for the proposed amendment area. However, the Bullsbrook scheme can only service land to 90 m AHD. The Corporation has planned the acquisition and construction of a high level tank site that will allow the entire site to be serviced. This upgrade is expected in the next five years.

Wastewater: Currently there is no wastewater planning for the proposed amendment area. However, the proponents reports state there is capacity to serve the area with some off-site upgrades to the system. The planning and servicing upgrade issues will need to be refined in the subsequent structure planning stage.

Transportation

Main Roads WA and Department of Transport raise no objections to the proposed amendment.

5 Aboriginal heritage

The *Aboriginal Heritage Act 1972* (AHA) provides for the protection and preservation of Aboriginal heritage and culture throughout Western Australia, including places and objects that are of significance to Aboriginal people. Aboriginal sites and materials are protected whether or not they have been previously recorded or reported.

The process of rezoning or reservation of land in a region scheme is not in itself directly affected by the AHA. Proposed changes to land-use are broad by nature and do not physically interfere with the land. Consideration of any protection that may be required is addressed more specifically at later stages of the planning process, typically being a local planning scheme amendment and when preparing a local structure plan.

Nevertheless, in recognising the importance of having reliable Aboriginal information on land and the values attached to it, the WAPC / Department of Planning, Lands and Heritage has entered into a Memorandum of Understanding with the South West Aboriginal Land and Sea Council (SWALSC) for the provision of Aboriginal consultative services. All MRS amendment proposals likely to have Aboriginal interest are now referred to SWALSC for comment before being released for public submission. SWALSC is the recognised Native Title Representative Body for Western Australia's south west region, and as such is also well placed to provide advice on Aboriginal heritage.

This amendment has been pre-referred to the SWALSC but no response was been received. However, it will be referred to SWALSC during the advertising period for the amendment.

6 Coordination of local and region scheme amendments

Under section 126(3) of the *Planning and Development Act 2005* the WAPC has the option to concurrently rezone land being zoned Urban under the MRS to a "Development" zone (or similar) in the Local Planning Scheme. As the subject land is being zoned Urban Deferred in the MRS, section 126(3) of the *Planning and Development Act 2005* is not applicable.

7 Substantiality

The *Planning and Development Act 2005* allows for amendments to the MRS to be processed as either "minor" or "major" amendments depending on whether they are considered to constitute a substantial alteration to the MRS or not. WAPC Policy *DC 1.9 Amendment to Region Schemes* sets out the criteria for deciding whether the major or minor process should be followed. In this regard, the amendment is proposed to be processed as a "major" amendment given it seeks to zone a new urban area which is considered to be a substantial/regional change in the MRS and in the general Bullsbrook locality.

8 Sustainability

The proposed amendment will facilitate the future urban development of the site in accordance with the BTLUMP and will complement the existing Industrial zoned areas in Bullsbrook, has regard to the protection of the environment and has access to the regional road network e.g. Great Northern Highway.

9 Environmental Protection Authority advice

The proposed amendment was referred to the EPA for advice on whether environmental assessment would be required.

The EPA has advised that the proposed amendment does not require formal assessment under Part IV of the *Environmental Protection Act 1986*. However, it has provided advice on the key environmental factors for the amendment. A copy of the notice from the EPA is included at appendix A.

10 The amendment process

The procedures for amending the MRS are prescribed by the *Planning and Development Act 2005.* The amendment proposed in this report is being made under the provisions of Section 41 of that act.

In essence, this procedure for a substantial alteration to the MRS (often referred to as a 'major' amendment) involves:

- formulation of the amendment by the WAPC;
- referral to the EPA for environmental assessment;
- completion of an Environmental Review (if required) to EPA instructions;
- public submissions being sought on the proposed amendment (including the Environmental Review if it was required);

- consideration of submissions (including hearings where requested);
- referral of WAPC recommendations, with or without any modifications to the amendment in response to submissions, to the Minister for Planning;
- approval by the Governor;
- consideration by both Houses of Parliament, which can disallow the amendment;
- amendment takes legal effect when no longer subject to disallowance after 12 sitting days; and
- where the WAPC has agreed to the parallel amendment of a local planning scheme under section 126(3) of the *Planning and Development Act 2005*, the local planning scheme amendment becomes effective upon gazettal of the MRS amendment.

An explanation of this process can also be found in the front of this report, entitled *'The Metropolitan Region Scheme, what it is and how it is amended'*.

11 Submissions on the amendment

The WAPC invites people to comment on this proposed amendment to the MRS.

The amendment is being advertised for public submissions for a period of three months from Friday 2 March 2018 to Friday 8 June 2018.

Copies of the amendment will be available for public inspection at:

i) Western Australian Planning Commission, 140 William Street, Perth

ii) City of Perth

ii) City of Fremantle

ii) City of Swan

ii) City of Kalamunda

iii) the State Reference Library, Northbridge.

Online submissions are encouraged via: *www.planning.wa.gov.au/public-comment.*

Written submissions on the amendment should be sent to:

The Secretary
Western Australian Planning Commission
Locked Bag 2506
PERTH WA 6001

and **must be received by Friday 8 June 2018.**

All submissions received by the WAPC will be acknowledged.

For your convenience a submission form (Form 41) for this amendment 1325/41 is attached to this report (Appendix C). Additional copies of this form are available from the display locations listed above and from the PlanningWA website *www.dplh.wa.gov.au*.

You should be aware that the calling for submissions is a public process, and all submissions lodged will together become a public document. It will be published and made available when the amendment is presented to both Houses of Parliament. Advice of disclosure and access requirements is shown on side two of the submission form.

Before making your submission, it is recommended that you read the information in Appendix II of this report regarding preparing a submission.

12 Hearings

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Presentations made to the hearings committee are an extension of the submission process, and the minutes of all hearings will become a public document. The minutes will be published and made available when the amendment is presented to both Houses of Parliament.

Before completing your submission form, please refer to the information regarding hearings in Appendix II of this report.

13 Modifications to the amendment

After considering any comments received from the public and Government agencies, the WAPC may make modifications to the amendment.

The recommendations of the WAPC, including any modifications, are published in a *Report on Submissions*. Anyone who has made a submission will receive a copy of this document when the amendment is tabled in Parliament. The report will also be available on the PlanningWA website *www.dplh.wa.gov.au*.

14 Final outcome

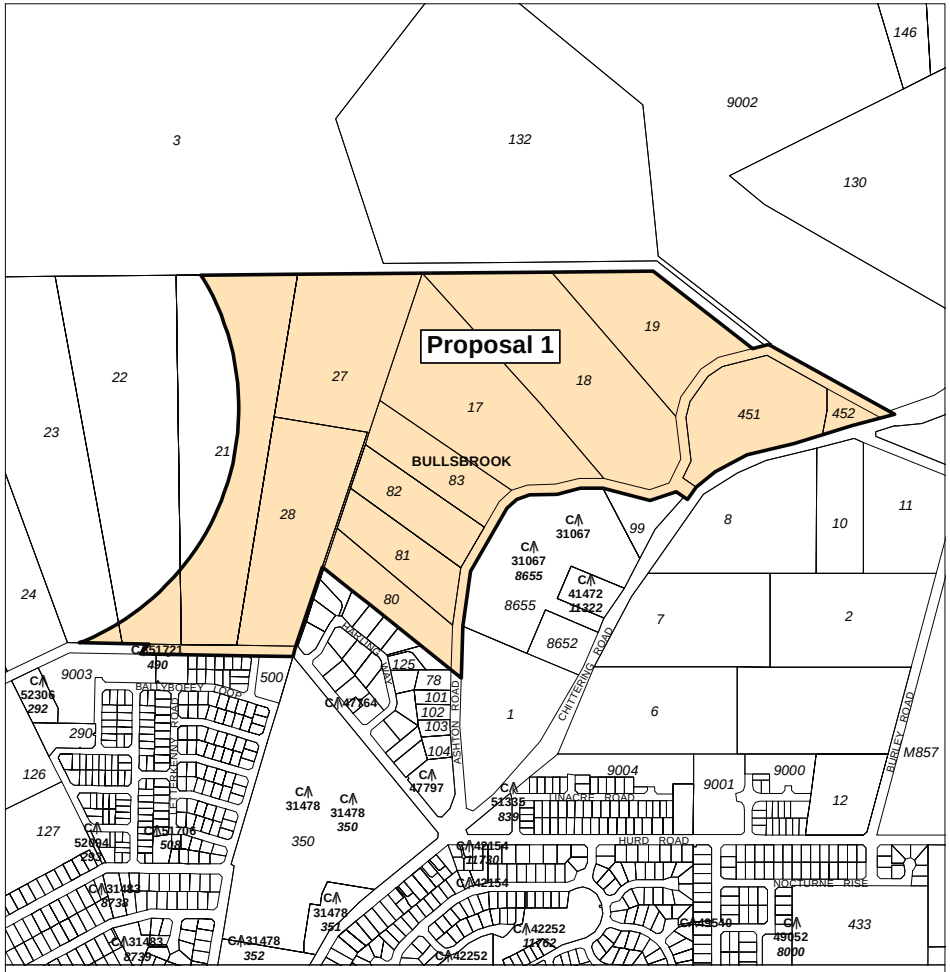
After considering the submissions, the WAPC may make modifications to the amendment. The WAPC will then submit the amendment plans, together with a *Report on Submissions* and a copy of all written submissions, to the Minister for Planning for presentation to the Governor.

If the Governor approves, a copy of the plans of the amendment together with the *Report on Submissions* will be laid before each House of Parliament for twelve sitting days. Either House may, by resolution, disallow an amendment within that time. As soon as the amendment is no longer subject to disallowance it becomes legally effective in the MRS.

People who have made submissions will be kept advised on the progress of the amendment, and along with all affected landowners, will be notified of the final outcome.

MRS Amendment 1325/41
North Bullsbrook Urban Precinct

Amendment Figure
Proposal 1



North Bullsbrook Urban Precinct
Proposed major amendment
as advertised

27 April 2017 Proposal 1

Proposed Amendment:

Urban deferred zone

Oracle reference no: 2865
File number: 809/02/21/0042P
Version number: 2

Western Australian Planning Commission

Date: 10/10/2017
Produced by Geospatial Research and Modelling, Department of Planning, Lands and Heritage, Perth WA
Base information supplied by Western Australian Land Information Authority LI 862-2016-1

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metres

Appendix A

Notice of environmental assessment

GOVERNMENT OF WESTERN AUSTRALIA

Environmental Protection Authority

The Secretary
Western Australian Planning Commission
Locked Bag 2506
PERTH WA 6001

Your Ref:
Our Ref: CMS15209
Enquiries: Angela.Coletti, 6364 7600
Email: Angela.Coletti@dwer.wa.gov.au

Department of Planning, Lands and Heritage
Received
Scanned 20 SEP 2017
Attachments
Scan QA
Doc No.
File No. RLS/05.70

Dear Sir/Madam

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

SCHEME:	**Metropolitan Region Scheme Amendment 1325-41 – North Bullsbrook Urban Precinct**
LOCATION:	**North Bullsbrook**
RESPONSIBLE AUTHORITY:	**Western Australian Planning Commission**
DECISION:	**Referral Examined, Preliminary Investigations and Inquiries Conducted. Scheme Amendment Not to be Assessed Under Part IV of EP Act. Advice Given. (Not Appealable)**

Thank you for referring the above proposed scheme to the Environmental Protection Authority (EPA).

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

Please note the following:

- For the purposes of Part IV of the EP Act, the scheme is defined as an assessed scheme. In relation to the implementation of the scheme, please note the requirements of Part IV Division 4 of the EP Act.
- There is no appeal right in respect of the EPA's decision to not assess the scheme.

Level 8, The Atrium, 168 St Georges Terrace, Perth, Western Australia 6000
Telephone 08 6145 0800 Facsimile 08 6145 0995 Email info@epa.wa.gov.au

Locked Bag 10, East Perth WA 6892

www.epa.wa.gov.au

A copy of this letter and the attached advice and recommendations will be made available to the public via the EPA website.

Yours sincerely

Anthony Sutton
Delegate of the Environmental Protection Authority
Executive Director
EPA Services

18 September 2017

Encl. Scheme Advice and Recommendations

ADVICE UNDER SECTION 48A(1)(a)
ENVIRONMENTAL PROTECTION ACT 1986

Metropolitan Region Scheme Amendment 1325/41 North Bullsbrook Urban Precinct

Location: Bullsbrook

Determination: Scheme Not Assessed – Advice Given (no appeals)

Determination Published: 18 September 2017

Summary

The Western Australian Planning Commission (WAPC) has initiated Metropolitan Region Scheme Amendment 1325/41 to rezone approximately 63.75 hectares (ha) from Rural to the Urban Deferred zone in Bullsbrook.

The Environmental Protection Authority (EPA) has considered the scheme amendment in accordance with the requirements of the *Environmental Protection Act 1986* (EP Act). The EPA considers that the scheme amendment, as set out, is unlikely to have a significant effect on the environment and does not warrant formal assessment under Part IV of the EP Act. The EPA has based its decision on the documentation provided by the WAPC. Having considered this matter the following advice is provided.

1. Environmental Factors

Having regard to EPA's *Statement of Environmental Principles, Factors and Objectives*, the EPA has identified the following preliminary environmental factors relevant to this scheme amendment:

a) Flora and Vegetation
b) Terrestrial Fauna

Advice and Recommendations regarding Environmental Factors

Flora and Vegetation and Terrestrial Fauna

The amendment area contains vegetation ranging from 'Completely Degraded' to 'Very Good' condition. Lots 17 and 18 Ashton Road, Bullsbrook contain remnant vegetation in 'Very Good' condition and may potentially contain a Threatened Ecological Community Swan Coastal Plain (SCP) 3c *Corymbia calophylla – Xanthorrhoea preissii* woodlands and shrublands. SCP 3c is listed as Endangered under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Critically Endangered, by the Department of Biodiversity, Conservation and Attractions.

There is potential habitat for threatened species including Black Cockatoos and Chuditch. All species of Black Cockatoos and Chuditch are protected under both the *Wildlife Conservation Act 1950* and under the EPBC Act.

The EPA expects flora and vegetation, and fauna surveys, will be undertaken prior to the local scheme amendment being referred to the EPA. The scheme amendment shall include

provisions to retain, protect and manage consolidated, and where required, linked areas of native vegetation, to protect threatened flora and vegetation, and fauna values.

Given the above, the EPA does not consider a concurrent amendment to the region and local planning schemes under section 126 of the *Planning and Development Act 2005* appropriate. The EPA's decision not to assess the MRS amendment is on the expectation that a separate local scheme amendment will be referred to the EPA for its consideration under section 48A of the EP Act.

EPA's Environmental Protection Bulletin No. 20 *Protection of naturally vegetated areas through planning and development* provides guidance on the protection of naturally vegetated areas.

Recommendation

The EPA concludes that the amendment can be managed to meet the EPA's environmental objectives, through investigation of the environmental values of the area and subsequent preparation of local planning scheme provisions to manage and protect the identified environmental factors of flora and vegetation, and terrestrial fauna as they relate to Black Cockatoos and Chuditch.

North Bullsbrook Urban Precinct

Proposed Major Amendment

Amendment No. 1325/41

As Advertised

Amending Plan 3.2702
Detail Plans
1.5825, 1.5826 & 1.5823

Appendix B

List of detail plans supporting the amendment

Appendix C

Submission form for this amendment (form 41)

Planning and Development Act 2005
Section 41 Amendment (Substantial)
Form 41

Submission

Metropolitan Region Scheme Amendment 1325/41

North Bullsbrook Urban Precinct

OFFICE USE ONLY

SUBMISSION NUMBER
RLS/0730

To: Secretary
Western Australian Planning Commission
Locked Bag 2506
Perth WA 6001

Title *(Mr, Mrs, Miss, Ms)* ..... First Name .....

Surname ..... (PLEASE PRINT CLEARLY)

Address ..... Postcode .....

Contact phone number ..... Email address .....

Submission (Please attach additional pages if required. It is preferred that any additional information be loose rather than bound)

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turn over to complete your submission

Hearing of submissions

Anyone who has made a written submission on the amendment has the opportunity to personally present the basis of their submission to a sub-committee of the WAPC. **You do not have to attend a hearing.** The comments presented by you in this written submission will be considered in determining the recommendation for the proposed amendment.

For information about the submission and hearings process, please refer to the amendment report and in particular appendix D.

Please choose one of the following:

☐ **No**, I do not wish to speak at the hearings. (Please go to the bottom of the form and sign)

OR

☐ **Yes**, I wish to speak at the hearings. (Please complete the following details)

I will be represented by:

☐ Myself – My telephone number (business hours): ……

or

☐ A spokesperson

Name of spokesperson: ……
Contact telephone number (business hours): ……
Postal address: ……

I would prefer my hearing to be conducted in:

☐ Public (members from the general public may attend your presentation)

OR

☐ Private (only the people nominated by you or the hearings committee will be permitted to attend)

You should be aware that:

- The WAPC is subject to the *Freedom of Information Act 1992* and as such, submissions made to the WAPC may be subject to applications for access under the act.
- In the course of the WAPC assessing submissions, or making its report on these submissions, copies of your submission or the substance of that submission, may be disclosed to third parties.
- Hearings may be recorded and transcribed. The minutes of all hearings, along with all written submissions, are tabled in Parliament and published as public records should the Governor approve the proposed amendment. The WAPC recommendations are similarly published in a report on submissions and tabled in Parliament.

To be signed by person(s) making the submission

Signature …… Date ……

Note: Submissions MUST be received by the advertised closing date, being close of business (5pm) on 8 JUNE 2018. Late submissions will NOT be considered.

Contacts: Telephone - (08) 6551 8002 Fax - (08) 6551 9001 Website - http://www.planning.wa.gov.au/public-comment

Appendix I

Your property and the planning system – region schemes

Your property and the planning system – region schemes

Rights to compensation in relation to reserved land

The Western Australian Planning Commission (WAPC) has statewide responsibility for planning how land in metropolitan and regional areas can be used and developed. It does this by reserving and zoning land for immediate and future development through region schemes and/or planning control areas.

Region schemes

The WAPC administers three region schemes which classify land into zones and reservations:

- Metropolitan Region Scheme
- Peel Region Scheme
- Greater Bunbury Region Scheme.

Zones are large areas identified for purposes such as industry (industrial zone) and residential (urban zone).

Reservations are required for public purposes such as schools, railways, major roads, and parks and recreation.

How do you amend a region scheme?

Schemes can be amended as regions grow and change. This process begins with the local government, landowner, State Government or WAPC making a request to amend a scheme. The WAPC considers the request and can either refuse or approve the initiation of an amendment.

The amendment process is lengthy and in general, takes between 12 to 24 months to complete and includes extensive consultation with landowners and the broader community. In some cases amendments are subject to assessment by the Environmental Protection Authority. Amendments can be classified as Major or Minor, in accordance with *Development Control Policy 1.9 – Amendment to Region Schemes*.

Planning Control Area

In some instances, the WAPC will use a planning control area (PCA) to protect land required for a particular purpose from development until it may be reserved in one of the region schemes. A PCA acts in a similar manner as a region scheme but can be applied as a temporary measure to enable an amendment to be progressed. This also provides affected landowners with rights to claim compensation while a decision is made to reserve land or not. A PCA is valid for up to five years.

This means the WAPC is the decision-making authority for any development applications on land within a PCA. A person must not commence and carry out development within the PCA area without the prior approval of the WAPC. There are penalties for failure to comply with this requirement.

The same compensation and alternative purchase rules apply as with a region scheme. However, if compensation is paid and the PCA or reservation is reduced or removed in the future, the compensation is repayable in whole or part upon the subsequent sale or subdivision of the property.

What if your land is proposed to be reserved?

The WAPC approaches landowners on land proposed to be reserved and invites them to comment through the amendment process.

The Government will ultimately acquire reserved land, but as the reservations are strategic and long-term requirements, the land can generally remain in private ownership until it is needed for the public purpose. Several options are available to the owners of reserved land:

- **Retain ownership of your property** and continue quiet enjoyment until it is needed for the public purpose. You may complete any development or subdivision approved prior to the reservation taking effect. Under non-conforming use rights, you may continue to use the property for the purpose for which it was legally being used immediately before the reservation came into effect.
- **Sell the property on the open market** to another person(s). The WAPC recognises that the reservation may make this difficult. Subject to acquisition priorities and the availability of funds, the WAPC would be willing to consider purchasing a reserved property if an owner is unable to achieve a private sale on the open market. This does affect your right to otherwise claim statutory compensation (outlined in the compensation section below).
- **Offer the property for sale** to the WAPC. Subject to acquisition priorities and the availability of funds, the WAPC would be willing to consider purchasing a reserved property. The WAPC purchases a property at its current market value, ignoring the impact of the reservation and proposed public purpose. The WAPC obtains two independent valuations to provide it with advice on the value of the property.

Am I entitled to claim compensation?

If your land is reserved in a region scheme or subject to a PCA and **you are the owner of the land when it was first reserved or the PCA was declared**, you may be able to make a claim for compensation for injurious affection if:

1. **Private Sale –** you sell the property on the open market at a reduced price (due to the effect of the reservation or PCA);
   or
2. **Refused development –** the WAPC has either refused a development application over the property or approved it subject to conditions that are unacceptable to you.

What is injurious affection?

Injurious affection occurs when the value of a piece of land is affected by the application of a reservation or restriction for a public purpose.

How do I claim compensation?

1. Private sale

If you wish to sell your property on the open market at a reduced price (affected value), you will need to complete a *Notice of Intention to Sell* form, which is available online at www.planning.wa.gov.au. The Department of Planning, Lands and Heritage will establish the extent of the reservation and forward the notice to the Board of Valuers.

The Board of Valuers will determine the value of the property as if there was no reservation or PCA (unaffected value). You may wish to attend the board's meeting to present any matters you believe are relevant to the value of your property.

Following the board's decision:

- The board will advise you of the unaffected value of the property.
- You pay the board's valuation fee to the department and you will be advised of the affected value of the property (as determined by the WAPC) – the minimum price for which you can sell the property and receive the full amount of compensation (the difference between the affected and unaffected values). The valuation fee is refundable upon the sale of the property and the payment of compensation.
- You then arrange the sale of the property (either privately or through an agent) – the sale price must not be less than the affected value.

You (and your agent) must inform prospective purchasers that you are selling the property at a reduced price and that you will be claiming compensation for injurious affection from the WAPC. You must also include a special condition in the offer and acceptance.

- After you sell the property, you can make a claim for compensation for injurious affection through the WAPC **within six months** of the property being sold (registered at Landgate).
- After the WAPC pays compensation, the WAPC will lodge a notification on the Certificate of Title to identify that it has paid compensation, which is only payable once.
- If the property does not sell within one year of the board's valuation, you may ask the board to revalue the property. The sale process is then repeated.
- Alternatively, you may wish to ask the WAPC to purchase the property, as you have been unable to sell it privately. The WAPC will purchase the property at its then fair market value (unaffected value).

2. Refused development

If the WAPC refused your development application or approved it subject to unacceptable conditions, you may make a claim for compensation for injurious affection **within six months** of the WAPC's decision.

The WAPC will either pay compensation or may elect to purchase the property instead of paying compensation. If the WAPC elects to purchase the property, it obtains valuations for the fair market value (unaffected value) as at the date of the election to purchase.

What is compulsory acquisition?

If land is required for a reservation and has not been previously acquired or compensation has been claimed, the Government may compulsorily acquire the property. The WAPC will obtain independent valuations and make an offer of compensation, in accordance with the *Land Administration Act 1997*.

How can I view a region scheme?

- online at www.planning.wa.gov.au/regionscheme
- office of the WAPC and the Department of Planning, Lands and Heritage Level 2, 140 William Street, Perth
- any local government office.

The WAPC operates in accordance with the *Planning and Development Act 2005* and receives administrative support from the Department of Planning, Lands and Heritage.

This information is correct as at February 2018.

Appendix II

Preparing a submission and hearings committees

Preparing a submission and hearings committees

The WAPC welcomes comment on proposed amendments to the MRS from interested individuals, groups and organisations.

What is a submission?

A submission is a way to express your opinion and provide information. It is an opportunity to explain why the amendment should be supported, withdrawn or modified. Suggestions of alternative courses of action are also welcomed.

Making a submission is not the same as voting in an election. The number of submissions received for or against a proposal will not in itself determine the result. Rather, it is the reasoned argument of why a particular thing should or should not be done. Your submission will assist the WAPC in reviewing its planning proposal before proceeding. Advertised proposals are often modified in response to the public submission process.

What should I say?

Your comments should focus on the particular issues that arise from the proposed amendment. If there are a number of components in the amendment, please indicate exactly which ones you are addressing.

It is important that you state your point of view clearly and give reasons for your conclusions and recommendations. These may include an alternative approach or other ways for the WAPC to improve the amendment or make it more acceptable. Indicate the source of your information or argument where applicable.

If you prefer not to write your own comments, you may consider joining a group interested in making a submission on similar issues. Joint submissions can increase the pool of ideas and information.

Before lodging your submission

The WAPC prefers to receive submissions online at *www.planning.wa.gov.au/public-comment*, however, hardcopy submissions can also be accepted (form 41 – appendix C).

Please remember to complete all fields in the submission form including your name, contact details and whether you would like to attend a hearing. Pleased limit the number of attachments, where possible, ensuring they are directly relevant to the proposed amendment you are commenting on.

The closing date for submissions and how to lodge them is shown on form 41 and in the submissions on the amendment section of the amendment report. To be eligible to make a presentation to the hearing committee, your written submission must be received by the closing date.

Some amendments may be subject to an environmental review. Under these circumstances, the WAPC will forward a copy of any submission raising environmental issues to the EPA.

You should be aware that all submissions lodged with the WAPC are subject to regulations on disclosure and access, and your submission will become a public document. Presentations made to the hearings committee are an extension of the submission process.

Do you want a hearing?

The *Planning and Development Act 2005* provides the opportunity for people who have made a submission to personally present the basis of their submission to a sub-committee of the WAPC. You do not have to attend a hearing. The comments presented by you in your submission will be considered in determining the recommendation for the proposed amendment.

Hearings are arranged so a person can explain or expand on their written submission to the WAPC in person. A hearing is for listening to points of view and planning rationale and is not a forum for general public debate. In the case of a group, a spokesperson must be appointed to represent the group. The time allocated for each presentation is five minutes.

The hearings committee is appointed by the WAPC and is usually comprised of two WAPC committee members and one other person with planning knowledge and expertise related to issues raised in submissions.

You may choose to have your presentation conducted in public or private. A public hearing allows other persons, including the media, to attend. In a private hearing only those persons nominated by you and by the hearings committee may attend.

Appendix B

Landfill Licence 2023

Government of Western Australia
Department of Water and Environmental Regulation

Licence

Licence number	L9162/2018/1
Licence holder	The Valleys Bullsbrook Pty Ltd
ACN	636 954 357
Registered business address	122 Main Street OSBOURNE PARK WA 6017
DWER file number	DER2018/001457
Duration	23/10/2018 to 22/10/2026
Date of issue	23/10/2018
Date of amendment	08/11/2023
Premises details	The Valleys Bullsbrook Landfill Facility 2510 Great Northern Highway BULLSBROOK WA 6084 Legal description – Part of Lot 903 on Deposited Plan 424344 Certificate of Title Volume 4032 Folio 72 As defined by the premises map in Schedule 1

Prescribed premises category description (Schedule 1, *Environmental Protection Regulations 1987*)	Assessed design capacity
Category 63: Class I inert landfill site	Not more than 500 tonnes per year

This Licence is granted to the Licence Holder, subject to the attached conditions, on 08 November 2023 by:

A/MANAGER WASTE INDUSTRIES
REGULATORY SERVICES
an officer delegated under section 20 of the *Environmental Protection Act 1986* (WA)

Licence history

Date	Reference number	Summary of changes
04/06/2007	L8153/2004/1	Licence issued
03/06/2011	L8153/2004/2	Amended Premises boundary
23/10/2018	L9162/2018/1	Licence issued
24/01/2020	L9162/2018/1	Licence transfer
15/09/2020	L9162/2018/1	Amend to extend licence duration
12/10/2021	L9162/2018/1	Amend to extend licence duration by 24 months
08/09/2022	L9162/2018/1	Amendment to extend by 12 months the submission date for the Landfill Closure and Post-Closure Management Plan and the licence expiry date. The premises name was also changed.
08/11/2023	L9162/2018/1	Amendment to remove *Category 13: Crushing of building materials* and *Category 62: Solid waste depot* activities, extend the expiry date, change the premises boundary to align with the landfill area only, update the premises location to reflect new title particulars and change conditions to reflect closure stage of landfill and waste no longer being accepted.

Interpretation

In this licence:

(a) the words 'including', 'includes' and 'include' in conditions mean "including but not limited to", and similar, as appropriate;

(b) where any word or phrase is given a defined meaning, any other part of speech or other grammatical form of that word or phrase has a corresponding meaning;

(c) where tables are used in a condition, each row in a table constitutes a separate condition;

(d) any reference to an Australian or other standard, guideline, or code of practice means the version of the standard, guideline, or code of practice in force at the time of granting of this licence and includes any amendments to the standard, guideline or code of practice which may occur from time to time during the course of the licence;

(e) unless specified otherwise, any reference to a section of an Act refers to that section of the EP Act; and

(f) unless specified otherwise, all definitions are in accordance with the EP Act.

NOTE: This licence requires specific conditions to be met but does not provide any implied authorisation for other emissions, discharges, or activities not specified in this licence.

Licence conditions

The licence holder must ensure that the following conditions are complied with:

Waste acceptance

1. The licence holder must not accept any additional waste onto the premises after 8 November 2023.

2. The licence holder must ensure that wastes for burial on the premises are only subjected to the process set out in Table 1 and in accordance with any process requirements described in that table.

Table 1: Waste processing

Waste type	Process	Process requirements
Clean fill	Handling and burial by landfilling	None specified.
Inert waste type 1	Handling and burial by landfilling	None specified.

Closure

3. The licence holder must engage a suitably qualified environmental consultant to undertake closure validation investigations[1] for the potential presence of waste, asbestos or other contaminants in the area shown in Schedule 1: Figure 1.

4. The licence holder must retain the services of the suitably qualified environmental consultant to prepare a report[1] on the closure validation investigations required by condition 3 and submit that report to the CEO:

   (a) by 22 October 2026; or

   (b) with any application under Part V of the *Environmental Protection Act 1986* to surrender this licence, if an application is submitted before the date specified in condition 4(a).

Note 1: Guidance for a preliminary site investigation within the DWER *Guideline: Assessment and management of contaminated sites* and the Department of Health *Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia* should be considered when determining an investigation approach and report format for closure validation.

Records and reporting

5. The Licence Holder must:

   (a) undertake an audit of their compliance with the conditions of this licence during the preceding Annual Period; and

   (b) prepare and submit to the CEO by no later than 31 days after the end of that annual period an Annual Audit Compliance Report in the approved form.

Definitions

In this licence, the terms in Table 2 have the meanings defined.

Table 2: Definitions

Term	Definition
EP Act	means the *Environmental Protection Act 1986*
ACM	means asbestos containing material and has the meaning defined in the *Guidelines for Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia.*
ACN	Australian Company Number
Annual Audit Compliance Report (AACR)	means a report submitted in a format approved by the CEO (relevant guidelines and templates may be available on the Department's website).
Annual Period	a 12 month period commencing from 1 July until 30 June of the immediately following year.
CEO	means Chief Executive Officer of the Department. "submit to / notify the CEO" (or similar), means either: Director General Department administering the *Environmental Protection Act 1986* Locked Bag 10 Joondalup DC WA 6919 or: info@dwer.wa.gov.au
Clean fill	has the same meaning given to that term in the *Landfill Waste Classification and Waste Definitions 1996 (as amended)*
Department	means the department established under section 35 of the *Public Sector Management Act 1994* (WA) and designated as responsible for the administration of the EP Act, which includes Part V Division 3.
Discharge	has the same meaning given to that term under the EP Act.
Emission	has the same meaning given to that term under the EP Act.
EP Act	*Environmental Protection Act 1986* (WA)
EP Regulations	Environmental Protection Regulations 1987 (WA)
Inert Waste Type 1	has the same meaning given to that term in the *Landfill Waste Classification and Waste Definitions 1996 (as amended)*
licence	refers to this document, which evidences the grant of a licence by the CEO under section 57 of the EP Act, subject to the specified conditions contained within.
licence holder	refers to the occupier of the premises, being the person specified on the front of the licence as the person to whom this licence has been granted.

Term	Definition
premises	refers to the premises to which this licence applies, as specified at the front of this licence and as shown on the premises map (Figure 1) in Schedule 1 to this licence.
Prescribed Premises	has the same meaning given to that term under the EP Act.
suitably qualified environmental consultant	means a person who: (a) holds a tertiary qualification in environmental science, environmental health or a related science field; and (b) has a minimum of three years of experience working in the area/field of contaminated land assessment and management.
waste	has the same meaning given to that term under the EP Act.

END OF CONDITIONS

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Schedule 1: Maps



Figure 1: Map of the premises boundary

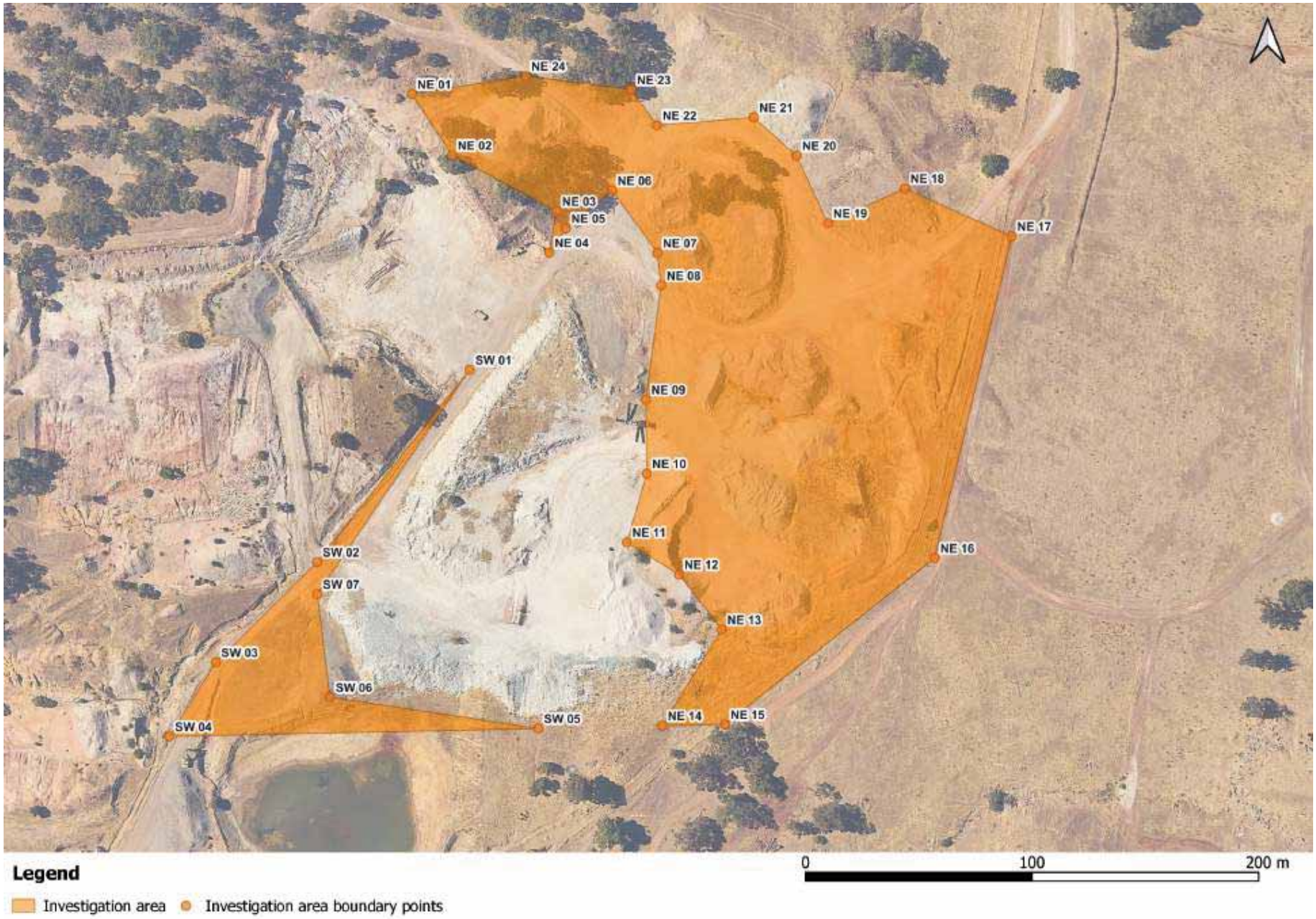

Figure 2: Closure validation investigation area relating to conditions 3 and 4

Schedule 2: List of coordinates

Premises boundary

The vertices of the premises boundary are the coordinates listed in Table 3.

Table 3: Premises boundary coordinates (GDA 2020 MGA Zone 50)

Point ID	Easting	Northing
1.	409905.09	6495909.78
2.	409884.68	6495893.09
3.	409774.97	6495731.61
4.	409780.58	6495686.12
5.	409921.97	6495664.96
6.	409953.54	6495715.96
7.	409934.60	6495740.26
8.	409911.64	6495754.46
9.	409920.42	6495784.77
10.	409920.06	6495817.39
11.	409926.75	6495867.90
12.	409925.17	6495882.18

Investigation area

The vertices of the closure validation investigation area boundary relating to conditions 3 and 4 are the coordinates listed in Table 4.

Table 4: Investigation area boundary coordinates (GDA 2020 MGA Zone 50)

Point ID	Easting	Northing
Southwest area		
SW01	409842.22	6495830.60
SW02	409774.94	6495745.79
SW03	409730.22	6495701.51
SW04	409709.75	6495668.80
SW05	409872.57	6495672.35
SW06	409780.58	6495686.12

Point ID	Easting	Northing
SW07	409774.97	6495731.61
Northeast area		
NE01	409816.77	6495952.27
NE02	409834.57	6495925.34
NE03	409880.62	6495900.65
NE04	409877.38	6495882.35
NE05	409884.68	6495893.09
NE06	409905.09	6495909.78
NE07	409925.17	6495882.18
NE08	409926.75	6495867.90
NE09	409920.06	6495817.39
NE10	409920.42	6495784.77
NE11	409911.64	6495754.46
NE12	409934.60	6495740.26
NE13	409953.54	6495715.96
NE14	409927.28	6495673.54
NE15	409954.94	6495674.15
NE16	410047.50	6495747.57
NE17	410081.54	6495889.52
NE18	410034.37	6495910.66
NE19	410000.33	6495895.30
NE20	409986.53	6495925.12
NE21	409967.62	6495942.03
NE22	409924.90	6495938.47
NE23	409913.55	6495954.27
NE24	409867.05	6495960.27

Appendix C

Landfill Licence Amendment 2022

Government of Western Australia
Department of Water and Environmental Regulation

Amendment Report

Application for Licence Amendment

Part V Division 3 of the *Environmental Protection Act 1986*

Licence Number	L9162/2018/1
Licence Holder	The Valleys Bullsbrook Pty Ltd
ACN	636 954 357
File Number	DER2018/001457
Premises	The Valleys Bullsbrook Landfill Facility 2510 Great Northern Highway, Lot 2792 and 1288 Taylor Road and Lot 834 Hurd Road Legal description – Part Lot 834 on Deposited Plan 246328, Part Lot 1288 on Deposited Plan 247994 and Part Lot 2792 on Deposited Plan 253699 Certificate of Title Volume 2997 Folio 448 As defined by the Premises map attached to the Revised Licence
Date of Report	08 September 2022
Decision	Revised licence granted

MANAGER WASTE INDUSTRIES
REGULATORY SERVICES
an officer delegated under section 20 of the *Environmental Protection Act 1986* (WA)

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1. Decision summary

The Delegated Officer has determined to make amendments to Licence L9162/2018/1. The amendments are administrative in nature therefore they do not alter the risk profile of the Premises, providing that activities, emissions and receptors as stated in existing approvals remain unchanged.

This Amendment Report documents the amendments made pursuant to section 59 and 59(B) of the *Environmental Protection Act 1986* (EP Act).

The decision report for the Existing Licence will remain on the department's website for future reference and will act as a record of the department's decision making.

2. Scope of assessment

2.1 Regulatory framework

In amending the licence, the department has considered and given due regard to its Regulatory Framework and relevant policy documents which are available at https://dwer.wa.gov.au/regulatory-documents.

2.2 Application summary

Licence L9162/2018/1 is held by The Valleys Bullsbrook Pty Ltd (Licence Holder) for The Valleys Bullsbrook Landfill Facility (the Premises), located at Part Lot 834 on Deposited Plan 246328, Part Lot 1288 on Deposited Plan 247994 and Part Lot 2792 on Deposited Plan 253699. The Premises relates to the categories and the assessed design capacity under Schedule 1 of the *Environmental Protection Regulations 1987* (EP Regulations) which are defined in existing Licence L9162/2018/1.

On 19 July 2022, the Licence Holder submitted an application to the department to amend Licence L9162/2018/1 under section 59B of the *Environmental Protection Act 1986* (EP Act). The amendment is limited only to extending the licence expiry date, extending the submission date for a Landfill Closure and Post-Closure Management Plan and changing the Premises name from The Valleys Bullsbrook to The Valleys Bullsbrook Landfill Facility.

The Licence Holder has previously informed the department of their intent to close the Premises and handover the area for redevelopment, which will require the final capping and closure of the Class I landfill. The landfill has been shut for a number of years, with the last load of waste being received in November 2018. Condition 3 of the Existing Licence requires the Licence Holder to submit a Landfill Closure and Post-Closure Management Plan by 31 October 2022 and the licence has an expiry date of 22 October 2023.

Land surrounding the Premises is currently in the process of being progressively developed for residential housing, however the land developer is yet to finalise their designs in the immediate area of the landfill footprint. As the Landfill Closure and Post-Closure Management Plan will be impacted by the proposed landfill site after-use and adjoining levels, the Licence Holder considers it preferable to wait until the land developer finalises their design on and around the current landfill footprint. After this design is determined, the Licence Holder will prepare and finalise their Landfill Closure and Post-Closure Management Plan. The Licence Holder does not intend to re-open the landfill or receive any additional waste at the Premises, however the marketing and removal of processed recycled materials remaining on the Premises will continue.

To allow for the development designs to be finalised, the submission date for the Landfill Closure and Post-Closure Management Plan is requested to be extended by 12 months, out to 31 October 2023. To facilitate this change, the licence expiry date is also requested to be extended by a corresponding 12 months, out to 22 October 2024.

3. Consultation

The Licence Holder was provided with the draft Amendment Report on 19 August 2022.

On 7 September 2022 the Licence Holder waived the comment period.

4. Conclusion

Based on the assessment in this Amendment Report, the Delegated Officer has determined that an amended licence will be granted, subject to conditions commensurate with the determined controls and necessary for administration and reporting requirements.

4.1 Summary of amendments

Table 1 below provides a summary of the proposed amendments and will act as a record of implemented changes. All proposed changes have been incorporated into the Revised Licence as part of the amendment process.

Table 1: Summary of licence amendments

Condition no.	Proposed amendments
Premises name	Changed from The Valleys Bullsbrook to The Valleys Bullsbrook Landfill Facility
Duration	Extended by 12 months to 22/10/2024
Condition 3	The submission date for the Landfill Closure and Post-Closure Management Plan was extended by 12 months to 31 October 2023

References

1. Department of Environment Regulation (DER) 2015, Guidance Statement: Setting Conditions, Perth, Western Australia.
2. Department of Water and Environmental Regulation (DWER) 2020, Guideline: Environmental Siting, Perth, Western Australia.
3. DWER 2020, Guideline: Risk Assessments, Perth, Western Australia.

Appendix 1: Application validation summary

SECTION 1: APPLICATION SUMMARY					
Application type					
Works approval	☐				
Licence	☐	Relevant works approval number:		None	☐
		Has the works approval been complied with?		Yes ☐ No ☐	
		Has time limited operations under the works approval demonstrated acceptable operations?		Yes ☐ No ☐ N/A ☐	
		Environmental Compliance Report / Critical Containment Infrastructure Report submitted?		Yes ☐ No ☐	
		Date Report received:			
Renewal	☐	Current licence number:			
Amendment to works approval	☐	Current works approval number:			
Amendment to licence	☒	Current licence number:	L9162/2018/1		
		Relevant works approval number:		N/A	☐
Registration	☐	Current works approval number:		None	☐
Date application received		19 July 2022			
Applicant and Premises details					
Applicant name/s (full legal name/s)		The Valleys Bullsbrook Pty Ltd			
Premises name		The Valleys Bullsbrook Landfill Facility			
Premises location		Part of Lot 834 on Deposited Plan 246328; Part Lot 1288 on Deposited Plan 247994; and Part or Lot 2792 on Deposited Plan 253699.			
Local Government Authority		City of Swan			
Application documents					
HPCM file reference number:		DWERDT632893			
Key application documents (additional to application form):		Cover letter			
Scope of application/assessment					

Summary of proposed activities or changes to existing operations.	**Licence amendment** Amendment to extend the expiry date of the licence and submission date for a Landfill Closure and Post-Closure Management Plan required by condition 3. The closure plan is currently required to be submitted by 31 October 2022 and the expiry date of the licence is 22 October 2023. The submission date for the Landfill Closure and Post-Closure Management Plan is requested to be extended by 12 months, out to 31 October 2023. To facilitate the change, the licence expiry date is also requested to be extended by a corresponding 12 months, out to 22 October 2024. The landfill has been closed for a number of years, with the last load of waste received at the premises in November 2018. The surrounding land is in the process of being progressively developed for residential housing, however the land developer is yet to finalise the development plan in the immediate area of the landfill footprint. As the Landfill Closure and Post-Closure Management Plan will be impacted by the landfill site after-use and adjoining levels, the Licence Holder considers it preferable to wait until the land developer finalises their development plans on and around the current landfill footprint. After this is determined, the Landfill Closure and Post-Closure Management Plan will be prepared. The Licence Holder does not intend to re-open the landfill or receive any additional waste at the premises, however the marketing and removal of processed recycled materials remaining on the premises will continue.

Category number/s (activities that cause the premises to become prescribed premises)

Table 1: Prescribed premises categories

Prescribed premises category and description	Assessed production or design capacity	Proposed changes to the production or design capacity (amendments only)
Category 13: Crushing of building materials	Not more than 50,000 tonnes per year	N/A
Category 62: Solid waste depot	More than 500 but not more than 5,000 tonnes per year	N/A
Category 63: Class I inert landfill site	More than 50,000 but not more than 500,000 tonnes per year	N/A

Legislative context and other approvals		
Has the applicant referred, or do they intend to refer, their proposal to the EPA under Part IV of the EP Act as a significant proposal?	Yes ☐ No ☒	Referral decision No: Managed under Part V ☐ Assessed under Part IV ☐
Does the applicant hold any existing Part IV Ministerial Statements relevant to the application?	Yes ☐ No ☒	Ministerial statement No: EPA Report No:
Has the proposal been referred and/or assessed under the EPBC Act?	Yes ☐ No ☒	Reference No:

Has the applicant demonstrated occupancy (proof of occupier status)?	Yes ☒ No ☐	Certificate of title ☒ General lease ☐ Expiry: Mining lease / tenement ☐ Expiry: Other evidence ☒ Expiry:
Has the applicant obtained all relevant planning approvals?	Yes ☐ No ☐ N/A ☒	Approval: Expiry date: If N/A explain why?
Has the applicant applied for, or have an existing EP Act clearing permit in relation to this proposal?	Yes ☐ No ☒	CPS No: N/A No clearing is proposed.
Has the applicant applied for, or have an existing CAWS Act clearing licence in relation to this proposal?	Yes ☐ No ☒	Application reference No: N/A Licence/permit No: N/A No clearing is proposed.
Has the applicant applied for, or have an existing RIWI Act licence or permit in relation to this proposal?	Yes ☐ No ☒	Application reference No: Licence/permit No: Licence / permit not required.
Does the proposal involve a discharge of waste into a designated area (as defined in section 57 of the EP Act)?	Yes ☐ No ☒	Name: N/A Type: N/A Has Regulatory Services (Water) been consulted? Yes ☐ No ☐ N/A ☒ Regional office: Swan Avon
Is the Premises situated in a Public Drinking Water Source Area (PDWSA)?	Yes ☐ No ☒	Name: N/A Priority: N/A Are the proposed activities/ landuse compatible with the PDWSA (refer to WQPN 25)? Yes ☐ No ☐ N/A ☒
Is the Premises subject to any other Acts or subsidiary regulations (e.g. *Dangerous Goods Safety Act 2004, Environmental Protection (Controlled Waste) Regulations 2004, State Agreement Act xxxx*)	Yes ☐ No ☒	
Is the Premises within an Environmental Protection Policy (EPP) Area?	Yes ☐ No ☒	

Is the Premises subject to any EPP requirements?	Yes ☐ No ☒	
Is the Premises a known or suspected contaminated site under the *Contaminated Sites Act 2003*?	Yes ☐ No ☒	Classification: N/A Date of classification: N/A

Appendix D

Landfill Licence Amendment 2023

Government of Western Australia
Department of Water and Environmental Regulation

Licence

Licence number	L9162/2018/1
Licence holder	The Valleys Bullsbrook Pty Ltd
ACN	636 954 357
Registered business address	122 Main Street OSBOURNE PARK WA 6017
DWER file number	DER2018/001457
Duration	23/10/2018 to 22/10/2026
Date of issue	23/10/2018
Date of amendment	08/11/2023
Premises details	The Valleys Bullsbrook Landfill Facility 2510 Great Northern Highway BULLSBROOK WA 6084 Legal description – Part of Lot 903 on Deposited Plan 424344 Certificate of Title Volume 4032 Folio 72 As defined by the premises map in Schedule 1

Prescribed premises category description (Schedule 1, *Environmental Protection Regulations 1987*)	Assessed design capacity
Category 63: Class I inert landfill site	Not more than 500 tonnes per year

This Licence is granted to the Licence Holder, subject to the attached conditions, on 08 November 2023 by:

A/MANAGER WASTE INDUSTRIES
REGULATORY SERVICES
an officer delegated under section 20 of the *Environmental Protection Act 1986* (WA)

Licence history

Date	Reference number	Summary of changes
04/06/2007	L8153/2004/1	Licence issued
03/06/2011	L8153/2004/2	Amended Premises boundary
23/10/2018	L9162/2018/1	Licence issued
24/01/2020	L9162/2018/1	Licence transfer
15/09/2020	L9162/2018/1	Amend to extend licence duration
12/10/2021	L9162/2018/1	Amend to extend licence duration by 24 months
08/09/2022	L9162/2018/1	Amendment to extend by 12 months the submission date for the Landfill Closure and Post-Closure Management Plan and the licence expiry date. The premises name was also changed.
08/11/2023	L9162/2018/1	Amendment to remove *Category 13: Crushing of building materials* and *Category 62: Solid waste depot* activities, extend the expiry date, change the premises boundary to align with the landfill area only, update the premises location to reflect new title particulars and change conditions to reflect closure stage of landfill and waste no longer being accepted.

Interpretation

In this licence:

(a) the words 'including', 'includes' and 'include' in conditions mean "including but not limited to", and similar, as appropriate;

(b) where any word or phrase is given a defined meaning, any other part of speech or other grammatical form of that word or phrase has a corresponding meaning;

(c) where tables are used in a condition, each row in a table constitutes a separate condition;

(d) any reference to an Australian or other standard, guideline, or code of practice means the version of the standard, guideline, or code of practice in force at the time of granting of this licence and includes any amendments to the standard, guideline or code of practice which may occur from time to time during the course of the licence;

(e) unless specified otherwise, any reference to a section of an Act refers to that section of the EP Act; and

(f) unless specified otherwise, all definitions are in accordance with the EP Act.

NOTE: This licence requires specific conditions to be met but does not provide any implied authorisation for other emissions, discharges, or activities not specified in this licence.

Licence conditions

The licence holder must ensure that the following conditions are complied with:

Waste acceptance

1. The licence holder must not accept any additional waste onto the premises after 8 November 2023.

2. The licence holder must ensure that wastes for burial on the premises are only subjected to the process set out in Table 1 and in accordance with any process requirements described in that table.

Table 1: Waste processing

Waste type	Process	Process requirements
Clean fill	Handling and burial by landfilling	None specified.
Inert waste type 1	Handling and burial by landfilling	None specified.

Closure

3. The licence holder must engage a suitably qualified environmental consultant to undertake closure validation investigations[1] for the potential presence of waste, asbestos or other contaminants in the area shown in Schedule 1: Figure 1.

4. The licence holder must retain the services of the suitably qualified environmental consultant to prepare a report[1] on the closure validation investigations required by condition 3 and submit that report to the CEO:

(a) by 22 October 2026; or

(b) with any application under Part V of the *Environmental Protection Act 1986* to surrender this licence, if an application is submitted before the date specified in condition 4(a).

Note 1: Guidance for a preliminary site investigation within the DWER *Guideline: Assessment and management of contaminated sites* and the Department of Health *Guidelines for the Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia* should be considered when determining an investigation approach and report format for closure validation.

Records and reporting

5. The Licence Holder must:

(a) undertake an audit of their compliance with the conditions of this licence during the preceding Annual Period; and

(b) prepare and submit to the CEO by no later than 31 days after the end of that annual period an Annual Audit Compliance Report in the approved form.

Definitions

In this licence, the terms in Table 2 have the meanings defined.

Table 2: Definitions

Term	Definition
EP Act	means the *Environmental Protection Act 1986*
ACM	means asbestos containing material and has the meaning defined in the *Guidelines for Assessment, Remediation and Management of Asbestos Contaminated Sites in Western Australia.*
ACN	Australian Company Number
Annual Audit Compliance Report (AACR)	means a report submitted in a format approved by the CEO (relevant guidelines and templates may be available on the Department's website).
Annual Period	a 12 month period commencing from 1 July until 30 June of the immediately following year.
CEO	means Chief Executive Officer of the Department. "submit to / notify the CEO" (or similar), means either: Director General Department administering the *Environmental Protection Act 1986* Locked Bag 10 Joondalup DC WA 6919 or: info@dwer.wa.gov.au
Clean fill	has the same meaning given to that term in the *Landfill Waste Classification and Waste Definitions 1996 (as amended)*
Department	means the department established under section 35 of the *Public Sector Management Act 1994* (WA) and designated as responsible for the administration of the EP Act, which includes Part V Division 3.
Discharge	has the same meaning given to that term under the EP Act.
Emission	has the same meaning given to that term under the EP Act.
EP Act	*Environmental Protection Act 1986* (WA)
EP Regulations	Environmental Protection Regulations 1987 (WA)
Inert Waste Type 1	has the same meaning given to that term in the *Landfill Waste Classification and Waste Definitions 1996 (as amended)*
licence	refers to this document, which evidences the grant of a licence by the CEO under section 57 of the EP Act, subject to the specified conditions contained within.
licence holder	refers to the occupier of the premises, being the person specified on the front of the licence as the person to whom this licence has been granted.

Term	Definition
premises	refers to the premises to which this licence applies, as specified at the front of this licence and as shown on the premises map (Figure 1) in Schedule 1 to this licence.
Prescribed Premises	has the same meaning given to that term under the EP Act.
suitably qualified environmental consultant	means a person who: (a) holds a tertiary qualification in environmental science, environmental health or a related science field; and (b) has a minimum of three years of experience working in the area/field of contaminated land assessment and management.
waste	has the same meaning given to that term under the EP Act.

END OF CONDITIONS

Schedule 1: Maps



Figure 1: Map of the premises boundary

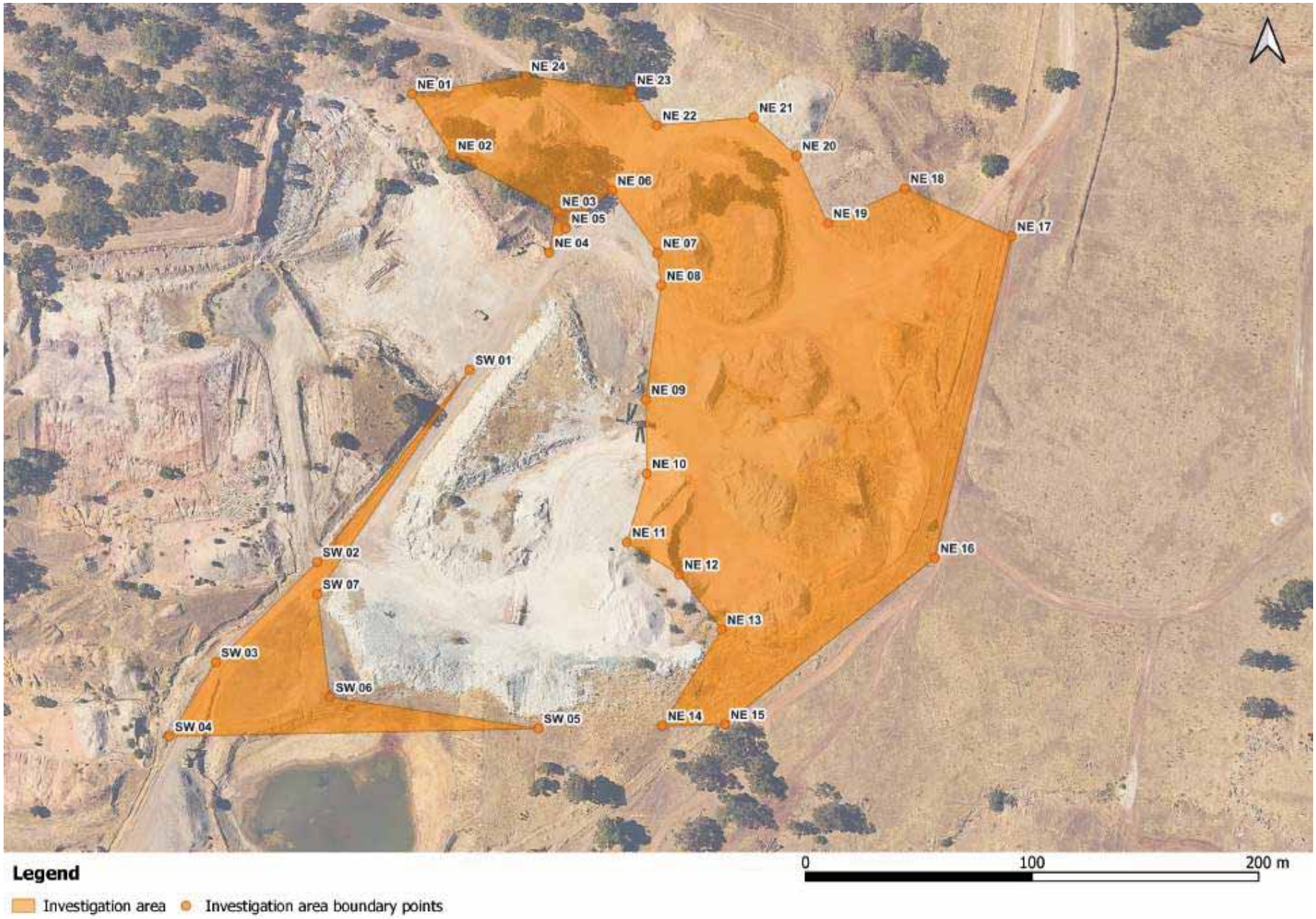


Figure 2: Closure validation investigation area relating to conditions 3 and 4

Schedule 2: List of coordinates

Premises boundary

The vertices of the premises boundary are the coordinates listed in Table 3.

Table 3: Premises boundary coordinates (GDA 2020 MGA Zone 50)

Point ID	Easting	Northing
1.	409905.09	6495909.78
2.	409884.68	6495893.09
3.	409774.97	6495731.61
4.	409780.58	6495686.12
5.	409921.97	6495664.96
6.	409953.54	6495715.96
7.	409934.60	6495740.26
8.	409911.64	6495754.46
9.	409920.42	6495784.77
10.	409920.06	6495817.39
11.	409926.75	6495867.90
12.	409925.17	6495882.18

Investigation area

The vertices of the closure validation investigation area boundary relating to conditions 3 and 4 are the coordinates listed in Table 4.

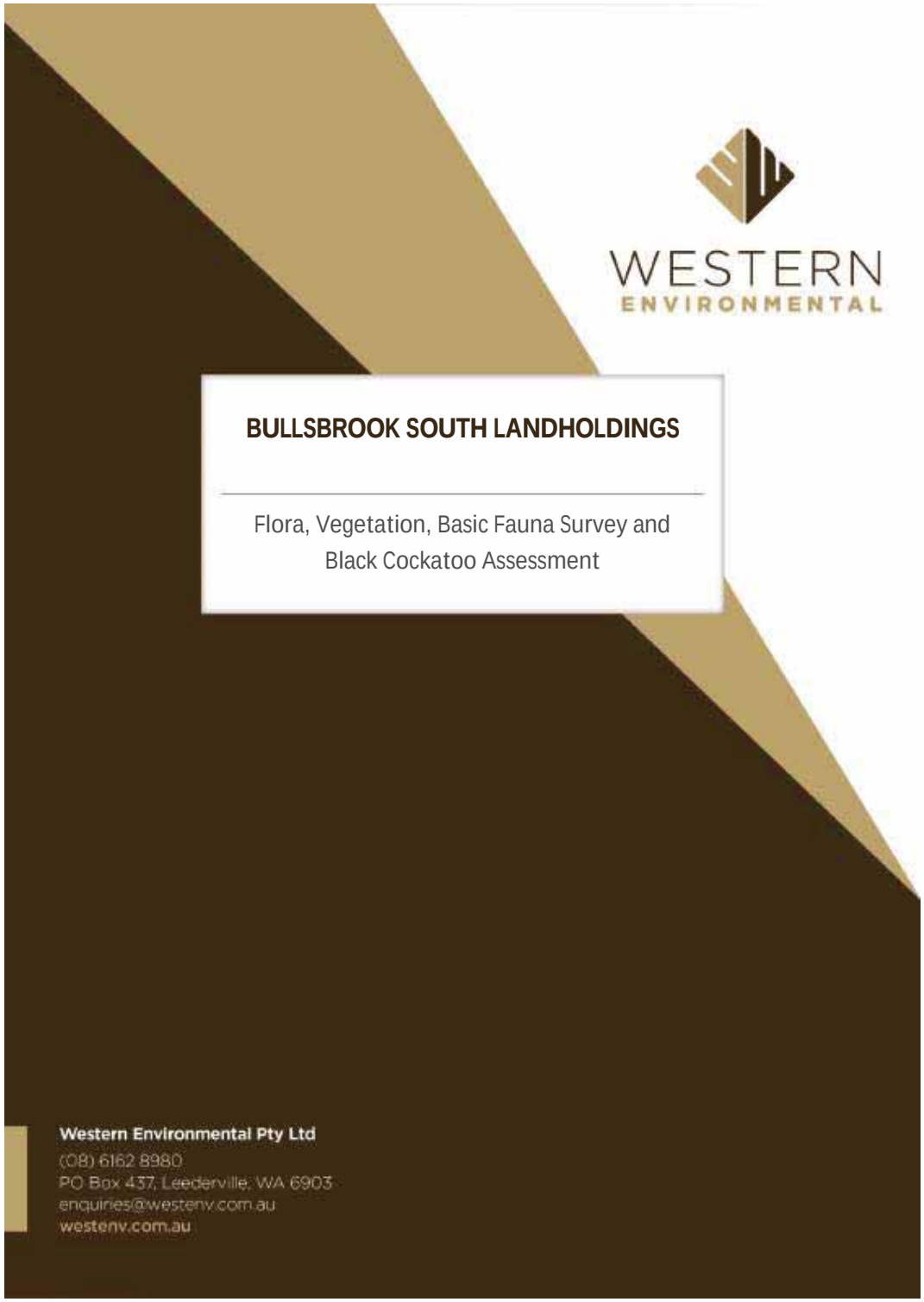
Table 4: Investigation area boundary coordinates (GDA 2020 MGA Zone 50)

Point ID	Easting	Northing
Southwest area		
SW01	409842.22	6495830.60
SW02	409774.94	6495745.79
SW03	409730.22	6495701.51
SW04	409709.75	6495668.80
SW05	409872.57	6495672.35
SW06	409780.58	6495686.12

Point ID	Easting	Northing
SW07	409774.97	6495731.61
Northeast area		
NE01	409816.77	6495952.27
NE02	409834.57	6495925.34
NE03	409880.62	6495900.65
NE04	409877.38	6495882.35
NE05	409884.68	6495893.09
NE06	409905.09	6495909.78
NE07	409925.17	6495882.18
NE08	409926.75	6495867.90
NE09	409920.06	6495817.39
NE10	409920.42	6495784.77
NE11	409911.64	6495754.46
NE12	409934.60	6495740.26
NE13	409953.54	6495715.96
NE14	409927.28	6495673.54
NE15	409954.94	6495674.15
NE16	410047.50	6495747.57
NE17	410081.54	6495889.52
NE18	410034.37	6495910.66
NE19	410000.33	6495895.30
NE20	409986.53	6495925.12
NE21	409967.62	6495942.03
NE22	409924.90	6495938.47
NE23	409913.55	6495954.27
NE24	409867.05	6495960.27

Appendix E

Flora, Vegetation, Basic Fauna Survey and Black Cockatoo Assessment



BULLSBROOK SOUTH LANDHOLDINGS

Flora, Vegetation, Basic Fauna Survey and Black Cockatoo Assessment

Report No:
A23.028-RPT-FVSR_A
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30-Jun-2023
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DRAFT

Prepared for:
Rowe Group

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30-Jun-2023	**5-Jul-2023**	**6-Jul-2023**

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Environmental Conclusions

In accordance with the scope of services, WEPL has conducted environmental field monitoring and/or testing in the preparation of this report. The nature and extent of monitoring and/or testing conducted is described in this report.

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Executive Summary

Rowe Group commissioned Western Environmental Pty Ltd (WEPL) to undertake a broadscale flora and vegetation assessment, a basic fauna survey and black cockatoo assessment to support the planning scheme amendment phases for the rezoning of multiple lots in Bullsbrook South. Biological surveys were undertaken in May of 2023 and comprised:

- Desktop assessment and summary of publicly available information.
- Flora and vegetation assessment in line with the requirements for a Reconnaissance level survey Targeted Priority and Threatened flora searches.
- Basic fauna survey, mapping habitat and likelihood of occurrence assessment.
- Targeted black cockatoo habitat assessment.

Flora Survey Results

DBCA database and Commonwealth PMST searches identified 69 conservation listed flora species as occurring within 20 km of the Survey Area or potentially occurring in the region. No previous records are present within the Survey Area. The historical clearing, soil structural breakdown and ongoing grazing leading to removal of the mid and ground stratums have rendered the habitat unsuitable for most native species. Due to the season of survey (May) some species identified by the desktop assessment would not have been present/ identifiable, however based on assessment of habitat type and quality it is not considered that they are likely to occur.

As per requirements for a Reconnaissance level survey, flora sampling focused on dominant and characteristic species. Native species diversity was very low with 12 species recorded. Additional species would be identified during a spring season survey.

Two introduced species **Asparagus asparagoides* (bridal creeper) and**Gomphocarpus fruticosus* (cotton bush), which listed as a Declared Pest at the species level under the *Biosecurity and Agricultural Management Act 2007* (BAM Act) were recorded.

Vegetation Survey Results

Six broad vegetation types were described. The vegetation present throughout the Survey Area was not considered to be representative of intact remnant native vegetation and was assed as in Completely Degraded condition throughout.

The Threatened Ecological Communities (TEC) desktop assessment identified 13 TEC's within 20 km of the Survey Area. A pre-survey likelihood of occurrence assessment was undertaken and determined that one TEC potentially intersected with the Survey Area, one as having a medium likelihood of occurrence and eleven as having a low likelihood of occurrence.

The northeastern corner of the Survey Area was identified in DBCA ecological community database search as intersecting with the mapped buffer of an occurrence of the Banksia Woodlands of the Swan Coastal Plain TEC. No Banksia Woodland vegetation is present meeting any key diagnostic characteristic of the TEC. Additionally, the vegetation is in Completely Degraded condition and does not provide any connectivity between patches of Banksia Woodland (DoTEE, 2016).

One State and Commonwealth listed TEC was identified as potentially occurring. The potential TEC occurs running along the narrow (3-5 m) verge on the northern side of Lage Rd covering 0.43 ha. Based on assessment of the limited characteristic species present suggests closest affinity to the *Corymbia calophylla — Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (floristic community type 3c) TEC. Vegetation is considered potentially not comprising an occurrence of the TEC due to the Completely Degraded condition and having lost most understorey and mid-storey taxa typical of the TEC. A follow up survey during the primary spring season to identify a more comprehensive flora list may be suitable to refine assessment of TEC presence in liaison with DBCA species and Communities branch.

Basic Fauna Survey Results

The vertebrate fauna desktop assessment identified 23 conservation listed species occurring within 20 km of the Survey Area. An assessment of the likelihood of occurrence within the Survey Area was undertaken and identified that of the potential conservation listed fauna, two had a high likelihood of occurrence, one had a medium likelihood of occurrence and 20 had a low likelihood of occurrence.

The two species that had a high likelihood of occurrence were:

- *Calyptorhynchus banksii naso* (forest red-tailed black cockatoo) - Vulnerable.
- *Zanda latirostris* (Carnaby's black cockatoo) (previously *Calyptorhynchus latirostris*) - Endangered

The one species that had a medium likelihood of occurrence was:

- *Falco peregrinus* (peregrine falcon)-OS.

Four habitat types were described. The degraded condition and lack of a shrub or ground layer results in the Survey Area providing limited habitat value to most species. Foraging evidence (chewed marri nuts) from both Carnaby's and forest red-tailed black cockatoo was recorded from several locations. There were no other observations of, or secondary evidence recorded for other Threatened or Priority fauna within the Survey Area and no core habitat is present.

Black Cockatoo Assessment Results

The Survey Area falls outside the modelled distribution for Baudin's black cockatoo, within the breeding range for Carnaby's black cockatoo and in the Likely to Occur range for Forest Red-tailed black cockatoo (DCCEEW, 2022).

Breeding Habitat

A total of 572 potential breeding trees were recorded. No evidence of current or previous nesting behaviour such as chew marks at hollow entrance attributed to black cockatoos, or flushed individuals was recorded. One marri tree (tree number 551) was assessed as possessing a hollow with sufficient entry diameter to potentially support a suitable nesting hollow. The tree has one upwards opening knot type hollow mid trunk with a slit type entrance of 15x 20 cm diameter. The hollow faces south and is accessible to black cockatoos. A nesting galah pair was observed and there is chew markings around entrance to hollow and on trunk attributed to galah. The presence of galah makes usage by black cockatoo unlikely at the time of survey however the potential suitability of the hollow to support black cockatoo breeding cannot be excluded. A follow up inspection of internal dimensions may be required allow more detailed understanding of actual suitability.

Foraging Habitat

Foraging habitat comprises primarily marri and wandoo trees with scattered sheoak, pines and a range of small-fruited eucalypts. The Commonwealth referral guidelines foraging quality scoring tool returns a score of eight out of ten (high) for the Survey Area. The Commonwealth referral guidelines specify that the tool is to be applied once to the entire impact area even if there is more than one type of foraging habitat present. The guidance identifies that “loss of greater than or equal to 1 ha of foraging habitat scoring 5-10 using the foraging quality scoring tool is likely to require referral”. A referral to the Commonwealth is therefore recommended if >1ha of vegetation is to be impacted.

The black cockatoo referral guidance allows for the inclusion of additional information for foraging habitat which may be considered during an assessment, such as the extent and density of recognised foraging plants. Additionally, for FHT_01 and FHT_02 individual high value foraging trees were reported as a number of trees within the habitat extent. The WEPL assessment of foraging habitat quality (using Bamford 2018 scoring tool) produced a numerical foraging habitat score value for habitat types. The assessment identified the following extents and scores for the two species:

- Forest red-tailed black cockatoo
    - 5.17 ha Low-2 quality.
    - 2.06 ha Moderate-4 quality.
    - 784 high value individually marked trees.
- Carnaby’s black cockatoo
    - 5.56 ha Low-2 quality.
    - 1.66 ha Low-Moderate-4 quality.
    - 771 high value individually marked trees.

Analysis of estimated foraging habitat extent within the region indicates there 23,338 ha of remnant native vegetation mapped within a 12 km buffer of the Survey Area. The estimated canopy extent of approximately 7.98 ha of foraging habitat present represents 0.065 % of the estimated regional habitat extent. It is expected that the majority of the regional vegetation would contain suitable foraging species with much of the vegetation including high quality banksia woodlands of the Bassendean Complex sandplains and the jarrah and marri forests of the Darling Scarp.

Roosting Habitat

Throughout the Survey Area, isolated stands of tall (> 10 m) eucalypts are scattered which may provide suitable roosting habitat. No evidence of roosting was observed or recorded by secondary evidence such as scats and tree chewing.

Acronyms and Abbreviations

Abbreviation	Full Title
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BC Act	*Biodiversity Conservation Act 2016*
°C	Degree Celsius
CR	Critically Endangered
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEWHA	Department of the Environment Water Heritage and the Arts
DPIRD	Department of Primary Industries and Regional Development
DRF	Declared Rare Flora
DWER	Department of Water and Environmental Regulation
DWER	Department of Water and Environmental Regulation
EIA	Environmental Impact Assessment
EN	Endangered
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection Biodiversity and Conservation Act 1999*
ESA	Environmentally Sensitive Area
FCT	Floristic Community Type
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
IBRA	Interim Biogeographic Regionalisation for Australia
IBSA	Index of Biodiversity Surveys for Assessments
km	Kilometres
m	Metres
MA	Marine
MI	Migratory
MNES	Matters of National Environmental Significance
NVIS	National Vegetation Information System
OS	Other Specially Protected
P	Priority
PEC	Priority Ecological Community

Abbreviation	Full Title
PF	Priority Flora
PMST	Protected Matters Search Tool
RAAF	Royal Australian Air Force
T	Threatened
TEC	Threatened Ecological Community
TPFL	Threatened and Priority Flora Database
TPFRF	Threatened and Priority Flora Report Forms
VU	Vulnerable
WA	Western Australia
WAH	Western Australian Herbarium
WC Act	*Wildlife Conservation Act 1950*
WEPL	Western Environmental Pty Ltd
WoNS	Weeds of National Significance

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Appendices

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1. Introduction

1.1 Project Background

Rowe Group commissioned Western Environmental Pty Ltd (WEPL) to undertake a broadscale flora and vegetation assessment, a basic fauna survey and black cockatoo assessment to support the planning scheme amendment phases for the rezoning of multiple lots in Bullsbrook South which has been divided into four parcels:

1. Parcel A, comprising 83.55 ha
2. Parcel B, comprising 90.41 ha
3. Parcel C, comprising 4.21 ha
4. Parcel D ,comprising 14.58 ha

1.2 Location

The Survey Area is located in south Bullsbrook in the Swan Coastal Plain region (SWP02) of Western Australia. The Survey Area covers 192.75 ha. See Figure 1 below.

1.3 Objectives

The purpose of the survey was to delineate key flora, vegetation and black cockatoo habitat values within the Survey Area and identify potential environmental sensitivities and values that may occur.

The scope of works included:

- Desktop assessment and summary of publicly available information and paid data base searches of Department of Biodiversity, Conservation and Attractions (DBCA) threatened and priority fauna, flora and vegetation databases.
- A broad scale flora and vegetation assessment in line with the requirements for a Reconnaissance level survey as set out in the Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016)
- A Basic fauna survey, mapping habitat and likelihood of occurrence as set out in the Technical Guidance –Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA ,2016)
- Assessment of black cockatoo habitat for foraging, roosting and breeding values and per the Commonwealth Referral Guidelines for 3 WA Threatened Black Cockatoo Species (DCCEEW, 2022)

This report presents the results of the field survey undertaken to support the above objectives.

Figure 1: Survey Area

1.4 Survey Limitations and Constraints

Limitations and constraints of the flora and vegetation survey as outlined in the Flora and Vegetation and Fauna Survey Technical Guidance are detailed below in Table 1.

Table 1: Limitations and Constraints of the Flora and Vegetation Survey

Possible Limitation	Degree of Limitation (Significant, Moderate or Negligible)	Potential Constraints on Survey Outcomes
Survey Level/ Scope	Negligible	The reconnaissance flora and vegetation survey, basic fauna survey and targeted assessment of black cockatoo habitat is considered appropriate due to the cleared and degraded condition of the Survey Area. The information collect is suitable to provide information required to support the development of the master plan and inform approvals referrals.
Availability of contextual information at a regional and local scale	Negligible	All data required to complete the scope of works including regional and local contextual information was available. DBCA data was reviewed as part of the desktop assessment.
Site Access	Moderate	A portion of the Survey Area (Parcel D) was not accessed due to lack of landholder permission. The remainder of the Survey Area was accessed by vehicle and on foot.
Survey Intensity and Extent	Moderate	Four person days of effort by experienced ecologists was applied. A portion of the Survey Area (Parcel D) was not accessed due to lack of landholder permission. Survey intensity was in line with the technical guidance for Reconnaissance flora and vegetation and Basic fauna surveys. Systematic Targeted flora searches were not undertaken due to lack of suitable habitat and season (May). This was not considered a limitation due to lack of suitable habitat. Survey effort for black cockatoos assessment was suitable to adequately sample habitats present. Assessment of potential Black cockatoo nesting hollows was undertaken however one hollow could not be assessed for internal dimensions due to height from ground. A follow up detailed hollow inspection may be required to confirm suitability.
Experience	Negligible	The ecologist leading the field survey (Andrew Fry) has been conducting flora and vegetation surveys and fauna habitat assessments in Western Australia for over 10 years.
Timing, weather, season	Moderate	The recommended primary survey period for flora and vegetation surveys for the region as per the EPA Technical Guidance occurs in spring (September-November). The survey was completed in late May. The seasonal timing although outside the primary survey window was considered appropriate considering the objectives of the survey. No annual or timing dependant Threatened or Priority flora are considered likely to occur within the Survey Area based on habitat assessment. A spring survey may provide additional species to assist in determining vegetation significance along Lage Rd.

Possible Limitation	Degree of Limitation (Significant, Moderate or Negligible)	Potential Constraints on Survey Outcomes
Proportion of the flora and fauna recorded and/or collected, and any identification issues	Negligible	Species sampling was in line with the technical guidance for Reconnaissance flora and vegetation and Basic fauna surveys
Mapping Reliability	Negligible	The majority of the Survey Area was traversed by foot and mapping reliability is considered high.
Disturbances (fire, flood etc.)	Negligible	Areas of disturbance associated with historic clearing for agricultural and residential purposes and weeds were recorded but were not a constraint on the results of the survey.

2. Existing Environment

2.1 Pre-European Vegetation Types

During the 1970s, John Beard and associates conducted a systematic survey of native vegetation, describing the vegetation systems in Western Australia at a scale of 1:250 000 in the south-west and at a scale of 1:1,000,000 in less developed areas (Beard, 1976).

Beard's mapping attempted to depict the native vegetation as it was presumed to be at the time of settlement and is known as the pre-European vegetation type and extent. Beard's vegetation maps are maintained in digital form by DPIRD (2019). Extents are updated periodically by Department of Biodiversity, Conservation and Attractions (DBCA) (GoWA, 2018). This mapping indicates that the Survey Area intersects three pre-European vegetation associations:

- Pinjarra_3: Forest - Medium forest; jarrah-marri
- Pinjarra_4: Woodland Southwest - Medium woodland; marri & wandoo
- East Darling_4: Woodland Southwest - Medium woodland; marri & wandoo

The pre-European vegetation association identified from the Survey Area (DPIRD-006) and its pre-European and current extents are listed in Table 2 (GoWA, 2018).

Table 2: Pre-European Vegetation Association Representation

Vegetation Association	Original Extent (ha)	Current Extent (ha)	% Remaining	% Managed for Conservation
Pinjarra_3	13,738.98	1,586.73	11.55	1.53
Pinjarra_4	10,632.64	1,237.66	11.64	1.17
East Darling_4	47,288.88	31,180.33	65.94	16.99

Regional vegetation for the Swan Coastal Plain (at vegetation complex level) was mapped by Heddle *et al*. (1980) and are maintained in digital form by DBCA (2018). The mapping indicates that the Survey Area intersects mainly one pre-European regional vegetation complex, but slightly intersects two other vegetation complexes:

- Guildford Complex (32): A mixture of open forest to tall open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) and woodland of *Eucalyptus wandoo* (Wandoo) (with rare occurrences of *Eucalyptus lane-poolei* (Salmon White Gum)). Minor components include *Eucalyptus rudis* (Flooded Gum) - *Melaleuca rhaphiophylla* (Swamp Paperbark).

- Forrestfield complex (29): Vegetation ranges from open forest of *Corymbia calophylla* (Marri) - *Eucalyptus wandoo* (Wandoo) - *Eucalyptus marginata* (Jarrah) to open forest of *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) - *Allocasuarina fraseriana* (Sheoak) - *Banksia* species. Fringing woodland of *Eucalyptus rudis* (Flooded Gum) in the gullies that dissect this landform.

- Darling Scarp (DS2): Mosaic of open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla,* with some admixtures with *Eucalyptus laeliae* in the north (subhumid zone), with occasional *Eucalyptus marginata* subsp. *elegantella* (mainly in subhumid zone) and *Corymbia haematoxylon* in the south (humid zone) on deeper soils adjacent to outcrops, woodland of *Eucalyptus wandoo* (subhumid and semiarid zones), low woodland of *Allocasuarina huegeliana* on shallow soils over granite outcrops, closed heath of Myrtaceae-Proteaceae species and lithic complex on or near granite outcrops in all climate zones.

The pre-European regional vegetation complex identified from the Survey Area (DBCA-046; DBCA-047) and its' pre-European and current extents are listed in Table 3 (GoWA, 2017).

Table 3: Pre-European Regional Vegetation Complexes

Vegetation Complex Name	System 6 Mapping Unit Number	Original Extent (ha)	Current Extent (ha)	% Remaining	% Managed for Conservation
Guildford Complex	32	90,513.13	4,522.01	5.00	0.26
Forrestfield Complex	29	22,812.92	2,804.97	12.30	1.37
Darling Scarp	DS2	32,448.29	13,536.76	41.72	7.67

Figure 2: Pre-European Veg Types

2.2 Environmentally Sensitive Areas and Conservation Estate

Environmentally Sensitive Areas (ESAs) are declared by the Department of Water and Environmental Regulation (DWER) to prevent the degradation of important environmental values such as Threatened Flora, Threatened Ecological Communities (TECs) or significant wetlands.

No ESAs intersects with the Survey Area (DWER-046). The closest ESA is 890 m northwest of the Survey Area (ID 10109) and is associated with a TEC. See Figure 3

The Survey Area is not identified as intersecting a Conservation Area (DBCA-011). The nearest conservation area is:

- Walyunga National Park (R 2065) located approximately 2.6 km to the southeast.

2.3 Wetlands and Hydrology

The southern half of the Survey Area intersects with one Multiple Use category, palusplain wetland (UID15282) (DBCA-019). See Figure 4.

2.4 Land Use History

The Survey Area has been historically developed for agriculture, paddocks and housing. An extractive land has been present in the central eastern portion which has since been revegetated.

Figure 3: Environmentally Sensitive Areas, Conservation Estate and Bush Forever

Figure 4: Surface Water Features and Geomorphic Wetlands

3. Methodology

3.1 Desktop Assessment

3.1.1 Database Searches

Database searches were undertaken to compile a list of potential conservation significant flora and ecological communities within or surrounding the Survey Area (Table 4). In addition, an EPBC Protected Matters Search Tool (PMST) was undertaken to identify the potential for Matters of National Environmental Significance (MNES) to occur within or surrounding the Survey Area (DEECCW, 2022).

Table 4: Database Searches of the Survey Area

Database Name	Date Received and Reference Number	Search Type	Search Area
Threatened and Priority Ecological Communities database search (Department of Biodiversity Conservation and Attractions)	10/08/2022 38-0822C	TECs and PECs	20 km buffer around the Survey Area
Threatened and Priority Flora (TPFL) database search (Department of Biodiversity Conservation and Attractions)	10/08/2022 60-0822FL	Threatened and Priority Flora	20 km buffer around the Survey Area
Western Australian Herbarium (WAHerb) flora database search (Department of Biodiversity Conservation and Attractions)	10/08/2022 60-0822FL	Threatened and Priority Flora	20 km buffer around the Survey Area
DBCA Threatened and Priority Fauna database search (Department of Biodiversity Conservation and Attractions)	06/06/2023 FAUNA#7742	Threatened and Priority Fauna	10 km buffer around the Survey Area
Protected Matters Search Tool Department of Agriculture Water and the Environment, 2022a)	06/06/2023	Commonwealth listed Threatened Flora and fauna and TECs	10 km buffer around the Survey Area

3.1.2 Likelihood of Occurrence

Conservation listed flora communities identified from the desktop assessment were assessed to determine the likelihood of their occurrence within the Survey Area, both prior to and post field survey. The assessment was completed based on the likelihood of occurrence criteria presented in Table 5.

Only species either recorded within the Survey Area or considered as having a high likelihood of occurrence in post field survey assessment will be discussed in detail. Species classified as having a low likelihood of occurrence will not be discussed unless a justification for this classification is required.

Table 5: Likelihood of Occurrence Criteria

Likelihood	Criteria
Recorded	Recorded in the Survey Area from database searches, previous survey by others or by current survey.
High	• Records of flora species <1 km from the Survey Area. With record <20 years old. • Records of fauna species <5 km from the Survey Area. With record <20 years old; or • For species with well understood and specific habitat preference/ requirements, when specific habitat is present in the Survey Area, and records present <10 km from the Survey Area. • Species with general habitat preference, which is present in the Survey Area, and records present <5 km from the Survey Area.

Medium	• There are records <10 km from the Survey Area, however:
	  • The species is strongly linked to a specific habitat, which is marginally suitable or small in extent in the Survey Area; or
	  • Species has a general habitat preference, but small extent of suitable habitat is present.
	• There is suitable habitat in the Survey Area, but records are >10 km from Survey Area.

Low	• Records are historical only, or are pre mapping procedures (e.g. records assigned to towns or place names). • The species has a well understood and specific habitat preference/ requirements, which is absent from the Survey Area; or • Suitable habitat is present, however there are no existing records of the species from the region despite reasonable previous search effort; or • There is some suitable habitat in the Survey Area, however the species is very infrequently recorded in the locality (e.g. migratory bird species). •

3.2 Flora and Vegetation Survey

3.2.1 Floristic Relevé

Relevé locations were selected using aerial photography, vegetation values and field observations to best represent the vegetation types present.

The following information was collected from within each relevé:

- Observer.
- Date.
- Quadrat/site number.
- Global Position System (GPS) location (GDA2020) of the north-west corner.
- Digital photograph (spatially referenced with a reference number), taken from the north-west corner, looking diagonally across the quadrat.
- Broad soil type and colour.

- Topography.
- List of flora species recorded with total foliar cover within the quadrat for each species.
- National Vegetation Information System (NVIS) Vegetation description (as per below).
- Vegetation condition.

Relevés, being an unmeasured area of approximately the same size as quadrats, were used to record vegetation as per requirements of a Reconnaissance level survey.

3.2.2 Vegetation Description and Classification

Vegetation was described using the height and estimated cover of dominant and characteristic species of each stratum based on NVIS, recorded at Level V (NVIS Technical Working Group, 2017). Up to three species per stratum from each stratum (upper, mid and ground) were used to formulate vegetation descriptions for each quadrat and each vegetation type. Vegetation type descriptions were created by combining relevé descriptions and modifying, where necessary, based on the wider vegetation.

3.2.3 Vegetation Condition Assessment

Vegetation condition was assessed at each relevé and during traverses of the Survey Area using the Vegetation Condition Scale for the appropriate bioregion as per the Flora and Vegetation Technical Guidance (EPA, 2016). As relevés are deliberately located in the best condition parts of a vegetation type, the condition rating of the relevé may not match that of the broader vegetation type due to the scale of mapping.

3.2.4 Field Survey Timing and Survey Team

The field survey was conducted on 23-25 May 2023. The survey was undertaken by WEPL senior ecologist Andrew Fry (Flora Licence FB62000002-2) and WEPL graduate environmental scientist Lovisa Thambert (Flora Licence FB62000468). Andrew has 10 years' experience in undertaking ecology surveys in WA.

3.3 Fauna Survey

The basic fauna survey incorporated a number of survey techniques as per the Terrestrial Fauna Technical Guidance (EPA, 2020). A basic survey is a low-intensity survey, conducted at the local scale to gather broad fauna and habitat information. The primary objectives are to verify the overall adequacy of the desktop study, and to map and describe habitats, with a focus on habitat for conservation listed fauna.

Fauna species were identified by active searches, secondary evidence such as scats, tracks, calls, remains, diggings and other signs. A fauna inventory was not compiled as part of this survey (not required under basic level survey) however observations are used to inform the fauna habitat type assessment.

Potential habitats for conservation listed species were identified and evaluated and the likelihood of occurrence assessed.

3.3.1 Fauna Habitat Type Assessment

The fauna habitat types present within the Survey Area were defined considering landform, vegetation, structure such as rockpiles and logs and fauna assemblage occupying the area.

The following information was used to define and map all fauna habitat types within the Survey Area at specific fauna habitat assessment points and during traverses of the Survey Area:

- Land systems and landform.
- Vegetation type and condition mapping.
- Soil characteristics.
- Structure such as rockpiles and logs.
- Fauna assemblage information from desktop assessment and field observations.
- Aerial imagery and historic imagery.

Each fauna habitat type is described considering suitability for various fauna species groups or conservation-listed species. In addition, fauna habitat types likelihood to harbour specialised fauna species which are not found in adjacent areas was taken into consideration. Habitat types were delineated in the field and digitised upon return from the field survey.

3.3.2 Fauna Taxonomy

Terrestrial vertebrate fauna taxa were identified in the field by an experienced ecologist.

Taxonomy and nomenclature follow the WA Museum checklist 2022 (Western Australian Museum, 2022). Conservation status follows the DBCA Threatened and Priority fauna list (DBCA, 2022b). Where required verification of identification of secondary evidence (tracks, scats, diggings) may be undertaken by a relevant species group expert.

3.3.3 Black cockatoo Habitat Assessment

The Swan Coastal Plain is used by Black cockatoos primarily for foraging resources, with some small patches of breeding habitat. Vegetation used by Black cockatoos is dominated by *Banksia* spp. and tuart (*Eucalyptus gomphocephala*) woodlands, as well as marri (*Corymbia calophylla*) and jarrah (*E. marginata*) (DCCEEW, 2022).

On the Swan Coastal Plain, Baudin's Black cockatoo and Carnaby's Black cockatoo are most commonly present from February through to September, with Forest Red-tailed Black cockatoo presence being flexible across the year. The timing of the survey in February provided good opportunity to record foraging individuals

and nesting for Carnaby's Black cockatoo. If no individuals are present, searching for foraging evidence is a reliable alternative as it will generally persist in the landscape (particularly marri nut chews) (DCCEEW, 2022).

The Black cockatoo habitat field survey followed the *Commonwealth referral guidelines for Threatened Black cockatoos* (DCCEEW, 2022) for identifying breeding, foraging and roosting habitat.

Breeding Habitat Assessment

The Commonwealth defines breeding habitat as trees species, known to support breeding, within the range of the species, which either have a suitable nest hollow or are of a suitable diameter at breast height (DBH) (1.3 m from the ground) to develop a hollow, including:

- Greater than 500 mm DBH for most Eucalypts (jarrah, marri or tuart); or
- 300 mm in the case of wandoo and salmon gum (MRWA, 2022).

All trees of species with the potential to form hollows (typically jarrah, marri and tuart) and with sufficient diameter (i.e. DBH >500 mm) were recorded using a GPS. The following was recorded for each such tree:

- Species
- DBH (approximately 1.3 m from the ground)
- Tree health (such as presence of dieback (*Phytophthora cinnamomi)* or marri canker (*Quambalaria coyrecup*) and other threatening processes); and
- Presence of hollows (as observable form the ground).

In addition to Commonwealth guidelines for assessing potential breeding trees, a scoring system based on that developed by Dr Mike Bamford was applied to class potential breeding trees.

Table 6: Black cockatoo Potential Breeding Tree Class

Class	Description of Tree and Hollows/Activity
1	Active nest observed; adult (or immature) bird seen entering or emerging from hollow, eggs present.
2	Hollow of suitable size and angle visible with chew marks around entrance.
3	Potentially suitable hollow visible but no chew marks present; or potentially suitable hollow present (as suggested by structure of tree, such as large, vertical trunk broken off at a height of >10m).
4	Tree with hollows or broken branches that might contain hollows, but hollows or potential hollows are not of a suitable size, or are aligned or obstructed so as to prevent access
5	Tree lacking large hollows or broken branches that might have large hollows; a tree with more or less intact branches and a spreading crown.

Where trees with potentially suitable hollow entrances were identified an internal inspection of hollow dimensions was undertaken using a pole camera or drone.

Foraging Habitat Assessment

The Commonwealth defines foraging habitat as areas including plants of species known to support foraging within the range of each black cockatoo species. Marri (*Corymbia calophylla*) and jarrah (*Eucalyptus marginata*) woodlands are particularly important to Baudin's black cockatoo and the forest red-tailed black cockatoo, while proteaceous heaths (shrublands dominated by *Banksia, Hakea* and *Grevillea* species) are also utilised by Carnaby's black cockatoo (DCCEEW, 2022).

The potential of the habitat within the Survey Area to support foraging was described, and any evidence was recorded, along with opportunistic sightings of any black cockatoo individuals. A mixed methodology of defining polygons around groves and marking of individual scattered high value foraging trees was utilised to quantify foraging habitat extent and quality. Where high quality foraging tree species were present within foraging habitat mapped as polygons or occurring as isolated paddock trees, these were individually marked to quantify number of high-quality foraging trees present. Groves or tree lines of foraging species were mapped as polygons and scored as per method described below.

Habitat mapping of the Survey Area was used in conjunction with the site assessment to determine the foraging quality using the Foraging Habitat Scoring Tool (DCCEEW, 2022). In addition to the DCCEEW, 2022 Foraging Habitat Scoring Tool a secondary assessment was undertaken using a scoring tool developed by Dr Mike Bamford in 2018 which produces a numerical foraging habitat score value for each identified fauna habitat type. See Appendix F for detailed scoring tool methodology. This methodology was only applied to groves of trees mapped as polygons. Isolated paddock trees were scored as either high or low value based on the understood foraging value as per listed in DCCEEW (2022) and Groom (2011).

Information collected for the Survey Area was also contextualised with consideration to the wider availability of foraging habitat for black cockatoos in the surround area (12 km radius). This buffer is selected as recommended in the Commonwealth referral guidelines due to black cockatoos mainly foraging within 12 km of their nest site during the breeding season and their reliance on this proximity of foraging resources to successfully raise chicks (DCCEEW, 2022). Analysis utilises Remnant Native Vegetation Extent mapping (DPIRD-005) and Vegetation Complexes- Swan Coastal Plain and South West forest region (DBCA-046 and DBCA-047) mapping to define extent and type of remnant vegetation.

Roosting Habitat Assessment

During the field survey, searches were conducted for evidence of roosting (e.g. piles of scats, feeding debris or chewed trees).

4. Results

4.1 Desktop Assessment and Likelihood of Occurrence

Flora

DBCA database and Commonwealth PMST searches identified 69 conservation listed flora species as occurring within 20 km of the Survey Area or potentially occurring in the region (see Figure 5). No previous records are present within the Survey Area. See Appendix C for database search results and likelihood of occurrence assessment. The likelihood of occurrence assessment identified that post survey all species had low likelihood of occurrence.

Ecological Communities

Thirteen State listed Threatened Ecological Communities (TEC) and Priority Ecological Community (PEC) occur within 20 km of the Survey Area or are identified by Commonwealth PMST as potentially occurring in the region (see Figure 5). The desktop and likelihood of occurrence assessment identified that:

- The Survey Area intersects the edge of the buffer of Banksia Woodland of Swan Coastal Plain TEC at two locations. This community is not present as there is no intact native vegetation and no diagnostic features that are characteristic for this TEC. This TEC was assessed of having low likelihood of occurrence, see Section 4.2.2.
- One community (SCP3c *Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands) was assessed as having a medium likelihood of occurrence.
- 11 communities were assessed as having a low likelihood of occurrence due to unsuitable geology, soils or hydrology association; or lack of characteristic vegetation community.

See Appendix C for database search results and likelihood of occurrence assessment.

Figure 5: Database Search Results Flora and Communities

4.2 Flora and Vegetation

4.2.1 Flora

Flora Species

As per requirements for a Reconnaissance level survey, flora sampling focused on dominant and characteristic species and did not attempt to collect a comprehensive flora inventory or list of non-native species. Native species diversity was very low. Common native species recorded are listed below in Table 7.

Table 7: Flora Species Recorded

Native Species	Planted and Non-Native Species
Banksia dallanneyi	**Corymbia citriodora* (lemon scented gum)
Banksia nivea	*Eucalyptus camaldulensis* (river red gum)
Corymbia calophylla	**Eucalyptus grandis* (rose gum)
Casuarina obesa	**Ficus carica* (fig tree)
Eucalyptus rudis	**Pinus* sp. (pines)
Eucalyptus wandoo	
Hakea lissocarpha	
Melaleuca rhaphiophylla	
Mesomelaena tetragona	
Lepidosperma sp.	
Taxandria linearifolia	
Xanthorrhoea preissii	

Threatened and Priority Flora

No Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) listed, or State BC Act listed Threatened Flora were recorded in the Survey Area or were assessed as having a high-medium post survey likelihood of occurrence.

The historical clearing, soil structural breakdown and ongoing grazing leading to removal of the mid and ground stratums have rendered the habitat unsuitable for most native species.

The only portion of the Survey Area which possessed any ground or mid stratum species is the narrow (3-5 m) verge on the northern side of Lage Rd. The vegetation is in Completely Degraded condition with sparse native plants present. This vegetation was traversed in more detail to identify potential Threatened or Priority species. The desktop assessment identified that Threatened species *Grevillea curviloba* is present in the area and that the species can persist in highly degraded road/rail corridors. The species is a perennial to 2m tall with distinctive leaf characteristics. No *Grevillea* species were recorded. Additionally, the typical vegetation and social association (peaty grey sand over limestone) does not match that present within the

Survey Area (TSSC, 2016). Based on these factors the species was assessed as having a low likelihood of occurrence

Due to the season of survey (May) some species identified by the desktop assessment would not have been present/ identifiable, however based on assessment of habitat type and quality it is not considered that they are likely to occur.

Flora of Other Significance

Flora may be considered of other conservation significance if it is a novel taxon or represents a range extension. None of the recorded taxa may be considered flora of other conservation significance.

Introduced Flora

As per requirements for a Reconnaissance level survey and considering the Survey Area comprises entirely farmland a comprehensive weed list was not prepared. Key observation regarding weeds were:

- Declared Pest and Weed of National Significance (WoNs) species *Asparagus asparagoides* (bridal creeper) is common along the verges of Lage Rd
- Declared Pest *Gomphocarpus fruticosus* (cotton bush) was recorded from three large occurrences in open paddocks and drainage lines.

See Figure 7 for locations.

Under the Declared Pest listing by DPIRD these species are required to have some form of management applied by the land holder that will reduce the numbers or distribution of the organism or prevent or contain the spread of the organism. It is recommended that the populations are controlled and soil movement from the affected areas is limited to prevent spread of seed stored in the soil.

4.2.2 Vegetation

Vegetation Types

The vegetation present throughout the Survey Area was considered not to be representative of intact remnant native vegetation and was described from observations while traversing Survey Area. Due to the Completely Degraded condition and highly depauperate nature of the vegetation a traverse sampling method considered suitable. Additionally, due to the degraded condition and low native species abundance Floristic Community Type (FCT) analysis was not suitable to be undertaken to assist in defining broad vegetation types. The vegetation present within the Survey Area is described below in Table 8 and shown in Figure 7.

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Table 8: Vegetation Present in Survey Area

Vegetation Unit Description	Total Area, Proportion (%) of the Survey Area	Sites	Vegetation Condition	Photograph
VT01-Marri and Wandoo over Paddocks Scattered paddock trees and denser groves of *Corymbia calophylla* and *Eucalyptus wandoo* over pasture grassland. Mid and ground stratum absent. Occurring on flats and lower hillslopes. Soil a clay loam with limited laterite influence on higher parts.	32.69 ha 16.96%	-	Completely Degraded	

Vegetation Unit Description	Total Area, Proportion (%) of the Survey Area	Sites	Vegetation Condition	Photograph
VT02 Wandoo Over Paddocks Stands of *Eucalyptus wandoo.* Trees have been previously cleared and are coppicing as multi stem mallee forms. Vegetation is subject to ongoing sheep grazing which has supressed/ removed the ground and mid stratum. Occurring at base of hills with a mixed clay loam and light laterite soil. Heavily compacted by sheep.	2.26 ha 1.17%	-	Completely Degraded	

Vegetation Unit Description	Total Area, Proportion (%) of the Survey Area	Sites	Vegetation Condition	Photograph
Creek-Creek with Flooded Gum Open woodland of *Eucalyptus rudis, Corymbia calophylla* and scattered *Eucalyptus wandoo*. Very occasional *Melaleuca rhaphiophylla* and *Taxandria linearifolia.* Ground stratum pasture grasses. Occurring along the Nambad Brook. Soil clay with alluvial river stone. Comprises highly degraded riparian vegetation zone.	3.13 ha 1.62%	-	Completely Degraded	

Vegetation Unit Description	Total Area, Proportion (%) of the Survey Area	Sites	Vegetation Condition	Photograph
Drain-Minor Drainage Line Minor drainage line with *Eucalyptus wandoo* over pasture grass. Soil clayey. Drainage line has been modified in several sections. No riparian associated species present.	3.18 ha 1.65%	-	Completely Degraded	

Vegetation Unit Description	Total Area, Proportion (%) of the Survey Area	Sites	Vegetation Condition	Photograph
Planted Trees-Windbreaks, Gardens, Revegetation Planted areas. Species typically non endemic including *Eucalyptus camaldulensis, Eucalyptus grandis, Corymbia citriodora* and endemic *Casuarina obesa*.	7.68 ha 3.98%	-	Completely Degraded	

Vegetation Unit Description	Total Area, Proportion (%) of the Survey Area	Sites	Vegetation Condition	Photograph
Paddocks-Paddock with Isolated Trees Paddock with very isolated *Corymbia calophylla* and *Eucalyptus wandoo* over pasture grasses.	143.81 ha 74.61%		Completely Degraded	
Total	**192.75 ha**			

Vegetation Condition

All areas of the Survey Area are in Completely Degraded condition (Table 9). The vegetation of the Survey Area has been degraded as a result of historic clearing for agriculture and ongoing grazing.

Table 9: Vegetation Condition Extents (as per EPA, 2016 condition scale)

Vegetation Condition	Extent (ha)	Extent (%)
Excellent	-	-
Very Good	-	-
Good	-	-
Degraded	-	-
Completely Degraded	192.75	100
Total	**192.75**	**100**

Threatened and Priority Ecological Communities

One State or Commonwealth listed Threatened Ecological Community (TEC) or DBCA listed PEC was identified as potentially occurring.

Potential presence identified for one of three associated TECs occurring on heavy soils on the eastern part of the Swan Coastal Plain (FCT 3a, 3b, 3c as originally described in Gibson *et al*. 1994). Communities listed as Critically Endangered by State and Endangered by Commonwealth. The potential occurrence comprises the polygon of VT01 Marri and Wandoo over Paddock running along the narrow (3-5 m) verge on the northern side of Lage Rd. Potential occurrence covers 0.43 ha. See representative images below.

The vegetation is in Completely Degraded condition with scattered *Corymbia calophylla* and *Eucalyptus wandoo* over very sparse mid and ground stratum species. This vegetation was traversed in an approximate 500m transect sampling flora present. Due to time of survey (May) annual species were not present and detectability of perennial species is reduced. Assessment of limited characteristic species suggests closest affinity to the *Corymbia calophylla — Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (floristic community type 3c) TEC. Characteristic species as per *Methods for survey and identification of Western Australian threatened ecological communities* (DBCA, 2023) present include:

- *Corymbia calophylla*
- *Eucalyptus wandoo*
- *Xanthorrhoea preissii*
- *Banksia dallanneyi*
- *Banksia nivea*
- *Mesomelaena tetragona*
- *Lepidosperma spp*.

Vegetation is considered potentially not comprising an occurrence of the TEC due to the Completely Degraded condition and having lost most understorey and mid-storey taxa typical of the TEC. A follow up survey during the primary spring season to identify a more comprehensive flora list may be suitable to refine assessment of TEC presence.



Photo:01
Description: Looking east along Lage Rd vegetation



Photo:02
Description: Looking west along Lage Rd

The northeastern corner of the Survey Area was identified in DBCA ecological community database search as intersecting with the mapped buffer of an occurrence of the Banksia Woodlands of the Swan Coastal Plain TEC. No Banksia Woodland vegetation is present meeting any key diagnostic characteristic of the TEC. Additionally, the present vegetation is in Completely Degraded condition and does not provide any connectivity between patches of Banksia Woodland (DoTEE, 2016).

Vegetation of Other Significance

As per the Flora and Vegetation Technical Guidance and EPA guidance, vegetation may be considered of significance for a range of reasons, other than a listing as a TEC or a PEC, including:

- Pre-European vegetation extent being below a threshold level.
- Scarcity.
- Unusual species.
- Novel combinations of species.
- A role as a refuge.
- A role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species.
- A restricted distribution.

The Survey Area is predominantly within the mapped extent of the Guildford complex and contains some key species as per the structural description in Heddle *et. al*, 1980. Key species are *Corymbia calophylla* and *Eucalyptus wandoo.* The state-wide vegetation statistics as per GoWA, 2017 report current extent of this vegetation complex is 5.00 % of pre-European extent. This is below the 30% of pre-European extent national objective and targets for biodiversity conservation in Australia (Commonwealth of Australia, 2001). Due to the vegetation present being in Completely Degraded condition it is not considered to represent an intact remnant of the Guilford complex vegetation type.

Figure 6: Vegetation Types

Figure 7: Vegetation Condition and Significant Weeds

4.3 Fauna

4.3.1 Desktop Assessment

Database searches identified 23 conservation listed fauna species potentially occurring within the Survey Area, comprising:

- Seven bird species.
- Nine mammal species.
- Two reptile species.
- Five invertebrate species.

The results of the DBCA Threatened and Priority Fauna database search are shown in Figure 8. Database searches are summarised in Appendix C.

4.3.2 Likelihood of Occurrence

Species listed as Marine only under the EPBC Act, as well as marine dependent bird species have been excluded from the likelihood of occurrence list as there is no marine habitat present.

The likelihood of occurrence for conservation listed fauna species found that:

- Two species had a high likelihood of occurrence.
- One species had a medium likelihood of occurrence.
- Twenty species had a low likelihood of occurrence.

The results of the likelihood of occurrence assessment are presented in Appendix C.

The two species that had a high likelihood of occurrence were:

- *Calyptorhynchus banksii naso* (forest red-tailed black cockatoo) - Vulnerable.
- *Zanda latirostris* ((Carnaby's black cockatoo) previously *Calyptorhynchus latirostris*) – Endangered.

The one species that had a medium likelihood of occurrence was:

- *Falco peregrinus* (peregrine falcon) - OS.

Figure 8: DBCA Database Search Results Fauna

4.3.3 Fauna Species

As per the scope of a basic fauna survey under the Technical Guidance the primary objectives are to verify the overall adequacy of the desktop study, and to map and describe habitats, with a focus on habitat for conservation listed fauna.

A desktop assessment of expected conservation significant terrestrial vertebrate fauna assemblage was undertaken through searches of DBCA database records and the Commonwealth PMST. Results are summarised in Appendix C.

4.3.1 Fauna Habitat Types

Four habitat types were described. These broadly align with the mapped vegetation type boundaries. Fauna habitat types were primarily defined to focus on black cockatoo foraging habitat values. The fauna habitat types are described below in Table 10 and shown in Figure 9.

For possibly occurring conservation listed fauna species, habitat types are assessed as either core, supporting or non-significant habitat. As per Commonwealth Matters of National Environmental Significance – Significant Impact Guidelines 1.1 "core" habitat is defined as that critical to the survival of the species and considered to contain denning/ breeding sites, primary foraging areas and refuge from drought, fire and other stresses (DotE, 2013). "Supporting" habitat is defined as that which is likely used for foraging and dispersing/ connective purposes but is not essential habitat for the continuation of a local population. "Non-significant" habitat is that which would be used only very infrequently for foraging or dispersing. Discussion of habitat type suitability for species identified as having a high or medium likelihood of occurrence is provided in Table 10 and discussed in Section 4.3.1

Table 10: Fauna Habitat Type Descriptions within the Survey Area

Fauna Habitat Type	Habitat Description	Total Area, Proportion of the Survey Area	Representative Photo
FHT-01 Isolated Paddock Trees	Scattered paddock trees and denser groves of *Corymbia calophylla* and *Eucalyptus wandoo* over pasture. Lack of mid and ground layer greatly reduces habitat quality. Large mature paddock trees present forming hollows. Foraging evidence from black cockatoo species recorded in several locations from chewed marri nuts. Supporting habitat for: • Black cockatoo species (high value foraging trees) • Peregrine falcon (foraging)	185.64 ha 96.25%	

Fauna Habitat Type	Habitat Description	Total Area, Proportion of the Survey Area	Representative Photo
FHT-02 Planted Eucalypts	Planted areas. Species typically non endemic including *Eucalyptus camaldulensis, Eucalyptus grandis, Corymbia citriodora* and a mix of other small fruited eucalyptus species. Supporting habitat for: • Peregrine falcon (foraging).	5.17 ha 2.68%	

Fauna Habitat Type	Habitat Description	Total Area, Proportion of the Survey Area	Representative Photo
FHT-03 Sheoak Windbreaks	Dense planted windbreaks of *Casuarina obesa*. Supporting habitat for: • Forest red-tailed black cockatoo (high value foraging) • Peregrine falcon (foraging)	0.39 ha 0.20%	

Fauna Habitat Type	Habitat Description	Total Area, Proportion of the Survey Area	Representative Photo
FHT-04 Wandoo Regrowth	Stands of *Eucalyptus wandoo*. Trees have been previously cleared and are coppicing as multi stem mallee forms. Supporting habitat for: • Black cockatoo species (high value foraging) • Peregrine falcon (foraging)	1.66 ha 0.86%	
Total		**192.86 ha**	

Figure 9: Fauna Habitat Types And Conservation Significant Fauna Observations

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4.3.1 Threatened and Priority Fauna

Black cockatoo species were subject to a specific habitat assessment as per the Commonwealth referral guidelines (DCCEEW, 2022) which is presented below. Foraging evidence (chewed marri nuts) from both Carnaby's and forest red-tailed black cockatoo was recorded from several locations. A group of forest red-tailed black cockatoo was also observed flying over the Survey Area.

There were no other observations of, or secondary evidence recorded for Threatened or Priority fauna within the Survey Area and no core or supporting habitat is present. The degraded condition and lack of a shrub or ground layer results in the Survey Area providing limited habitat value to most species.

Fauna species of conservation significance which were recorded or assessed as having a high or medium likelihood of occurrence are discussed in detail below:

Falco peregrinus **(peregrine falcon) – OS**

This species is uncommon but wide-ranging across Australia. Habitat is extremely diverse, comprising most dryland habitats of Australia. The peregrine falcon nests primarily on ledges of cliffs, shallow tree hollows, and ledges of buildings or antennas

No breeding or core habitat is present, but all habitat types of the Survey Area may be used as supporting habitat for foraging on occasion with the species an infrequent visitor.

4.3.2 Black cockatoo Habitat Assessment

A Black cockatoo habitat assessment was undertaken by WEPL ecologists during the field survey in May 2023.

Observations and Previous Records

The Survey Area falls outside the modelled distribution for Baudin's black cockatoo, within the breeding range for Carnaby's black cockatoo and in the Likely to Occur range for Forest Red-tailed black cockatoo (DCCEEW, 2022). Numerous records for Carnaby's black cockatoo and forest red-tailed black cockatoo were present in DBCA database search results within 5 km of the Survey Area.

A confirmed Carnaby's black cockatoo breeding location is present approximately 13 km northeast of the Survey Area in the Muchea area (DBCA-054). The Survey Area does not overlap with the (12 km) key foraging area buffer of this confirmed breeding location. Three mapped black cockatoo roosting sites are present within 3-5 km to the northeast of the Survey Area (DBCA-64; DBCA-50). All are confirmed Carnaby's black cockatoo roost sites (Roost Code XK27, Bullsbrook, no specific ID code supplied for other two) (DBCA-64; DBCA-50). See Figure 10.

Foraging evidence (chewed marri nuts) from both Carnaby's and forest red-tailed black cockatoos were opportunistically recorded during the field survey, with evidence from Carnaby's at eight locations and evidence from forest red-tailed at three locations. Additionally, calls were heard, and individuals of forest Red-tailed Black cockatoo were seen flying adjacent to the Survey Area. See Figure 9.

Breeding Habitat Assessment

Potential Black cockatoo breeding trees are defined as those which either have a suitable nest hollow or are of a suitable DBH (> 500 mm for most species, >300mm for wandoo and salmon gum) to develop a hollow (DEECCW 2022). Breeding typically occurs in native eucalypt species particularly marri, jarrah, wandoo and tuart however many species of eucalypt including non-endemic species may develop suitable hollows for breeding (DEECCW 2022). A summary of understood suitable nesting hollow characteristics for the three species is provided below in Table 11.

Table 11: Black cockatoo Nesting Hollow Characteristics

Species	Baudin's Black cockatoo	Carnaby's Black cockatoo	Forest Red-tailed Black cockatoo
Tree species and hollow characteristic	Nesting mainly in karri, marri, jarrah, wandoo, bullich, and tuart Preferred hollow dimensions have not been specifically studies but are considered likely to be similar to that of the Carnaby's Black cockatoo	Nesting mainly in salmon gum, wandoo, tuart, jarrah, flooded gum, karri and marri. Utilise hollows from 10-65 cm diameter (average 26 cm) and >1 m deep	Nesting mainly in jarrah, marri, karri, wandoo, bullich, blackbutt and tuart Utilise hollow from 12-150 cm diameter (average 34 cm) and >1 m depth
Sources	DCCEEW, 2022.	DCCEEW, 2022, Saunders *et al.,* 2014a, Saunders *et al.,* 2014b.	DCCEEW, 2022, Johnstone *et al.,* 2013.

A total of 572 potential breeding trees were recorded, see summary in Table 12. No evidence of current or previous nesting behaviour such as chew marks at hollow entrance attributed to black cockatoos, or flushed individuals was recorded.

The large majority of potential breeding trees (536 trees) did not show signs of potential nesting hollow development (Class 5 trees). Thirty-five trees were assessed as possessing small hollows which are of an insufficient size to support nesting (<10cm entrance); or which have an entrance of >10cm but the internal dimensions are not suitable, or the hollow is not accessible (Class 4 trees). These Class 4 trees are however of sufficient age and growth form to be developing hollows.

One marri tree (tree number 551) was assessed as possessing a hollow with sufficient entry diameter to potentially support a suitable nesting hollow (Class 3 trees). Tree is located in the northwest corner of the Survey Area. A detailed inspection of internal dimensions via pole camera was not possible because the hollow was too high up (15m+) to reach with the pole camera. Drone operation is also not permitted in the location due to the very close proximity to RAAF Pearce Airbase runways. The tree has one upwards opening knot type hollow mid trunk with a slit type entrance of 15x 20 cm diameter. The hollow faces south and is accessible to black cockatoos. A nesting galah pair was observed and there is chew markings around entrance to hollow and on trunk attributed to galah. Galah are a recognised nest competitor for black cockatoo with

Johnstone and Kirkby (Cataby research project 2004 – 2008) having reported numerous instances of failed breeding attempts attributed to corellas or galahs (Groom, 2010). The presence of galah makes usage by black cockatoo unlikely at the time of survey however the potential suitability of the hollow to support black cockatoo breeding cannot be excluded. A follow up inspection of internal dimensions may be required allow more detailed understanding of actual suitability.

See Figure 11 for tree locations. See Appendix D for summary of tree locations, species, DBH and tree health.

Table 12: Black cockatoo Potential Breeding Tree Summary

Tree Species	Class 3	Class 4	Class 5	Total
Dead		4	6	10
Eucalyptus sp. (planted)			26	26
Flooded Gum		2	40	42
Marri	1	8	248	257
River Red Gum (planted)			17	17
Wandoo		21	199	220
Total	**1**	**35**	**536**	**572**

Foraging Habitat Assessment

The majority of Survey Area has been historically cleared for pasture. Some areas of remnant isolated trees are present interspersed with paddocks and groves of native or planted non endemic eucalypts. Areas of intact remnant native vegetation habitat are not present.

Foraging habitat comprises primarily marri and wandoo trees with scattered sheoak, pines and a range of small-fruited eucalypts. Marri, pines and to a lesser extent wandoo are high value foraging species for Carnaby's black cockatoo (DCCEEW, 2022; Groom, 2011). Marri, wandoo and sheoak are high value foraging for forest red-tail black cockatoo (DCCEEW, 2022). Other small-fruited eucalypt species including flooded gum, planted river red gum, rose gum and lemon scented gum are considered species which may be foraged on occasion but are not assessed as high value foraging species.

Where occurring as consistent groves of a tree species foraging habitat was mapped as polygons. Where trees are occurring as scattered paddock trees, individual trees of high value foraging species were recorded. See Figure 12 and Figure 13 for foraging habitat extent.

The Commonwealth referral guidelines provides a foraging quality scoring tool to guide referral information (DCCEEW, 2022). The tool advises that if the Survey Area contains native vegetation used for foraging at any time by a black cockatoo species and is >1 ha in size, that it is considered at face value to be of very high quality and assigned a starting score of 10. The tool then allows for subtractions if attributes are present which reduce the functionality of the foraging habitat. The Commonwealth referral guidelines specify that the tool is to be applied once to the entire impact area even if there is more than one type of foraging habitat present. The calculated foraging habitat quality score is shown below in Table 13. Scores of 5-10 are identified as representing high value foraging habitat.

Table 13: Foraging Quality Scoring Tool (DCCEEW, 2022)

Attribute	Baudin's Black cockatoo	Carnaby's Black cockatoo	Forest Red-tailed Black cockatoo
Starting score	Not in mapped distribution	10- eucalypt woodland/ paddock trees with marri and wandoo	10- eucalypt woodland/ paddock trees with marri and wandoo
Foraging potential (-2 if no foraging evidence)	-	No change, foraging evidence present	No change, foraging evidence present
Connectivity (-2 if no other foraging habitat in 12km)	-	No change, other foraging habitat <12 km away	No change, other foraging habitat <12 km away
Proximity to breeding habitat (-2 if no breeding habitat in 12km)	-	-2 No recorded breeding habitat within 12 km	-2, No recorded breeding habitat within 12 km
Proximity to roosting (-1 if >20km from known night roost)	-	No change, known roosting site <20 km distant	No change, known roosting site <20 km distant
Impact from significant plant disease (-1 if >50% impact)	-	No change, impact from plant disease affecting <50% of foraging plants	No change, impact from plant disease affecting <50% of foraging plants
Total score	**NA**	**8**	**8**

The Black cockatoo referral guidance allows for the inclusion of additional information for foraging habitat which may be considered during an assessment, such as the extent and density of recognised foraging plants within a Survey Area. As an additional source of information, WEPL provides an assessment of foraging habitat quality using a scoring tool developed by Dr Mike Bamford in 2018 to produce a numerical foraging habitat score value for each identified habitat type. For fauna habitat type FHT_01 Isolated Paddock Trees and FHT_02 Planted Eucalypts it was considered more appropriate to mark individual high value foraging trees and present the foraging habitat score as a number of trees within the extent The WEPL foraging habitat score and tree counts are summarised below in Table 14 and Table 15 with a detailed scoring tool calculator provided in Appendix E. See Figure 12 and Figure 13 for foraging habitat extent mapping.

Table 14: High Value Foraging Tree Count

Tree Species	Count of Individually Marked Trees	Carnaby's High Value Foraging Trees	Forest Red-Tailed High Value Foraging Trees
Marri	459	Y	Y
Pines	5	Y	-
Sheoak	18	-	Y
Wandoo	307	Y (lower value than marri)	Y
Total	**789**	**771**	**784**

Table 15: WEPL Combined Foraging Habitat Score

Habitat Type	Carnaby's Foraging Habitat Score	Forest Red-Tailed Foraging Habitat Score	Justification	Area (ha) and % of Survey Area
FHT_01	See individual high value tree counts.		Isolated paddock trees with high value trees individually marked and counted	185.64 96.25%
FHT_02	Low-2 (both species) Individually marked high value trees are captured in tree counts		Planted small fruit eucalypts, mainly river red gum. High value trees individually marked and counted	5.17 2.68%
FHT_03	Low-2	Moderate-4	Sheoak windbreak	0.39 0.20%
FHT_04	Low-Moderate- 3	Moderate-4	Wandoo regrowth woodland	1.66 0.86%
Total	**Low=5.56 ha Low-Moderate=1.66 ha 771 high value trees**	**Low=5.17 ha Moderate=2.06 784 high value trees**		**192.86 100%**

*Application of foraging habitat quality scoring: 0- None; 1-2-Low; 3-Low Moderate; 4- Moderate; 5-Moderate to High; 6- High; 7-10 Very High.

Analysis of estimated foraging habitat extent within the local area was also undertaken to provide further context. The estimated extent of foraging habitat is calculated for a buffer of 12 km around and including the Survey Area. This buffer is selected as recommended in the Commonwealth referral guidelines due to black cockatoos mainly foraging within 12 km of their nest site during the breeding season and their reliance on this proximity of foraging resources to successfully raise chicks (DCCEEW, 2022).

Analysis considers Remnant Native Vegetation Extent mapping (DPIRD-005) and Vegetation Complexes-Swan Coastal Plain and South West forest region (DBCA-046 and DBCA-047). See summary of regional vegetation complexes and extents in Table 16 and displayed in Figure 14.

Analysis indicates there is 23,338 ha of remnant native vegetation mapped within a 12 km buffer of the Survey Area. It is expected that the majority of this vegetation would contain suitable foraging species at the same or greater rate than that present within the Survey Area. Much of this regional remnant native vegetation occurs within the jarrah forest to the east and regionals park and nature reserves.

Within the Survey Area there is 7.22 ha of Low to Moderate foraging habitat (FHT_02, 03, and 04) mapped as polygons and 789 individually marked high value foraging paddock trees. The paddock trees are estimated to have a canopy extent of approximately 7.98 ha (estimating canopy covers 10x10m each). This totals 15.2 ha of foraging habitat. This represents 0.065 % of the estimated regional habitat extent. The habitat quality within the Survey Area is considered likely to be of similar quality than much of the regional foraging habitat, which includes high quality banksia woodlands of the Bassendean Complex sandplains and the jarrah and marri forests of the Darling Scarp.

Table 16 Regional Foraging Habitat Extent

Vegetation Complex	Remnant Extent (ha)
Bassendean Complex-Central and South	0.43
Bassendean Complex-North	5763.44
Bassendean Complex-North Transition	703.36
Beermullah Complex	371.09
Coolakin, Ck	354.15
Coonambidgee Complex	6.70
Darling Scarp, DS2	1013.53
Dwellingup, D2	1391.51
Dwellingup, D3	551.30
Dwellingup, D4	607.66
Forrestfield Complex	131.68
Guildford Complex	227.43
Helena 2, He2	6807.51
Mogumber Complex-South	950.36

Vegetation Complex	Remnant Extent (ha)
Murray 2, My2	1530.15
Pindalup, Pn	121.63
Reagan Complex	545.38
Southern River Complex	87.80
Swan Complex	128.12
Williams, Wi	0.09
Yalanbee, Y6	1018.04
Yanga Complex	883.47
Yarragil 1, Yg1	144.03
Grand Total	**23,338.85**

Roosting Habitat Assessment

Known roost sites are present 3.5 km northeast and 6.7 km southwest of the Survey Area (DBCA-064). No evidence of night roosting (e.g. piles of scats, feeding debris or chewed trees) were recorded within the Survey Area.

Night roosting locations are typically in proximity to foraging habitat (Black cockatoos mainly foraging within 20km of night roosts) and with access to water points <2km from roosting location (DCCEEW, 2022). Any groups of tall trees, particularly large native eucalypts in proximity to water sources may provide night roosting habitat (DCCEEW, 2022). Throughout the Survey Area, isolated stands of tall (> 10 m) eucalypts are scattered which may provide suitable roosting habitat. Adjacent bush lands with foraging potential were located < 4 km from the Survey Area and access to permanent water was present from farm dams and the Ellen Brook (DWER-031) that flows 2 km west of the Survey Area.

Figure 10: Known Black cockatoo Roosting and Breeding Sites within 12 km Buffer

Figure 11: Black cockatoo Potential Breeding Habitat

Figure 12: Carnaby's Black cockatoo Foraging Habitat

Figure 13: Forest Red-tailed Black cockatoo Foraging Habitat

Figure 14: Black cockatoo Foraging Habitat Extent 12 km Buffer

5. Discussion

5.1 Flora of Conservation Significance

No Commonwealth listed, or State listed Threatened Flora or DBCA listed Priority flora were recorded in the Survey Area or were assessed as having a high-medium post survey likelihood of occurrence.

5.2 Vegetation Significance

One State and Commonwealth listed Threatened Ecological Community (TEC) was identified as potentially occurring. Assessment of limited characteristic species present suggests closest affinity to the *Corymbia calophylla — Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (floristic community type 3c) TEC. Vegetation is considered potentially not comprising an occurrence of the TEC due to the Completely Degraded condition and having lost most understorey and mid-storey species typical of the TEC. A follow up survey during the primary spring season to identify a more comprehensive flora list may be suitable to refine assessment of TEC presence.

The Survey Area is predominantly within the mapped extent of the Guildford complex and contains some key species as per the structural description in Heddle *et. al*, 1980. Key species are *Corymbia calophylla* and *Eucalyptus wandoo.* The state-wide vegetation statistics report current extent of this vegetation complex is 5.00 % of pre-European extent. Due to the vegetation present being in Completely Degraded condition it is not considered to represent an intact remnant of the Guilford complex vegetation type and is not considered to be of conservation significance.

5.3 Fauna Habitat Significance

Four habitat types were described. The degraded condition and lack of a shrub or ground layer results in the Survey Area providing limited habitat value to most species. Foraging evidence (chewed marri nuts) from both Carnaby's and forest red-tailed black cockatoo was recorded from several locations. There were no other observations of, or secondary evidence recorded for Threatened or Priority fauna within the Survey Area and no core habitat for conservation significant species is present.

5.4 Black Cockatoos

The Survey Area falls outside the modelled distribution for Baudin's black cockatoo, within the breeding range for Carnaby's black cockatoo and in the Likely to Occur range for Forest Red-tailed black cockatoo (DCCEEW, 2022).

A total of 572 potential breeding trees were recorded. No evidence of current or previous nesting behaviour such as chew marks at hollow entrance attributed to black cockatoos, or flushed individuals was recorded. One marri tree (tree number 551) was assessed as possessing a hollow with sufficient entry diameter to potentially support a suitable nesting hollow. The tree has one upwards opening knot type hollow mid trunk

with a slit type entrance of 15x 20 cm diameter. The hollow faces south and is accessible to black cockatoos. A nesting galah pair was observed and there is chew markings around entrance to hollow and on trunk attributed to galah. The presence of galah makes usage by black cockatoo unlikely at the time of survey however the potential suitability of the hollow to support black cockatoo breeding cannot be excluded. A follow up inspection of internal dimensions may be required allow more detailed understanding of actual suitability.

Foraging habitat comprises primarily marri and wandoo trees with scattered sheoak, pines and a range of small-fruited eucalypts. The Commonwealth referral guidelines foraging quality scoring tool returns a score of eight out of ten (high) for the Survey Area. The Commonwealth referral guidelines specify that the tool is to be applied once to the entire impact area even if there is more than one type of foraging habitat present. The guidance identifies that "loss of greater than or equal to 1 ha of foraging habitat scoring 5-10 using the foraging quality scoring tool is likely to require referral". A referral to the Commonwealth is therefore recommended if >1ha of vegetation or high value foraging tree canopy is to be impacted.

The black cockatoo referral guidance allows for the inclusion of additional information for foraging habitat which may be considered during an assessment, such as the extent and density of recognised foraging plants. Additionally, for FHT_01 and FHT_02 individual high value foraging trees were reported as a number of trees within the extent. The WEPL assessment of foraging habitat quality (using Bamford 2018 scoring tool) produced a numerical foraging habitat score value for habitat types. The assessment identified the following extents and scores for the two species:

- Forest red-tailed black cockatoo
    - 5.17 ha Low-2 quality.
    - 2.06 ha Moderate-4 quality.
    - 784 high value individually marked trees.
- Carnaby's black cockatoo
    - 5.56 ha Low-2 quality.
    - 1.66 ha Low-Moderate-4 quality.
    - 771 high value individually marked trees.

Analysis of estimated foraging habitat extent within the region indicates there 23,338 ha of remnant native vegetation mapped within a 12 km buffer of the Survey Area. The estimated canopy extent of 7.98 ha of foraging habitat present represents 0.065 % of the estimated regional habitat extent. It is expected that the majority of the regional vegetation would contain suitable foraging species with much of the vegetation including high quality banksia woodlands of the Bassendean Complex sandplains and the jarrah and marri forests of the Darling Scarp.

Throughout the Survey Area, isolated stands of tall (> 10 m) eucalypts are scattered which may provide suitable roosting habitat. No evidence of roosting was observed or recorded by secondary evidence such as scats and tree chewing.

6. References

Beard, J. S. (1976). *Vegetation Survey of Western Australia. Western Australia 1: 1 000 000 Vegetation Series*. Design and cartography by Dept. of Geography, University of W.A.

Bureau of Meteorology (BoM). (2007). *About Climate Statistics*. Retrieved 18 February 2021 from http://www.bom.gov.au/climate/cdo/about/about-stats.shtml.

Bureau of Meteorology. (2022). *Monthly Climate Data Statistics*. www.bom.gov.au/climate/data.

Commonwealth of Australia. (2001). *National Objectives and Targets for Biodiversity Conservation 2001-2005*, Canberra.

Commonwealth of Australia. (2012) *Interim Biogeographic Regionalisation for Australia, Version 7*. Department of Sustainability, Environment, Water, Population and Communities.

Department of Agriculture Water and the Environment. (2022b). *Weeds of National Significance*. https://weeds.org.au/.

Department of Biodiversity Conservation and Attractions (DBCA). (2023a). Methods for survey and identification of Western Australian threatened ecological communities.

Department of Biodiversity Conservation and Attractions (DBCA). (2023b). *Threatened and Priority Fauna List.* Retrieved on 5 September 2022 from https://www.dpaw.wa.gov.au/plants-and-animals/Threatened-species-and-communities/Threatened-animals.

Department of Climate Change, Energy, the Environment and Water (DCCEEW). (2022). *Referral Guidelines for 3 Threatened Black Cockatoo Species.*

Department of Climate Change, Energy, the Environment and Water (DCCEEW). (2022a). *Protected Matters Search Tool*. Retrieved on 13 February 2023 from http://www.environment.gov.au/webgisframework/apps/pmst/pmst.jsf.

Department of Primary Industries and Regional Development (DPIRD). (2022). *Declared Plants*. https://www.agric.wa.gov.au/organisms.

Department of the Environment (DotE). (2013). *Matters of National Environmental Significance: Significant Impact Guidelines 1.1.* Canberra, Australia.

Department of the Environment and Energy. (DotEE). (2016). *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community*. Canberra, Australia.

Department of the Environment Water Heritage and the Arts (DEWHA). (2010). *Survey Guidelines for Australia's Threatened Birds: Guidelines for Detecting Birds Listed as Threatened under the EPBC Act*. Canberra, Australia.

Department of Sustainability Environment Population and Communities (DSEWPaC). (2011). *Survey Guidelines for Australia's Threatened Mammals*. Canberra, Australia.

Environmental Protection Authority (EPA). (2016). *Technical Guidance - Flora and Vegetation surveys for Environmental Impact Assessment*.

Environmental Protection Authority (EPA). (2020). *Technical Guidance - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*.

Environmental Protection Authority (EPA). (2021). *Statement of Environmental Principles, Factors and Objectives*.

Government of Western Australia (GoWA). (2018). *2018 Statewide Vegetation Statistics - Full Report*. https://catalogue.data.wa.gov.au/dataset/dbca-statewide-vegetationstatistics/resource/b7bd60c2-bff6-4637-b213-aee4706412c7.

Groom, C. (2011) *Plants Used by Carnaby's Black Cockatoo.* Department of Environment and Conservation.

Heddle, E.M., Loneragan, O.W. & Havel, J.J. (1980). *Vegetation Complexes of the Darling System, WA*, in Atlas of Natural Resources, Darling System WA, Department of Conservation and Environment

Johnstone, R. E., Kirkby T. & Sarti K. (2013). The Breeding Biology of the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* Gould in South-Western Australia. I. Characteristics of Nest Trees and Nest Hollows. *Pacific Conservation Biology,* 19(2), 121–142.

Johnstone, R. E. & Storr, G. M. (1998). *Handbook of Western Australian Birds – Non-passerines (Emu to Dollarbird).* (Volume 1, pp. 278–280) Western Australian Museum.

NVIS Technical Working Group. (2017). *Australian Vegetation Attribute Manual Version 7.0*. Commonwealth of Australia.

Saunders, D. A., P.R. Mawson, and P.R. Dawson. (2014b). *Use of tree hollows by Carnaby's Cockatoo and the fate of large hollow-bearing trees at Coomallo Creek, Western Australia 1969- 2013*. Biological Conservation 177:185-193

Threatened Species Scientific Committee. (2016). *Conservation Advice Grevillea curviloba subsp. curviloba curved-leaf grevillea. Canberra: Department of the Environment*. Canberra, Australia.

Western Australian Herbarium. (2022). *FloraBase - The Western Australian Flora*. Perth, Australia. Retrieved on 5 September 2022 from https://florabase.dpaw.wa.gov.au.

Western Australian Museum. (2022). *Checklist of the Terrestrial Vertebrate Fauna of Western Australia*. Retrieved on 5 September 2022 from http://museum.wa.gov.au/research/departments/terrestrialzoology/checklist-terrestrial-vertebrate-fauna-western-australia.

Databases used

Department of Biodiversity Conservation and Attractions (DBCA). (2017). *RAMSAR Sites (DBCA-010).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/ramsar-sites.

Department of Biodiversity Conservation and Attractions (DBCA). (2018). *Vegetation Complexes-Swan Coastal Plain (DBCA-046).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/vegetation-complexes-swan-coastal-plain.

Department of Biodiversity, Conservation and Attractions (DBCA). (2018) *Vegetation Complexes – South West Forest Region of Western Australia (DBCA-047).* Accessed on 18 April 2023 from https://catalogue.data.wa.gov.au/dataset/vegetation-complexes-swf-50k.

Department of Biodiversity, Conservation and Attractions (DBCA). (2022). *Geomorphic Wetlands, Swan Coastal Plan (DBCA-019).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/geomorphic-wetlands-swan-coastal-plain.

Department of Biodiversity, Conservation and Attractions (DBCA), (2018) *Carnaby's Cockatoo Confirmed Breeding Areas within the Swan Coastal Plain and Jarrah Forest IBRA Regions (DBCA-054).* Accessed on 10 September 2022 from https://catalogue.data.wa.gov.au/dataset/carnabys-cockatoo-confirmed-breeding-areas

Department of Biodiversity, Conservation and Attractions (DBCA). (2018) *Carnaby's Cockatoo Confirmed Roost Sites (DBCA-050).* Accessed on 18 April 2023 from https://catalogue.data.wa.gov.au/dataset/black-cockatoo-roosting-sites-buffered.

Department of Biodiversity, Conservation and Attractions (DBCA). (2019) *Black Cockatoo Roosting Sites - Buffered (DBCA-064).* Accessed on 18 April 2023 from https://catalogue.data.wa.gov.au/dataset/black-cockatoo-roosting-sites-buffered.

Department of Biodiversity Conservation and Attractions (DBCA). (2023). *DBCA - Legislated Lands and Waters (DBCA-011).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/dbca-legislated-lands-and-waters.

Department of Water and Environmental Regulation (DWER). (2018). *Hydrography, Linear (Hierarchy) (DWER-031).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/hydrography-linear-hierarchy.

Department of Water and Environmental Regulation (DWER). (2021). *Clearing Regulations - Environmentally Sensitive Areas (DWER-046).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/clearing-regulations-environmentally-sensitive-areas-dwer-046.

Department of Primary Industries and Regional Development (DPIRD). (2019). *Pre-European Vegetation (DPIRD-006).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006.

Department of Primary Industries and Regional Development (DPIRD). (2022). *Soil Landscape Mapping – Systems (DPIRD-064).* Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/soil-landscape-mapping-systems.

Appendix A
Legislation

Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act aims to protect matters of national environmental significance (MNES). Under the EPBC Act, the Commonwealth Department of Climate Change, Energy and the Environment lists threatened species and communities in categories determined by criteria set out in the EPBC Act.

Projects likely to cause a significant impact on MNES should be referred to the DCCEEW for assessment under the EPBC Act.

Biodiversity Conservation Act 2016

The Biodiversity Conservation Act 2016 aims to conserve and protect biodiversity and biodiversity components within the State and to promote ecologically sustainable use of biodiversity components in the State.

Environmental Protection Act 1986

Declared Rare Flora (DRF) and Threatened Ecological Communities (TECs) are given special consideration in environmental impact assessments and have special status as Environmentally Sensitive Areas (ESAs) under the EP Act and the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. Exemptions for a clearing permit do not apply in an ESA. In addition, habitat necessary for the maintenance of indigenous fauna is considered in the clearing principles and assessed during consideration of applications for a clearing permit.

Biosecurity and Agricultural Management Act 2007

Plants may be 'Declared' by the Minister for Agriculture and Food under the BAM Act. The Western Australian Organism List contains information on the area(s) in which a plant is declared and the control and keeping categories to which it has been assigned in Western Australia. A declaration may apply to the whole State, to districts, individual properties or even to single paddocks. If a plant is 'Declared', landholders are obliged to control that plant on their properties.

Weeds of National Significance

The Australian Government along with the State and Territory governments has endorsed 32 WoNS. Four major criteria were used in determining WoNS:

- The invasiveness of a weed species.
- A weed's impacts.
- The potential for spread of a weed.
- Socio-economic and environmental values.

Each WoNS has a national strategy and a national coordinator, responsible for implementing the strategy. WoNS are regarded as the worst weeds in Australia because of their invasiveness, potential for spread, and economic and environmental impacts.

Department of Biodiversity, Conservation and Attractions Priority Lists

DBCA lists 'Priority' flora and fauna that have not been assigned statutory protection as "Threatened" under the BC Act and are under consideration for declaration as Threatened. Flora and fauna assessed as Priority 1-3 are considered to be in urgent need of further survey. Priority 4 flora requires monitoring every 5 -10 years.

DBCA maintains a list of Priority Ecological Communities (PECs) which identifies plant communities that require further investigation before possible nomination for TEC status. Once listed, a community becomes a PEC and, when endorsed by the WA Minister for Environment, becomes a TEC and protected as an ESA under Environmental Protection (Clearing of Native Vegetation) Regulations 2004.

Informal Recognition of Flora and Fauna

Certain populations or communities of flora and/or fauna may be of local significance or interest because of their patterns of distribution and abundance. For example, specific locations of flora and may be locally significant because they are range extensions to the previously known distribution, or are newly discovered taxa (and have the potential to be of more than local significance). In addition, many species are in decline as a result of threatening processes (land clearing, grazing, and changed fire regimes) and relict populations of such species assume local importance for DBCA. It is not uncommon for DBCA to make comment on these species of interest.

WEPL Report: bullsbrook south landholdings: Flora, Vegetation, Basic Fauna Survey and Black Cockatoo Assessment

Appendix B

Definitions and Criteria

EPBC Act Categories for Flora, Fauna and Ecological Communities

Category	Threatened Species	Threatened Ecological Communities
Extinct	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.	N/A.
Extinct in the wild	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.	N/A.
Critically Endangered (CE)	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.	An ecological community is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (EN)	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.	An ecological community is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (VU)	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.	An ecological community is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish. (ii) the species is the focus of a plan of management that provides for	N/A.

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Category	Threatened Species	Threatened Ecological Communities
	management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long-term survival in nature are maximised. (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory. (iv) cessation of the plan of management would adversely affect the conservation status of the species.	

Conservation Codes for Western Australian Flora and Fauna (DBCA)

Conservation Codes for Western Australian Flora and Fauna	
Threatened, Extinct and Specially Protected fauna or flora[1] are species[2] which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such. **The Wildlife Conservation (Specially Protected Fauna) Notice 2018 and the Wildlife Conservation (Rare Flora) Notice 2018 have been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the** *Biodiversity Conservation Act 2016***.** **Categories of Threatened, Extinct and Specially Protected fauna and flora are:**	
T	**Threatened species** Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act). Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna. Threatened Flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora. The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using International Union for Conservation of Nature (IUCN) Red List categories and criteria as detailed below.
CR	**Critically endangered species** Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered undersection 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.
EN	**Endangered species** Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.

Conservation Codes for Western Australian Flora and Fauna	
VU	**Vulnerable species** Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable undersection 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.
Extinct species **Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.**	
EX	**Extinct species** Species where "there is no reasonable doubt that the last member of the species has died", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act). Published as presumed extinct under schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for extinct fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for extinct flora.
EW	**Extinct in the wild species** Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act). Currently there are no threatened fauna or Threatened Flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.
Specially protected species **Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.** **Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.**	
MI	**Migratory species** Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species. Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.

Conservation Codes for Western Australian Flora and Fauna	
CD	**Species of special conservation interest (conservation dependent fauna)** Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
OS	**Other specially protected species** Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
P	**Priority species** Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora. Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.
1	**Priority 1: Poorly-known species** Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
2	**Priority 2: Poorly-known species** Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
3	**Priority 3: Poorly-known species** Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

Conservation Codes for Western Australian Flora and Fauna	
4	**Priority 4: Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

[1] The definition of flora includes algae, fungi and lichens.

DBCA Definitions and Criteria for TECs and PECs

Criteria	Definition
Threatened Ecological Communities	
Presumed Totally Destroyed (PD)	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B): A. Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats or B. All occurrences recorded within the last 50 years have since been destroyed.
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A. The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii): i. geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years). ii. modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years). ii. there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes.

Criteria	Definition
	iii. there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes. C. The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C): A. The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii): i. the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years). ii. modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): i. geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years). ii. there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes. iii. there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes. The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C): A. The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated.

Criteria	Definition
	B. The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. C. The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.
Priority Ecological Communities	
Priority One	**Poorly known ecological communities** Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority Two	**Poorly known ecological communities** Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, state forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities, but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority Three	**Poorly known ecological communities** i. Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or. ii. Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or. iii. Communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities, but do not meet adequacy of survey requirements and / or are not well defined, and known threatening processes exist that could affect them.
Priority Four	**Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list**. These communities require regular monitoring. i. Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change These communities are usually represented on conservation lands. ii. Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. iii. Ecological communities that have been removed from the list of threatened communities during the past five years.

Criteria	Definition
Priority Five	**Conservation Dependent Ecological Communities** Ecological Communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Appendix C

Desktop Assessment Results and Likelihood of Occurrence Assessments

Flora Database Search Results (DBCA Database Search using 20 Km Buffer, PMST 10 km buffer), Likelihood and Flora Survey Records

Species	Conservation Status		Source		Species information (WAH 2022)		Habitat Occurs Within the Survey Area	Likelihood of Occurrence
	State	Federal	PMST	DBCA	Flowering Period	Preferred Habitat		
Acacia anomala	T			x	Aug to Sep	Lateritic soils. Slopes.	Yes	Low
Acacia aphylla	T	VU	x		Aug to Oct	Sand, loam, clay loam. Granite outcrops, hills.	No	Low
Andersonia gracilis	T	EN	x		Sep to Nov	White/grey sand, sandy clay, gravelly loam. Winter-wet areas, near swamps.	No	Low
Anigozanthos viridis **subsp.** *terraspectans*	T	VU	x		Aug to Sep	Grey sand, clay loam. Winter-wet depressions.	No	Low
Anthocercis gracilis	T	VU	x		Sep to Oct	Sandy or loamy soils. Granite outcrops.	Yes	Low
Banksia mimica	T	EN	x		Dec or Jan to Feb	White or grey sand over laterite, sandy loam.	Yes	Low
Caladenia huegelii	T			x	Sep to Oct	Grey or brown sand, clay loam.	Yes	Low
Paracaleana dixonii	T	EN	x		Oct to Dec or Jan	Grey sand over granite.	No	Low
Chamelaucium lullfitzii	T	EN	x			white/yellow sand supporting open low woodland with Eucalyptus todtiana (Pricklybark), Banksia attenuata (Coast Banksia), and Hibbertia sp.	No	Low
Conospermum densiflorum **subsp**. *unicephalatum*	T	EN	x		Sep to Nov	Clay soils. Low-lying areas.	Yes	Low

Species	Conservation Status		Source		Species information (WAH 2022)		Habitat Occurs Within the Survey Area	Likelihood of Occurrence
	State	Federal	PMST	DBCA	Flowering Period	Preferred Habitat		
Darwinia foetida	T	CR	x	x		Occurs on grey-black sandy rises in winter-damp to wet clay flats	No	Low
Diplolaena andrewsii	T			x	Jul to Oct	Loam, clay. Granite outcrops & hillsides.	No	Low
Diuris micrantha	T	VU	x		Sep to Oct	Brown loamy clay. Winter-wet swamps, in shallow water.	No	Low
Diuris purdiei	T	EN	x		Sep to Oct	Grey-black sand, moist. Winter-wet swamps.	No	Low
Drakaea elastica	T	EN	x		Oct to Nov	White or grey sand. Low-lying situations adjoining winter-wet swamps.	No	Low
Eleocharis keigheryi	T			x	Aug to Nov	Clay, sandy loam. Emergent in freshwater: creeks, claypans.	No	Low
Eucalyptus leprophloia	T	EN	x		Aug to Oct	White or grey sand over laterite. Valley slopes.	No	Low
Eucalyptus x balanites	T	EN	x		Oct to Dec or Jan to Feb	Sandy soils with lateritic gravel.	Yes	Low
Grevillea althoferorum	T	EN	x		Sep to Nov	Grey sand with gravel.	No	Low
Grevillea althoferorum **subsp**. *fragilis*	T			x		Occurs at the base of the Darling Scarp in greyish-yellow colluvial sand in Banksia low woodland	No	Low
Grevillea christineae	T			x	Aug to Sep	Clay loam, sandy clay, often moist.	Yes	Low

Species	Conservation Status		Source		Species information (WAH 2022)		Habitat Occurs Within the Survey Area	Likelihood of Occurrence
	State	Federal	PMST	DBCA	Flowering Period	Preferred Habitat		
Grevillea corrugata	T	EN	x		Aug to Sep	Gravelly loam. Roadsides.	Yes	Low
Grevillea curviloba	T			x	Aug to Oct	Grey sand, sandy loam. Winter-wet heath.	No	Low
Grevillea curviloba **subsp**. *curviloba*	T	EN	x		Oct	Grey sand. Winter-wet heath.	No	Low
Grevillea curviloba **subsp.** *incurva*	T	EN	x		Aug to Sep	Sand, sandy loam. Winter-wet heath. open heath in winter-wet areas on sand over limestone, or over ironstone at sites with a high-water table	No	Low
Grevillea flexuosa	T	VU	x		Jul to Oct	Red-brown sand with laterite & gravel, sand over granite. Ridgetop plateau & associated breakaways.	No	Low
Hypocalymma sylvestre	T	EN	x		Aug	Yellow-brown sandy loam. Woodland on lateritic hilltop.	No	Low
Macarthuria keigheryi	T	EN	x		Sep to Dec or Feb to Ma	White or grey sand.	No	Low
Melaleuca sciotostyla	T	EN	x		Aug	Orange clayey sand with lateritic pebbles. Scree slopes.	No	Low
Synaphea **sp. Fairbridge Farm (D. Papenfus 696)**	T	CR	x		Oct	Sandy with lateritic pebbles. Near winter-wet flats, in low woodland with weedy grasses.	No	Low

Species	Conservation Status		Source		Species information (WAH 2022)		Habitat Occurs Within the Survey Area	Likelihood of Occurrence
	State	Federal	PMST	DBCA	Flowering Period	Preferred Habitat		
Thelymitra dedmaniarum	T			x	Nov to Dec or Jan	Granite.	No	Low
Thelymitra stellata	T	EN	x		Oct to Nov	Sand, gravel, lateritic loam.	Yes	Low
Trithuria occidentalis	T			x		Muddy inundated areas	No	Low
Hydrocotyle striata	1			x		Clay. Springs.	No	Low
Gastrolobium crispatum	1			x	Sep to Oct	Yellow or brown sandy loam, red laterite soils. Steep gullies, slopes, ridges, breakaways.	Yes	Low
Gastrolobium nudum	2			x	Feb	Red-brown clay, brown loam, gravel, laterite, granite. Flats, slopes, hilltops, ridges, valleys, breakaways.	Yes	Low
Hibbertia glomerata subsp. ginginensis	2			x	Jul to Sep	Sand, brown clay, laterite. Near roadsides.	Yes	Low
Millotia tenuifolia **var.** *laevis*	2			x	Sep to Oct	Granite or laterite soils.	Yes	Low
Netrostylis **sp. Chandala (G.J. Keighery 17055)**	2			x		No information		Low
Poranthera moorokatta	2			x		White silica sand in open spaces between shrubs, not in shaded areas or in areas of high litter cover	No	Low

Species	Conservation Status		Source		Species information (WAH 2022)		Habitat Occurs Within the Survey Area	Likelihood of Occurrence
	State	Federal	PMST	DBCA	Flowering Period	Preferred Habitat		
Schoenus **sp. Bullsbrook (J.J. Alford 915)**	2			x		Grey peaty sand. Low-lying flats.	Yes	Low
Stylidium squamellosum	2			x	Oct to Nov	Brown to red-brown clay loam. Winter-wet habitats and depressions, open woodland, shrubland.	Yes	Low
Acacia drummondii **subsp**. *affinis*	3			x	Jul to Aug	Lateritic gravelly soils.	Yes	Low
Acacia oncinophylla **subsp**. *oncinophylla*	3			x	Aug to Oct	Granitic soils.	No	Low
Adenanthos cygnorum **subsp**. *chamaephyton*	3			x	Jul or Sep to Dec or Jan	Grey sand, lateritic gravel.	Yes	Low
Beaufortia purpurea	3			x	Oct to Dec or Jan to Feb	Lateritic or granitic soils. Rocky slopes.	No	Low
Cyathochaeta teretifolia	3			x		Grey sand, sandy clay. Swamps, creek edges.	No	Low
Eryngium pinnatifidum **subsp.** *palustre* **(G.J. Keighery 13459**)	3			x		Winter-wet flats. Brown sandy loam.	No	Low
Guichenotia tuberculata	3			x	Aug to Oct	Sand clay over laterite, sand.	Yes	Low

Species	Conservation Status		Source		Species information (WAH 2022)		Habitat Occurs Within the Survey Area	Likelihood of Occurrence
	State	Federal	PMST	DBCA	Flowering Period	Preferred Habitat		
Haemodorum loratum	3			x	Nov	Grey or yellow sand, gravel.	Yes	Low
Halgania corymbosa	3			x	Aug to Nov	Gravelly soils, soils over granite.	Yes	Low
Lasiopetalum glutinosum **subsp**. *glutinosum*	3			x		Grows in open woodland and low scrub	No	Low
Persoonia rudis	3			x	Sep to Dec or Jan	White, grey or yellow sand, often over laterite.	Yes	Low
Phlebocarya pilosissima **subsp.** *pilosissima*	3			x	Aug to Oct	White or grey sand, lateritic gravel.	Yes	Low
Platysace ramosissima	3			x	Oct to Nov	Sandy soils.	No	Low
Schoenus capillifolius	3			x	Oct to Nov	Brown mud. Claypans.	No	Low
Stylidium aceratum	3			x	Oct to Nov	Swamp heathland.	No	Low
Stylidium asteroideum	3			x		No information		Low
Stylidium paludicola	3			x	Oct to Dec	Peaty sand over clay. Winter wet habitats	No	Low
Styphelia filifolia	3			x		Sandy soils of the coastal plain and in low-lying situations.	No	Low
Tetratheca pilifera	3			x	Aug to Oct	Gravelly soils.	Yes	Low
Verticordia serrata **var**. *linearis*	3			x	Sep to Oct	White sand, gravel. Open woodland.	Yes	Low

Species	Conservation Status		Source		Species information (WAH 2022)		Habitat Occurs Within the Survey Area	Likelihood of Occurrence
	State	Federal	PMST	DBCA	Flowering Period	Preferred Habitat		
Cyanicula ixioides **subsp.** *ixioides*	4			x	Aug to Oct.	No information		Low
Darwinia pimelioides	4			x	Sep to Oct	Loam, sandy loam. Granite outcrops.	No	Low
Drosera occidentalis	4			x	Oct to Dec or Jan.	Grey sand	No	Low
Hydrocotyle lemnoides	4			x	Aug to Oct	Swamps.	No	Low
Oxymyrrhine coronata	4			x		Lateritic gravel.	Yes	Low
Persoonia sulcata	4			x	Sep to Nov	Lateritic or granitic soils.	Yes	Low
Schoenus natans	4			x	Oct	Winter-wet depressions.	No	Low
Stylidium longitubum	4			x	Oct to Dec	Sandy clay, clay. Seasonal wetlands.	No	Low

Threatened Ecological Communities Search Results (DBCA Database Search using 20 Km Buffer, PMST 10 km buffer),

Floristic Community Type	Community name	Conservation Status		Database		Likelihood of Occurrence	Justification
		State	Federal	PMST	DBCA		
	Clay Pans of the Swan Coastal Plain		CR	x		Low	No claypans
	Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community		CR	x		Low	No Tuart
Mound Springs SCP	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	CR	EN		x	Low	Not on mound springs
SCP3a	Corymbia calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain (floristic community type 3a as originally described in Gibson et al. (1994))	CR	EN	x	x	medium	Occurrence in close proximity. Soil suitable.
SCP3c	Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain (floristic community type 3c as originally described in in Gibson et al. (1994))	CR	EN	x	x		
	Assemblages of plants and invertebrate animals of tumulus (organic mound) springs of the Swan Coastal Plain		EN	x		Low	Not on mound springs
Muchea Limestone	Shrublands and woodlands on Muchea Limestone of the Swan Coastal Plain	EN	EN	x	x	Low	Soil not limestone associated
Banksia WL SCP	Banksia Woodlands of the Swan Coastal Plain ecological communityP3	P3	EN	x	x	Low	No Banksia present
SCP22	Banksia ilicifolia woodlands	P3			x	Low	No Banksia present
SCP21c	Low lying Banksia attenuata woodlands or shrublands	P3			x	Low	No Banksia present
SCP23b	Swan Coastal Plain Banksia attenuata - Banksia menziesii woodlands	P3			x	Low	No Banksia present

Fauna Database Search Results (DBCA Database Search using 20 Km Buffer, PMST 10 km buffer), Likelihood and Fauna Survey Records

Scientific Name	Common Name	Conservation Status		Database		Likelihood of Occurrence	Justification
		State	Federal	PMST	DBCA		
Aves							
Botaurus poiciloptilus	Australasian bittern	EN	EN	x	x	Low	No habitat present (deeper freshwater).
Rostratula australis	Australian Painted Snipe	EN	EN	x		Low	No habitat present (deep freshwater with connectivity to watercourses), however closest record <5 km from the Survey Area
Zanda baudinii	Baudin's Black-Cockatoo, Long-billed Black-cockatoo (previously Calyptorhynchus baudinii)	EN	EN	x	x	Low	Outside of population distribution
Zanda latirostris	Carnaby's black cockatoo, Short-billed Black-cockatoo (previously Calyptorhynchus latirostris)	EN	EN	x	x	High	Potential foraging and roosting habitat are available within the survey area to support this species. Recorded <5km from Study Area.
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	VU	VU	x	x	High	Potential foraging and roosting habitat are available within the survey area to support this species. Recorded <5km from study area.
Leipoa ocellata	malleefowl		VU	x		Low	Locally extinct
Falco peregrinus	peregrine falcon	OS			x	Medium	Could potentially use this area for foraging, however no close records present.
Mammals							

Scientific Name	Common Name	Conservation Status		Database		Likelihood of Occurrence	Justification
		State	Federal	PMST	DBCA		
Bettongia penicillata ogilbyi	woylie, brush-tailed bettong	CR	EN	x	x	Low	Study Area is not within current range, locally extinct.
Petrogale lateralis lateralis	black-flanked rock-wallaby, black-footed rock-wallaby, moororong	EN	EN	x	x	Low	Locally extinct.
Dasyurus geoffroii	chuditch, western quoll	VU	VU	x	x	Low	Habitat too fragmented, locally extinct.
Macrotis lagotis	bilby, dalgyte, ninu	VU	VU		x	Low	Locally extinct.
Falsistrellus mackenziei	western false pipistrelle, western falsistrelle	P4			x	Low	Habitat too fragmented, locally extinct.
Hydromys chrysogaster	water-rat, rakali	P4			x	Low	No suitable habitat present (study area far from watersource).
Isoodon fusciventer	quenda, southwestern brown bandicoot	P4			x	Low	Habitat not present (dense vegetation), however several records <5km from Study Area.
Notamacropus eugenii derbianus	tammar wallaby	P4			x	Low	Locally extinct.
Notamacropus irma	Western brush wallaby	P4			x	Low	Study Area not within home range. Recorded <5km from Study Area.
Reptiles							

Scientific Name	Common Name	Conservation Status		Database		Likelihood of Occurrence	Justification
		State	Federal	PMST	DBCA		
Ctenotus gemmula **(Swan Coastal Plain population)**	jewelled southwest Ctenotus (Swan Coastal Plain population)	CR	CR		x	Low	Habitat too fragmented, no close records present.
Neelaps calonotos	black-striped snake, black-striped burrowing snake	P3			x	Low	Habitat too fragmented, no close records present.
Insects							
Hesperocolletes douglasi	Douglas' Broad-headed Bee, Rottnest Bee		CR	x		Low	Presumed extinct until 2015 when one individual was found in Banksia Woodland. Habitat is not present and previous records from >5 km from the Survey Area.
Leioproctus douglasiellus	a short-tongued bee	EN	CR		x	Low	Associated host plant not present.
Euoplos inornatus	inornate trapdoor spider (northern Jarrah Forest)	P3			x	Low	No suitable habitat present.
Leioproctus contrarius	a short-tongued bee	P3			x	Low	No suitable habitat present. Host plants *Scaevola repens* var. *repens* and Lechenaultia spp not present.
Synemon gratiosa	graceful sunmoth	P4			x	Low	Habitat lacking host plant *Lomandra hermaphrodita*

WESTERN

Appendix D

Potential Black cockatoo Breeding Habitat

WEPL Report: bullsbrook south landholdings: Flora, Vegetation, Basic Fauna Survey and Black Cockatoo Assessment

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
1	Wandoo	5	950	None	409460.6405	6494199.096	
2	Wandoo	5	440		409454.6583	6494194.443	
3	Wandoo	5	370	None	409448.6761	6494197.766	
4	Wandoo	5	650	None	409446.682	6494172.176	
5	Wandoo	4	980	Has a small hollow, not suitbale	409414.4447	6494174.17	
6	Wandoo	5	650	None	409418.9093	6494188.11	
7	Wandoo	5	460	None	409404.0072	6494185.561	
9	Wandoo	5	350	None	409411.1629	6494192.132	
11	Wandoo	5	350	None	409413.1375	6494196.179	
12	Wandoo	5	570	None	409418.074	6494201.215	
13	Wandoo	5	550	None	409439.5971	6494205.263	
14	Wandoo	5	350	None	409437.2276	6494201.412	
15	Wandoo	5	830	None	409412.3713	6494204.857	
16	Wandoo	5	450	None	409406.9333	6494210.216	
18	Wandoo	5	570	None	409398.7369	6494213.211	
19	Wandoo	5	500	None	409397.1953	6494193.549	
20	Wandoo	5	650	None	409390.2355	6494206.868	
21	Wandoo	5	520	None	409391.6475	6494215.468	
22	Wandoo	5	420	None	409395.6269	6494216.752	
23	Wandoo	4	700	Broken off branches, no hollows developed	409398.4114	6494228.217	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
24	Wandoo	4	1100	Broken off branches and small hollows, not suitable for bc	409384.6883	6494219.265	
25	Wandoo	5	400	None	409384.9724	6494209.435	
26	Wandoo	5	600	None	409373.8044	6494210.077	
27	Wandoo	5	610	None	409372.3125	6494190.098	
28	Wandoo	5	600	None	409362.6547	6494201.002	
29	Wandoo	5	520	None	409363.5894	6494206.766	
30	Wandoo	5	430	None	409363.5877	6494210.272	
31	Wandoo	5	560	None	409367.2474	6494222.872	
32	Wandoo	5	700	None	409369.7398	6494229.352	
34	Wandoo	5	750	None	409363.4092	6494254.978	
35	Wandoo	5	870	None	409406.902	6494254.498	
36	Wandoo	5	570	None	409412.2321	6494245.946	
37	Wandoo	4	1000	Broken branches and small hollows, not suitable for bc	409338.0011	6494267.955	
38	Wandoo	5	650	None	409344.0764	6494203.714	
39	Wandoo	4	750	One small	409349.6754	6494193.515	
40	Wandoo	5	460	None	409349.4686	6494196.385	
41	Wandoo	5	700	None	409335.4343	6494198.149	
44	Wandoo	5	580	None	409325.4074	6494208.716	
45	Wandoo	5	440	None	409323.3249	6494204.397	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
46	Wandoo	5	400	None	409324.1785	6494199.569	
48	Wandoo	5	350	None	409326.1171	6494193.822	
49	Wandoo	5	700	None	409321.5091	6494193.412	
50	Wandoo	5	520	None	409318.9549	6494190.345	
51	Wandoo	5	600	None	409311.4497	6494190.727	
52	Wandoo	5	330	None	409309.8919	6494194.776	
53	Wandoo	5	500	None	409306.5877	6494196.838	
54	Wandoo	5	330	None	409305.053	6494193.99	
55	Wandoo	5	480	None	409303.474	6494192.677	
56	Wandoo	5	400	None	409299.6013	6494192.509	
57	Wandoo	5	360	None	409298.1805	6494194.524	
58	Wandoo	5	710	None	409297.5635	6494199.229	
59	Wandoo	5	300	None	409297.872	6494208.87	
60	Wandoo	5	650	None	409306.8962	6494210.181	
62	Wandoo	5	570	None	409315.8288	6494215.07	
63	Wandoo	5	710	None	409313.6975	6494215.66	
65	Wandoo	5	510	None	409303.2372	6494218.805	
66	Wandoo	4	500	Small hollow	409302.3139	6494223.339	
67	Wandoo	5	620	None	409296.3214	6494234.882	
68	Wandoo	5	1000	None	409242.4926	6494280.607	
69	Marri	5	1600	None	408648.7406	6494305.264	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
70	Marri	5	1080	None	408661.6418	6494297.906	
71	Marri	5	1950	None	408707.1106	6494267.123	
72	Marri	5	1070	None	408723.9972	6494273.738	
73	Marri	5	920	None	408658.0611	6494317.152	
74	Marri	5	1320	None	408665.07	6494330.14	
75	Marri	5	1080	None	408656.3834	6494340.845	
76	Marri	5	1180	None	408675.4828	6494358.388	
77	Marri	5	1170	None	408688.2296	6494366.858	
78	Marri	5	1130	None	408673.5108	6494381.174	
79	Marri	5	1540	None	408666.3044	6494404.696	
80	Marri	5	1310	None	408678.3477	6494417.591	
81	Marri	4	1000	One small	408668.8116	6494445.916	
82	Marri	5	1130	N9ne	408745.8319	6494482.911	
83	Marri	4	1280	Broken branches that could have developed hollows, can't see from ground. No chew marks present.	408725.7029	6494454.938	
84	Marri	5	1010	None	408717.6649	6494464.325	
85	Marri	5	1060	None	408707.6011	6494460.309	
86	Marri	5	970	None	408708.1018	6494448.041	
87	Marri	5	1030		408724.0073	6494445.998	
88	Marri	5	980	None	408728.8574	6494445.406	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
89	Marri	5	950	None	408737.3452	6494443.909	
90	Marri	5	1280	None	408699.156	6494416.178	
91	Marri	5	1090	None	408715.7544	6494396.839	
92	Marri	5	100	None	408696.2926	6494388.126	
93	Marri	5	1090	None	408713.0998	6494373.379	
94	Marri	5	1050	None	408723.5636	6494363.54	
95	Marri	5	1060	None	408719.827	6494380.164	
96	Marri	5	1430	None	408728.2885	6494396.463	
97	Marri	5	750	None	408743.1773	6494394.031	
98	Marri	5	1090	None	408751.1354	6494410.758	
99	Marri	5	1270	Nobe	408753.3735	6494417.739	
100	Marri	5	1000	None	408741.8758	6494426.897	
101	Marri	5	860	None	408725.8976	6494423.972	
102	Marri	5	1020	None	408774.1499	6494408.224	
103	Marri	5	970	None	408770.2203	6494396.888	
104	Marri	5	1170	None	408772.7286	6494389.353	
105	Marri	5	950	None	408758.133	6494377.253	
106	Marri	5	950	None	408749.1059	6494362.96	
107	Marri	5	850	None	408745.6077	6494339.697	
108	Marri	5	800	None	408750.2488	6494281.369	
109	Marri	5	1110	None	408783.6241	6494337.137	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
110	Marri	5	1340	None	408795.8508	6494370.521	
111	Marri	5	1170	None	408817.6793	6494347.569	
114	Marri	5	1040	None	408846.1987	6494350.678	
115	Marri	5	2040	N9ne	408825.4917	6494390.722	
116	Marri	5	1640	None	408835.5562	6494385.773	
117	Marri	5	1280	None	408840.0615	6494399.744	
119	Wandoo	5	930	None	408855.1058	6494372.033	
121	Marri	5	630	None	408850.4722	6494365.383	
122	Marri	5	800	None	408855.5486	6494365.027	
123	Marri	5	1480	None	408862.447	6494368.22	
124	Marri	5	830	None	408862.6504	6494360.096	
125	Marri	5	800	None	408865.0599	6494352.473	
126	Marri	5	790	None	408864.8112	6494438.328	
127	Marri	5	800	None	408860.7786	6494459.092	
128	Marri	5	670	None	408856.9385	6494462.636	
129	Marri	5	840	None	408857.0433	6494474.409	
131	Marri	5	850	None	408869.5201	6494481.625	
132	Marri	5	550	None	408876.6113	6494484.863	
133	Marri	5	650	None	408883.1866	6494481.933	
134	Marri	5	850	None	408873.7438	6494478.206	
135	Marri	5	520	None	408876.5423	6494473.127	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
136	Marri	5	600	None	408881.2631	6494467.639	
137	Marri	5	800	None	408895.3332	6494476.366	
138	Marri	5	1120	None	408875.3748	6494441.686	
139	Wandoo	4	1090	One small hollow, not suitable for bc	408907.5053	6494415.078	
140	Wandoo	5	800	None	408934.7847	6494422.318	
141	Marri	5	980	None	408930.1235	6494464.961	
142	Marri	5	1100	None	408939.6145	6494473.11	
143	Marri	5	890	None	408962.566	6494462.129	
144	Marri	5	1220	None	408927.156	6494374.399	
145	Marri	5	720	None	408906.3152	6494341.865	
146	Marri	5	750	None	408904.7293	6494321.214	
147	Marri	5	680	None	408911.4999	6494316.531	
148	Wandoo	5	870	N9ne	408917.6063	6494316.217	
150	Marri	5	1050	None	408935.1527	6494320.484	
151	Marri	5	880	None	408942.2553	6494326.32	
152	Marri	5	550	None	408969.3252	6494081.992	
153	Marri	5	700	None	408973.6146	6494081.616	
154	Eucalyptus	5	890	None	408978.3937	6494081.207	
155	Eucalyptus	5	1020	None	408975.9007	6494061.289	
158	Wandoo	5	420	None	408974.1955	6494050.844	
159	Eucalyptus	5	870	None	408970.2489	6494044.541	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
160	Wandoo	5	340	None	408971.5847	6494041.934	
161	Eucalyptus	5	1120	None	408978.1045	6494023.88	
162	Marri	5	650	None	408971.8862	6494020.487	
163	Eucalyptus	5	1000	None	408978.1694	6494014.852	
164	Wandoo	5	320	None	408972.0474	6494006.913	
167	Wandoo	5	350	None	408971.6462	6493998.744	
168	Wandoo	5	720	None	408971.3813	6493993.739	
169	Eucalyptus	5	800	None	408978.9009	6493988.68	
172	Wandoo	5	700	None	408976.7397	6493998.626	
173	Wandoo	5	300	None	408978.508	6493997.596	
175	Eucalyptus	5	860	None	408977.1465	6493974.12	
176	Wandoo	5	400	None	408971.6286	6493973.401	
177	Eucalyptus	5	1080	None	408978.7885	6493961.206	
178	Eucalyptus	5	680	None	408979.1522	6493953.893	
179	Eucalyptus	5	630	None	408978.2765	6493931.302	
180	Wandoo	5	600	None	408975.4299	6493928.85	
183	Wandoo	5	310	None	408971.1512	6493925.176	
184	Wandoo	4	1200	Two small hollows, not suitable for bc	408978.0479	6493925.194	
185	Wandoo	5	420	Small hollow formation, not suitable for bc	408974.5783	6493920.062	
187	Wandoo	5	300	None	408978.4715	6493910.777	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
188	Wandoo	5	360	None	408976.7777	6493910.016	
189	Eucalyptus	5	620	None	408979.9427	6493907.321	
190	Eucalyptus	5	1230	None	408980.7157	6493897.477	
191	Wandoo	5	450	None	408973.3778	6493900.207	
193	Wandoo	5	600	None	408960.6619	6493922.857	
194	Wandoo	5	700	None	408961.4147	6493970.4	
195	Wandoo	5	550	None	408962.164	6493976.227	
196	Wandoo	5	600	None	408962.9599	6493990.073	
197	Wandoo	5	620	None	408963.6881	6494042.324	
198	Marri	5	500	None	408964.5114	6494047.477	
199	Marri	5	600	None	408964.4729	6494051.694	
200	Marri	5	620	None	408962.7139	6494052.854	
202	Marri	5	570	Nobe	408915.7925	6493886.665	
203	Marri	5	650	Nobe	408904.7877	6493884.945	
207	Marri	5	700	None	408850.5141	6493880.087	
211	Marri	5	570	None	408847.3915	6493870.11	
212	Marri	5	550	None	408853.7552	6493871.485	
215	Marri	5	650	Nobe	408867.1038	6493867.983	
218	Marri	5	580	None	408901.2395	6493874.902	
219	Marri	5	500	Nobe	408904.5384	6493873.763	
222	Marri	5	750	None	408907.1911	6493870.33	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
224	Marri	5	570	None	408907.1287	6493876.193	
227	Wandoo	5	70		409713.1824	6495321.537	
228	Wandoo	5	130		409713.1812	6495293.12	
229	Wandoo	5	60		409732.1003	6495243.911	
230	Wandoo	5	80		409776.136	6495282.986	
231	Wandoo	5	70		409719.7759	6495003.296	
232	Wandoo	4	60		409694.7064	6495005.611	
233	Wandoo	5	70		409695.9878	6494994.671	
234	Wandoo	5	50		409691.8268	6494994.778	
235	Wandoo	5	90		409686.2768	6494968.322	
236	Wandoo	5	60		409665.2552	6494964.123	
237	Wandoo	5	60		409651.2843	6494966.171	
238	Wandoo	5	50		409636.6621	6494952.249	
239	Marri	5	70		409633.1047	6494976.777	
240	Marri	5	80		409653.7803	6494984.569	
241	Marri	5	70		409624.9106	6495022.448	
242	Marri	5	80		409614.9435	6495005.358	
243	Marri	5	80		409601.955	6495000.442	
244	Wandoo	5	80		409599.0888	6494951.231	
245	Marri	5	70		409577.6166	6494973.8	
246	Marri	5	70		409562.634	6494975.015	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
247	Dead	5	80		409554.8369	6494968.353	
248	Marri	5	70		409539.8079	6494984.054	
249	Marri	5	80		409542.2732	6494957.822	
250	Marri	5	70		409515.3735	6494949.347	
251	Marri	5	50		409513.6074	6494970.893	
252	Marri	5	60		409541.9696	6495009.57	
253	Dead	4	60		409547.9347	6495012.695	
254	Marri	5	120		409539.6396	6495032.598	
255	Marri	4	110		409502.1505	6495022.859	
256	Marri	5	60		409468.9606	6495028.122	
257	Marri	5	50		409437.0674	6494967.121	
258	Marri	5	80		409420.0448	6494971.686	
259	Marri	4	90		409429.1459	6494989.215	
260	Marri	5	90		409418.9674	6494996.691	
261	Marri	5	90		409410.0849	6495014.2	
262	Marri	5	80		409387.2271	6494998.408	
263	Marri	5	90		409363.0845	6495023.615	
264	Marri	5	50		409348.8209	6494978.119	
265	Wandoo	5	60		409358.0164	6494971.151	
266	Dead	5	60		409342.8857	6494968.787	
267	Marri	5	50		409319.1075	6494971.058	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
268	Marri	5	70		409323.0874	6494990.787	
269	Marri	5	100		409311.8063	6494993.638	
270	Marri	5	80		409304.7139	6494988.618	
271	Marri	5	70		409291.1058	6495004.106	
272	Marri	5	60		409323.5786	6495012.376	
273	Marri	5	50		409311.1305	6495025.145	
274	Marri	5	50		409303.9672	6495023.144	
275	Marri	5	60		409290.631	6495025.04	
276	Marri	5	60		409255.7208	6494985.857	
277	Marri	5	60		409246.8915	6494979.08	
278	Marri	5	60		409236.987	6494970.602	
279	Wandoo	4	80		409222.8706	6494967.851	
280	Marri	5	70		409211.7546	6494973.759	
281	Marri	5	80		409216.6951	6494990.78	
282	Marri	4	60		409215.4611	6494998.082	
283	Marri	5	70		409217.784	6495000.231	
284	Marri	5	70		409237.0407	6495015.767	
285	Marri	5	60		409250.9517	6495018.046	
286	Marri	5	70		409251.1591	6495021.77	
287	Dead	4	60		409264.7025	6495030.112	
288	Marri	5	80		409153.0822	6494996.13	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
289	Marri	5	90		409134.3206	6494988.464	
290	Marri	5	50		409129.5274	6494987.507	
291	Marri	5	80		409122.2215	6494993.495	
292	Wandoo	5	80		409129.3972	6495010.578	
293	Marri	5	100		409127.3602	6495020.82	
294	Marri	5	110		409166.5794	6494960.009	
295	Marri	5	80		409248.625	6494930.104	
296	Marri	5	80		409253.8208	6494962.117	
297	Marri	5	70		409264.6789	6494972.565	
298	Marri	5	80		409271.9315	6494975.416	
299	Marri	5	80		409286.7488	6494969.015	
300	Wandoo	5	60		409312.034	6494957.233	
301	Marri	5	60		409302.3844	6494931.175	
302	Marri	5	55		409318.1636	6494923.022	
303	Marri	5	50		409342.8907	6494947.671	
304	Marri	5	50		409348.2091	6494946.364	
305	Marri	5	70		409356.622	6494953.027	
306	Marri	5	60		409359.446	6494936.165	
307	Wandoo	4	100		409354.5422	6494895.631	
308	Marri	5	50		409365.9893	6494919.782	
309	Marri	5	50		409373.4081	6494936.276	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
310	Marri	5	100		409395.0092	6494953.629	
311	Marri	5	70		409389.1178	6494966.203	
312	Marri	5	60		409406.9448	6494966.696	
313	Marri	5	60		409430.9139	6494952.173	
314	Marri	5	110		409452.1909	6494949.727	
315	Wandoo	5	40		409428.0534	6494940.192	
316	Marri	5	90	One	409435.5255	6494919.169	
317	Marri	5	70		409419.3076	6494923.48	
318	Marri	5	100		409401.7278	6494907.244	
319	Wandoo	4	60		409427.6871	6494820.075	
320	Marri	5	80		409527.1211	6494926.729	
321	Marri	5	70		409546.4753	6494924.672	
322	Marri	5	60		409527.2617	6494904.415	
323	Marri	5	70		409541.8909	6494849.375	
324	Marri	5	60		409565.8807	6494841.209	
325	Marri	5	60		409574.7386	6494830.973	
326	Wandoo	5	70		409590.4854	6494784.629	
327	Marri	5	80		409597.5637	6494852.739	
328	Wandoo	4	80		409615.0363	6494874.959	
329	Wandoo	4	50		409638.2814	6494887.283	
330	Marri	5	70		409662.1086	6494867.289	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
331	Marri	5	60		409690.7682	6494856.523	
332	Marri	5	80		409689.9152	6494882.049	
333	Wandoo	5	50		409643.7346	6494900.754	
334	Wandoo	5	60		409660.5152	6494914.526	
335	Dead	5	50		409642.5107	6494930.541	
336	Wandoo	5	40		409639.8591	6494928.9	
337	Wandoo	4	70		409634.8901	6494923.557	
338	Wandoo	4	80		409606.1702	6494921.539	
339	Wandoo	5	60		409719.5154	6494772.814	
340	Flooded Gum	5	70		409719.3409	6494639.902	
341	Flooded Gum	4	100		409716.2414	6494637.718	
342	Flooded Gum	4	80		409698.8748	6494641.685	
344	Marri	5	80		409699.4848	6494665.786	
345	Marri	5	60		409700.5264	6494667.164	
351	Marri	5	110		409684.2423	6494691.388	
359	Marri	5	70		409706.2548	6494715.169	
360	Flooded Gum	5	90		409665.7536	6494688.956	
361	Wandoo	5	40		409668.6574	6494687.676	
362	Flooded Gum	5	120		409652.9898	6494703.235	
363	Flooded Gum	5	90		409644.7292	6494710.531	
364	Wandoo	5	40		409657.8843	6494719.677	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
365	Wandoo	5	30		409658.4504	6494720.808	
366	Wandoo	5	40		409658.3942	6494721.219	
367	Wandoo	4	50		409655.0285	6494720.107	
368	Dead	5	50		409613.8575	6494728.818	
370	Wandoo	5	40		409600.3964	6494694.508	
371	Marri	5	50		409570.7812	6494690.519	
372	Flooded Gum	5	100		409548.5373	6494691.373	
373	Flooded Gum	5	60		409547.1491	6494691.463	
374	Flooded Gum	5	50		409546.8325	6494691.505	
375	Flooded Gum	5	70		409541.7869	6494691.112	
376	Wandoo	5	50		409535.1397	6494711.226	
377	Wandoo	5	40		409529.7079	6494715.368	
379	Flooded Gum	5	50		409472.211	6494712.703	
380	Wandoo	5	70		409475.896	6494728.592	
381	Wandoo	5	60		409459.1926	6494732.85	
382	Flooded Gum	5	50		409468.3121	6494713.148	
383	Flooded Gum	5	50		409385.7346	6494724.366	
384	Wandoo	5	60		409393.0786	6494738.812	
385	Wandoo	5	40		409351.5547	6494747.174	
386	Dead	4	50	Chimney type mid way, upwards opening, does not develop any depth. Pole cam inspected . Galah in	409340.714	6494734.99	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
				tree and shell fragment on ground			
387	Wandoo	4	60	Big dead branch with several potentials. Pole cam inspected. None are suitable hollows	409333.374	6494768.097	
388	Flooded Gum	5	80		409313.3941	6494765.141	
389	Flooded Gum	5	60		409303.3216	6494770.596	
390	Wandoo	5	50		409282.9294	6494768.808	
391	Wandoo	5	50		409272.5274	6494762.709	
395	Wandoo	4	50		409230.224	6494753.893	
396	Dead	5	50		409224.3524	6494750.272	
398	Wandoo	5	40		409222.6519	6494767.178	
399	Flooded Gum	5	700		409135.924	6494760.566	
400	Wandoo	5	40		409136.2784	6494766.1	
401	Flooded Gum	5	60		409129.4714	6494767.372	
402	Wandoo	5	50		409121.9901	6494777.164	
403	Wandoo	5	50		409178.5171	6494743.596	
404	Wandoo	5	40		409213.456	6494740.775	
405	Wandoo	5	40		409213.3701	6494745.706	
406	Flooded Gum	5	60		409224.5219	6494744.854	
408	Marri	5	50		409232.9899	6494729.731	
409	Marri	5	50		409235.9774	6494726.634	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
410	Marri	5	50		409236.8381	6494727.788	
411	Wandoo	5	50		409279.3025	6494738.581	
412	Dead	4	60		409295.1323	6494751.529	
414	Marri	5	120		409302.6975	6494744.983	
415	Marri	5	50		409314.128	6494746.833	
416	Flooded Gum	5	70		409320.8741	6494733.578	
417	Flooded Gum	5	90		409324.1027	6494723.436	
418	Wandoo	5	50		409361.0181	6494711.562	
419	Wandoo	5	50		409361.8101	6494714.226	
420	Flooded Gum	5	120		409383.2742	6494721.253	
421	Flooded Gum	5	60		409442.6751	6494711.522	
422	Flooded Gum	5	60		409445.3018	6494711.135	
423	Flooded Gum	5	70		409461.1524	6494707.581	
424	Flooded Gum	5	50		409475.5574	6494707.523	
425	Wandoo	5	50		409483.4111	6494703.678	
426	Flooded Gum	5	70		409497.8688	6494707.188	
427	Flooded Gum	5	60		409498.5587	6494707.153	
428	Flooded Gum	5	50		409499.2341	6494707.309	
429	Marri	5	50		409512.9191	6494709.831	
430	Flooded Gum	5	60		409517.3658	6494711.825	
431	Flooded Gum	5	60		409519.4547	6494712.872	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
432	Wandoo	5	50		409568.3823	6494681.638	
433	Wandoo	5	40		409592.997	6494686.044	
435	Flooded Gum	5	70		409620.1699	6494703.698	
436	Flooded Gum	5	50		409624.051	6494717.435	
437	Flooded Gum	5	70		409628.1357	6494717.844	
438	Flooded Gum	5	50		409639.7617	6494706.4	
439	Flooded Gum	5	50		409651.7631	6494694.489	
442	Flooded Gum	5	70		409689.0419	6494639.086	
443	Flooded Gum	5	60		409698.1309	6494629.943	
444	Flooded Gum	5	60		409711.1176	6494630.63	
445	Flooded Gum	5	50		409712.2061	6494631.353	
446	Flooded Gum	5	60		409714.5036	6494634.726	
447	Flooded Gum	5	60		409719.1008	6494639.08	
448	Wandoo	5	50		409381.3991	6494630.153	
449	Marri	5	70		409427.9299	6494455.346	
451	Wandoo	5	50		409517.7404	6494503.368	
452	Marri	5	50		409335.2071	6494433.267	
454	Marri	5	70		409299.3939	6494425.669	
455	Wandoo	5	30		409294.4915	6494437.882	
456	Marri	5	70		409288.4113	6494466.266	
457	Marri	5	70		409258.9696	6494459.111	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
458	Marri	5	80		409228.0901	6494470.137	
459	Marri	5	50		409135.9874	6494382.265	
460	Marri	5	80		409180.4547	6494384.043	
461	Marri	5	100		409315.1315	6494389.217	
462	Marri	5	60		409265.6832	6494387.833	
464	Marri	5	80		409199.5393	6494378.833	
465	Marri	5	50		409194.9822	6494380.952	
466	Wandoo	5	50		409182.9756	6494361.423	
467	Wandoo	5	40		409172.0294	6494358.578	
472	River Red Gum	5	70		409335.1335	6494414	
473	River Red Gum	5	80		409341.3214	6494406.058	
474	River Red Gum	5	80		409345.1283	6494410.733	
475	River Red Gum	5	60		409353.7248	6494413.337	
476	River Red Gum	5	60		409356.8389	6494412.526	
477	Eucalyptus	5	50		409300.65	6494432.089	
481	Eucalyptus	5	50		409461.872	6494437.569	
483	River Red Gum	5	50		409518.0543	6494466.972	
485	River Red Gum	5	60		409637.7947	6494537.367	
486	River Red Gum	5	80		409649.6007	6494538.339	
500	Wandoo	5	40		409599.8242	6494494.149	
503	Wandoo	5	50		409576.8039	6494478.288	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
504	Wandoo	5	30		409576.8957	6494471.643	
506	Wandoo	5	50		409579.975	6494453.643	
509	Wandoo	5	50		409548.8215	6494439.866	
510	Wandoo	5	30		409560.8601	6494426.28	
511	Wandoo	5	30		409561.5972	6494426.099	
512	Wandoo	5	40		409564.9089	6494428.137	
517	Wandoo	5	70		409033.0905	6494129.232	
518	Wandoo	5	50		409021.1524	6494125.293	
519	Wandoo	5	40		409013.2486	6494123.331	
520	Wandoo	5	40		408983.8426	6494105.603	
521	Wandoo	5	40		409100.4509	6494144.942	
522	Wandoo	5	40		409119.7162	6494161.929	
524	Wandoo	5	50		409147.9727	6494172.274	
525	Wandoo	5	40		409151.5805	6494166.611	
526	Wandoo	5	40		409160.9545	6494166.85	
527	Wandoo	5	40		409172.2847	6494182.145	
528	Wandoo	5	50		409172.8908	6494180.252	
529	Wandoo	5	30		409178.2566	6494172.163	
530	Wandoo	5	40		409187.6896	6494166.941	
531	Wandoo	5	50		409190.4985	6494175.13	
532	Wandoo	5	40		409188.5937	6494178.306	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
533	Wandoo	5	40		409206.6678	6494173.709	
534	Wandoo	5	40		409196.8574	6494188.168	
535	Wandoo	5	50		409193.1749	6494194.315	
536	Wandoo	5	50		409237.7059	6494210.334	
537	Wandoo	5	50		409239.559	6494191.916	
538	Marri	5	100		408960.1109	6494268.212	
539	Wandoo	5	50		408833.958	6494232.729	
540	Marri	5	90		408618.1636	6494286.44	
541	Marri	5	100		408596.6674	6494276.058	
542	Marri	5	80		408550.2037	6494278.008	
543	Marri	5	100		408549.9624	6494299.83	
544	Marri	5	90		408545.3912	6494321.248	
545	Marri	5	100		408529.6629	6494333.482	
546	Marri	5	100		408501.2389	6494343.527	
548	Marri	5	80		408506.0123	6494318.566	
549	Marri	5	80		408513.9488	6494304.351	
550	Marri	5	100		408477.0673	6494275.351	
551	Marri	3	120	One upwards opening knot hollow mid trunk. 20 cm slit opening, Galah pair present, chew and wear on hollow. Potentially suitable. Not internally inspected, too high for pole cam	408469.915	6494260.767	

Tree #	*Species*	Class BAMfo	DBH (mm)	Hollow notes	Location (GDA2020 / MGA50)		Photo
					Easting	Northing	
552	Marri	5	50		408445.8259	6494278.497	
558	Marri	5	60		408449.5927	6494258.826	
561	Marri	5	50		408433.1069	6494245.296	
563	Eucalyptus	5	50		408368.275	6494237.535	
565	Marri	5	70		408459.2936	6494317.162	
580	Marri	5	100		408462.0109	6494340.438	
581	Marri	5	60		408463.6411	6494341.636	
589	Marri	5	50		408451.9489	6494346.021	
597	Marri	5	80		408456.1718	6494392.224	
610	Marri	5	50		408469.5085	6494406.527	
616	Marri	5	80		408445.3402	6494408.764	
620	Marri	5	80		408452.1528	6494422.469	
623	Marri	5	90		408478.4303	6494427.081	
642	Marri	4	70	One 20 cm slit hollow. Facing downwards and has bees present, not suitable	408469.0388	6494450.081	
649	Marri	5	60		408464.2709	6494474.833	
659	Marri	4	50		408495.3559	6494469.388	
662	Marri	5	50		408505.5772	6494469.251	
666	Marri	5	100		408528.0019	6494445.045	
667	Marri	5	90		408548.2972	6494435.769	
668	Marri	5	90		408534.9419	6494412.342	

Appendix E

Black cockatoo Foraging Habitat Scoring Tool

Bamford 2018 Foraging Habitat Scoring Tool Method

Application of the Offset Assessment Guide (offsets guide) developed by the federal environment department for assessing Black cockatoo foraging habitat requires the calculation of a score out of 10. The following system has been developed by Bamford Consulting to provide an objective scoring system that is practical and can be used by trained field zoologists with experience in the environments frequented by the species.

Calculating the total score (out of 10) requires the following steps:

a) Determining a score out of six for the vegetation composition, condition and structure; plus

b) Determining a score out of three for the context of the site; plus

c) Determining a score out of one for species density.

d) Determining the total score out of 10, which may require moderation for context and species density with respect to the vegetation composition.

Calculation of scores and the moderation process are described in detail below.

Site Score	Description of Vegetation Values		
	Carnaby's Cockatoo	**Baudin's Cockatoo**	**Forest Red-tailed Cockatoo**
0	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: Water bodies (e.g. salt lakes, dams, rivers);Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: Water bodies (e.g. salt lakes, dams, rivers);Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: Water bodies (e.g. salt lakes, dams, rivers);Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).
1	Negligible to low foraging value. Examples: Scattered specimens of known food plants but projected foliage cover of these is < 2%. This could include urban areas with scattered foraging trees; Paddocks that are partly vegetated with melons or other known food-source weeds (e.g. Erodium spp.) that represent a short-term and/or seasonal food source; Blue Gum plantations (foraging by Carnaby's Cockatoos has been reported but appears to be unusual).	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. This could include urban areas with scattered foraging trees	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. This could include urban areas with scattered foraging trees
2	Low foraging value. Examples: Shrubland in which species of	Low foraging value. Examples: Woodland with scattered	Low foraging value. Examples: Woodland with scattered

Site Score	Description of Vegetation Values		
	Carnaby's Cockatoo	**Baudin's Cockatoo**	**Forest Red-tailed Cockatoo**
	foraging value, such as shrubby banksias, have < 10% projected foliage cover; Woodland with tree banksias 2-5% projected foliage cover; Open eucalypt woodland/mallee of small-fruited species; Paddocks that are densely vegetated with melons or other known food-source weeds (e.g. Erodium spp.) that represent a short-term and/or seasonal food source.	specimens of known food plants (e.g. Marri and Jarrah) 1-5% projected foliage cover; Urban areas with scattered foraging trees.	specimens of known food plants (e.g. Marri, Jarrah or Sheoak) 1- 5% projected foliage cover; Urban areas with scattered food plants such as Cape Lilac, Eucalyptus caesia and E. erythrocorys.
3	Low to Moderate foraging value. Examples: Shrubland in which species of foraging value, such as shrubby banksias, have 10-20% projected foliage cover; Woodland with tree banksias 5-20% projected foliage cover; Eucalypt Woodland/Mallee of small fruited species; Eucalypt Woodland with Marri < 10% projected foliage cover.	Low to Moderate foraging value. Examples: Eucalypt Woodland with known food plants (especially Marri) 5-20%projected foliage cover; Parkland-cleared Eucalypt Woodland/Forest with known foodplants 10-40% projected foliage cover (poor long-term viability without management);Younger areas of (managed)revegetation with known foodplants 10-40% projected foliage cover (establishing food sources with good long-term viability).	Low to Moderate foraging value. Examples: Eucalypt Woodland with known food plants (especially Marri and Jarrah) 5-20% projected foliage cover; Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).
4	Moderate foraging value. Examples: Woodland/forest with tree banksias 20- 40% projected foliage cover; Eucalypt Woodland/Forest with Marri 20-40% projected foliage cover.	Moderate foraging value. Examples: Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. Eucalypt Woodland/Forest with diverse, healthy understorey and known food trees (especially Marri) 10-20% projected foliage cover. Orchards with highly desirable food sources (e.g. apples, pears, some stone fruits).	Moderate foraging value. Examples: Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; Sheoak Forest with 40-60% projected foliage cover.
5	Moderate to High foraging value. Examples: Banksia Forest with 40-60% projected foliage cover; Banksia Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or	Moderate to High foraging value. Examples: Marri-Jarrah Forest with 40-60% projected foliage cover; Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed	Moderate to High foraging value. Examples: Marri-Jarrah Forest with 40-60% projected foliage cover; Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree

Site Score	Description of Vegetation Values		
	Carnaby's Cockatoo	**Baudin's Cockatoo**	**Forest Red-tailed Cockatoo**
	some tree deaths; Pine plantations with trees more than 10 years old.	invasion and/or some tree deaths.	deaths. Sheoak Forest with > 60% projected foliage cover.
6	High foraging value. Example: Banksia Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).

Vegetation structural class terminology follows Keighery (1994).

Site context.

The maximum score is given in situations where foraging habitat is supporting breeding birds. It can also be given in fragmented landscapes where there is little foraging habitat remaining and thus what is left has a high contextual value. The site context score is species-specific as it depends upon factors such as the vegetation type and extent, and the presence of breeding birds, and the following table, developed by Bamford consulting in conjunction with DEE, provides a guide to the assignation of site context scores (note that 'local area' is defined as within a 12 km radius of the centre point of the study site).

Site context score	Percentage of the existing native vegetation within the "local" area that the study site represents	
	'Local' breeding known/likely	'Local' breeding unlikley
3	>5%	>10%
2	1-5%	5-10%
1	0.1-1%	1-5%
0	<0.1%	<0.1%

Species density

Assignation of the species density score (0 or 1) is based upon the Black cockatoo species being either abundant or not abundant and is species specific. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence.

Note that context and species density scores are affected by the vegetation score and this is discussed below.

Moderation of scores for the calculation of a value out of 10

The foraging value score provides a numerical value that reflects the suitability of vegetation as foraging habitat for Black cockatoos, and this numerical value is designed to provide the information needed by the Federal Department of the Environment and Energy (DoEE) to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed above. These three components are drawn from the DoEE offsets guide but the scoring approach was developed by Bamford Consulting Ecologists.

a. A score out of six for the vegetation composition, condition and structure

b. A score out of three for the context of the site

c. A score out of one for species density.

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are considered. Assigning a score out of 10 represents step D and may require moderation rather than simple addition.

The score out of six for vegetation characteristics and value can be compared across a site, while a score out of 10 is the overall foraging value and is used for the purposes of aiding offset calculations. The calculation out of 10 requires the vegetation characteristics (out of 6) to be combined with the scores given for context and species density. It is considered that the context and density scores are not independent of vegetation characteristics; otherwise habitat of absolutely no value for Black cockatoo foraging (such as concrete or a wetland) could get a foraging score out of 10 as high as 4 if it occurred in an area where the species breed (context score of 3) and are abundant (species density score of 1). Similarly, vegetation of negligible or low characteristics which could not support Black cockatoos could be assigned a score as high as 6 out of 10. In that case, the score of 6 would be more a reflection of nearby vegetation of high characteristics than of the foraging value of the negligible to low scoring vegetation. The Black cockatoos would only be present because of vegetation of high characteristics, so applying the context and species density scores to vegetation of low characteristics would not give a true reflection of their foraging value.

For this reason, the context and species density scores need to be moderated for the vegetation characteristic score to prevent vegetation of little or no foraging value receiving an excessive score out of 10. A simple approach is assigning a context and species density score of zero to with a characteristic score of low (2), negligible (1) or none (0), on the basis that birds will not use such areas unless they are adjacent to at least low-moderate quality foraging habitat (>3). The approach to calculating a score out of 10 can be summarised as follows.

Vegetation composition, condition and structure score	Context score	Species density score
3-6 (low/moderate to high value)	Assessed as per B above	Assessed as per C above
0-2 (no to low value)	0	0

Final Score out of Ten

The final score out of ten is scaled:

- O-None.
- 1-Negligable.
- 2-Low.
- 3-Low to Moderate.
- 4-Moderate.
- 5-Moderate to High.
- 6-7 High.
- 7-10 Very High.

WEPL Report: bullsbrook south landholdings: Flora, Vegetation, Basic Fauna Survey and Black Cockatoo Assessment

Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
0	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: Water bodies (e.g. salt lakes, dams, rivers);Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	0				No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: Water bodies (e.g. salt lakes, dams, rivers);Bare ground; Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	0			
1	Negligible to low foraging value. Examples: Scattered specimens of known food plants but projected foliage cover of these is < 2%. This could include urban areas with scattered foraging trees; Paddocks that are partly vegetated with melons or other known food-source weeds (e.g. Erodium spp.) that represent a short-term and/or seasonal food source; Blue Gum plantations (foraging by Carnaby's Cockatoos has been reported but appears to be unusual).					Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. This could include urban areas with scattered foraging trees				

Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
2	Low foraging value. Examples: Shrubland in which species of foraging value, such as shrubby banksias, have < 10% projected foliage cover; Woodland with tree banksias 2-5% projected foliage cover; Open eucalypt woodland/mallee of small-fruited species; Paddocks that are densely vegetated with melons or other known food-source weeds (e.g. Erodium spp.) that represent a short-term and/or seasonal food source.		2	2		Low foraging value. Examples: Woodland with scattered specimens of known food plants (e.g. Marri, Jarrah or Sheoak) 1- 5% projected foliage cover; Urban areas with scattered food plants such as Cape Lilac, Eucalyptus caesia and E. erythrocorys.		2		

Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
3	Low to Moderate foraging value. Examples: Shrubland in which species of foraging value, such as shrubby banksias, have 10-20% projected foliage cover; Woodland with tree banksias 5-20% projected foliage cover; Eucalypt Woodland/Mallee of small fruited species; Eucalypt Woodland with Marri < 10% projected foliage cover					Low to Moderate foraging value. Examples: Eucalypt Woodland with known food plants (especially Marri and Jarrah) 5-20% projected foliage cover; Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).				

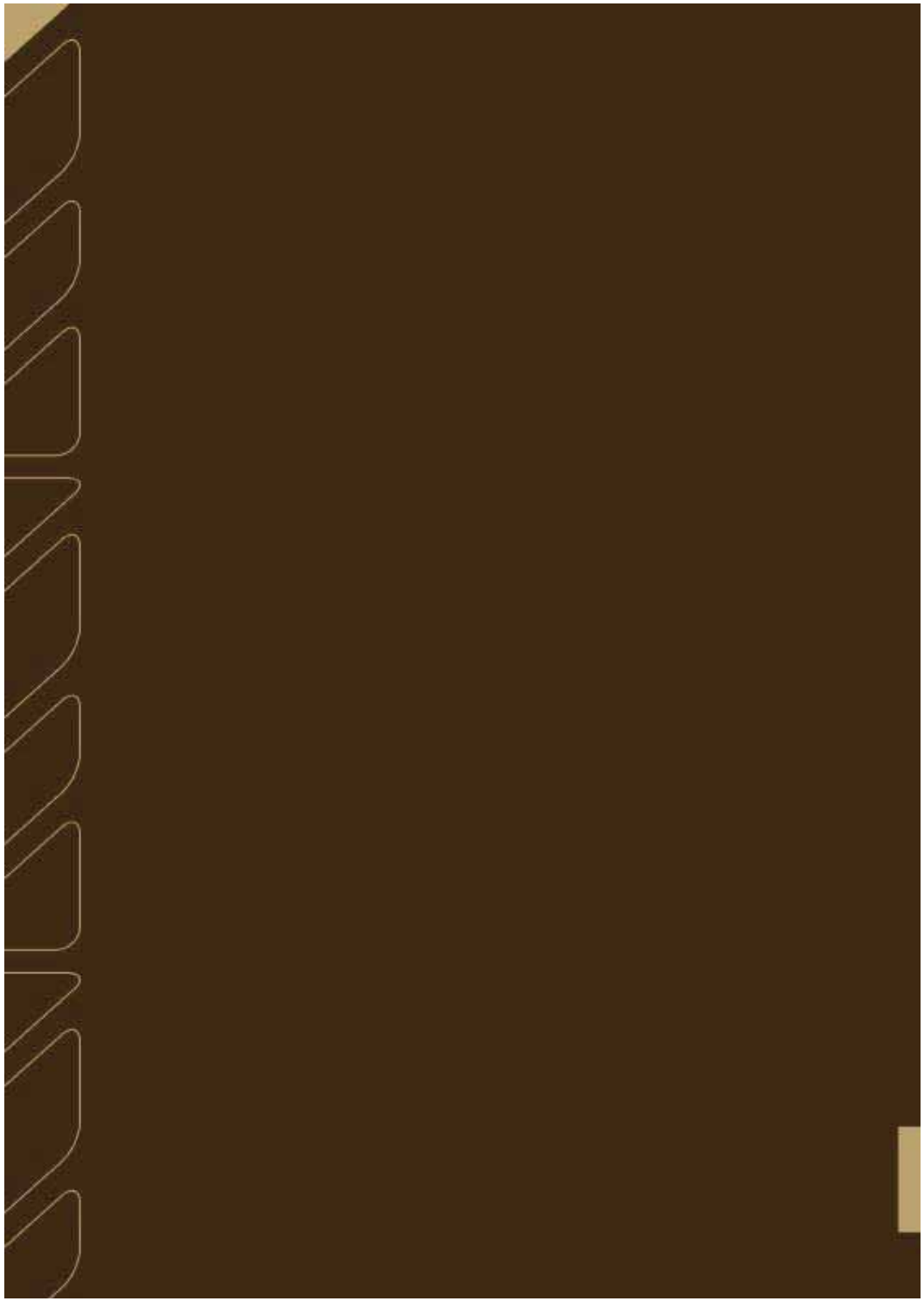
Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
4	Moderate foraging value. Examples: Woodland/forest with tree banksias 20- 40% projected foliage cover; Eucalypt Woodland/Forest with Marri 20-40% projected foliage cover.					Moderate foraging value. Examples: Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; Sheoak Forest with 40-60% projected foliage cover.			4	4

Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
5	Moderate to High foraging value. Examples: Banksia Forest with 40-60% projected foliage cover; Banksia Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; Pine plantations with trees more than 10 years old.					Moderate to High foraging value. Examples: Marri-Jarrah Forest with 40-60% projected foliage cover; Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. Sheoak Forest with > 60% projected foliage cover.				
6	High foraging value. Example: Banksia Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).					High foraging value. Example: Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).				

Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
Site Context Score- Percentage of the existing native vegetation within the "local" area that the study site represents NOTE- if starting score < 3 always score 0										
0- (<0.1%)		0	0	0	0		0	0	0	0
1- (0.1-1% breeding likely: 1-5% breeding unlikely)										
2- (1-5% breeding likely: 5-10% breeding unlikely)										

Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
3- (>5% breeding likley:>10% breeding unlikely)										
Species Density NOTE- if starting score <3 always score 0										
0- (species is recorded or reported very infrequently and there is little or no foraging evidence)		0	0	0	0		0	0		0

Starting site score	Foraging habitat for Carnaby's Cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth	Foraging habitat for Forest Red-tailed Black cockatoo	FHT01 Paddock Gtrees	FHT02 Planted Eucalypts	FHT03 Sheoak Windbreak	FHT004 Wandoo Regrowth
1- (species is seen or reported regularly and/or there is abundant foraging evidence)		1					1			
Total		2	2	2	0		2	2	4	4





Attachment 4

Local Water Management Strategy

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LOCAL WATER MANAGEMENT STRATEGY

Bullsbrook South Urban Expansion Area

PW011323
25/09/2025



Document status

Version	Purpose of document	Authored by	Reviewed by	Review Date
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Approval for issue

Name	Signature	Date
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Executive summary

This Local Water Management Strategy (LWMS) has been prepared on behalf of Mirvac WA Pty Ltd, to support the Local Structure Plan (LSP) submission for a number of lots in Bullsbrook, within the City of Swan. The LSP area comprises approximately 204 hectares (ha) of land in Bullsbrook, comprising Lots 2, 4, 5, 6, 20, 61, 100, 201, 400, 802, 803, 900, and 1011. The site is delineated by the Kingsford Estate to the north, the Great Northern Highway to the west and Stock Road to the south. The area is proposed to be developed for low to medium density residential purposes and to incorporate a primary school, a commercial precinct, local public open space, and a foreshore reserve for the Nambad Brook.

An inventory of the key elements for inclusion in the LWMS report, together with a cross-reference to the relevant sections in this document, is presented in Table 1.

Table 1: Design objectives and strategies

Key LWMS elements	Details
Introduction (Section 0)	Mirvac WA Pty Ltd are seeking Structure Plan approval for a 204 ha. parcel of land located in Bullsbrook, within the City of Swan. The site is currently zoned "General Rural" and "Landscape" under the City of Swan Planning Scheme No. 17. The development of the Local Structure Plan is in accordance with the Regional Water Management Strategy Report for Bullsbrook Townsite Area, the District Water Management Strategy for Marin Bullsbrook Urban, and the Addendum to the District Water Management Strategy for the Bullsbrook South Expansion Area. The majority of the site has been cleared of vegetation for agricultural purposes, with remnant vegetation existing towards the east and northeast boundaries of the site, as well as along the Nambad Brook.
Climate (Section 2.3)	The site is characterized by a Mediterranean climate, experiencing an average of 656 mm rainfall annually, with the majority being received between May and September. The site experiences monthly mean minimum temperatures between 8.2 ºC and 17.6 ºC and monthly mean maximum temperatures between 17.9 ºC and 33.6 ºC.
Topography (Section 2.4)	The eastern portion of the site is at a higher elevation and relief (up to approximately 95 mAHD at the eastern boundary) than the western part of the site which is at a minimum of approximately 35 mAHD at the western boundary.
Geology (Section 2.5)	The majority of the site is underlain by the Forrestfield System, with smaller sections located on the Murray Valley System and the Pinjarra System. The site is predominantly underlain by silty sands. The low-lying land at the western part of the site is classified as pebbly silt, whereas a schist formation exists towards the east. Two geotechnical investigations have been undertaken across the site which generally encountered sandy gravel / silty gravel overlying clayey sand in the northern portion of the site and sandy clay / clay in the central and southern portions of the site. The majority of the site is not mapped as having a known Acid Sulphate Soils risk, with only two small areas at the eastern boundary mapped as having a 'low to moderate' risk of ASS occurring.
Groundwater (Section 2.8)	The site is underlain by the Perth - Superficial, Perth - Leederville, and Perth - Yarragadee aquifers. Groundwater underlying the site generally has a south-westerly flow direction. The historical maximum groundwater level across the site has been estimated from groundwater level data monitored at locations within and adjacent to the site, as well as long-term Department of Water and Environmental Regulation monitoring. The estimated maximum groundwater levels generally range from 2 metre below ground level (mbgl) to 22 mbgl. Whilst there is expected to be at least several metres separation to the superficial aquifer, there is potential for shallow perched groundwater to occur at the site given the soil conditions.
Surface hydrology (Section 2.9)	Several non-perennial watercourses and agricultural drains traverse the site itself from east to west, with culverts beneath Great Northern Hwy connecting these to drains down-gradient of the site which ultimately discharge into the Ellen Brook located approximately 1.5 kms west of the site. The Nambad Brook has been identified as the most significant watercourse within the site and transects the northeastern portion.
Wetlands (Section 2.10)	The majority of the site is classified as a Multiple Use Wetland (MUW). There are no Resource Enhancement Wetlands (REW) or Conservation Category Wetlands (CCW) mapped within the site, and the nearest CCW is located approximately 300 m to the west of the site.
Foreshore area (Section 3)	A biophysical assessment of the Nambad Brook was undertaken by Western Environmental (Western Environmental Pty Ltd, 2023) which described the hydrological and ecological values of the watercourse and defined a foreshore area for the Nambad Brook. The LSP layout has been informed by the biophysical assessment, with the defined foreshore area being wholly contained within the POS corridor (other than one proposed road crossing).
Water conservation and non-potable water supply (Section 5)	The use of water efficient fixtures and fittings within households will be promoted, to reduce household potable water use. POS areas will be irrigated with groundwater abstracted from the aquifers underlying the subject area. Irrigation application rates will be tailored to suit the water requirements of the proposed landscaping (shrubs, turf, and littoral) used within POS areas, to ensure efficient use of water for irrigation. Waterwise landscaping design will also incorporate waterwise native plants to reduce irrigation demand and turf will be limited to areas of active recreation. Two existing groundwater licences are associated with the landholdings within the LSP area, with one of these being for an allocation of 27,800 kL from the Superficial Aquifer and held by the major landowner / developer. In addition to this, three applications for the transfer of a combined Leederville aquifer allocation of 52,032 kL are currently in progress with the Department of Water and Environmental Regulation. Therefore, the total anticipated groundwater allocation for the LSP area is 81,332 kL, which is sufficient to meet the permanent irrigation requirements of the LSP area including POS areas and future school oval.
Stormwater management (Section 6)	The following design objectives and criteria are adopted in the stormwater management strategy and preliminary drainage design: ▪ Manage stormwater quantity and quality with a water sensitive urban design approach which seeks to minimise drainage infrastructure and long-term maintenance requirements and incorporate stormwater management infrastructure within the urban form and landscaped areas. ▪ Maintain pre-development peak flow rates from the site, to protect downstream properties and receiving watercourses from increased flood risk. ▪ Manage, retain and/or detain, and treat stormwater run-off from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical. ▪ Habitable floor levels to be at least 0.3 m above the 1% AEP flood level of the urban drainage system and road reserve. ▪ Habitable floor levels to be at least 0.5 m above the 1% AEP flood level of the Nambad Brook. The preliminary stormwater drainage demonstrates that the land is capable of managing stormwater for all events up to 1% AEP event. Stormwater run-off from constructed impervious surfaces generated by the first 15 mm of rainfall will be managed at-source as much as practical using soakwells (on lots) and bio-retention basins/swales located in the POS. Other, at-source infiltration mechanisms will be considered at detailed design stage and incorporated within road reserves where

	practical (e.g., potential use of tree pits or roadside swales at locations where there is no crossover frontage for lots). A pit-and-pipe drainage system will be designed to cater for flows up to 20% AEP. Where practical (e.g., adjacent to pervious POS areas or open channel drainage systems), overland flow of stormwater rather than piped conveyance will be utilised to promote at-source infiltration and disconnection of impervious catchment areas. Rainfall events greater than 20% AEP will be conveyed via overland flow through the road network to flood detention basins or open channel conveyance systems. Stormwater events greater than 1EY will be allowed to overtop bioretention basins and be conveyed to the Nambad Brook, vegetated conveyance channels and culverts along the Great Northern Highway. Flood storage for all rainfall events up to and including the 1% AEP will be provided by a combination of bioretention basins/swales, flood detention basins, the Nambad Brook and conveyance channels. A preliminary design for these systems is presented herein which manages flow rates discharging off-site through culverts along the Great Northern Highway in line with pre-development hydrological modelling and design criteria for the regional drainage system. Structural and non-structural controls will be used to improve stormwater quality. The use of bio-retention basins and flood detention basins, native vegetation where possible, minimal fertiliser application, and soil amendment will assist with the management of groundwater and surface water quality. Native vegetation will be maintained in all suitable stormwater management areas to remove nutrient through plant uptake prior to infiltrating to the groundwater.
Groundwater management (Section 7)	Underlying groundwater resources will be protected by minimising nutrient export to maintain or improve the quality of groundwater leaving the site through: ▪ encouraging infiltration of stormwater as close to source as possible (e.g., use of soakwells, road run-off directed to bioretention areas within the streetscape or POS) to prevent mobilisation of contaminants to downstream drainage / infiltration areas. ▪ all drainage areas will have adequate separation to the superficial aquifer given this is estimated to occur generally several metres or more beneath the site. Separation from drainage areas to potential perched groundwater systems will be provided through the use of imported fill and subsoil drainage. ▪ utilising waterwise gardening and landscaping practices to minimise fertiliser use and irrigation. Amended soil with a PRI >10 will be used beneath bioretention areas. Infrastructure will be protected from groundwater inundation through: ▪ clay grading and / or subsoil drainage to provide a minimum of 1.2 m between lot levels and the post-development controlled groundwater level (CGL).
Monitoring (Section 8)	Pre-development surface water and groundwater monitoring was completed by Cardno over the subject site and a broader area in 2007-2009. The monitoring program included 6 bores within the LSP area (and several others nearby) which were monitored monthly for levels and quarterly for quality over 25 months. Post-development surface water and subsoil drainage discharge monitoring is proposed to be undertaken for a period of two years, after which a decision will be made in consultation with the City of Swan and DWER as to whether subsequent monitoring is required. The post-development monitoring program will involve quarterly analysis of water quality, and opportunistic monitoring of surface water levels and quality during the monitoring period.
Implementation (Section 9)	Details regarding the UWMP requirements, roles, and responsibilities related to water management have been provided.

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1. Introduction

1.1. Project background

Mirvac WA Pty Ltd ('Mirvac') is progressing Local Structure Planning over a group of landholdings with a combined area of approximately 186 hectares (ha) in Bullsbrook within the City of Swan (CoS), comprising Lots 2, 5, 6, 20, 61, 100, 201, 400, 802, 803 and 1011 Great Northern Highway, and Lots 4 and 900 Lage Road. The subject area of the Local Structure Plan is bound by the Kingsford Estate to the north, the Great Northern Highway to the west and Stock Road to the south, as show in Figure A.

The combined landholdings (hereafter referred to as "the site") are proposed for residential development, including the provision of low to medium density residential lots in conjunction with other land uses such as a primary school, a commercial precinct, as well as multiple areas of public open space (POS) and a foreshore reserve associated with the Nambad Brook.

This Local Water Management Strategy (LWMS) has been prepared on behalf of Mirvac to support the Local Structure Planning for the Bullsbrook South Urban Expansion Area project by detailing the integrated water management strategies to be implemented in the proposed development.

1.2. Planning background

The site is zoned under the Local Planning Scheme (LPS) as "General rural" and "Landscape" for the City of Swan Planning Scheme No. 17 (Department of Planning, Lands and Heritage, 2021). According to the Metropolitan Regional Scheme (MRS) the site is zoned as "Urban Deferred", however, the site is currently the subject of an MRS amendment and Lifting of Urban Deferment assessment by the Western Australian Planning Commission (WAPC). As such, Mirvac is advancing the LSP for the Bullsbrook South site concurrent with the MRS amendment and the Lifting of Urban Deferment.

1.3. Previous water management planning

GHD prepared the Regional Water Management Strategy Report for Bullsbrook Townsite Area (GHD, 2012) which included the subject site. The design criteria from this were incorporated into the DWMS (Emerge Associates, 2021) as well as the DWMS Addendum (Pentium Water, 2024) that were prepared for the site and have guided water management criteria adopted in this LWMS. The key Regional Water Management Strategy (RWMS) design criteria that are relevant to this LWMS include the following:

Water Conservation and Water Use Efficiency

- Developments should aim to achieve a target of less than 100 kL per person per year, and where a non-drinking water source is available, should achieve a target of not more than 60 kL/person/yr.
- Waterwise landscaping techniques should be employed in POS and irrigation should be restricted during the day.

Stormwater Management

- The 1 EY one hour event should be retained at the source through the use of retention (soakage) or stage devices.
- Floodways are to be maintained with respect to their ecological value and current hydraulic capacity; and should be restored if required so they function as an ecological environment and a healthy watercourse.
- Flood detention/storage areas shall be incorporated into POS and located outside defined floodways. Where the 1-year critical duration EY event has already been retained (i.e., part of the initial losses), this volume does not need to be accommodated again in the detention/storage areas.

- To reduce health risks from mosquitoes, retention and detention treatments should be designed to ensure that between the months of November to May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.
- Swales/vegetated bioretention systems are to be sized at a minimum of 2% of the constructed impervious area from which they receive run-off.
- Residential development may not occur within floodways.
- Minimum habitable floor levels shall be a minimum of 0.5 m above the 1% AEP flood level in rivers or main drainage networks.
- Minimum habitable floor levels shall be a minimum of 0.3 m above the 1% AEP flood level in local drainage networks.

Project infrastructure

- Development may not occur within floodways.
- Minimum habitable floor levels must be at least 0.5 m above the 1% AEP flood levels within flood storage basins or surface water features.
- Minimum habitable floor levels must be at least 0.3 m above the 1% AEP flood levels in local drainage networks.
- Minor roads shall be passable in the 20% AEP event.

Groundwater Management

- Where a perched water table exists or the predicted maximum groundwater level is at or within 1.2 metres of natural ground levels, measures should be implemented to ensure that adequate separation of building floor slabs from groundwater is achieved. This may include lowering the groundwater levels where possible, the importation of clean fill or installation of subsoil drainage.
- Proposals to lower groundwater levels must demonstrate no or negligible impact on groundwater dependent ecosystems. In particular where subsoil drainage is proposed within the groundwater capture zones of wetlands, designs must be developed with consideration of ecological water requirements for groundwater dependent ecosystems.

Nutrient Management

- Clean fill imported onto the site is to have a capacity to reduce phosphorus export via soil leaching, while also meeting soil permeability and soil compaction criteria specified by the City of Swan.
- Manage groundwater quality at pre-development (winter) concentrations and if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the catchment.
- If the pollutant outputs of the development exceed catchment ambient conditions, the proponent shall achieve water quality improvements within the development area. If catchment ambient conditions have not been determined, the development should meet relevant water quality guidelines stimulated in ANZECC (ANZECC, 2000).
- Prior to the construction of flood detention/storage areas, phosphorus retention index testing (PRI) will be undertaken to measure the PRI of the soils. A PRI of less than 10 is considered low and will require amendment.

1.4. Proposed structure plan

The Local Structure Plan for the Bullsbrook South Urban Expansion Area covers approximately 186 ha and includes Lots 2, 5, 6, 20, 61, 100, 201, 400, 802, 803 and 1011 Great Northern Highway, and Lots 4 and 900 Lage Road. The Local Structure Plan is shown in Appendix A. The proposed development of the site will provide sustainable and affordable housing in Perth's northeast area. The development will allow for the creation of several hundred residences, as well as a primary school, a commercial precinct, and multiple areas of public open space (POS) and a foreshore reserve associated with the Nambad Brook.

1.5. Design objectives

This LWMS has been prepared in accordance with State Planning Policy 2.9: Water Resources (Government of Western Australia, 2007) and has been developed with reference to the following guidance documents:

- Western Australia State Water Plan (Government of Western Australia, 2007)

- Stormwater Management Manual for Western Australia (Department of Water, 2004-2007)
- Interim: Developing a Local Water Management Strategy (Department of Water, 2008)
- Better Urban Water Management (Department of Planning and Infrastructure, 2008)
- Liveable Neighbourhoods (Western Australian Planning Commission, 2015b)
- Water monitoring guidelines for better urban water management strategies and plans (Department of Water, 2012)
- Decision Process for Stormwater Management in WA (Department of Water and Environmental Regulation, 2017)
- Operating Policy 4.3: Identifying and establishing waterways foreshore areas (Department of Water, 2012)

These documents guide how stormwater will be managed in the development and influence the form and function of the public open space and the developable area.

The LWMS details the integrated water management strategies to facilitate future urban water management planning. The LWMS will achieve integrated water management through the following design objectives:

- Effectively manage the risk to human life, property damage and environmental degradation from water contamination, flooding, and waterlogging.
- Maintain and if possible, improve water quality (surface and groundwater) within the development in relation to pre-development water quality.
- Reduce potable water consumption within both public and private spaces using practical and cost-effective measures.
- Implement best management practices in regard to stormwater and groundwater management.
- Incorporate where possible, low maintenance, cost-effective landscaping, and stormwater treatment systems.
- Reduce the use of natural resources (e.g., sand fill) where possible.

1.6. Previous studies

A number of on-site investigations and environmental reports have previously been completed for the site and surrounding land to support the proposed land use planning changes. The documents that have been referred to for the preparation of the LWMS include:

- District Water Management Strategy - Marlin Bullsbrook Urban (Emerge Associates, 2021)
- Addendum to District Water Management Strategy - Bullsbrook South Urban Expansion Area (Pentium Water, 2024)
- Regional Water Management Strategy - Bullsbrook Townsite Area (GHD, 2012)
- Biophysical assessment for Nambad Brook - Marlin Bullsbrook (Emerge Associates, 2018)
- Bullsbrook Surface and Groundwater Monitoring - Marlin Bullsbrook (Cardno, 2010)
- District Water Management Strategy - Great Northern Gateway (Cardno, 2012)
- Local Water Management Strategy - Bullsbrook Landholding (RPS, 2018)
- Local Water Management Strategy - South Bullsbrook Industrial Precinct (Bioscience, 2014)
- Local Water Management Strategy - South Bullsbrook Industrial Precinct LSP1 (Emerge Associates, 2014)
- Local Water Management Strategy - Lot 301 Stock Road & Lot 302 Lage Road Bullsbrook (Cardno, 2011)
- Local Water Management Strategy Addendum - Lot 301 Stock Road & Lot 302 Lage Road Bullsbrook (Cardno, 2017)
- Environmental Assessment Report - Bullsbrook South Urban Expansion Area (Western Environmental Pty Ltd, 2024)
- Report on Preliminary Geotechnical Study - Proposed Residential Subdivision - Various Lots Great Northern highway & Lage Road, Bullsbrook (Galt Geotechnics, 2022)
- Report on Preliminary Geotechnical Investigation - Proposed Bullsbrook Urban Precinct (Douglas Partners, 2020)

2. Existing environment

2.1. Site location and surrounding land use

The site is located in the suburb of Bullsbrook, which is part of the City of Swan, located approximately 35 km to the northeast of Perth CBD and 700 m south of the Bullsbrook townsite. The site has been predominantly cleared of vegetation and used for agricultural grazing and associated activities, other than a small extent of quarrying within Lot 201 which is evident from historical photographs and appears to have ceased and been rehabilitated in the 1980s or 1990s.

Small patches of remnant vegetation exist towards the east and northeast boundaries of the site, as well as along the Nambad Brook. The Nambad Brook traverses the northern part of the site, flowing in an east to west direction, before crossing under the Great Northern Highway via large culverts and then flowing southwest to its confluence with Ellen Brook approximately 1.5 kms west of the site.

The site is surrounded by the following land uses:

- northeast: slightly northeast of the site is the landfill operated by the City of Swan, which is to be decommissioned and rehabilitated according to an 'End of Life Management Plan'. The distance between the boundary of the subject site and the closest point of the landfill is approximately 270 m.
- northwest: immediately northwest of the site is the Swan Valley Nursery zoned as 'Urban Deferred', with residential properties as part of the Kingsford development zoned as 'Urban' further north.
- east: immediately east of the site is undeveloped agricultural land of the Darling Scarp zoned as 'Rural'. A quarry is also evident approximately 500 m to the east of the site, which is also zoned as 'Rural'. The Walyunga National Park is located approximately 550 m south-east of the site, zoned as 'Regional Open Space'.
- south: bounding the site to the south is Stock Road, beyond which is the Lynward Park Horse Stud zoned as 'Urban Deferred'. Further south is an unnamed private road reserve, with the area south of this road comprising agricultural land zoned as 'Rural'.
- west: immediately west of the site is the Great Northern Highway, with a mix of commercial/industrial and agricultural land uses immediately west of the Great Northern Highway. The land further west is zoned as 'Industrial', with the RAAF Base Pearce located approximately 800 m northwest of the site, zoned as 'Public Purposes - Commonwealth Government'.

2.2. Historical land use

Historical photographs were reviewed by Western Environmental (Western Environmental Pty Ltd, 2024) in 2023, which yielded the following observations:

Based on the earliest available historical aerial photograph (1965) the site is cleared of most vegetation and most likely used for agricultural purposes, i.e., paddocks inferred for livestock and/or crops. Small patches of remnant vegetation are evident in the southeastern and northeastern areas of the site. There are approximately five to ten rural residential properties present in the central and southern parts of the site.

An inferred rural residential property on Lot 201 has had a small extension added between 1965 and 1974, according to the aerial images available for this period. However, the aerial photographs from 1985 and 1989 indicate this property has been demolished in this time period.

A cleared patch of sand is evident in the 1974 aerial, and additional rural residential properties are present in the northern and central parts of Lot 61 and in the southeastern corner of Lot 802.

The aerial photographs of 1977 indicate the small extent of a quarry and associated dam being present on the southeastern part of Lot 201, with an additional dam evident on the western portion of Lot 201 and on the southeastern portion of Lot 900.

A cleared sandy area is also evident on the southern part of Lot 900 in the 1983 aerial photograph. As indicated by the 1985 aerial, a dam has been constructed on Lot 61, which also indicated the expansion of the quarry in the southeastern corner of Lot 201 to the east and the north. Agricultural land uses are evident on the southern portion of Lot 900 in both the aerial photographs of 1985 and 1989.

According to the aerial photograph of 2000, the quarry on Lot 201 appears to have been decommissioned and rehabilitated, with two dams now being visible in the area. The aerial also indicates a small amount of agricultural cropping is evident on the western side of Lot 803. Brown structures are evident both north and east of the structures on Lot 61, which could indicate the presence of laydown areas or dams, although these are no longer present in the 2004 aerial image. However, this aerial does show the presence of a laydown area comprising pipes, tyres, and drums within the southern/central part of Lot 900.

The 2015 aerial photograph shows the inferred rural residential structures on Lot 802 appear to have deteriorated, with only the footprint of the central structures still present. Similarly, the structure located on Lot 61 appears to be dilapidated according to the 2018 aerial.

According to the aerial imagery, the site surrounds have predominantly comprised agricultural and rural residential land on all sides. A quarry approximately 200 m southeast of the site is first evident from the 1979 aerial, after which it moves further north expanding in size to the current location. The presence of commercial and industrial land uses was first indicated by the 1981 aerial, after which it has expanded both towards the north and the south between 1981 and 2000. The RAAF Base Pearce is first evident on the 1983 aerial, although it should be noted that this area had been redacted from earlier available aerials.

2.3. Climate

Bullsbrook experiences a Mediterranean climate with cool, wet winters and hot, dry summers. Peak rainfall periods are usually between May and September. The nearest Bureau of Meteorology (BoM) weather station to the site is the Pearce RAAF weather station (Station Number 009053), located approximately 2 km to the northwest of the site. Based on the rainfall data (Bureau of Meteorlogy, 2023) collected from 1937 to 2023 at this station, the local area experiences an average of 656 mm rainfall annually.

Other climate data has also been taken from the Pearce RAAF weather station. Based on climate data, the local area experiences a mean maximum temperature of 33.6 °C and a mean minimum temperature of 8.2 °C (Bureau of Meteorlogy, 2023). The monthly mean climatic data for rainfall and temperature is summarised in Table 2 below, with monthly rainfall data for the previous years presented in Figure 1. As shown in this figure, rainfall recorded exceeded the average rainfall for this site on a few occasions, but other months were exceptionally dry where recorded rainfall was greatly below the average.

Evaporation data estimated from The Department of Agriculture and Food (Luke, Burke, & O'Brien, 1987) indicates that evaporation generally exceeds rainfall annually at the site. On average there are three months of the year (June to August) where the rainfall exceeds the evaporation at the site.

Table 2: BoM Pearce RAAF weather station (No. 009053) monthly temperature, rainfall, and evaporation

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall	10.0	12.9	16.4	33.9	82.3	130.1	134.0	105.6	67.6	36.6	22.2	10.7	655.6
Mean max temp	33.6	33.3	30.6	26.4	22.1	19.0	17.9	18.5	20.2	23.6	27.3	30.6	25.3
Mean min temp	17.0	17.6	16.1	13.3	10.7	9.3	8.4	8.2	8.8	10.2	12.6	14.7	12.2
Mean evaporation	297	257	224	123	87	59	60	69	106	154	203	259	1,898

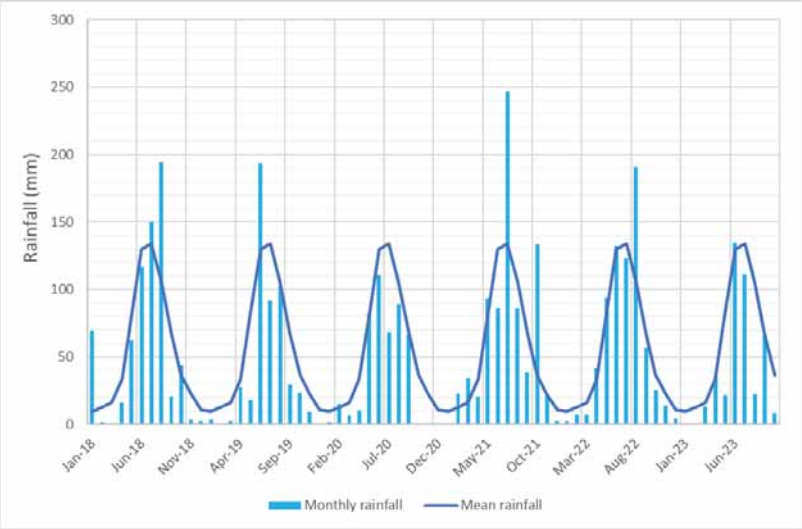

Figure 1: Previous years of monthly and historical rainfall - Pearce RAAF (No. 009053)

2.4. Topography

The site is located at the base of the Darling Scarp, with the land immediately to the east of the site comprising foothills of the Darling Scarp. The site itself has more gentle slopes, typically ~3% in the flatter western parts and ~5-10% on the steeper eastern side.

The topographic surface generally grades from the east to the west. The central-eastern boundary has a higher elevation (approximately 95 mAHD) than the north- and southeastern parts of the site (approximately 64 mAHD). The minimum elevation of approximately 35 mAHD can be found at the southwestern boundary (Figure B).

2.5. Geology

The site is located on the eastern boundary of the Gnangara Mound and is several 100 meters to the east of the Darling Fault, at the foothills of the Darling Scarp. As a result, the geology of the area is highly variable. According to the surface geology map (Department of Water and Environmental Regulation, 2023) the majority of the site is underlain by Colluvium including valley-fill deposits (Qrc), although a small section at the eastern part of the site is characterized by undifferentiated Precambrian crystalline rocks (Ag).

The naturally occurring soils mapped across the site are expected to be of low permeability, which will need to be considered in regard to the stormwater management strategy for the site and the feasibility of stormwater disposal via infiltration.

2.5.1. Land systems

Regional land systems have previously been mapped over the site and surrounding area. The mapping describes and groups the land with a recurring pattern on topography, soil type, and vegetation. Land systems mapping provides an indication of variability of the soils present over the survey area. According to the Soil Landscape Mapping data published by the Department of Primary Industries and Regional Development, the site is underlain by three different land systems (Figure C):

Forrestfield System (213Fo): underlaying the majority of the site, described as undulating foot slopes of the Darling and Whicher Scarps. The system consists of duplex sandy gravels, pale deep sands, and grey deep sandy duplexes. The vegetation generally consists of woodland of *Eucalyptus marginata*, *Eucalyptus calophylla*, and *Eucalyptus Wandoo* and some *Banksia grandis*.

Murray Valleys System (255Mv): underlaying a small portion at the eastern boundary of the site, described as Western Darling Range from the Avon Valley to Harvey. The system consists of deeply incised valleys with red loamy earths, shallow duplexes, and rock outcrops. The vegetation mainly consists of Jarrah-Marri-Wandoo Forest and woodland with mixed shrubland.

Pinjarra System (213Pj): underlaying a small portion at the northern boundary of the site, described as Swan Coastal Plain from Perth to Capel. The system consists of poorly drained coastal plain with variable alluvial and aeolian soils. The vegetation is variable and includes Jarrah, Marri, Wandoo, paperbark *sheoaks* and *rudis*.

2.5.2. Surface geology units

Environmental geological mapping (Gozzard, 1986) is provided in Figure D and indicates the site is dominated by three main surficial geological units:

Silty Sands (Msg): The majority of the site is comprised of silty sand that is described as strong brown, firm, friable and dispersive in parts. This unit occasionally has pebbly horizons with little matrix containing quartzite, quartz granite and laterite pebbles of colluvial origin.

Pebbly Silt (Mgs1): The northwestern boundary of the site is subject to a small amount of pebbly silt associated with the Guildford Formation. This geological unit is described as strong brown silt with occasional coarse grained, laterite, quartz, and heavily weathered granite pebbles with some fine to medium-grained quartz sand of alluvial origin.

Schist (SC2): Small parts at the eastern boundary of the site are mapped as schist that is described as grey to pale, highly schistose quarts mica schist.

2.5.3. Australian Soil Classification

The Australian Soil Resource Information System (ASRIS) contains interpolated soil data for the survey area, including classification of soils in line with the Australian Soil Classification (ASC). According to ASRIS, the majority of the site is classified as chromosols, described as soils with strong texture contrast between A horizons and B horizons. The latter are not strongly acid and are not sodic. Other areas of the site are underlain by hydrosols, tenosols, kurosols, and kandosols.

2.5.4. Soil Groups of Western Australia

The Soil Groups of Western Australia characterize the majority of the site as consisting of yellow/brown deep sandy duplex, with small areas of the site mapped as semi-wet soil, duplex sandy gravel, shallow gravel, pale deep sand, and yellow/brown shallow loamy duplex (Figure E).

2.5.5. Site investigation

A preliminary geotechnical investigation was undertaken by Douglas Partners (Douglas Partners, 2020) for the site, which included the excavation of 57 test pits to depths between 0.9 and 2.8 m, as well as Perth sand penetrometer (PSP) or dynamic cone penetrometer (DCP) testing. The main results from the Geotechnical Investigation include:

- The topsoil was generally 100mm thick and was predominantly sandy, fine to medium sized gravel/sand, low to medium plasticity fines, dark grey, brown, with roots.
- Two broad subsurface condition types were identified:
  - Site classification of 'M' across the majority of the site
  - Site classification of 'S' for a small area of the site
- No free groundwater was observed in any of the test pits excavated to a maximum depth of 3 m.
- Measured soil permeability ranged from 0.8 m/day to 20 m/day, whereas derived permeability (Hazen's formula) ranged from 1.2 m/day to 10 m/day.

A more recent preliminary geotechnical study was undertaken by Galt Geotechnics (Galt Geotechnics, 2022) for the subject site, which included the excavation of test pits at 18 locations, extending to depths between 1.0 and 3.2 m, as well as dynamic cone penetrometer

testing, and sample collecting for geotechnical laboratory testing. The main results from the preliminary geotechnical report include:

- The soil in the northern part of the site generally consisted of sandy gravel and silty gravel, characterized by fine to coarse grained, angular to sub-rounded, brown, approximately 5% to 20% non-plasticity fines soil overlaying clayey sand or sand.
- The soil of the central part of the site was predominantly sandy clay or clay with high plasticity, red brown, approximately 15% to 40% fine to coarse grained sand with traces of gravel.
- The soil of the central and southern parts was generally similar to the soil of the central part, but with a thin and irregular overlay of granular material (gravel or sand).
- Three broad subsurface condition types were identified:
  - Site classification of 'S' for the northern part of the site
  - Site classification of 'M' for the central and southern parts of the site
  - Site classification of 'H1/H2' for the central part of the site
- No groundwater was observed in any of the test pits. However, shallow perched groundwater is expected to develop on clayey soils during winter periods.

The Galt Geotechnics and Douglas Partners geotechnical reports are included as Appendices B and C, respectively.

2.5.6. Acid Sulphate Soils

Acid Sulphate Soil (ASS) is naturally occurring soil containing iron sulphides, which when oxidised, can lead to acidification of soils and groundwater and, consequently, extensive environmental damage. Department of Water and Environmental Regulation (DWER) broad-scale Acid Sulphate Soil (ASS) risk mapping is based on surface geology mapping and provides a broad-scale indication of the risk of occurrence of ASS. The majority of the site has not been assigned an ASS risk rating and it is therefore assumed there is 'no known ASS disturbance risk occurring within 3m of the surface', as indicated in Figure F. However, two areas at the eastern boundary of the site have been mapped as having a 'low to moderate' risk of acid sulphate soils occurring within 3m of the natural soil surface.

2.6. Contaminated sites

A search of the DWER Contaminated Sites database has been undertaken and no recorded contaminated sites were identified at the site or in its immediate surroundings (<1 km radius of the site centre). However, a former petrol station located approximately 1.5 km northwest of the site, identified as Lot 1 on Diagram 9938 (2532 Great Northern Highway), has been identified as 'remediated for restricted use' due to hydrocarbon impacted soils being present beneath the on-site building and forecourt area on-site. Based on the distance of this lot from the site and as it is inferred down-hydraulic gradient of the site, it is not considered to pose a constraint on the proposed development.

2.7. Public Drinking Water Source Areas

The Perth Groundwater Map (Department of Water and Environmental Regulation, 2023) indicates the site is not located within a Public Drinking Water Source Protection Area (PDWSA). The nearest PDWSA is the P1 Gnangara Underground Water Pollution Control Area located approximately 8 kms to the west of the site. No well head protection zones were identified on-site or within the immediate site surrounds.

2.8. Groundwater

2.8.1. Aquifers

Groundwater resource mapping available from the DoW Water Register (Department of Water and Environmental Regulation, 2022) indicates that the site is underlain by a multi-layered aquifer system comprising the following resources:

- Bandy Spring Subarea (unconfined) of the Swan Groundwater Area (Perth - Superficial Aquifer)
- Swan Subarea (confined) of the Swan Groundwater Area (Perth - Leederville Aquifer)
- Swan Subarea (confined) of the Swan Groundwater Area (Perth - Yarragadee Aquifer)

The aquifers are managed under the Gnangara Groundwater Areas Allocation Plan (Department of Water and Environmental Regulation, 2022).

2.8.2. Groundwater levels

2.8.2.1. Regional groundwater levels

Regional groundwater mapping by DWER indicates the groundwater flows in a south-westerly direction towards Ellen Brook, located approximately 1.5 kms to the west of the site. In the Perth Groundwater Map (Department of Water and Environmental Regulation, 2023), the site is mapped on the fringe of the Gnangara Jandakot groundwater contours, with the western boundary of the site just outside of the available DoW datasets. Due to the close proximity to the site, these groundwater contours could still be indicative of groundwater levels and range from 5 metres below ground level (mbgl) in the southwest to 15 mbgl in the northwest.

The Perth Groundwater Atlas, however, provides groundwater contours from May 2003 which cover the western boundary of the site. These contours are considered to be minimum groundwater elevations and suggest that minimum groundwater levels at the western boundary of the site are between approximately 35 mAHD and 40 mAHD (which correspond to groundwater depths of between approximately 1 and 4 mbgl) (Emerge Associates, 2021).

2.8.2.2. Site-specific groundwater levels

A site-specific pre-development groundwater monitoring program (Appendix E) over a relatively large area was undertaken by Cardno (Cardno, 2010), which encompassed the subject site. The monitoring program included the installation of 13 groundwater monitoring bores followed by monthly measurements of groundwater levels and quarterly collection of groundwater samples over a 25-month period from November 2007 to December 2009. Seven of the 13 monitoring bores were located in the subject area, of which the hydrograph is shown in Figure 2. Peak groundwater levels were generally observed in October, although some locations experienced the peak groundwater elevations in July.

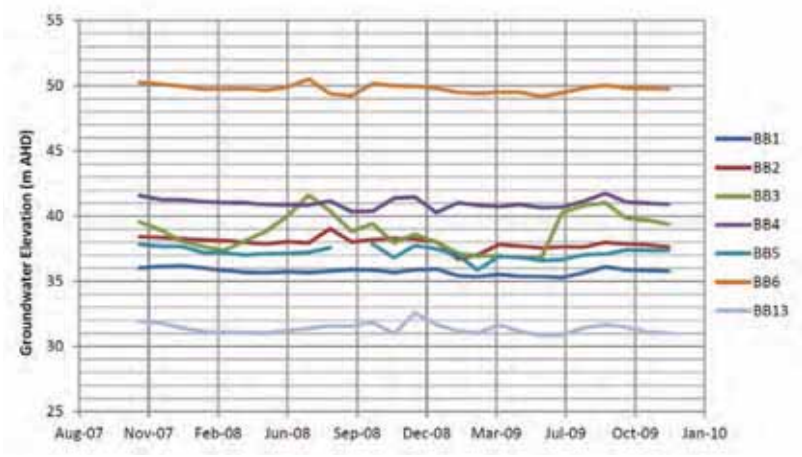

Figure 2: Groundwater hydrograph (Emerge Associates, 2021)

Emerge Associates (Emerge Associates, 2021) estimated maximum groundwater levels using the Cardno monitoring data along with long-term data from a nearby DWER monitoring bore to adjust the site-specific data to reflect longer-term observations for the area (Appendix F). As such, peak elevations measured in October 2008 and 2009 were referenced to DWER long term records from nearby monitoring location GD15 (WIN Site ID 5426). Maximum

groundwater level contours presented in the DWMS (Emerge Associates, 2021) range from 33 mAHD in the southwestern corner of the site to 50 mAHD at the northern boundary of the site.

The results of the Cardno monitoring program and the estimation of maximum groundwater level contours by Emerge Associates indicate a south-westerly groundwater flow direction. The least clearance to the maximum groundwater level is observed at monitoring bore BB3 at the northwestern boundary of the site, where the groundwater was at the natural ground surface. However, this is considered to be reflective of locally perched groundwater rather than the regional superficial aquifer, as evident from the hydrographs in Figure 2 showing unusually high fluctuations in BB3. Pentium Water have re-contoured estimated maximum groundwater levels (refer to Figure G) excluding the anomalous BB3 values and several other anomalous data values from other bores, as indicated in Appendix D. The depth from natural surface level to the interpolated maximum groundwater levels range from approximately 2 m in the southwest to approximately 22 m in the northeast.

Typically, there is at least several metres separation to the superficial aquifer, however, there is also expected to be shallow groundwater near or at the ground surface as a result of perching on low permeability soils.

2.8.3. Groundwater quality

Groundwater quality monitoring has also been undertaken as part of the Cardno (Cardno, 2010) groundwater monitoring program, which included the quarterly collection of groundwater samples between November 2007 and December 2009, which were sent to a NATA accredited laboratory to be analysed for a suite of nutrients. Physic-chemical parameters were also measured in the field as part of the monitoring events. The average results measured by Cardno and the relevant guideline values for lowland rivers in southwest Western Australia (ANZECC, 2000) are provided as Appendix E and summarised in Table 3.

Table 3: Summary of average groundwater quality monitoring results (Cardno, 2010)

Parameter	Guideline	BB1	BB2	BB3	BB4	BB5	BB6	BB13
Temperature (°C)		22.79	22.28	21.70	22.71	21.95	21.53	22.28
Electrical Conductivity (mS/cm)	0.12 - 0.30	5.50	3.03	0.41	2.37	1.38	2.82	5.86
Dissolved Oxygen (% saturation)	80 - 120	36.35	19.87	34.83	34.94	55.07	36.62	27.13
pH (pH units)	6.5 - 8.0	5.40	5.68	4.99	6.00	5.75	4.89	5.29
Redox (mV)		46.13	105.13	181.75	58.50	143.50	128.15	138
Ammonium as N (mg/L)	0.08	0.046	0.017	0.038	0.028	0.012	0.050	0.026
Nitrates and Nitrites as N (mg/L)	0.15	0.191	1.015	0.673	2.243	0.857	0.280	0.008
Total Kjeldahl Nitrogen as N (mg/L)		0.628	0.466	1.120	1.314	0.720	0.438	0.413
Total Nitrogen as N (mg/L)	1.20	0.743	1.111	1.431	3.425	1.347	0.773	0.455
Phosphate as P (mg/L)	0.040	0.009	0.015	0.002	0.032	0.014	0.010	0.016
Total Phosphorous as P (mg/L)	0.065	0.192	0.105	1.079	2.005	0.229	0.280	0.694

Note: Orange shading indicates guideline exceedance.

The physico-chemical parameters measured during the groundwater monitoring program indicated that the average pH ranged from acidic to slightly acidic, ranging from 4.89 to 6.00, while salinity (measured as electrical conductivity) was found to be fresh to brackish with average concentrations ranging from 410 µS/cm to 5860 µS/cm.

Nutrient parameters indicated that average nutrient concentrations in bores within the subject site were generally low to moderate. Average concentration of total nitrogen and NO_x (nitrates and nitrites) were 1.33 mg/L and 0.75 mg/L respectively, with the average total nitrogen concentration at BB4 being slightly elevated, although this was generally moderate throughout the monitoring period. Average concentrations of total phosphorous and phosphate were 0.65 mg/L and 0.014 mg/L respectively, although notably high concentrations of total phosphorous were recorded at monitoring bores BB3 and BB4. These measurements were generally accompanied with a relatively high standard deviation which indicates significant variability in total phosphorous concentrations during the monitoring period, although an outlier may have skewed the results as well.

2.9. Surface hydrology

The site falls within the catchment area of the Ellen Brook which is located approximately 1.5 kms west of the site. Several non-perennial watercourses and agricultural drains traverse the site itself from east to west, as shown in Figure H. The largest of these watercourses is the Nambad Brook which enters the northeastern part of the site via a relatively large, constructed dam located immediately east outside of the site boundary. A less defined broad feature runs in parallel approximately 100-150 m north of the Nambad Brook, comprising a broad low-lying valley floor. In the central portion of the site a broad agricultural drainage feature is present, with two branches originating in the east and converging in the centre of the site before heading west. The agricultural drain has likely replaced the lower reaches of these smaller creeks. The drain has a clearly defined channel with an approximate depth between 0.5 to 1 m and a width between 1 and 3 m. This feature was found to have been subject to several course modifications having been straightened from the original course in sections, particularly following the north-south running section of Lage Rd and running west from Lage Rd. Several dams are also present within the site boundaries (Western Environmental Pty Ltd, 2024).

There are a total of seven culverts along the western site boundary which discharge water from the site beneath Great Northern Highway, as shown in Figure H. The southern-most of these culverts (culvert No. 7) is a relatively new culvert, installed as part of the Great Northern Highway-Stock Road intersection roundabout works; it appears that this culvert replaces a previous culvert at this approximate location which discharged in a southerly direction beneath Stock Road. Culvert No. 1 facilitates drainage from a catchment area to the north of the site and largely within the Kingsford Estate development area; it is understood from the Kingsford LWMS (RPS, 2017) that this catchment will be partially re-routed to Ki-it Monger Brook as part of the Kingsford development.

2.9.1. Nambad Brook

The Nambad Brook has an approximate 238 ha catchment area upstream of a large existing dam adjacent to the eastern boundary of the site. Overflow from the dam is via a spillway into the watercourse that flows through the site from east to west, discharging under the Great Northern Highway via culverts, ultimately discharging into the Ellen Brook. As part of the biophysical site assessments of the Nambad Brook undertaken by Emerge Associates in 2018 (Emerge Associates, 2018) as well as by Western Environmental in 2024 (Western Environmental Pty Ltd, 2024), the Nambad Brook has been identified as a clearly defined channel and incised along its length with the exception of two points where local vehicle access paths cross the channel. The absence of the incised channel in these locations is likely the result of mechanical erosion due to vehicle and stock access. Elevation at the bottom of the channel ranges from approximately 64 mAHD immediately after discharging from the dam weir to 46.25 mAHD at the point of confluence within Lot 401 to the west of the site (average slope of 1.4%) (Emerge Associates, 2018). The Nambad Brook conveys overflow from the upstream catchment that drains to the dam as well as run-off from local catchments via sheet flow during storm events, having a total contributing catchment area of approximately 267 ha (to the location where it meets Great Northern Hwy). The channel has an approximate depth between 1 to 1.5 m and a width between 2 and 10 m (Western Environmental Pty Ltd, 2024). Fringing this is a floodplain between 5 to 25 m wide on either side. During major rainfall events the channel would become fully inundated and spill into this floodplain.

2.9.2. Flow monitoring

Pre-development surface water monitoring in the study area has previously been undertaken by Cardno (Cardno, 2010), which included continuous measurement of the flow rate within Nambad Brook at its intersection with Great Northern Highway for the period June 2009 to October 2009. A rain gauge and flow meter were installed at this location with flow rates measured at 10-minute intervals. The flow rate monitoring captured the flow response to several rainfall events during the monitoring period, with velocities ranging from 0 m/s to 3 m/s. The cumulative volume of water observed to flow through this section of the Nambad Brook during 2009 was 225 GL. The highest peak discharge rate observed was 0.99 m^3/s in October 2009.

The highest observed monthly discharge was 119 GL, in July 2009, which was due to two significant rainfall events being experienced within two days. During this rainfall event 53.7 mm of rainfall occurred over 21 hours, which was estimated to equate to a 2-year average recurrence interval (50% annual exceedance probability) rainfall event. The peak discharge measured during this rainfall event was 0.77 m^3/s. Overall, monitoring at this location captured four significant rainfall events, which are summarised in Table 4.

Table 4: Observed significant rainfall events and corresponding peak discharge rates for Nambad Brook (Cardno, 2010)

Date	Observed Duration (min)	Observed Total Rainfall (mm)	Corresponding Design Rainfall Event	Observed Peak Discharge (m^3/s)
31 Jan 2009	30	8.6	1 year 30 min	0.00
18 June 2009	30	6.0	1 year 30 min	0.00
19 July 2009	1,270	53.7	2 year 1,440 min	0.77
20 July 2009	2,410	54.8	1 year 2,880 min	0.54

2.9.3. Hydrological modelling

A number of previous studies have included hydrological modelling to estimate design flow rates for the Nambad Brook as well as the smaller agricultural drain within the site and the other, minor culvert outlets from the site. These studies used the flow monitoring data discussed above to inform or calibrate the modelling estimates of major event (i.e., 1% AEP) design flows. The relevant studies include a District Water Management Strategy prepared by Cardno (Cardno, 2012) for the Great Northern Gateway located immediately downstream of the subject site, and a Local Water Management Strategy prepared by Emerge Associates (Emerge Associates, 2014) for the southern portion of the same development. These studies are included in this report as Appendices G and H, respectively.

The pre-development modelling undertaken by Cardno (Cardno, 2012) indicates that the peak discharge from the site via the Nambad Brook (culvert No. 2) during a 1% AEP event is 21.6 m^3/s. The peak discharge rates from the agricultural drain (culvert No. 4) and the southern outlet (culvert No. 6) are estimated to be 7.5 m^3/s and 5.3 m^3/s, respectively. Emerge Associates (Emerge Associates, 2014) estimated the peak discharges from these culverts at 7.17 m^3/s and 5.26 m^3/s, respectively.

Further hydrological modelling of both the existing and proposed post-development scenarios have been undertaken as part of this LWMS to inform the drainage conveyance and detention storage requirements and to demonstrate the structure plan's ability to accommodate these appropriately within the urban design. This modelling effort is further elaborated upon in Section 6 and Appendix M.

The 1% AEP peak flow rates estimated in these studies, for the culvert locations as shown in Figure H, are summarised in Table 5 below.

Table 5: 1% AEP peak flow estimates for DWMS discharge locations

Culvert No.	Great Northern Gateway Industrial Cell DWMS (Cardno, 2012)	South Bullsbrook Industrial Precinct LWMS (Emerge Associates, 2014)	Bullsbrook South LWMS (Pentium Water)
	(m^3/s)	(m^3/s)	(m^3/s)
1	1.8	N/A	N/A
2	21.6	N/A	21.9
3	0.9	N/A	0.8
4	7.5	7.17	8.9
5	5.5	0.3	0.2
6	5.3	5.26	6.9
7	N/A	N/A	1.1

Notes: Hydrological modelling undertaken by Cardno (Cardno, 2012) and Emerge Associates (Emerge Associates, 2014) has been completed prior to the instalment of culvert No. 7. Hydrological modelling undertaken by Pentium Water (herein) has not included culvert No. 1 due to this culvert being outside the LSP boundary.

2.9.4. Surface water quality

A pre-development monitoring report detailing surface water quantity relevant to the site was prepared by Cardno (Cardno, 2010), and is provided as Appendix E. This report included surface water quality monitoring undertaken on eight occasions in Nambad Brook, at the point where the Nambad Brook crosses the Great Northern Highway (downstream of the site). A summary of the average results and the relevant guidelines for lowland rivers in southwest Western Australia (ANZECC, 2000) is provided in Table 6.

Table 6: Summary of average surface water quality monitoring results (Cardno, 2010)

Parameter	ANZECC	July 2008	Aug 2008	Aug 2008	June 2009	Aug 2009	Sep 2009	Sep 2009	Oct 2009	Mean
Temp (°C)		14.67	12.96	15.01	15.00	16.74	14.77	17.98	18.73	15.73
EC (mS/cm)	0.12 - 0.30	0.19	0.56	0.64	0.78	0.79	1.46	0.49	0.15	0.63
DO (%)	80 - 120	88.7	87.3	74.0	68.4	57.9	92.9	98.7	84.3	81.5
pH	6.5 - 8.0	7.26	6.93	7.36	7.67	6.98	6.98	7.01	7.00	7.15
Redox (mV)		202	117	112	115	140	124	104	127	130
NH_4-N (mg/L)	0.08	0.031	<0.003	0.018	0.200	0.040	0.040	0.110	0.030	0.059
NO_x-N (mg/L)	0.15	0.083	0.007	0.160	0.330	0.170	0.150	<0.010	0.050	0.120
TKN (mg/L)		1.00	0.50	0.60		0.50	0.60	0.40	0.40	0.50
TN (mg/L)	1.20	1.10	0.53	0.76	1.80	0.70	0.80	0.40	0.50	0.82
FRP (mg/L)	0.040	0.008	0.004	0.005	0.140	<0.010	<0.010	0.020	<0.010	0.026
TP (mg/L)	0.065	0.210	0.042	0.037	0.260	0.030	0.010	0.050	0.010	0.081

Note: Orange shading indicates guideline exceedance.

Water quality sampling indicated that nutrient concentrations were generally low to moderate, with average concentrations of total nitrogen and NO_x (nitrates and nitrites) being 0.82 mg/L and 0.12 mg/L, respectively whilst average concentrations of total phosphorus and phosphate were 0.081 mg/L and 0.024 mg/L, respectively.

The pH values were generally neutral, and the electrical conductivity was found to be slightly elevated. The peak in electrical conductivity values observed in September closely corresponds with the measured groundwater level peaks. Relatively high nutrient concentrations were observed during June and July; however, the baseline concentrations were all generally low. This is likely to correspond with the first rainfall events of the winter season flushing accumulated nutrients from the catchment.

2.10. Wetlands and GDEs

According to the Department of Biodiversity Conservation and Attractions (Department of Biodiversity, Conservation and Attractions, 2018) there are no natural water bodies within the site. However, there are several small, constructed farm dams or soaks located within the site, as well as a large, constructed dam on Nambad Brook immediately east of the site boundary.

The Department of Biodiversity Conservation and Attractions *Swan Coastal Plain Geomorphic Wetland Mapping* has identified a number of geomorphic wetlands within and in close proximity to the site (Figure I). The majority of the site is mapped as 'Multiple Use Wetland' (MUW) (UFI 15282) covering much of the southern and western portions of the site. The nearest 'Conservation Category Wetland' (CCW) or 'Resource Enhancement Wetland' (REW) are small mapped CCW areas associated with the Nambad Brook, including UFI 12417 and UFI 12419 located approximately 300 m and 475 m west of the site, respectively. Other small CCW areas in proximity to the site are associated with the Ki-it Monger Brook, including UFI 12415 and UFI 12424 located approximately 525 m and 550 m northwest of the site, respectively.

2.11. Sewage Sensitive Areas

Sewage Sensitive Areas (SSAs) are proclaimed under the *Government Sewerage Policy* (GSP) (Department of Planning, Lands and Heritage, 2019) to protect groundwater and surface water systems. A review of the GSP online data set (Geoscience Australia, 2023) maps the majority of the site as an estuary catchment on the Swan and Scott Coastal Plain, as well as being within 1 km of significant wetlands. It is understood that the developed site will need to be connected to reticulated sewerage, which is discussed further in Section 4.

2.12. Vegetation and Flora

2.12.1. Regional vegetation

Native vegetation is described and mapped at different scales in order to illustrate patterns in its distribution. To this extent, the Interim Biogeographic Regionalisation for Australia (IBRA) describes a system of 85 'biogeographic regions' (bioregions) and 403 sub-regions covering the entirety of the Australian continent (Thackway & Cresswell, 1995). Bioregions are defined on the basis of climate, geology, landforms, vegetation, and fauna.

At a continental scale the IBRA divides the Perth region into the Swan Coastal Plain (SWA) bioregion on the western side and the Jarrah Forest (JAF) bioregion on the eastern side (Environment Australia, 2000). The site occurs directly along the interface of these two IBRA regions, dividing the site in half along a north to south axis (Western Environmental Pty Ltd, 2024). Each of these bioregions is further subdivided into two floristic subregions: SWA1 'Dandaragan Plateau' and SWA2 'Perth' in the Swan Coastal Plain region and JAF1 'northern Jarrah Forest' and JAF2 'southern Jarrah Forest' in the Jarrah Forest region. The site is located on the boundary of the SWA2 and JAF1 subregions, and south of the SWA1 bioregion. The eastern side of SWA2 historically supported *Corymbia calophylla* (Marri) forest or woodland with a *Eucalyptus Wandoo* (Wandoo) component and some *Eucalyptus marginata* (Jarrah) on higher ground, with *Eucalyptus rudis* (flooded gum) or *Melaleuca spp.* (paperback) swamp in less well drained areas (Beard, 1990). The SWA2 subregion is recognised as a biodiversity hotspot and contains a wide variety of endemic flora and vegetation types. The JAF1 subregion is characterised as containing 'Jarrah Forest on ironstone gravels, Marri-Wandoo woodlands on loamy soils and *sclerophyll*-type understorey species' (Beard, 1990).

2.12.2. Vegetation system association mapping

Fine scale vegetation complex mapping indicates there are three vegetation complexes occurring within the site: the Guildford complex, the Forrestfield complex, and the Darling Scarp complex (Heddle, Loneragan, & Havel, 1980). Descriptions of these vegetation complexes are summarised below (Department of Biodiversity, Conservation and Attractions, 2017):

- The Guildford complex is described as a mixture of open forest to tall open forest of *Corymbia calophylla* (Marri), *Eucalyptus wandoo* (Wandoo), and *Eucalyptus marginata* (Jarrah) and woodland of *Eucalyptus wandoo* (Wandoo) (with rare occurrences of *Eucalyptus lane-poolei* (Salmon White Gum)). Minor components include *Eucalyptus rudis* (Flooded Gum) and *Melaleuca rhaphiophylla* (Swamp Paperbark).
- The Forrestfield complex is described as ranging from open forest of *Corymbia calophylla* (Marri), *Eucalyptus wandoo* (Wandoo), and *Eucalyptus marginata* (Jarrah) to open forest of *Eucalyptus marginata* (Jarrah), *Corymbia calophylla* (Marri), *Allocasuarina fraseriana* (Sheoak), and *Banksia* species. Fringing woodland of *Eucalyptus rudis* (Flooded Gum) in the gullies that dissect this landform can also be found.
- The Darling Scarp complex is described as low open woodland to lichens according to depth of soils with woodland components being chiefly Wandoo, with *Eucalyptus laeliae* in the north, *Eucalyptus haematoxylon* in the south, and Marri throughout the region.

2.12.3. Watercourse vegetation

In the Nambad Brook a small number of plants of riparian associated species *Melaleuca rhaphiophylla* and *Taxandria linearifolia* were present (Western Environmental Pty Ltd, 2024). Mature flooded gum (*Eucalyptus rudis*) trees are present within the channel feature. Flooded gum occurs within riparian zones, but also occurs in seasonally damp situations outside of these. Riparian vegetation, although severely degraded, is considered present within the Nambad Brook. The drainage feature running parallel 100m to the north of the Nambad Brook did not have any native vegetation present, or non-native vegetation indicating a riparian zone. The central drainage feature has scattered native species Wandoo (*Eucalyptus Wandoo*) present. However, Wandoo is not associated with riparian vegetation, and therefore no riparian vegetation is considered present associated with the central drainage feature.

2.12.4. Threatened Ecological Communities

As part of the Environmental Assessment undertaken by Western Environmental (Western Environmental Pty Ltd, 2024), an initial assessment for the potential presence of threatened and priority ecological communities was undertaken through the analysis of the Department of Biodiversity, Conservation and Attractions (DBCA) Threatened Ecological Communities Dataset and through the Department of Climate Change, Energy, Environment and Water (DCCEEW) Protect Matters Search Tool (Department of Climate Change, Energy, the Environment and Water, 2023). The DBCA dataset indicates that the northern corner of the site intersects with a feature mapped as potentially representing a threatened ecological community or an associated buffer, however, the area of the site intersecting this feature does not contain any remnant vegetation. The vegetation that appears to be associated with this feature occurs approximately 100m towards the east of the boundary. The DCCEEW Protected Matters Search Tool identified five ecological communities being likely or known to be present within the area (Department of Climate Change, Energy, the Environment and Water, 2023), which are shown in the table below:

Table 7: Protected Matters Search Tool - Ecological Communities (Department of Climate Change, Energy, the Environment and Water, 2023)

Community name	Presence assessment	Threatened category
Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain	Community may occur within area	Critically endangered

Community name	Presence assessment	Threatened category
Clay Pans of the Swan Coastal Plain	Community likely to occur within area	Critically endangered
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Community known to occur within area	Endangered
Banksia Woodlands of the Swan Coastal Plain	Community likely to occur within area	Endangered
Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain	Community known to occur within area	Endangered

Since the site has historically been cleared of the majority of native vegetation for agricultural purposes and associated activities, the site assessment concluded the site contains limited flora and vegetation. Therefore, remaining potentially suitable habitat for conservation significant ecological communities is expected to be limited.

2.12.5. Threatened and Priority Flora

As part of the Environmental Assessment undertaken by Western Environmental (Western Environmental Pty Ltd, 2024), an initial assessment for the potential presence of threatened and priority flora was undertaken through the analysis of the DBCA public Threatened and Priority Flora Dataset and the DCCEEW Protected Matters Search Tool (Department of Climate Change, Energy, the Environment and Water, 2023). The DBCA public Threatened and Priority Flora Dataset does not indicate any previous records of threatened or priority flora occurring within the site, however, several records of threatened flora were recorded approximately 3 km northeast and northwest of the site. The DCCEEW Protected Matters Search Tool identified eight listed flora species having habitat being likely or known to occur within the area (Department of Climate Change, Energy, the Environment and Water, 2023), which are shown in the table below:

Table 8: Protected Matters Search Tool - Flora (Department of Climate Change, Energy, the Environment and Water, 2023)

Species name	Common name	Presence assessment	Threatened category
Synaphea sp. Fairbridge Farm (D. Papenfus 696)	Selena's Synaphea	Species or species habitat likely to occur within area	Critically endangered
Diplolaena andrewsii	-	Species or species habitat likely to occur within area	Endangered
Grevillea curviloba subsp. *curviloba*	Curved-leaf Grevillea	Species or species habitat known to occur within area	Endangered
Grevillea curviloba subsp. *incurva*	Narrow curved-leaf Grevillea	Species or species habitat likely to occur within area	Endangered
Grevillea christineae	Christine's Grevillea	Species or species habitat likely to occur within area	Endangered
Thelymitra stellata	Star Sun-orchid	Species or species habitat likely to occur within area	Endangered
Acacia anomala	Grass Wattle, Chittering Grass Wattle	Species or species habitat likely to occur within area	Vulnerable
Eleocharis keigheryi	Keighery's Eleocharis	Species or species habitat likely to occur within area	Vulnerable

2.12.6. Bush Forever

Bush Forever areas are locally significant natural areas that require conservation. There are no Bush Forever sites located within the proposed development boundary, however, there are a number of Bush Forever sites in close proximity to the site (Figure J). These include Bush Forever site No. 294 approximately 500 m to the northwest of the site, with vegetation including *Banksia attenuata* and *Banksia menziesii* woodland with scattered *Eucalyptus todtiama*, *Eucalyptus calophylla* woodland, and *Eucalyptus Wandoo* tall woodland. Bush Forever site 296 is located approximately 1.2 kms to the west of the site following the Ellen Brook, with vegetation including *Eucalyptus rudis* open forest to woodland over/or *Melaleuca rhaphiophylla* low open forest to low woodland. Multiple smaller Bush Forever sites (No. 86, 88, 89) are located between 1.2 kms and 1.8 kms north of the suite. The vegetation in these sites includes *Eucalyptus accedens* and *Eucalyptus Wandoo* woodland, *Eucalyptus accedens*, *Eucalyptus calophylla*, and *Eucalyptus marginata* open forest to woodland with *Allocasuarina humilis* and *Calytrix angulate* (Department of Environmental Protection, 2000).

2.13. Fauna

As part of the Environmental Assessment undertaken by Western Environmental (Western Environmental Pty Ltd, 2024), an initial assessment for the potential presence of threatened and priority fauna was undertaken through the analysis of the DBCA public Threatened and Priority Fauna Dataset and the DCCEEW Protected Matters Search Tool (Department of Climate Change, Energy, the Environment and Water, 2023). The DBCA public Threatened and Priority Flora Dataset does not indicate any previous records of threatened or priority fauna occurring within the site. The DCCEEW Protected Matters Search Tool identified seven listed fauna species with habitat being likely or known to occur within the search area (Department of Climate Change, Energy, the Environment and Water, 2023), which are listed in the table below:

Table 9: Protected Matters Search Tool - Fauna (Department of Climate Change, Energy, the Environment and Water, 2023)

Species name	Common name	Type	Presence assessment	Threatened category
Dasyurus geoffroii	Chuditch, Western Quoll	Mammal	Species or species habitat likely to occur within area	Vulnerable
Petrogale lateralis lateralis	Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby	Mammal	Translocated population known to occur within area	Endangered
Calyptorhynchus banksii naso	Forest Red-tailed Black-cockatoo, Karrak	Bird	Species or species habitat likely to occur within area	Vulnerable
Calyptorhynchus (Zanda) *latirostris*	Carnaby's Black-cockatoo, Short-billed Black-cockatoo	Bird	Species or species habitat known to occur within area	Endangered
Leipoa ocellata	Malleefowl	Bird	Species or species habitat likely to occur within area	Vulnerable
Rostratula australis	Australian Painted Snipe	Bird	Species or species habitat known to occur within area	Endangered
Galaxiella nigrostriata	Blackstriped Dwarf Galaxias, Black-stripe Minnow	Fish	Species or species habitat likely to occur within area	Endangered

As the majority of the site has been cleared of native vegetation and lacks intact understory vegetation, it is highly unlikely that these areas provide habitat for Chuditch, Black-flanked Rock-wallaby or Malleefowl. Due to a lack of intact wetland habitat, it is also considered unlikely that habitat for Australian Painted Snipe or Black-stripe Minnow is present. However, the remnant trees along the Nambad Brook will have some habitat value and allow for ecological linkage across the site, as well as the remnant vegetation existing towards the east and northeast boundaries of the site. As such, in submissions for MRS Amendment

1323/41 the Department of Biodiversity, Conservation and Attractions (DBCA) has identified these pockets of remnant vegetation and paddock trees might provide Carnaby's Black Cockatoo habitat. The site also has some potential to support suitable potential breeding, roosting, and foraging habitat for both Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo. Furthermore, in their advice on the amendment for rezoning the Western Australian Environmental Protection Authority (EPA) advised that remnant vegetation should be retained where possible, particularly around the Nambad Brook.

2.14. Heritage

2.14.1. Aboriginal Heritage

A search of the Department of Planning Lands and Heritage (DPLH) Aboriginal Heritage Inquiry System (AHIS) database identified three registered sites, comprising Ki-It Monger Brook 2 (AHIS ID 3583), Ellen Brook - Upper Swan (AHIS ID 3525), and South Bullsbrook (AHIS ID 4362).

2.14.2. European Heritage

A search of the DPLH's database indicated there are no places listed on the Register of Heritage Places within the site.

2.15. Summary of constraints and opportunities from the existing environment

The previous sections have identified the following key constraints and opportunities for development at the site in regard to the current existing environment:

- The site has relatively significant relief / surface gradients, with surface elevations ranging from 35 mAHD in the west to 95 mAHD in the east.
- The majority of the site is underlain by the Forrestfield System, a small section at the eastern boundary is underlain by the Murray Valleys System, and a section at the northern boundary is underlain by the Pinjarra System. The surface geology of the majority of the site is identified as silty sands. The low-lying land at the western part of the site is classified as pebbly silt, whereas a schist formation exists towards the east. Soil types at the site generally have low permeability, resulting in lower infiltration capacity and relatively higher rates of rainfall runoff.
- The majority of the site is not mapped as having a known Acid Sulphate Soils risk, with only two small areas at the eastern boundary mapped as having a ''low to moderate' risk of ASS soils. As such, dewatering or ASS management is not expected to be required due to the significant depth to groundwater.
- Several non-perennial watercourses and agricultural drains traverse the site from east to west, discharging into the Ellen Brook located approximately 1.5 kms west of the site. The Nambad Brook has been identified as the most significant watercourse within the site and transects the northeastern portion.
- Hydrological modelling for the Nambad Brook has estimated the 1% AEP peak flows within the Nambad Brook to be 21.9 m^3/s, with peak flows in the smaller agricultural drain modelled to be 8.9 m^3/s. The outlet at the southwest corner of the site was modelled to have a peak discharge of 6.9 m^3/s.
- Surface water within the Nambad Brook was observed to have low to moderate nutrient concentrations, slightly elevated E.C., and neutral pH. The peak nutrient concentrations were generally observed during June and July, following the first rainfall events in the winter.
- Groundwater underlying the site generally has a south-westerly flow direction. The estimated maximum groundwater level across the site ranges between approximately 2 and 22 metres below ground level. As such, there is generally considerable depth to groundwater, indicating no significant groundwater level management measures are likely to be required (other than local clay grading and subsoil drainage to control perched groundwater).
- The majority of the site is classified as a 'Multiple Use Wetland' (MUW). The nearest 'Conservation Category Wetland' (CCW) is located approximately 300 m to the west of the site.
- The majority of the site has been cleared of vegetation, with remnant vegetation existing towards the east and northeast boundaries of the site, as well as along the Nambad Brook.
- The site has historically been used for agricultural grazing and associated activities.

3. Nambad Brook foreshore area

3.1. Biophysical assessment

A foreshore area is defined as 'the land that adjoins or directly influences a waterway. It is the area of transition between the edge of the waterway and the furthest extent of riparian vegetation, the floodplain and riverine landforms, or a negotiated area endorsed by the DoW.' (Department of Water, 2012).

A biophysical assessment of the Nambad Brook was completed by Emerge Associates in 2018 (Emerge Associates, 2018), which described the hydrological and ecological values of the watercourse and defined a foreshore area. This assessment confirmed the presence of waterways characteristics throughout the length of the Nambad Brook, including a consistently incised channel, distinguishable floodplain landforms, consistent volumetrically significant flows, and a relatively large contributing catchment area (Emerge Associates, 2018). The foreshore area was determined as a result of the combined extent of associated riparian vegetation and the 1% AEP floodplain.

More recently, an updated biophysical assessment of the Nambad Brook has been completed by Western Environmental in 2024 (Western Environmental Pty Ltd, 2024) in line with River Restoration No. 16 Determining Foreshore Reserves (Water and Rivers Commission, 2001) and Operational Policy 4.3: Identifying and establishing waterway foreshore areas (Department of Water, 2012) to determine the extent of a foreshore reserve, as displayed in Figure K (Western Environmental Pty Ltd, 2024). The biophysical assessment for the Nambad Brook undertaken by Western Environmental is provided as Appendix I.

Both a vegetation and habitat site assessment were undertaken which focused on determining the extent of riparian vegetation to assist in defining the waterway of the Nambad Brook (Western Environmental Pty Ltd, 2024). Riparian vegetation was defined by the presence of species which are known to occur within or directly adjacent to waterways. Due to the mainly cleared nature of the site, limited plant species were present to assist in defining waterways (refer Section 2.12). The Guildford Complex remains within the mature tree vegetation surrounding the Nambad Brook, as well as small sections throughout the site where remnant vegetation is proposed to be maintained in POS. The trees surrounding the Nambad Brook will be maintained through the establishment of a foreshore setback for the purposes of conservation, flood protection and better urban water management.

The proposed LSP layout (provided in Appendix A) wholly contains the Western Environmental (Western Environmental Pty Ltd, 2024) defined foreshore area within a proposed POS corridor (other than a small area associated with a proposed road crossing), thereby ensuring that the objectives of the foreshore management area can be accommodated. This POS corridor will also provide for non-foreshore POS areas that perform associated hydrological and environmental functions such as stormwater treatment and detention.

It is anticipated that a foreshore management plan will need to be prepared as a condition of subdivision approval where relevant (i.e., for stages adjacent to Nambad Brook) and that future detailed landscape designs (at subdivision stage) will need to demonstrate consistency with the foreshore management plan in terms of the types and locations of landscape treatments in relation to the foreshore area determined herein.

3.2. Hydrological assessment

In addition to the biophysical assessment undertaken by Western Environmental, Pentium Water has undertaken hydraulic modelling (Appendix M) to assess the impact of the proposed development on the hydrological function of the Nambad Brook, in particular the non-retention of the drainage feature located to the north of Nambad Brook. This minor flow path to the north of the Nambad Brook channel has not been identified as possessing either a defined channel or riparian vegetation within the biophysical assessment (Western Environmental Pty Ltd, 2024) and is not proposed to be retained within the established foreshore area or associated POS corridor.

The hydrological assessment included determining potential flow rate, depth, and velocity through the Nambad Brook in the 20% and 1% AEP storm events under pre- and post-development conditions. The modelled post-development condition was inclusive of the removal of the minor northern flow path, and included the contribution of post-development urban stormwater flows to the flow through the retained Nambad Brook channel.

The assessment determined that the removal of the minor northern flow path does not compromise the hydrological function of the Nambad Brook. This is primarily because the Nambad Brook channel is a much more significant channel with a significantly larger catchment area and flow rate. Under pre-development conditions, the vast majority of flow through Nambad Brook and northern flow path originates from the catchment area upstream of the dam and flows directly into the Nambad Brook channel rather than the minor northern flow path. Figure 3 below illustrates the relative size of the two catchment areas.

Additionally, the catchment area related to the minor northern channel will be significantly reduced by the proposed development of the upstream site (i.e., separate development), the drainage design for which (JDA Consultant Hydrologists, 2023) shows that the catchment area for this minor northern channel will be approximately half diverted north and half diverted south, to where the large dam will connect into the Nambad Brook channel via culverts. As a result, the flows through the minor channel, were it be retained, would be significantly reduced. This catchment area change is also illustrated in Figure 1 and provides further justification for not retaining the minor northern flow path as its current hydrological function will be significantly altered as part of development of both the LSP area and the upstream land.

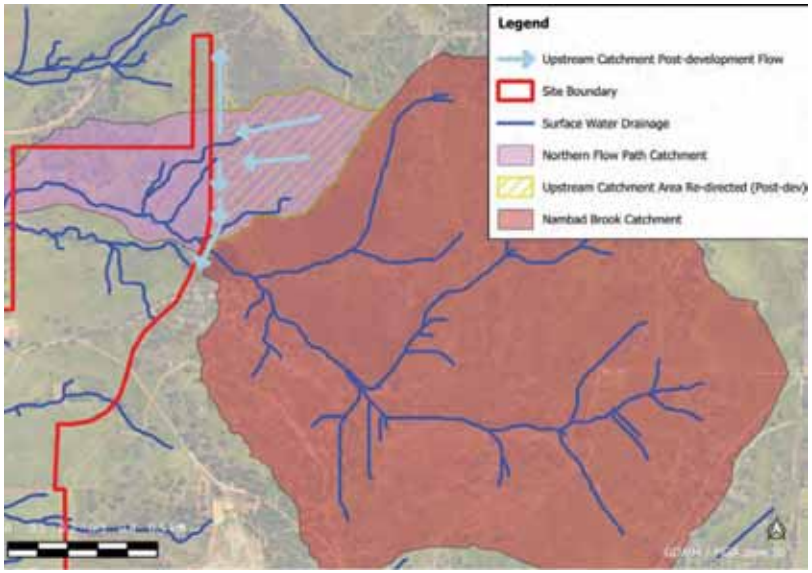

Figure 3: Catchment area for minor northern flow path

In the post-development scenario, the catchment area of northern flow path (the portion that falls within the LSP area) will drain to bioretention basins located adjacent to the retained Nambad Brook channel. The post-development modelling has assessed the peak 20% and 1% AEP flows through the creek under pre-development conditions (i.e., when the northern flow path catchment does not contribute flow to Nambad Brook) and post-

development conditions (i.e., when the northern flow path catchment is reduced in size but contributes flow to the Nambad Brook channel).

The results of the hydraulic modelling are provided in Appendix M and demonstrate that peak flow rate through the Nambad Brook channel increases slightly under post-development conditions, however the impact on flow depths and velocities is very minor. Whilst smaller rainfall events (e.g., the 1 EY event) were not modelled, these will be significantly attenuated under post-development conditions due to the routing of all stormwater flows through off-line bioretention basins (located outside of the foreshore area) which will be sized to completely retain and infiltrate the first 15 mm of rainfall. Therefore, Nambad Brook will not experience a significant change in the frequency or magnitude of flow during small rainfall events.

The results demonstrate that because Nambad Brook is relatively highly incised (with a typical depth of approximately 2.5m for the main flow channel and floodplain combined) it has more than sufficient hydraulic capacity for the additional flow that results from removal of the minor northern flow path. As such, the combined hydrological function of the Nambad Brook and minor northern flow path is not impacted by the proposed development layout and removal of the northern flow path.

Post-development flood mapping of the Nambad Brook is provided in Appendix M and demonstrates that the defined foreshore area is sufficient to contain the 1% AEP flood extent. Additionally, long-sections of the Nambad Brook channel for the pre- and post-development (including depths and velocities) have been provided in Appendix M.

4. Water servicing

4.1. Potable water supply

Potable water supply is proposed to be via a connection to the Water Corporation's integrated water supply scheme. As part of this scheme an existing water supply infrastructure along the Great Northern Highway includes a 300 mm diameter main feeding the Bullsbrook townsite district level supply tanks. The supply main is proposed to be connected to the future Gnangara reservoir to the west of Ellenbrook, providing a secondary source of water to Bullsbrook. The Water Corporation has also indicated that the existing tank is to be supplemented by a new higher-level tank further east on Chittering Road, with additional transfer mains near the town centre. The Water Corporation's long-term plan is for the existing supply main to provide water to a series of large capacity tanks located on high land to the east of Bullsbrook. More specifically, supply of water to the site will be via a southward extension of a reticulation main currently located south of the intersection of Chittering Road and Great Northern Highway.

Additionally, the future planning for water supply to the north of the urban expansion area (in the Kingsford estate) includes both a 250 mm diameter main proposed in Squadron Boulevard as well as a 150 mm diameter main in Wylde Boulevard, which could be extended to service the Bullsbrook South development. These reticulated mains are proposed to be reinforced with a 300 mm diameter Mild Steel Cement Lined (MCSL) pipe than runs through the Kingsford Estate and out to the Great Northern Highway just north of the Nambad Brook, travelling south on the Great Northern Highway (Pritchard Francis, 2023).

4.2. Wastewater servicing

The subject area is not currently serviced by reticulated water, however, Water Corporation's current sewer catchment planning accounts for the portion of the site north of the Nambad Brook within the catchment for the Bullsbrook Central sewer planning that grades to the future type 90 wastewater pump station (WWPS) being built by Water Corporation under project number CS03513 (Pritchard Francis, 2023). The timing for completion of this sewer outfall is mid 2025 in line with the opening of the Neighbourhood Centre adjacent to the site (in Kingsford Estate). Further details regarding this catchment plan are included as Appendix J. For the Bullsbrook South Urban Expansion Area this equates to approximately 560 lots under a residential density coding and approximately 8.6 l/sec of flow.

The proposed staging of development within the urban expansion area focuses on land to the north of Lage Road, which is hereafter referred to as 'Parcel A', with everything south of Lage Road referred to as 'Parcel B'. Part of Parcel A is not within the sewer planning catchment as described in the previous paragraph. Therefore, it is proposed the Water Corporation catchment boundary will be amended temporarily to allow approximately half of the approved area north of the Nambad Brook to be reallocated south and allow for the initial stages of development near Lage Road (Pritchard Francis, 2023). Information regarding the indicative sewer routes supporting this amendment can be found in Appendix J. According to this information, there is an option to divert flows to gravitate south when the area north of the Nambad Brook is further developed, thus not impacting the ultimate flows allowed for in the Bullsbrook Central sewer catchment planning (Pritchard Francis, 2023).

The estimated timeframe for development of Parcel A includes 280 lots south of Nambad Brook from 2025 to 2028 plus another 280 lots north of the Brook, being developed until approximately 2031 (for 560 lots in total) before additional sewer outfall capacity is required. The balance of the Parcel A landholding (approximately 350 lots) would need to gravitate south, through Parcel B to a sewer outfall on Stock Road, with this outfall being required after 2031. Approximate staging and timing of sewer catchments through the urban expansion area can be found in Appendix J.

For Parcel B (the portion of the subject site south of Lage Road), the approval of a scoping report for an interim Type 40 WWPS on Stock Road is due for completion imminently. The construction of this WWPS will allow limited flow (16 l/sec) to be pumped to the existing sewer transfer main on the Great Northern Highway that is currently being commissioned.

This flow has initially been allocated to the industrial land adjacent to Stock Road, with the timing and flow rate required for this land to be confirmed through monitoring. Longer-term planning involves an upgrade of the Type 40 to a Type 180 WWPS that will provide the final sewer outfall for the greater Bullsbrook area. Parcel B will ultimately gravitate along Stock Road (or a similar alternative route) to this outfall point. The Type 180 WWPS should be available prior to 2032 to enable the development of Parcel B and the remainder of Parcel A thereafter (Pritchard Francis, 2023).

The engineering servicing report for the Bullsbrook South urban expansion area is provided as Appendix J and includes further detail on the future wastewater servicing arrangements.

4.3. Non-potable water supply - Irrigation of POS

The long-term irrigation water requirement for public open space will be sourced from groundwater abstraction under a 5C license to take water. There is a total POS provision of approximately 31.4 ha, however this number includes POS that is associated with retained watercourses and associated foreshore areas, drainage channels and retained vegetation which will not be irrigated. An estimate of the total POS irrigation area and demand is provided in Table 10 below, based on the standard 10% POS provision criteria, and the assumption that approximately 60% of that POS area is permanently irrigated (i.e., turfed POS). Also included is the primary school oval, assumed to occupy 20% of the primary school site (or 0.70 ha) as well as the playing fields located adjacent to the primary school. This estimation of irrigation demand, whilst consistent with the methodology employed by DWER in assessing water demands across the Northeast Corridor for new development areas, is considered to represent the minimum necessary irrigation volume to deliver a reasonable standard of POS across the LSP area. A Landscape Concept Plan is provided as Appendix K.

Table 10: Irrigation water demand

Area	Irrigated area (ha)	Irrigation rate (kL/ha/yr)	Total water demand (kL/yr)
Public open space (based on POS provision at 10% of LSP area, irrigated at 60%)	11.21	6,750	75,668
Primary School oval	0.70	10,000	7,000
Total irrigation demand	**11.91**	**-**	**82,668**

4.3.1. Groundwater licenses

There are currently four groundwater licenses associated with landholdings within the site, as summarised in Table 11. The total groundwater allocation associated with these four licences is 94,613 kL. This volume is sufficient to meet the permanent irrigation requirements of the LSP area based on the level of landscape amenity (i.e., amount of turfed open space area) detailed in Table 10 above. It is considered that this volume would support the long-term irrigation demand of an alternative (i.e., lower irrigation demand) landscape outcome comprising a greater proportion of low-water use planting whilst still providing adequate active and useable POS areas for the community.

Licence 210887 was issued by DWER as an interim licence with a three-year period, following which the licence volume is to be reviewed and decreased to account for any additional allocation since acquired by Mirvac (or other proponents within the LSP area) via trades with third parties.

Table 11: Summary of existing and pending groundwater allocations

Licence number	Status	Address	Parties	Aquifer	Volume (kL/yr)
210887	Current	Lot 900 Lage Road (Plan 420367); Lot 4 Lage Road (Plan 59157)	Mirvac (WA) Pty Ltd	Perth - Leederville	50,313
211199	Current	Lot 900 Lage Road (Plan 420367)	Mirvac (WA) Pty Ltd	Perth - Leederville	15,000
180972	Current	Lot 61 Great Northern Highway (Plan 42250)	Marlin Bullsbrook Pty Ltd	Perth - Superficial	27,800
166199	Current	Lot 1 Great Northern Highway (Diagram 61074)	Lotus 55 Investment Aust Pty Ltd	Perth - Leederville	1,500
Total					**94,613**

5. Water conservation

Conservation of water through fit-for-purpose use and best management practices is encouraged to minimize the waste of water. Fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water. Fit-for-purpose principles have been utilised in the water conservation strategy for the site.

5.1. Proposed strategy

The State Water Plan (Government of Western Australia, 2007) is a strategic policy and planning framework to meet the state's water demands to the year 2030. One of the key targets is to reduce scheme water consumption to 40 kL - 60 kL per person per year. Water conservation measures will be adopted at the LSP to create a "Waterwise" development and minimise water-servicing requirements. The water conservation strategy will aim to reduce water demand through incorporating a variety of effective initiatives, which are described in more detail below. Furthermore, the development will comply with the following objective:

- No potable water should be used outside the homes and buildings and achieve efficient use of scheme water, where alternative water sources are available.

Water conservation strategies will also be implemented in order to meet the two water conservation and water use efficiency criteria from the RWMS (GHD, 2012):

- Developments should aim to achieve a target of less than 100 kL per person per year, and where a non-drinking water source is available, should achieve a target of not more than 60 kL/ person/yr.
- Waterwise landscaping techniques should be employed in POS and irrigation should be restricted during the day.

Methods that will be utilised to achieve these criteria include:

- Irrigation of POS with groundwater
- Water efficient fixtures and fittings (WEFA) installed in households
- Waterwise landscaping design incorporating waterwise native plants to reduce irrigation demand and limiting turf to areas of active recreation

5.1.1. POS irrigation

As discussed in Section 4.3, the POS will be irrigated with groundwater abstracted from the aquifers underlying the subject area, with no scheme water to be used for POS irrigation.

5.1.2. Household water conservation

The Building Code of Australia sets minimum standards of efficiency for water using fixtures and fittings in homes. These include:

- All tap fittings, except bath outlets, garden taps and toilets must be a minimum 4-star WELS rated.
- All showerheads must be a minimum of 3-star WELS rated.
- An outdoor private swimming pool or spa associated with a Class 1 building must be supplied with a cover or blanket.
- All internal hot water outlets (such as taps, showers and washing machine water supply fittings) must be connected to a hot water system or a recirculating hot water system with pipes installed and insulated in accordance with AS/NZS 3500.
- Lot owners will be encouraged to install grey water systems for the irrigation of individual household landscaping.
- Lot owners will also be encouraged to install rainwater tanks. Rainwater tanks can be connected to water using fixtures such as toilets, washing machines and external taps to reduce potable water demand as well as assisting in reducing stormwater run-off.

5.1.3. Waterwise landscaping

The landscaping design will incorporate a number of measures to minimise the long-term irrigation requirement and create a waterwise urban development. These will include but are not limited to:

- Minimising areas of turf and selecting turf species endorsed by the UWA Turf Industries Research Steering Committee.
- Improving soil with conditioner certified to Australian Standard AS4454 to a minimum depth of 150 mm where turf is to be planted and a minimum depth of 300 mm for garden beds.
- Designing and installing the irrigation systems according to best water efficient practices:
  - Control systems must be able to irrigate different zones with different irrigation rates.
  - Emitters must disperse coarse droplets or be subterranean.
  - Utilise subsoil irrigation where appropriate.
- Mulching garden beds to 75 mm with a product certified by Australian Standard AS4454.
- Minimising the use of fertiliser pesticides and utilizing slow-release fertilizers.

Waterwise landscaping and gardening principles will be implemented within all landscaped POS areas across the development and promoted to lot owners at the point of sale. This is consistent with the vision of the site, which promotes the planting design of the streetscape and POS consisting of predominantly endemic native species and remnant vegetation around the Nambad Brook, tying the POS areas into the surrounding environment. Additionally, low to no water requirement native vegetation is proposed to be used in most areas.

5.2. Landscape concept

The landscape treatments for POS areas and the Nambad Brook foreshore will include a variety of passive and recreational areas. The design will effectively integrate drainage management areas within POS to provide maximum amenity and functionality of POS areas for the benefit of the public. A Landscape Concept Plan has been prepared for the LSP (included as Appendix K) to broadly describe the landscape design intent and proposed uses for various POS areas.

The landscape concept in Appendix K illustrates the foreshore area that has been determined (refer to Section 3) and demonstrates how the core conservation objectives for Nambad Brook will be accommodated within the foreshore area whilst amenities and stormwater treatment basins will be located outside of the foreshore area.

It is noted that more detailed landscape design will be undertaken at subdivision stage and that these will need to detail landscape treatments consistent with a foreshore management plan which is anticipated to be prepared as a condition of subdivision approval where relevant (i.e., for stages adjacent to Nambad Brook).

6. Stormwater management

6.1. Design criteria and objectives

The objectives and preliminary design criteria that will be used to guide the stormwater management strategy for this site were identified in the DWMS (Emerge Associates, 2021) and the RWMS (GHD, 2012). The drainage design criteria have also been established with reference to Decision Process for Stormwater Management in WA (Department of Water and Environmental Regulation, 2017). These criteria are summarised below.

6.1.1. Design criteria

6.1.1.1. Small / common events (1 EY - one hour event)

The following criteria are adopted for the management of small rainfall events, defined as the one hour - one exceedance per year (one hour - 1 EY) rainfall event:

- Maintain the pre-development hydrological regime by encouraging infiltration close-to-source.
- Manage, retain and/or detain, and treat (if required) stormwater run-off from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.

6.1.1.2. Minor events (20% AEP)

- Provide piped drainage system capacity for the critical 20% AEP event to maintain serviceability of roads and pedestrian areas.

6.1.1.3. Major events (1% AEP)

- Provide adequate flood detention storage to maintain pre-development flow rates downstream of the site.
- Habitable floor levels to be at least 0.3 m above the 1% AEP flood level of the urban drainage system and road reserve.
- Habitable floor levels at least 0.5 m above the 1% AEP flood level of the Nambad Brook to protect people and property from flooding.

6.1.2. Design objectives

The development aims to implement current water sensitive urban design (WSUD) principles and best management practices (BMPs) to effectively manage water quality and quantity from both minor and major storm events.

In accordance with the Stormwater Management Manual for Western Australia (Department of Water, 2004-2007), the drainage system will aim to achieve the following objectives:

- Maintain the existing hydrological regime where possible and minimise fill requirements.
- Maintain or improve pre-development stormwater quality.

Stormwater run-off from constructed impervious surfaces generated by the first 15 mm of rainfall will be managed as close to source as practical. This will primarily be achieved through the use of soakwells and bio-filtration areas in the POS. Where practical, other at-source infiltration mechanisms such as tree pits and median or roadside swales will be considered and incorporated at detailed design stage within suitable road reserve areas (e.g. where there is no crossover frontage for lots).

It is noted that this LWMS presents a preliminary drainage strategy and proof of concept erring on the side of conservatism in the adoption of WSUD features given the planning framework. This is to ensure that POS areas, bio-retention basins and swales have been appropriately/conservatively sized and credited to provide flexibility in the adoption of WSUD features at the detailed design stage. This conservative approach is taken primarily to address any planning concerns with the provision of POS.

6.2. Drainage strategy

The earthworks and drainage strategy has been derived using the surface contours, existing stormwater catchments and flow directions where possible in order to provide post-development catchment boundaries and low points with minimal impact on the existing landform. The preliminary earthworks design was prepared by Pritchard Francis civil engineering consultants and is provided as Appendix L. The earthworks and drainage strategy are also cognisant of the existing discharge locations at Great Northern highway and the anticipated capacity of those outlets and downstream drainage systems (including reference to the water management planning reports for the proposed downstream developments).

Stormwater from the catchments within the development area will be treated and infiltrated as close to the source as possible or directed to bioretention basins or swales designed to retain and infiltrate runoff generated from the first 15 mm of rainfall. The larger rainfall events will be partially attenuated within the bioretention basins and swales, which are intended to provide a small amount of additional storage above the 15 mm event Top Water Level, or in some cases the bioretention basins are intended to be co-located with flood detention basins comprising a larger, upper tier or section of the bioretention basin which will provide significant additional storage volume.

Bioretention basins are intended to typically overtop via a small spillway set at the 15 mm event TWL and overland flow towards living streams or Nambad Brook. Flood detention basins will typically discharge via a piped outlet structure to living streams or the Great Northern Highway culvert outlets. The piped outlets from flood detention basins enables discharge rates to be better controlled and optimised in relation to the basin storage capacity.

External upstream catchment areas draining into the site will need to be managed via the conveyance of these flows through the development area. Most of these flows will be maintained through Nambad Brook or as proposed living streams roughly aligned with existing minor creeks and agricultural drains. In a small number of locations, in the absence of natural or proposed (i.e., living stream) watercourses, these external flows will be piped through the development area towards flood detention basins or living streams.

Drainage practices and design concepts intended for stormwater management at the site are described further in this section, however, will be subject to further design and engineering specifications during the detailed design phase. This information will be included in subsequent UWMPs.

Stormwater modelling has been completed by Pentium Water, which has been documented in more detail in the modelling summary provided as Appendix M. The preliminary stormwater drainage plan, illustrating treatment and storage areas for the minor and major rainfall events is provided in Figures N to P. The details over Lot 401 are indicative only for the purposes of modelling overall Nambad Brook catchment flows to the interface with the Great Northern Highway. Water management planning and drainage design over Lot 401 are subject to future planning and approvals.

All plans are preliminary designs only and subject to change at detailed engineering design phase. Nevertheless, they demonstrate that the LSP design has considered drainage requirements in terms of managing small, minor, and major stormwater events, and has allocated appropriate amounts and locations of POS for stormwater management purposes.

6.3. Drainage design

An XPSWMM hydrological and hydraulic model was developed to represent the proposed LSP development as well as the contributing upstream catchment areas. The model was used to simulate the post-development drainage design for the purpose of quantifying the development impact on flow rates and flood levels, and to confirm the size requirements for the bioretention and flood detention basins.

The indicative flood storage basin / swale depths and shapes provided herein are based on a preliminary assessment of constraints (e.g., minimum subsoil drainage level achievable, separation from basin invert to subsoil drainage, existing ground surface levels, slope, etc.). However, the ultimate design geometry of the storage areas may be adjusted (at detailed design stage) to suit the landscape design whilst remaining cognisant of the various physical and hydrological constraints.

The preliminary stormwater drainage design maintains the peak 1% AEP event pre-development discharge rates at each of the existing culverts along the Great Northern Highway as determined by the pre-development modelling undertaken by Pentium Water (refer Section 2.9.3) and is consistent with the design flow rates that have been allowed for by downstream developments. As described in greater detail in the stormwater modelling summary (Appendix M), the preliminary design presented herein achieves attenuation of post-development flow rates to meet those that have been allowed for in the water management planning for downstream development, which in some cases are lower than the pre-development flow rates estimated by Pentium Water. Therefore, this LWMS has been developed with cognisance to the previous water management planning surrounding the site.

6.3.1. Existing flow paths and conveyance of upstream flows

The existing defined watercourses within the site are shown in Figure H, which include the Nambad Brook and two other minor, non-perennial water courses entering the site on the eastern boundary. The Nambad Brook is a significant creek line with existing ecological values and a proposed foreshore area that has been defined through a biophysical assessment (refer to Section 3). Therefore, the alignment, cross-sectional shape, and hydrological function of the brook will be maintained in its existing state. The following design elements will be integrated with the brook:

- retention of existing vegetation along the creek line through the establishment of a foreshore area
- supplementary planting and rehabilitation within the foreshore area
- POS landscape features such as footpaths parallel to the banks and pedestrian footbridges across the brook. No culverts will be utilized as part of pedestrian footbridges across the brook.
- vehicle bridge crossing as part of the internal road network, including the installation of culverts at road crossings to facilitate flow continuity.
- vegetated stormwater treatment and detention basins located outside of the core creek line, which will attenuate stormwater flows into the brook and maintain peak flows rates at existing levels.
- integration between the brook, pedestrian access, and other areas of public open space.

The preference for the two water courses entering the site on the eastern boundary will be that these are maintained in their natural form. However, these may require realignment and modification in sections to appropriately convey water through the LSP area and to be integrated with the post-development earthworks design. These channels, or the modified sections of these channels, will function as open conveyance channels and it is anticipated that they will be designed and constructed to enhance their hydrological and ecological function (i.e., including vegetation for water quality treatment and soil stabilisation) as well as to provide a feature of the public open space areas.

As described in previous sections, all stormwater catchments from the developed area that discharge into Nambad Brook or the minor water courses / conveyance channels will first be directed to bioretention areas for treatment and detention.

The southern half of the site is devoid of existing flow channels, and as such, flow from upgradient catchments and the eastern parts of the site are planned to be conveyed through the site either via a proposed conveyance channel through the east-west aligned POS corridor in the southern portion of the site, or via piped conveyance through to downstream flood detention basins or living streams.

Figures N to P provide the preliminary stormwater management design which illustrates the proposed conveyance types and routes for upstream catchment areas through the development. Appendix M provides a summary of the stormwater modelling undertaken to inform the preliminary design, including modelled long-sections of Nambad Brook and the smaller conveyance channel alignments.

Appropriate erosion and scour protection measures will be considered and incorporated into the design of conveyance systems and outlets wherever required to prevent damage to the

banks of Nambad Brook and the minor conveyance channels, and to minimise the mobilisation and transport of sediment to downstream waterways and wetlands.

6.3.2. Bioretention and flood storage areas

The drainage design includes proposed bioretention basins and swales which are sized to retain and infiltrate the first 15 mm of rainfall for water quality treatment purposes. Preliminary bioretention basin sizing has been undertaken based on the catchment areas described in the modelling summary (Appendix M). The basins are assumed to have a design water depth of 0.3 m with 1:4 batters and have been sized on the basis that the basins will be constructed with amended soil to provide adequate water quality treatment. The basins were sized with a design permeability of 3 m/d for the first 15 mm of rainfall (but modelled with lower infiltration rates for larger rainfall events). The preliminary design details including the required base area, 15 mm event storage volume and inundation area for the bioretention basins are described in Table 12.

The majority of the bioretention basins are modelled as overtopping via a spillway into an adjacent creek or conveyance channel via overland flow across vegetated surfaces. These basins will provide a modest amount of flood storage in major rainfall events, with modelled depths over the spillways generally 0.2-0.3 m (i.e., total basin depth of approximately 0.5-0.6 m in the 1% AEP event). The bioretention basins (with only minor flood storage function) are identified as such in Table 12 which provides their modelled 20% AEP and 1% AEP depths, volumes, and inundation areas. These details have been modelled on the assumption that the basins have 1:6 batters above the bioretention portion / 15 mm event TWL.

A smaller number of the basins or swales are intended to provide a more significant flood storage function, and these typically have 1% AEP storage depths of 0.9-1.2 m, with discharge from the basins controlled via a piped outlet (e.g., via a "bubble-down" pit set at the 15 mm event TWL). The modelled pipe outlet size, discharge rate, storage volumes and inundation areas of these flood storage basins and swales are also provided in Table 12.

6.3.3. Preliminary design basin and swale configurations

As described above, the basins which are designated as bioretention basins (as opposed to flood detention basins) are assumed to comprise the following:

- A bioretention area sized to retain the 15 mm event to a depth of 0.3, with 1:4 batters.
- 1:6 batters above the bioretention area to contain larger events up to the design 1% AEP depths (typically ~0.5-0.6m) described in Table 12.

The design geometry of the flood detention basins and swales is variable based on the shape and natural slope of the area where they will be located. The preliminary design configurations for the flood detention basins and swales are provided as follows:

- Flood detention basins M, O, P+Q, R & T are assumed to comprise the same geometry as described above for the bioretention basins, except the total depth of these is greater (typically 0.9-1.2m) and discharge from these basins has been modelled as controlled via a pipe rather than overland flow via a spillway. Therefore, these basins will have a bioretention area of 0.3 m depth with 1:4 batters, above which the batter slopes reduce to 1:6.
- Swale I+J was modelled as comprising a 6 m base width swale with a typical depth of 0.5 m below the natural surface, with larger rainfall events able to inundate the natural ground surface through the broader POS area above the formal swale. This swale is anticipated to be divided into segments that can overtop from one to another (either via weirs or pipe connections), to convey flows in a southerly direction to Great Northern Highway culvert outlet no. 3t. The separate swale segments will be required to maximise storage whilst integrating with the natural slope of the land.
- Swale L2 was modelled as comprising 150 m long by 5 m base width swale. The lower 0.3 m of the swale was modelled with 1:4 batters and sized to retain the 15 mm event, with 1:6 batters above that up to a design 1% AEP storage depth of ~0.8m.
- Swale S was modelled as comprising a tiered / stepped swale. The lower tier comprises a 110 m long by 3.5 m base width swale sized to retain the 15 mm event to a depth of 0.3 m, with 1:4 batters. Above this is a wider tier with a flat base of 12 width and then 1:6 batters up to the 1% AEP storage depth of ~0.7 m.
- "C6 inflow_a" refers to an area of detention assumed within the POS area on the eastern boundary. As this area is for managing inflow from an external catchment only, there is

no proposed bioretention or formal basin area. Rather, it is assumed that some inundation over the natural ground surface will occur in this location as external catchment inflows back-up behind the piped conveyance through the site.

- "C4 inflow_e" refers to a detention basin for managing external catchment inflow. It is proposed that the external catchment flows will be piped a short distance to this basin where they will be detailed within a landscaped POS basin to assist with controlling flow rates and piped drainage infrastructure sizes through the development. The detention basin is assumed to comprise a basin of 1.2 m deep with 1:6 batters.

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Table 12: Modelled drainage basin details

Type	Catchment	Base area (m^2)	Pipe outlet size (mm)	15 mm			20% AEP				1% AEP			
				Depth (m)	Top area (m^2)	Volume (m^3)	Depth (m)	Top area (m^2)	Volume (m^3)	Peak discharge (m3/s)	Depth (m)	Top area (m^2)	Volume (m^3)	Peak discharge (m3/s)
Bio-retention	A	122	-	0.30	181	45	0.38	208	60	-	0.46	236	77	-
	AA	725	-	0.30	760	237	0.47	877	362	-	0.63	994	516	-
	AB	282	-	0.30	368	97	0.40	415	137	-	0.51	471	185	-
	B	526	-	0.30	642	175	0.45	736	280	-	0.62	851	413	-
	C	404	-	0.30	506	136	0.42	573	203	-	0.54	644	277	-
	D	293	-	0.30	381	101	0.44	449	158	-	0.59	529	231	-
	E	500	-	0.30	613	167	0.44	699	261	-	0.59	797	373	-
	F	85	-	0.30	135	33	0.36	152	44	-	0.43	174	55	-
	G	318	-	0.30	409	109	0.40	459	154	-	0.49	506	198	-
	H	344	-	0.30	439	117	0.43	507	175	-	0.55	574	244	-
	K	257	-	0.30	340	89	0.40	386	124	-	0.51	439	172	-
	L1	401	-	0.30	458	129	0.42	522	189	-	0.53	584	251	-
	N	764	-	0.30	902	250	0.47	1029	409	-	0.65	1172	608	-
	U	368	-	0.30	466	125	0.43	536	189	-	0.56	610	265	-
	V	1068	-	0.30	1230	344	0.50	1404	609	-	0.71	1599	922	-
	W	471	-	0.30	581	158	0.44	665	246	-	0.60	768	358	-
	Y	621	-	0.30	747	205	0.45	849	328	-	0.62	972	479	-
	Z	165	-	0.30	232	59	0.37	258	78	-	0.45	290	100	-
Flood storage	I+J	1710	450	0.30	2414	618	0.72	3419	1240	0.45	1.04	4195	3511	0.9
	L2	750	300	0.30	1128	281	0.46	1435	485	0.18	0.83	2179	1135	0.32
	M	352	300	0.30	448	120	0.46	533	200	0.13	0.81	745	421	0
	O	480	300	0.30	591	160	0.44	676	248	0.15	0.93	1016	663	0
	P+Q	729	300	0.30	865	239	0.43	959	378	0.11	0.93	1367	1051	0
	R	517	300	0.30	632	172	0.49	752	299	0.18	0.95	1085	720	0
	S	385	375	0.30	660	157	0.44	1801	384	0.08	0.70	2265	912	0.2
	T	929	300	0.30	1081	301	0.50	1245	537	0.26	1.12	1825	1493	0
	C6 Inflow a	75	525	-	-	-	0.77	497	152	0.24	1.12	748	371	1.14
	C4 Inflow e	450	450	-	-	-	0.58	812	363	0.3	1.15	1261	944	0.56
	Total	**14091**	**-**	**-**	**17209**	**4624**	**-**	**22851**	**8292**	**-**	**-**	**28896**	**16945**	**-**

6.4. Structural controls

6.4.1. Small drainage system (15 mm rainfall)

Retaining small rainfall events close to the source is particularly important for the management of water quality. Rainfall events up to 15 mm (equivalent to the 1 EY - 1 hour event) account for approximately 99% of all stormwater run-off and the majority of pollutants from road and roof surfaces. Run-off generated from rainfall events up to 15 mm will be retained and infiltrated as close to source, and as high in the catchment, as possible with the aim to maintain the pre-development hydrologic regime and maximise close-to-source treatment and infiltration of stormwater.

On this basis, the 15 mm event will be infiltrated within lot boundaries with run-off from roofs and impermeable surfaces being directed into soakwells. Having the majority of lots retain and infiltrate the minor rainfall events on-site will provide better water quality outcomes and assist in reducing short term peak flow rates. Pre-development monitoring indicates that the majority of the site has over 5 m clearance to groundwater (refer Section 2.8.2). In addition, imported fill will be used wherever required to obtain 'Class A' geotechnical site classification, thus ensuring that all lots will have suitable conditions for infiltration from soakwells.

Road reserve runoff will be directed to bioretention basins and swales located within the road reserves and POS areas which are designed to retain and infiltrate the first 15 mm. The bioretention areas will provide both water quality treatment as well as some attenuation of flow rates. Vegetated bioretention areas will be sized to retain and infiltrate the 15 mm event and will be underlain by appropriate soil media to increase nutrient uptake, comprising either high PRI soil or an alternative treatment media with appropriate nutrient removal efficiencies. Bioretention areas will also be vegetated using plant species with high nutrient uptake to provide treatment prior to infiltration.

Preliminary locations for bioretention areas are indicated in Figures N to P. It is noted that these have been located and sized to ensure that potential infrastructure requirements for the first 15mm criteria has been considered for the entire development area. However, opportunity to introduce a greater degree of close-to-source infiltration in upper catchment areas (e.g., through measures such as roadside swales or tree pits) will be investigated at subdivision stage.

6.4.2. Minor drainage system (20% AEP event)

The stormwater drainage system will ensure that road reserves and pedestrians areas remain trafficable in the 20% AEP event. This will include the use of a pit-and-pipe drainage system in most areas of the site, however opportunities for avoiding piped conveyance (e.g., where short distances of overland / gutter flow can be appropriately managed) will be identified at subdivision stage.

Stormwater will be conveyed to the bioretention areas described above. Most of the bioretention areas will be allowed to overtop for events greater than the 15 mm event, typically via a spillway or a bubble-down pit into a piped outlet. These basins still provide a small amount of flood detention above the 15 mm event, although maximum water depths are fairly small. Stormwater overflows from the bioretention areas during the 20% AEP event will be conveyed by Nambad Brook or vegetated conveyance channels towards the Great Northern Highway culvert outlets.

6.4.3. Major drainage system (1% AEP event)

The major drainage system design will ensure that rainfall events greater than the capacity of piped drainage systems and bioretention basins are safely and effectively managed via overland flow paths and flood detention areas (either the proposed flood detention basins and swales, or within Nambad Brook and the other vegetated conveyance channels).

Flood protection for properties will be provided by ensuring finished lot levels have at least 0.3 m freeboard to local stormwater drainage Top Water Levels and at least 0.5 m freeboard to flood levels in major flow paths.

6.4.4. Vegetation

Vegetation will be included in all suitable stormwater management areas to help prevent erosion, maintain soil infiltration, restrict water flows, and remove particulate and soluble pollutants, particularly nitrogen. The plants will mainly be associated with bio-retention areas and will be appropriately selected based on their intended function, using native vegetation as much as possible. The plant species to be used within stormwater management areas will be identified within the subsequent UWMPs.

6.5. Non-structural controls

Non-structural controls will be used to provide additional stormwater quality management and will include establishing operation and maintenance activities and controlling land use and management. The LSP will use the following non-structural controls to improve stormwater quality and reduce contamination.

6.5.1. Nutrient control and landscaping

Design guidelines and a landscaping policy will be implemented to control POS landscaping designs and practices. It is expected that these measures will provide improvement of stormwater quality through ensuring:

- Appropriate native plant species are continually used
- Bioretention areas to contain an amended soil with a minimum PRI of 10
- POS and bioretention areas to be maintained
- Recommended fertiliser, pesticide and irrigation regimes are followed

6.5.2. Waste and construction management

Waste management plans will include provisions for stormwater protection through:

- "At source" management of litter, sediment, and organic material such as regular street sweeping
- Prompt removal of litter when discovered
- Discouraging waste dumping in drains and drainage swale through restricted access (i.e., bollards around POS) and signage
- Providing sufficient public facilities for rubbish disposal
- All development construction projects, including road and infrastructure construction, will be subject to sediment and erosion control measures.

7. Groundwater management

The main principles of groundwater management are to protect underlying groundwater resources by minimising the export of nutrients and to protect infrastructure from groundwater inundation, as summarised in Table 13. The main objective to protect the underlying groundwater resources is defined as maintaining or improving the quality of groundwater leaving the site. Improvements to groundwater quality can be achieved by either reducing the total nutrient load received by groundwater, or by the treatment of surface water prior to infiltration to groundwater (as discussed in Section 6.2). The reduction of the nutrient loads will be achieved by multiple methods, including infiltration at the source, soil amendment and planting, as well as the lower nutrient input loads that will result from the change of land use.

Table 13: Groundwater management principles and objectives

Principle	Objective	Approach / design criteria
Protect underlying groundwater resources by minimising nutrient export	Maintain or improve the quality of groundwater leaving the site	Encourage infiltration of stormwater as close to source as possible (e.g., use of soakwells where possible, road run-off directed to bioretention areas within the streetscape or POS) to prevent mobilisation of contaminants to downstream drainage / infiltration areas
		Provide a minimum clearance of 500 mm between bioretention and flood storage areas to MGL or CGL
		Utilise waterwise gardening practices to minimise fertiliser use and irrigation. Use amended soil (PRI >10) beneath bioretention areas
Protect infrastructure from groundwater inundation		Provide a minimum of 1.2 m between lot levels and MGL or CGL

7.1. Groundwater level management

Due to the several metres or more clearance to groundwater across the site, the development is not expected to significantly impact, or be impacted by, the superficial aquifer groundwater levels. Therefore, no active management of groundwater levels related to the superficial aquifer (i.e., widespread subsoil drains) is expected to be required. However, perched groundwater levels may need to be locally managed to establish a controlled groundwater level and maintain separation to finished lot levels.

The potential for perched groundwater is expected to be controlled via a combination of clay grading, fill importation, and subsoil drains. The site is intended to be developed to deliver lots with A Class geotechnical classification, which will require the importation of structural fill. This, in combination with grading the clay sub-surface will provide for sub-surface drainage of perched groundwater towards drainage systems and creek lines. Subsoil drains may also be used in areas where groundwater has the potential to collect and perch on the clay sub-grade. This approach of utilizing clay grading and/or localised lowering of perched groundwater is acceptable as there are no groundwater dependent ecosystems located within the site boundary.

Given the depth of structural fill likely to be required to achieve A class geotechnical classification, the separation from finished lot levels to the clay sub-grade is expected to be in the order of 1.2-1.8 m. This, together with the natural slope of the site and clay grading, is anticipated to be adequate to control post-development groundwater levels and mounding. Further assessment of the earthworks and fill design will be undertaken at detailed design stage to confirm groundwater mounding potential and subsoil drainage requirements. Where subsoil drains are considered necessary, these will be installed with a minimum separation to lot levels of 1.2 m, in accordance with City of Swan requirements.

7.2. Groundwater quality management

7.2.1. Infiltration close to source

The proposed stormwater management strategy includes a series of measures to facilitate the infiltration of stormwater run-off as close to the source as possible. These measures prevent the mobilisation of contaminants that are typically transported with higher loads during first flush rainfall events, which will instead be retained and infiltrated higher in the catchment, providing further opportunity for nutrient uptake and attenuation through the soil profile.

7.2.2. Change of land use

The majority of the site is currently zoned as “General Rural” and “Landscape” and being used for rural residential and agricultural purposes with associated activities. As such, the use of fertilizers and livestock could result in increased nutrient loads reaching the underlying groundwater system. Because the proposed development will change the land use from agricultural to residential, the nutrient loading to the site is expected to decrease as a result of a reduced nutrient inputs from sources associated with land use, including:

- Removal of livestock
- Reduced fertiliser usage
- Increased native plant cover (non-fertilised) in landscaped areas

7.2.3. Vegetation and soil amendment

As discussed in Section 5.1.3, POS areas will utilise waterwise landscaping including the use of native vegetation and aim to minimise the use of turf and use appropriate turf species. Native vegetation will also be retained within the POS areas. In addition to the conservation of water, the use of waterwise principles will also minimise the overall fertiliser requirements and therefore the nutrient load that could be transported to the groundwater via infiltration will be reduced.

As discussed in Section 6.4.2, high phosphorus retention index soils or an alternative soil treatment media with equivalent efficiencies will be utilised beneath bio-retention areas to provide additional treatment of stormwater prior to infiltration to groundwater. Additionally, lot owners will be encouraged to implement similar waterwise landscaping principles and minimise the use of fertiliser within their lot.

Subsoil drains, where required, will be graded to outfall into stormwater bioretention basins wherever possible to provide water quality treatment of subsoil water / intercepted groundwater. Where it is not possible to grade subsoil drains into stormwater bioretention basins (e.g., where the invert of these is required to be elevated above any potential groundwater mounding or impermeable layers) then subsoil drains will outfall to vegetated conveyance channels which will also be constructed or modified, if possible, to include amended soil and appropriate plant species to promote nutrient uptake.

8. Monitoring

8.1. Pre-development monitoring

A pre-development surface water and groundwater monitoring program has already been completed (Cardno, 2010). This program included the monitoring of surface water at the point where the Nambad Brook crosses the Great Northern Highway ("SW" in Table 14), and the monitoring of groundwater at seven groundwater monitoring bores. The results of this program have been summarised in Section 2.8.3 and Section 2.9.4, with the full report available as Appendix E.

8.2. Subdivision works monitoring

Any Urban Water Management Plan (UWMP) prepared as a condition of subdivision approval shall include detail of measures to be incorporated into the drainage system and road design to mitigate against the export of sediment from subdivision construction areas into adjoining watercourses inclusive of the Nambad Brook. Post installation of these measures, the subdivider shall undertake for the duration of subdivision work and on a quarterly basis a testing regime of the surrounding watercourses to ascertain the presence of suspended solids in the water. Details of such subdivision phase monitoring programs will be included in future UWMPs.

8.3. Post-development monitoring

8.3.1. Groundwater

No post-development groundwater monitoring is proposed given there is generally several metres or more separation from the regional superficial aquifer.

8.3.2. Surface water

A post-development surface water and subsoil drainage water quality monitoring program is proposed to assess the performance of the stormwater treatment and drainage system and to identify any impacts of the development on the quality of surface water flows leaving the site. The proposed period for post-development monitoring is two years, after which a review should be undertaken including a discussion of the results with the City of Swan and DWER. As development of the site is likely to take place in a staged manner over several years or more, the post-development monitoring program across the overall LSP area will also likely be staged and ongoing over a period of more than two years.

The proposed surface water monitoring network has been determined by establishing monitoring locations at the points where surface water features enter and leave the site, as shown in Figure Q. These would be sampled opportunistically up to five times per year for the duration of the monitoring period.

Post-development surface water monitoring is proposed to include measuring of field parameters and taking samples for analysis at a NATA accredited laboratory for a suite of nutrients including TN, TKN, NH_4-N, NO_x-N, TP, and FRP.

Post-development monitoring of selected drainage basins/swales will also be undertaken to enable an assessment of the post-development stormwater quality prior to and following treatment within vegetated bioretention areas. Post-development monitoring commitments for drainage infrastructure will be confirmed at the UWMP stage.

8.3.3. Subsoil drainage

The extent and locations of subsoil drainage infrastructure are not known at this stage; therefore, no specific subsoil discharge monitoring locations are proposed. However, it is considered likely the parts of the site (particularly in the lower-lying, flatter western portion of the site) will utilise subsoil drainage to control potential perching of infiltrated stormwater.

It is proposed that future Urban Water Management Plans will identify suitable subsoil discharge locations for monitoring the quality of subsoil drainage water flowing into

bioretention basins for treatment as well as subsoil drainage water / infiltrated stormwater discharging from beneath stormwater infiltration areas into conveyance channels or the Great Northern Highway culverts.

8.4. Trigger values

There is limited pre-development surface water quality data available upon which to establish trigger values. A single surface water monitoring location in proximity to the site was included in the pre-development monitoring program, which was at the intersection of Nambad Brook with Great Northern Highway, downstream of the site boundary. The post-development surface water monitoring results will be compared to the baseline values obtained from the pre-development monitoring, as well as to ANZECC guidelines (ANZECC, 2000). The proposed trigger levels are provided in Table 14 below, based on average pre-development data and ANZECC guidelines (ANZECC, 2000). If any water quality parameters exceed the relevant trigger value from Table 15 (being the higher of either the pre-development average concentration or the ANZECC guideline value) by 20% or more for two consecutive sampling occasions, contingency measures identified below shall be employed.

Table 14: Preliminary post-development water quality trigger values

Monitoring Bore	TN mg/L	TKN mg/L	NO_x-N mg/L	NH_4-N mg/L	TP mg/L	FRP mg/L
ANZECC	1.20	-	0.150	0.080	0.065	0.040
SW	0.82	0.50	0.120	0.059	0.081	0.026

8.5. Contingency measures

In the event post-development data exceeds trigger values by at least 20% on two consecutive occasions, an immediate re-sampling will be undertaken to verify the exceedance. If this confirms a deterioration in water quality then an investigation will be undertaken to establish the likely cause of the exceedances, the most likely impacts, and available remedies.

The primary contingency measure available in the event of deterioration in water quality will include assessment of whether the pollution is a point or diffuse source. This will require an investigation into the location of the contamination and an assessment of whether the pollution is due to the development or an external factor. At that point, a specific contingency plan will be implemented, which may include:

- Removal of the pollution
- Assessment into the functionality of the drainage system and bio-infiltration areas
- Further soil amendment in infiltration / treatment areas
- Increased planting of nutrient stripping vegetation in infiltration areas
- Review of drainage maintenance plans to ensure correct practices are being implemented
- Increased public awareness and education programs
- Increased monitoring program including monitoring up-gradient of the site to determine potential off-site nutrient sources

8.6. Reporting

The results obtained from post-development monitoring will be compared to pre-development monitoring data and ANZECC guidelines (ANZECC, 2000) and submitted annually to the City of Swan. The report will outline and impact the development has had on the hydrological conditions and water quality and present necessary contingency measures where required.

9. Implementation

9.1. Further work

Following the approval of the LSP, the preparation of UWMPs will be required as a condition of subdivision approval for the various stages of the development, and will include the following design measures in more detail:

- Compliance with this LWMS' criteria and objectives to the satisfaction of the City of Swan.
- Detailed stormwater drainage design including locations, dimensions, and final levels for drainage infrastructure, bioretention and flood storage areas, stormwater flow paths, and areas of inundation.
- Specific detailed information on structural and non-structural BMPs to be implemented within each subdivision.
- Final subdivision layout including final cut and fill levels, minor and major drainage layouts, and overland flow paths.
- Management of subdivision works, including details of license application for dewatering or dust suppression if required.
- Updated POS landscape design concepts which will include cross-sections, stormwater storage areas, plant species, and irrigation requirements.
- Detailed post-development monitoring program including sampling locations, parameters, and frequency, as well as water quality trigger levels.
- Finalised implementation plan including roles and responsibilities of all parties involved.

9.2. Implementation plan

The effectiveness of this LWMS will rely on the system's regular maintenance and grouped knowledge. The following operation and maintenance program is proposed in Table 15 below.

Table 15: Roles and responsibilities

Principle	Role	Responsibility	Timescale
Monitoring	Surface water and subsoil monitoring	The proponent	Surface water levels and quality monitoring at multiple locations five times per year for a period of two years following practical completion
Reporting	Report on monitoring results	The proponent	At the completion of three years of post-development surface water monitoring
Irrigation bore	Bore installation and maintenance. Recording volumes abstracted	The proponent	As per the bore license conditions specified by DWER until handover to CoS
Subdivision management	Construction and site works management	The proponent	As required during construction until handover to CoS
	Waste and pollution management	The proponent	As required during construction until handover to CoS
	Dust suppression and erosion control	The proponent	As required during construction until handover to CoS
Drainage infrastructure	Visual inspections, rectifying issues and maintenance	The proponent	As required following practical completion until handover to CoS
POS and landscaped	Landscaping, revegetation, and ongoing replanting	The proponent	As specified within the POS design documentation until handover to CoS

Principle	Role	Responsibility	Timescale
community areas	Fertiliser application	The proponent	As specified within the POS design documentation until handover to CoS
	Irrigation installation and scheduling	The proponent	As specified within the POS design documentation until handover to CoS
	Foreshore management plan	The proponent	As required at the subdivision stage
Public information	Supply of information and educational packages	The proponent	Upon settlement with residents

10. References

ANZECC. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.*

Beard, J. (1990). *Plant Life of Western Australia.* Kenthurst, NSW: Kangaroo Press Pty Ltd.

Bioscience. (2014). *Local Water Management Strategy - South Bullsbrook Industrial Precinct.* Bioscience.

Bureau of Meteorlogy. (2023, September). *Climate Data Online*. Retrieved from http://www.bom.gov.au/climate/data/

Cardno. (2010). *Bullsbrook Surface and Groundwater Monitoring - Final Monitoring Report.* Subiaco: Cardno.

Cardno. (2011). *Local Water Management Strategy - Lot 301 Stock Road and Lot 302 Lage Road, Bullsbrook.* Subiaco: Cardno.

Cardno. (2012). *District Water Management Stragey - Great Northern Gateway Industrial Cell.* Subiaco: Cardno.

Cardno. (2017). *Local Water Management Strategy Addendum - Lot 301 Stock Road and Lot 302 Lage Road, Bullsbrook.* Subiaco: Cardno.

Department of Biodiversity, Conservation and Attractions. (2017). *South West Vegetation Complex Statistics.* Perth: Government of Western Australia.

Department of Biodiversity, Conservation and Attractions. (2018). *Directory of Important Wetlands in Australia.* Western Australia: Department of Biodiversity, Conservation and Attractions.

Department of Climate Change, Energy, the Environment and Water. (2023, November). *Protected Matters Search Tool*. Retrieved from https://pmst.awe.gov.au

Department of Environmental Protection. (2000). *Bush Forever - Directory of Bush Forever Sites.* Government of Western Australia.

Department of Planning and Infrastructure. (2008). *Better Urban Water Management.* Government of Western Australia.

Department of Planning, Lands and Heritage. (2019). *Government Sewerage Policy.* Perth.

Department of Planning, Lands and Heritage. (2021). *City of Swan, Local Planning Scheme No. 17.* Department of Planning, Lands and Heritage.

Department of Water. (2004-2007). *Stormwater Management Manual for Western Australia.* Government of Western Australia.

Department of Water. (2008). *Interim: Developing a Local Water Management Strategy .* Government of Western Australia.

Department of Water. (2012). *Operational policy 4.3: Identifying and establishing waterways foreshore areas.* Perth: Government of Western Australia.

Department of Water. (2012). *Water monitoring guidelines for better urban water management strategies and plans.* Government of Western Australia.

Department of Water and Environmental Regulation. (2017). *Decision process for stormwater management in Western Australia.* Government of Western Australia.

Department of Water and Environmental Regulation. (2022). *Gnangara groundwater allocation plan.* Joondalup: Government of Western Australia.

Department of Water and Environmental Regulation. (2022). *Water Register.*

Department of Water and Environmental Regulation. (2023, October). *Perth Groundwater Map*. Retrieved from Perth Groundwater Map: https://maps.water.wa.gov.au/Groundwater/

Douglas Partners. (2020). *Report on Preliminary Geotechnical Investigation - Proposed Bullsbrook Urban Precinct.* Osborna Park: Douglas Partners.

Emerge Associates. (2014). *Local Water Management Strategy - South Bullsbrook Industrial Precinct LSP1.* Emerge Associates.

Emerge Associates. (2018). *Biophysical Assessment for Nambad Brook - Marlin Bullsbrook Structure Plan Support.* Perth: Emerge Associates.

Emerge Associates. (2021). *District Water Management Strategy - Marlin Bullsbrook Urban.* Perth: Emerge Associates.

Environment Australia. (2000). *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1 - Summary Report.* Department of Environment and Heritage.

Galt Geotechnics. (2022). *Report on Preliminary Geotechnical Study - Proposed Residential Subdivision - Varius Lots Great Northern Highway & Lage Road, Bullsbrook.* Osborne Park: Galt Geotechnics.

Geoscience Australia. (2023, September). *National Map*. Retrieved from https://nationalmap.gov.au/

GHD. (2012). *Regional Water Management Strategy - Report for Bullsbrook Townsite Area.* GHD.

Government of Western Australia. (2007). *State Planning Policy 2.9: Water Resources.* Government of Western Australia.

Gozzard, J. (1986). *Perth Metropolitan Region Environmental Geology Series.* Western Australia: Geological Survey Western Australia.

Heddle, E., Loneragan, O., & Havel, J. (1980). *Vegetation Complexes of the Darling System Western Australia.* Perth: Department of Conservation and Environment.

JDA Consultant Hydrologists. (2023). *Lot 302 Lage Road, Bullsbrook - Urban Water Management Plan.* WAPC.

Luke, G., Burke, K., & O'Brien, T. (1987). *Evaporation Data for Western Australia.* Perth, Western Australia: Department of Primary Industries and Regional Development.

Pentium Water. (2024). *Addendum to District Water Management Strategy - Bullsbrook South Urban Expansion Area.* Perth: Pentium Water.

Pritchard Francis. (2023). *Bullsbrook South Land Holdings Local Structure Plan - Engineering Servicing Report.* Pritchard Francis.

RPS. (2018). *Local Water Management Strategy - Bullsbrook Landholding.* Perth: RPS.

Thackway, & Cresswell. (1995). *An Interim Biogeographic Regionalisation for Australia: A framework for setting priorities in the National Reserves System Cooperative Program.* Canberra: Australian Conservation Agency.

Water and Rivers Commission. (2001). *Determining Foreshore Reserves.* Government of Western Australia.

Western Australian Planning Commission. (2015b). *Liveable Neighbourhoods - Draft.* Government of Western Australia.

Western Environmental Pty Ltd. (2024). *Biophysical Assessment - Bullsbrook South Urban Expansion Area.* West Perth: Western Environmental Pty Ltd.

Figures

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GDA94 / MGA zone 50

Figure A

Bullsbrook South Locality Map

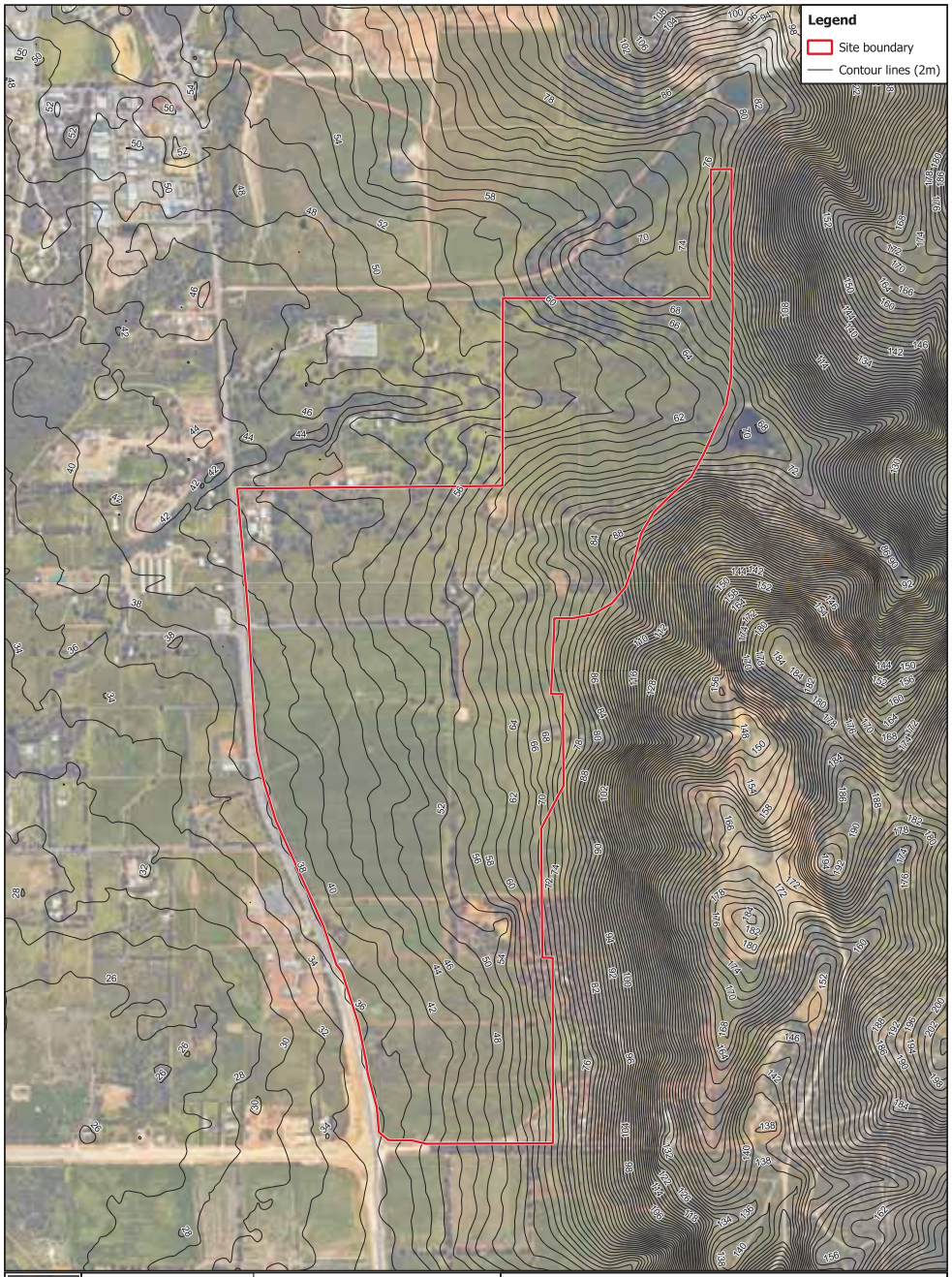

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Figure B

Bullsbrook South Topography Map

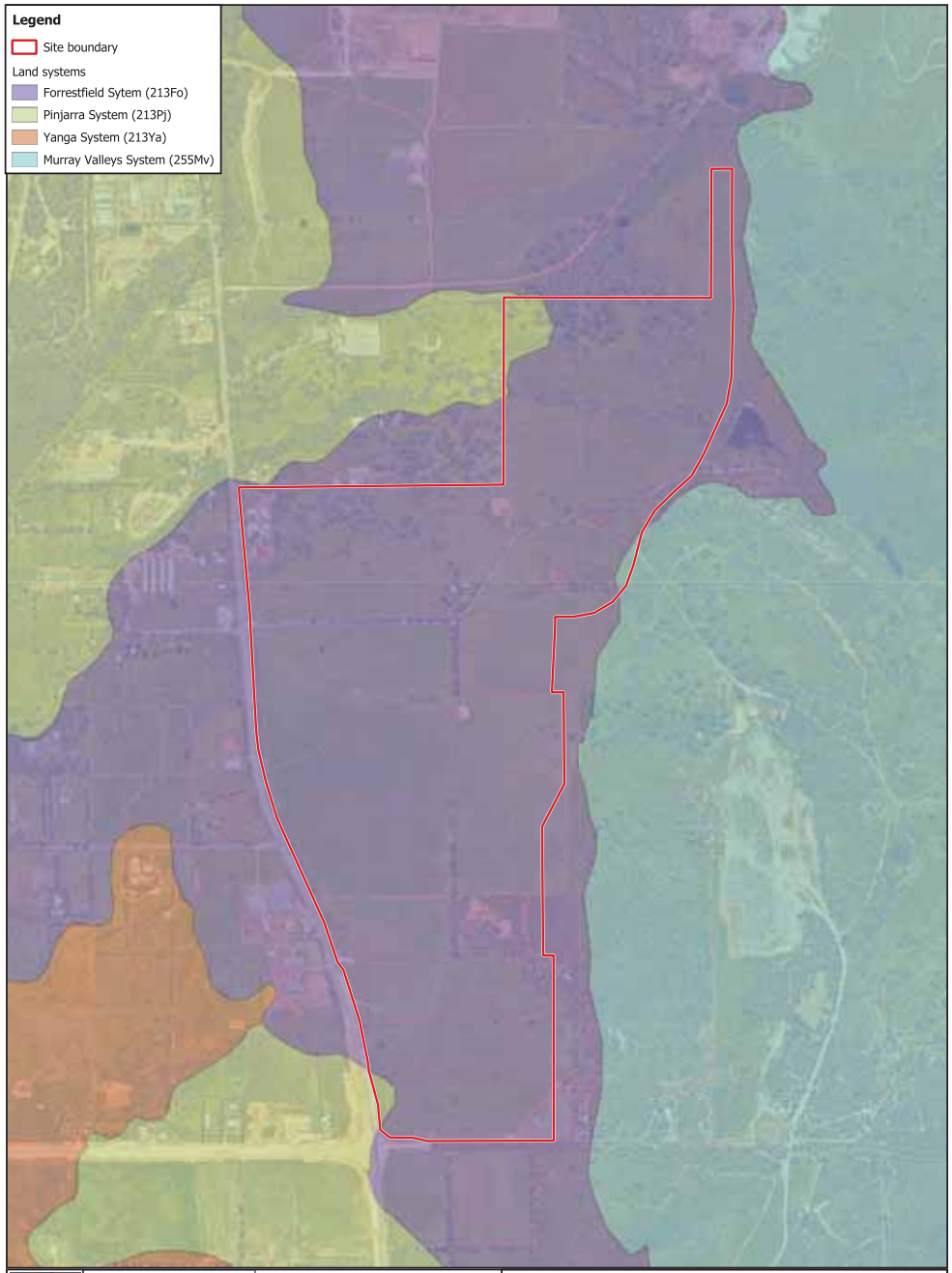

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Figure C

Bullsbrook South Land Systems Map

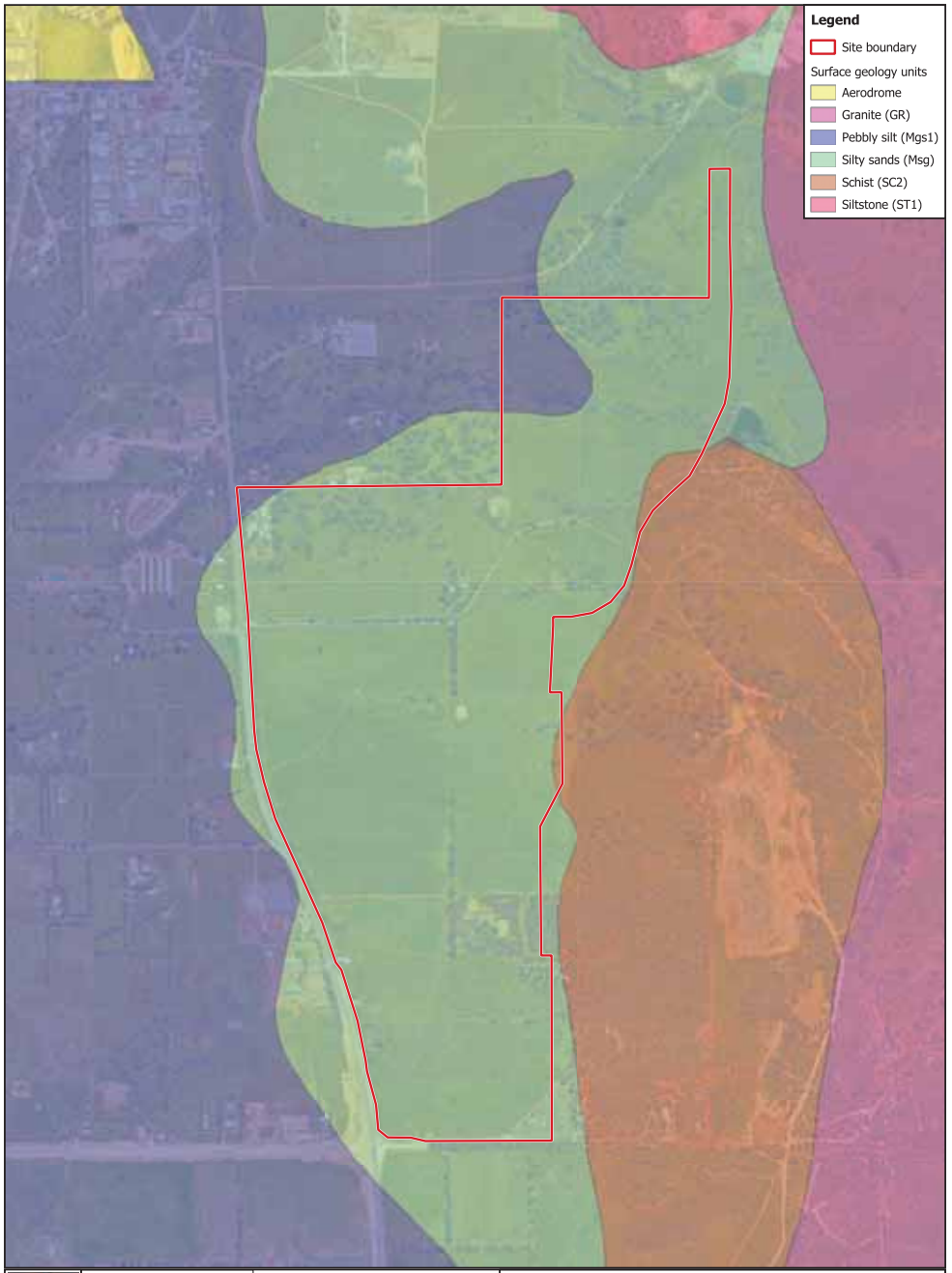

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Figure D

Bullsbrook South Surface Geology Units Map

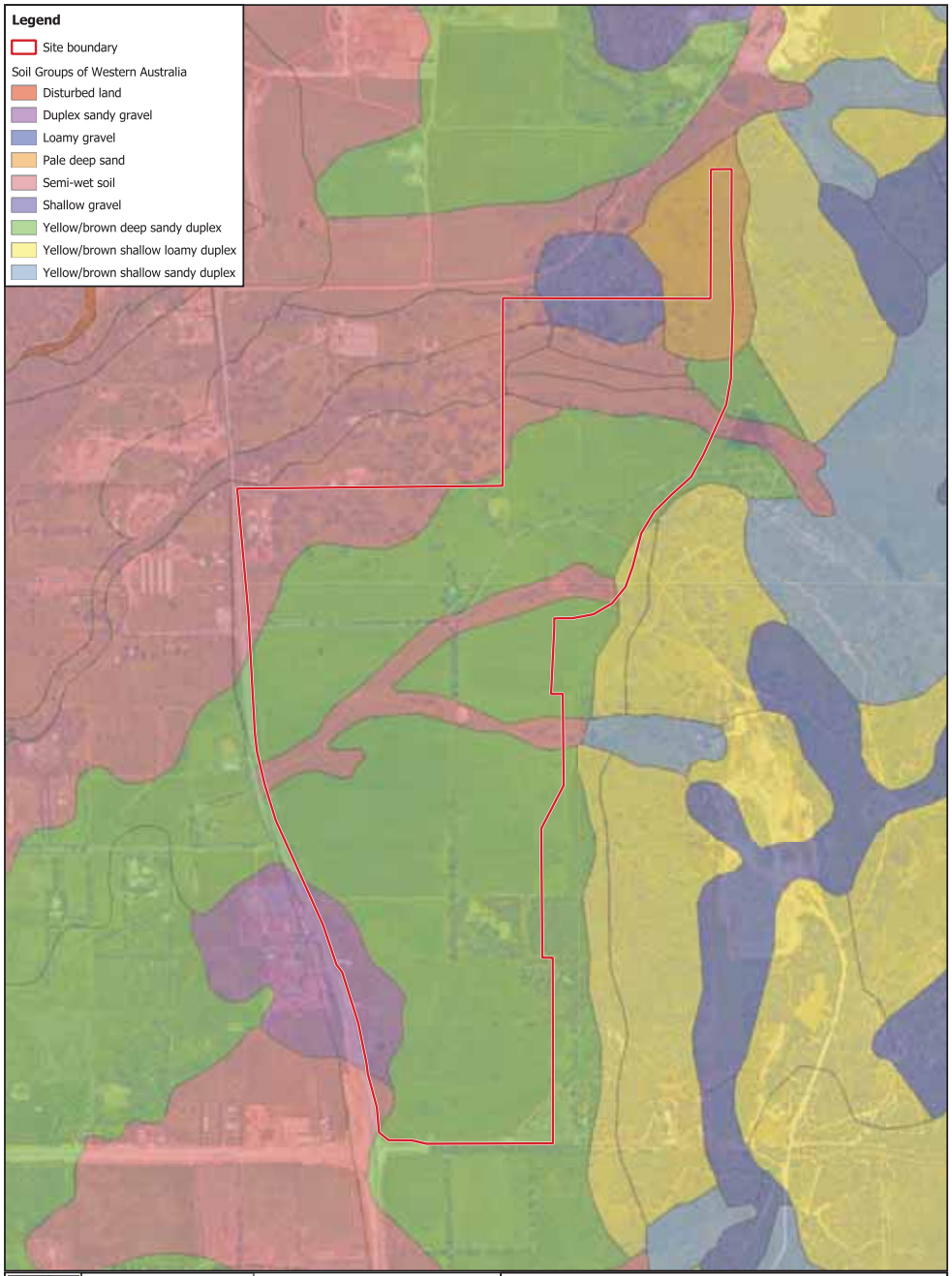

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Figure E

Bullsbrook South Soil Groups of Western Australia Map

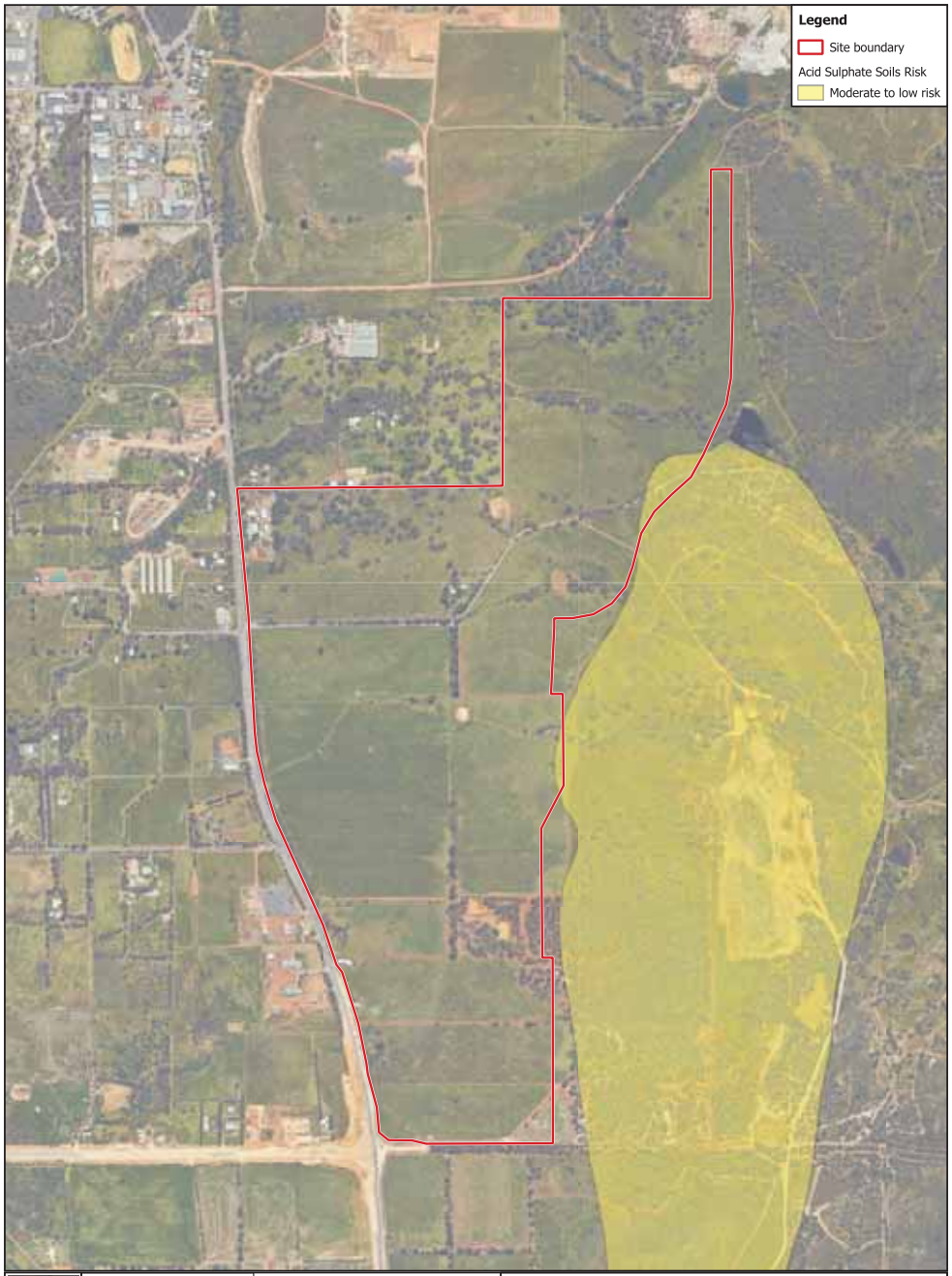

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Figure F

Bullsbrook South Acid Sulphate Soils Risk Map

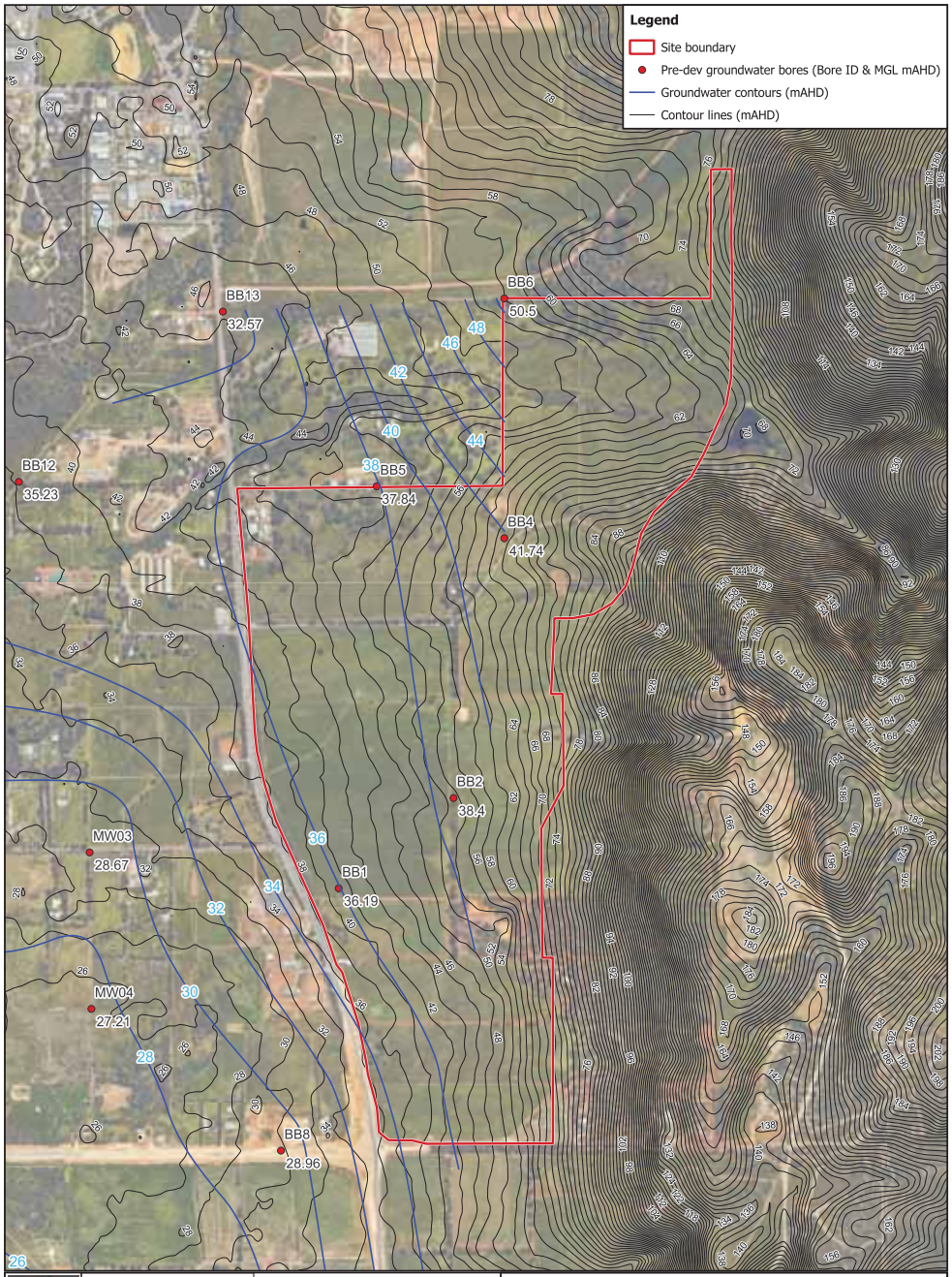

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Figure G

Bullsbrook South Estimated Maximum Groundwater Contours Map

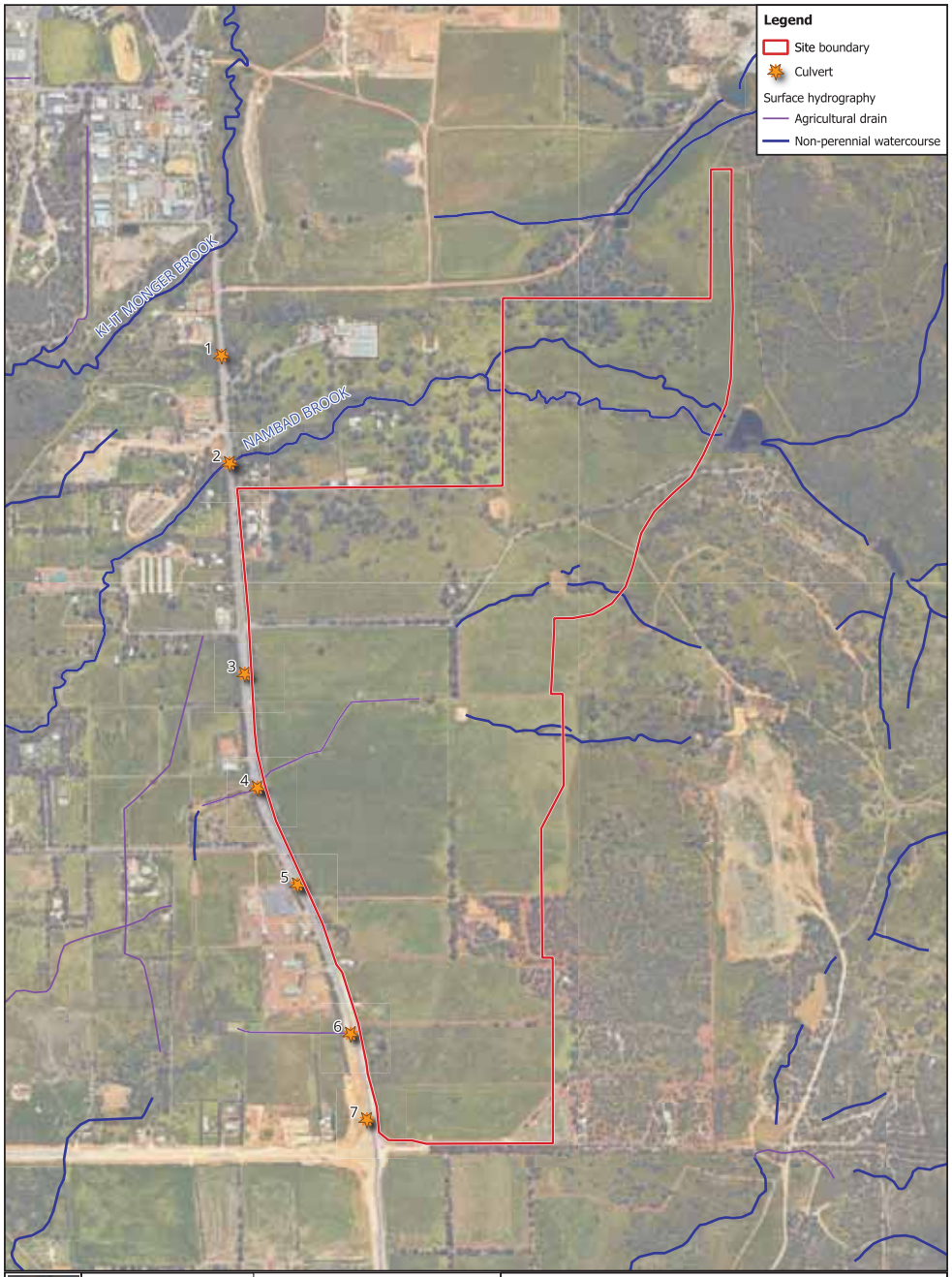

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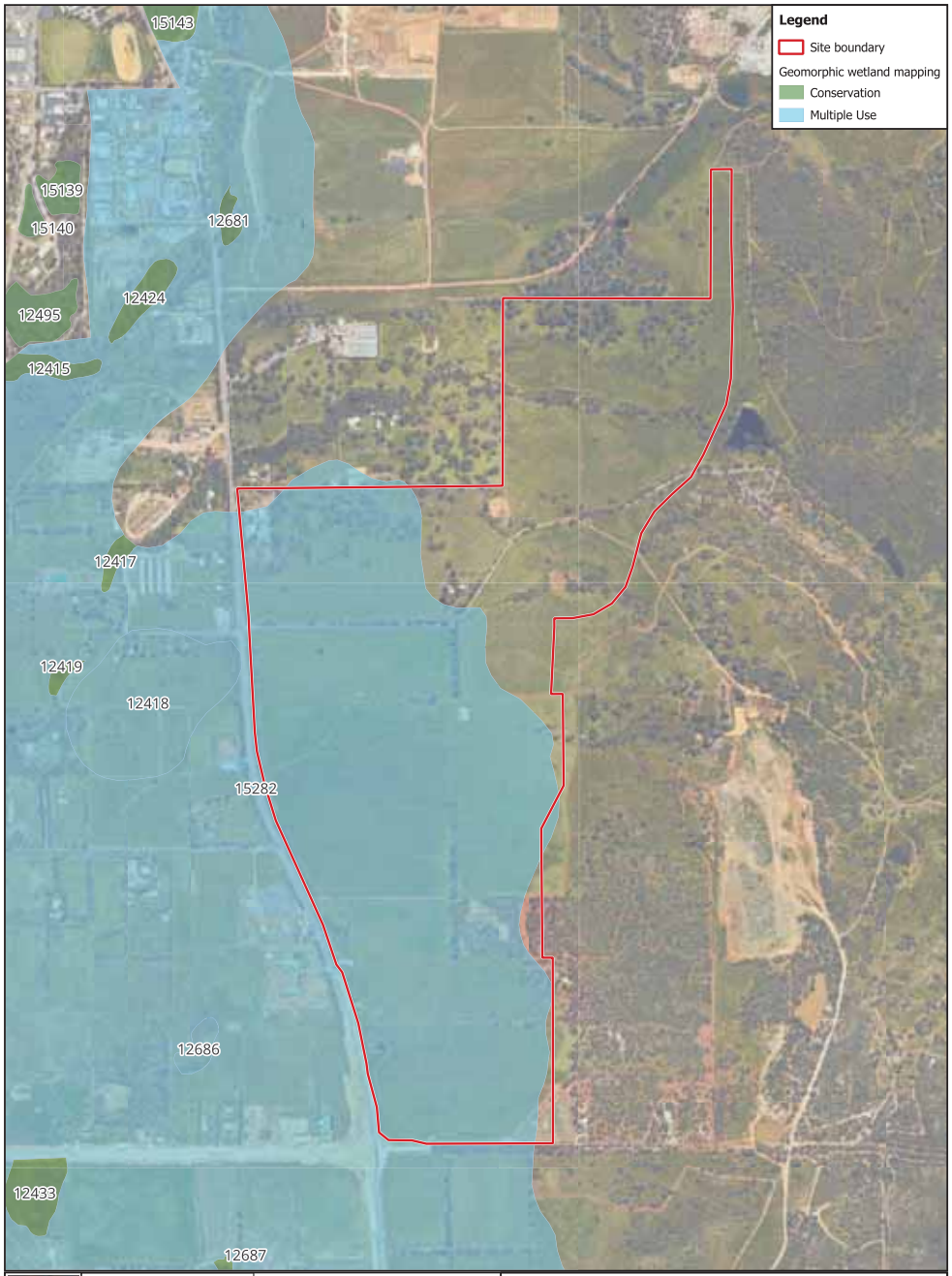
Figure H

Bullsbrook South Watercourses & Drains Map



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GDA94 / MGA zone 50

Figure I

Bullsbrook South Wetlands and GDEs Map



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GDA94 / MGA zone 50

Figure J

Bullsbrook South Bush Forever Map



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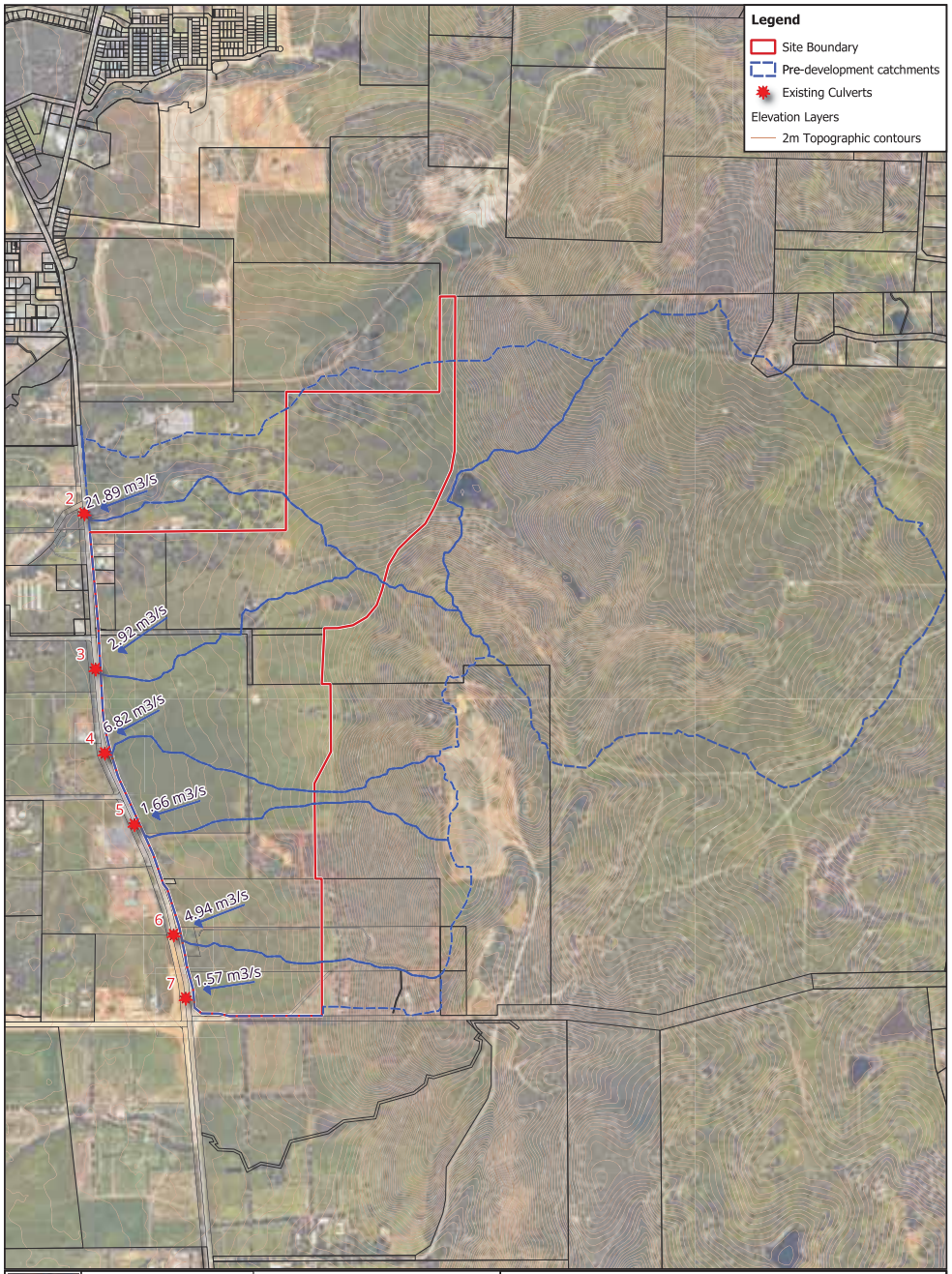
GDA94 / MGA zone 50

Figure K

Bullsbrook South Nambad Brook Foreshore Reserve Map



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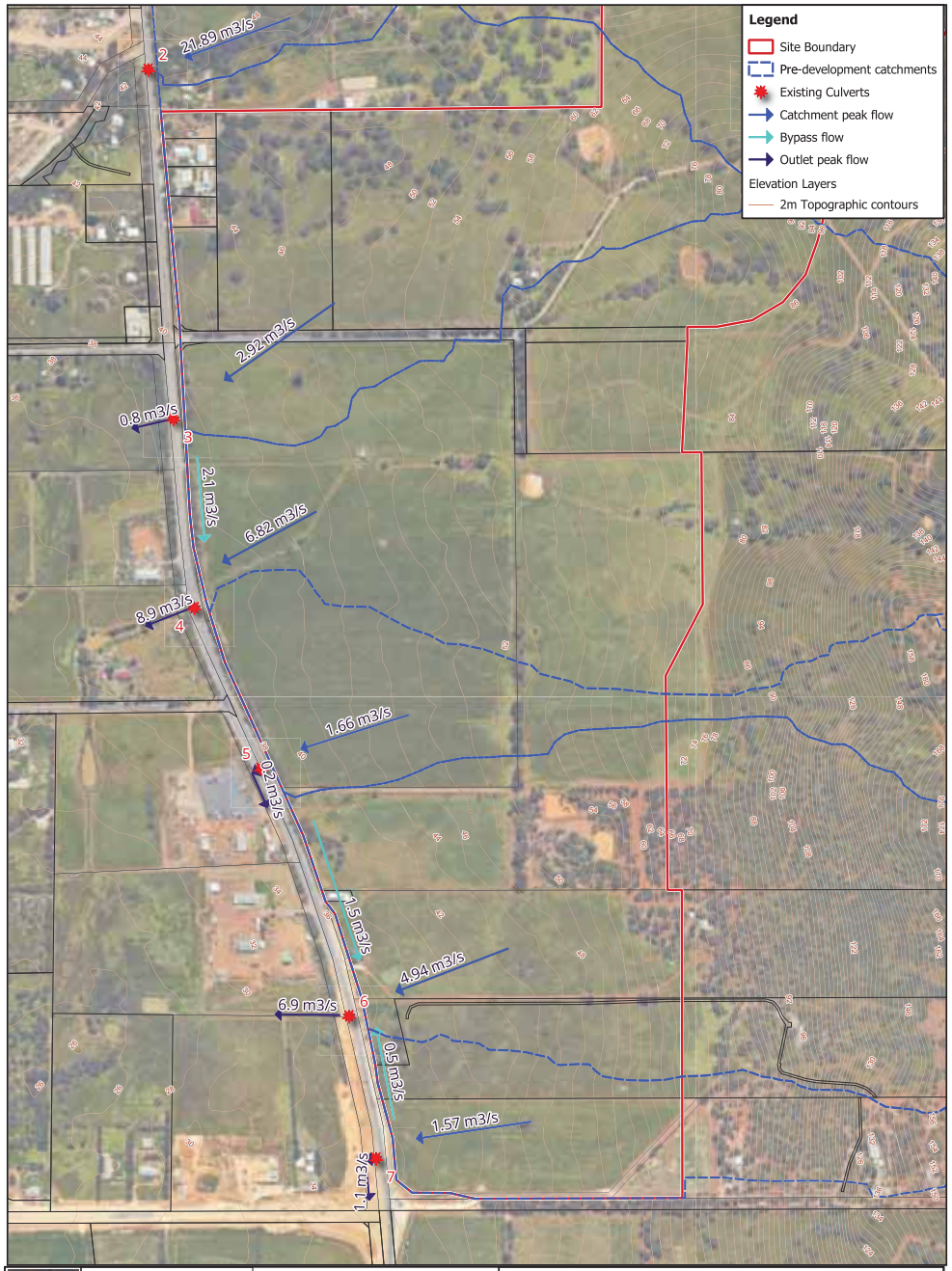
GDA94 / MGA zone 50

Figure L

Pre-development catchments and hydrological modelling (1% AEP peak flows)



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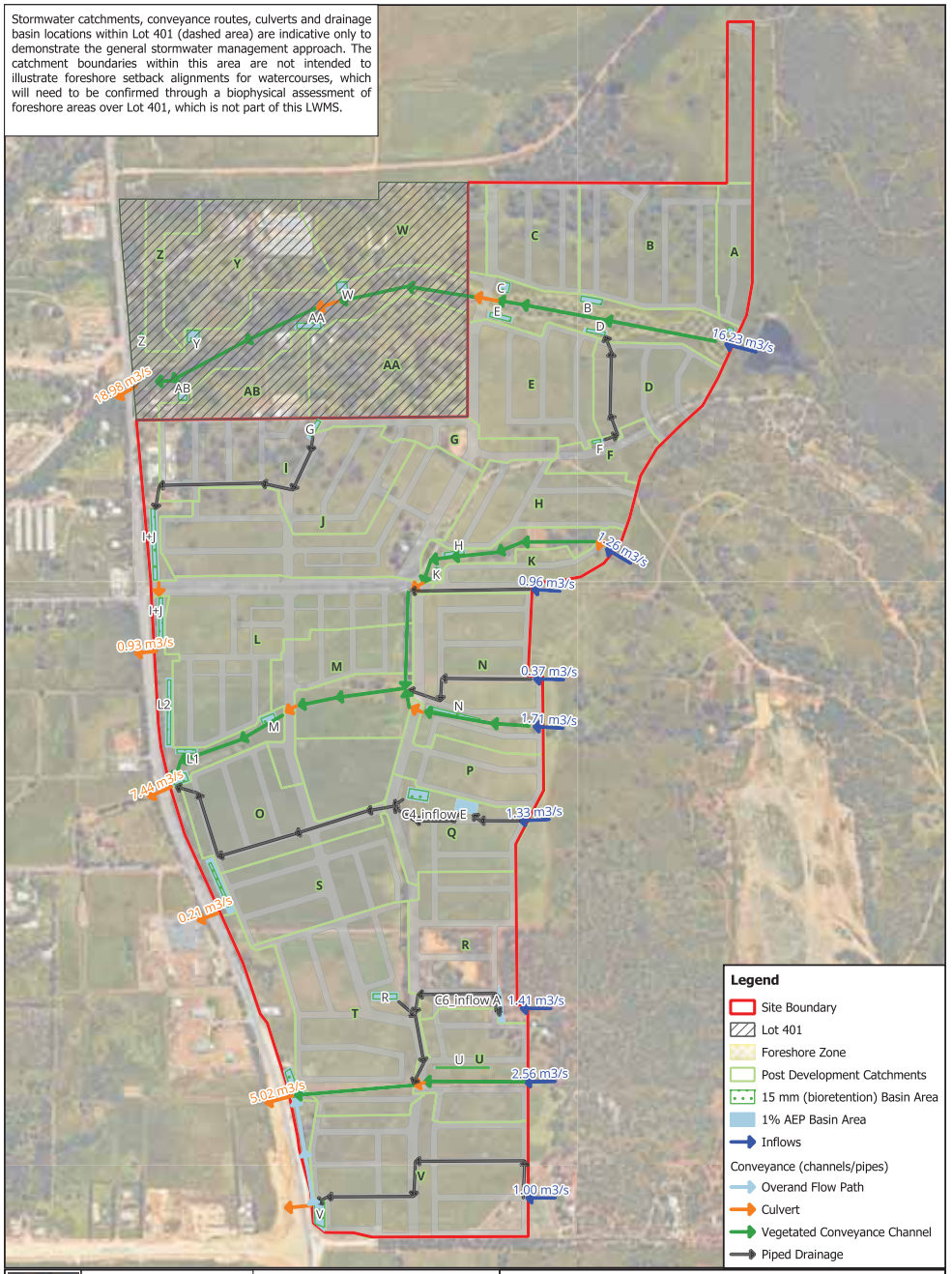
GDA94 / MGA zone 50

Figure M

Estimated 1% AEP peak flows at outlets

Stormwater catchments, conveyance routes, culverts and drainage basin locations within Lot 401 (dashed area) are indicative only to demonstrate the general stormwater management approach. The catchment boundaries within this area are not intended to illustrate foreshore setback alignments for watercourses, which will need to be confirmed through a biophysical assessment of foreshore areas over Lot 401, which is not part of this LWMS.



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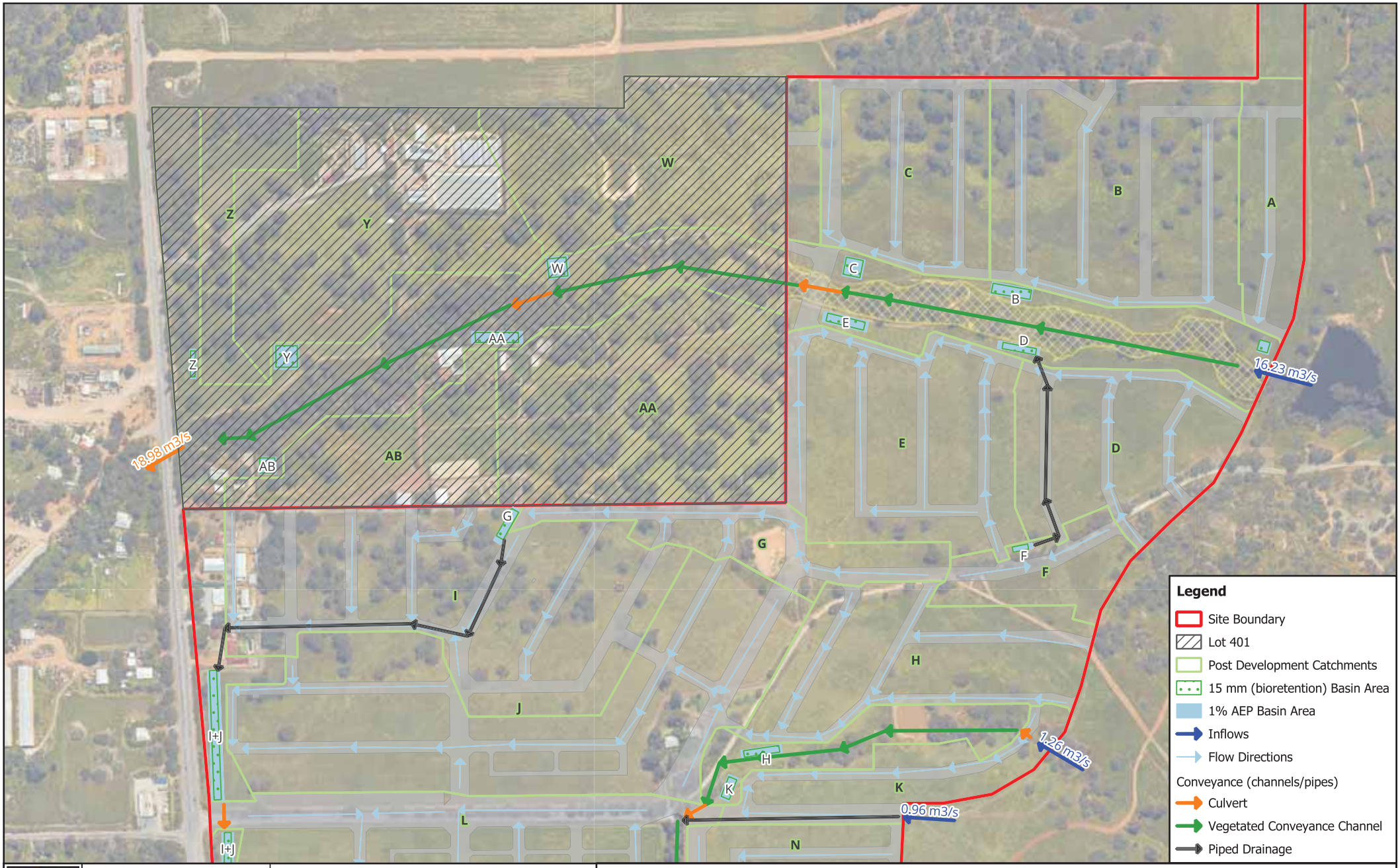
GDA94 / MGA zone 50

Figure N

Stormwater Management Plan (Overall)



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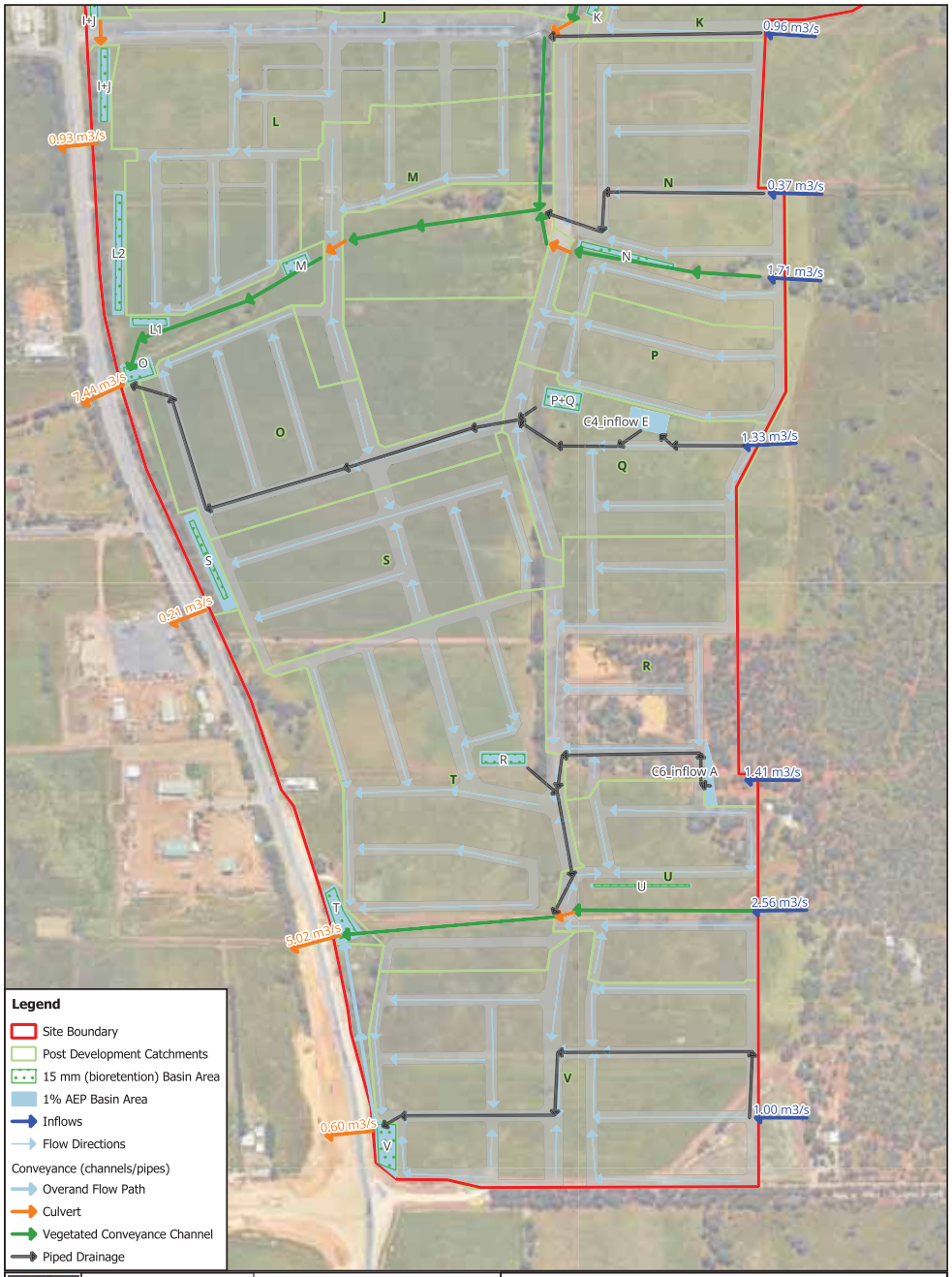
GDA94 / MGA zone 50

Figure O

Stormwater Management Plan (North)



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Sources: data.gov.au, DWER, landgate

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GDA94 / MGA zone 50

Figure P

Stormwater Management Plan (South)



PENTIUM WATER

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Sources: data.gov.au, DWER, landgate

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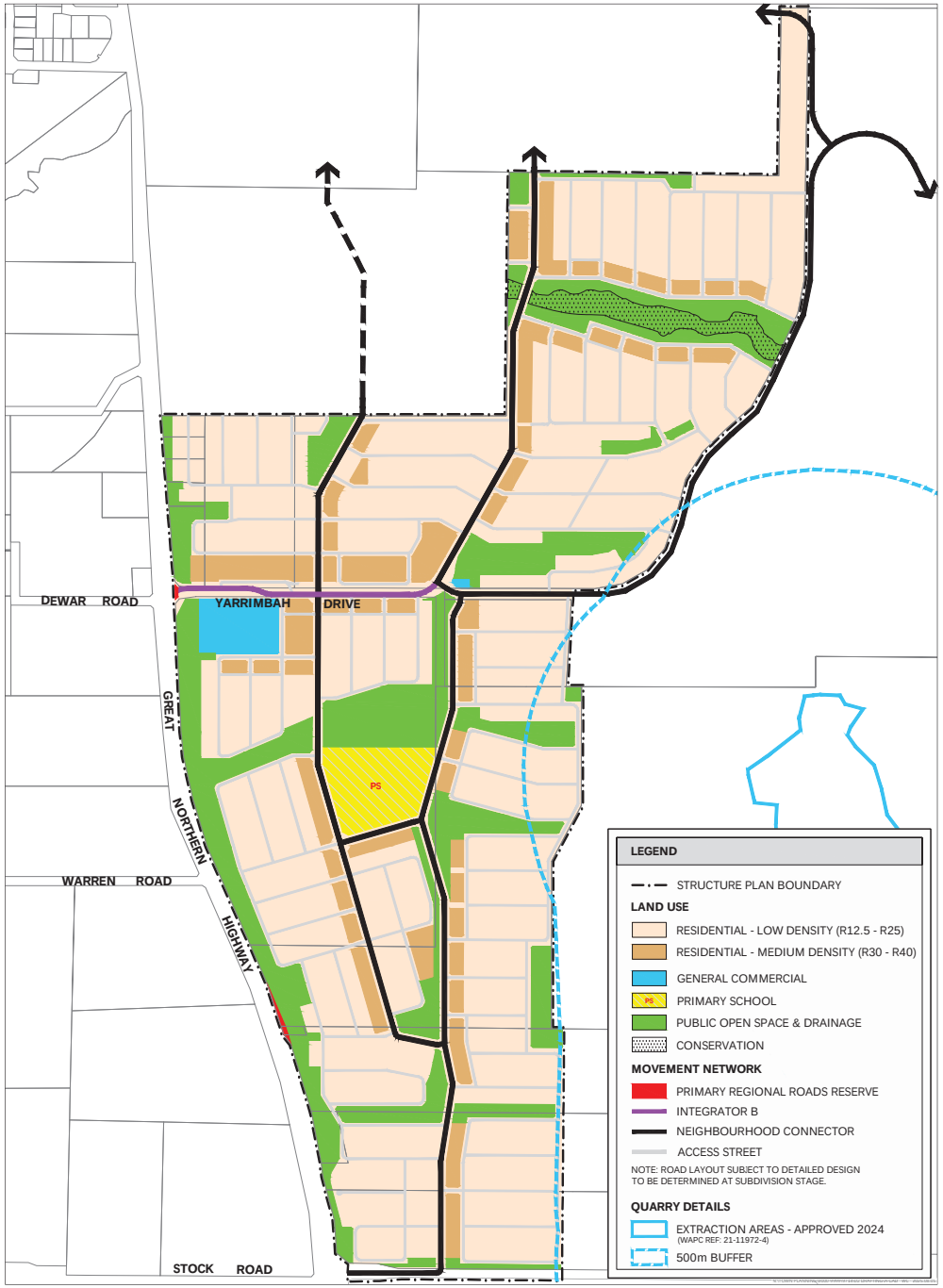
GDA94 / MGA zone 50

Figure Q

Bullsbrook South Proposed Post-development Monitoring Locations

Appendix A: Local Structure Plan

Rowe Group, 2025



PLAN 1 - LOCAL STRUCTURE PLAN

VARIOUS LOTS - GREAT NORTHERN HIGHWAY

BULLSBROOK

N

0 200 m

SCALE @ A3: 1:7500

9714-LSP-01-F

DRAWN: WC
DATE CREATED: 2025.08.05
PROJECTION: PCG94
CADASTRE: MNG 1056704-006a

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ROWE GROUP DESIGN

Appendix B: Report on Preliminary Geotechnical Study - Proposed Residential Subdivision

Galt Geotechnics, 2022

Report on

PRELIMINARY GEOTECHNICAL STUDY
PROPOSED RESIDENTIAL SUBDIVISION
VARIOUS LOTS - GREAT NORTHERN HIGHWAY &
LAGE ROAD, BULLSBROOK

Submitted to:
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J2201093 001 R Rev1

18 August 2022

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2. Site Description and Proposed Development 1
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4. Fieldwork 1
5. Laboratory Test Results 3
6. Site Conditions 3
6.1 Geology 3
6.2 Subsurface Soil Conditions 3
6.3 Groundwater 4
7. Preliminary geotechnical assessment 4
8. Closure 6

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Table 3 Summary of Site Classifications 5
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FIGURES

FIGURE 1: SITE AND TEST LOCATION PLAN

J2201093 001 R Rev1
18 August 2022

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APPENDIX B: SITE PHOTOGRAPHS
APPENDIX C: TEST PIT REPORTS
APPENDIX D: DYNAMIC CONE PENETROMETER TEST RESULTS
APPENDIX E: LABORATORY TEST RESULTS
APPENDIX F: UNDERSTANDING YOUR REPORT

1. INTRODUCTION

This revised report presents the outcomes of Galt Geotechnics Pty Ltd's (Galt's) preliminary geotechnical study for the proposed residential subdivision for Bullsbrook South covering various lots along Great Northern Highway and Lage Road, Bullsbrook ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

This report was aimed at a broad assessment and confirmation of the high-level geotechnical suitability of the site for the proposed residential development. We note that the outcomes presented in this report should be used as a high-level assessment to guide future detailed investigations for detailed design.

This revised report supersedes our previous report (J2201093 001 R Rev0, dated 16 May 2022) and includes confirmation that the site is considered geotechnically suitable for the proposed development.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The site is irregular in shape, comprising multiple lots covering an area of over 187 ha (refer Figure 1). The site is mostly pastoral land, and is vegetated with grass and some mature trees scattered across parts of the site.

Publicly available survey information indicates the site slopes up from around RL 40 m AHD along the western boundary to around RL 80 m AHD along the eastern boundary.

A residential subdivision is proposed across the area. The proposed subdivision masterplan is presented in Appendix A, Supplied Drawings.

3. PROJECT OBJECTIVES

The objectives of the study were to:

- broadly assess subsurface soil and groundwater conditions across the site;
- provide a preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings"; and
- assess key geotechnical issues relating to earthworks of the site.

This study was not intended for detailed design, but rather to inform the project team of broad geotechnical conditions and provide an appreciation of high-level planning for ground-related issues to inform detailed design.

4. FIELDWORK

Galt carried out the following fieldwork on 6 April 2022:

- excavation of test pits at 18 locations, extending to depths of between 1.0 m and 3.2 m;
- testing with a dynamic cone penetrometer (DCP) adjacent to each borehole, extending to refusal depths of between 0.1 m and 0.7 m; and
- collection of samples for geotechnical laboratory testing.

General

BMD selected the location of the test pits and carried out the excavation of the test pits. Our geotechnical engineer observed the test pitting, logged the materials encountered in the test pits, performed the penetrometer testing and collected samples for laboratory testing.

The investigation was carried out in general accordance with AS1726-2017 "Geotechnical site investigations".

The approximate test locations are shown on Figure 1, Site and Location Plan. Photographs of the site are presented in Appendix B.

Details of the tests are presented below in Table 1.

Table 1: Summary of Tests

Test Name	Test Depth (m)	Reason for Termination	Stratigraphy
TP01/BH15	2.2	Target depth	Sandy GRAVEL overlying Clayey SAND/SAND
TP02/BH14	2.5		GRAVEL overlying Clayey SAND
TP03/BH13	2.5		Silty SAND overlying SAND/ Clayey SAND overlying Sandy CLAY
TP04/BH10	3.2		Silty GRAVEL overlying SAND/Clayey SAND overlying CLAY overlying ROCK
TP05/BH24	2.1	Refusal	Silty GRAVEL overlying SAND/Clayey SAND overlying Extremely Weathered ROCK overlying ROCK
TP06/BH09	1.0		GRAVEL overlying Sandy CLAY overlying ROCK
TP07/BH25	3.0	Target depth	Clayey Sandy GRAVEL overlying CLAY
TP08/BH08	1.5	Refusal	Sandy Silty GRAVEL overlying Sandy CLAY
TP09/BH07	1.0		GRAVEL overlying Sandy CLAY overlying possible SCHIST
TP10/BH06	2.5	Target depth	Sandy CLAY overlying CLAY overlying possible SCHIST
TP11/BH05	3.0		Sandy CLAY overlying CLAY overlying Sandy CLAY
TP12/BH04	2.7		Sandy CLAY overlying CLAY
TP13/BH18	3.0		Sandy CLAY overlying CLAY
TP14/BH19	3.0		Sandy CLAY overlying Clayey SAND
TP15/BH20	3.0		CLAY
TP16/BH21	3.0		Clayey GRAVEL overlying Sandy CLAY overlying Clayey SAND
TP17/BH16	2.8		Sandy CLAY overlying CLAY
TP18/BH01	2.5		GRAVEL overlying Clayey Gravelly SAND overlying Clayey SAND overlying Sandy CLAY

Notes: 1. GNE – Groundwater not encountered in any test pits

Test Pits

Test pits were excavated using a 33 tonne CAT330F excavator equipped with a 0.65 m wide rock bucket. The excavator was supplied and operated by BMD.

Test pit reports are presented in Appendix C, along with a method of soil and rock description and a list of explanatory notes and abbreviations used in the reports.

Dynamic Cone Penetrometer (DCP) Tests

DCP tests were carried out in accordance with AS 1289.6.3.2. Tests were carried out adjacent to each test pit and the results of the tests are presented in Appendix D.

5. LABORATORY TEST RESULTS

Laboratory testing was conducted by Western Geotechnical and Laboratory Services, a NATA accredited laboratory. The testing comprised determination of:

particle size distribution on 6 samples; and
Atterberg limits and linear shrinkage on 6 samples;

The laboratory test results are presented in Appendix E along with the test methods followed and a summary of the test results is presented in Table 2.

Table 2: Summary of Laboratory Test Results

Test Name	Sample Depth (m)	Soil Class (AS1726 2017)	% Gravel	% Sand	% Fines	LL (%)	PI (%)	LS (%)
TP01/BH15	1.5 to 2.0	SAND (SP) [2]	16	82	2	42	18	5.0
TP04/BH10	0.8 to 1.2	SAND (SP-SC) [2]	10	84	6	39	15	6.0
TP07/BH25	0.8 to 1.2	CLAY (CH)	16	17	67	59	38	8.0
TP11/BH05	0.7 to 1.1	CLAY (CH)	13	12	75	68	45	14.0
TP15/BH20	0.5 to 1.0	CLAY (CH)	16	13	71	66	43	12.0
TP17/BH16	2.2 to 2.7	Clayey GRAVEL (GC)	63	10	27	57	36	9.5

Notes **1.** LL – Liquid Limit PI – Plasticity Index LS – Linear Shrinkage

2. Despite the low fines content for TP01/BH15 and TP04/BH10, our tactile assessment of these sand samples displayed clayey properties. This sandy material must be assumed to have a low hydraulic conductivity when compacted (unless further testing can justify otherwise).

6. SITE CONDITIONS

6.1 Geology

The Muchea sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is underlain by predominantly Sandy SILT.

The findings of our investigation are broadly consistent with the geological mapping. Shallow clayey soils were predominantly present across the site with variable sand thicknesses in some areas. Rock (possibly granite or schist) was also noted along parts of the (more elevated) northeast corner of site.

6.2 Subsurface Soil Conditions

The subsurface soil conditions are somewhat variably across the site. Typical soil profiles have been broadly summarised as follows:

Parts of the northern end of site (typically Zone 1 – refer to Section 7)

Sandy GRAVEL/Silty GRAVEL (GP/GM): fine to coarse grained, angular to sub-rounded, brown, about 5% to 20% non-plastic fines extending from the surface to depths of typically between 0.3 m to 0.5 m; overlying
Clayey SAND/ SAND (SC/SP): fine to coarse grained, orange brown, 5-15% low to medium plasticity fines extending to depths of between 0.9 m and 2.4 m;
Extremely Weathered ROCK/ ROCK – possibly quartz rich, metamorphic rock present from depths of between 0.9 m and 2.8 m.

Central part of site (typically Zone 3 – refer to Section 7)

Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 m.

Central and south of the site (Zone 2 – refer to Section 7)

Zone 2 is as Zone 3 but with a thin and irregular overlay of granular material (gravel or sand), typically about 0.3 m to 0.4 m thick.

Based on our experience on nearby sites, we anticipate that pockets of silty sand (up to several metres deep, and possibly loose) may be present in some areas, not yet identified.

Note: 1. Subsurface conditions are variable. Reference should be made to the test pit reports for the specific soil conditions

6.3 Groundwater

The Perth Groundwater Atlas (2003) shows the end of summer level to be around RL 35 m to 45 m AHD. This is within about 5 m of the current ground surface near the western site boundary.

We did not encounter any groundwater in any of the test pits. However, we expect shallow perched groundwater to develop on the clayey soils during winter. Drainage designs must take this into account.

7. PRELIMINARY GEOTECHNICAL ASSESSMENT

Based on the findings of our investigation, we note that the following key geotechnical issues relating to this site and associated earthworks.

Site Suitability

We consider that the subject site is geotechnically suitable for the proposed residential development, subject to normal engineering design and site preparation practices. A more detailed geotechnical investigation prior to detailed design will assist in the identification of any areas requiring specific treatment.

Preliminary Site Classification

We have assessed the site in accordance with AS 2870-2011 “Residential Slabs and Footings” which defines the site classes as summarised in Table 3.

Table 3 Summary of Site Classifications

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock site with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

Under current conditions, we consider the preliminary site classifications to be as follows:

Zone 1 – Class S (thick layers of inert granular material and/or low reactive clayey soils)

Zone 2: Class M (thin layer of inert granular material overlying shallow high plasticity clayey)

Zone 3 -Class H1/Class H2 (near surface high plasticity clay soils)

If required, the site classifications can be improved by placement and compaction of inert fill material. The thicknesses required in each zone are summarised in Table 4. The indicative soil zones are shown on Figure 1.

Table 4: Indicative Required Thickness of Inert Fill (m)

Zone	Current Site Class	Current nominal thickness of mostly granular surficial in-situ soil (m)	Improvement to Class M	Improvement to Class S	Improvement to Class A
Zone 1	S	0.9 to 2.4	-	-	1.8
Zone 2	M	0.3 to 0.4	-	0.5	1.8
Zone 3	H1/H2	0	0.4	0.9	1.8

We note the following:

The delineation of the site classification zones is approximate only and based on very limited data. This will need to be supported by substantial additional testing on site for detailed design.
Shrink-swell testing is required to better refine site classes.
We note shallow rock was present in isolated areas within Zone 2. The site classification for areas underlain by shallow rock may be improved to Class S (these areas should be confirmed through further investigation).
It is likely that the sand/clayey sand present in the north of the site (Zone 1) is very loose in situ (testing done to date has not proven this, however we have worked on nearby sites which had similar sand. This may require substantial earthworks to compact this material. Without such compaction, the sand/clayey sand may be collapsible (subject to consolidation under constant stress when inundated).

The thicknesses of fill presented in Table 4 to improve the site classifications is in addition to the mostly granular surficial in-situ soil layer (nominal thickness also shown in Table 4).

Drainage Control and Construction Issues

Compaction and trafficking of the clayey areas of the site must NOT be attempted when the site is wet (i.e. following rainfall or if the site has been over-wetted during moisture conditioning). It will be necessary to let the site dry out or trim wet soil off to expose underlying drier material. Attempting to traffic or compact the wet clayey soils is likely to result in soil disturbance and significant softening of the clayey soils. Where shaping or grading of the underlying clay surface is carried out, the surface should be graded to divert rainfall and surface water away from any work areas and to avoid ponding.

Due to the low permeability of the clayey soils, storm water runoff is expected to pond on the clayey soils during the wetter months of the year. This may cause difficulties during construction including:

heaving and rutting of saturated clayey soils when trafficked; and
softening of clayey soils when water is allowed to pond at the base of excavations.

We recommend that earthworks are carried out in the summer months, even though earthworks conducted in summer can have their own issues such as dust control and rapid drying out of soils.

The moisture conditioning of the clayey soils is likely to be somewhat onerous (given that they are highly plastic, which tends to make them 'cloddy' and more difficult to moisten), however proper moisture conditioning is essential to successful compaction of clayey soils.

Compaction

No loose/soft soils, as inferred from DCP testing, were encountered during our investigation. As noted above, it is possible that the clayey sand may be very loose to loose in situ and collapsible.

Compaction control, on both in-situ sand and clayey soils, should be done with the nuclear density gauge in accordance with AS1289.5.8.1, to a depth of 0.3 m.

The use of penetrometers (either Perth sand or dynamic cone) would be limited to:

spot checks of clayey fill for the contractor's satisfaction before undertaking NDG testing; and
testing of clean sand fill (<5% fines, <5% gravel), which would be imported from off-site.

Stormwater Disposal

Based on the soil profile, we do not consider that disposal of stormwater by infiltration is appropriate for the site. Stormwater should instead be diverted using drains or otherwise to a disposal area or similar located away from structures.

8. CLOSURE

We draw your attention to Appendix F of this report, "Understanding your Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD





Piravin Anandacoomaraswamy	Owen Woodland CPEng
Geotechnical Engineer	Geotechnical Engnieer

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Figures

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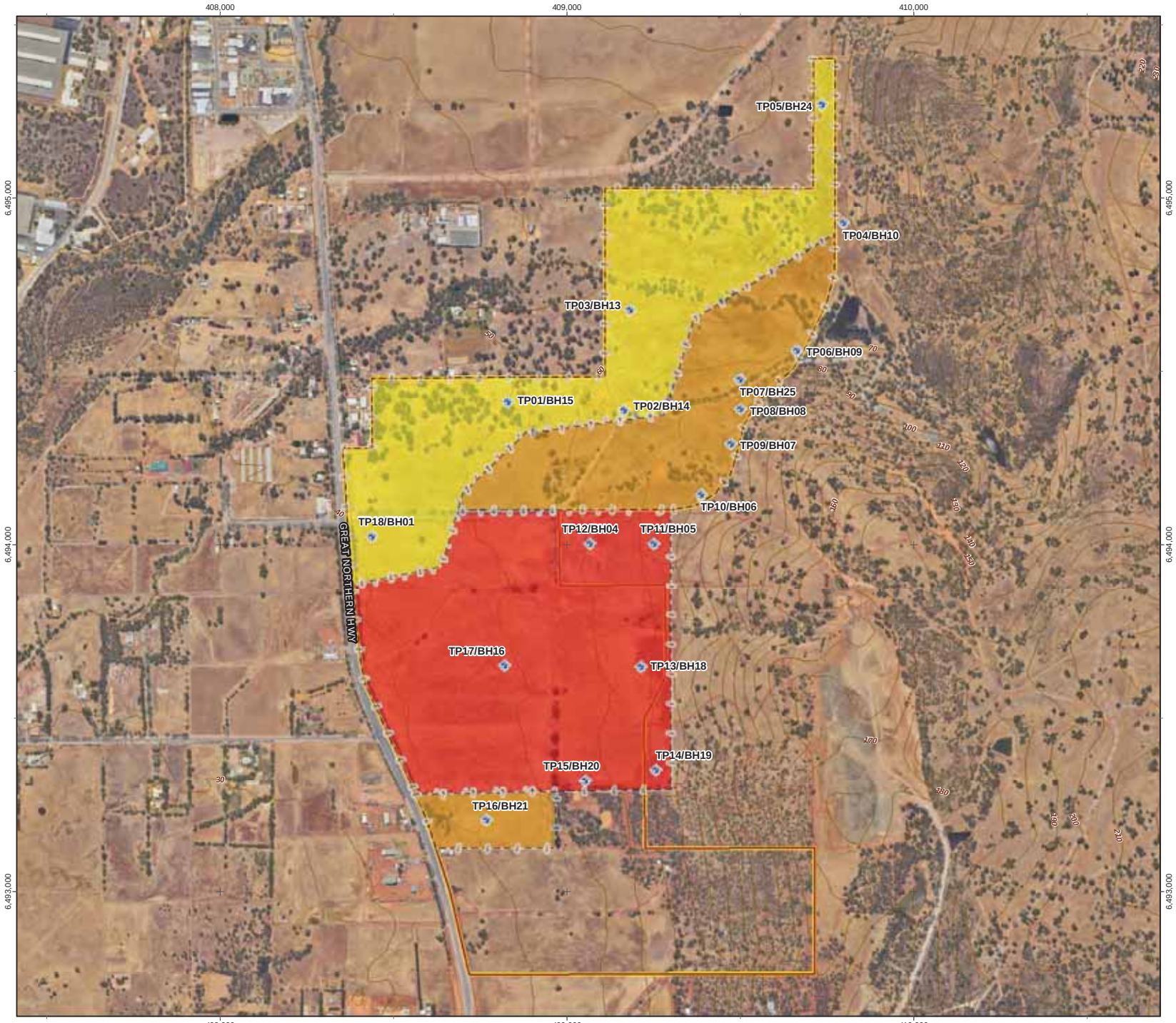



Legend

Site Boundary

Preliminary Site Classifications (AS2870-2011)

Possible Class H1/H2

Possible Class M

Possible Class S

Test Pit

N

0 175 350 525 700 875

Meters

NOTES

Aerial Imagery and Cadastre sourced from Landgate/SLIP



SCALE	1:11,000 (A3)
DRAWN	CED
DATE DRAWN	12/05/2022
CHECKED	–
DATE CHECKED	–
PROJECTION	GDA 1994 MGA Zone 50

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CLIENT	**PRITCHARD FRANCIS**
PROJECT	DUE DILIGENCE
LOCATION	GREAT NORTHERN HIGHWAY BULLSBROOK
TITLE	SITE & LOCATION PLAN
Job No	J2201093
Fig No	FIGURE 1
Rev	**A**

Appendix A: Supplied Drawings

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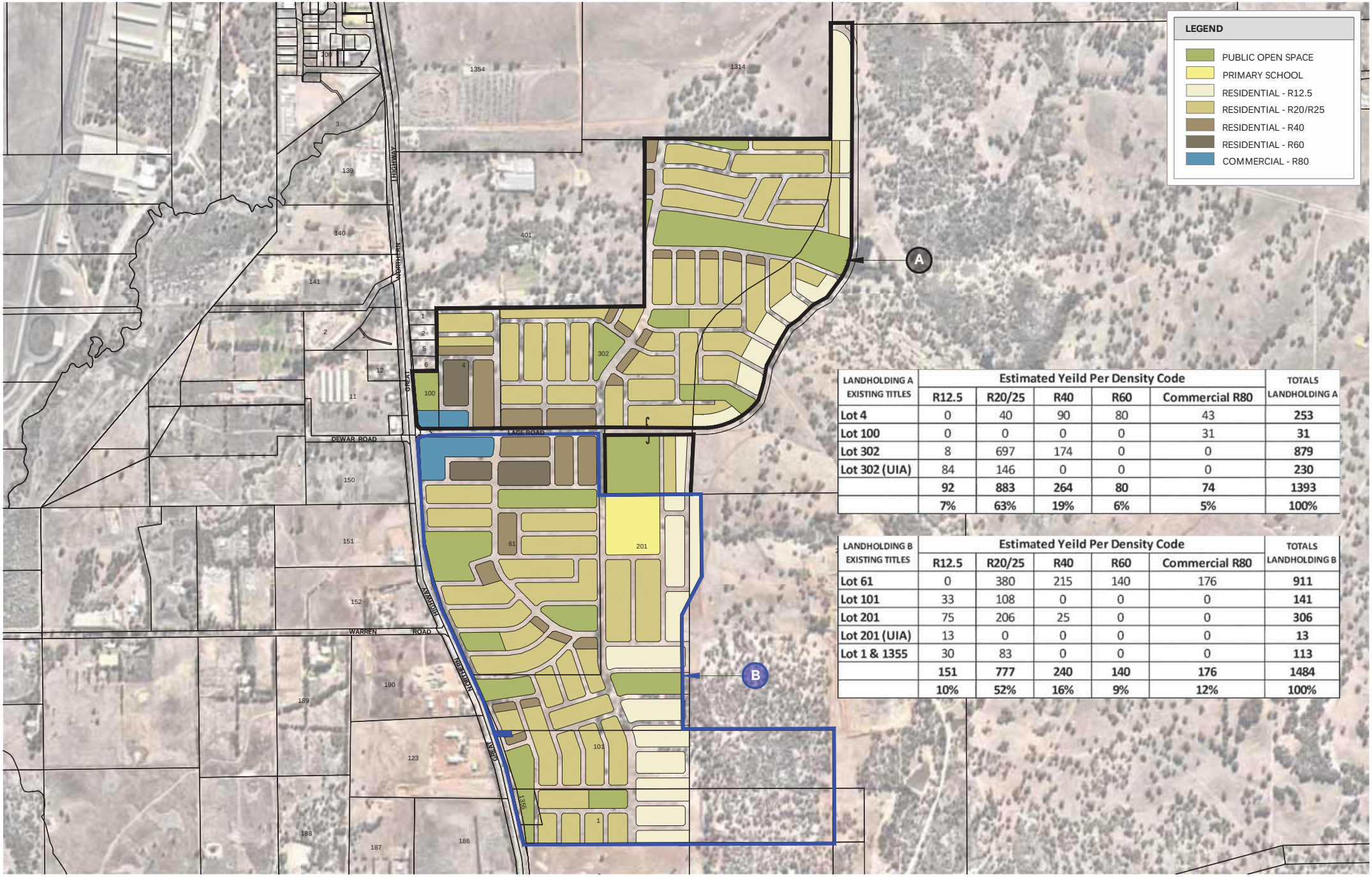

LANDHOLDING A EXISTING TITLES	Estimated Yeild Per Density Code					TOTALS LANDHOLDING A
	R12.5	R20/25	R40	R60	Commercial R80	
Lot 4	0	40	90	80	43	253
Lot 100	0	0	0	0	31	31
Lot 302	8	697	174	0	0	879
Lot 302 (UIA)	84	146	0	0	0	230
	92	883	264	80	74	1393
	7%	63%	19%	6%	5%	100%

LANDHOLDING B EXISTING TITLES	Estimated Yeild Per Density Code					TOTALS LANDHOLDING B
	R12.5	R20/25	R40	R60	Commercial R80	
Lot 61	0	380	215	140	176	911
Lot 101	33	108	0	0	0	141
Lot 201	75	206	25	0	0	306
Lot 201 (UIA)	13	0	0	0	0	13
Lot 1 & 1355	30	83	0	0	0	113
	151	777	240	140	176	1484
	10%	52%	16%	9%	12%	100%

BULLSBROOK SOUTHERN PRECINCT MAJOR LANDHOLDINGS A & B

CONCEPT STRUCTURE PLAN

LOTS 4, 61, 100 & PT 302 LAGE ROAD AND LOTS 1,101, 201 & 1355 GREAT NORTHERN HIGHWAY, BULLSBROOK

NORTH

0m 200m

SCALE @ A3: 1:11,000

4790-CON-12-E

ROWE GROUP

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Appendix B: Site Photographs



Photograph 1: View of site from near TP02/BH14



Photograph 2: View of rock recovered from TP05/BH24



Photograph 3: Excavator ripping through shallow rock present near TP06/BH09



Photograph 4:Rock recovered from TP09/BH07



Photograph 5: Looking west from near TP11/BH05



Photograph 6: Looking east at excavator positioned near TP14/BH19

Appendix C: Test Pit Reports

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Length of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & SOIL CLASSIFICATION SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES / BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	GM	Silty GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

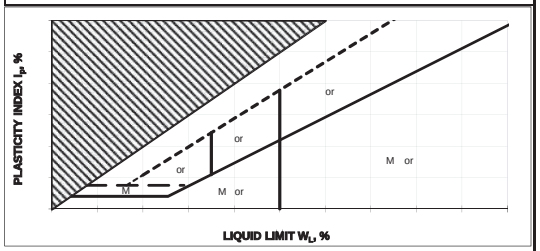
NOTE: Dual classification given for soils with a fines content between 5% and 12%.

SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-2017. Material properties are assessed in the field by visual/tactile methods in combination with field and laboratory testing techniques (where used).
NOTE: AS 1726-2017 defines a fine grained soil where the total dry mass of fine fractions (<0.075 mm particle size) exceeds 35%.

PARTICLE SIZE		
Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	19 to 63
	Medium	6.7 to 19
	Fine	2.3 to 6.7
SAND	Coarse	0.6 to 2.36
	Medium	0.21 to 0.6
	Fine	0.075 to 0.21
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY - MODIFIED CASAGRANDE CHART - AS1726-2017



RESISTANCE TO EXCAVATION		
Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

MOISTURE CONDITION	
Symbol	Term
D	Dry
M	Moist
W	Wet

CEMENTATION	
Cementation	Description
Weakly cemented	Soil may be easily disaggregated by hand in air or water
Moderately cemented	Effort is required to disaggregate the soil by hand in air or water

CONSISTENCY		
Symbol	Term	Undrained Shear Strength (kPa)
VS	Very Soft	0 to 12
S	Soft	12 to 25
F	Firm	25 to 50
St	Stiff	50 to 100
VSt	Very Stiff	100 to 200
H	Hard	>200

ORGANIC SOILS	
Material	Organic Content % of dry mass
Inorganic soil	<2%
Organic soil	2% to 25%
Peat	>25%

DENSITY		
Symbol	Term	Density Index (%)
VL	Very Loose	<15
L	Loose	15 to 35
MD	Medium Dense	35 to 65
D	Dense	65 to 85
VD	Very Dense	>85

TEST PIT: TP01/BH15

Job Number: J2201093
Client: Pritchard Francis
Project: Bullsbrook Southern Precinct Major
Location: Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook

Contractor: BMD
Machine: CAT 330F
Operator: JB
Bucket: 650 mm toothed

Date: 06/04/2022
Logged: PA
Checked Date: 13/05/2022
Checked By: ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP	Sandy GRAVEL: fine to coarse grained, angular to sub-rounded, brown, approximately 30% fine to coarse grained sand, trace fines	D	L D VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5									
			1.0									
			1.5		B(TP01-01)			SC / SP	Clayey SAND/SAND: fine to coarse grained, orange-brown, 5-15% low to medium plasticity fines			Ripper used at 1.2 m. Sand easily ripped.
			2.0									
			2.5						Hole terminated at 2.20 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GIG EXCAVATION J2201093.GPJ <<Drawingfiles>> 28/04/2022 13:13 6.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01.2015-02-21 | Prj: GALT 1.01.2015-02-21

TEST PIT: TP02/BH14

Sheet 1 OF 1

Job Number: J2201093
Client: Pritchard Francis
Project: Bullsbrook Southern Precinct Major
Location: Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook

Contractor: BMD
Machine: CAT 330F
Operator: JB
Bucket: 650 mm toothed

Date: 06/04/2022
Logged: PA
Checked Date: 13/05/2022
Checked By: ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E-F			0.0				GP-GM		GRAVEL: fine to coarse grained, angular to sub-rounded, brown, with sand, with fines, trace organics in top 100 mm		L VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP02-01)			SC	Clayey SAND: fine to coarse grained, orange-brown, 15-25% low to medium plasticity fines, with gravel	D		
			1.0									
			1.5									
			2.0									
			2.5						Hole terminated at 2.50 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J2201093.GPJ <<Drawingfiles>> 28/04/2022 13:13 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2015-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP03/BH13

Sheet 1 OF 1

Job Number: J2201093
Client: Pritchard Francis
Project: Bullsbrook Southern Precinct Major
Location: Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook

Contractor: BMD
Machine: CAT 330F
Operator: JB
Bucket: 650 mm toothed

Date: 06/04/2022
Logged: PA
Checked Date: 13/05/2022
Checked By: ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					SM	Silty SAND: fine to coarse grained, brown, 15-25% non-plastic fines, trace gravel	D	D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					SC / SP	SAND/Clayey SAND: fine to coarse grained, orange-brown, 5-20% low to medium plasticity fines, trace gravel		VD	
			1.0									
			1.5					CI	Sandy CLAY: medium plasticity, orange-brown, 30-50% fine to coarse grained sand, with gravel	D		
			2.0									
			2.5						Hole terminated at 2.50 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP04/BH10

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0		B(TP04-01)			GM	Silty GRAVEL: fine to coarse grained, angular to sub-rounded, pale brown, 15-25% non-plastic fines, with sand, trace organics in top 50 mm	D	MD / D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP04-02)			SC / SP	SAND/Clayey SAND: fine to coarse grained, orange-brown, 5-15% low to medium plasticity fines, with gravel			
			1.0									
			1.5									
			2.0									
			2.5					CI-CH	CLAY: medium to high plasticity, grey, with fines			
H			3.0						ROCK, possible quartz-rich, metamorphic rock			Rock very slowly ripped with single tyne ripper with extreme difficulty.
			3.5						Hole terminated at 3.20 m Refusal on rock Groundwater not encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP05/BH24

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					GM	Silty GRAVEL: fine to coarse grained, angular to sub-rounded, pale brown, 15-25% non-plastic fines, with sand, trace organics in top 50 mm		VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP05-01)			SC / SP	SAND/Clayey SAND: fine to coarse grained, orange-brown, 5-15% low to medium plasticity fines, with gravel			
			1.0						Extremely Weathered ROCK, recovered as cobbles, gravel and boulder in a soil matrix	D		
			1.5									
			2.0						ROCK, possible quartz-rich, metamorphic rock			
			2.5						Hole terminated at 2.10 m Refusal on rock Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP06/BH09

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP-GM	GRAVEL: fine to coarse grained, angular to sub-angular, grey-brown, with sand, with fines		VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP06-01)			CI / SP	Sandy CLAY: medium to high plasticity, brown mottled grey, 30-50% fine to medium grained sand, trace gravel	D		
	H		1.0						Hole terminated at 1.00 m Refusal on rock Groundwater not encountered			
			1.5									
			2.0									
			2.5									
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP07/BH25

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP	Clayey Sandy GRAVEL: fine to coarse grained, brown, 30-40% fine to coarse grained sand, 15-30% low to medium plasticity fines		D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5						CLAY: high plasticity, orange-brown, with sand, with gravel			
	F-H		1.0		B(TP07-01)							
			1.5					CH / SP		D		
			2.0									
	F		2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP08/BH08

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0				GM		Sandy Silty GRAVEL: fine to coarse grained, brown, fine to coarse grained sand, non-plastic fines, trace organics in top 50 mm	D	D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP08-01)		CH		Sandy CLAY: high plasticity, brown, 30-40% fine to coarse grained sand, trace gravel			
H			1.0									
			1.5						Hole terminated at 1.50 m Refusal on rock Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

TEST PIT: TP09/BH07

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0				GP-GM		GRAVEL: fine to coarse grained, pale brown, with sand, with fines, trace organics in top 50 mm	D	D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP09-01)		CI-CH		Sandy CLAY: medium to high plasticity, brown, 30-50% fine to coarse grained sand			
H			1.0						Possible SCHIST, recovered as boulders, cobbles and gravel			Rock ripped with single tyne ripper attachments; moderately difficult ripping.
			1.5						Hole terminated at 1.00 m Refusal on rock Groundwater not encountered			
			2.0									
			2.5									
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP10/BH06

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0		B(TP10-01)			CL-CI	Sandy CLAY: low to medium plasticity, brown, 40-60% fine to coarse grained sand, trace gravel	D	D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CI	CLAY: medium to high plasticity, brown, with sand	D / M		
			1.0									
			1.5									
F			2.0						Possible SCHIST, recovered as cobbles and gravel in a soil matrix	D		Rock easily broken up with single tyne ripper attachment
			2.5									
			3.0						Hole terminated at 2.60 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP11/BH05

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0		B(TP11-01)			CI	Sandy CLAY: medium plasticity, red-brown, 30-50% fine to medium grained sand	D	MD / D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CH	CLAY: high plasticity, red-brown, trace sand, with gravel			
			1.0									
			1.5							D / M		
			2.0					CI	Sandy CLAY: medium plasticity, pale yellow, 35-45% fine to coarse grained sand			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP12/BH04

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					CI	Sandy CLAY: medium plasticity, red-brown, 30-50% fine to medium grained sand, trace gravel	D	VSt / H	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CH	CLAY: high plasticity, red-brown, with sand, trace gravel	D / M		
			1.0									
			1.5									
			2.0						Red-brown mottled white			
			2.5									
			3.0						Hole terminated at 2.70 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP13/BH18

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					CI	Sandy CLAY: medium plasticity, red-brown, 40-50% fine to medium grained sand, trace organics in top 50 mm	D	VSt	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CH	CLAY: high plasticity, red-brown, with sand, trace gravel	D / M		
			1.0									
			1.5									
			2.0									
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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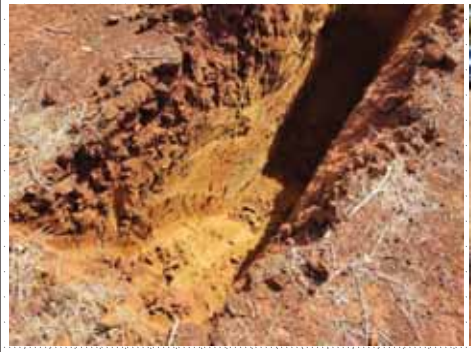
TEST PIT: TP14/BH19

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						Sandy CLAY: medium plasticity, red-brown, 30-50% fine to coarse grained sand, trace gravel		VSt	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CI				
	E		1.0									
			1.5		B(TP14-01)				Clayey SAND: fine to coarse grained, orange-brown, 15-25% low plasticity fines	D		
			2.0					SC				
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP15/BH20

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description				
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
			0.0						CLAY: high plasticity, brown, with sand, trace gravel	D		Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP15-01)							
	E		1.0					CH				
			1.5							D / M		
			2.0						Grey			
			2.5							M		
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP16/BH21

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					GC	Clayey GRAVEL: fine to medium grained, red-brown, 15-20% low plasticity fines, with sand		D	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					CI	Sandy CLAY: medium plasticity, brown, 40-60% fine to medium grained sand			
			1.0						Clayey SAND: fine to coarse grained, orange-brown, 15-30% low plasticity fines			
			1.5		B(TP16-01)			SC		D		
			2.0						With gravel			
			2.5									
			3.0						Hole terminated at 3.00 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP17/BH16

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
E			0.0					CI	Sandy CLAY: medium plasticity, brown, 40-50% fine to coarse grained sand, trace gravel	D	VSt	Consistency/density assessed from DCP test adjacent to test pit.
			0.5		B(TP17-01)							
			1.0							D / M		
			1.5									
			2.0		B(TP17-02)			CH	CLAY: high plasticity, grey, with gravel, trace sand			
			2.5									
			3.0						Hole terminated at 2.80 m Target depth Groundwater not encountered			
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J2201093.GPJ <<Drawingfiles>> 28/04/2022 13:14 10.02.00.04 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2015-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP18/BH01

Sheet 1 OF 1

Job Number:	J2201093	**Contractor:**	BMD	**Date:**	06/04/2022
Client:	Pritchard Francis	**Machine:**	CAT 330F	**Logged:**	PA
Project:	Bullsbrook Southern Precinct Major	**Operator:**	JB	**Checked Date:**	13/05/2022
Location:	Lots 4, 900 and 61 Lage Road and Lots 1, 101, 202 and 803 Great Northern Highway, Bullsbrook	**Bucket:**	650 mm toothed	**Checked By:**	ORW

Excavation					Sampling		Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	SOIL CLASS	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
	E-F		0.0					GP	GRAVEL: fine to medium grained, rounded to sub-rounded, brown, with sand, trace fines	D	D / VD	Consistency/density assessed from DCP test adjacent to test pit.
			0.5					SC	Clayey Gravelly SAND: fine to coarse grained, orange mottled red, approximately 30% fine to medium grained gravel, approximately 15-20% low plasticity fines			
	E		1.0		B(TP18-01)							
			1.5					SC	Clayey SAND: fine to coarse grained, orange-brown, 15-30% low plasticity fines			
			2.0					CI	Sandy CLAY: low to medium plasticity, grey mottled red, 40-60% fine to coarse grained sand			
			2.5						Hole terminated at 2.50 m Target depth Groundwater not encountered			
			3.0									
			3.5									

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GIS_EXCAVATION J2201093.GPJ <<DrawingFiles>> 28/04/2022 13:14 10.02.00.04 Datgel DGD, CPT Photo, Monitoring Tools | Lib: GALT 1.01.2015-02-21 Prj: GALT 1.01.2013-02-21

Appendix D: Dynamic Cone Penetrometer Test Results

Galt Geotechnics Pty Ltd

www.galtgeo.com.au
50 Edward Street OSBORNE PARK WA 6017

ABN: 64 625 054 729

DYNAMIC CONE PENETROMETER RECORD SHEET
AS 1298.6.3.2

Client:	Pritchard Francis	**Job No:**	J2201093
Project:	Proposed Residential Subdivision	**Date:**	6-Apr-22
Location:	Bullsbrook South	**Engineer:**	PA

Location:	TP01/BH15	TP02/BH14	TP03/BH13	TP04/BH10	TP05/BH24	TP06/BH09	TP07/BH25	TP08/BH08
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	1	1	1	2	1	7 HB	2	2
100-200	2	7 HB	5	3 HB	8		2 HB	5
200-300	4	10	4	5	6			7 HB
300-400	4	10+	6	9	10			
400-500	4		7	10	7 HB			
500-600	7		9	10+				
600-700	10+		10+					
700-800								
800-900								
900-1000								

Location:	TP09/BH07	TP10/BH06	TP11/BH05	TP12/BH04	TP13/BH18	TP14/BH19	TP15/BH20	TP16/BH21
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	2	4	3	5	3	2	-	2
100-200	5 HB	4 HB	9 HB	10+	10+	4		7 HB
200-300						3 HB		
300-400								
400-500								
500-600								
600-700								
700-800								
800-900								
900-1000								

Location:	TP17/BH16	TP18/BH01						
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**							
0-100	3	1						
100-200	8	5						
200-300	3 HB	10						
300-400		10						
400-500		7 HB						
500-600								
600-700								
700-800								
800-900								
900-1000								

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
0 = Penetration due to hammer weight only
R: Refusal

Appendix E: Laboratory Test Results

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ABN: 64 625 054 729

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

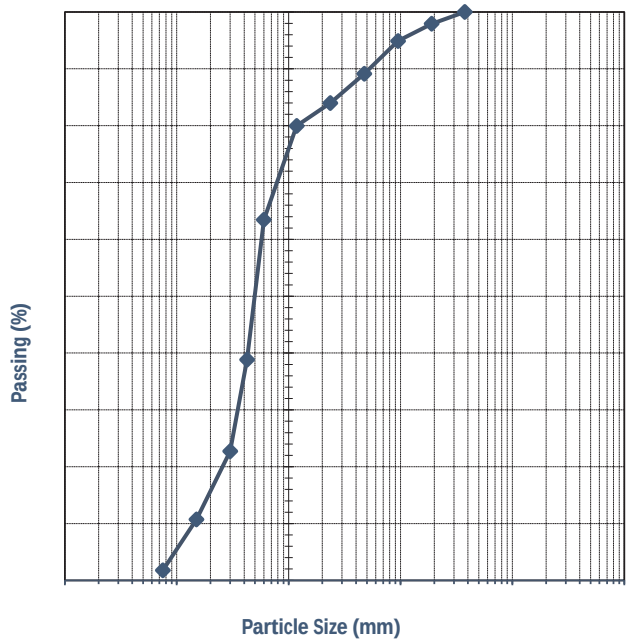
TEST REPORT - AS 1289.3.6.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5445_1_PSD**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5445**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP01/BH15 1.5-2.0m**	*Date Tested:*	**11/4/22-12/4/22**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	98
9.5	95
4.75	89
2.36	84
1.18	80
0.600	63
0.425	39
0.300	23
0.150	11
0.075	2



Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5445_1_PI**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5445**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP01/BH15 1.5-2.0m**	*Date Tested:*	**12/04/2022**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method: Sampled by Client, Tested as Received
History of Sample: Oven Dried <50°C
Method of Preparation: Dry Sieved

AS 1289.3.1.1	**Liquid Limit (%)**	**42**
AS 1289.3.2.1	**Plastic Limit (%)**	**24**
AS 1289.3.3.1	**Plasticity Index (%)**	**18**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**5.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 13/April/2022

NATA **Accreditation No. 20599**
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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

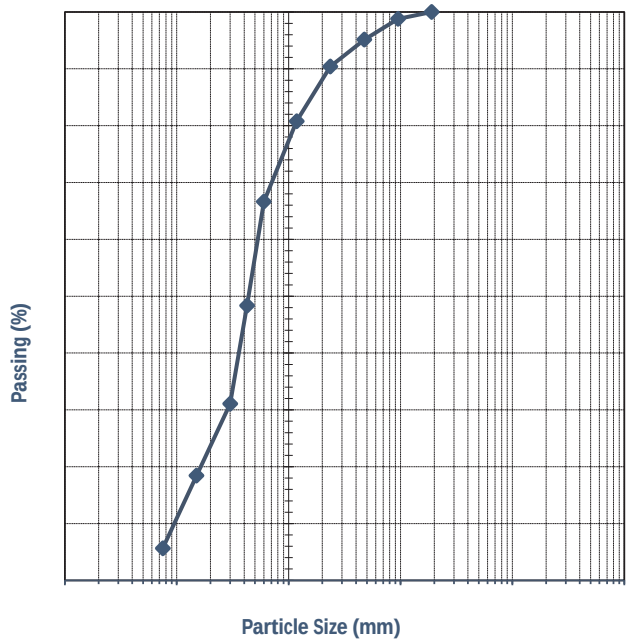
TEST REPORT - AS 1289.3.6.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5446_1_PSD**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5446**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP04/BH10 0.8-1.2m**	*Date Tested:*	**11/4/22-12/4/22**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	99
4.75	95
2.36	90
1.18	81
0.600	67
0.425	48
0.300	31
0.150	18
0.075	6



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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5446_1_PI**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5446**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP04/BH10 0.8-1.2m**	*Date Tested:*	**12/04/2022**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method: Sampled by Client, Tested as Received
History of Sample: Oven Dried <50°C
Method of Preparation: Dry Sieved

AS 1289.3.1.1	**Liquid Limit (%)**	**39**
AS 1289.3.2.1	**Plastic Limit (%)**	**24**
AS 1289.3.3.1	**Plasticity Index (%)**	**15**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**6.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

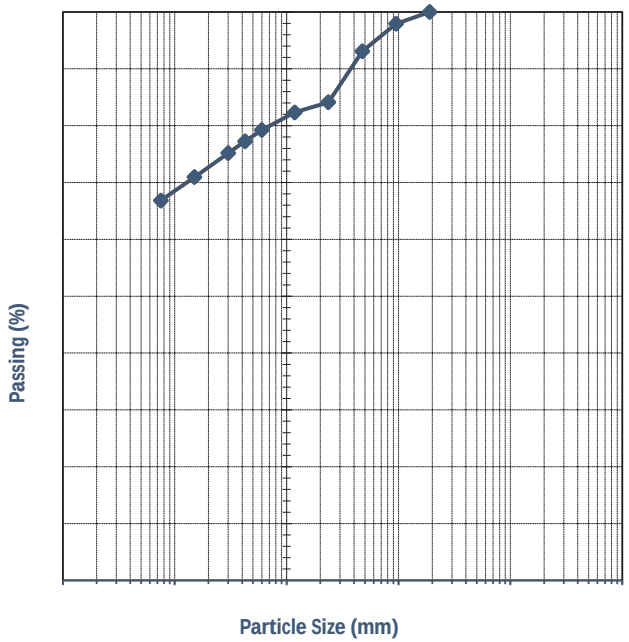
TEST REPORT - AS 1289.3.6.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5447_1_PSD**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5447**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP07/BH25 0.8-1.2m**	*Date Tested:*	**11/4/22-12/4/22**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	98
4.75	93
2.36	84
1.18	82
0.600	79
0.425	77
0.300	75
0.150	71
0.075	67



Comments:

Approved Signatory:

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5447_1_PI**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5447**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP07/BH25 0.8-1.2m**	*Date Tested:*	**12/04/2022**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**59**
AS 1289.3.2.1	**Plastic Limit (%)**	**21**
AS 1289.3.3.1	**Plasticity Index (%)**	**38**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**8.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Curled**

Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

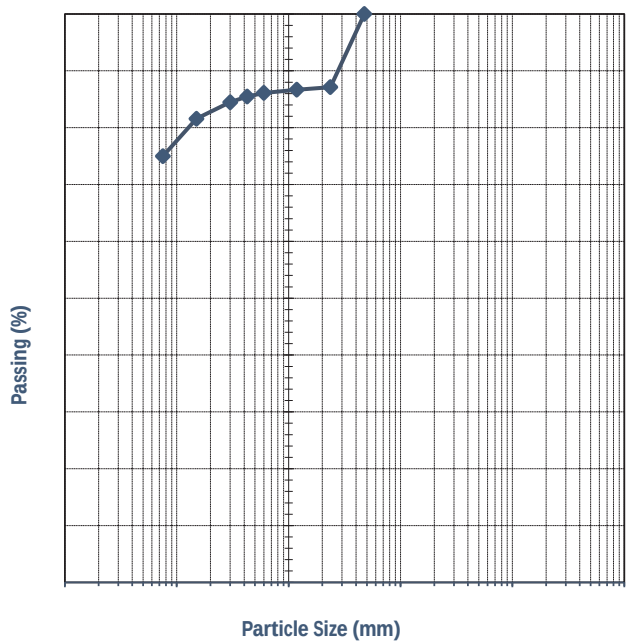
TEST REPORT - AS 1289.3.6.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5448_1_PSD**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5448**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP11/BH05 0.7-1.1m**	*Date Tested:*	**11/4/22-12/4/22**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	87
1.18	87
0.600	86
0.425	85
0.300	84
0.150	82
0.075	75



Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 12/April/2022

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5448_1_PI**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5448**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP11/BH05 0.7-1.1m**	*Date Tested:*	**12/04/2022**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method: **Sampled by Client, Tested as Received**
History of Sample: **Oven Dried <50°C**
Method of Preparation: **Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**68**
AS 1289.3.2.1	**Plastic Limit (%)**	**23**
AS 1289.3.3.1	**Plasticity Index (%)**	**45**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**14.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Curled**

Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

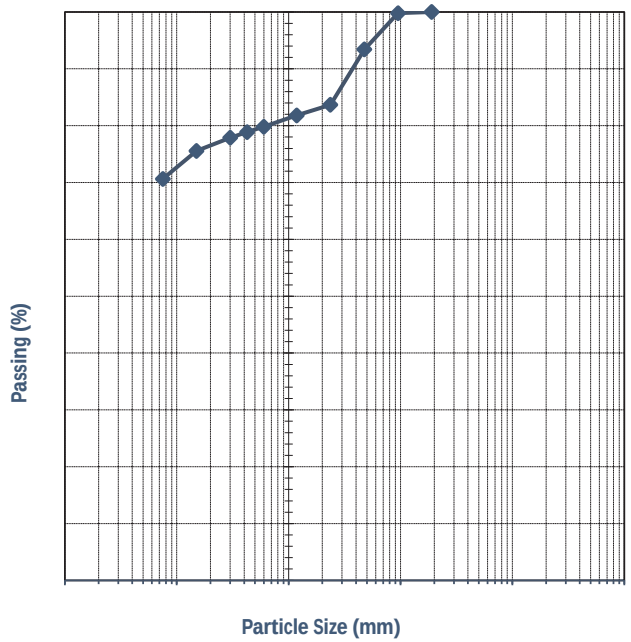
TEST REPORT - AS 1289.3.6.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5449_1_PSD**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5449**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP15/BH20 0.5-1.0m**	*Date Tested:*	**11/4/22-12/4/22**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: Sampled by Client, Tested as Received

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	100
4.75	93
2.36	84
1.18	82
0.600	80
0.425	79
0.300	78
0.150	76
0.075	71



Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 12/April/2022

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5449_1_PI**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5449**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP15/BH20 0.5-1.0m**	*Date Tested:*	**12/04/2022**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method: Sampled by Client, Tested as Received
History of Sample: Oven Dried <50°C
Method of Preparation: Dry Sieved

AS 1289.3.1.1	**Liquid Limit (%)**	**66**
AS 1289.3.2.1	**Plastic Limit (%)**	**23**
AS 1289.3.3.1	**Plasticity Index (%)**	**43**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**12.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Curled**

Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 13/April/2022

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

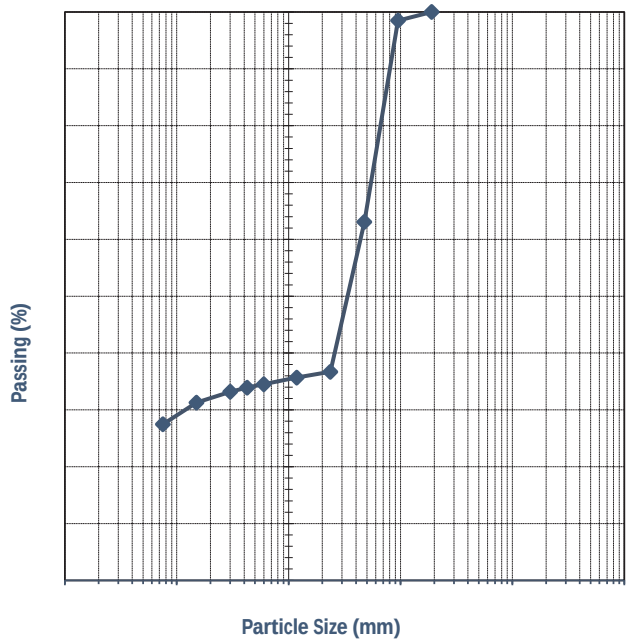
TEST REPORT - AS 1289.3.6.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5450_1_PSD**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5450**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP17/BH16 2.2-2.7m**	*Date Tested:*	**11/4/22-12/4/22**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	100
9.5	98
4.75	63
2.36	37
1.18	36
0.600	35
0.425	34
0.300	33
0.150	31
0.075	27



Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 12/April/2022

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Pritchard Francis**	*Ticket No.*	**S6043**
Client Address:	**-**	*Report No.*	**WG22.5450_1_PI**
Project:	**Bullsbrook South**	*Sample No.*	**WG22.5450**
Location:	**Various Lots, Lage Road & Great Northern Highway, Bullsbrook**	*Date Sampled:*	**Not Specified**
Sample Identification:	**TP17/BH16 2.2-2.7m**	*Date Tested:*	**12/04/2022**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method: **Sampled by Client, Tested as Received**
History of Sample: **Oven Dried <50°C**
Method of Preparation: **Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**57**
AS 1289.3.2.1	**Plastic Limit (%)**	**21**
AS 1289.3.3.1	**Plasticity Index (%)**	**36**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**9.5**
AS 1289.3.4.1	**Length of Mould (mm)**	**125**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Curled**

Comments:

Approved Signatory:

Name: Cody O'Neill
Date: 13/April/2022

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Appendix F: Understanding Your Report

UNDERSTANDING YOUR REPORT

GALT FORM PMP11 Rev3

1. EXPECTATIONS OF THE REPORT

This document has been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

3. SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

Geotechnical advice presented in a Galt Environmental report has been provided by Galt Geotechnics under a sub-contract agreement. Similarly, environmental advice presented in a Galt Geotechnics report has been provided by Galt Environmental under a sub-contract agreement.

Unless specifically noted otherwise, no parties shall draw any inferences about the applicability of the Western Australian state government landfill levy from the contents of this document.

Appendix C: Report on Preliminary Geotechnical Investigation - Proposed Bullsbrook Urban Precinct

Douglas Partners, 2020

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Geotechnics | Environment | Groundwater

Integrated Practical Solutions



Douglas Partners
Geotechnics | Environment | Groundwater

FS 604853

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d 2011 'Foundation Mainte d oo r or Homeowner's Guide'

Report on Preliminary Geotechnical Investigation
Proposed Bullsbrook Urban Precinct
Various Lots, Stock Road, Bullsbrook, WA

1. Introduction

r or r r l o r l r o l o d r o l r r or ro o d ll roo r r o o d ll roo o w o o d l d d o r Mr rr o ro ro M o l o M rl ll roo d d w d r ord w o l r r ro o l d d o r

o r r r or d r ood ro o d d lo w ll o r d o o o r d l lo d o d ro dw ool d l o r

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- l o or ro o d d lo
- r o d o l d d o o r o ro l ro d o d o o r d
- d d o o o l d o w ro o d d lo r or o l o d r r l ll
- l l l o or r d l d lo ord w r r o
- r l r r o r r l d o o l r l r o o d r wor o l r r ro d or ro o d ro d d r d l dw ll
- r l o o r d o l d l o or o or w r d o l
- d o ro dw r o r d d l o or ro o d d lo d
- l r o l o wor r r d

r l r o l o l d d o o o r w r d ro r or d o ro r d d o o r d ro d o d o d o l r o d l or or o l d l

d l o ld wor r r d r or o r w o d r o d o o l d o

2. Site Description

o r ollow wo ro o d d lo r r w d

- ro o d lo r o o d o d o d d l d o l d d r ld o or r or r w d r ld o w d low l d ro o d lo o o d
- ro o d lo r o o d r or r w o d l d o d o r or r w o w d o l d ro o d lo o or

o o o r d d lo d l d r l d w o o r l o r r d ll r o o low d o o r d ro o r o w r l o o r d w o o low d o o



Photo 1: w o ro o d lo r loo or ro lo o



Photo 2: w o ro o d lo r loo ro lo o

o r ld d d o d w r o r d r l r lo o w o o low o ro d l d d l d r r d w or o d o w or d r o



Photo 3: w o o o d o d w ro o d lo r loo or ro lo o

r l r o l o ro o d ll roo r r
ro o o o d ll roo o r

r wo l l r l oo r ro r l o d r o r o l
roo ro w d r o ollow lo o

- ro o d lo r o r or r d r o or r l d
- ro o d lo r lo or r o d r

d o l l l d ro o d d lo r r ll lo ro

- ro o d lo r o w r or r o o
  or r or r d o r or r d
- ro o d lo r o w r or r o o
  or w r or r d o r or r

l d M ro l olo d ro o d d lo
r r r do l d rl oll o r d l o r l o
ld ord or o r ow lo w r o d r o d or w r or r
o ro o d lo r ro o r ow o ro lo
o r l o r o d r o ro o d lo r d lo or r l
o r o d r d o r or r o ro o d lo r

r ll o r d r ro dw r l l d
M ro dw r l l r d r o r l o w r or r o
ro o d lo r o or w r or r o ro o d lo
r w r ro l o w r or r d
or w r or r low ro d l l r ol d or o l l r o
l o ld o d r d w o

l d r d r ll mapped as "*no known risk of acid sulphate soils occurring within 3 m of natural soil surface*" n area of "*moderate to low risk of acid sulphate soils occurring within 3 m of natural soil surface*" ow lo r o d r o
ro o d d lo r d o r or r o ro o d lo r
o d w o o d ro

3. Field Work Methods for the Preliminary Geotechnical Investigation

ld wor w rr d o o o r d w d o r d r d
o l r ro o l r r ld wor o r d o o
o r w r d ro r or d o ro r
d d o o r d ro d o d o d o d l r o

w r d r o or d w wd oo d
or o o w wd oo d ro d o d o w r r ll
ro d r l d r l o r d o d o w
d w o o d l o lo o o r low r r o
ro o d d lo r lo o d

ro d o d o w r lo d r l ord w l r d
o l r ro o l r r ol l w r r o r d or
o ll or or

o ro r or r d ro r w rr d o
ord w d r l o d o
r d r l o ro r r r d o lo d

l r o lo o d w r rr d o
o d od ord w d or ll d od
d o w d low ro d l l lo o d o d
r l r d d d l o

lo o w r o o d r l o r d ro lo o r ow o
r w d r l o lo o w r rr d ro l l l l
d d o ld o d r d w o l o lo d
r o d r l o

4. Field Work Results

4.1 Ground Conditions

l o l d d r o o o d o o r d
d d r r l r o l o r r d o lo d
The logs should be read in conjunction with the notes 'About this Report' and accompanying explana or o o d d

ro d o d o o r d lo o r ll o r d rr d oll o l
d rl o l o ld ord or o d low r r o ro o d d lo
r o r d o l r o l d d r l o rl l r o o o l rr d
oll d o l ld ord or o ro dl r d o wo o l
llow l r o o w r o r do l r l r o l d d r l
w r r o o l d l o rl or l o l w r d d d r l
o o

r o ro d o d o ro d d low

- **TOPSOIL (SAND SP-SM, Silty SAND SM, Gravelly Silty SAND SM, Silty SANDY GRAVEL GM, Gravelly Sandy SILT ML and Sandy CLAY CI) –** r ll r ll r do l d o d d r l o d r d d low o d l d r r row w roo

- **Unit 1A: Predominately Granular Colluvium (SAND SP-SC/Clayey SAND SC, SAND SP-SM, Silty SAND SM, Sandy GRAVEL GP-GM/GP-GC and GRAVEL GP-GM) –** o o r r d d o o r d l r r l low o d l r or row o

o r d lo o o d r l r oll l
r l w r d d o r d loo d l r w r ord d
lo o o o d d o r l r ow r w d

- **Unit 1B: Predominately Clayey Colluvium and Possible Guildford Formation (Gravelly Clayey SAND SC, Clayey SAND SC, Clayey Sandy GRAVEL GC, Gravelly Sandy CLAY CI, Sandy CLAY CI and CLAY CI)** – low o d l o o r r d d o o r d r l r llow r d or row w r o o o o ld r d o l o r d ll lo o o r o d o low r l l rd ro d o d o r l d r l o lo o w o or or o o llow r d

  l oll d ld ord or o o l w r r ll d d o r d d o rd oo d o o r l r ro l r w d w r r ord d lo o d

- **Unit 2: Bedrock (inferred granite and schist)** r l w r d o l w r d ro w r ll o r d r r o lo o d o d low r r o lo o

  o o o w lo o w r o l or ll r ll l M d w r ord d o d o o ll d l r o w d o l r r d r ld wor o o r o l o r ow r w d

4.2 Groundwater

o r ro dw r w o r d o d o d o do o r d w d o r o l o w lo o w r ro dw r w o r d d o d ro dw r w r d l ll d ollow l w r l d d lo r r o or o ro dw r l l

o ld o d ro dw r l l r d l o d o d o d roo d l d d w ll r or r w

4.3 Infiltration Testing

l r o w r rr d o o d or ll d od lo o d d o w d low ro d l l ld r l l w r d od l d d d o d od d od d o or l r l l o d ro r l d r o r l ro l ro d l r o locations, using the Hazen's formula. The Hazen's formula provides an indication of the permeability or l d w ro d d r l loo o d o d o ld o d r d w o l r r l r l

Table 1: Summary of Permeability Analysis

Test Location	Depth (m)	Measured Permeability		Derived Permeability[3]		Material
		(m/s)	(m/day)	(m/s)	(m/day)	
						d w l
						l d d d
						d w l loo o d d
						w d r l r d
						d M w l loo
						l d r d
						l r d r d
						l d d d

o o d
ll d
's formula (assumes sand in loose condition, with rounded sand particles).
o r l d d

5. Laboratory Testing

or or w rr d o o l d o l l oll d d r o l r r l r o l o d o r d d r o o

- r l d r o o l d
- r r l d l r r o o r l

l o r r d l w r r d d

Table 2: Summary of Laboratory Testing for Soil Characterisation

Test Location	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	D_{10}	D_{60}	LL (%)	PL (%)	PI (%)	LS (%)	Material
											d w l
											l d w r l
											w d r l
											d M w l
											l d
											r ll l w d
											l r d
											l r d

o r r l ll r
d r l l r r d ll r
r l r l l r r d ll r
o o l r l r l
o o l r l r l
– d
– l l
– l d
– l r r
o d

r l o o r r o ld d l or or l o d o MM r l
d MM r l w l o r d ll d r l
ord w l or or r l r l d d d r
r d l low

Table 3: Summary of Remoulded Permeability Testing

Test Location	Material Type	OMC (%)	MMDD (t/m^3)	Permeability	
				(m/s)	m/day
	l d w r l				
	w d r l				
	d M w l				
	l d				

o M o r o
MM Mod d dr d

6. Proposed Development

d r ood ro o d d lo w ll o r d o o o r d l
lo d o d ro dw ool d l o r

7. Comments

7.1 Suitability of the Site for Development

r l o o d ro d o d o ro r ll o o
rr d oll d o l o ld ord or o o l ro l r ll o r l ro
r do l r l r o l d d r l w r o o l d l o
o w r o rl or l o l w r d d d r l o o
r d ro w lo ll o r d w d o o

ro dw r w o o r d o d o o
o r d w d o r o w lo o w r
ro dw r d ro dw r w r o r d d o d
r l o o r ow r r d ro dw r d o o r
d r w o o ro r o r d llow l oll l r l

d o l l or o o l o l o r o d o d lo
o l o d o l d

- o rr o low r l d r l oll l r l llow d d
- o l llow r d ro dw r o r o o o d l oll l
  r l w w r r l l d o r ro ro w o
  ro d r o o ro d r
- rd ro d o d o r l r o rr o ro w r d o r d w
  d

o l d o l o r w ll o l o o or w r d o l w
ro o d d lo r d d o d l l o ro d r l ro d
o ro r d w ll o r l oll l r l rd ro d
r l r o rr o ro o ld o d d o ro d d lo o w
ro o d d lo

o r o r l r l d o rr o llow loo d o o r oll l
o l d o l or o roll d ll o ld r l ro d l ro o o ld o
o r l lo d o d o l ro o d ll d r r ow r d
or o r o ld r d l ddr d d rd r wor

o d r d o l o r o ld l ollow l d d
r r o d ro o l d o ro o d d lo r r ll
l o d lo or ro o d ll roo r r ro d d ro o

7.2 Site Classification

7.3 Site Preparation

7.3.1 Timing of the Earthworks

r l r o d d r wor r rr d o d r dr r r od o r
o l or ollow r o

- or o r w r d d o l dr o d o
- d r r or o rol o w r o r d o w o d
- dl o d o d o o l o ld r o

o o d o o o r l l dr r r
r o d d o l d r or o r o r l d o d o w r
o o or ro r r d r d r r l d r o r o
o ld l d o o o o d o l l o r d l or o r o
l d ll o d o d r r d r r o r o ld l d r d
ro o d d lo r r or do o o l or r r dr
d o r o o oo dr roll r r or o r o l
ro d r d o o r r o o dr o low r r l r o w
r d dd o ll w r oll o o ld r o d d l

7.3.2 Stripping

ll o o l o d d l r o r l o ld r d ro ld lo d
r d r r o d ro or o l d or o l r l l

o l r roo r ro l r o r o o ld o l l r o d d
o ll d w r l o l r o l ro r o rro d ro d d
o d o dr d r o o o l d r l o od d o o
or o d r l r r d r l

r o d d ollow r d r or o ll r l r d d
o l r o d r w r r o r l o o l o or roo r
r d l l r l w ll r r r o l d o ll d w r l o
l r o l ro r o rro d ro d

7.3.3 Proof Rolling and Compaction

d r d o d r l w r r ll d d o r d
d o rd ow r llow loo d o o r o l w r r ord d o d o w
d low r l l d d r o r l r r
ro r or o l o ll or o r o w ro o d d lo r

o roll d ll r l o l or d o o ld r d o l w o r d o
d o lo o w ro o d lo r d o d r d o or
l o d o r l rr o d o l r d o r o r
l ll o ld l d

- o o ll r l d r d o o ll d l
r o ll w d o l r r d r ld wor o o r
ow r d o r l o o l o rr o d r l
r l o r d lo o o r l d d

- r or r d o or o r o or
r l d r l r r o ld r d o l
- o o o o o o dr d r o o o l r l
o od d o o d
- r l o d r l d ll ollow r d r d
o

l or ro o d d ro d l l w r o l l o wr r or
ow r r l l llow d o loo d or o o r r l w ro o d
d lo r o d r d roo roll d r d o ld l o
d loo d o o r o l d o loo d or o o r r l
do o l d d o r d lo o

r d r d d o l r r o d d
o d r d ld d lo roo roll d roll r
o or r r ow o d or o d r o o o ld
o ll o d l d or o or l r l oor l r l o ld
d d r l d w l r r l ll o d o dr d r o o o l
d r l o od d o o or o d r l r r d r l
r r l r r d o ld o d o dr d r o o
o l r l o od d o o

d o r l r d o r d w ll o d ollow o o l r
o r o

o roll r oo dr or d oo d o r or od o ld d r o
o r wor o r or d o o r d r d d o ro dw r d
d o o o l oo dr roll r r rr d o o r l r r d
d d oo roll r o o l r d o r o o r o d d o o
l r d or w r llow ro dw r w d o l o roll r

r o d d o o o rol o l d r ll r l rr d o
l r r o r d ord w o o o rol
d r l or o l ro o d d ll o ld rr d o r d
ro r ord w od d r l r
r d o d o low o o low r rod r o o
d o o l low o d o l l o ld o d o o l l
o d r l orr l d o dr d o r l o od d o o ow r low o
o l l l ro d d orr l o w r d ro r
d dr d r o l d r d d l or or d ollow
r w o l r

7.4 Excavation Conditions and Groundwater

7.5 Design Parameters for Batter Slopes and Earth Retaining Systems

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Table 4: Suggested Soil Parameters for Retaining Wall Design

Soil Type	Drained Angle of Friction Φ' (degrees)	Undrained Shear Strength C_u (kPa)	Soil Unit Weight above Water γ (kN/m³)	Coefficient of Active Earth Pressure K_a	Coefficient of Earth Pressure at Rest K_0	Coefficient of Passive Earth Pressure K_p[1]

7.6 Re-use of Topsoil

o ld o d l d d ll r l ll r d d r l o r o w l d d r or r o o r l o l d d r l d r or o r l o d r d l or ll o l r o ld r o d ro or d o r r l r

7.7 Re-use of In Situ Clayey Soil

l r l r o r l d dl d o o d l w ll o l r d d r o r o r l l o l r r d r l r d r w w r r o r l r r l ll o l o ld o d r d w o

r l ro o d o r d r o d d o l d o o rr d o d r dr o ord r o dl o d o d o o r o r or ord r o o o d d l d r r l l o r or r d o r r o d

r o d d r o o o o wor d r l r d o l r

r o d d l r l r l d loo l w l r o d o dr d r o o o l r l o od d o o

o o o rol o r l l r l o ld rr d o l r r o r d ord w

It should be noted that the excavated clayey soils from the site, will not form a 'non reactive fill', d d o o d l o

7.8 Re-use of In-situ Natural Granular Soils and Imported Fill

or d ll r r d o ld o r d ll r l d l d d r l d r l r l o or or d ll o ld l or r r r l ll ro d d o r r dr o o l d w l w o r l r l o ld r ro or r d r l r r

r l r l r r l w r r ord d r l r lo o w ro o d lo r r w d o o l o o r l r l r l w r o ld d r or o l r r r l ll o r r o ro o d d lo r ow r o d r rro d lo o d currently have a site classification 'Class ', and in order to maintain this site classification, l o r l r r l o ld o l r l r l r r l from these areas will therefore possibly amend their site classification from ' " to 'M' if less o r l r r l r o r l o l ollow o o r o

r l d l d d r l d r l r l o o ld l or r r r l ll ow r o o w r l d r d low r l o r o d d r l r d r r l llw r o o d ld lo d r r w r l o d r o o r o l o dr d ro ro o d d lo r

r o d d r l d or d d ll l d loo l w l r o d o dr d r oo o l r l o od d o o r l r o ld o d o dr d r oo o l r l o od d o o

o o o rol o d o ld rr d o r d ro r ord w od d r d o

7.9 Suitability of the Units 1A and 1B Soils for Re-use as Structural Fill

l o r l d o l or r r r l ll d ro rr ro o d d lo r l o r d l low

Table 5: Suitability of Units 1A and 1B Soils for Re-use as Structural Fill

Soil Type	Suitable for Re-use as Structural Fill	Suitable for Re-use to Achieve Site Class		
		'A'	'S'	'M'
ol ro d d r l d r l				
ol ro d l d		o	o	
ol ro		o	o	

o o o d r d d r l d r d o low
ro d d r o d o l d d o r ollow d
ro d d r o d o l d d o r ollow d

7.10 Soil Permeability

llow o l o d o w r ll o r o r l o r l r o r l r o r low r l d r or o d r d or w r d o l o w ll or dr o l

o w ll or dr o ld o d r d o l o r dr r l r ll l d o l r d r l ll l r o ro l w o ro o d o w ll dr d l r d r l r r d r l o o l r d w r o d o d ll o r o d r l l o l wo ld d o o d r d d o o or w r d o l o d l d d d lo o ld o d r d r or o l o

l r l o o lr d w r d lo r o l r l

l o lr o o d o l r l l o w

- r l r M r l o d d r l d r l w r o o l d l d o d d
- l r l r M r l o l d l d r l d l r l d d d

ll r d l or or r l r d l o low r r l d o l d r o d or d r r r o or r d r r l ll or or r l d r l l o w d d d or o or d o ld o d r l l low r l r l r r d or d o l o r o w o d d o

r or r l l o d d or r l l d o w o d

r l low r d d or o o o l w o r l r ll d l d l d l

7.11 Drainage and Reactive Materials

l r l o r d llow d w ro o d d lo r o ld r ll o d r d o r o or dr r o r d w r o ld d o o d o o o l r l o r d r l l llow d d o or d r l r ll l d o d rl l r l o d r o o ld o l l dr r o o rol w r o d o r o ld l d

- r d r o l r d ror o l r l r ll w ro ro o d r r
- l r dr o o rol ro dw r d d r w ro ld d
- ro o d d lo r l l o r w o o d r dr r l r w o l r r o lood low r or o o ro o d d lo r d lo roo

l r l d rl r od r l r d r or w ll w ll d r w o r r o r l r o r o d d r l r o o o r o w l r l ro do o o ro r r r

- w ll dr d o d r o r o d ro o l o r r o

- dr d w o o d l r l l d
- l d d r r d o o d l d ro d r r
- o l r r r l d d o r r d
- rr l r or w r ro d r r o d d

d o o d o ro d d o 2011 'Foundation Maintenance and Footing Performance A Homeowner's Guide'

7.12 Further Geotechnical Testing

d o r l r or o oll d r o r l r ro d o wo ro d o d o ollow o ld ddr d ord r o l ddr ro d o d o w ro o d d lo r

- r r r w ll o l o l r l w ro o d d lo r d d o
- r r d l d o ll o r d lo o d
- r r d o rd ro d o d o dro lo o o ro o d d o or d r ro d r

8. References

Residential Slabs and Footings. d rd r l

Methods of Testing Soils for Engineering Purposes. d rd r l

Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test. d rd r l

Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test. d rd r l

Geotechnical Site Investigation. d rd r l

Guidelines on Earthworks for Commercial and Residential Developments. d rd r l

r o ro r *Perth Groundwater Atlas, Second Edition*

TMI Assessment and Climate Zones in Western Australia

o r d *Re-assessment of TMI Based Climate Zones in Metropolitan Perth, WA*

9. Limitations

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Appendix A

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Douglas Partners

Introduction

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Borehole and Test Pit Logs

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Reports

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About this Report

Site Anomalies

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Information for Contractual Purposes

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Site Inspection

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Douglas Partners

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse) - with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse) - with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'Mix of Soil and Cobbles/Boulders' with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour. Soil tends to stick together. Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour. Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

Rock Strength

Rock strength is defined by the Unconfined Compressive Strength and it refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects.

The Point Load Strength Index $Is_{(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

Strength Term	Abbreviation	Unconfined Compressive Strength MPa	Point Load Index * $Is_{(50)}$ MPa
Very low	VL	0.6 - 2	0.03 - 0.1
Low	L	2 - 6	0.1 - 0.3
Medium	M	6 - 20	0.3 - 1.0
High	H	20 - 60	1 - 3
Very high	VH	60 - 200	3 - 10
Extremely high	EH	>200	>10

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Residual Soil	RS	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely weathered	XW	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible
Highly weathered	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately weathered	MW	The whole of the rock material is discoloured , usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	No signs of decomposition or staining.
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.

Rock Descriptions

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100 \text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or stronger. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Douglas Partners

Introduction

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Drilling or Excavation Methods

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Sampling and Testing

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Description of Defects in Rock

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Defect Type

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Orientation

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Coating or Infilling Term

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Coating Descriptor

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Shape

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Roughness

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Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General



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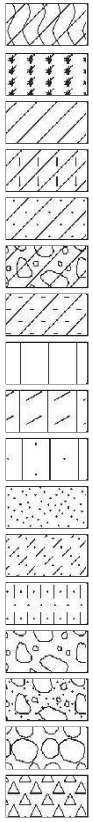
Soils



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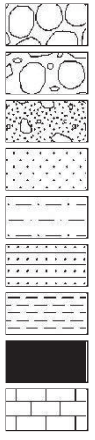
Sedimentary Rocks



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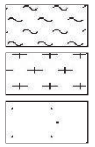
Metamorphic Rocks



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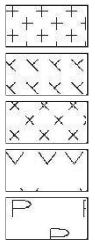
Igneous Rocks



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Test Pits

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Large Diameter Augers

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Continuous Core Drilling

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Standard Penetration Tests

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Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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Appendix B

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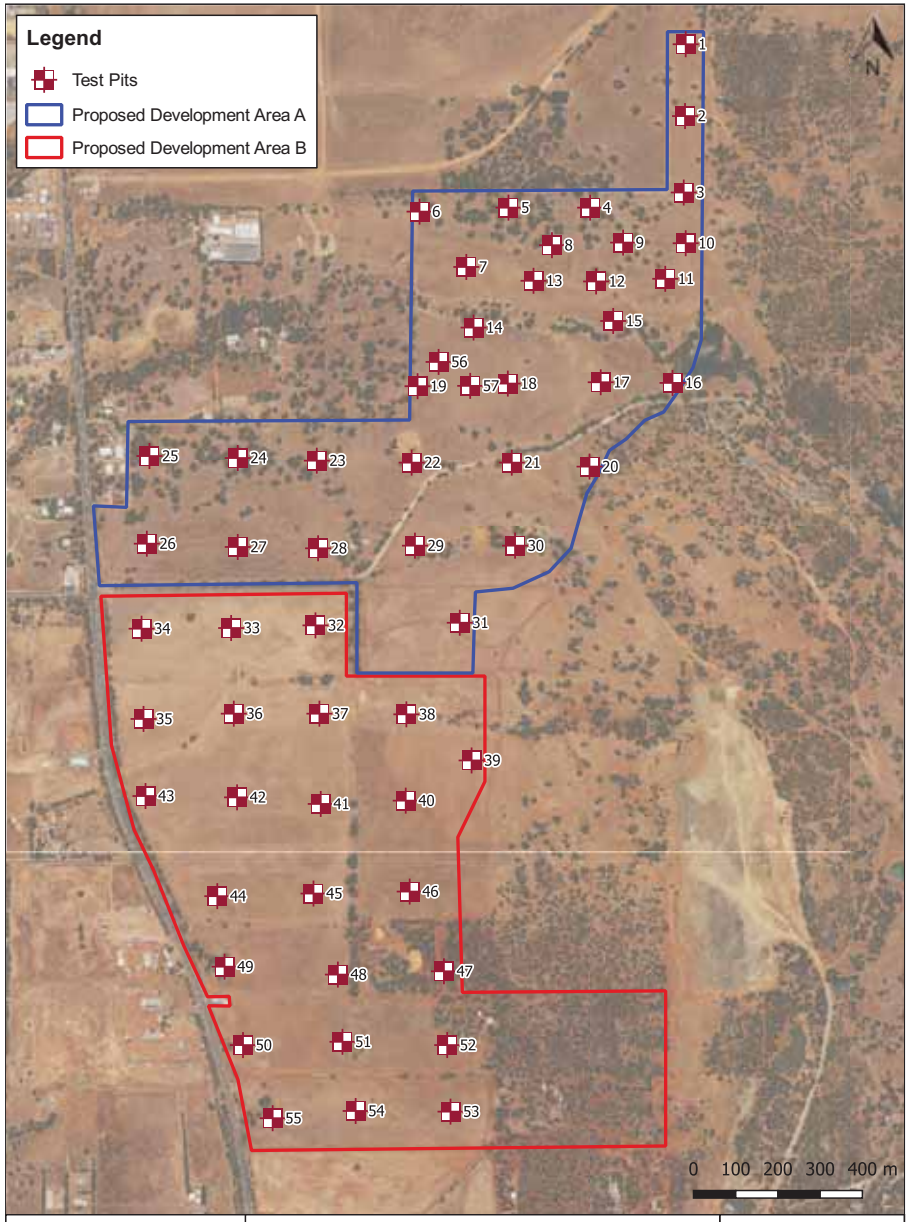
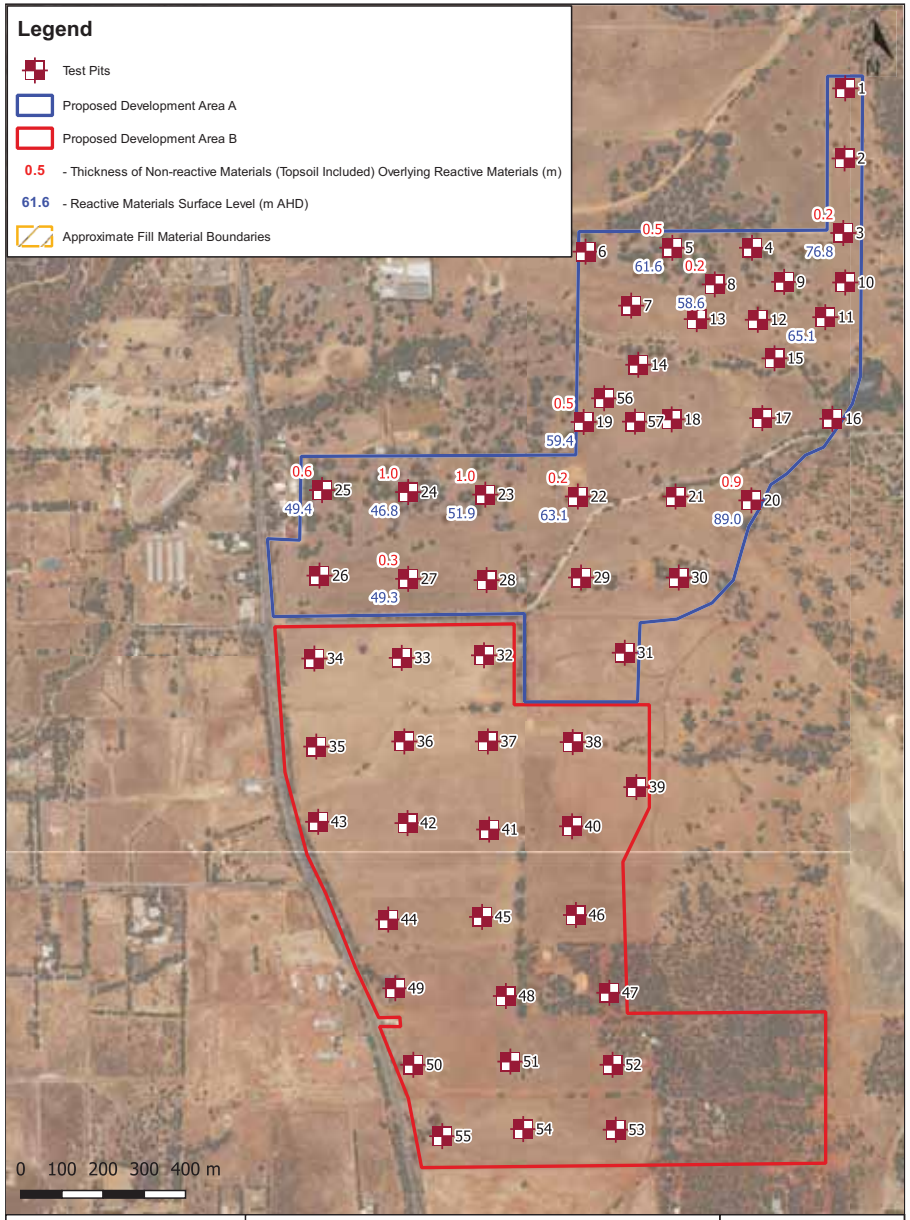
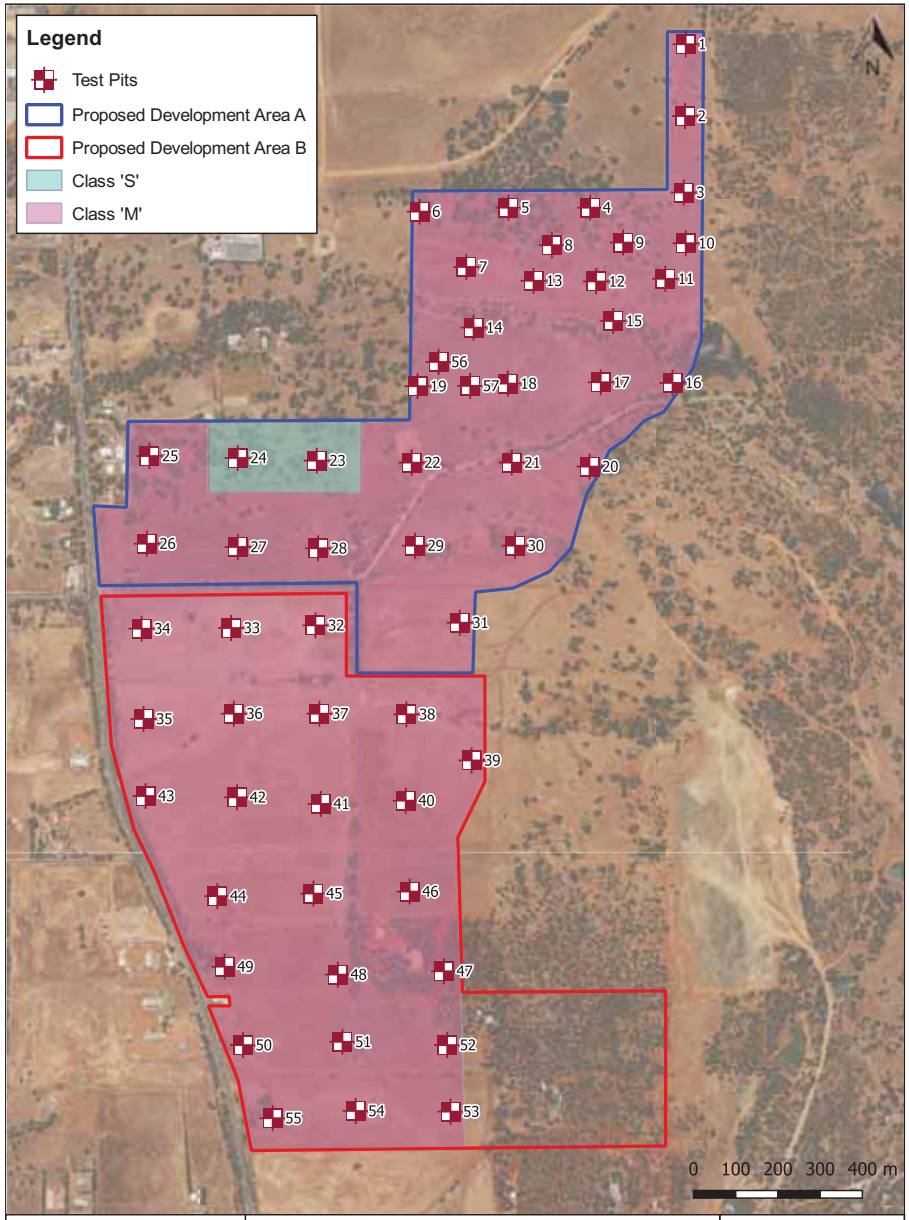




Douglas Partners	**Thickness of Non Reactive Soils Overlying Reactive Soils and Approximate Fill Boundaries** **Proposed Bullsbrook Urban Precinct** **Various Lots, Stock Road, Bullsbrook, WA**	PROJECT: 96731.00 Drawing No: 2 REV: 0
	CLIENT: Marlin Bullsbrook Pty Ltd	DATE: 10/11/2020



Douglas Partners	**Site Classification Based on Current Site Levels** **Proposed Bullsbrook Urban Precinct** **Various Lots, Stock Road, Bullsbrook, WA**	PROJECT: 96731.00 Drawing No: 3 REV: 0
	CLIENT: Marlin Bullsbrook Pty Ltd	DATE: 4/11/2020

Appendix C

r l r o l o l

TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 80.5 m AHD*
EASTING: 409754
NORTHING: 6495376

PIT No: 1
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
80	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, grey-brown, fine to medium sized gravel, low plasticity silt, with roots, dry to moist.		D	0.3				
	0.6	Clayey Sandy GRAVEL GC: fine to coarse sized gravel, light brown, fine to medium grained sand, medium plasticity, dry to moist, very dense. Gravel is granite.							
79	1	Sandy CLAY CI: medium plasticity, orange-brown, fine to coarse grained sand, with gravel, moist, hard.		D	1.0				
	1.5	Pit discontinued at 1.5m (Refusal on hard ground)							
78	2								
	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics | Environment | Groundwater

TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 85.4 m AHD*
EASTING: 409755
NORTHING: 6495203

PIT No: 2
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
85	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, grey-brown, fine to medium sized gravel, low plasticity silt, with roots, dry to moist.							
	0.4	Gravelly Sandy CLAY CI: medium plasticity, orange-brown, fine to coarse grained sand, fine to coarse sized gravel, moist, very stiff to hard.							
	1	Sandy CLAY CI: medium plasticity, orange-brown, fine to coarse grained sand, with gravel, moist, hard.							1
84	1.3	SCHIST: highly weathered, low to medium strength, grey, schist.		D	1.4		Rock sample		
	1.6	Pit discontinued at 1.6m (Refusal on rock)							
83	2								
	3								
82									

5 10 15 20





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 77 m AHD*
EASTING: 409752
NORTHING: 6495022

PIT No: 3
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
77	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.2	Silty SAND SM: fine to medium grained sand, light brown, low plasticity silt, with gravel, dry to moist.							
	0.5	Gravelly Sandy CLAY CI: medium plasticity, light brown, fine to coarse grained sand, fine to coarse sized gravel, with cobbles, moist, stiff to very stiff.							
76	1	Sandy CLAY CI: medium plasticity, orange-brown, fine to coarse grained sand, trace gravel, moist, hard.		D	1.5				1
	1.7	Pit discontinued at 1.7m (Refusal on hard ground)							
75	2								
74	3								

5 10 15 20





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 68.4 m AHD*
EASTING: 409530
NORTHING: 6494982

PIT No: 4
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
68	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.2	Gravelly Clayey SAND SC: fine to medium grained sand, grey-brown, medium plasticity clay, fine to medium sized gravel, moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, with gravel, moist, very stiff to hard.							
67	1	- becoming red-brown and orange-brown from 1.0 m depth.		D	1.0				
	2	2.0 Pit discontinued at 2.0m (Refusal on hard ground)							
66	3								
65									





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 62.1 m AHD*
EASTING: 409335
NORTHING: 6494984

PIT No: 5
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
62	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.5	Sandy GRAVEL GP-GC: fine to medium sized lateritic gravel, orange-brown, fine to medium grained sand, with clay, dry to moist, very dense. Clay is medium plasticity.		D	0.3				
61	1	Sandy CLAY CI: medium plasticity, orange-brown mottled red-brown, fine to medium grained sand, trace gravel, moist, hard.			1.0		pp >600		
	1.3	Pit discontinued at 1.3m (Refusal on hard ground)							
60	2								
59	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 54.5 m AHD*
EASTING: 409128
NORTHING: 6494976

PIT No: 6
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
54	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		SAND SP-SC/Clayey SAND SC: fine to medium grained, grey-brown, with clay, moist, medium dense.		D	0.3				
	0.5	Sandy CLAY CI: medium plasticity, orange-brown, mottled light brown, fine to medium grained sand, trace gravel, moist, hard.							
53	1	- 10 mm diameter tree roots observed to 0.6 m depth.							
	2.0	Pit discontinued at 2.0m (Refusal on hard ground)							
52	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 55.1 m AHD*
EASTING: 409234
NORTHING: 6494843

PIT No: 7
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
55	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, yellow-brown, fine to medium grained sand, moist, very stiff.		D	0.5				
		- becoming stiff from 0.3 m depth.							
		- becoming firm from 0.45 m depth.							
54	1	- becoming very stiff from 0.8 m depth.							
		- becoming red-brown and grey-brown, clay content increasing from 0.9 m depth.			1.0		pp >600		
	1.1	Pit discontinued at 1.1m (Refusal on rock)							
53	2								
52	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 58.8 m AHD*
EASTING: 409438
NORTHING: 6494894

PIT No: 8
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
58	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.2	SAND SP-SC: fine to medium grained, light brown, with clay, moist. Possibly clayey sand.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, stiff to very stiff.							
	1	- becoming hard from 0.6 m depth.							1
57		- becoming orange-brown and red-brown, mottled grey, very stiff from 1.3 m depth.							
		- becoming hard from 1.6 m depth.							
	1.9								
	2	Pit discontinued at 1.9m (Refusal on hard ground)							
56	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 63.8 m AHD*
EASTING: 409609
NORTHING: 6494902

PIT No: 9
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
63	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.2	Clayey SAND SC: fine to medium grained sand, grey-brown, medium plasticity, with gravel, dry to moist.							
		Sandy CLAY CI/Clayey SAND SC: medium plasticity, orange-brown, fine to medium grained sand, with gravel, moist, stiff.							
	1	- becoming soft to firm from 0.45 m depth.							1
		- becoming very stiff from 0.9 m depth.							
	1.2								
62		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, with gravel, moist, very stiff.							
		- becoming hard from 1.5 m depth.							
		- becoming orange-brown, mottled red-brown and grey from 1.7 m depth.							
	2								2
	2.0	Pit discontinued at 2.0m (Refusal on hard ground)							
61	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 71.8 m AHD*
EASTING: 409755
NORTHING: 6494900

PIT No: 10
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
71	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.2	Clayey SAND SC: fine to medium grained sand, light brown, medium plasticity, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to coarse grained sand, with gravel, moist, very stiff. - becoming hard from 0.6 m depth.							
	1								1
70	1.3	Pit discontinued at 1.3m (Refusal on hard ground)							
	2								2
69	3								3





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 65.3 m AHD*
EASTING: 409709
NORTHING: 6494819

PIT No: 11
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
65	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.		D	0.15				
	0.2	Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, dry to moist.		D	0.5				
		Clayey SAND SC: fine to medium grained sand, light yellow-brown, low plasticity clay, with gravel, moist, medium dense. Clay content increasing with depth. - becoming dense to very dense from 0.75 m depth.							
	1								1
64	1.3	Sandy CLAY CI: medium plasticity, orange-brown, mottled grey, fine to medium grained sand, with gravel, dry to moist, hard.							
	2								2
63	2.6	Pit discontinued at 2.6m (Refusal on hard ground)							
	3								3
62									





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 59 m AHD*
EASTING: 409544
NORTHING: 6494810

PIT No: 12
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, mottled red-brown, fine to coarse grained sand, with gravel and cobbles, moist, hard.							
58	1								1
	1.2	COBBLES and Sandy CLAY CI: medium plasticity, orange-brown, mottled grey, fine to coarse grained sand, granite and laterite cobbles, with boulders, moist. Boulders are granite and laterite.							
	1.6	Sandy CLAY CI: medium plasticity, orange-brown and grey, fine to medium grained sand, moist to wet, very stiff.		D	1.8		pp = 350	19-10-20	
57	2								2
	2.2	Pit discontinued at 2.2m (Hard digging below groundwater)							
56	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: Groundwater observed at 1.8 m depth.

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 57.4 m AHD*
EASTING: 409397
NORTHING: 6494811

PIT No: 13
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
57	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, dry to moist, stiff to very stiff.		D	0.5				
	1	- becoming hard from 0.6 m depth.							1
		- becoming red-brown, mottled grey from 0.9 m depth.							
56	1.2	Pit discontinued at 1.2m (Refusal on hard ground)							
	2								
55	3								
54									





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 54.6 m AHD*
EASTING: 409253
NORTHING: 6494700

PIT No: 14
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
54	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		Clayey SAND SC/Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, stiff to very stiff.							
	0.8	Gravelly Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, fine to coarse sized gravel, with cobbles, moist, very stiff to hard.							
53	1.1	Sandy CLAY CI: medium plasticity, orange-brown, fine to coarse grained sand, with gravel, moist.							
	1.6	Gravelly Sandy CLAY CI: medium plasticity, orange-brown and grey, fine to medium grained sand, fine to coarse sized gravel, with cobbles, moist.							
	1.8	Pit discontinued at 1.8m (Refusal on hard ground)							
52	2								
	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 61.4 m AHD*
EASTING: 409587
NORTHING: 6494716

PIT No: 15
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
61	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, yellow-brown, fine to medium grained sand, moist, stiff.							
		- becoming very stiff from 0.6 m depth.							
60		- becoming very stiff to hard from 1.5 m depth.							
		- becoming red-brown and grey, with cobbles and gravel from 1.8 m depth.							
	2.1	Pit discontinued at 2.1m (Refusal on hard ground)							
59	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 70.4 m AHD* **PIT No:** 16
EASTING: 409727 **PROJECT No:** 96731.00
NORTHING: 6494570 **DATE:** 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
70	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, dark grey-brown, fine to coarse sized gravel, low plasticity silt, with roots, dry to moist.							
		Clayey Sandy GRAVEL GC: fine to coarse sized granite gravel, brown, medium plasticity, fine to medium grained sand, with cobbles, dry to moist, medium dense.		D	0.4				
	0.7	Sandy CLAY CI: medium plasticity, orange-brown and red-brown, fine to coarse grained sand, with gravel, moist, hard.			1.0		pp >600		
69	1								1
	1.6	Pit discontinued at 1.6m (Refusal on hard ground)							
68	2								
	3								
67									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 67.4 m AHD* **PIT No:** 17
EASTING: 409554 **PROJECT No:** 96731.00
NORTHING: 6494570 **DATE:** 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
67	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, hard.							
66	1								1
	1.8	Pit discontinued at 1.8m (Refusal on hard ground)							
65	2								
	3								
64									

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 65.7 m AHD* **PIT No:** 18
EASTING: 409335 **PROJECT No:** 96731.00
NORTHING: 6494569 **DATE:** 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
65	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, fine to medium sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, mottled red-brown, fine to medium grained sand, with gravel, dry to moist, hard.			0.5		pp >600		
	1				1.0		pp >600		1
64					1.5		pp >600		
	1.8	Pit discontinued at 1.8m (Refusal on hard ground)							
63	2								
	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 59.9 m AHD* **PIT No:** 19
EASTING: 409124 **PROJECT No:** 96731.00
NORTHING: 6494561 **DATE:** 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, grey-brown, fine to coarse sized gravel, low plasticity silt, with roots, dry to moist.							
	0.5	Sandy GRAVEL GP-GC: fine to medium sized lateritic gravel, dark orange-brown, fine to coarse grained sand, with clay, dry to moist, medium dense.		D	0.4				
		Clayey Sandy GRAVEL GC: fine to medium sized lateritic gravel, dark orange-brown, mottled red-brown, medium plasticity, fine to coarse grained sand, moist, loose.		D	0.6				
	1	- becoming dense to very dense from 0.6 m depth.							1
58	1.9	Pit discontinued at 1.9m (Refusal on hard ground)							
	2								
57	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 89.9 m AHD*
EASTING: 409529
NORTHING: 6494369

PIT No: 20
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
89	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, dark grey-brown, fine to coarse sized gravel, low plasticity silt, with roots, dry to moist.							
		FILL/Gravelly Silty SAND SM, BOULDERS and COBBLES (Possibly Organic): fine to medium grained, dark grey-brown, fine to coarse sized gravel, low plasticity silt, boulders and cobbles, dry to moist.		D	0.5				
	0.9	Sandy CLAY CI: medium plasticity, brown, fine to medium grained sand, with boulders, moist, very stiff.			1.3		pp = 350		
88	1.7	Pit discontinued at 1.7m (Refusal on hard ground)							





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 81.2 m AHD*
EASTING: 409345
NORTHING: 6494379

PIT No: 21
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
81	0.1	TOPSOIL/Silty Sandy GRAVEL GM: fine to coarse sized granite gravel, grey-brown, low plasticity silt, fine to medium grained sand, with roots, dry to moist.							
	0.3	Gravelly Sandy CLAY CI: medium plasticity, light red-brown, fine to medium grained sand, fine to coarse sized gravel, moist, hard.		D	0.4 0.5		pp >600		
80	1	Sandy CLAY CI: medium plasticity, red-brown, mottled light brown, fine to medium grained sand, trace gravel, moist, hard.			1.0		pp >600		
79	1.5	Pit discontinued at 1.5m (Refusal on hard ground)							





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 63.9 m AHD*
EASTING: 409109
NORTHING: 6494380

PIT No: 22
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
63	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, dark grey-brown, low plasticity silt, with roots, dry to moist.							
	0.2	Silty SAND SM: fine to medium grained sand, dark grey-brown, low plasticity silt, with gravel, dry to moist.							
	1	Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, with gravel, dry to moist, hard.							
62	2.0	Pit discontinued at 2.0m (Refusal on hard ground)							
61	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 52.9 m AHD*
EASTING: 408882
NORTHING: 6494385

PIT No: 23
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
52	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, dark grey-brown, low plasticity silt, with roots, dry to moist.							
		GRAVEL GP: fine to coarse sized lateritic gravel, light brown, with sand, trace clay, dry to moist, very dense. Sand is fine to medium grained.		D	0.8				
	1.0	Clayey Sandy GRAVEL GP-GC: fine to medium sized lateritic gravel, red-brown, medium plasticity, fine to medium grained sand, dry to moist, medium dense.		D	1.3				
51	1.4	Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, dry to moist, hard.			2.0		pp >600		
50	2.5	Pit discontinued at 2.5m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 47.8 m AHD*
EASTING: 408695
NORTHING: 6494391

PIT No: 24
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
47	0.1	TOPSOIL/SAND SP-SM: fine to medium grained sand, dark grey-brown, with silt, with roots, dry to moist.							
		SAND SP-SM: fine to medium grained sand, light brown, with silt, moist, loose.		D	0.5				
	1.0	Clayey SAND SC/Sandy CLAY CI: fine to medium grained, orange-brown, medium plasticity, trace gravel, moist, medium dense/stiff.		D	1.5				
45	3.0	Pit discontinued at 3.0m (Target depth)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 50 m AHD*
EASTING: 408488
NORTHING: 6494400

PIT No: 25
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
50	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
		GRAVEL GP-GM: fine to medium sized lateritic gravel, light brown, with sand and silt, moist, medium dense. Sand is fine to medium grained.		D	0.4				
49	0.6	Sandy CLAY CI: medium plasticity, orange-brown and red-brown, fine to medium grained sand, with gravel, moist, very stiff to hard. Clay content increasing with depth.							
47	3.0	Pit discontinued at 3.0m (Target depth)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 44 m AHD*
EASTING: 408479
NORTHING: 6494189

PIT No: 26
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
44	0.05	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.5	Clayey Sandy GRAVEL GC: fine to medium sized lateritic gravel, yellow-brown, fine to medium grained sand, medium plasticity, , moist, very dense.		D	0.4				
43	1	Gravelly Sandy CLAY CI: medium plasticity, brown mottled red-brown, fine to medium grained sand, fine to medium sized gravel, dry to moist, hard. Clay content increasing with depth.		D	1.0		pp >600		
					1.5		pp >600		
42	2								
	2.2	Pit discontinued at 2.2m (Refusal on hard ground)							
41	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 49.6 m AHD*
EASTING: 408694
NORTHING: 6494179

PIT No: 27
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, grey-brown, low plasticity silt, with roots, dry to moist.							
	0.3	GRAVEL GP-GM: fine to medium sized lateritic gravel, light brown, with sand and silt, moist, very dense. Sand is fine to medium grained.							
49	1	Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, with gravel, dry to moist, very stiff to hard.							
48	2	- becoming red-brown mottled grey from 1.7 m depth.							
47	2.7	Pit discontinued at 2.7m (Refusal on hard ground)							
	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 55.7 m AHD*
EASTING: 408883
NORTHING: 6494176

PIT No: 28
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
55	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, dark grey-brown, low plasticity silt, with roots, dry to moist.							
	0.3	Clayey Sandy GRAVEL GP-GC: fine to medium sized lateritic gravel, light brown, fine to medium grained sand, medium plasticity, moist, dense.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, with gravel, moist, very stiff to hard.							
54	1	- becoming red-brown mottled brown and light grey from 1.2 m.							
	2			D	2.0		pp >600		
53	2.8	Pit discontinued at 2.8m (Refusal on hard ground)							
	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 63.6 m AHD*
EASTING: 409114
NORTHING: 6494183

PIT No: 29
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
63	0.1	TOPSOIL/Silty SAND SM: fine to medium grained sand, dark brown, low plasticity silt, with roots, dry to moist.							
		Gravelly CLAY CI/Clayey GRAVEL GC: medium plasticity, orange-brown, with sand, moist, stiff to very stiff. Sand is fine to medium grained.		D	0.5				
		- becoming hard from 0.5 m depth.							
62	1								
		- becoming red-brown, mottled light grey from 1.7 m depth.		D	1.9				
	2.0	Pit discontinued at 2.0m (Refusal on rock)							
61	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 78.2 m AHD*
EASTING: 409352
NORTHING: 6494186

PIT No: 30
PROJECT No: 96731.00
DATE: 19/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
78	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to coarse grained sand, grey-brown, fine to coarse sized gravel, low plasticity silt, with roots, dry to moist.							
		Gravelly Sandy CLAY CI: medium plasticity, brown, fine to coarse grained sand, fine to coarse sized gravel, with cobbles, dry to moist, hard.							
	0.9	Pit discontinued at 0.9m (Refusal on hard ground)							
77	1								
76	2								
75	3								





RIG: Hitachi 5 tonne excavator with a 650 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 71 m AHD*
EASTING: 409222
NORTHING: 6494002

PIT No: 31
PROJECT No: 96731.00
DATE: 12/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
71	0.05	TOPSOIL/Sandy CLAY CI: medium plasticity, dark brown, fine to medium grained sand, with roots, dry to moist.							
		CLAY CI: medium plasticity, dark brown, with cobbles and sand, moist, very stiff.		D	0.5				
		- granite rock observed on one side of test pit from 0.5 m depth.							
70	1.0	GRANITE: extremely weathered, granite, excavated as a Sandy CLAY CI: medium plasticity, orange-brown, mottled red-brown, fine to medium grained sand, moist, very stiff.		D	1.3				
		- becoming hard from 1.35 m depth.							
69	2								
	2.2	Pit discontinued at 2.2m (Refusal on hard ground)							
68	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 52.6 m AHD*
EASTING: 408880
NORTHING: 6493996

PIT No: 32
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
52	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, dark brown, fine to medium grained sand, fine to medium sized gravel, with roots, dry to moist.							
		Sandy CLAY CI/Clayey SAND SC: medium plasticity, dark brown, fine to medium grained sand, with gravel, moist, hard. Possibly fill to 0.3 m depth.		D	0.5				
		- becoming very stiff from 0.45 m depth.							
	0.9	Sandy CLAY CI: medium plasticity, brown, fine to medium grained sand, trace gravel, moist, very stiff. Becoming orange-brown with depth.							
51	1				1.5		pp = 300		
	2	- becoming hard from 2.0 m depth.			2.0		pp >600		
		- with cobbles and gravel from 2.1 m depth.							
	2.3	Pit discontinued at 2.3m (Refusal on hard ground)							
50	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 48.3 m AHD*
EASTING: 408678
NORTHING: 6493988

PIT No: 33
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
48	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, dark brown, fine to medium grained sand, fine to medium sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, hard.			0.5		pp >600		
47	1								
		- becoming red-brown, mottled grey from 1.4 m depth.			1.5		pp = 450		
	2				2.0		pp >600		
46					2.5		pp >600		
	2.7	Pit discontinued at 2.7m (Refusal on hard ground)							
45	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 41.8 m AHD* **PIT No:** 34
EASTING: 408467 **PROJECT No:** 96731.00
NORTHING: 6493988 **DATE:** 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
41	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, grey-brown, fine to medium sized gravel, low plasticity silt, with roots, dry to moist.							
		Clayey GRAVEL GC: fine to medium sized lateritic gravel, yellow-brown, medium plasticity, trace sand, dry to moist, very dense.		D	0.5				
	0.9	Pit discontinued at 0.9m (Refusal on hard ground)							
40	1								
	2								
39	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 41.2 m AHD* **PIT No:** 35
EASTING: 408475 **PROJECT No:** 96731.00
NORTHING: 6493775 **DATE:** 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
41	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, very stiff to hard.			0.5		pp >600		
40	1				1.0		pp = 550		
					1.5		pp = 400		
39	2				2.0		pp >600		
	2.3	- becoming red-brown, mottled orange-brown from 2.2 m depth.							
		Pit discontinued at 2.3m (Refusal on hard ground)							
38	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 46.1 m AHD*
EASTING: 408688
NORTHING: 6493788

PIT No: 36
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
46	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, stiff to very stiff.							
		- becoming soft to firm from 0.6 m depth.							
45	1								
		- becoming stiff from 1.35 m depth.			1.5		pp = 550		
44	2	- becoming red-brown, mottled grey, with gravel from 1.9 m depth.			2.0		pp = 350		
		- becoming very stiff from 1.95 m depth.							
		- becoming hard from 2.5 m depth.			2.5		pp >600		
	2.8	Pit discontinued at 2.8m (Refusal on hard ground)							
43	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 52.8 m AHD*
EASTING: 408887
NORTHING: 6493788

PIT No: 37
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
52	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, brown, fine to medium grained sand, trace gravel, moist, very stiff.							
		- becoming stiff from 0.3 m depth.							
		- becoming firm from 0.6 m depth.							
	1	- becoming stiff from 0.9 m depth.			1.0		pp = 250		
		- becoming red-brown and grey from 1.5 m depth.			1.5		pp = 400		
51	2	- becoming very stiff from 1.65 m depth.							
		- becoming hard from 2.0 m depth.			2.0		pp = 550		
					2.5		pp = 550		
50	2.8	Pit discontinued at 2.8m (Refusal on hard ground)							
	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 60.7 m AHD*
EASTING: 409093
NORTHING: 6493785

PIT No: 38
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
60	0.1	TOPSOIL/Sandy SILT ML: low plasticity, light red-brown, fine to coarse grained sand, with gravel and roots, dry to moist.							
		Clayey GRAVEL GC: fine to medium sized lateritic gravel, red-brown, medium plasticity, trace sand, dry to moist, medium dense to dense. - becoming orange-brown from 0.5 m depth. - becoming Sandy CLAY CI and COBBLES between 0.5 m and 0.7 m depth.			1.5		pp = 400		
59	1.7	Gravelly Sandy CLAY AND COBBLES CI: medium plasticity, orange-brown mottled grey, fine to medium grained sand, fine to coarse sized gravel, cobbles, moist, very stiff.							
58	2.5	Pit discontinued at 2.5m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 70.8 m AHD*
EASTING: 409247
NORTHING: 6493677

PIT No: 39
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
70	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, light red-brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Clayey GRAVEL GC: fine to medium sized lateritic gravel, red-brown, medium plasticity, trace sand, moist, medium dense to dense. - becoming brown from 1.2 m depth.			1.5		pp = 450		
69	1.6	Gravelly Sandy CLAY AND COBBLES CI: medium plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, cobbles, moist, hard.							
68	2.1	Pit discontinued at 2.1m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 58.6 m AHD*
EASTING: 409093
NORTHING: 6493580

PIT No: 40
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
58	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to medium sized gravel, with roots, moist.							
		Clayey GRAVEL GC: fine to medium sized lateritic gravel, brown, medium plasticity, with cobbles, trace sand, moist, very stiff.		D	0.5				
57	1.0	Gravelly Sandy CLAY AND COBBLES Cl: medium plasticity, brown mottled grey, fine to medium grained sand, fine to coarse sized gravel, cobbles, moist, very stiff.			1.0		pp = 350		
	1.6	Sandy CLAY Cl: medium plasticity, brown, fine to medium grained sand, with cobbles and gravel, moist.							
56	2.3	Pit discontinued at 2.3m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 50.1 m AHD*
EASTING: 408891
NORTHING: 6493572

PIT No: 41
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
50	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY Cl: medium plasticity, brown, fine to medium grained sand, trace gravel, moist, stiff.							
49	1.0	- becoming very stiff from 0.75 m depth.			1.0		pp = 350		
		- becoming hard from 1.35 m depth.			1.5		pp = 450		
48	2.0				2.0		pp >600		
					2.5		pp >600		
47	2.8	Pit discontinued at 2.8m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 45.4 m AHD*
EASTING: 408896
NORTHING: 6493588

PIT No: 42
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per mm)
45	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, brown, fine to medium grained sand, trace gravel, moist, hard.			0.5		pp = 500		
	1				1.0		pp = 350		1
44		- becoming very stiff from 1.0 m depth.			1.5		pp = 350		
		- becoming orange-brown, mottled grey from 1.7 m depth.							
	2	- becoming hard from 2.0 m depth.			2.0		pp >600		2
43					2.5		pp >600		
	2.6	Pit discontinued at 2.6m (Refusal on hard ground)							
	3								
42									





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 39.5 m AHD*
EASTING: 408475
NORTHING: 6493591

PIT No: 43
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
39	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, hard.			0.5		pp = 450		
	1	- becoming very stiff from 1.0 m depth.			1.0		pp = 300		1
				D	1.3				
38		- becoming red-brown, mottled grey from 1.5 m depth.			1.5		pp = 250		
	2				2.0		pp = 300		2
37					2.5		pp = 350		
	2.8	Pit discontinued at 2.8m (Refusal on hard ground)							
	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 41.8 m AHD*
EASTING: 408645
NORTHING: 6493354

PIT No: 44
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
41	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY Cl: medium plasticity, brown, fine to medium grained sand, trace gravel, moist, hard.			0.5		pp >600		
	1			D	1.0		pp = 400		1
					1.5		pp = 400		
40		- becoming brown, mottled grey from 1.8 m depth.							
	2				2.0		pp = 450		2
					2.5		pp >600		
39	2.7	Pit discontinued at 2.7m (Refusal on hard ground)							
	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 49.6 m AHD*
EASTING: 408876
NORTHING: 6493362

PIT No: 45
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
49	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY Cl: medium plasticity, brown, fine to medium grained sand, trace gravel, moist, hard.			0.5		pp = 500		
		- becoming stiff to very stiff from 0.3 m depth.							
	1				1.0		pp = 300		1
		- becoming hard from 1.35 m depth.			1.5		pp = 550		
48		- with cobbles and gravel from 1.6 m depth.							
	2				2.0		pp >600		2
	2.1	Pit discontinued at 2.1m (Refusal on hard ground)							
47									
	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 59.6 m AHD*
EASTING: 409100
NORTHING: 6493365

PIT No: 46
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to medium sized gravel, with roots, moist.							
		CLAY Cl: medium plasticity, brown, with sand, trace gravel, moist, stiff to very stiff.			0.5		pp = 450		
		- becoming hard from 0.75 m depth.			1.0		pp = 400		
58	1				1.5		pp = 300		
		- becoming very stiff from 1.5 m depth.							
	2				2.0		pp = 300		
57	2.2	Gravelly CLAY Cl: medium plasticity, red-brown, mottled orange-brown and grey, with sand, moist.		D	2.5				
	3	3.0 Pit discontinued at 3.0m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 60.7 m AHD*
EASTING: 409184
NORTHING: 6493178

PIT No: 47
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
	0.4	Gravelly Sandy CLAY Cl: medium plasticity, red-brown, fine to medium grained sand, fine to coarse sized gravel, trace cobbles, moist, hard.							
60		CLAY Cl: medium plasticity, brown, with sand, trace cobbles, moist, hard.			0.5		pp >600		
	1			D	1.0		pp >600		
59					1.5		pp >600		
	2				2.0		pp >600		
58	2.5	Pit discontinued at 2.5m (Refusal on hard ground)							
	3								

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 48.7 m AHD*
EASTING: 408933
NORTHING: 6493168

PIT No: 48
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
48	0.1	TOPSOIL/Sandy CLAY Cl: medium plasticity, brown, fine to medium grained sand, with gravel and roots, dry to moist.							
		Sandy CLAY Cl: medium plasticity, orange-brown, fine to medium grained sand, with gravel, moist, very stiff to hard.			0.5		pp = 450		
		- becoming red-brown, mottled brown, trace gravel from 0.8 m depth.			1.0		pp = 550		
47					1.5		pp = 350		
					2.0		pp = 450		
46					2.5		pp = 500		
	3.0	Pit discontinued at 3.0m (Target depth)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 40.1 m AHD*
EASTING: 408664
NORTHING: 6493187

PIT No: 49
PROJECT No: 96731.00
DATE: 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
40	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, dry to moist.							
		Sandy CLAY Cl: medium plasticity, orange-brown, fine to medium grained sand, trace gravel, moist, hard.							
39		- becoming stiff to very stiff from 0.3 m depth.							
		- becoming hard from 0.9 m depth.							
	1.7	Clayey Sandy GRAVEL GC: fine to coarse sized lateritic gravel, orange-brown, medium plasticity, fine to coarse grained sand, dry to moist.		D	1.9				
38	2.0	Pit discontinued at 2.0m (Refusal on rock)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 37.4 m AHD*
EASTING: 408707
NORTHING: 6493005

PIT No: 50
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
37	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to coarse grained, brown, fine to medium sized gravel, low plasticity silt, with roots, dry to moist.							
		Clayey Sandy GRAVEL GC: fine to medium sized lateritic gravel, orange-brown, medium plasticity, fine to coarse grained sand, dry to moist, medium dense.		D	0.5				
		- becoming dense to very dense from 0.45 m depth.							
36	1.0	Gravelly Sandy CLAY CI: medium plasticity, orange-brown, fine to coarse grained sand, fine to coarse sized lateritic gravel, moist.							
35	2.0	Sandy CLAY CI: medium plasticity, brown, mottled grey, fine to medium grained sand, dry to moist, hard.			2.1		pp >600		
					2.5		pp >600		
	2.7	Pit discontinued at 2.7m (Refusal on hard ground)							
34	3								





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 44.9 m AHD*
EASTING: 408943
NORTHING: 6493010

PIT No: 51
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
44	0.1	TOPSOIL/Gravelly Sandy CLAY CI: medium plasticity, brown, fine to medium grained sand, fine to coarse sized gravel, with roots, moist.							
		CLAY CI: medium plasticity, brown, with sand, moist, stiff.							
		- becoming firm from 0.3 m depth.							
	1	- becoming stiff from 0.9 m depth.		D	1.0				
43	2	- becoming red-brown, mottled grey from 1.8 m depth.							
		- becoming very stiff from 2.5 m depth.			2.5		pp = 350		
42	3.0	Pit discontinued at 3.0m (Target depth)			3.0		pp = 350		





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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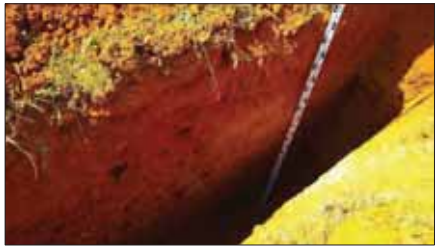
TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 59.7 m AHD*
EASTING: 409192
NORTHING: 6493003

PIT No: 52
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.1	TOPSOIL/Gravelly Sandy SILT ML: low plasticity, brown, fine to coarse grained sand, fine to medium sized gravel, with roots, dry to moist.							
		Sandy CLAY CI: medium plasticity, red-brown, fine to medium grained sand, moist, very stiff.							
		- becoming stiff from 0.3 m depth.							
58	1	- becoming very stiff from 0.9 m depth.							
		- becoming orange-brown from 1.1 m depth.			1.5		pp = 300		
	2				2.0		pp = 300		
57					2.5		pp = 300		
	3	3.0 Pit discontinued at 3.0m (Target depth)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 59.7 m AHD*
EASTING: 409200
NORTHING: 6492845

PIT No: 53
PROJECT No: 96731.00
DATE: 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.1	TOPSOIL/Sandy CLAY CI: medium plasticity, red-brown, fine to medium grained sand, with gravel and roots, moist.							
		Gravelly Sandy CLAY CI: medium plasticity, red-brown, fine to medium coarse sand, fine to medium sized gravel, moist, hard.							
		- becoming stiff between 0.3 m and 0.6 m depth.							
58	0.9	Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, with gravel, moist, hard.			1.5		pp = 350		
	1.9	Gravelly Sandy CLAY AND COBBLES CI: medium plasticity, orange-brown, fine to medium grained sand, fine to coarse sized gravel, cobbles, moist.							
57	2.8	Pit discontinued at 2.8m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket.
LOGGED: YC
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 44.9 m AHD* **PIT No:** 54
EASTING: 408978 **PROJECT No:** 96731.00
NORTHING: 6492847 **DATE:** 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
44	0.1	TOPSOIL/Sandy CLAY Cl: medium plasticity, brown, fine to medium grained sand, with gravel and roots, moist.							
		Sandy CLAY Cl: medium plasticity, orange-brown, fine to medium grained sand, with gravel, moist, very stiff.							
		- becoming stiff from 0.6 m depth.		D	1.0				
43	1.5	Gravelly Sandy CLAY Cl: medium plasticity, brown, mottled grey, fine to medium grained sand, fine to coarse sized gravel, with cobbles, moist, very stiff.			1.4		pp = 300		
					2.5		pp = 350		
42	3.0	Pit discontinued at 3.0m (Target depth)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 38.9 m AHD* **PIT No:** 55
EASTING: 408781 **PROJECT No:** 96731.00
NORTHING: 6492831 **DATE:** 20/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
		Sandy CLAY Cl: medium plasticity, brown, fine to medium grained sand, moist, very stiff.							
		- becoming stiff from 0.3 m depth.							
38	1								
		- becoming very stiff from 1.2 m depth.							
37	2			D	2.0				
		- becoming blue-grey and brown, trace gravel from 2.3 m depth.			2.5		pp = 400		
36	3.0				2.9		pp = 350		
		Pit discontinued at 3.0m (Target depth)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 59.5 m AHD* **PIT No:** 56
EASTING: 409168 **PROJECT No:** 96731.00
NORTHING: 6494623 **DATE:** 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
59	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, dark grey-brown, fine to medium sized gravel, low plasticity silt, with roots, dry to moist.							
		Gravelly Sandy CLAY CI: medium plasticity, orange-brown, fine to medium grained sand, fine to coarse sized gravel, with cobbles, moist, hard.		D	0.5				
58	1.6	Pit discontinued at 1.6m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Marlin Bullsbrook Pty Ltd
PROJECT: Proposed Bullsbrook Urban Precinct
LOCATION: Various Lots, Stock Road, Bullsbrook, WA

SURFACE LEVEL: 65.2 m AHD* **PIT No:** 57
EASTING: 409243 **PROJECT No:** 96731.00
NORTHING: 6494566 **DATE:** 21/10/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
65	0.1	TOPSOIL/Gravelly Silty SAND SM: fine to medium grained sand, grey-brown, fine to coarse sized gravel, low plasticity silt, with roots, dry to moist.							
		Clayey Sandy GRAVEL GC: fine to medium sized lateritic gravel, orange-brown, medium plasticity, fine to coarse grained sand, dry to moist, dense to very dense.		D	0.5				
64	0.9	Pit discontinued at 0.9m (Refusal on hard ground)							





RIG: JCB 8 tonne backhoe with a 450 mm wide toothed bucket. **LOGGED:** YC **SURVEY DATUM:** MGA94

WATER OBSERVATIONS: No free groundwater observed

REMARKS: *Surface level inferred from publicly available LiDAR data.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Appendix D

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

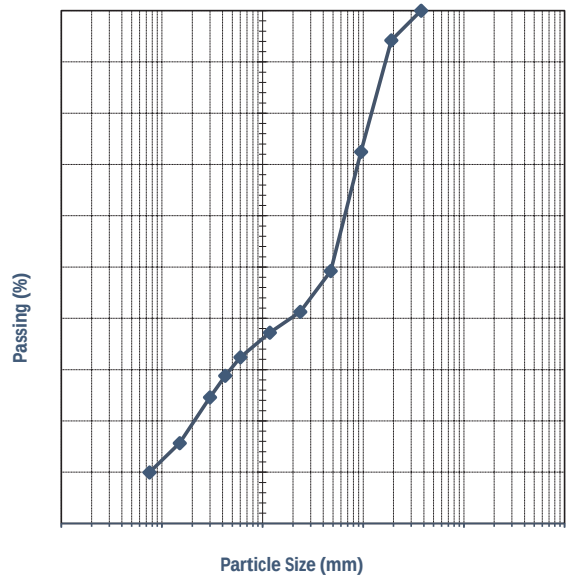
TEST REPORT - AS 1289.3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9774_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9774**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**5, 0.3m**	*Date Tested:*	**28-29/10/2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	94
9.5	72
4.75	49
2.36	41
1.18	37
0.600	32
0.425	29
0.300	25
0.150	16
0.075	10



Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

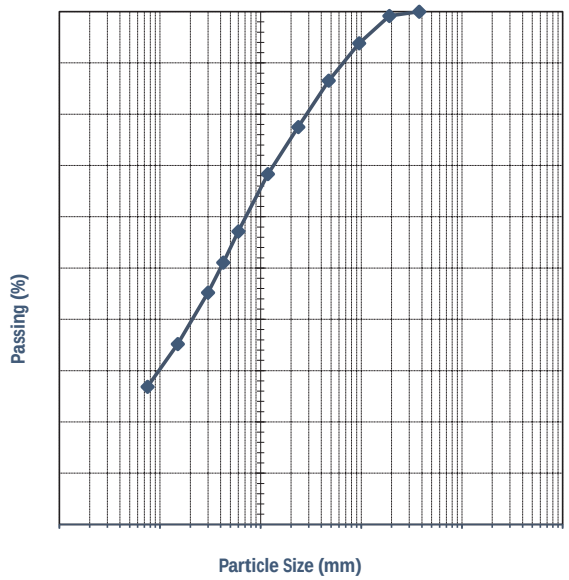
TEST REPORT - AS 1289.3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9775_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9775**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**11, 0.5m**	*Date Tested:*	**28-29/10/2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	99
9.5	94
4.75	87
2.36	77
1.18	68
0.600	57
0.425	51
0.300	45
0.150	35
0.075	27



Comments:

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Name: Brooke Elliott
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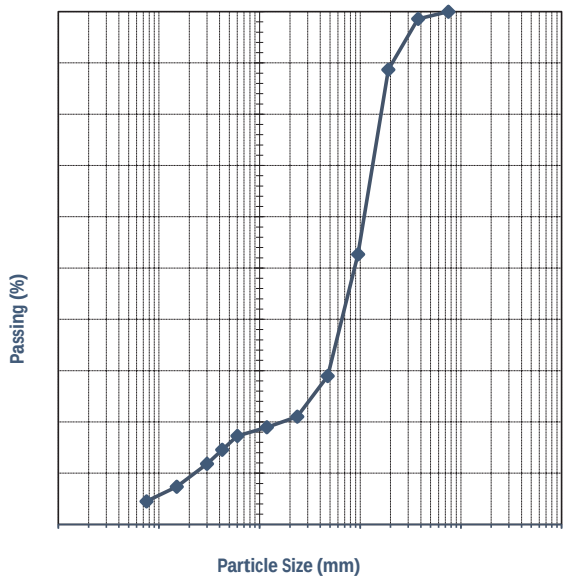
TEST REPORT - AS 1289.3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9776_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9776**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**23, 0.8m**	*Date Tested:*	**28-29/10/2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	100
37.5	99
19.0	89
9.5	53
4.75	29
2.36	21
1.18	19
0.600	17
0.425	15
0.300	12
0.150	7
0.075	5



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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

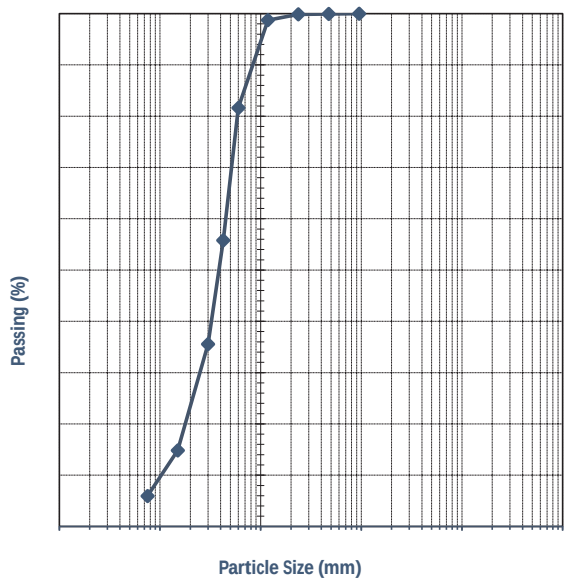
TEST REPORT - AS 1289.3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9777_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9777**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**24, 0.5m**	*Date Tested:*	**28-29/10/2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	100
1.18	99
0.600	82
0.425	56
0.300	36
0.150	15
0.075	6



Comments:

Approved Signatory:

Name: Brooke Elliott
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SOIL | AGGREGATE | CONCRETE | CRUSHING

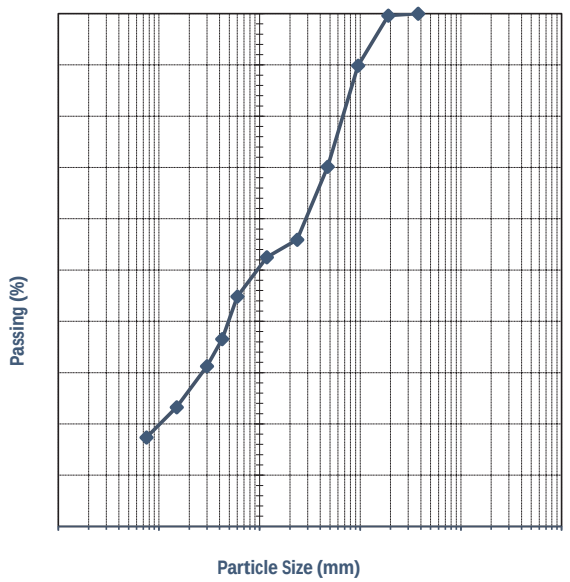
TEST REPORT - AS 1289.1.1*,3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9778_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9778**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**26, 0.4m**	*Date Tested:*	**28-29/10/2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	100
9.5	90
4.75	70
2.36	56
1.18	52
0.600	45
0.425	37
0.300	31
0.150	23
0.075	17



*Comments: *AS 1289.1.1- Deviation from standard: Insufficient sample according to test method requirements. NATA accreditation does not cover the performance of this service.*

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

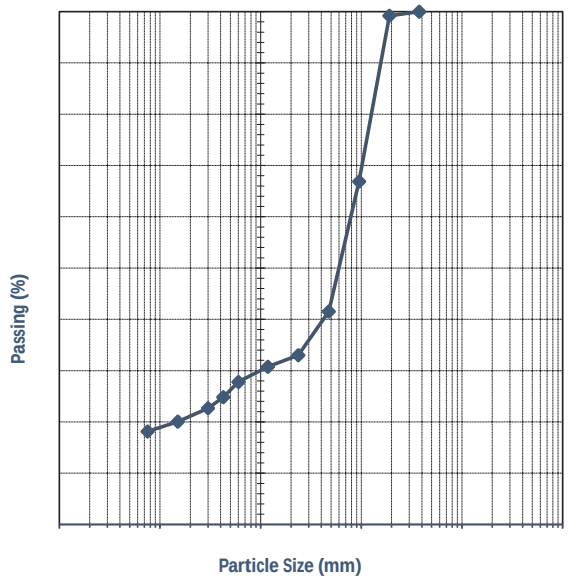
TEST REPORT - AS 1289.1.1*,3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9779_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9779**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**34, 0.5m**	*Date Tested:*	**28-29/10/2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	99
9.5	67
4.75	42
2.36	33
1.18	31
0.600	28
0.425	25
0.300	23
0.150	20
0.075	18



*Comments: *AS 1289.1.1- Deviation from standard: Insufficient sample according to test method requirements. NATA accreditation does not cover the performance of this service.*

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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SOIL | AGGREGATE | CONCRETE | CRUSHING

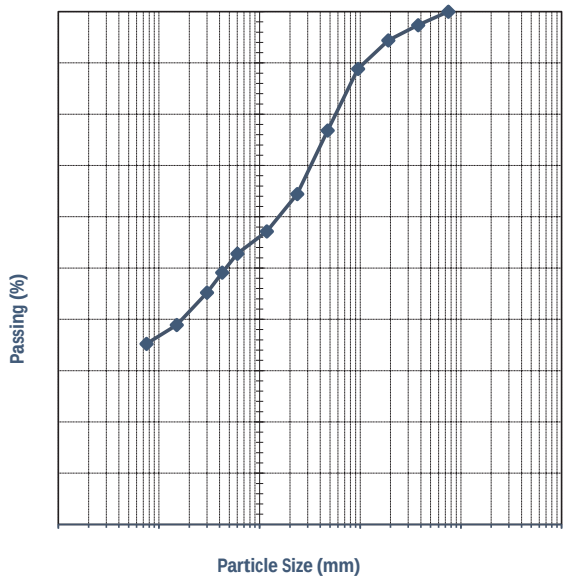
TEST REPORT - AS 1289.1.1*,3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9780_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9780**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**29, 0.5m**	*Date Tested:*	**28-29/10/2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	100
37.5	97
19.0	94
9.5	89
4.75	77
2.36	64
1.18	57
0.600	53
0.425	49
0.300	45
0.150	39
0.075	35



*Comments: *AS 1289.1.1- Deviation from standard: Insufficient sample according to test method requirements. NATA accreditation does not cover the performance of this service.*

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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SOIL | AGGREGATE | CONCRETE | CRUSHING

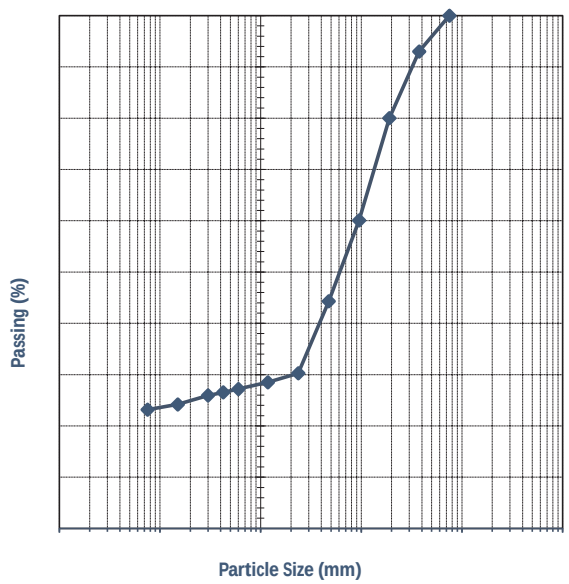
TEST REPORT - AS 1289.1.1*,3.6.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9781_1_PSD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9781**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**40, 0.5m**	*Date Tested:*	**28-10-2020**

TEST RESULTS - Particle Size Distribution of Soil

Sampling Method: **Sampled by Client, Tested as Received**

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	100
37.5	93
19.0	80
9.5	60
4.75	44
2.36	30
1.18	29
0.600	27
0.425	27
0.300	26
0.150	24
0.075	23



*Comments: *AS 1289.1.1- Deviation from standard: Insufficient sample according to test method requirements. NATA accreditation does not cover the performance of this service.*

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9775_1_PI**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9775**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**11, 0.5m**	*Date Tested:*	**29-10-2020**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**19**
AS 1289.3.2.1	**Plastic Limit (%)**	**13**
AS 1289.3.3.1	**Plasticity Index (%)**	**6**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**2.5**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**-**

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9778_1_PI**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9778**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**26, 0.4m**	*Date Tested:*	**29-10-2020**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**37**
AS 1289.3.2.1	**Plastic Limit (%)**	**20**
AS 1289.3.3.1	**Plasticity Index (%)**	**17**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**6.5**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9780_1_PI**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9780**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**29, 0.5m**	*Date Tested:*	**29-10-2020**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**38**
AS 1289.3.2.1	**Plastic Limit (%)**	**18**
AS 1289.3.3.1	**Plasticity Index (%)**	**20**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**5.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Cracked**

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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WG_AS 1289.3.1.1,3.2.1,3.3.1,3.4.1_TR_2 Page 1 of 1

WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.3.1.1, 3.2.1, 3.3.1 & 3.4.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9781_1_PI**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9781**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**40, 0.5m**	*Date Tested:*	**29-10-2020**

TEST RESULTS - Consistency Limits (Casagrande)

Sampling Method:	**Sampled by Client, Tested as Received**
History of Sample:	**Oven Dried <50°C**
Method of Preparation:	**Dry Sieved**

AS 1289.3.1.1	**Liquid Limit (%)**	**49**
AS 1289.3.2.1	**Plastic Limit (%)**	**20**
AS 1289.3.3.1	**Plasticity Index (%)**	**29**
AS 1289.3.4.1	**Linear Shrinkage (%)**	**10.0**
AS 1289.3.4.1	**Length of Mould (mm)**	**250**
AS 1289.3.4.1	**Condition of Dry Specimen:**	**Curled**

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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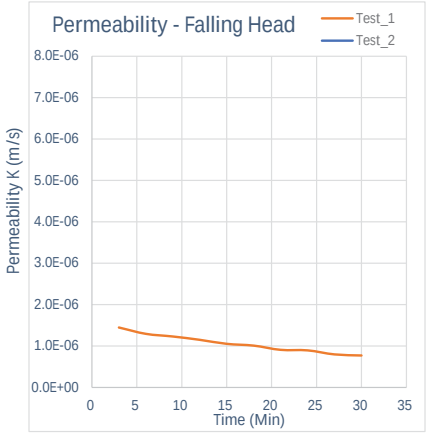
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT AS 1289.6.7.2

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9872_1_FHPERM**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9872**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification	**11, 0.3m**	*Date Tested:*	**28-30/10/2020**

TEST RESULTS - FALLING HEAD PERMEABILITY

Sampling Method: Sampled by Client, Tested as Received



Compaction Details	
Compaction Method	**AS 1289.5.2.1**
Hammer Type	**Modifed**
% Retained of 19.0mm	**0**
Maximum Dry Density (t/m^3)	**2.1**
Optiumum Moisture (%)	**7.5**
Target Dry Density Ratio	**92**
Target Moisture Ratio	**100**

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	**91.9**
Laboratory Moisture Ratio (%)	**102.7**
Surchare (kPa)	**3**

Coefficient of Permeability K_{20} (m/s) 1.06E-06

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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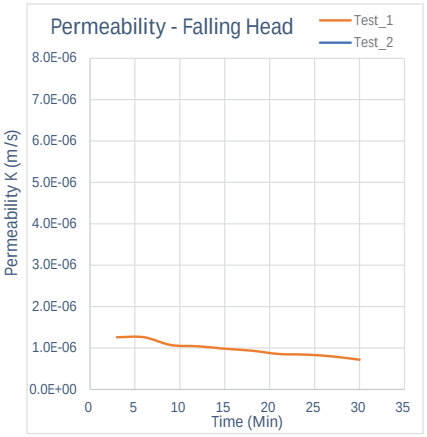
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT AS 1289.6.7.2

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9873_1_FHPERM**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9873**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification	**23, 0.3m**	*Date Tested:*	**28-30/10/2020**

TEST RESULTS - FALLING HEAD PERMEABILITY

Sampling Method: Sampled by Client, Tested as Received



Compaction Details	
Compaction Method	AS 1289.5.2.1
Hammer Type	Modifed
% Retained of 19.0mm	5
Maximum Dry Density (t/m^3)	2.2
Optiumum Moisture (%)	8
Target Dry Density Ratio	95
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	95.0
Laboratory Moisture Ratio (%)	100.8
Surchare (kPa)	3

Coefficient of Permeability K_{20} (m/s) 9.78E-07

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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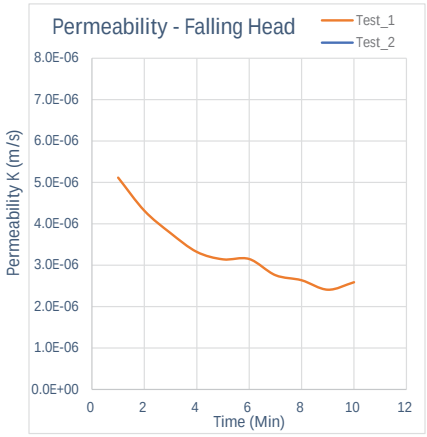
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT AS 1289.6.7.2

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9874_1_FHPERM**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9874**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification	**24, 0.3m**	*Date Tested:*	**28/10-2/11/2020**

TEST RESULTS - FALLING HEAD PERMEABILITY

Sampling Method: Sampled by Client, Tested as Received



Compaction Details	
Compaction Method	AS 1289.5.2.1
Hammer Type	Modifed
% Retained of 19.0mm	0
Maximum Dry Density (t/m^3)	1.83
Optiumum Moisture (%)	14
Target Dry Density Ratio	95
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	94.7
Laboratory Moisture Ratio (%)	101.9
Surchare (kPa)	3

Coefficient of Permeability K_{20} (m/s) 3.32E-06

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

Accreditation No. 20599
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WESTERN GEOTECHNICAL & Laboratory Services

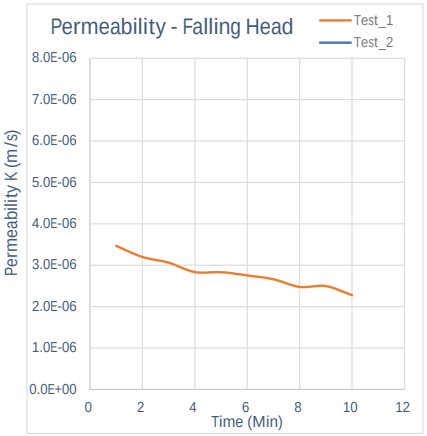
SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT AS 1289.6.7.2

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9785_1_FHPERM**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9785**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification	**50, 0.3m**	*Date Tested:*	**28/10-2/11/2020**

TEST RESULTS - FALLING HEAD PERMEABILITY

Sampling Method: Sampled by Client, Tested as Received



Compaction Details	
Compaction Method	AS 1289.5.2.1
Hammer Type	Modifed
% Retained of 19.0mm	2
Maximum Dry Density (t/m^3)	2.22
Optiumum Moisture (%)	8.5
Target Dry Density Ratio	92
Target Moisture Ratio	100

Specimen Conditions at Compaction	
Laboratory Density Ratio (%)	92.0
Laboratory Moisture Ratio (%)	100.3
Surchare (kPa)	3

Coefficient of Permeability K_{20} (m/s) **2.81E-06**

Comments:

Approved Signatory:

Name: Brooke Elliott
Date: 03-November-2020

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WESTERN GEOTECHNICAL & Laboratory Services

SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9782_1_MMDD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9782**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**11, 0.3m**	*Date Tested:*	**28-10-2020**

TEST RESULTS - Modified Maximum Dry Density

Sampling Method: **Sampled by Client, Tested as Received**

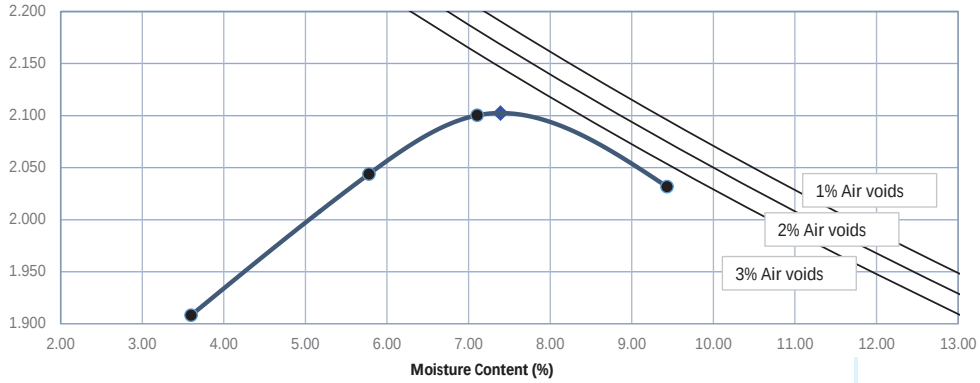
Sample Curing Time: **2 h**

Method used to Determine Liquid Limit: **Visual / Tactile Assessment by Competent Technician**

Material + 19.0mm (%): **0** **Material + 37.5mm (%)** **-**

Moisture Content (%)	3.6	5.8	7.1	9.4	
Dry Density (t/m^3)	1.908	2.044	2.100	2.032	

Dry Density (t/m³)



Modified Maximum Dry Density (t/m³) **2.10**

Optimum Moisture Content (%) **7.5**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.645 t/m³*

Approved Signatory:

Name: Luis Wythes
Date: 29-October-2020

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9783_1_MMDD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9783**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**23, 0.3m**	*Date Tested:*	**28-10-2020**

TEST RESULTS - Modified Maximum Dry Density

Sampling Method: Sampled by Client, Tested as Received

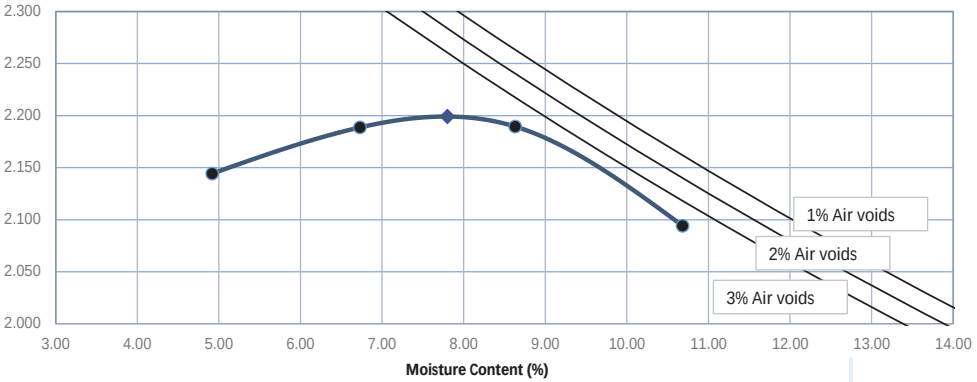
Sample Curing Time: 2 h

Method used to Determine Liquid Limit: Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%): 5 **Material + 37.5mm (%)** -

Moisture Content (%)	**4.9**	**6.7**	**8.6**	**10.7**	
Dry Density (t/m³)	**2.144**	**2.189**	**2.190**	**2.094**	

Dry Density (t/m³)



Modified Maximum Dry Density (t/m³) **2.20**

Optimum Moisture Content (%) **8.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.848 t/m³*

Approved Signatory:

Name: Luis Wythes

Date: 29-October-2020

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9784_1_MMDD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9784**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**24, 0.3m**	*Date Tested:*	**28-10-2020**

TEST RESULTS - Modified Maximum Dry Density

Sampling Method: Sampled by Client, Tested as Received

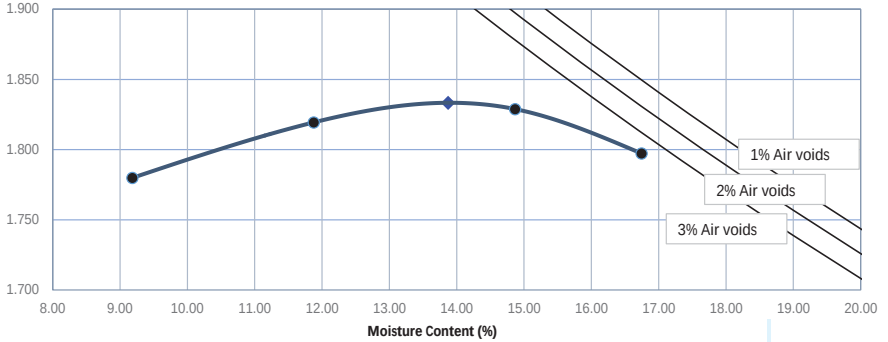
Sample Curing Time: 2 h

Method used to Determine Liquid Limit: Visual / Tactile Assessment by Competent Technician

Material + 19.0mm (%): 0 **Material + 37.5mm (%)** -

Moisture Content (%)	**9.2**	**11.9**	**14.9**	**16.7**	
Dry Density (t/m³)	**1.780**	**1.819**	**1.829**	**1.797**	

Dry Density (t/m³)



Modified Maximum Dry Density (t/m³) **1.83**

Optimum Moisture Content (%) **14.0**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.719 t/m³*

Approved Signatory:

Name: Luis Wythes

Date: 03-November-2020

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SOIL | AGGREGATE | CONCRETE | CRUSHING

TEST REPORT - AS 1289.5.2.1

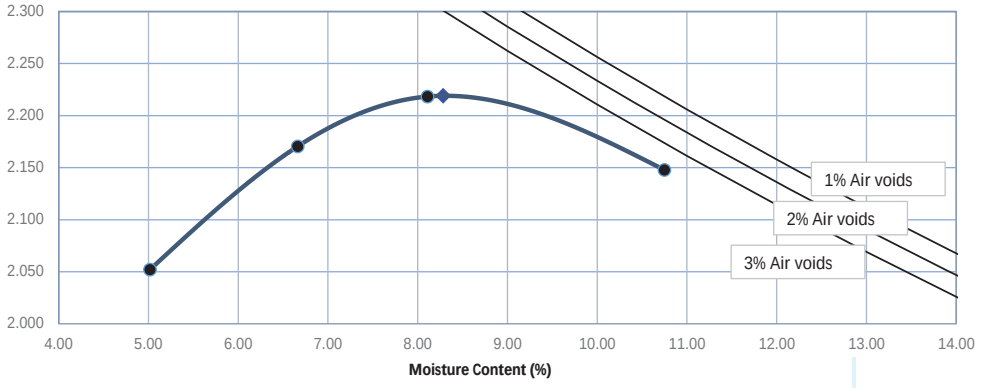
Client:	**Marlin Bullsbrook Pty Ltd**	*Ticket No.*	**S1923**
Client Address:	**-**	*Report No.*	**WG20/9785_1_MMDD**
Project:	**Proposed Bullsbrook Urban Precinct**	*Sample No.*	**WG20/9785**
Location:	**Various Lots, Stock Road, Bullsbrook**	*Date Sampled:*	**19-10-2020**
Sample Identification:	**50, 0.3m**	*Date Tested:*	**28-10-2020**

TEST RESULTS - Modified Maximum Dry Density

Sampling Method:	**Sampled by Client, Tested as Received**		
Sample Curing Time:	**2 h**		
Method used to Determine Liquid Limit:	**Visual / Tactile Assessment by Competent Technician**		
Material + 19.0mm (%):	**2**	**Material + 37.5mm (%)**	**0**

Moisture Content (%)	**5.0**	**6.7**	**8.1**	**10.7**	
Dry Density (t/m³)	**2.052**	**2.170**	**2.218**	**2.148**	

Dry Density (t/m³)



Modified Maximum Dry Density (t/m³) **2.22**

Optimum Moisture Content (%) **8.5**

Comments: *The above air void lines are derived from a calculated apparent particle density of 2.952 t/m³*

Approved Signatory:

Name: Luis Wythes

Date: 29-October-2020

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Appendix E

2011 ‘Foundation Mainte d oo r or
A Homeowner’s Guide’

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO PUBLISHING
BTF 18-2011
replaces Information Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870-2011, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction
There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion
All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation
This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume, particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil
All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure
This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.

In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes
1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands (possibly mine subsidence, collapsing soils) soil subject to erosion, reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater. Further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

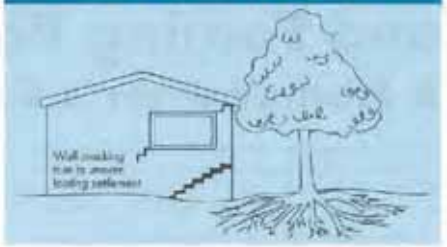
Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the lip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, causing noticeable doming of flooring.

As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become uneven.

Trees can cause shrinkage and damage



Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation causes a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, intermittent seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem. Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870-2011.

AS 2870-2011 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

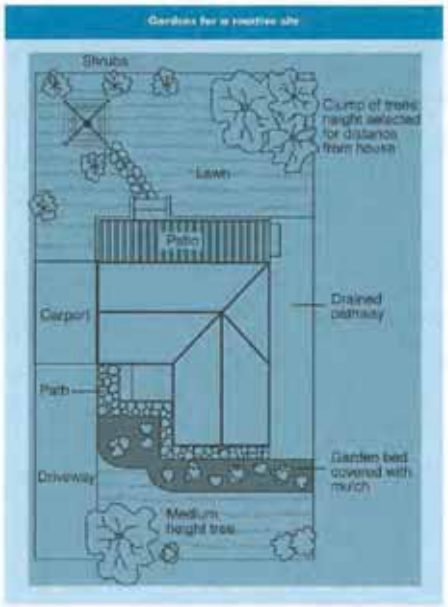
Condensation
In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly.	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired.	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 mm but also depends on number of cracks	4



The garden
The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees
Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs
State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation
Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lower FAIB, MIAMA, Partner, Construction Diagnosis.

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

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Appendix D: Corrected Groundwater Levels

Pentium Water, 2024

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Appendix D - Groundwater levels (mAHD)

Bore ID	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	**Max**
BB1	36.02	36.14	36.19	36.02	35.83	35.69	35.66	35.74	35.67	35.77	35.90	35.86	35.67	35.88	35.93	35.42	35.34	35.52	35.38	35.36	35.28	35.66	36.10	35.88	35.83	35.78	36.19
BB2	38.40	38.35	38.26	38.16	38.11	37.98	37.86	38.03	37.94	-	38.00	38.19	38.28	38.23	38.04	36.70	37.01	37.82	37.69	37.55	37.63	37.61	37.99	37.85	37.79	37.63	38.40
BB3	39.56	38.93	38.05	37.64	37.33	38.10	38.83	40.00	41.60	40.39	38.81	39.42	37.96	38.59	38.00	37.15	36.93	36.95	36.80	36.81	40.27	40.80	41.03	39.82	39.68	39.37	41.60
BB4	41.57	41.27	41.25	41.11	41.03	41.01	40.87	40.84	40.83	41.16	40.33	40.37	41.38	41.46	40.27	41.01	40.83	40.74	40.87	40.64	40.67	41.14	41.74	41.08	40.99	40.91	41.74
BB5	37.82	37.68	37.66	37.20	37.19	37.00	37.12	37.15	37.21	37.56	-	37.84	36.80	37.73	37.48	37.01	35.87	36.90	36.82	36.60	36.66	37.03	37.09	37.39	37.37	37.35	37.84
BB6	50.24	50.12	49.96	49.73	49.74	49.76	49.66	49.90	50.50	49.38	49.22	50.16	49.99	49.95	49.81	49.48	49.40	49.48	49.49	49.18	49.45	49.83	50.03	49.84	49.78	49.76	50.50
BB7	25.56	25.36	25.11	24.65	24.87	25.06	25.15	26.03	-	25.77	25.84	25.53	25.35	25.28	24.80	23.81	23.81	24.54	24.42	24.37	26.15	26.19	26.26	25.85	24.86	24.79	26.26
BB8	27.61	27.21	26.91	26.62	26.47	26.41	26.31	26.77	-	-	27.58	27.41	27.24	27.25	26.72	26.12	25.26	26.11	26.12	25.82	26.02	27.54	28.96	27.93	27.92	27.64	28.96
BB9	28.65	27.43	26.73	26.26	26.13	26.33	28.42	28.61	28.65	28.72	28.79	28.65	28.22	27.23	26.71	26.24	-	26.20	26.13	26.13	28.37	28.96	-	28.75	28.59	27.65	28.96
BB10	23.03	22.45	21.86	21.43	21.33	21.23	21.24	21.48	21.83	22.29	22.43	22.53	22.38	22.22	21.84	21.22	21.20	20.98	21.01	20.94	20.93	21.50	22.24	22.71	21.51	21.22	23.03
BB11	32.81	32.16	31.01	30.58	30.49	31.21	30.54	31.79	-	32.03	32.00	32.94	32.82	33.25	30.88	30.43	29.49	30.19	30.38	30.78	31.00	31.60	32.48	33.14	32.74	32.13	33.25
BB12	35.23	34.99	34.69	34.33	34.28	34.28	34.12	34.30	-	34.88	35.09	35.06	35.08	35.01	34.56	32.98	33.01	33.95	33.80	33.65	33.86	34.02	34.52	34.87	34.75	34.30	35.23
BB13	31.92	31.79	31.41	31.13	31.07	31.06	31.03	31.19	31.38	31.57	31.56	31.85	30.96	32.57	31.66	31.18	31.01	31.64	31.16	30.83	30.89	31.42	31.67	31.47	31.09	31.02	32.57
MW01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.39
MW03	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.67
MW04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.21
MW06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27.11

Maximum
Minimum
Discarded

Appendix E: Bullsbrook Surface and Groundwater Monitoring - Final Monitoring Report

Cardno, 2010



Bullsbrook Surface and Groundwater Monitoring

Final Monitoring Report

Prepared for Marlin Bullsbrook

June 2010

Project Number V7106

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Bullsbrook Surface and Groundwater Monitoring – Final Monitoring Report
Prepared for Marlin Bullsbrook

Executive Summary

The locality of Bullsbrook is situated 36km to the north east of the Perth City Centre, immediately west and east of the Great Northern Highway, within the City of Swan. The Bullsbrook area has been identified in the North Eastern Corridor Extension Strategy (NECES) (WAPC 2003) as having areas that are suitable for urban development. Marlin Pty Ltd (Marlin) has acquired 910ha in the Bullsbrook area (Development Area) and this area is currently under assessment for residential development. To gather more accurate hydrological data and enable calibration of catchment based surface water modelling it was decided to gather data from a larger and broader area. The "study area" therefore includes and surrounds the proposed Development Area.

This report documents the results of; groundwater level monitoring, undertaken on a monthly basis between November 2007 and December 2009; ground water quality monitoring undertaken on a quarterly basis over the same period; and surface water quality and quantity monitoring undertaken between June 2008 and May 2010. The initial results were reported in the Initial Monitoring Report (Cardno BSD, 2008).

Groundwater levels were measured on a monthly basis for 25 months on all installed bores. The level monitoring indicates that groundwater may intersect with the surface at some locations during the annual peak (usually October). If they are proposed to be developed, these areas may require fill or other methods to achieve appropriate separation to groundwater prior to development. Furthermore, it should be noted that some sections of the study area are prone to localised flooding.

Groundwater quality sampling for nutrient concentrations was usually conducted on a quarterly basis over 25 months (8 occasions). Nutrient concentrations in groundwater varied both spatially within the study area and temporally over the duration of the monitoring period. There were occasions over the monitoring period when nutrient concentrations were in excess of the default trigger values (i.e. those given for surface water quality). Overall, the main concern in regard to groundwater quality within the study area relates to TP and NO_x concentrations. The data presented in this report suggests these concentrations are part of a regional problem rather than being site specific.

The surface water quantity data has captured four clearly defined significant rainfall events which can be used for the calibration of future hydrological models. Surface water quality samples were taken from Nambad Brook and Bandy Creek in response to rainfall events. Surface water samples were taken on eight occasions over the monitoring period and provide baseline data for future comparison.

This report concludes the Scope of Work regarding hydrological monitoring for the study area and no further pre development monitoring is required.

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1 Introduction

1.1 Project Background

The locality of Bullsbrook is situated 36km to the north east of the Perth City Centre, immediately west and east of the Great Northern Highway, within the City of Swan. The Bullsbrook area has been identified in the North Eastern Corridor Extension Strategy (NECES) (WAPC 2003) as having areas that are suitable for urban development. Marlin Pty Ltd (Marlin) has acquired 910ha in the Bullsbrook area (Development Area) and this area is currently under assessment for residential development. To gather more accurate hydrological data and enable calibration of catchment based surface water modelling it was decided to gather data from a larger and broader area. The "study area" therefore includes and surrounds the proposed Development Area. The locality of the overall study area in relation to the Development Area is shown in **Figure 1**.

The Development Area is made up from a number of different land holdings including Lots 302, 4, 61, 1010, 2, 13, 56 and 30. This area covers the 910ha referred to above. The study area covers 1730ha and includes data from bores on both the eastern and western sides of Great Northern Highway. The study area boundaries and cadastral boundaries are shown in **Figure 2**.

The historical use of the Bullsbrook area has been rural, including stock grazing, feed production, arable pastures and viticulture in the more fertile plains and lower lying areas. These viticulture plantings have predominately occurred along the Great Northern Highway. Therefore, much of the study area has historically either been cleared of native vegetation or extensively grazed. Past and present mining operations are also undertaken in the area with a number of quarries still providing resource material. As discussed, the development area is proposed for future residential development. Such a land use change can have implications for the types and quantity of pollutants released to local surface and groundwater, which can in turn affect the ecological health of downstream receiving environments.

1.2 Monitoring Objective

Cardno has been engaged to gather baseline data within the study area prior to development. The objective of collecting this data is to characterise the pre-development hydrological environment of the study area. To achieve this objective, Cardno developed the SAP detailed in the following sections of this report. It was determined that in order to achieve the project objective, the SAP would need to:

- Identify and quantify nutrient hotspots so that appropriate management measures can be implemented to avoid exacerbating the current situation;
- Determine groundwater quality and surface water quality to provide baseline data against which the effectiveness of future urban stormwater management and development impacts can be compared;
- Understand the groundwater levels within the study area to determine if fill is required to achieve satisfactory separation distance; and
- Characterise surface water flows for validation of future hydrological models of the study area.

Baseline data will be used to calibrate detailed hydrological modelling of the site, inform the future design process and will ensure that any future development is able to fulfil the stormwater management requirements of the Department of Water (DoW).

1.3 Purpose of this Report

This report documents the results of; groundwater level monitoring, undertaken on a monthly basis between November 2007 and January 2010; ground water quality monitoring undertaken on a quarterly basis between November 2007 and November 2009; and surface water quality and quantity data undertaken between June 2008 and May 2010. This report is a standalone document that presents the results of the entire SAP.

2 Sampling and Analysis Plan Rationale

2.1 Key Documents and Inputs

There are a number of published guidelines and standards available which provide direction regarding the discharge characteristics that residential development should aim to achieve. These were key inputs utilised for development of the SAP, and include:

- National Water Quality Management Strategy (ANZECC 2000).
- Stormwater Management Manual for Western Australia (DOW 2007).
- Development of Sampling and Analysis Programs (DOE 2001).
- Better Urban Water Management (WAPC 2008).

The guidance documents detailed above were reviewed to determine the likely data requirements for the study area. These documents point to the need for accurate baseline data prior to development.

2.2 Groundwater Methodology

Thirteen groundwater bores were installed within the study area at locations which would provide the best representation of anticipated groundwater systems and provide coverage outside the development area. These locations will allow for the identification of nutrient hotspots and development of underlying groundwater contours up to the 90mAHD contour to the east of the study area. The locations of these groundwater bores are shown in **Figure 2**.

Groundwater bores were constructed of Class 18 threaded PVC machine slotted screen and blank casing sections. A 3m screened section was installed in each of the bores to approximately bisect the observed groundwater level. Graded gravel pack was placed around the screened section extending to at least 0.5m above the top of the screened section. A bentonite seal was placed above the gravel pack and the bore annulus was backfilled with any available cuttings and concrete to the surface. Each bore was completed with approximately 0.5m of PVC casing extending above the ground surface and a protective steel casing. All bores were logged for hydrogeological and geotechnical parameters on installation. Bore completion log sheets are contained in **Appendix A**.

2.2.1 Groundwater Levels

Groundwater levels were measured on a monthly basis for 25 months on all installed bores. The bores were measured using an audible dip meter to record standing water levels. All bores have been surveyed to provide an accurate elevation, thereby allowing accurate calculation of groundwater contours.

2.2.2 Groundwater Quality

A clear understanding of the existing groundwater quality is important to determine whether the quality of water in the superficial aquifer is slowly improving with time or at least not degrading as a result of development. Groundwater quality sampling for nutrient concentrations was conducted on a quarterly basis over 25 months (i.e. 8 occasions). Bores were purged using an electric pump prior to sampling. A Hydrolab Quanta water quality meter was used to collect field chemical data. Purging of the well was continued for approximately five minutes before samples were collected for *in situ* physiochemical and laboratory analysis. Physiochemical parameters measured *in situ* include:

- pH.
- Temperature.

- Electrical Conductivity (EC)/ Salinity.
- Oxidation-Reduction Potential (Eh).

Upon collection, groundwater samples are placed directly into laboratory prepared and supplied containers. The samples are then placed on ice immediately following collection and transported to the laboratory under standard Chain of Custody procedures. Samples are submitted to a National Association of Testing Authority (NATA) accredited laboratory for analysis. The parameters selected for groundwater analysis include:

- Total Nitrogen (TN).
- Total Phosphorous (TP).
- Ortho-Phosphorous (Ortho P).
- Oxides of Nitrogen (NO_x).
- Total Kjeldahl Nitrogen (TKN).
- Ammonium (NH_4).

2.3 Surface Water Methodology

The main surface water systems within the study area are the Nambad Brook and Bandy Spring. The Ellen Brook runs adjacent to the western boundary of the site. The locations of the surface water features and the sampling locations are shown in **Figure 3**.

2.3.1 Surface Water Quality

Surface water quality samples were taken from the locations shown in **Figure 3.** Surface water samples were aimed to be collected on five occasions per winter over the 25 month monitoring period (10 occasions in total). This monitoring occurred in response to rainfall events to ensure that samples captured runoff events. This methodology results in sporadic data collection; however, it avoids sampling being scheduled when there is no flow to sample. Monitoring parameters were consistent with those for groundwater.

2.3.2 Surface Water Quantity

Surface water quantity was measured using a Hach Sigma Flow Meter to record velocity and depth of water in the culvert at the location shown in **Figure 3**. A rainfall collection station was also installed at this location. The results from the monitoring logger can be utilised for the calibration of future hydrological models of the site, which will aim to characterise surface water runoff attributes. Analysis of this data allows the quantity of surface water flowing through the system to be determined, and the captured peak flows can be attributed to specific rainfall events.

2.4 Chain of Custody

Standard Chain of Custody forms are completed for all samples transferred to the laboratory, detailing the sample identification, collection date and the requested analysis. Upon receipt of the samples the laboratory completes the Chain of Custody forms and provides a copy to Cardno for confirmation. Completed Chain of Custody forms for sampling undertaken are provided in **Appendix B**.

2.5 Laboratory Analysis

All laboratory analysis was conducted by a National Association of Testing Authorities (NATA) accredited laboratory with all primary and QA/QC samples submitted to a NATA accredited laboratory for analysis. Laboratory certificates of analysis are included in **Appendix B**.

3 Assessment Criteria

In order to provide an indication of the relative concentration of nutrient levels and physiochemical parameters within both surface and groundwater, comparison with the 'default trigger values for slightly disturbed ecosystems (lowland river) in South Western Australia' (ANZECC 2000) is made in the following sections. While the default trigger values are applicable to nutrient concentrations within surface water features, they are not specifically intended for application to groundwater nutrient concentrations. However, as there are no nationally published trigger values available for groundwater quality, a comparison of nutrient concentrations and some field chemistry parameters are made to the 'default trigger values' to provide some context to the measured concentrations. As such, the 'default trigger values' are hereafter referred to as the 'guideline values'. These guideline values are shown in **Table 3.1**.

Table 3.1 ANZECC Guideline Values

TN (µg/L)	TP (µg/L)	Ortho P (µg/L)	NH_4 (µg/L)	NO_x (µg/L)	DO (% Sat)	pH	Salinity (mS/cm)
1200	65	40	80	150	80-120	6.5-8.0	0.12-0.3

Discussion of nutrient concentrations in the following sections refers to their relative concentration compared to the guideline values. The terms 'low', 'moderate', high' and 'very high' are used in the following manner:

- 'Low' – nutrient concentration below, equal to or marginally above default trigger value;
- 'Moderate' – nutrient concentration up to five times the default trigger value;
- 'High' – nutrient concentration between five and 10 times the default trigger value; and
- 'Very High' – nutrient concentrations more than 10 times the default trigger value.

Principally, comparison is made for the TN and TP concentrations. However, some comment is also provided for nutrient species (Ortho P, NH_4, NO_X) where these form a substantial portion of the overall nutrient concentrations.

4 Results

4.1 Groundwater Levels

Depth to groundwater was measured monthly from November 2007 to December 2009. Depth to groundwater results are attached in **Appendix C**. Depth to groundwater ranged from 0mBGS (i.e. intersecting with surface level (Bore BB7, July 2008)) to 23.7mBGS (Bore BB4, January 2009).

Analysis of DoW groundwater bore level data across Perth and within a 10km radius of the study area indicate that groundwater levels are typically at their lowest in April and their highest in October, with seasonal fluctuations of approximately up to 2m. A hydrograph of the groundwater levels of the thirteen bores within the study area is shown in **Figure 4.1**.

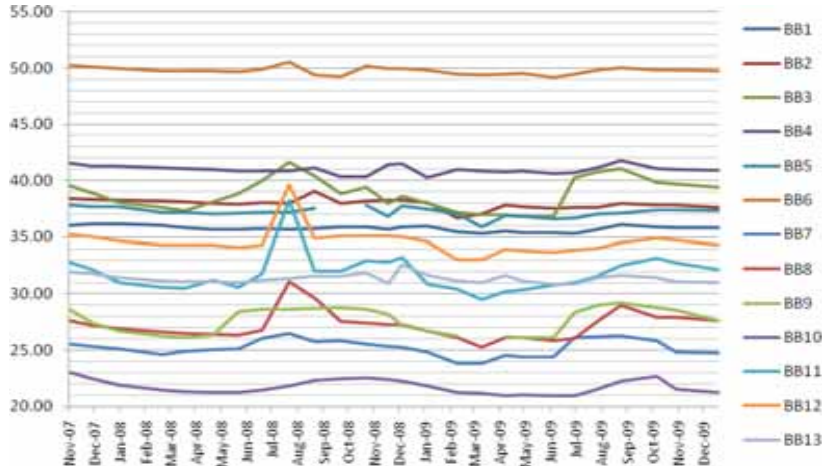

Figure 4.1 Bullsbrook Hydrograph

As shown in **Figure 4.1**, maximum groundwater levels were generally observed in October. The hydrograph indicates the water level in each of the bores followed a similar pattern, with seasonal lows around April and seasonal highs around October. The spike in groundwater levels in July 2008 was likely a result of significant rainfall falling in this month. This spike in groundwater level therefore potentially reflects surface water drainage and localised infiltration attributes rather than overarching regional groundwater levels.

Whilst events such as these are important considerations for future water management at the site they are not considered to be representative of actual groundwater contours. As such, annual average maximum groundwater levels (AAMGLs) have been generated using the October 2008 and October 2009 groundwater levels which have been referenced to DoW Bore 5422. Groundwater contours have been generated using these referenced AAMGLs (see **Figure 2**). These contours generally indicate a south westerly groundwater flow direction.

4.2 Groundwater Quality

Groundwater quality monitoring was usually conducted quarterly between November 2007 and October 2009 (8 occasions). A summary of the results is shown in **Table 4.2.1**. Complete results from each groundwater quality monitoring occasion are shown in **Appendix D**.

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Table 4.2.1 Summary of Groundwater *in situ* and Laboratory Analysis Results

	Guideline Values	BB1	BB2	BB3	BB4	BB5	BB6	BB7	BB8	BB9	BB10	BB11	BB12	BB13
Field Chemistry Parameters														
Temp (°C)	-	22.79 (1.50)	22.28 (1.04)	21.70 (1.30)	22.71 (1.46)	21.95 (1.39)	3.93 (1.75)	4.73 (2.40)	7.73 (1.02)	4.01 (2.02)	4.57 (1.70)	5.35 (1.50)	7.15 (0.98)	5.25 (0.87)
Salinity (mS/cm)	0.12-0.3	5.50 (2.17)	3.03 (0.65)	0.41 (0.27)	2.37 (0.57)	1.38 (0.08)	7.30 (0.42)	7.70 (7.93)	7.69 (1.81)	7.67 (0.36)	7.37 (0.62)	8.22 (0.95)	7.50 (0.41)	8.02 (2.66)
DO (%)	80-120	36.35 (12.36)	19.87 (6.11)	34.83 (17.72)	34.94 (14.18)	55.07 (11.46)	34.83 (18.76)	34.94 (9.20)	45.71 (13.83)	27.35 (7.77)	34.89 (14.87)	40.33 (14.75)	39.59 (15.35)	29.86 (14.46)
pH	6.5-8.0	5.40 (0.58)	5.68 (0.20)	4.99 (0.49)	6.00 (0.38)	5.75 (0.21)	11.68 (0.52)	10.43 (0.25)	11.79 (0.43)	11.77 (0.35)	10.26 (0.18)	12.90 (0.10)	10.80 (0.29)	11.28 (0.48)
Redox	-	46.13 (0.58)	105.13 (0.20)	181.75 (0.49)	58.50 (0.38)	143.50 (0.21)	30.60 (0.52)	11.89 (0.25)	31.88 (0.43)	19.66 (0.35)	32.43 (0.18)	15.34 (0.10)	30.08 (0.29)	28.15 (0.48)
Laboratory Analytes														
TN (µg/L)	1200	743 (808)	1,111 (434)	1,431 (1,561)	3,425 (1,509)	1,347 (792)	1,431 (1,654)	3,425 (6,100)	1,045 (831)	1,271 (4,312)	2,428 (359)	2,235 (1,161)	1,120 (339)	1,656 (580)
TP (µg/L)	65	192 (408)	105 (114)	1,079 (2,627)	2,005 (2,298)	229 (117)	1,079 (235)	2,005 (1,010)	210 (867)	592 (304)	1,542 (571)	1,107 (133)	338 (177)	908 (450)
Ortho-P (µg/L)	40	9.20 (6.22)	15 (18.53)	2.33 (0.58)	31.88 (28.13)	14.00 (16.42)	10.40 (16.35)	17.84 (8.50)	10.00 (20.74)	12.21 (5.45)	12.91 (10.71)	13.11 (6.28)	10.38 (17.53)	12.22 (19.04)
NH_4 (µg/L)	80	45.88 (29.47)	16.60 (12.01)	38.40 (11.57)	28.25 (16.24)	11.83 (5.78)	7.72 (14.07)	6.64 (29.71)	10.62 (29.80)	4.61 (29.89)	8.33 (26.81)	7.49 (630.60)	9.82 (17.30)	6.09 (12.83)
NO_2+NO_3 (µg/L)	150	191 (428)	1,015 (321)	673 (846)	2,243 (473)	857 (811)	117 (808)	452 (75)	178 (336)	166 (2,266)	191 (7.29)	407 (16.92)	177 (11.61)	223 (10.30)
TKN (µg/L)	-	628 (830)	466 (208)	1,120 (1,249)	1,314 (1,449)	780 (506)	188 (299)	263 (6,137)	235 (1,005)	95 (1,929)	231 (351)	258 (1,209)	216 (313)	148 (642)

Note: the above statistics are 'average'/'standard deviation'. Guideline values are the ANZECC trigger values for Lowland Rivers in South Western Australia.

As shown in **Table 4.2.1**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicates:

- 'Low' to 'moderate' TN concentrations.
- 'Moderate' to 'very high' TP concentrations.
- 'Low' Ortho P and NH_4 concentrations.
- 'Low' to 'very high' NO_x concentrations.
- Salinity values that exceed the guideline range.
- pH values within, below and above the guideline range.

Notably high average concentrations of TP were recorded at Bores BB3, BB6, BB7, BB10, BB11 and BB13. These 'very high' concentrations were generally accompanied with a relatively high standard deviation which indicates significant variability in TP concentrations. TN concentrations were generally moderate with no notable highs.

The spatial mapping of the average TN and TP concentrations is shown in **Figures 3** and **4** respectively. **Figure 3** indicates TN concentrations are generally 'moderate' throughout the study area. TP concentrations were generally 'very high' throughout the study area. Both TN and TP concentrations were lower around Bores BB1, BB2 and BB8.

4.3 Surface Water Quality

Surface water quality samples were taken from the locations shown in **Figure 3**. Surface water samples were aimed to be sampled on five occasions per winter over the 25 month monitoring period. During 2008, sampling locations were visited on six occasions in response to rainfall events. Samples were able to be taken on three of these six site visits. During 2009, sampling locations were visited on eight occasions in response to rainfall events. Samples were able to be taken on five of these eight site visits. At the end of the 25 month monitoring period, surface water from Nambad Brook and Bandy Creek had been sampled a total of eight times. **Table 4.3.1** shows the surface water results for Nambad Brook.

Table 4.3.1 Surface Water Quality Results for Nambad Brook

	Guideline Values	Jul-08	Aug-08	Aug-08	Jun-09	Aug-09	Sep-09	Sep-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	14.67	12.96	15.01	15.00	16.74	14.77	17.98	18.73
Salinity (mS/cm)	0.12-0.3	0.19	0.56	0.64	0.78	0.79	1.46	0.49	0.15
DO (%)	80-120	88.70	87.30	74.00	68.40	57.90	92.90	98.70	84.30
pH	6.5-8.0	7.26	6.93	7.36	7.67	6.98	6.98	7.01	7.00
Redox	-	202	177	122	115	140	124	104	127
Laboratory Analytes									
TN (µg/L)	1,200	1,100	530	760	1,800	700	800	400	500
TP (µg/L)	65	210	42	37	260	30	10	50	10
Ortho-P (µg/L)	40	8	4	5	140	<10	<10	20	<10
NH_4 (µg/L)	80	31	<3	18	200	40	40	110	30
NO_2+NO_3 (µg/L)	150	83	7	160	330	170	150	<10	50
TKN (µg/L)	-	1,000	500	600	-	500	600	400	400

As shown in **Table 4.3.1**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicates:

- 'Low' TN concentrations.
- 'Low' to 'moderate' TP concentrations.
- 'Low' to 'moderate' Ortho P concentrations.
- 'Low' to 'moderate' NO_x and NH_4 concentrations.
- Salinity values that generally exceed the guideline range.
- pH values within the guideline range.
- DO concentrations within or slightly below the guideline range.

Table 4.3.2 shows the surface water quality results for Bandy Spring.

Table 4.3.2 Surface Water Quality Results for Bandy Spring

	Guideline Values	Jul-08	Aug-08	Aug-08	Jun-09	Aug-09	Sep-09	Sep-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	14.36	18.18	17.25	16.56	17.40	14.33	17.13	19.58
Salinity (mS/cm)	0.12-0.3	0.31	0.48	1.72	0.17	0.41	0.59	1.25	0.49
DO (%)	80-120	89.3	105.3	114.8	69.8	68.9	92.4	92.5	98.5
pH	6.5-8.0	7.32	8.40	8.61	7.43	7.03	6.44	7.28	6.65
Redox	-	305	145	107	103	145	172	122	125
Laboratory Analytes									
TN (µg/L)	1,200	830	540	810	670	2,700	2,200	2,500	2,300
TP (µg/L)	65	110	25	25	150	570	390	480	520
Ortho-P (µg/L)	40	13	<2	5	92	470	380	420	240
NH_4 (µg/L)	80	17	13	18	44	60	50	60	30
NO_2+NO_3 (µg/L)	150	120	12	160	36	100	140	170	80
TKN (µg/L)	-	700	500	600	-	2,600	2,100	2,300	2,200

As shown in **Table 4.3.2**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicates:

- 'Low' to 'moderate' TN concentrations.
- 'Low' to 'high' TP concentrations.
- 'Low' to 'very high' Ortho P concentrations.
- 'Low' to 'moderate' NO_x concentrations.
- 'Low' NH_4 concentrations.
- Salinity values that generally exceed the guideline range.
- pH values that varied across the monitoring period.
- DO concentrations within or below the guideline range.

Analysis of the surface water quality data over the two winters indicates higher levels of nutrient concentrations were observed during July/ August. The flat plains of the Ellen Brook catchment are known to suffer mobilisation of nutrients and seasonal salinity (WRC, 2002). The nutrient concentration trends observed are likely the cause of mobilisation of nutrients in the early rainfall events. Salinity levels reached their peak in August/ September.

4.4 Surface Water Quantity

The data logger recorded four significant rainfall events from September 2008 to December 2009. For the recording period, the onsite rain gauge was used and a flow meter recorded data in Nambad Brook for the velocity and water level in 10 minute increments in the culvert on the western side of Great Northern Highway. The location of the data logger is shown in **Figure 3**.

Table 4.4.1 Recorded Monthly Rainfall and Runoff Data for Bullsbrook

Year	Month	Rainfall (mm)	Cumulative Rainfall per year (mm)	Runoff (GL)	Cumulative Runoff per year (GL)	Peak Discharge Flow Rate (m^3/s)
2008	Sep	5.47	5.47	0	0	0
	Oct	5.89	11.36	0	0	0
	Nov	3.71	15.07	0	0	0
	Dec	0.72	15.79	0	0	0
2009	Jan	0.92	0.92	0	0	0
	Feb	0.03	0.95	0	0	0
	Mar	0.33	1.28	0	0	0
	Apr	1.73	3.01	0	0	0
	May	6.24	9.25	0	0	0
	Jun	17.08	26.33	1.31	1.31	0.46
	Jul	22.6	48.93	119.07	120.38	0.77
	Aug	14.16	63.09	61.20	181.57	0.66
	Sep	7.32	70.41	36.63	218.2	0.88
	Oct	2.00	72.41	6.85	225.05	0.99
	Nov	5.14	77.55	0	225.05	0
	Dec	0	77.55	0	225.05	0

As shown in **Table 4.4.1**, rainfall was recorded each month over the monitoring period with the exception of December 2009. Runoff was recorded between June 2009 and October 2009 with flow velocities ranging between 0-3m/s and a cumulative total of 225GL of water flowing through the monitoring location. July recorded the greatest amount of runoff with 119GL observed during the month. This result was influenced by two significant rainfall events occurring within two days. The significant rainfall events recorded over the monitoring period are shown in **Table 4.4.2**

Table 4.4.2 Significant Rainfall Events

Date	Observed Duration (min)	Observed Total Rainfall (mm)	Corresponding Designed Rainfall Event	Observed Peak Discharge (m^3/s)
31/01/2009	30	8.6	1yr 30min	0
18/06/2009	30	6.0	1yr 30min	0
19/07/2009	1270	53.7	2yr 1440min	0.77
20/07/2009	2410	54.8	1yr 2880min	0.54

As shown in **Table 4.4.2**, the event with the highest peak discharge occurred on the 19th July 2008. This event saw 53.7mm fall in approximately 21 hours. The hourly rainfall for the significant rainfall events in July and the average discharge rates in response to these events are shown in **Figure 4.4**.

The discharge and rainfall for the two significant rainfall events in July presented in **Figure 4.4** can be used for the calibration of future hydrological models.

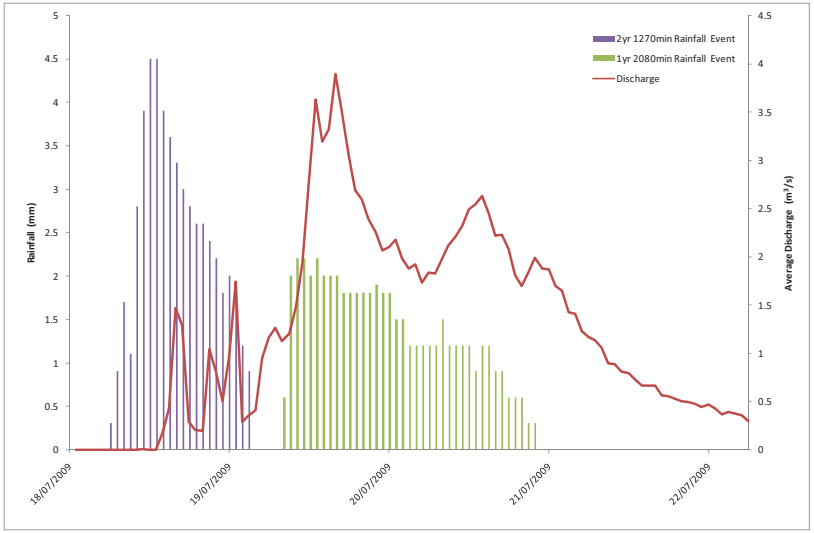


Figure 4.4 Average Discharge and Hourly Rainfall for Significant Rainfall Events in July 2009

5 Conclusions and Recommendations

This SAP was able to capture groundwater levels and groundwater quality from November 2007 to December 2009, and surface water quality and flow volumes over the same period. Thirteen groundwater bores and a Hach Sigma Flow Meter and rainfall collection station were installed within the study area.

Groundwater levels were measured on a monthly basis for 25 months on all installed bores. Groundwater may intersect with the surface at some locations during the annual peak (usually October). If they are proposed to be developed, these areas may require fill or other methods to achieve appropriate separation to groundwater prior to development. Furthermore, it should be noted that some sections of the study area are prone to localised flooding, generally to the west of the Great northern Highway.

Groundwater quality sampling for nutrient concentrations was usually conducted on a quarterly basis over 25 months (8 occasions). Nutrient concentrations in groundwater varied both spatially within the study area and temporally over the duration of the monitoring period. There were occasions over the monitoring period when nutrient concentrations were in excess of the default trigger values (i.e. those given for surface water quality). Overall, the main concern in regard to groundwater quality within the study area relates to TP and NO_x concentrations. The data presented in this report suggests the concentrations observed are a characteristic of regional nutrient concentrations rather than site specific/ introduced nutrient levels.

The surface water quantity data has captured four clearly defined significant rainfall events which can be used for the calibration of future hydrological models. Surface water quality samples were taken from Nambad Brook and Bandy Creek in response to rainfall events. Surface water samples were taken on eight occasions over the monitoring period and provide baseline data for future comparison.

This report concludes the scope of work in regards to hydrological monitoring of the study area. No inherent errors or deficiencies have been identified and the data presented within is robust and comprehensive enough to facilitate

This report concludes the scope of work with regards to the hydrological monitoring of the study area. As no inherent deficiencies have been identified, the monitoring parameters and methodology are considered to have been adequate to have achieved the aims of the pre-development hydrological investigation and as such, Cardno is of the opinion that the current dataset is robust and comprehensive enough to assist in future planning of the proposed development.

6 References

Australian and New Zealand Environment and Conservation Council (ANZECC), 2000, *National Water Quality Management Strategy,* Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Department of Environment (DOE), 2001, *Development of Sampling and Analysis Programs*, State Government of Western Australia, Perth.

Department of Water (DOW), 2007, *Stormwater Management Manual for Western Australia*, State Government of Western Australia, Perth.

Department of Water (DOW), 2008, *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions*, DOW, Perth.

Waters and Rivers Commission (WRC), 2002. *Hydrogeological Information for Management Planning in the Ellen Brook Catchment.* Waters and Rivers Commission: Perth.

Western Australian Planning Commission (WAPC), 2003, *North East Corridor Extension Strategy (NECES)*. Final Government of Western Australia.

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

Figures

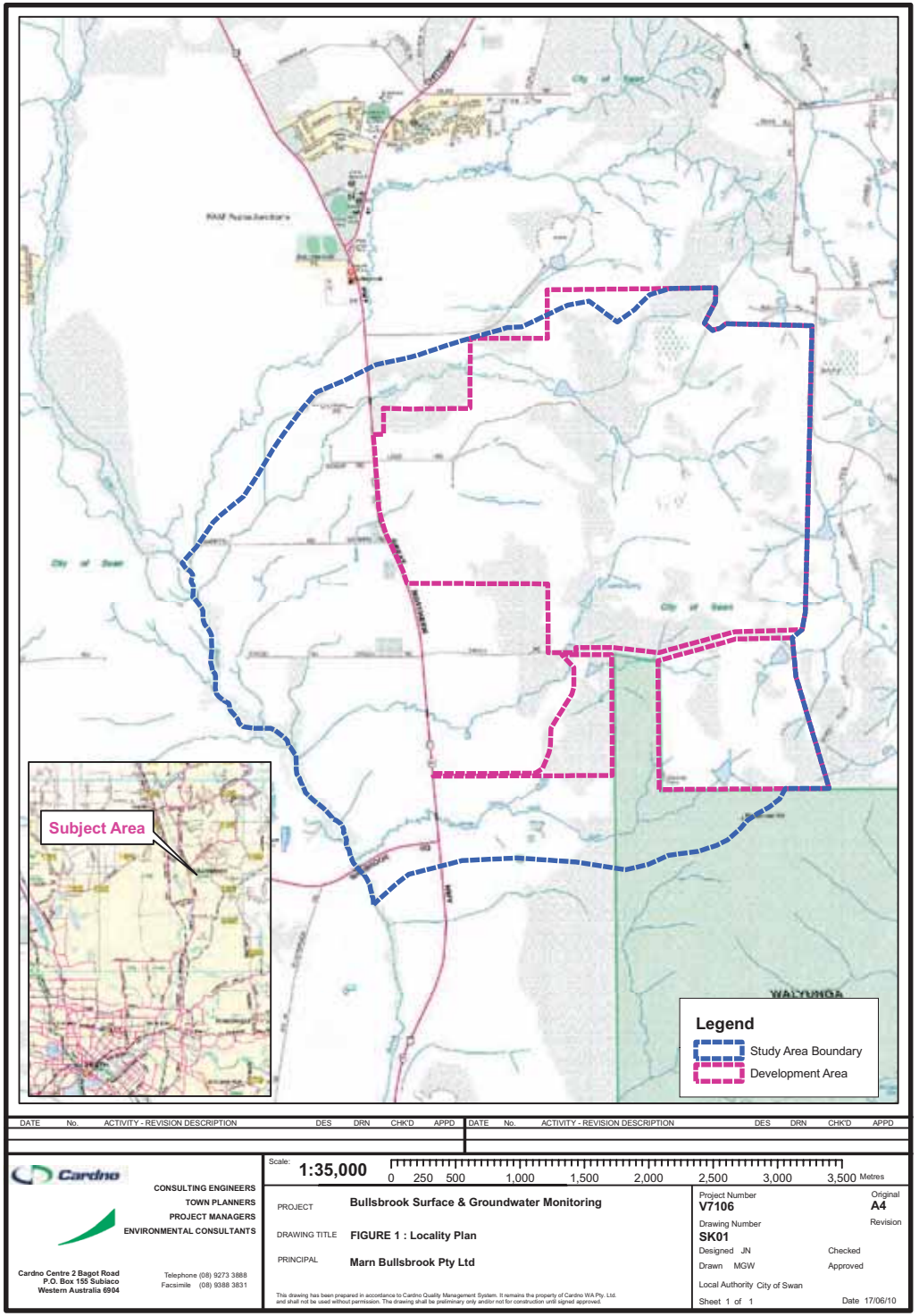
Figure 1 Locality Plan

Figure 2 Groundwater Bore locations and Referenced AAMGL Contours

Figure 3 Surface Water Features

Figure 4 TN Mapping

Figure 5 TP Mapping



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

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

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Scale: 1:35,000

0 250 500 1,000 1,500 2,000 2,500 3,000 3,500 Metres

PROJECT: Bullsbrook Surface & Groundwater Monitoring

DRAWING TITLE: FIGURE 1 : Locality Plan

PRINCIPAL: Marn Bullsbrook Pty Ltd

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Project Number: V7106

Original: A4

Drawing Number: SK01

Revision:

Designed: JN

Checked:

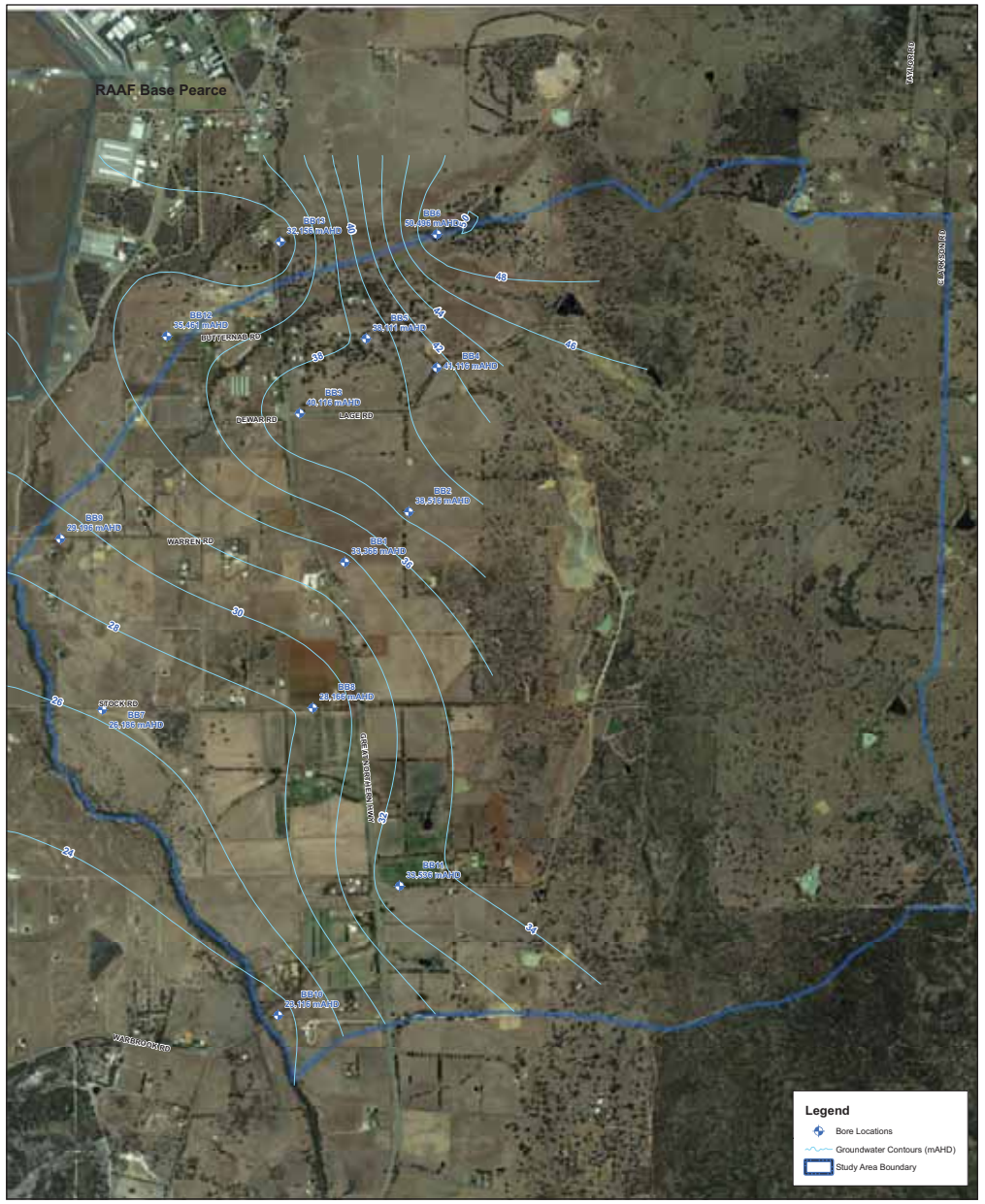
Drawn: MGW

Approved:

Local Authority: City of Swan

Sheet: 1 of 1

Date: 17/06/10



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Scale: 1:18,000

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

PROJECT **Bullsbrook Surface & Groundwater Monitoring**

DRAWING TITLE **FIGURE 2: Groundwater Bore Locations & AAMGL Contours**

PRINCIPAL **Marn Bullsbrook Pty Ltd**

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Project Number **V7106**

Original **A3**

Drawing Number **SK02**

Revision **00**

Designed JN

Checked

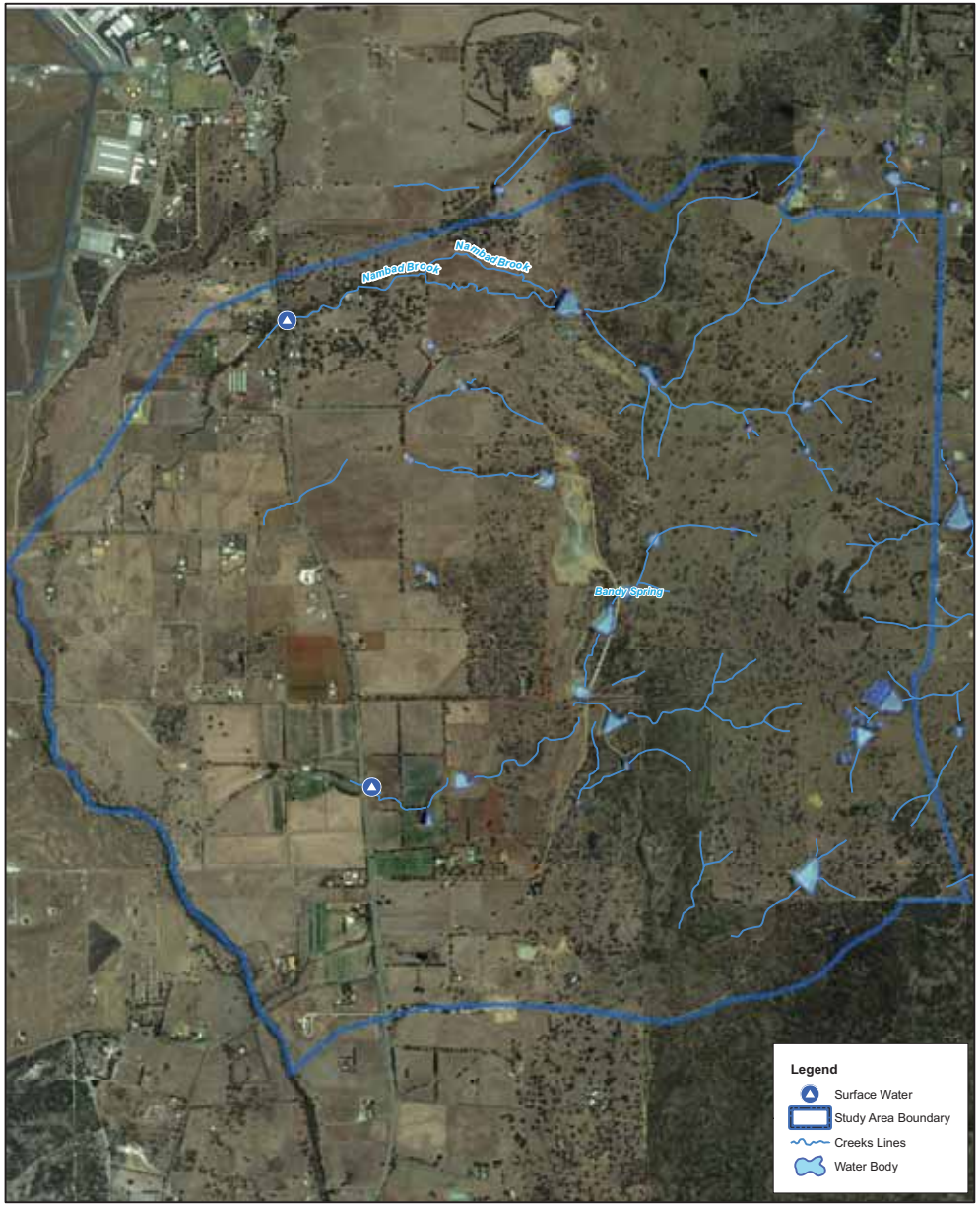
Drawn MGW

Approved

Local Authority City of Swan

Sheet 1 of 1

Date 17/06/10



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

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

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Scale: 1:26,000

0 250 500 1,000 1,500 2,000 2,500 Meters

PROJECT: Bullsbrook Surface & Groundwater Monitoring

DRAWING TITLE: FIGURE 2 :Surface Water Features & Surface Water Sampling Locations

PRINCIPAL: Marn Bullsbrook Pty Ltd

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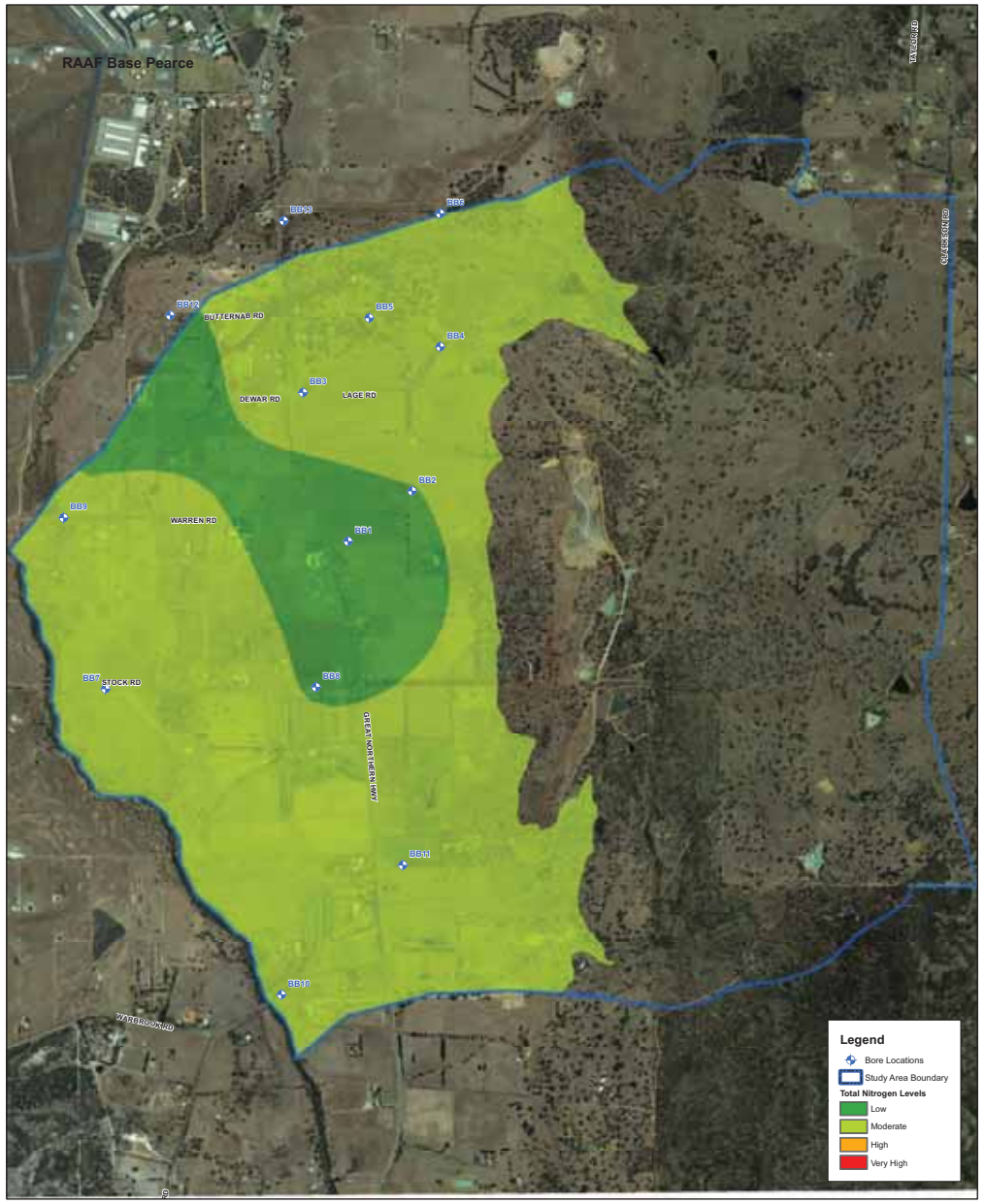
Project Number: V7106
Original: A4
Drawing Number: SK03
Revision: 00
Designed: JN
Checked:
Drawn: MGW
Approved:
Local Authority: City of Swan
Sheet: 1 of 1
Date: 17/06/10



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

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

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Scale: 1:18,000

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

PROJECT **Bullsbrook Surface & Groundwater Monitoring**

DRAWING TITLE **FIGURE 4: Total Nitrogen Mapping**

PRINCIPAL **Marn Bullsbrook Pty Ltd**

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Project Number **V7106**

Original **A3**

Drawing Number **SK04**

Revision **00**

Designed JN

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Local Authority City of Swan

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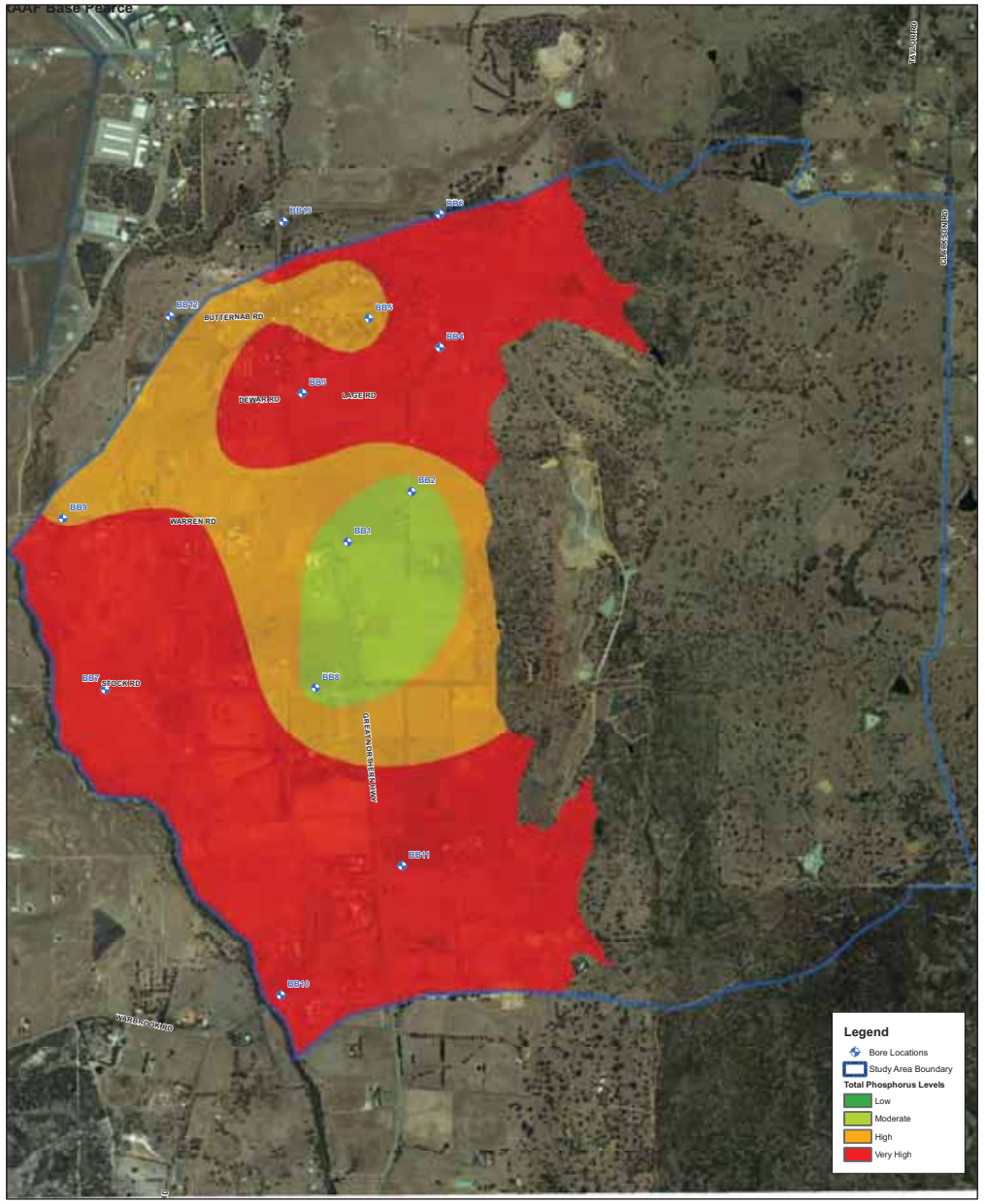
Date 17/06/10



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

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

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Scale: 1:18,000

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

PROJECT: **Bullsbrook Surface & Groundwater Monitoring**

DRAWING TITLE: **FIGURE 5: Total Phosphorus Mapping**

PRINCIPAL: **Marn Bullsbrook Pty Ltd**

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Project Number: **V7106**

Original: **A3**

Drawing Number: **SK05**

Revision: **00**

Designed JN

Checked

Drawn MGW

Approved

Local Authority City of Swan

Sheet 1 of 1

Date 17/06/10

Appendix A

Bore Logs

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7060
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	23/10/07

Bore Name:	BB1	**Total Depth:**	14.00	m
Bore Location:	0408633 / 6493325	**RL Top of Casing:**	41.21	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	40.52	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)		Soil Profile Description & Comments					Construction Details				
		Texture	Colour	Particle Size	Comments / Observations	Moisture content	Groundwater Depth	Graphic Log		Screen & Casing	
0.00											
	0.50	Sandy Clay	Dark Brown	Even & Fine	Plastic and grainy	Damp					
	1.00		Lighter Brown								
	2.00		Brown to Orange		Laterite & Quartz inclusions appear.	Starting Dry out					
	2.50				Same parent material but appearing drier.	Dry					
	3.00				Slight change in colour as moisture	Damp					
	3.50	Sandy Clay			increases.						
	4.00										
	4.50		Mix of Greys & Browns		Presenting as Sandy Clay (drill encountered hardened layer)						
5.00					Compacted and hardened layer, iron cemented Sands						
	5.50					Very Dry					
	6.00										
	6.50										
	7.00	Sandy Clay	Orange & Brown		Lightly cemented Sandy Clay						
	7.50			Even							
	8.00										
	8.50	Clayey Sand				Moist					
	9.00			Medium	Sand becoming larger in granule size						
	9.50										
10.0											
	10.5										
	11.0										
	11.5	Clayey Sand	Greys		Larger granule size, quartz grains appearing						
	12.0										
	12.5				Greater percentage of fines	Saturated	12.1m				
	13.0	Sandy Clay	Greys & Whites		Borderline of Clay & Sand, back to Sandy Clay						
	13.5										
	14.0				End of casing and bore						
	14.5										
15.0											

Notes: Bore is near entrance of gate, approximately 150m east of Great Northern Hwy, near tree along fenceline.

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	23/10/07

Bore Name:	BB2	**Total Depth:**	22.50	m
Bore Location:	0408965 / 6493586	**RL Top of Casing:**	54.33	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	53.55	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)		Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00		Sandy Gravel	Dark Brown	Fine	Slope wash, silt with colluvium,	Damp
					Just appearing Clay, high level humas	
			Dark Brown	Uneven		Dry
	2.50	Gravelly Clay	Lighter Brown		Quartz / laterite clasps to 10mm	
		Sandy Clay	Yellow to Light Brown		More even consisitancy with scattered	Dry
					to 20mm	
5.00						
		Sandy Clay			Greater percentage of gravels than above	
		Grey Clay	Grey		Hard level layer, cemented	Moist
	7.50	Brown			Cemented Clay, colour change	Moist
		Clay				
10.0		Sandy Clay	Red		Hardened cemented Layer	Dry
	12.5					
15.0						
	17.5			Unifiorm & Even		Sticky
		Sandy Clay	Red		Lighter colour change, still red, oxide appearance	
20.0						
	22.5				End of casing and bore	
25.0						

Notes: Bore location along boundary fenceline, north of tree, Euc citrodora. Great Northern Hwy 500m to West.

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	23/10/07

Bore Name:	BB3	**Total Depth:**	8.50	m
Bore Location:	0408398 / 6494099	**RL Top of Casing:**	42.35	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	41.60	mAHD
Drilling Method:	Auger	**Logged by:**	David Coremans	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)		Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00		Gravel Sand	Brown	Medium	Uneven, organic material high	Dry
	0.50	Clayey Sand	Orange	Medium	Some gravel clasps appearing,	Dry
	1.00				more even	
	1.50	Sandy Clay	Red Brown	Medium	Even consistancy	Dry
	2.00					
	2.50					
	3.00	Clayey Sand	Red Brown	Fine	Small grained, some plasticity,	
	3.50				well sorted.	
	4.00					
	4.50					
5.00		Clayey Sand	Light Grey	Fine	Clay inclusions, soft, well sorted.	Dry
	5.50					
	6.00	Clayey Sand	Dark Red brown		Quartz Sand	Moist
	6.50					
	7.00					
	7.50					
	8.00					
	8.50				**End of casing and bore**	
	9.00	Clayey Sand	Light to White		Clay percentage increasing.	Moist
	9.50					
10.0						
	10.5					
	11.0	Clayey Sand	White Grey	Fine	Quartz Sand, even, plastic Clay between	Saturated
	11.5					
	12.0					
	12.5	Sandy Clay	White Grey	Fine	Kalinite Clay, poor structure.	Saturated

Notes: Near corner of Large Rd & Great Northern Hwy just inside Farmers paddock. North East of intersection 20m in.

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	24/10/07

Bore Name:	BB4	**Total Depth:**	28.00	m
Bore Location:	0409112 / 6494337	**RL Top of Casing:**	64.78	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	63.97	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)		Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00		Gravelly Clay	Light Brown	Course	Laterite intrusions to 15mm	Dry
	1.00	Gravelly Clay	Darker Brown	Fine to Medium	High percentage of Fines	Dry
	2.00	Clayey Sand	Dark Orange	Fine	Very Fine Silt material.	
	3.00		Orange Red	Fine		Dry
	4.00					
5.00		Sandy Clay	Orange Red	Even	Cemented layer, slight moisture increase	
	6.00					
	7.00					
	8.00	Sandy Clay	Orange Red	Uneven	Scatterings of lateritic gravel to 15mm	Dry
	9.00					
10.0						
	11.0					
	12.0	Sandy Clay	Red Brown		Quartz inclusions to 40mm	Dry
	13.0					
	14.0					
15.0						
	16.0					
	17.0					
	18.0	Clayey Sand	Brown	Medium	Clay at approximately 30%	Moist
	19.0					
20.0						
	21.0					
	22.0					
	23.0					
	24.0					
25.0						
	26.0					
	27.0					
	28.0				End of casing and bore	
	29.0					
30.0						

Groundwater Depth: 22.5m

Notes: Just inside farm gate along access track at Humpreys Farm, under P radiata tree, approx 40m south of dam.

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	25/10/07

Bore Name:	BB5	**Total Depth:**	13.00	m
Bore Location:	0408743 / 6494487	**RL Top of Casing:**	49.24	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	48.56	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)		Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00		Sand	Light Brown	Fine	Even consistancy	Moist
	0.50					
	1.00				Quartz appearing, fine.	
	1.50					
	2.00	Sand			Fine and Medium grained sand.	Moist
	2.50					
	3.00	Clayey Sand	Light Brown	Even	Clay appearing, less than 10%	Moist
	3.50					
	4.00	Gravelly Sand			Uneven, gravel clasts to 20mm	Moist
	4.50		Red Brown			
5.00		Clayey Sand	Red Brown		Becoming more consistant, drying out	Dry
	5.50					
	6.00					
	6.50	Sandy Clay	Brown	Fine	High proportion of fines	Dry
	7.00					
	7.50					
	8.00	Sandy Clay	Brown	Fine	Even, becoming sticky	
	8.50					
	9.00					
	9.50					
10.0		Sandy Clay	Lighter Brown			Moist
	10.5					
	11.0					
	11.5					
	12.0					
	12.5	Sandy Clay	Light Brown	Medium	Even consistancy	Saturated
	13.0				End of casing and bore	
	13.5					
	14.0					
	14.5					
15.0						

Groundwater Depth: 11.3m

Notes: Bore in paddock, just off firebreak approx 10m from the south boundary fencline of R Brennen (Opp House)

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	25/10/07

Bore Name:	BB6	**Total Depth:**	12.00	m
Bore Location:	0409112 / 6495030	**RL Top of Casing:**	56.33	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	55.62	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Soil Profile Description & Comments | **Construction Details**

Depth (mBGL)		Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00						
	0.50	Sandy Gravel	Grey	Medium	Laterite stones to 15mm	Dry
	1.00				Uneven	
	1.50					
	2.00	Sandy Clay	Light Brown	Uneven	Laterite stones to 10mm	Dry
	2.50	Sandy Clay	Yellow to Orar	Uneven	No laterite, higher percentage of fines	Dry
	3.00					
	3.50					
	4.00					
	4.50		Yellow to Orange		Small clusters of sand clay podsols	
5.00						
	5.50	Sandy Clay	Red		Dramatic colour change	Moist
	6.00					
	6.50					
	7.00					
	7.50					
	8.00	Clayey Sand	Brown	Even	Sticky, auger material clinging together	Moist
	8.50					
	9.00					
	9.50					
10.0		Clayey Sand	Lighter Brown		Slightly higher percentage clay	Moist
	10.5					
	11.0					
	11.5					
	12.0				End of casing and bore	
	12.5	Clayey Sand	Brown to Yellow		Very sticky, even	Saturated
	13.0					
	13.5					
	14.0					
	14.5					
15.0						

Construction Details: Groundwater Depth: 11m; Graphic Log; Screen & Casing

Notes: Top SW corner of Humpheys paddock north of fenced off tree reserve

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen; Casing; Gravel Pack; Concrete; Bentonite; Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	01/11/07

Bore Name:	BB7	**Total Depth:**	4.50	m
Bore Location:	0407372 / 6492558	**RL Top of Casing:**	27.17	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	26.51	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Soil Profile Description & Comments | **Construction Details**

Depth (mBGL)		Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00		Sand	Grey	Course	Recent waterlogging during winter	Wet
	0.2					
	0.4				Little or no Clay	
	0.6					
	0.8					
1.00						
	1.2					
	1.4					
	1.6					
	1.8					
2.00		Sandy Clay	Grey	Course	Even consistancy	Wet
	2.2					
	2.4					
	2.6					
	2.8					
3.00		Sandy Clay	Light Brown	Medium	Increase in percentage of Clay	Saturated
	3.2					
	3.4					
	3.6					
	3.8					
4.00		Sandy Clay	Darker Brown		Percentage Clay reduced, dark Sand	Saturated
	4.2					
	4.4					
	4.6				4.5m End of casing and bore	
	4.8					
5.00						
	5.2					
	5.4					
	5.6					
	5.8					
6.00						

Construction Details: Groundwater Depth: 2.5m; Graphic Log; Screen & Casing

Notes:

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen; Casing; Gravel Pack; Concrete; Bentonite; Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	01/11/07

Bore Name:	BB8	**Total Depth:**	9.00	m
Bore Location:	0408466 / 6492567	**RL Top of Casing:**	32.20	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	31.41	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)	Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00	Sandy Loam	Dark Brown	Course	High organic levels, laterite intrusions	Moist
0.50					
1.00	Sandy Loam	Dark Brown	Medium	Clay lumps appearing, laterite gravels 10mm max	
1.50		Light Brown		Quartz and laterite to 40mm	Moist
2.00		Yellow			
2.50	Sandy Clay	Light Brown		No moisture change, appears more Even	
3.00	Sandy Gravel	Cream	Medium	Cemented and weathered , drying out, laterite to 20mm	
3.50					Dry
4.00	Sandy Gravel	Cream	Medium	Laterite intrusions to 20mm, more Even and consistant	
4.50	Sandy Clay	Brown		Clay appearingsand starting to bind	
5.00				More even consistancy	Moist
5.50					
6.00					
6.50					
7.00	Sandy Clay	Brown	Medium	Change in colour, Clay appearing in higher percent	
7.50	Clayey Sand	Dark Brown		Even consistancy	Saturated
8.00					
8.50					
9.00	Sandy Clay	Green	Medium	End of casing and bore	Saturated
9.50					
10.0					
10.5					
11.0					
11.5					
12.0					
12.5					
13.0					
13.5					
14.0					
14.5					
15.0					

Construction Details: Groundwater Depth (7m); Graphic Log; Screen & Casing

Notes: Bore on Stock Rd 300m West of Grt Northern Hwy, near Euc Wandoo along side grapevines

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	01/11/07

Bore Name:	BB9	**Total Depth:**	4.00	m
Bore Location:	0407153 / 6493447	**RL Top of Casing:**	30.38	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	29.63	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)	Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00	Sand	Brown	Medium	Topsoil, high level humas	Moist
0.20					
0.40					
0.60					
0.80					
1.00					
1.20					
1.40					
1.60	Sand	Yellow	Course	Fairly even consistancy	Moist
1.80					
2.00	Sandy Clay	Yellow	Course	Clay appearing, laterite in pebble form to 20mm	
2.20				becoming saturated	
2.40					
2.60					
2.80					
3.00				More uneven in consistancy	
3.20					
3.40					Saturated
3.60	Clayey Sand	Brown	Medium	More even consistancy, binded, plastic	
3.80					
4.00				End of casing and bore	
4.2					
4.4					
4.6					
4.8					
5.00					

Construction Details: Groundwater Depth (2.3m); Graphic Log; Screen & Casing

Notes: Bore to the North of Gate 177 Wilkes on Warrend Rd, Near fenceline before RAAF

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	01/11/07

Bore Name:	BB10	**Total Depth:**	7.00	m
Bore Location:	0408286 / 6490968	**RL Top of Casing:**	25.86	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	25.13	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)	Texture	Colour	Particle Size	Comments / Observations	Moisture content	Groundwater Depth	Graphic Log	Screen & Casing
0.00	Sand	Yellow	Course	Even consistancy	Moist			
1.00	Sandy Clay	Brown	Course	Laterite intrusions to 10mm				
1.50				Traces of yellow sand				
2.00				Laterite intrusions to 20mm				
3.50	Sandy Clay	Green	Medium	Hardened layer of sand mixed with				
4.00				laterite pebbles	Saturated			
5.00	Sandy Clay		Medium	Even consistancy	Saturated	4.8m		
7.00				End of casing and bore				

Notes: Bore located on North side Warbrook Rd, 50m East of Gate 22 DeLamarie Park, in Rd Reserve

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	01/11/07

Bore Name:	BB11	**Total Depth:**	13.50	m
Bore Location:	0408917 / 6491641	**RL Top of Casing:**	43.30	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	42.44	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)	Texture	Colour	Particle Size	Comments / Observations	Moisture content	Groundwater Depth	Graphic Log	Screen & Casing
0.00	Gravelly Sand		Uneven	Laterite to 60mm	Dry			
0.50		Brown Yellow		Laterite Gravel over 50%				
1.00			Course					
1.50	Gravel Sand	Brown Yellow		Laterite pebbles more even in size, to 10mm				
2.50	Sandy Gravel	Light Brown	Medium	Laterite pebbles becoming smaller	Dry			
5.00	Sandy Gravel	Light Brown		Even consistancy	Dry			
6.00	Sand	Red	Medium	Appears to be consistant, mineral	Dry			
7.00	Sand	Red	Medium	Laterite intrusions to 15-20mm	Dry			
7.50		Red		Hardened cemented layer				
8.00				Grey clay clumps appearing				
10.5	Sandy Clay	Red	Course	Laterite intrusions to 30mm	Moist			
12.5	Sandy Clay	White	Medium	Thick and sticky, clay % increase	Saturated	12m		
13.5				End of casing and bore				

Notes: North side of Midland Brick private access Rd, approximately 100m East of Grt Northern Hwy

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen
Casing
Gravel Pack
Concrete
Bentonite
Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	01/11/07

Bore Name:	BB12	**Total Depth:**	9.00	m
Bore Location:	0407708 / 6494500	**RL Top of Casing:**	40.23	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	39.59	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)	Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00	Sandy Clay	Light Brown	Medium	Uneven consistancy and low percentage	Dry
0.50		to Yellow		clay content	
3.00	Sandy Clay	Dark Brown	Fine		Dry
4.50					Moist
5.00	Sandy Clay	Dark Brown	Fine	Greater percentage of clay, moisture increase	
6.00	Sandy Clay	Grey	Fine	More even consistancy	Moist
8.00	Sandy Clay	White	Course	Very even consistancy, sand base	Saturated
9.00				End of casing and bore	

Construction Details: Groundwater Depth — 7.8m; Graphic Log; Screen & Casing

Notes: End of Butternab Rd, within Rd Reserve, in North corner 5m North of gate. Large Old Euc Wandoo to West of bore

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen, Casing, Gravel Pack, Concrete, Bentonite, Fill Sand

GW Bore Soil & Construction Log

Project:	Bullsbrook Groundwater Monitoring	**Job No.:**	V7106
Client:	Marlin Bullsbrook Pty Ltd	**Date:**	02/11/07

Bore Name:	BB13	**Total Depth:**	16.50	m
Bore Location:	0408298 / 6494992	**RL Top of Casing:**	46.53	mAHD
Datum:	PCG 94/AHD	**RL Natural Surface:**	45.76	mAHD
Drilling Method:	Auger	**Logged by:**	Ian Gale	
Bore Diameter:	50mm	**Well Diameter:**	50	mm

Depth (mBGL)	Texture	Colour	Particle Size	Comments / Observations	Moisture content
0.00	Sand	Grey	Fine	Topsoil, past grazing and arable land	Dry
1.00	Sandy Clay	Brown	Fine		Dry
2.00	Sandy Clay	Brown	Medium	Slight intrusion of lateritic pebbles	Dry
3.00		Yellow	Medium	Greater percentage of fines, sand conglomerates	
3.50				cemented	Dry
4.50	Sandy Gravel	Yellow	Fine	Greater percentage of fines	
5.00				Quartz make up over 50% of sample	
5.50				Up to 50mm in size	
6.00	Sandy Clay	Red		Cemented layer. Quartz to 30mm	Dry
7.00	Sandy Clay	Red		Clumps of clay appearing, even consistancy	
10.0	Sandy Clay	red	Fine	Quartz no longer evident	Dry
12.5	Sandy Clay	White	Course	Even consistancy and sticky	Moist
15.5					Saturated
16.0	Sandy Clay	White	Course	Sticky sand material of even consistancy	
16.5				End of casing and bore	

Construction Details: Groundwater Depth — 12.5m; Graphic Log; Screen & Casing

Notes: North Western corner of R Brennans property, just East of Grt Northern Hwy, access from Hwy.

Texture: Sand, Sandy Loam, Clayey Sand, Silt, Loam, Sandy Loam, Clay Loam, Clay, Sandy Clay
Particle Size: Fine, Medium, Coarse
Colour: Dark, Medium, Light + Colour, Mottled
Structure: Density (Firm, Soft, Cemented); Sorted (Well, Moderately, Poorly), Clay Plasticity
Organic Content: None (N), Low (L), Medium (M), High (H)

Screen, Casing, Gravel Pack, Concrete, Bentonite, Fill Sand

Appendix B

Laboratory Certificates of Analysis and Chain of Custody Forms

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: David Coremans
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 7/12/2007
Date Received: 13/11/2007
Our Reference: CAR07-26
Your Reference: V7106



METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			07112201			07150502A	
BB1	9/11/2007	41	<2	2	49	280	300
BB2	9/11/2007	20	4	680	24	770	<200
BB3	9/11/2007	48	<2	69	26	170	<200
BB4	9/11/2007	42	13	2000	3400	2800	900
BB5	9/11/2007	6	3	84	67	290	200
BB6	9/11/2007	31	3	12	120	830	800
BB7	9/11/2007	84	3	240	200	2000	1800
BB8	9/11/2007	41	5	58	350	1000	1000
BB9	9/11/2007	38	6	1800	150	2500	800
BB10	9/11/2007	71	3	<2	580	490	500
BB11	9/11/2007	31	3	3	70	100	<200
BB12	9/11/2007	44	3	28	57	230	200
BB13	9/11/2007	35	6	4	900	390	400
QA1	9/11/2007	38	6	53	340	900	800

Signatory:
Date: 7/12/07

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM

From: Cardno BSD 2 Bagot Road SUBIACO WA 6008 Phone: (08) 9273 3888 Fax: (08) 9388 3831 Email: david.coremans@cardno.com.au	Order No: TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)	To: Marin and Freshwater Research Laboratories Murdoch University Phone: (08) 9360 2907 Fax: ( )
Project Manager: David Coremans Contact: David Coremans	Job Location/Name: Bullsbrook SAP Job Number: V7106	Contact: Sample Collection Date: 9/11/07

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	TKN	Ortho-P	NH4	NO2 + N03	
1	BB1		x	x				2	x	x	x	x	x	x	Unfiltered
2	BB2		x	x				2	x	x	x	x	x	x	Unfiltered
3	BB3		x	x				2	x	x	x	x	x	x	Unfiltered
4	BB4		x	x				2	x	x	x	x	x	x	Unfiltered
5	BB5		x	x				2	x	x	x	x	x	x	Unfiltered
6	BB6		x	x				2	x	x	x	x	x	x	Unfiltered
7	BB7		x	x				2	x	x	x	x	x	x	Unfiltered
8	BB8		x	x				2	x	x	x	x	x	x	Unfiltered
9	BB9		x	x				2	x	x	x	x	x	x	Unfiltered
10	BB10		x	x				2	x	x	x	x	x	x	Unfiltered
11	BB11		x	x				2	x	x	x	x	x	x	Unfiltered
12	BB12		x	x				2	x	x	x	x	x	x	Unfiltered
13	BB13		x	x				2	x	x	x	x	x	x	Unfiltered
14	QA1		x	x				2	x	x	x	x	x	x	Unfiltered

Relinquished by :	Date : 12/11/07 Time : 2:45	Received by Linda + Likong	Date : Time : 12/11/07	Condition:
Signature :				

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

17/10/2007 04:19 61893606513 MAFRL PAGE 01

Marine and Freshwater Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

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Accreditation Number: 10603
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Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

RECEIVED
Cardno
Subiaco Office 07 APR 2008
SIGNED
FILE

WATER QUALITY DATA

Contact: Ian Gale
Customer: Cardno BSD
Address: 2 Bagot Road Subiaco, WA 6008

Date of Issue: 28/03/2008
Date Received: 29/02/2008
Our Reference: CAR08-2
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			08031301-08031801			08031102	
BB1	29/02/2008	88	5	12	17	330	300
BB2	29/02/2008	7	9	980	75	1200	<200
BB3	29/02/2008	49	2	11	200	830	800
BB4	29/02/2008	53	21	2400	7000	6900	4500
BB5	29/02/2008	4	5	470	320	1800	1300
BB6	29/02/2008	74	4	26	160	590	600
BB7	29/02/2008	14	11	150	360	2200	2000
BB8	29/02/2008	100	15	32	490	2500	2400
BB10	29/02/2008	60	4	<2	900	820	800
BB11	29/02/2008	32	3	4	330	2200	2200
BB13	29/02/2008	11	11	<2	800	1800	1800
QA1	29/02/2008	47	8	12	240	870	900
BB12	29/02/2008	22	4	3	150	390	400

Signatory: [signature]
Date: 28/3/08

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

CHAIN OF CUSTODY FORM

From: Cardno BSD 2 Bagot Road SUBIACO WA 6008 Phone: (08) 9273 3888 Fax: (08) 9388 3831 Email: david.coremans@cardno.com.au	Order No: TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)	To: Marin and Freshwater Research Laboratories Murdoch University Phone: (08) 9360 2907 Fax: ()
Project Manager: David Coremans Contact: ~~David Coremans~~ IAN GALE	Job Location/Name: Bullsbrook SAP Job Number: V7106	Contact: Ian Gale Sample Collection Date: 29/02/2008

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	TKN	Ortho-P	NH4	NO2 + N03	
1	BB1		x	x				2	x	x	x	x	x	x	Unfiltered
2	BB2		x	x				2	x	x	x	x	x	x	Unfiltered
3	BB3		x	x				2	x	x	x	x	x	x	Unfiltered
4	BB4		x	x				2	x	x	x	x	x	x	Unfiltered
5	BB5		x	x				2	x	x	x	x	x	x	Unfiltered
6	BB6		x	x				2	x	x	x	x	x	x	Unfiltered
7	BB7		x	x				2	x	x	x	x	x	x	Unfiltered
8	BB8		x	x				2	x	x	x	x	x	x	Unfiltered
9	~~BB9~~		x	x				2	x	x	x	x	x	x	Unfiltered
10	BB10		x	x				2	x	x	x	x	x	x	Unfiltered
11	BB11		x	x				2	x	x	x	x	x	x	Unfiltered
12	BB12		x	x				2	x	x	x	x	x	x	Unfiltered
13	BB13		x	x				2	x	x	x	x	x	x	Unfiltered
14	QA1		x	x				2	x	x	x	x	x	x	Unfiltered

FAXED

Relinquished by :	Date : Time :	Received by MAFRL	Date : 29/2 Time : 3pm Condition: cold Signature :

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Ian Gale
Customer: Cardno BSD
Address: 2 Bagot Rd, Subiaco, WA 6008

Date of Issue: 25/07/2008
Date Received: 30/05/2008
Our Reference: CAR08-7
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			08060901a-08072202			08070801a-08071602	
BB1	30/05/2008	88	6	120	28	440	300
BB2	30/05/2008	35	<2	580	97	920	300
BB3	30/05/2008	25	<2	280	21	400	<200
BB4	30/05/2008	15	11	2600	1900	3600	900
BB5	30/05/2008	17	4	330	210	1000	700
BB6	30/05/2008	57	4	12	150	660	600
BB7	30/05/2008	18	13	91	250	1000	900
BB8	30/05/2008	23	15	10	470	1500	1500
BB9	30/05/2008	77	11	6200	480	12000	5300
BB10	30/05/2008	100	3	6	1500	1100	1100
BB11	30/05/2008	1600	5	14	340	2800	2800
BB12	30/05/2008	65	3	22	80	560	500
BB13	30/05/2008	12	9	5	1500	530	500
QA1	30/05/2008	32	15	8	640	560	600

Signatory:
Date: 25/7/08

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM

From: Cardno BSD 2 Bagot Road SUBIACO WA 6008 Phone: (08) 9273 3888 Fax: (08) 9388 3831 Email: ian.gale@cardno.com.au	Order No: TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)	To: Marin and Freshwater Research Laboratories Murdoch University Phone: (08) 9360 2907 Fax: ()
Project Manager: David Coremans Contact: Ian Gale	Job Location/Name: Bullsbrook SAP Job Number: V7106	Contact: Sample Collection Date: 30/05/2008

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	TKN	Ortho-P	NH4	NO2 + N03	
1	BB1		x	x				2	x	x	x	x	x	x	Unfiltered
2	BB2		x	x				2	x	x	x	x	x	x	Unfiltered
3	BB3		x	x				2	x	x	x	x	x	x	Unfiltered
4	BB4		x	x				2	x	x	x	x	x	x	Unfiltered
5	BB5		x	x				2	x	x	x	x	x	x	Unfiltered
6	BB6		x	x				2	x	x	x	x	x	x	Unfiltered
7	BB7		x	x				2	x	x	x	x	x	x	Unfiltered
8	BB8		x	x				2	x	x	x	x	x	x	Unfiltered
9	BB9		x	x				2	x	x	x	x	x	x	Unfiltered
10	BB10		x	x				2	x	x	x	x	x	x	Unfiltered
11	BB11		x	x				2	x	x	x	x	x	x	Unfiltered
12	BB12		x	x				2	x	x	x	x	x	x	Unfiltered
13	BB13		x	x				2	x	x	x	x	x	x	Unfiltered
14	QA1		x	x				2	x	x	x	x	x	x	Unfiltered

Relinquished by :	Date : Time :	Received by	Date : 30/5/08 Condition: Cold Time : 3:15
Signature : CELESTE WILSON			

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Ian Gale
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 1/09/2008
Date Received: 30/07/2008
Our Reference: CAR08-13
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			08082501			08080801	
Bandy	30/07/2008	17	13	120	110	830	700
Nambad	30/07/2008	31	8	83	110	1100	1000
Central	30/07/2008	48	7	150	210	1200	1100
QA	30/07/2008	30	7	80	100	1100	1000



Signatory:
Date: 1/9/08

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM Bulkbrod Surface Water Sampling Page 1 of 1

From: Cardno BSD 2 Bagot Road SUBIACO WA 6008 Phone: (08) 9273 3888 Fax: (08) 9388 3831 Email: ian.gale@cardno.com.au	Order No: TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)	To: Marin and Freshwater Research Laboratories Murdoch University Phone: (08) 9360 2907 Fax: ()
Project Manager: David Coremans	Job Location/Name: Bullsbrook SAP	Contact:
Contact: Ian Gale	Job Number: V7106	Sample Collection Date: 30/05/2008

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	TKN	Ortho-P	NH4	NO2 + N03	
1	Bandy		x	x				2	x	x	x	x	x	x	Unfiltered
2	Nambad		x	x				2	x	x	x	x	x	x	Unfiltered
3	Central		x	x				2	x	x	x	x	x	x	Unfiltered
4	QA		x	x				2	x	x	x	x	x	x	Unfiltered

Relinquished by : Ian Gale	Date : 30/7/08 Time : 3:35	Received by Darren Evans	Date : 30/7/08 Time : 3:35	Condition: Signature:

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
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Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Kylie McKay
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 5/09/2008
Date Received: 20/08/2008
Our Reference: CAR08-18
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			08082501			08082902	
BC1	19/08/2008	<3	4	7	42	530	500
NB1	19/08/2008	13	<2	12	25	540	500
QA	19/08/2008	12	2	12	26	560	600



Entered

Bullsbrook

Signatory:

Date: 5/9/08

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM

From: Cardno BSD 2 Bagot Road SUBIACO WA 6008 Phone: (08) 9273 3888 Fax: (08) 9388 3831 Email: ian.gale@cardno.com.au	Order No: TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)	To: Marin and Freshwater Research Laboratories Murdoch University Phone: (08) 9360 2907 Fax: () Contact: Kylie McKay
Project Manager: David Coremans Contact: Ian Gale	Job Location/Name: Bullsbrook SAP Job Number: V7106	Sample Collection Date: 30/05/2008

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	TKN	Ortho-P	NH4	NO2 + N03	
1	Bandy		x	x				2	x	x	x	x	x	x	Unfiltered
2	Nambad		x	x				2	x	x	x	x	x	x	Unfiltered
3	QA		x	x				2	x	x	x	x	x	x	Unfiltered

Relinquished by :	Date : Time :	Received by	Date : Time :	Condition:	Signature :

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Ian Gale
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco 6008

Date of Issue: 7/01/2009
Date Received: 27/11/2008
Our Reference: CAR08-32
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			08121101			09010603	
BB1	27/11/2008	20	<2	<2	1200	2500	2500
BB2	27/11/2008	16	<2	1100	370	1800	700
BB3	27/11/2008	<3	<2	1000	17	1100	<200
BB4	27/11/2008	21	23	2400	330	3200	800
BB5	27/11/2008	<3	2	900	200	1000	<200
BB6	27/11/2008	48	2	4	440	220	200
BB7	27/11/2008	59	3	<2	500	3900	3900
BB8	27/11/2008	11	14	180	1700	3000	2800
BB9	27/11/2008	6	7	370	170	810	400
BB10	27/11/2008	45	4	<2	1500	900	900
BB11	27/11/2008	68	6	4	190	440	400
BB12	27/11/2008	20	3	18	400	800	800
BB13	27/11/2008	32	4	4	540	170	<200
QA	27/11/2008	14	13	200	1400	2800	2500

ENTERED

Signatory:
Date: 7/1/2009

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM _____ _____ _____ Page 1 of 1

From: Cardno BSD 2 Bagot Road SUBIACO WA 6008 Phone: (08) 9273 3888 Fax: (08) 9388 3831 Email: ian.gale@cardno.com.au	Order No: TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)	To: Marin and Freshwater Research Laboratories Murdoch University Phone: (08) 9360 2907 Fax: () Contact:
Project Manager: David Coremans	Job Location/Name: Bullsbrook SAP	
Contact: Ian Gale	Job Number: V7106	Sample Collection Date: 30/05/2008

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	TKN	Ortho-P	NH4	NO2 + N03	
1	BB1		x	x				2	x	x	x	x	x	x	Unfiltered
2	BB2		x	x				2	x	x	x	x	x	x	Unfiltered
3	BB3		x	x				2	x	x	x	x	x	x	Unfiltered
4	BB4		x	x				2	x	x	x	x	x	x	Unfiltered
5	BB5		x	x				2	x	x	x	x	x	x	Unfiltered
6	BB6		x	x				2	x	x	x	x	x	x	Unfiltered
7	BB7		x	x				2	x	x	x	x	x	x	Unfiltered
8	BB8		x	x				2	x	x	x	x	x	x	Unfiltered
9	BB9		x	x				2	x	x	x	x	x	x	Unfiltered
10	BB10		x	x				2	x	x	x	x	x	x	Unfiltered
11	BB11		x	x				2	x	x	x	x	x	x	Unfiltered
12	BB12		x	x				2	x	x	x	x	x	x	Unfiltered
13	BB13		x	x				2	x	x	x	x	x	x	Unfiltered
14	QA1		x	x				2	x	x	x	x	x	x	Unfiltered
													FAXED		

Relinquished by :SV	Date : 27/11/08 Time :3:30pm	Received by K Wennagow	Date : 27/11/08 Condition: Good Time : 15:30	Signature :

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

Marine and Freshwater Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
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Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Jorma Nolan
Customer: Cardno BSD
Address: 2 Bagot Rd, Subiaco, WA 6008

Date of Issue: 17/03/2009
Date Received: 17/02/2009
Our Reference: CAR09-9
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			09030901			09030503	
BB 1	17/02/2009	49	20	7	60	150	<200
BB 2	17/02/2009	5	48	1500	150	1400	<200
BB 3	17/02/2009	43	3	230	650	1200	900
BB 4	17/02/2009	11	95	2900	390	3100	<200
BB 5	17/02/2009	16	44	2300	230	2400	<200
BB 6	17/02/2009	49	11	3	260	160	<200
BB 7	17/02/2009	82	27	28	450	3000	3000
BB 8	17/02/2009	41	70	19	760	820	800
BB 10	17/02/2009	70	23	10	1500	1000	1000
BB 11	17/02/2009	82	18	11	260	470	500
BB 12	17/02/2009	19	50	3	530	240	200
BB 13	17/02/2009	29	43	2	470	250	300
QA 1	17/02/2009	59	3	230	840	2100	1900



ENTERED

Signatory: [signature]
Date: 17/3/2009

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM

From: Cardno
2 Bagot Road
SUBIACO WA 6008
Phone: (08) 9273 3888 Fax: (08) 9388 3831
Email: jorma.nolan@cardno.com

Order No:

TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)

To: Marin and Freshwater Research Laboratories
Murdoch University
Phone: (08) 9360 2907 Fax: ()

Contact:

Project Manager: David Coremans

Contact: Jorma Nolan

Job Location/Name: BILLSBROOK
Job Number: V7106

Sample Collection Date: 17/2/09

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	NH4	TKN	Ortho P	NO2 + N03	
1	BB1		X	X				2	X	X	X	X	X	X	Unfiltered
2	BB2		X	X				2	X	X	X	X	X	X	Unfiltered
3	BB3		X	X				2	X	X	X	X	X	X	Unfiltered
4	BB4		X	X				2	X	X	X	X	X	X	Unfiltered
5	BB5		X	X				2	X	X	X	X	X	X	Unfiltered
6	BB6		X	X				2	X	X	X	X	X	X	Unfiltered
7	BB7		X	X				2	X	X	X	X	X	X	Unfiltered
8	BB8		X	X				2	X	X	X	X	X	X	Unfiltered
9	BB9		X	X				2	X	X	X	X	X	X	Unfiltered
10	BB10		X	X				2	X	X	X	X	X	X	Unfiltered
11	BB11		X	X				2	X	X	X	X	X	X	Unfiltered
12	BB12		X	X				2	X	X	X	X	X	X	Unfiltered
13	BB13		X	X				2	X	X	X	X	X	X	Unfiltered
14	QA		X	X				2	X	X	X	X	X	X	Unfiltered

Relinquished by : JORMA NOLAN Date : 17/2/09 Time : 16:15

Received by

Date : Condition:
Time :

Signature :

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
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Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Jorma Nolan
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 23/07/2009
Date Received: 12/06/2009
Our Reference: CAR9-20
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			09062601-071301			09071502	
BB 1	12/06/2009	49	9	29	55	540	500
BB 2	12/06/2009	<3	7	840	51	1300	400
BB 3	12/06/2009	27	<2	9	94	350	300
BB 4	12/06/2009	11	21	2200	2000	3500	1300
BB 5	12/06/2009	17	10	1600	150	2200	600
BB 6	12/06/2009	50	3	14	120	170	<200
BB 7	12/06/2009	24	11	55	87	900	800
BB 8	12/06/2009	57	14	9	660	1100	1100
BB 10	12/06/2009	25	9	23	130	150	<200
BB 11	12/06/2009	68	<2	4	49	180	<200
BB 12	12/06/2009	43	2	3	130	270	300
BB 13	12/06/2009	9	7	19	130	140	<200
QA	12/06/2009	28	<2	12	86	240	200

ENTERED

RECEIVED
Cardno
Subiaco Office 27 JUL 2009
SIGNED
FILE

Signatory:

Date: 23/7/09

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Marine and Freshwater Research Laboratory Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Kylie McKay
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 4/12/2008
Date Received: 29/08/2008
Our Reference: CAR08-19e
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			08111701			08092402	
Bullsbrook 1	16/09/2008	12	6	13	120	310	300
Bullsbrook 2	16/09/2008	<3	7	1400	57	1400	<200
Bullsbrook 3	29/08/2008	<3	2	2300	66	2600	300
Bullsbrook 4	16/09/2008	43	2	1300	830	2000	700
Bullsbrook 5	29/08/2008	11	30	320	430	740	400
Bullsbrook 6	16/09/2008	52	4	<2	800	750	800
Bullsbrook 7	29/08/2008	36	4	30	1600	18000	18000
Bullsbrook 8	29/08/2008	22	29	1000	2900	2200	1200
Bullsbrook 9	29/08/2008	3	18	1600	890	4100	2500
Bullsbrook 10	29/08/2008	38	2	10	1300	550	500
Bullsbrook 12	29/08/2008	14	11	7	420	370	400
Bullsbrook 13	29/08/2008	37	49	27	1000	360	300
Bullsbrook 14 (SW 3)	29/08/2008	18	5	160	25	810	600
Bullsbrook 15 (QA SW)	29/08/2008	44	4	30	38	780	800
QA GW	29/08/2008	34	21	1600	930	2300	800
SW1	29/08/2008	43	3	32	37	760	700
QA	16/09/2008	19	27	1100	780	1400	300

Signatory: G Woodward
Date: 4/12/08

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY

Marine and Freshwater Research Laboratory
Murdoch University
Environmental Science
Murdoch, Western Australia 6150
Phone: 93602907, Fax: 93606613

To: Marine and Freshwater Research Laboratory	From:
Address: Murdoch University South St Murdoch 6150	Address:
Phone: 93602907 Fax: 93606613	Phone: Fax:
Email:	Email:
Courier Details:	Job Number: PO/ Account #:

Sample Preservation: None / Warm / Cool / On Ice / Frozen / Acidified / Filtered / Other: _____

Sample Type: Water / Bore / Fresh / Estuarine / Marine / Brine / Plant / Sediment / Soil / Other: _____

No	Sample Code	Sampling Date	Analysis Required							
			ANP							
1	SW1		✓	✓						
2	SW2 (BBK)		✓	✓						
3	[redacted] BB3		✓	✓						
4	BB5		✓	✓						
5	BB7		✓	✓						
6	BB8		✓	✓						
7	BB9		✓	✓						
8	BB10		✓	✓						
9	BB12		✓	✓						
10	BB13		✓	✓						
11	QA(W)		✓	✓						
12	QA SW (BB15)		✓	✓						
13	BB3		✓	✓						
14										
15										
16										
17										
18										
19										
20										

Relinquished by:	Date:	Time:	Received by:	Date:	Time	Job Number:
Sample Condition:						

Please acknowledge receipt of samples by signing where appropriate, quoting job number and returning to the sender by fax.

BB = Bull Creek.

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Ian Gale
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco 6008

Date of Issue: 7/01/2009
Date Received: 27/11/2008
Our Reference: CAR08-32
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			08121101			09010603	
BB1	27/11/2008	20	<2	<2	1200	2500	2500
BB2	27/11/2008	16	<2	1100	370	1800	700
BB3	27/11/2008	<3	<2	1000	17	1100	<200
BB4	27/11/2008	21	23	2400	330	3200	800
BB5	27/11/2008	<3	2	900	200	1000	<200
BB6	27/11/2008	48	2	4	440	220	200
BB7	27/11/2008	59	3	<2	500	3900	3900
BB8	27/11/2008	11	14	180	1700	3000	2800
BB9	27/11/2008	6	7	370	170	810	400
BB10	27/11/2008	45	4	<2	1500	900	900
BB11	27/11/2008	68	6	4	190	440	400
BB12	27/11/2008	20	3	18	400	800	800
BB13	27/11/2008	32	4	4	540	170	<200
QA	27/11/2008	14	13	200	1400	2800	2500

ENTERED

Signatory:
Date: 7/1/2009

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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Marine and Freshwater Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

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Accreditation Number: 10603
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MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Jorma Nolan
Customer: Cardno BSD
Address: 2 Bagot Rd, Subiaco, WA 6008

Date of Issue: 17/03/2009
Date Received: 17/02/2009
Our Reference: CAR09-9
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			09030901			09030503	
BB 1	17/02/2009	49	20	7	60	150	<200
BB 2	17/02/2009	5	48	1500	150	1400	<200
BB 3	17/02/2009	43	3	230	650	1200	900
BB 4	17/02/2009	11	95	2900	390	3100	<200
BB 5	17/02/2009	16	44	2300	230	2400	<200
BB 6	17/02/2009	49	11	3	260	160	<200
BB 7	17/02/2009	82	27	28	450	3000	3000
BB 8	17/02/2009	41	70	19	760	820	800
BB 10	17/02/2009	70	23	10	1500	1000	1000
BB 11	17/02/2009	82	18	11	260	470	500
BB 12	17/02/2009	19	50	3	530	240	200
BB 13	17/02/2009	29	43	2	470	250	300
QA 1	17/02/2009	59	3	230	840	2100	1900



ENTERED

Signatory: [signature]
Date: 17/3/2009

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM

From: Cardno
2 Bagot Road
SUBIACO WA 6008
Phone: (08) 9273 3888 Fax: (08) 9388 3831
Email: jorma.nolan@cardno.com

Order No:

TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)

To: Marin and Freshwater Research Laboratories
Murdoch University
Phone: (08) 9360 2907 Fax: ()

Contact:

Project Manager: David Coremans

Contact: Jorma Nolan

Job Location/Name: BILLSBROOK
Job Number: V7106

Sample Collection Date: 17/2/09

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	NH4	TKN	Ortho P	NO2 + N03	
1	BB1		X	X				2	X	X	X	X	X	X	Unfiltered
2	BB2		X	X				2	X	X	X	X	X	X	Unfiltered
3	BB3		X	X				2	X	X	X	X	X	X	Unfiltered
4	BB4		X	X				2	X	X	X	X	X	X	Unfiltered
5	BB5		X	X				2	X	X	X	X	X	X	Unfiltered
6	BB6		X	X				2	X	X	X	X	X	X	Unfiltered
7	BB7		X	X				2	X	X	X	X	X	X	Unfiltered
8	BB8		X	X				2	X	X	X	X	X	X	Unfiltered
9	BB9		X	X				2	X	X	X	X	X	X	Unfiltered
10	BB10		X	X				2	X	X	X	X	X	X	Unfiltered
11	BB11		X	X				2	X	X	X	X	X	X	Unfiltered
12	BB12		X	X				2	X	X	X	X	X	X	Unfiltered
13	BB13		X	X				2	X	X	X	X	X	X	Unfiltered
14	QA		X	X				2	X	X	X	X	X	X	Unfiltered

Relinquished by : JORMA NOLAN Date : 17/2/09 Time : 16:15

Received by

Date : Condition:
Time :

Signature :

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Jorma Nolan
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 23/07/2009
Date Received: 12/06/2009
Our Reference: CAR9-20
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			09062601-071301			09071502	
BB 1	12/06/2009	49	9	29	55	540	500
BB 2	12/06/2009	<3	7	840	51	1300	400
BB 3	12/06/2009	27	<2	9	94	350	300
BB 4	12/06/2009	11	21	2200	2000	3500	1300
BB 5	12/06/2009	17	10	1600	150	2200	600
BB 6	12/06/2009	50	3	14	120	170	<200
BB 7	12/06/2009	24	11	55	87	900	800
BB 8	12/06/2009	57	14	9	660	1100	1100
BB 10	12/06/2009	25	9	23	130	150	<200
BB 11	12/06/2009	68	<2	4	49	180	<200
BB 12	12/06/2009	43	2	3	130	270	300
BB 13	12/06/2009	9	7	19	130	140	<200
QA	12/06/2009	28	<2	12	86	240	200

ENTERED

RECEIVED
Cardno
Subiaco Office 27 JUL 2009
SIGNED
FILE

Signatory:

Date: 23/7/09

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM

From: Cardno
2 Bagot Road
SUBIACO WA 6008
Phone: (08) 9273 3888 Fax: (08) 9388 3831
Email: jorma.nolan@cardno.com

Order No:

TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)

To: Marin and Freshwater Research Laboratories
Murdoch University
Phone: (08) 9360 2907 Fax: ()

Contact:

Project Manager: David Coremans

Contact: Jorma Nolan

Job Location/Name: BILLSBROOK
Job Number: V7106

Sample Collection Date: 17/2/09

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	NH4	TKN	Ortho P	NO2 + N03	
1	BB1		X	X				2	X	X	X	X	X	X	Unfiltered
2	BB2		X	X				2	X	X	X	X	X	X	Unfiltered
3	BB3		X	X				2	X	X	X	X	X	X	Unfiltered
4	BB4		X	X				2	X	X	X	X	X	X	Unfiltered
5	BB5		X	X				2	X	X	X	X	X	X	Unfiltered
6	BB6		X	X				2	X	X	X	X	X	X	Unfiltered
7	BB7		X	X				2	X	X	X	X	X	X	Unfiltered
8	BB8		X	X				2	X	X	X	X	X	X	Unfiltered
9	BB9		X	X				2	X	X	X	X	X	X	Unfiltered
10	BB10		X	X				2	X	X	X	X	X	X	Unfiltered
11	BB11		X	X				2	X	X	X	X	X	X	Unfiltered
12	BB12		X	X				2	X	X	X	X	X	X	Unfiltered
13	BB13		X	X				2	X	X	X	X	X	X	Unfiltered
14	QA		X	X				2	X	X	X	X	X	X	Unfiltered

Relinquished by : JORMA NOLAN Date : 17/2/09 Time : 16:15

Received by

Date : Condition:
Time :

Signature :

* Pb, As, Cd, Hg, Cu, Cr, Zn, Ni

Other _____

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA
Accreditation Number: 10603
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Jorma Nolan
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 23/07/2009
Date Received: 12/06/2009
Our Reference: CAR9-20
Your Reference: V7106

METHOD SAMPLE CODE	Sampling Date	2000 AMMONIA µg.N/L	4100 ORTHO-P µg.P/L	2100 NO3+NO2 µg.N/L	4700 TOTAL-P µg.P/L	2700 TOTAL-N µg.N/L	2700-2100 TKN calculated µg.N/L
Reporting Limit		<3	<2	<2	<5	<50	<200
File			09062601-071301			09071502	
BB 1	12/06/2009	49	9	29	55	540	500
BB 2	12/06/2009	<3	7	840	51	1300	400
BB 3	12/06/2009	27	<2	9	94	350	300
BB 4	12/06/2009	11	21	2200	2000	3500	1300
BB 5	12/06/2009	17	10	1600	150	2200	600
BB 6	12/06/2009	50	3	14	120	170	<200
BB 7	12/06/2009	24	11	55	87	900	800
BB 8	12/06/2009	57	14	9	660	1100	1100
BB 10	12/06/2009	25	9	23	130	150	<200
BB 11	12/06/2009	68	<2	4	49	180	<200
BB 12	12/06/2009	43	2	3	130	270	300
BB 13	12/06/2009	9	7	19	130	140	<200
QA	12/06/2009	28	<2	12	86	240	200

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Cardno
Subiaco Office 27 JUL 2009
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FILE

Signatory:

Date: 23/7/09

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

This document may not be reproduced except in full.

...N OF CUSTODY FORM _____ Page __1__ of __1__

From: Cardno 2 Bagot Road SUBIACO WA 6008 Phone: (08) 9273 3888 Fax: (08) 9388 3831 Email: jorma.nolan@cardno.com	Order No: TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)	To: Marin and Freshwater Research Laboratories Murdoch University Phone: (08) 9360 2907 Fax: ()
Project Manager: David Coremans Contact: Jorma Nolan	Job Location/Name: Bullsbrook Job Number: V7106	Contact: Sample Collection Date: 7 / 12 / 09

Laboratory Sample No.	Sample Identification	Sample Type		Preservation Method			No. of Containers		Analyses Requested						Comments
		Soil	Water	Ice	Acid	None	Glass	Plastic	TN	TP	NH4	TKN	Ortho P	NO2 + NO3	
1	BB1		X	X				2	X	X	X	X	X	X	Unfiltered
2	BB2		X	X				2	X	X	X	X	X	X	Unfiltered
3	BB3		X	X				2	X	X	X	X	X	X	Unfiltered
4	BB4		X	X				2	X	X	X	X	X	X	Unfiltered
5	BB5		X	X				2	X	X	X	X	X	X	Unfiltered
6	BB6		X	X				2	X	X	X	X	X	X	Unfiltered
7	BB7		X	X				2	X	X	X	X	X	X	Unfiltered
8	BB8		X	X				2	X	X	X	X	X	X	Unfiltered
~~9~~	~~BB9~~		X	X				2	X	X	X	X	X	X	Unfiltered DRX.
10	BB10		X	X				2	X	X	X	X	X	X	Unfiltered
11	BB11		X	X				2	X	X	X	X	X	X	Unfiltered
12	BB12		X	X				2	X	X	X	X	X	X	Unfiltered
13	BB13		X	X				2	X	X	X	X	X	X	Unfiltered
14	QA		X	X				2	X	X	X	X	X	X	Unfiltered

Relinquished by:	Date: 12/6/09 Time: 1650	Received by	Date: 12/6/09 Time: 2:50	Condition: Appropriate	Signature:

Other _____

Marine and Freshwater
Research Laboratory
Environmental Science

Telephone: (08) 9360 2907 Facsimile: (08) 9360 6613

NATA

Accreditation Number: 10603
This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance with ISO/IEC 17025.

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

WATER QUALITY DATA

Contact: Jorma Nolan
Customer: Cardno BSD
Address: 2 Bagot Road, Subiaco, WA 6008

Date of Issue: 20/07/2009
Date Received: 19/06/2009
Our Reference: CAR09-21
Your Reference: V9021,V7106

METHOD SAMPLE CODE Reporting Limit	Sampling Date	2000 AMMONIA µg.N/L <3	4100 ORTHO-P µg.P/L <2	2100 NO3+NO2 µg.N/L <2	4700 TOTAL-P µg.P/L <5	2700 TOTAL-N µg.N/L <50
File			09070902		09071501	
PV1	19/06/2009	76	22	2200	180	5100
PV2	19/06/2009	1100	<2	310	59	2400
QAPV	19/06/2009	1100	2	310	56	2500
BB1	19/06/2009	200	140	330	260	1800
BB2	19/06/2009	44	92	36	150	670
QABB	19/06/2009	51	100	48	150	570

ENTERED

RECEIVED
Cardno
Subiaco Office 27 JUL 2009
SIGNED
FILE

Signatory:
Date: 20/7/2009

All test items tested as received. Spare test items will be held for two months unless otherwise requested.

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CHAIN OF CUSTODY FORM

From: Cardno
2 Bagot Road
SUBIACO WA 6008
Phone: (08) 9273 3888 Fax: (08) 9388 3831
Email: jorma.nolan@cardno.com

Order No:

TATime: 24 hr /48 hr / 3 -5 days/10-14days (Circle)

To: Marin and Freshwater Research Laboratories
Murdoch University
Phone: (08) 9360 2907 Fax: ()

Project Manager: David Coremans

Contact: Jorma Nolan

Job Location/Name: Bullsbrook / Parkerville

Job Number: V9021 / V7106

Contact:

Sample Collection Date: 15 / 6 /09

Laboratory Sample No.	Sample Identification	Sample Type: Soil	Sample Type: Water	Preservation Method: Ice	Preservation Method: Acid	Preservation Method: None	No. of Containers: Glass	No. of Containers: Plastic	Analyses Requested: TN	Analyses Requested: TP	Analyses Requested: ANP	Analyses Requested	Analyses Requested	Analyses Requested	Comments: All unfiltered
	PV1		✓	✓				2	✓	✓	✓				V9021
	PV2		✓	✓				2	✓	✓	✓				V9021
	QAPV		✓	✓				2	✓	✓	✓				V9021
	BB1		✓	✓				2	✓	✓	✓				V7106
	BB2		✓	✓				2	✓	✓	✓				V7106
	QABB		✓	✓				2	✓	✓	✓				V7106

Relinquished by : JORMA NOLAN Date : 15/6/09 Time : 1445

Received by Date : 15/6/09 Time : 1445 Condition:

Signature :

Other

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0904961**	Page	: 1 of 3
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JORMA NOLAN	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: jorma.nolan@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V7106	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 01-SEP-2009
Sampler	: JN	Issue Date	: 08-SEP-2009
Site	: Bullsbrook		
		No. of samples received	: 3
Quote number	: EP-379-09	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Perth Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: WATER				Client sample ID	BB 1	BB 2	BB QA	----	----
				Client sampling date / time	01-SEP-2009 15:00	01-SEP-2009 15:00	01-SEP-2009 15:00	----	----
Compound	CAS Number	LOR	Unit		EP0904961-001	EP0904961-002	EP0904961-003	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.04**	**0.05**	**0.04**	----	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.15**	**0.14**	**0.15**	----	----
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.6**	**2.1**	**0.7**	----	----
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		**0.8**	**2.2**	**0.8**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.01**	**0.39**	**0.02**	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		<0.01	**0.38**	<0.01	----	----

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V7106	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Bullsbrook P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (Date): ASAP QUOTE NO.: EP/379/09	

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		Suite 1											Notes:
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles												
1	BB1		1/09/2009				X											unfiltered
2	BB2		1/09/2009				X											unfiltered
3	BBQA		1/09/2009				X											unfiltered

Environmental Division
Perth
Work Order
EP0904961

Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date: 1/9/09	Name:	Date: 1/9/09	Con' Note No:
Of: Cardno	Time:	Of: ALS	Time: 16:50	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0905692**	Page	: 1 of 3
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JORMA NOLAN	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: jorma.nolan@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V7106	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 02-OCT-2009
Sampler	: JLN	Issue Date	: 12-OCT-2009
Site	: Bullsbrook		
		No. of samples received	: 3
Quote number	: EP-379-09	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Perth Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: WATER				Client sample ID	BB1	BB2	BBQA	----	----
				Client sampling date / time	02-OCT-2009 14:51	02-OCT-2009 14:51	02-OCT-2009 14:51	----	----
Compound	CAS Number	LOR	Unit		EP0905692-001	EP0905692-002	EP0905692-003	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.03**	**0.03**	**0.04**	----	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.05**	**0.08**	**0.03**	----	----
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.4**	**2.2**	**0.4**	----	----
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		**0.5**	**2.3**	**0.4**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.01**	**0.52**	**0.02**	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		<0.01	**0.24**	<0.01	----	----

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V7106	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Bullsbrook P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (**Date**): ASAP QUOTE NO.: EP/379/09	

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		Suite 1	Notes:
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles		
1	BB1		2/10/2009			2	X	unfiltered
2	BB2		2/10/2009			2	X	unfiltered
3	BBQA		2/10/2009			2	X	unfiltered

Environmental Division
Perth
Work Order
EP0905692

Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date:2/10/09	Name: Josh	Date: 2/10/09	Con' Note No:
Of: Cardno	Time: 1500	Of: ALS	Time: 16:42	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS LABORATORY GROUP

ENFM (204/5)

Analytical Charges

Suite 1

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3 H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
TOTAL SUITE COST FOR WATER SAMPLES:				**82.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Suite 2

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3 H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
Dissolved Metals by ICPMS – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020F	USEPA 6020 ICPMS	0.0001 - 0.01	22.00
Total Recoverable Metals by ICPMS (incl digest) – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020T	USEPA 6020 ICPMS	0.0001 - 0.01	28.00
Mercury – **Dissolved**	EG035F	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
Mercury - **Total Recoverable**	EG035T	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
TPH (C6-C36) [19]	EP080/ EP071	USEPA 5030/8260 USEPA 3510/8015 P&T-GC/MS/FID	20-100 µg/L	49.00
OC/OP Pesticides	**W-12**	GC/ECD/FPD-MS	0.5-2 µg/L	65.00
TOTAL SUITE COST FOR WATER SAMPLES:				**266.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Where metals suites are stipulated '**T**' denotes Total metals analysis (eg. W-2 T = 8 Total Metals). Where no '**T**' is present in the suite code, this denotes dissolved/filtered metals.

For metals in waters, field filtration status must be clearly indicated on the bottle label (via tick) indicating whether total or dissolved metals are required.

Package Prices apply only when specific ALS Group Codes ('W' & 'NT' suites) are selected on COCs. Standard LORs apply for suites.

Administration Charges

An administration fee of $30.00 is applicable to each submission of samples submitted regardless of the size of the submission.

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Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0905899**	Page	: 1 of 5
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JORMA NOLAN	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: jorma.nolan@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V7106	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 15-OCT-2009
Sampler	: ----	Issue Date	: 22-OCT-2009
Site	: ----		
		No. of samples received	: 13
Quote number	: EP-379-09	No. of samples analysed	: 13

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Perth Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: WATER				Client sample ID	MW1	MW2	MW3	MW4	MW6
				Client sampling date / time	14-OCT-2009 15:00	14-OCT-2009 15:00	14-OCT-2009 15:00	14-OCT-2009 15:00	14-OCT-2009 15:00
Compound	CAS Number	LOR	Unit		EP0905899-001	EP0905899-002	EP0905899-003	EP0905899-004	EP0905899-005
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.02**	<0.01	<0.01	**0.03**	**0.02**
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**1.16**	**1.04**	**1.49**	**2.15**	**5.10**
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.2**	<0.1	**3.3**	**0.1**	<0.5
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		**1.4**	**1.0**	**4.8**	**2.3**	**5.1**
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.01**	**0.02**	**7.56**	**0.19**	**0.19**
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	<0.01	**0.05**	<0.01

Analytical Results

Sub-Matrix: WATER				Client sample ID	MW7	MW8	MW9	MW10	MW11
				Client sampling date / time	14-OCT-2009 15:00	14-OCT-2009 15:00	14-OCT-2009 15:00	14-OCT-2009 15:00	14-OCT-2009 15:00
Compound	CAS Number	LOR	Unit		EP0905899-006	EP0905899-007	EP0905899-008	EP0905899-009	EP0905899-010
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		<0.01	0.01	0.03	0.02	<0.01
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		0.08	0.23	3.62	0.02	0.05
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		11.0	0.6	2.3	0.1	<0.1
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		11.1	0.9	5.9	0.2	<0.1
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		3.02	1.27	0.31	0.28	0.03
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		<0.01	0.01	<0.01	0.03	<0.01

Analytical Results

Sub-Matrix: WATER				Client sample ID	MW12	MW13	QA	----	----
				Client sampling date / time	14-OCT-2009 15:00	14-OCT-2009 15:00	14-OCT-2009 15:00	----	----
Compound	CAS Number	LOR	Unit		EP0905899-011	EP0905899-012	EP0905899-013	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.03**	**0.04**	**0.03**	----	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.03**	<0.01	<0.01	----	----
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**1.1**	<0.1	**0.2**	----	----
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		**1.2**	<0.1	**0.2**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.28**	**0.21**	**0.33**	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		<0.01	<0.01	<0.01	----	----

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V7106	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Bullsbrook P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (**Date**): ASAP QUOTE NO.: EP/379/09	*

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		suite 1								Notes:
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles									
1	MW1		14/10/2009			2	x								ufiltered
2	MW2		14/10/2009			2	x								ufiltered
3	MW3		14/10/2009			2	x								ufiltered
4	MW4		14/10/2009			2	x								ufiltered
5	MW6		14/10/2009			2	x								ufiltered
6	MW7		14/10/2009			2	x								ufiltered
7	MW8		14/10/2009			2	x								ufiltered
8	MW9		14/10/2009			2	x								ufiltered
9	MW10		14/10/2009			2	x								ufiltered
10	MW11		14/10/2009			2	x								ufiltered
11	MW12		14/10/2009			2	x								ufiltered
12	MW13		14/10/2009			2	x								ufiltered

Environmental Division
Perth
Work Order
EP0905899

Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date: 15/10/09	Name: Josh	Date: 15/10/09	Con' Note No:
Of: Cardno	Time: 0900	Of: ALS	Time: 1607	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V7106	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Bullsbrook P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (**Date**): ASAP QUOTE NO.: EP/379/09	*

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		suite 1										Notes:
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles											
13	QA		14/10/2009			2	x										ufiltered

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date:15/10/09	Name: Josh	Date: 15/10/09	Con' Note No:
Of: Cardno	Time: 0900	Of: ALS	Time: 11:07	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS LABORATORY GROUP

ENFM (204/5)

Analytical Charges

Suite 1

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3 H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
TOTAL SUITE COST FOR WATER SAMPLES:				**82.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Suite 2

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3 H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
Dissolved Metals by ICPMS – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020F	USEPA 6020 ICPMS	0.0001 - 0.01	22.00
Total Recoverable Metals by ICPMS (incl digest) – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020T	USEPA 6020 ICPMS	0.0001 - 0.01	28.00
Mercury – **Dissolved**	EG035F	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
Mercury - **Total Recoverable**	EG035T	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
TPH (C6-C36) [19]	EP080/ EP071	USEPA 5030/8260 USEPA 3510/8015 P&T-GC/MS/FID	20-100 µg/L	49.00
OC/OP Pesticides	**W-12**	GC/ECD/FPD-MS	0.5-2 µg/L	65.00
TOTAL SUITE COST FOR WATER SAMPLES:				**266.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Where metals suites are stipulated '**T**' denotes Total metals analysis (eg. W-2 T = 8 Total Metals). Where no '**T**' is present in the suite code, this denotes dissolved/filtered metals.

For metals in waters, field filtration status must be clearly indicated on the bottle label (via tick) indicating whether total or dissolved metals are required.

Package Prices apply only when specific ALS Group Codes ('W' & 'NT' suites) are selected on COCs. Standard LORs apply for suites.

Administration Charges

An administration fee of $30.00 is applicable to each submission of samples submitted regardless of the size of the submission.

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Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0905366**	Page	: 1 of 3
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JORMA NOLAN	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: jorma.nolan@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V7106	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 18-SEP-2009
Sampler	: JLN	Issue Date	: 25-SEP-2009
Site	: Bullsbrook		
		No. of samples received	: 3
Quote number	: EP-379-09	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Perth Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: WATER				Client sample ID	BB1	BB2	QABB	----	----
				Client sampling date / time	17-SEP-2009 15:00	17-SEP-2009 15:00	17-SEP-2009 15:00	----	----
Compound	CAS Number	LOR	Unit		EP0905366-001	EP0905366-002	EP0905366-003	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.11**	**0.06**	**0.10**	----	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	**0.17**	**0.09**	----	----
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.4**	**2.3**	**2.8**	----	----
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		**0.4**	**2.5**	**2.9**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.05**	**0.48**	**0.52**	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		**0.02**	**0.42**	**0.42**	----	----

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V7106	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Bullsbrook P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (**Date**): ASAP QUOTE NO.: EP/379/09	*

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact: Yes No N/A
SAMPLE TEMPERATURE
CHILLED: Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

Notes:

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		suite 1											
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles												
1	BB1		17/09/2009			2	x											ufiltered
2	BB2		17/09/2009			2	x											ufiltered
3	QABB		17/09/2009			2	x											ufiltered

Environmental Division
Perth
Work Order
EP0905366

Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date:17/09/09	Name: LW	Date: 18-9	Con' Note No:
Of: Cardno	Time:	Of: ALS	Time: 1530	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Analytical Charges

Suite 1

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3 H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
TOTAL SUITE COST FOR WATER SAMPLES:				**82.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Suite 2

Parameter	ALS Method/ Package Code	Technique/ Method Reference	Limit of Reporting (mg/L) (or as indicated)	Price per Sample ($)
Nitrogen - Ammonia as N	EK055G	APHA 4500-NH_3 H	0.01	20.00
Total Nitrogen *(incl TKN + NO_x)* + Total Phosphorus	**NT-11**	EK062, EK061, EK057, EK058, EK067	0.01 (TN, TKN - 0.1)	50.00
Phosphorus – Reactive	EK071G	APHA 4500-P G	0.01	12.00
Dissolved Metals by ICPMS – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020F	USEPA 6020 ICPMS	0.0001 - 0.01	22.00
Total Recoverable Metals by ICPMS (incl digest) – As, Cd, Cr, Cu, Pb, Ni, Zn, Al, Fe	EG020T	USEPA 6020 ICPMS	0.0001 - 0.01	28.00
Mercury – **Dissolved**	EG035F	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
Mercury - **Total Recoverable**	EG035T	APHA 3112 Hg-B CV/FIMS	0.0001	10.00
TPH (C6-C36) [19]	EP080/ EP071	USEPA 5030/8260 USEPA 3510/8015 P&T-GC/MS/FID	20-100 µg/L	49.00
OC/OP Pesticides	**W-12**	GC/ECD/FPD-MS	0.5-2 µg/L	65.00
TOTAL SUITE COST FOR WATER SAMPLES:				**266.00**

Please note: *to receive analysis at the above cost, the ALS quotation number must be referenced on the COC.*

Where metals suites are stipulated '**T**' denotes Total metals analysis (eg. W-2 T = 8 Total Metals). Where no '**T**' is present in the suite code, this denotes dissolved/filtered metals.

For metals in waters, field filtration status must be clearly indicated on the bottle label (via tick) indicating whether total or dissolved metals are required.

Package Prices apply only when specific ALS Group Codes ('W' & 'NT' suites) are selected on COCs. Standard LORs apply for suites.

Administration Charges

An administration fee of $30.00 is applicable to each submission of samples submitted regardless of the size of the submission.

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Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **EP0904749**	Page	: 1 of 3
Client	: **CARDNO (WA) PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: MR JORMA NOLAN	Contact	: Michael Sharp
Address	: PO BOX 155 SUBIACO WA, AUSTRALIA 6904	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: jorma.nolan@cardno.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 9273 3888	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9388 3831	Facsimile	: +61-8-9209 7600
Project	: V7106	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 21-AUG-2009
Sampler	: JLN	Issue Date	: 27-AUG-2009
Site	: Bullsbrook		
		No. of samples received	: 3
Quote number	: EP-379-09	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

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Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Perth Inorganics

General Comments

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When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: WATER				Client sample ID	BB1	BB2	QABB	----	----
				Client sampling date / time	[21-AUG-2009]	[21-AUG-2009]	[21-AUG-2009]	----	----
Compound	CAS Number	LOR	Unit		EP0904749-001	EP0904749-002	EP0904749-003	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.04**	**0.06**	**0.02**	----	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		**0.17**	**0.10**	**0.16**	----	----
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		**0.5**	**2.6**	**0.5**	----	----
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		**0.7**	**2.7**	**0.6**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.03**	**0.57**	<0.01	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		<0.01	**0.47**	<0.01	----	----

CHAIN OF CUSTODY DOCUMENTATION

ALS Laboratory Group

CLIENT: Cardno	SAMPLER: JLN
ADDRESS / OFFICE: 2 Bagot Rd, Subiaco	MOBILE:
PROJECT MANAGER (PM): Dave Coremans	PHONE:
PROJECT ID: V7106	EMAIL REPORT TO: jorma.nolan@cardno.com.au
SITE: Bullsbrook P.O. NO.:	EMAIL INVOICE TO: (if different to report)
RESULTS REQUIRED (Date): ASAP QUOTE NO.: EP/379/09	*

FOR LABORATORY USE ONLY
COOLER SEAL (circle appropriate)
Intact Yes No N/A
SAMPLE TEMPERATURE
CHILLED Yes No

COMMENTS / SPECIAL HANDLING / STORAGE OR DISPOSAL:

SAMPLE INFORMATION (note: S = Soil, W=Water)					CONTAINER INFORMATION		suite 1	Notes:
ALS ID	SAMPLE ID	MATRIX	DATE	Time	Type / Code	Total bottles		
1	BB1		21/08/2009			2	x	ufiltered
2	BB2		21/08/2009			2	x	ufiltered
3	QABB		21/08/2009			2	x	ufiltered

Environmental Division
Perth
Work Order
EP0904749
Telephone : +61-8-9209 7655

RELINQUISHED BY:		RECEIVED BY		METHOD OF SHIPMENT
Name: Jorma Nolan	Date:21/8/09	Name: Linda	Date: 21-8	Con' Note No:
Of: Cardno	Time:	Of: ALS	Time: 1534	
Name:	Date:	Name:	Date:	Transport Co:
Of:	Time:	Of:	Time:	

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; V = VOA Vial HCl Preserved; VS = VOA Vial Sulphuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS LABORATORY GROUP

COC Page ___ of ___

ENFM (204/5)

Appendix C

Groundwater Levels Results and Survey Data

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94862
Bullsbrook
7-Dec-07

McMULLENNOLAN
www.mapsurvey.com.au

Pnt ID	Easting PCG94	Northing PCG94	Easting MGA 50	Northing MGA 50	Top Of Bore	Ground Ht
Bore 1	70770.25	292285.90	408633.00	6493325.00	41.21	40.52
Bore 2	71123.72	292565.49	408965.00	6493586.00	54.33	53.55
Bore 3	70560.97	293091.40	408398.00	6494099.00	42.35	41.60
Bore 4	71261.20	293331.05	409112.00	6494337.00	64.78	63.97
Bore 5	70909.92	293453.42	408743.00	6494487.00	49.24	48.56
Bore 6	71283.59	294006.08	409112.00	6495030.00	56.33	55.62
Bore 7	69517.92	291557.92	407372.00	6492558.00	27.17	26.51
Bore 8	70619.09	291546.41	408466.00	6492567.00	32.20	31.41
Bore 9	69311.12	292437.07	407153.00	6493447.00	30.38	29.63
Bore 10	70416.78	289949.86	408286.00	6490968.00	25.86	25.13
Bore 11	71054.42	290619.64	408917.00	6491641.00	43.30	42.44
Bore 12	69878.41	293485.84	407708.00	6494500.00	40.23	39.59
Bore 13	70474.32	293973.96	408298.00	6494992.00	46.53	45.76

Note : GPS Position and Height.

Bores Were Locked All Heights Are Top Of Metal Casing

Table C1 Groundwater Levels (mBGS)

Bore ID	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
BB1	4.50	4.38	4.33	4.50	4.69	4.83	4.86	4.78	4.85	4.75	4.62	4.66	4.85	4.64	4.59	5.10	5.18	5.00	5.14	5.16	5.24	4.86	4.42	4.64	4.69	4.74
BB2	15.15	15.20	15.29	15.39	15.44	15.57	15.69	15.52	15.61	14.52	15.55	15.36	15.27	15.32	15.51	16.85	16.54	15.73	15.86	16.00	15.92	15.94	15.56	15.70	15.76	15.92
BB3	2.04	2.67	3.55	3.96	4.27	3.50	2.77	1.60	0.00	1.21	2.79	2.18	3.64	3.01	3.60	4.45	4.67	4.65	4.80	4.79	1.33	0.80	0.57	1.78	1.92	2.23
BB4	22.40	22.70	22.72	22.86	22.94	22.96	23.10	23.13	23.14	22.81	23.64	23.60	22.59	22.51	23.70	22.96	23.14	23.23	23.10	23.33	23.30	22.83	22.23	22.89	22.98	23.06
BB5	10.74	10.88	10.90	11.36	11.37	11.56	11.44	11.41	11.35	11.00	-	10.72	11.76	10.83	11.08	11.55	12.69	11.66	11.74	11.96	11.90	11.53	11.47	11.17	11.19	11.21
BB6	5.38	5.50	5.66	5.89	5.88	5.86	5.96	5.72	5.12	6.24	6.40	5.46	5.63	5.67	5.81	6.14	6.22	6.14	6.13	6.44	6.17	5.79	5.59	5.78	5.84	5.86
BB7	0.95	1.15	1.40	1.86	1.64	1.45	1.36	0.48	0.00	0.74	0.67	0.98	1.16	1.23	1.71	2.70	2.70	1.97	2.09	2.14	0.36	0.32	0.25	0.66	1.65	1.72
BB8	3.80	4.20	4.50	4.79	4.94	5.00	5.10	4.64	0.32	1.74	3.83	4.00	4.17	4.16	4.69	5.29	6.15	5.30	5.29	5.59	5.39	3.87	2.45	3.48	3.49	3.77
BB9	0.98	2.20	2.90	3.37	3.50	3.30	1.21	1.02	0.98	0.91	0.84	0.98	1.41	2.40	2.92	3.39	-	3.43	3.50	3.50	1.26	0.67	0.39	0.88	1.04	1.98
BB10	2.10	2.68	3.27	3.70	3.80	3.90	3.89	3.65	3.30	2.84	2.70	2.60	2.75	2.91	3.29	3.91	3.93	4.15	4.12	4.19	4.20	3.63	2.89	2.42	3.62	3.91
BB11	9.63	10.28	11.43	11.86	11.95	11.23	11.90	10.65	4.20	10.41	10.44	9.50	9.62	9.19	11.56	12.01	12.95	12.25	12.06	11.66	11.44	10.84	9.96	9.30	9.70	10.31
BB12	4.36	4.60	4.90	5.27	5.31	5.31	5.47	5.29	0.00	4.71	4.50	4.53	4.51	4.58	5.03	6.61	6.58	5.64	5.79	5.94	5.73	5.57	5.07	4.72	4.84	5.29
BB13	13.84	13.97	14.35	14.63	14.69	14.70	14.73	14.57	14.38	14.19	14.20	13.91	14.80	13.19	14.10	14.58	14.75	14.12	14.60	14.93	14.87	14.34	14.09	14.29	14.67	14.74

Table C2 Groundwater Levels (mAHD)

Bore ID	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09
BB1	36.02	36.14	36.19	36.02	35.83	35.69	35.66	35.74	35.67	35.77	35.90	35.86	35.67	35.88	35.93	35.42	35.34	35.52	35.38	35.36	35.28	35.66	36.10	35.88	35.83	35.78
BB2	38.40	38.35	38.26	38.16	38.11	37.98	37.86	38.03	37.94	39.03	38.00	38.19	38.28	38.23	38.04	36.70	37.01	37.82	37.69	37.55	37.63	37.61	37.99	37.85	37.79	37.63
BB3	39.56	38.93	38.05	37.64	37.33	38.10	38.83	40.00	41.60	40.39	38.81	39.42	37.96	38.59	38.00	37.15	36.93	36.95	36.80	36.81	40.27	40.80	41.03	39.82	39.68	39.37
BB4	41.57	41.27	41.25	41.11	41.03	41.01	40.87	40.84	40.83	41.16	40.33	40.37	41.38	41.46	40.27	41.01	40.83	40.74	40.87	40.64	40.67	41.14	41.74	41.08	40.99	40.91
BB5	37.82	37.68	37.66	37.20	37.19	37.00	37.12	37.15	37.21	37.56	-	37.84	36.80	37.73	37.48	37.01	35.87	36.90	36.82	36.60	36.66	37.03	37.09	37.39	37.37	37.35
BB6	50.24	50.12	49.96	49.73	49.74	49.76	49.66	49.90	50.50	49.38	49.22	50.16	49.99	49.95	49.81	49.48	49.40	49.48	49.49	49.18	49.45	49.83	50.03	49.84	49.78	49.76
BB7	25.56	25.36	25.11	24.65	24.87	25.06	25.15	26.03	26.51	25.77	25.84	25.53	25.35	25.28	24.80	23.81	23.81	24.54	24.42	24.37	26.15	26.19	26.26	25.85	24.86	24.79
BB8	27.61	27.21	26.91	26.62	26.47	26.41	26.31	26.77	31.09	29.67	27.58	27.41	27.24	27.25	26.72	26.12	25.26	26.11	26.12	25.82	26.02	27.54	28.96	27.93	27.92	27.64
BB9	28.65	27.43	26.73	26.26	26.13	26.33	28.42	28.61	28.65	28.72	28.79	28.65	28.22	27.23	26.71	26.24	-	26.20	26.13	26.13	28.37	28.96	29.24	28.75	28.59	27.65
BB10	23.03	22.45	21.86	21.43	21.33	21.23	21.24	21.48	21.83	22.29	22.43	22.53	22.38	22.22	21.84	21.22	21.20	20.98	21.01	20.94	20.93	21.50	22.24	22.71	21.51	21.22
BB11	32.81	32.16	31.01	30.58	30.49	31.21	30.54	31.79	38.24	32.03	32.00	32.94	32.82	33.25	30.88	30.43	29.49	30.19	30.38	30.78	31.00	31.60	32.48	33.14	32.74	32.13
BB12	35.23	34.99	34.69	34.33	34.28	34.28	34.12	34.30	39.59	34.88	35.09	35.06	35.08	35.01	34.56	32.98	33.01	33.95	33.80	33.65	33.86	34.02	34.52	34.87	34.75	34.30
BB13	31.92	31.79	31.41	31.13	31.07	31.06	31.03	31.19	31.38	31.57	31.56	31.85	30.96	32.57	31.66	31.18	31.01	31.64	31.16	30.83	30.89	31.42	31.67	31.47	31.09	31.02

Appendix D

Groundwater Quality Results

Table D.1 Groundwater Quality Results for BB1

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	23.86	24.96	22.7	20.68	22.54	24.35	21.36	21.85
Salinity (mS/cm)	0.12-0.3	6.77	6.72	6.61	0.736	3.84	5.91	6.66	6.74
DO (%)	80-120	-	37.6	36.9	57.3	-	26	21.8	38.5
pH	6.5-8.0	5.61	5.43	5.62	4.16	6.19	5.67	5.25	5.29
Redox	-	-125	236	171	7	-24	25	41	38
Laboratory Analytes									
TN (µg/L)	1,200	280	330	440	310	2,500	150	540	1,400
TP (µg/L)	65	49	17	28	120	1,200	60	55	10
Ortho-P (µg/L)	40	<2	5	6	6	<2	20	9	<10
NH_4 (µg/L)	80	41	88	88	12	20	49	49	20
NO_2+NO_3 (mg/L)	0.15	2	12	120	13	<2	7	29	1,160
TKN (µg/L)	-	300	300	300	300	2,500	<200	500	200

Table D.2 Groundwater Quality Results for BB2

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	22.90	22.92	22.16	20.62	23.00	23.53	20.90	22.22
Salinity (mS/cm)	0.12-0.3	3.61	3.33	3.16	3.61	2.98	3.01	3.01	1.54
DO (%)	80-120	10.70	14.60	22.00	16.36	0.00	27.90	24.40	23.10
pH	6.5-8.0	5.81	5.65	5.65	5.22	5.89	5.78	5.65	5.77
Redox	-	113	156	-4	125	23	100	165	1630
Laboratory Analytes									
TN (µg/L)	1,200	770	1200	920	1,400	1,800	1,400	400	1,000
TP (µg/L)	65	24	75	97	57	370	150	51	20
Ortho-P (µg/L)	40	4	9	<2	7	<2	48	7	<10
NH_4 (µg/L)	80	20	7	35	<3	16	5	<3	<10
NO_2+NO_3 (mg/L)	0.15	680	980	580	1,400	1,100	1,500	840	1,040
TKN (µg/L)	-	<200	<200	300	<200	700	<200	400	<100

Table D.3 Groundwater Quality Results for BB3

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	21.62	23.06	23.03	20.16	20.40	23.40	21.24	20.70
Salinity (mS/cm)	0.12-0.3	0.63	0.36	0.30	0.00	0.22	0.73	0.77	0.28
DO (%)	80-120	19.80	15.80	45.60	47.60	0.00	62.80	19.70	32.50
pH	6.5-8.0	5.17	4.74	4.77	5.71	5.10	4.68	4.19	5.53
Redox	-	177	193	222	134	164	189	194	181
Laboratory Analytes									
TN (µg/L)	1,200	170	830	400	2,600	1,100	1,200	350	4,800
TP (µg/L)	65	26	200	21	66	17	650	94	7,560
Ortho-P (µg/L)	40	<2	2	<2	2	<2	3	<2	<10
NH_4 (µg/L)	80	48	49	25	<3	<3	43	27	<10
NO_2+NO_3 (mg/L)	0.15	69	11	280	2,300	1,000	230	9	1,490
TKN (µg/L)	-	<200	800	<200	300	<200	900	300	3,300

Table D.4 Groundwater Quality Results for BB4

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	24.84	24.64	21.86	22.53	22.89	22.71	20.51	21.70
Salinity (mS/cm)	0.12-0.3	2.62	2.65	2.52	2.70	2.52	2.35	0.99	2.64
DO (%)	80-120	46.50	29.60	27.50	28.20	0.00	42.50	56.20	14.10
pH	6.5-8.0	6.50	5.96	6.04	5.16	6.16	6.04	6.04	6.09
Redox	-	26	148	32	-128	43	115	134	98
Laboratory Analytes									
TN (µg/L)	1,200	2,800	6,900	3,600	2,000	3,200	3,100	3,500	2,300
TP (µg/L)	65	3,400	7,000	1,900	830	330	390	2,000	190
Ortho-P (µg/L)	40	13	21	11	21	23	95	21	50
NH_4 (µg/L)	80	42	53	15	43	21	11	11	30
NO_2+NO_3 (mg/L)	0.15	2,000	2,400	2,600	1,300	2,400	2,900	2,200	2,150
TKN (µg/L)	-	900	4,500	900	700	800	<200	1,300	100

Table D.5 Groundwater Quality Results for BB5

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	23.54	23.44	21.76	20.87	21.79	23.39	19.84	20.96
Salinity (mS/cm)	0.12-0.3	1.45	1.40	1.37	1.51	1.37	1.35	1.26	1.32
DO (%)	80-120	42.80	56.70	63.70	55.20	0.00	73.90	41.00	52.20
pH	6.5-8.0	6.06	5.49	5.51	6.04	5.70	5.78	5.64	5.80
Redox	-	148	150	141	109	166	128	144	162
Laboratory Analytes									
TN (µg/L)	1,200	290	1800	1,000	740	1,000	2,400	2,200	0
TP (µg/L)	65	67	320	210	430	200	230	150	0
Ortho-P (µg/L)	40	3	5	4	30	2	44	10	0
NH_4 (µg/L)	80	6	4	17	11	<3	16	17	0
NO_2+NO_3 (mg/L)	0.15	84	470	330	320	900	2,300	1,600	0
TKN (µg/L)	-	200	1,300	700	400	<200	<200	1,300	0

Table D.6 Groundwater Quality Results for BB6

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	22.48	23.48	22.16	21.96	21.47	21.18	17.56	21.93
Salinity (mS/cm)	0.12-0.3	2.98	2.92	2.93	3.17	2.98	1.85	3.05	2.64
DO (%)	80-120	12.56	21.50	36.10	54.60	0.00	60.40	56.10	51.70
pH	6.5-8.0	5.85	4.78	4.85	5.21	4.60	4.64	4.09	5.12
Redox	-	0	124	162	3.17	173	161	220	182
Laboratory Analytes									
TN (µg/L)	1,200	830	590	660	750	220	160	170	5,100
TP (µg/L)	65	120	160	150	800	440	260	120	190
Ortho-P (µg/L)	40	3	4	4	4	2	11	3	50
NH_4 (µg/L)	80	31	74	57	52	48	49	50	30
NO_2+NO_3 (mg/L)	0.15	12	26	12	<2	4	3	13	2,150
TKN (µg/L)	-	800	600	600	800	200	<200	<200	100

Bullsbrook Surface and Groundwater Monitoring – Final Monitoring Report
Prepared for Marlin Bullsbrook

Table D.7 Groundwater Quality Results for BB7

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	20.59	25.14	21.46	17.08	20.01	23.35	21.42	19.99
Salinity (mS/cm)	0.12-0.3	16.20	20.30	19.00	0.15	6.66	12.51	15.40	0.75
DO (%)	80-120	47.00	53.10	46.80	36.10	0.00	45.80	38.60	25.40
pH	6.5-8.0	5.94	5.49	5.85	5.62	5.39	5.42	5.18	5.65
Redox	-	109	168	112	130	99	112	148	99
Laboratory Analytes									
TN (µg/L)	1,200	2,000	2,200	1,000	18,000	3,900	3,000	900	11,100
TP (µg/L)	65	200	360	250	1,600	500	450	87	3,020
Ortho-P (µg/L)	40	3	11	13	4	3	27	11	<10
NH_4 (µg/L)	80	84	14	18	36	59	82	24	<10
NO_2+NO_3 (mg/L)	0.15	240	150	91	30	<2	28	55	80
TKN (µg/L)	-	1,800	2,000	900	18,000	3,900	3,000	800	11,000

Table D.8 Groundwater Quality Results for BB8

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	22.60	24.45	22.90	20.84	22.36	23.27	22.40	22.30
Salinity (mS/cm)	0.12-0.3	4.70	4.64	0.02	1.13	2.53	4.08	3.43	0.95
DO (%)	80-120	43.00	46.30	29.20	30.50	0.00	24.90	60.10	56.60
pH	6.5-8.0	5.97	5.68	5.91	6.99	6.31	5.96	6.11	6.66
Redox	-	74	160	33	58	92	96	120	86
Laboratory Analytes									
TN (µg/L)	1,200	1,000	2,500	1,500	2,200	3,000	820	1,100	900
TP (µg/L)	65	350	490	470	2,900	1,700	760	660	1,270
Ortho-P (µg/L)	40	5	15	15	29	14	70	14	10
NH_4 (µg/L)	80	41	100	23	22	11	41	57	10
NO_2+NO_3 (mg/L)	0.15	58	32	10	1,000	180	19	9	230
TKN (µg/L)	-	1,000	3,400	1,500	1,200	2,800	800	1,100	600

Table D.9 Groundwater Quality Results for BB9

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	20.93	0	22.93	17.63	22.05	0	0	20.51
Salinity (mS/cm)	0.12-0.3	1.40	0	0.78	1.29	1.15	0	0	1.77
DO (%)	80-120	88.00	0	91.20	76.20	0.00	0	0	93.80
pH	6.5-8.0	6.78	0	6.28	7.03	6.27	0	0	6.30
Redox	-	87.8	0	90	106	135	0	0	163
Laboratory Analytes									
TN (µg/L)	1,200	2,500	0	12,000	4,100	810	0	0	5,900
TP (µg/L)	65	150	0	480	890	170	0	0	310
Ortho-P (µg/L)	40	6	0	11	18	7	0	0	<10
NH_4 (µg/L)	80	38	0	77	3	6	0	0	30
NO_2+NO_3 (mg/L)	0.15	1,800	0	6,200	1,600	370	0	0	3,620
TKN (µg/L)	-	800	0	5,300	2,500	400	0	0	2,300

Table D.10 Groundwater Quality Results for BB10

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	21.74	26.32	23.35	21.06	21.92	23.60	23.30	21.50
Salinity (mS/cm)	0.12-0.3	1.76	1.89	1.89	0.09	1.50	1.89	1.79	1.22
DO (%)	80-120	33.80	47.40	66.00	19.00	0.00	33.00	36.40	47.50
pH	6.5-8.0	5.45	5.44	5.96	5.84	5.75	5.71	5.68	5.72
Redox	-	77	78	33	81	61	67	64	97
Laboratory Analytes									
TN (µg/L)	1,200	490	820	1,100	550	900	1,000	150	200
TP (µg/L)	65	580	900	1,500	1,300	1,500	1,500	130	280
Ortho-P (µg/L)	40	3	4	3	2	4	23	9	30
NH_4 (µg/L)	80	71	60	100	38	45	70	25	20
NO_2+NO_3 (mg/L)	0.15	<2	<2	6	10	<2	10	23	20
TKN (µg/L)	-	500	800	1,100	500	900	1,000	<200	100

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Table D.11 Groundwater Quality Results for BB11

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	22.17	25.44	22.07	0	21.31	22.85	20.84	21.84
Salinity (mS/cm)	0.12-0.3	2.46	0.00	2.41	0	2.29	2.34	1.05	2.33
DO (%)	80-120	19.10	51.70	22.90	0	0.00	24.50	52.40	33.50
pH	6.5-8.0	5.71	5.73	5.90	0	5.87	5.73	5.95	5.71
Redox	-	-348	-4	-69	0	-9	48	38	95
Laboratory Analytes									
TN (µg/L)	1,200	100	2,200	2,800	0	440	470	180	<100
TP (µg/L)	65	70	330	340	0	190	260	49	30
Ortho-P (µg/L)	40	3	3	5	0	6	18	<2	<10
NH_4 (µg/L)	80	31	32	1,600	0	68	82	68	<10
NO_2+NO_3 (mg/L)	0.15	3	4	14	0	4	11	4	50
TKN (µg/L)	-	<200	2,200	2,800	0	400	500	<200	<100

Table D.12 Groundwater Quality Results for BB12

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	21.76	21.87	21.76	20.05	20.41	21.70	19.25	20.82
Salinity (mS/cm)	0.12-0.3	3.72	3.21	3.30	3.47	4.37	4.10	3.39	3.55
DO (%)	80-120	48.40	25.40	36.70	22.50	0.00	58.80	53.00	59.30
pH	6.5-8.0	5.98	5.27	5.40	5.23	5.16	5.12	5.07	5.17
Redox	-	-38	99	71	131	141	160	150	119
Laboratory Analytes									
TN (µg/L)	1,200	230	390	560	370	800	240	270	1,200
TP (µg/L)	65	57	150	80	420	400	530	130	280
Ortho-P (µg/L)	40	3	4	3	11	3	50	2	<10
NH_4 (µg/L)	80	44	22	65	14	20	19	43	30
NO_2+NO_3 (mg/L)	0.15	28	3	22	7	18	3	3	30
TKN (µg/L)	-	200	400	500	400	800	200	300	1,100

Table D.13 Groundwater Quality Results for BB13

	Trigger Values	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	Jun-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	23.36	23.08	22.47	21.57	22.70	22.45	20.66	21.98
Salinity (mS/cm)	0.12-0.3	5.84	9.33	0.01	6.29	5.90	7.54	5.98	5.99
DO (%)	80-120	0.00	20.10	30.20	21.60	0.00	51.20	53.30	40.60
pH	6.5-8.0	5.89	5.32	5.59	5.63	5.38	4.32	5.01	5.21
Redox	-	88	119	169	92	72	149	216	195
Laboratory Analytes									
TN (µg/L)	1,200	390	1,800	530	360	170	250	140	<100
TP (µg/L)	65	900	800	1,500	1,000	540	470	130	210
Ortho-P (µg/L)	40	6	11	9	49	4	43	7	<10
NH_4 (µg/L)	80	35	11	12	37	32	29	9	40
NO_2+NO_3 (mg/L)	0.15	4	<2	5	27	4	2	19	<10
TKN (µg/L)	-	400	1,800	500	300	<200	300	<200	<100

Appendix F: District Water Management Strategy - Marlin Bullsbrook Urban

Emerge Associates, 2021

DISTRICT WATER MANAGEMENT STRATEGY

MARLIN BULLSBROOK URBAN

Project Number EP15-018

Prepared for Marlin Bullsbrook Pty. Ltd.
March 2021

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Executive Summary

Marlin Bullsbrook Pty Ltd (the proponent) proposes the initiation of a Metropolitan Region Scheme (MRS) amendment over a collection of landholdings within the locality of Bullsbrook (herein referred to as 'the site'). The parcels of land within the site are described in **Section 1.1**, with the location of the site shown on **Figure 1**. The proponent has control of several lots within the site.

The site is comprised of lots zoned 'General Rural', 'Landscape' and 'Recreation' under the City of Swan (CoS) Local Planning Scheme (LPS) No. 17 (CoS 2013) and 'Rural' under the Metropolitan Region Scheme (MRS) (WAPC 2014). This District Water Management Strategy (DWMS) details the water management approach proposed for the development to support a MRS amendment application to rezone the site to 'urban'. The DWMS has been prepared in accordance with *Better Urban Water Management* (WAPC 2008), and *State Planning Policy 2.9 Water Resources* (WAPC 2006).

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. Characteristics of the existing environment within the site have been investigated. In summary, the environmental investigations conducted to date indicate that:

- The site receives 652 mm of rainfall annually, on average. The majority of rainfall is received between May and September.
- Surface elevations within the site range from 35 m Australian height datum (AHD) in the west to 85 m AHD in the east. The site therefore has a westerly aspect.
- The site is primarily underlain by colluvial sandy silt. The low lying land to the west of the site is classified as pebbly silt associated with the Guildford Formation. A schist formation exists to the east of the site.
- Acid sulfate soil (ASS) risk mapping indicate that there is no known risk of encountering ASS within 3 m of the natural ground surface within the majority of the site. An area to the east of the site associated with the schist deposit is classified as having a 'moderate to low risk'.
- The majority of the site is classified as a multiple use wetland (MUW). The nearest conservation category wetland (CCW) is located approximately 250 m to the northwest of the site.
- Nambad Brook transects the north eastern portion of the site, and a small agricultural drain exists in the centre of the site. Flows within these features discharge into Ellen Brook, located approximately 1.2 km to the west of the site.
- 1% AEP peak flows within Nambad Brook were modelled to be 21.6 m^3/s, with peak flows in the smaller agricultural drain modelled to be 7.5 m^3/s. The outlet at the south western corner of the site was modelled to have a peak discharge of 5.26 m^3/s.
- Surface water within Nambad Brook (downstream of the site) was observed to have low to moderate nutrient concentrations, slightly elevated EC, and neutral pH. The peak nutrient concentrations were generally observed during June and July.
- Groundwater underlying the site flows from east to west. The estimated MGL at seven locations within and adjacent to the site range from 32.57 m AHD to 50.50 m AHD. The corresponding depth to MGL is estimated to range from 0.00 m to 22.23 m.
- The site has historically been cleared for rural purposes.

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MARLIN BULLSBROOK URBAN

The overall objective for integrated water cycle management for the development is to mimic the existing hydrological regime of the site. The design objectives seek to deliver best practice outcomes using a water sensitive urban design (WSUD) approach, including detailed management approaches for:

- Water supply and conservation
- Flood mitigation
- Surface water quality.
- Groundwater management.

The objectives and principles proposed in this DWMS are informed by the *Regional Water Management Strategy* (RWMS) which was prepared by GHD (2012) to support the endorsed *Bullsbrook Townsite Land Use Master Plan* (Bullsbrook Master Plan) (CoS 2014), and based on the characteristics of the existing environment and a contemporary best-practice approach to integrated water cycle management.

The primary objectives which have informed the preparation of this DWMS are as follows:

- Provide a broad level stormwater management framework to support future urban residential development.
- Incorporate appropriate best management practices (BMP) into the drainage system that address the environmental and stormwater management issues identified.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise ongoing operation and maintenance costs for the land owners and CoS.
- Develop a water supply and conservation strategy for the site that will aim to meet water use targets.
- Maintain existing runoff regimes entering and leaving the site.
- Manage runoff water quality to protect downstream environments.
- Protect infrastructure and downstream environments from flooding during large storm events.
- Maintain and protect sensitive riparian vegetation within the site.
- Protect underlying groundwater resources by minimising nutrient export from the site.
- Gain support from Department of Water (DoW) and CoS for the proposed method to manage stormwater within the site and potential impacts on downstream areas.

The objectives described above have been used to develop a set of design criteria that are proposed to guide the development of the site. These proposed criteria are presented in **Table E1**. This table provides a readily auditable summary of the required outcomes which can be used in future planning stages to demonstrate that the agreed objectives for water management at the site have actually been achieved.

Table E1: *Proposed criteria and management approach*

Management Aspect	DWMS Objective	Proposed Design Criteria and Management Approach
Water supply and conservation	• Develop a water supply and conservation strategy for the site that will aim to meet water use targets.	WC1: Utilise fit for purpose water sources throughout the development.
		WC2: Consumption target for water of 100 kL/person/year, including not more than 60 kL/person/year of scheme water.
Stormwater management	• Provide a broad level stormwater management framework to support future urban residential development. • Incorporate appropriate best management practices (BMP) into the drainage system that address the environmental and stormwater management issues identified. • Protect infrastructure and downstream environments from flooding during large storm events. • Manage runoff water quality to protect downstream environments.	SW1: Retain and treat the 1 exceedance per year event (1EY) as close to source as possible where practicable, and consistent with the pre-development environment.
		SW2: Post-development peak discharge rates should not exceed pre-development peak discharge rates.
		SW3: Provide flow pathways for existing upstream flows entering the site.
		SW4: Provide a minimum clearance of 500 mm between habitable floor levels and the 1% average exceedance probability (AEP) flood levels within onsite storage areas.
		SW5: Minor roads must remain passable in the 20% AEP event.
		SW6: Swales and vegetated bio-retention areas (BRA) are to be sized to at least 2% of the connected impervious area.
		SW7: Utilise appropriate structural and non-structural measures to reduce nutrient loads
		SW8: Surface water quality leaving the site should be the same or better than that entering the site.
Groundwater management	• Protect underlying groundwater resources by minimising nutrient export from the site.	GW1: Provide a minimum clearance of 1.2 m between lot levels and MGL.
		GW2: Provide a minimum clearance of 500 mm between BRA and flood storage area (FSA) inverts to MGL.
		GW3: Maintain or improve the quality of groundwater leaving the site.
Implementation and ongoing management	• Minimise development construction costs, which will result in reduced land costs for future home owners. • Minimise ongoing operation and maintenance costs for the land owners and CoS.	Minimise the use of fill by mimicking the existing topography and catchment areas.
		Use groundwater for the irrigation of public open space (POS).
		DoW and CoS approval will be sought at each stage of planning (DWMS, LWMS, UWMP etc).

Management Aspect	DWMS Objective	Proposed Design Criteria and Management Approach
	• Gain support from DoW and CoS for the proposed method to manage stormwater within the site and potential impacts on downstream areas.	

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Preliminary Concept Plan

Appendix B
Pre-development Monitoring Report

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DoW Monitoring Bore GD15 - Hydrograph

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DISTRICT WATER MANAGEMENT STRATEGY
MARLIN BULLSBROOK URBAN

1 Introduction

1.1 Background

Marlin Bullsbrook Pty Ltd (the proponent) proposes the initiation of a Metropolitan Region Scheme (MRS) amendment over a collection of landholdings within the locality of Bullsbrook (herein referred to as 'the site'). The parcels of land comprising the site are described in **Table 1**. The proponent has control of several lots within the site.

The location of the site is shown on **Figure 1**, with aerial imagery illustrating the current condition and cadastral boundaries of the site shown on **Figure 2**.

Table 1: *Land ownership and lot details for landholdings comprising the site*

Lot No. / Address	Plan / Diagram	Volume / Folio	Proprietor/s	Approximate area within site (ha)
Lot 1 (No. 2428) Great Northern Highway	D22890	1213 / 929	EM Warren	0.54
Part Lot 1 (No. 2242) Great Northern Highway	D61074	1948 / 370	Lotus 55 Investment Aust Pty Ltd	9.1
Lot 2 (No. 2424) Great Northern Highway	D22890	1213 / 929	EM Warren	0.44
Part Lot 2 (No. 2234) Great Northern Highway	D61074	1857 / 582	DJ and EG Manuel	9.28
Part Lot 2 (No. 2306) Great Northern Highway	D2206	10 / 346A	Midland Brick Co Pty Ltd	11.52
Lot 5 (No. 2422) Great Northern Highway	P31211	2574 / 499	M Bozanich	0.45
Lot 6 (No. 2416) Great Northern Highway	P31211	2574 / 500	DKM and GM Bozanich	0.43
Lot 61 (No. 2342) Great Northern Highway	P42250	2582 / 885	Timevalley Pty Ltd	41.28
Lot 100 Great Northern Highway	D6254	1634 / 859	G and E Park, and McRae Investments Pty Ltd	1.31
Lot 100 (No. 2286) Great Northern Highway	P27953	2053 / 531	JE Bounsell	0.09
Part Lot 101 (No. 2274) Great Northern Highway	P27953	1334 / 698	Beta International Pty Ltd	11.39
Lot 1355 (No. 2258) Great Northern Highway	P231314	1950 / 340	Lotus 55 Investment Aust Pty Ltd	0.81
Lot 1415 (No. 2430) Great Northern Highway	P252653	1912 / 591	RT Brennan	40.93
Lot 4 Lage Road	D59157	1642 / 965	G and E Park, and McRae Investments Pty Ltd	7.66
Part Lot 302 (No. 61) Lage Road	P29235	2096 / 311 and 2096 / 751	G and E Park, and McRae Investments Pty Ltd	53.9

1.2 Town planning context

The site is comprised of lots zoned 'General Rural', 'Landscape' and 'Recreation' under the City of Swan (CoS) Local Planning Scheme (LPS) No. 17 (CoS 2013) and 'Rural' under the Metropolitan Region Scheme (MRS) (WAPC 2014). A scheme amendment is proposed to rezone the site "Urban" under the MRS and 'Residential Development' under the LPS No. 17.

This proposal is in accordance with the established land use planning framework set out for the Bullsbrook Locality, as described in the endorsed *Bullsbrook Townsite Land Use Master Plan* (Bullsbrook Master Plan) (CoS 2014). The rezoning will facilitate residential development of the site following detailed local structure planning and subdivision approval.

1.3 Purpose of this report

It is important that the manner in which stormwater runoff from urban zoned areas is to be managed to avoid flooding and protect the environment is clearly documented early in the planning process. This approach provides the framework for actions and measures to achieve the desired outcomes at subdivision and development stages.

This District Water Management Strategy (DWMS) details the water management approach proposed for the development to support a MRS amendment application to rezone the site from 'rural' to 'urban', and has been prepared in accordance with *Better Urban Water Management* (WAPC 2008).

1.4 Policy framework

There are a number of State Government policies of relevance to the site. These policies include:

- *State Water Strategy* (Government of WA 2003)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Liveable Neighbourhoods Edition 4* (WAPC 2007)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009)

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that rural residential developments should aim to achieve. These are key inputs that relate either directly or indirectly to the site and include:

- *Better Urban Water Management* (WAPC 2008)
- *Australian Runoff Quality* (Engineers Australia 2006)
- *Australian Rainfall and Runoff* (Ball J *et al.* 2019)
- *Decision Process for Stormwater Management in Western Australia* (DoW 2017)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *Guidelines for district water management strategies* (DoW 2013)
- *National Water Quality Management Strategy* (ANZECC 2000)
- *Development Design Specification D4: Subsurface drainage design* (CoS 1998)
- *Development Design Specification D5: Stormwater drainage design* (CoS 2002a)
- *Handbook of Stormwater Drainage Design* (CoS 2002b).

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The guidance documents listed indicate a need for accurate water quality baseline data prior to residential development. This will ensure that any future development is able to fulfil the stormwater management requirements of the Department of Water and Environmental Regulation (DWER) and engineering standards specified by the CoS, but will also ensure that realistic water quality criteria that are practically achievable are adopted.

1.5 Regional Water Management Strategy

A *Regional Water Management Strategy* (RWMS) was prepared by GHD (2012) to support the Bullsbrook Master Plan, which was developed to assist broad ranging strategic land use planning across the greater Bullsbrook area. It was identified within the Bullsbrook Master Plan that drainage was likely to be a major constraint to development and that more detailed investigations were required prior to endorsement of the document by the WAPC. The RWMS provides guiding steps for implementation of further investigations within the Bullsbrook Townsite area.

The design criteria adopted in the RWMS were based on the design objectives in *Better Urban Water Management* (WAPC 2008), taking into consideration the site specific conditions and developmental constraints. The key design criteria proposed in the RWMS which are relevant to the site are summarised in the following sections.

1.5.1 Water conservation and water use efficiency

- Developments should achieve a maximum water consumption target of 100 kL/person/year. Where a non-drinking water source is available, the target should be not more than 60 kL/person/year of scheme water.
- Water wise landscaping should be employed in public open space (POS) and irrigation restricted during the day.

1.5.2 Stormwater management

- Retain or detain the 1EY (or nominally the first 15mm) at source.
- Floodways are to be maintained with respect to their ecological value and current hydraulic capacity; and should be restored if required so they function as an ecological environment and a healthy watercourse.
- Avoid modification of existing channels and floodways unless it is to ensure continuation of flows or works to restore the function of the channel or floodway as an ecological environment.
- Incorporate flood storage areas into POS, located outside of defined floodways.
- Stormwater management features should be designed such that any detained, immobile water is fully infiltrated within 96 hours to prevent the creation of mosquito breeding habitat.
- Swales and vegetated bio-retention systems are to be sized at a minimum of 2% of the constructed impervious area from which they receive runoff.

1.5.3 Protect infrastructure

- Development may not occur within floodways.
- Minimum habitable floor levels must be at least 500 mm above the 1% AEP flood levels within flood storage basins or surface water features.

- Minimum habitable floor levels must be at least 300 mm above the 1% AEP flood levels in local drainage networks.
- Minor roads shall be passable in the 20% AEP event.

1.5.4 Groundwater management

- Where a perched water table exists or the predicted maximum groundwater level (MGL) is at or within 1.2 m of natural ground levels, measures should be implemented to ensure that adequate separation of building floor slabs from groundwater is achieved.
- Proposals to lower or control groundwater levels must demonstrate no or negligible impact of groundwater dependent ecosystems.

1.5.5 Nutrient management

- Where subsoil drainage is proposed, a treatment system such as a swale or bio-filter at each outlet point will be required.
- Maintain or improve the quality of groundwater leaving the site.
- Where the pre-development pollutant concentrations are known, the outputs of the development must not exceed these values. Where the existing concentrations are not known, the development outputs must not exceed the relevant guidelines stipulated in the *National Water Quality Management Strategy* (ANZECC 2000).
- Prior to construction of flood storage areas, phosphorous retention index (PRI) testing will be undertaken. If the existing soils have a PRI less than 10, soils will require amendment with high PRI soils such as red clays.

1.6 DWMS objectives

This DWMS has been developed in consideration of the objectives and principles detailed in *Better Urban Water Management* (WAPC 2008) and the RWMS (GHD 2012). It is intended to support the rezoning of the site from 'rural' to 'urban' and is further based on the following major objectives:

- Provide a broad level stormwater management framework to support future urban residential development.
- Incorporate appropriate best management practices (BMP) into the drainage system that address the environmental and stormwater management issues identified.
- Minimise development construction costs, which will result in reduced land costs for future home owners.
- Minimise ongoing operation and maintenance costs for the land owners and CoS.
- Develop a water supply and conservation strategy for the site that will aim to meet water use targets.
- Maintain existing runoff regimes entering and leaving the site.
- Manage runoff water quality to protect downstream environments.
- Protect infrastructure and downstream environments from flooding during large storm events.
- Maintain and protect sensitive riparian vegetation within the site.
- Protect underlying groundwater resources by minimising nutrient export from the site.
- Gain support DWER and CoS for the proposed method to manage stormwater within the site and potential impacts on downstream areas.

Detailed objectives for water management within the site are further discussed in **Section 4**.

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2 Proposed Development

The site covers approximately 209 ha. The development will allow for the creation of approximately 3,000 residential lots. Residential densities proposed range between R12.5 and R60. The development of the site will allow for a minimum public open space requirement of 20.9 ha, including significant areas of conservation reserve.

A primary school and adjacent playing fields are also proposed, although are unlikely to be constructed for some time following completion of the development.

The concept plan for the site is provided in **Appendix A**.

3 Pre-Development Environment

3.1 Sources of information

The following sources of information were used to provide a broad regional environmental context to the site:

- *National Water Quality Management Strategy* (NWQMS) (ANZECC 2000)
- *Perth Metropolitan Region 1:50,000 Environmental Geology Series* (Gozzard 1982)
- *Bulletin 64/2009: Acid Sulfate Soil Risk Mapping (WAPC 2009)*
- *Perth Groundwater Atlas* (DoW 2015a)
- *Water Register (*DoW 2015b)
- *Weather and Climate Statistics data* (BoM 2015)
- *Bullsbrook Surface and Groundwater Monitoring - Final Monitoring Report* (Cardno 2010)
- *District Water Management Strategy - Great Northern Gateway Industrial Cell* (Cardno 2012)
- *Local Water Management Strategy - South Bullsbrook Industrial Precinct Local Structure Plan 1* (Emerge Associates 2014).

3.2 Climate

The site experiences a dry Mediterranean climate of hot, dry summers and cool wet winters. The closest weather station to the site which records rainfall and temperature data is at Pearce RAAF base (Station #009053), located approximately 2km to the north west of the site. Based on the data collected at this location spanning 1937 to 2020, the local area experiences an average annual rainfall of 652 mm. The average maximum and minimum temperatures recorded at the Pearce RAAF base weather station are 25.2°C and 12.2°C, respectively (BoM 2020).

3.3 Geotechnical conditions

3.3.1 Topography

The site is located on the darling scarp, with natural surface elevations ranging from 35 m Australian height datum (AHD) in the west to 85 m AHD in the east. As such, the site has a westerly aspect with an overall grade of approximately 7%. The steeper gradients are experienced in the eastern portion of the site. The topographic contours across the site are shown on **Figure 3**.

3.3.2 Soils and geology

The site is predominantly underlain by colluvial sandy silt (Msg). The low lying land associated with Nambad Brook and to the west of the site is classified as pebbly silt associated with the Guildford Formation (Mgs_1), and a deposit of Schist (SC_2) lies to the east of the site.

The geological units identified at the site are described below (Gozzard 1982), with regional mapping illustrated on **Figure 4**.

Msg Sandy Silt: strong brown, firm, friable, dispersive in part, occasional pebbly horizons with little matrix containing quartzite, quartz, granite, laterite, of colluvial origin (Colluvium (Qc)).

SC_2 Schist: grey to pale grey, highly schistose quartz mica schist (Migmatite (Am)).

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Mgs_1 Pebbly Silt: strong brown, silt with common fine to occasionally coarse grained, sub-rounded laterite, quartz, heavily weathered granite pebbles, some fine to medium grained quartz sand, of alluvial origin (Guildford Formation (Qpa)).

These soil types typically exhibit low permeability, which may limit the capacity of the site to dispose of stormwater via infiltration.

3.3.3 Acid sulfate soils

Regional acid sulfate soil (ASS) risk mapping published by the WAPC (2009) indicates that the majority of the site is classified as having no known risk of actual or potential ASS occurring within 3 m of the natural soil surface. An area to the east of the site, associated with the Schist deposit, is classified as having 'moderate to low' risk. Regional ASS risk mapping is shown on **Figure 5**.

3.4 Wetlands

A multiple use wetland (MUW) (UFI #15282) covers the majority of the site. The nearest conservation category wetland (CCW) is located approximately 170 m to the north west of the site, associated with segments of Nambad Brook (UFI #15282). Geomorphic wetlands are shown on **Figure 6**.

3.5 Surface water

3.5.1 Surface water quantity

The site is within the Ellen Brook catchment, with Ellen Brook located approximately 1.5 km to the west of the site. Nambad Brook, a tributary to Ellen Brook, transects the north eastern portion of the site. A smaller agricultural drain transects the middle of the site, flowing from east to west. A pre-development monitoring report detailing surface water quantity relevant to the site was prepared by Cardno (2010), and is provided in **Appendix B**.

Surface water flows were measured over a two year period during 2008 and 2009 in Nambad Brook, where is passes beneath Great Northern Highway (downstream of the site). A rain gauge and flow meter were installed at this location with flow rates measured at 10 minute intervals (Cardno 2010).

Flows were observed in Nambad Brook between June 2009 and October 2009, with velocities ranging from 0 m/s to 3 m/s. The cumulative volume of water observed to flow through this section of Nambad Brook during 2009 was 225 GL. The peak discharge rate observed was 0.99 m^3/s in October 2009.

The highest observed monthly discharge was 119 GL, in July 2009, which was due to two significant rainfall events being experienced within two days. Overall, monitoring at this location captured four significant rainfall events, which are summarised in **Table 2**.

The information presented in **Table 2** was used during the preparation of a DWMS for the industrial land to the west of the site to calibrate a pre-development model of the flows within Nambad Brook, the smaller agricultural drain in the middle of the site and a number of other discharge points that were identified (Cardno 2012). More recently, Emerge Associates (2014) have undertaken additional modelling of the two southern most discharge points during the preparation of a Local Water Management Strategy for the southern portion of the industrial site to the west.

Table 2: Observed significant rainfall events and corresponding peak discharge rates (Nambad Brook)

Date	Observed Duration (min)	Observed Total Rainfall (mm)	Corresponding Design Rainfall Event	Observed Peak Discharge (m^3/s)
31 Jan 2009	30	8.6	1 year 30 min	0.00
18 June 2009	30	6.0	1 year 30 min	0.00
19 July 2009	1,270	53.7	2 year 1,440 min	0.77
20 July 2009	2,410	54.8	1 year 2,880 min	0.54

(Cardno 2010)

The pre-development modelling indicates that the peak discharge from the site via Nambad Brook during a 1% AEP event is 21.6 m^3/s. The peak discharge rates from the agricultural drain and the southern outlet are estimated to be 7.5 m^3/s and 5.26 m^3/s, respectively. The locations of these and the other minor discharge points and their modelled peak discharge rates are shown on **Figure 6**.

3.5.2 Surface water quality

Surface water quality monitoring was undertaken on eight occasions in Nambad Brook, at the point where this feature crosses Great Northern Highway (downstream of the site). A summary of the results and the relevant guideline values for lowland rivers in South Western Australia (ANZECC 2000) is provided in **Table 3**. A pre-development monitoring report detailing surface water quality relevant to the site was prepared by Cardno (2010), and is provided in **Appendix B**.

Table 3: Summary of surface water quality (Nambad Brook)

Parameter	Guideline	Jul-08	Aug-08	Aug-08	Jun-09	Aug-09	Sep-09	Sep-09	Oct-09
Temperature [°C]		14.67	12.96	15.01	15.00	16.74	14.77	17.98	18.73
Electrical Conductivity (EC) [mS/cm]	0.12-0.30	0.19	0.56	0.64	0.78	0.79	1.46	0.49	0.15
Dissolved Oxygen (DO) [% saturation]	80 - 120	88.7	87.3	74.0	68.4	57.9	92.9	98.7	84.3
pH [pH units]	6.5 - 8.0	7.26	6.93	7.36	7.67	6.98	6.98	7.01	7.00
eH (Redox) [mV]		202	117	112	115	140	124	104	127
Ammonium (NH_4) [mg/L]	0.08	0.031	<0.003	0.018	0.200	0.040	0.040	0.110	0.030
Nitrites and Nitrates (NO_2 + NO_3) [mg/L]	0.15	0.083	0.007	0.160	0.330	0.170	0.150	<0.010	0.050
Total Kjeldahl Nitrogen (TKN) [mg/L]		1.00	0.50	0.60		0.50	0.60	0.40	0.40
Total Nitrogen (TN) [mg/L]	1.20	1.10	0.53	0.76	1.80	0.70	0.80	0.40	0.50
Phosphate (Ortho-P, PO_4) [mg/L]	0.040	0.008	0.004	0.005	0.140	<0.010	<0.010	0.020	<0.010
Total Phosphorous (TP) [mg/L]	0.065	0.210	0.042	0.037	0.260	0.030	0.010	0.050	0.010

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(Cardno 2010)

These results indicate that all nutrient concentrations are low to moderate, electrical conductivity (EC) is slightly elevated, and pH values are generally neutral. Relatively high nutrient concentrations were observed during June and July, however the baseline concentrations were all generally low. This is likely to correspond with the first rainfall events of the winter season flushing accumulated nutrients from the catchment. EC values were observed to peak in September, which corresponds with the peak groundwater levels.

3.6 Groundwater

3.6.1 Groundwater resources

Groundwater resource mapping available from the DoW Water Register (DoW 2015) indicates that the site is underlain by a multi-layered aquifer system comprised of the following resources:

- Perth - Superficial Swan (unconfined)
- Perth - Leederville (confined)
- Perth - Yarragadee North (confined).

Four groundwater licences have been issued to landholdings within the site. These are summarised in **Table 4**. The Perth - Superficial Swan aquifer is proposed to be used as a source of non-potable water for irrigation purposes. The use of groundwater is further described in **Section 5.1.2**.

Table 4: Summary of existing groundwater licences

Licence Number	Licence Address	Aquifer	Licence Allocation (kL)	Parties
161848	Lots 1 & 2 Great Northern Highway (Diagram 61074)	Leederville	1,500	Manuel, Dennis and Ellen
166199	Lot 1 Great Northern Highway (Diagram 61074)	Leederville	1,500	Lotus 55 Investment Aust Pty Ltd
163481	Lot 1415 Great Northern Highway (Plan 252653)	Superficial Swan	10,222	Brennan, Richard Thomas
180972	Lot 61 Great Northern Highway (Plan 42250)	Superficial Swan	27,800	Marlin Bullsbrook Pty Ltd

3.6.2 Groundwater levels

The site is on the fringe of the available DoW datasets. The *Perth Groundwater Atlas* provides groundwater contours from May 2003 which cover the western boundary of the site. These contours, considered to be the minimum groundwater elevations, suggest that minimum groundwater levels at the western boundary of the site are between approximately 35 m AHD and 43 m AHD.

The results of a site specific groundwater investigation undertaken by Cardno (2010) are provided in **Appendix B**. This two year investigation measured the depth to groundwater at thirteen locations in the vicinity of the site, including seven locations within or immediately adjacent to the site. The hydrograph at the seven locations within and adjacent to the site is provided in **Chart 1**. The locations

of the monitoring bores are shown on **Figure 3**. Peak groundwater elevations were generally observed in October, although the peak at some locations was observed to occur in July.

Maximum groundwater levels (MGL) have been estimated based on the data recorded by Cardno (2010). Peak elevations measured in October 2008 and 2009 were referenced to DoW long term records from nearby monitoring location GD15 (WIN Site ID 5426). The location of GD15 is shown on **Figure 3**, and the long term hydrograph for GD15 is provided in **Appendix C**.

Where the maximum recorded elevation at a particular location is greater than the referenced MGL (i.e. where the peak occurred in July), the maximum observed water level at that location has been used. The resulting MGLs at the nearby monitoring locations are provided in **Table 5**, with MGL contours shown on **Figure 3**.

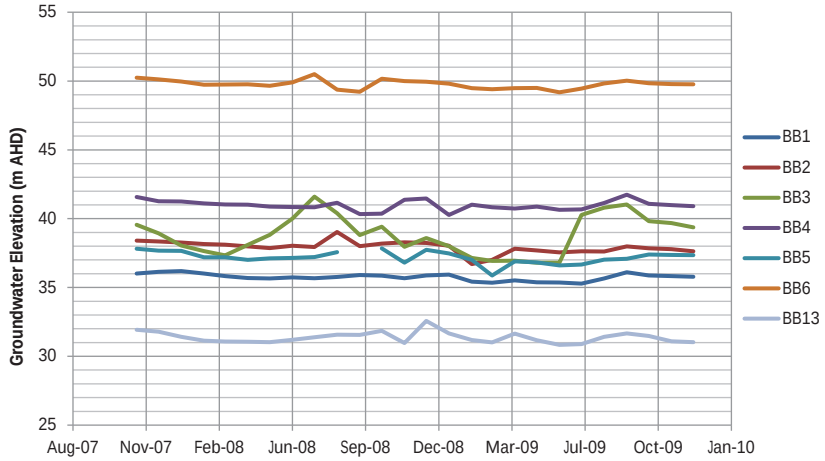

Chart 1: *Groundwater hydrograph*

The results of the monitoring program and the MGL contours indicate a south westerly groundwater flow direction. The least clearance to the MGL is observed at BB3 (western boundary of the site), where the groundwater was at the natural ground surface. The clearance at BB2 and BB4 (eastern portion of the site) is estimated to be 14.52 m and 22.23 m, respectively.

Table 5: *Estimated maximum groundwater levels*

Bore ID	MGL (m AHD)	Natural ground level (m AHD)	Depth to MGL (m)
BB1	36.21	40.52	4.31
BB2	39.03	53.55	14.52
BB3	41.60	41.60	0.00
BB4	41.74	63.97	22.23
BB5	38.17	48.56	10.39
BB6	50.50	55.62	5.12
BB13	32.57	45.76	13.19

3.6.3 Groundwater quality

Groundwater quality monitoring was conducted on a quarterly basis between November 2007 and October 2009. A summary of the results measured by Cardno (2010) and the relevant guideline values for lowland rivers in South Western Australia (ANZECC 2000) is provided in **Appendix B** and summarised in **Table 6**.

Table 6: *Summary of average groundwater quality monitoring results*

Parameter	Guideline	BB1	BB2	BB3	BB4	BB5	BB6	BB13
Temperature [°C]		22.79	22.28	21.70	22.71	21.95	21.53	22.28
Electrical Conductivity (EC) [mS/cm]	0.12 - 0.30	5.50	3.03	0.41	2.37	1.38	2.82	5.86
Dissolved Oxygen (DO) [% saturation]	80 - 120	36.35	19.87	34.83	34.94	55.07	36.62	27.13
pH [pH units]	6.5 - 8.0	5.40	5.68	4.99	6.00	5.75	4.89	5.29
eH (Redox) [mV]		46.13	105.13	181.75	58.50	143.50	128.15	138
Ammonium as N (NH_4-N) [mg/L]	0.08	0.046	0.017	0.038	0.028	0.012	0.05	0.026
Nitrites and Nitrates as N (NO_2-N + NO_3-N) [mg/L]	0.15	0.191	1.015	0.673	2.243	0.857	0.28	0.008
Total Kjeldahl Nitrogen as N (TKN-N) [mg/L]		0.628	0.466	1.120	1.314	0.720	0.438	0.413
Total Nitrogen as N (TN) [mg/L]	1.20	0.743	1.111	1.431	3.425	1.347	0.773	0.455
Phosphate as P (Ortho-P, PO_4-P) [mg/L]	0.040	0.009	0.015	0.002	0.032	0.014	0.010	0.016
Total Phosphorous as P (TP) [mg/L]	0.065	0.192	0.105	1.079	2.005	0.229	0.280	0.694

Source: Cardno (2010)

Notably high average concentrations of total phosphorous (TP) were recorded at BB3 and BB4. These were generally accompanied with a relatively high standard deviation which indicates significant variability in TP concentrations during the monitoring period, or that an outlier may have skewed the results. The average total nitrogen (TN) concentration at BB4 is slightly elevated, although this was generally moderate throughout the monitoring period.

3.7 Current and historical land use

Based on a review of historical aerial imagery, the majority of remnant vegetation across the site was cleared prior to 1965 primarily to support a range of agricultural land uses. The majority of the site has since supported such land uses, including cropping and grazing, with the exception of some areas of remnant vegetation associated with existing waterways and the Darling Escarpment.

A small area of approximately 3.5 ha within Lot 2 in the south east portion of the site has historically been quarried to extract clay resources with operations commencing in the mid 1970's, before extraction was ceased and the area rehabilitated and revegetated around 2001.

3.8 Summary of existing environment

In summary, the environmental investigations carried out to date indicate that:

- The site receives 652 mm of rainfall annually, on average. The majority of rainfall is received between May and September.
- Surface elevations within the site range from 35 m Australian height datum (AHD) in the west to 85 m AHD in the east. The site therefore has a westerly aspect.
- The site is primarily underlain by colluvial sandy silt. The low lying land to the west of the site is classified as pebbly silt associated with the Guildford Formation. A schist formation exists to the east of the site.
- Acid sulfate soil (ASS) risk mapping indicate that there is no known risk of encountering ASS within 3 m of the natural ground surface within the majority of the site. An area to the east of the site associated with the schist deposit is classified as having a 'moderate to low risk'.
- The majority of the site is classified as a multiple use wetland (MUW). The nearest conservation category wetland (CCW) is located approximately 250 m to the northwest of the site.
- Nambad Brook transects the north eastern portion of the site, and a small agricultural drain exists in the centre of the site. Flows within these features discharge into Ellen Brook, located approximately 1.2 km to the west of the site.
- 1% AEP peak flows within Nambad Brook were modelled to be 21.6 m^3/s, with peak flows in the smaller agricultural drain modelled to be 7.5 m^3/s. The outlet at the south western corner of the site was modelled to have a peak discharge of 5.26 m^3/s.
- Surface water within Nambad Brook (downstream of the site) was observed to have low to moderate nutrient concentrations, slightly elevated EC, and neutral pH. The peak nutrient concentrations were generally observed during June and July.
- Groundwater underlying the site flows from east to west. The estimated MGL at seven locations within and adjacent to the site range from 32.57 m AHD to 50.50 m AHD. The corresponding depth to MGL is estimated to range from 0.00 m to 22.23 m.
- The site has historically been cleared for rural purposes.

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4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this DWMS and future management strategies must achieve. The water management strategy covers stormwater management, groundwater management and water supply and conservation.

4.1 Integrated water cycle management

The *State Water Strategy* (Government of WA 2003) and *Better Urban Water Management* (WAPC 2008) endorse the promotion of integrated water cycle management and application of WSUD principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies.

The key principles of integrated water cycle management include:

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

Integrated water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Stormwater management design objectives should therefore seek to deliver best practice outcomes in terms of:

- Water supply and conservation
- Flood mitigation
- Surface water quality
- Groundwater management.

The first step in applying integrated water cycle management in urban residential catchments is to establish agreed environmental values for receiving environments. The existing environmental context of the site has been discussed in **Section 3** of this document. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines and site specific studies undertaken in and around the site development. These were detailed in **Section 1.4** and **Section 3.1**.

The design criteria discussed in the following sections are based on the assessment of the existing environment within the site and downstream, and with the aim of achieving the integrated water cycle outcomes discussed above.

4.2 Water supply and conservation

Water conservation design criteria have been determined in line with the guidelines presented in *Better Urban Water Management* (WAPC 2008). This DWMS proposes the following criteria.

Criterion WC1 Utilise fit for purpose water sources throughout the development.

Criterion WC2 Consumption target for water of 100 kL/person/year, including not more than 60 kL/person/year of scheme water.

The manner in which these objectives are proposed to be achieved is further detailed in **Section 5**.

4.3 Stormwater management

The principle behind stormwater management at the site is to mimic the pre-development hydrological conditions, as described in **Section 3.5**. This principle and the documents discussed in **Section 1.4** have guided the stormwater management criteria. This DWMS proposes the following stormwater management criteria:

Criterion SW1 Retain and treat the 1EY as close to source as possible where practicable, and consistent with the pre-development environment.

Criterion SW2 Post-development peak discharge rates should not exceed pre-development peak discharge rates.

Criterion SW3 Provide flow pathways for existing upstream flows entering the site.

Criterion SW4 Provide a minimum clearance of 500 mm between habitable floor levels and the 1% AEP flood levels within onsite storage areas.

Criterion SW5 Minor roads must remain passable in 20% AEP event.

Criterion SW6 Swales and vegetated bio-retention areas (BRA) are to be sized to at least 2% of the connected impervious areas.

Criterion SW7 Utilise appropriate structural and non-structural measures to reduce nutrient loads.

Criterion SW8 Surface water quality leaving the site should be the same or better than that entering the site.

The manner in which these objectives are proposed to be achieved is further detailed in **Section 6**.

4.4 Groundwater management

The principle behind the groundwater management strategy is to maintain the existing groundwater hydrology. This DWMS proposes the following groundwater management criteria:

Criterion GW1 Provide a minimum clearance of 1.2 m between lot levels and the MGL.

Criterion GW2 Provide a minimum clearance of 500 mm between swale, BRA and flood storage area (FSA) inverts to MGL.

Criterion GW3 Maintain or improve the quality of groundwater leaving the site.

The manner in which these objectives are proposed to be achieved is further detailed in **Section 7**.

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5 Water Conservation Strategy

5.1 Fit-for-purpose water use

Conservation of water through fit-for-purpose use and best management practices is encouraged so that water is not wasted. Fit-for-purpose principles have been utilised in the water conservation strategy for the site and will achieve **Criterion WC1**.

5.1.1 Scheme water

An existing high level tank on Chittering Road currently supplies the Bullsbrook town via a 300 mm supply main located. The supply main is proposed to be connected to the future Gnangara reservoir to the west of Ellenbrook, providing a secondary source of water to Bullsbrook.

The Water Corporation has also indicated that the existing tank is to be supplemented by a new higher level tank further east on Chittering Road, with additional transfer mains near the town centre. This upgrade, proposed to commence in 2018, is intended to supply water to urban zoned land at elevations greater than 95 m AHD. The Water Corporation's long term plan is for the existing supply main to provide water to a series of large capacity tanks located on high land to the east of Bullsbrook.

Supply of water to the site will be via a southwards extension of a reticulation main currently located south of the intersection of Chittering Road and Great Northern Highway. The Water Corporation's 5 year capital investment program (CIP) has identified these works as planned and funded.

5.1.2 Groundwater

The site is located within the Bandy Spring groundwater management subarea. The DoW *Water Register* indicates that the Superficial Swan aquifer in this area is fully allocated. There are two groundwater licences within the site which grant an allocation from the Superficial Swan aquifer, as described in **Table 4**. These licences have a combined annual allocation of 38,022 kL.

The superficial aquifer is proposed to be used for irrigation of POS where necessary. The area of POS which can be irrigated, based on a combined allocation of 38,022 kL and an irrigation rate of 6,750 kL/ha, is 5.63 ha. This represents 22.5% of the POS area within the current concept plan. The remaining 77.5% may therefore be designed as dry POS (native species, hard surfaces, gravel and/or mulch) or used for conservation purposes.

The water requirement for the proposed primary school and adjacent playing fields is estimated to be 31,725 kL/a. Notwithstanding this, water for the irrigation of the proposed primary school and adjacent playing fields will not be required until the Department of Education is prepared to develop the school. This is not likely to occur for some time following completion of the development.

With respect to confined groundwater resources, the site is located within the Swan Confined groundwater management subarea. There are two existing licences within the site for the Leederville aquifer, as described in **Table 4**. The Leederville aquifer in this area is fully allocated.

The purpose of this DWMS is to support the rezoning of the land. Once zoned for urban purposes, all land with water availability will be able to progress through the planning process. Confirmation of the available water resources will therefore be provided in future relevant planning documents. Notwithstanding that the current planning stage is to demonstrate that development of the land is

possible, the proponent commits to making the water currently licensed within the MRS amendment area available for use by the future school site as a priority.

5.1.3 Stormwater harvesting

The potential for a stormwater harvesting and storage system has been considered to supplement any additional irrigation needs, should this be required. This could be achieved by utilising the significant existing dams within and immediately upstream of the site.

Preliminary estimates of the irrigation capacity provided by four dams which exist upstream of the site boundary and within the proponent's landholdings have been undertaken. These dams are estimated to have a combined capacity of approximately 12,180 kL, and a combined catchment area of approximately 373 ha. This preliminary estimate has been based on the following assumptions:

- Runoff coefficient of 0.2 in all catchments
- Median monthly rainfall statistics from Pearce RAAF (BoM station #009053)
- Average daily evaporation statistics from Perth Airport (BoM station #009021).

Based on preliminary estimates, this system has the capacity to provide more than 32,000 kL of stormwater per annum. This has the potential to supply the additional volume needed for the irrigation of either POS or the proposed primary school and adjacent playing fields, should this be required by the CoS and Department of Education.

Additional information regarding the need for stormwater harvesting and any proposed design details will be addressed in the future LWMS.

5.1.4 Rainwater

Collection of rainwater from roof surfaces can potentially be undertaken, with this water stored in rainwater tanks for later use. Rainwater can be utilised for all non-potable at-lot purposes.

It is not currently proposed that the installation of rainwater tanks will be mandated. If rainwater tanks are to be included in the proposed water conservation strategy, this will be described in the future LWMS.

5.1.5 Recycled water

Waste water can be recycled and used as potable or non-potable water (depending on the quality of the treatment). However, specialised infrastructure is required to do so and the costs involved can be significant. Therefore, onsite waste water treatment and reuse is not proposed as part of the DWMS.

5.2 Water conservation measures

The proponent is committed to minimising both potable and non-potable water uses. The development will utilise water efficient fixtures and appliances (WEFA) and water wise gardening (WWG) principles to reduce water use within the development. These measures are further discussed in the following sections.

5.2.1 Water efficient fixtures and appliances

A significant reduction of in-house water consumption can be achieved with the adoption of WEFA. The water conservation strategy for the site proposes that all dwellings implement WEFA. Water

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efficient fittings will be mandated through the building licence, while uptake of water efficient appliances can be encouraged by state and local government rebates, as well as education from the proponent at point of sale.

5.2.2 Water wise gardens

Employing water use efficiency measures can significantly reduce the total water usage. Irrigation requirements can be reduced on an estate scale by employing WWG measures including:

- Improve soil with conditioner certified to Australian Standard AS4454 to a minimum depth of 150 mm where turf is to be planted and a minimum depth of 300 mm for garden beds.
- Design and install the irrigation system according to best water efficient practices.
  - Control systems must be able to irrigate different zones with different irrigation rates.
  - Emitters must disperse coarse droplets or be subterranean.
  - Utilise subsoil irrigation where appropriate.
- Minimise the amount of turf areas.
- Mulch garden beds to 75 mm with a product certified to Australian Standard AS4454.
- Retain remnant native trees and vegetation where possible.
- Minimise use of fertiliser and utilise slow release fertilisers.

WWG principles will be implemented within all landscaped areas across the development and promoted to lot owners at point of sale. As a guide, the irrigation rates and approach proposed in the North West Coastal Water Supply Strategy will be adopted. This is consistent with the vision for the site, which will see development of POS areas which tie in to the surrounding environment and utilise low to no water requirement native vegetation in most areas.

The adoption of WEFA and WWG principles will assist in achieving **Criterion WC2**.

5.2.3 Educational material

Educational material will be provided to lot purchasers to provide information on water efficiency and quality protection measures that they can implement within lots. Specific water conservation and protection topics may include:

- Water use reduction
- Water efficient technologies
- Fertiliser use
- Planting species.

Provision of educational material will assist in achieving **Criteria WC2, SW7** and **GW3**.

5.3 Wastewater

The existing Bullsbrook wastewater treatment plant (WWTP), located to the north of the Bullsbrook townsite, is licenced to treat 230 ML of wastewater per year (approximately 1,000 lots) and has the capacity to treat up to 360 ML (approximately 1,500 lots). This facility is able to service existing 'Urban' zoned land.

The Water Corporation's conceptual planning for the Bullsbrook sewer district indicates that a new wastewater pumping station is to be constructed to divert sewer flows from the existing pumping station on North Avenue via a sewer transfer main to Ellenbrook. The existing Bullsbrook WWTP will therefore become redundant.

The site ultimately drains to a gravity sewer along the Great Northern Highway, south to Stock Road and then west to pumping station 'A'. Early development of the site may require a temporary pumping station to transfer wastewater to Ellenbrook per the Water Corporation's current planning.

The Water Corporation has planned these works on the assumption that wastewater flows from the proposed industrial precinct to the west of the site will commence in 2017. The Water Corporation's five year capital investment program (CIP) has identified these works as planned and funded.

6 Stormwater Management

The principle behind the stormwater management strategy is to maintain the existing hydrology of the site. The site is characterised by generally low permeability soils and significantly steep slopes. The adoption of the development drainage system and the utilisation of various WSUD strategies can achieve the design criteria stated in **Section 4.3**.

6.1 WSUD Strategies

A number of WSUD strategies may be required to maintain flows, detain catchment runoff and provide the desired water quality outcomes. Examples of possible WSUD techniques are discussed below and should be further investigated within LWMS and UWMP documents.

6.1.1 Maintenance of existing flow pathways

As mentioned above, the principle behind the stormwater management strategy is to maintain the existing hydrology of the site. Where possible, this will include the preservation of existing flow pathways. The existing flow pathways within the site are shown on **Figure 6**, which include Nambad Brook and two other minor, non-perennial water courses entering the site on the eastern boundary.

The Nambad Brook flow path will be maintained during development of the site. It is envisaged that any works in this area may involve some measure of revegetation works and construction of stormwater management features.

The preference for the two water courses entering the site on the eastern boundary will be that these are maintained in their natural form. However, depending on the design outcome these may require minor realignment to appropriately convey water past the proposed primary school and playing fields. This would be via open channel and would likely be built in as a feature of the open space. Alternatively, the flow path could be integrated into the open space, or the location of the school may be modified in the future. It should be noted that the location of the school and playing fields depicted in the current concept plan (provided in **Appendix A**) is the CoS preferred location however this may be revised during structure planning to account for other constraints, such as the slope of the site, or retention of the existing waterways. Where any of the waterways are modified, this may require a Bed and Banks permit under the *Rights in Water and Irrigation Act 1914* and the proponent will comply with any such requirements.

6.1.2 Lot scale storage

A primary objective in the stormwater management strategy is to retain the 1EY as close to source as possible. This could potentially be achieved by the use of soakwells on each lot, however this would likely require imported fill to achieve this. Further, the steep slopes in the eastern portion of the site would restrict the ability to achieve at source retention via infiltration. Other lot scale storage systems may also be considered, and where proposed will be detailed in future LWMS and UWMP documents.

Where lot scale storage cannot be achieved, treatment of runoff will be provided in downstream structures, located as close to source as practicable.

6.1.3 Swales

Swales can provide both conveyance of stormwater and retention/detention storage. These could potentially be located within medians in road reserves or integrated into POS in areas with flatter topography (e.g. along the western boundary of the site adjacent to Great Northern Highway). Stormwater could be directed into the swales via flush kerbing or other methods which minimise the use of more traditional piped drainage. Swales typically have a flooding depth of up to 500 mm, with a width of up to 6 m to provide sufficient conveyance capacity and to provide a large surface area for stormwater to infiltrate into the underlying soils and ultimately to groundwater (where geotechnical conditions permit). Swales will assist in retaining the 1EY event, and to convey runoff in larger events to the nearest downstream flood storage area (FSA) (described in **Section 6.1.5**).

6.1.4 Bio-retention areas

Stormwater will be retained and treated in vegetated bio-retention areas (BRAs) which will be sized to retain the 1EY event from the road network. BRAs will be located either within road reserves, in POS or within drainage reserves. The BRAs will typically have a depth of 300 mm and will be underlain by appropriate soil media to increase nutrient uptake. The soil media can be comprised of either high PRI (>10) soil or alternative treatment media with appropriate nutrient removal efficiencies. BRAs will also be vegetated using plant species with high nutrient uptake to provide treatment prior to infiltration. BRAs will be designed such that the inverts of the basins are at least 500 mm above the MGL.

6.1.5 Flood storage areas

FSAs are designed to detain surface runoff from the site, up to the 1% AEP event. These areas will typically be designed to achieve a maximum flooding depth of 1.2 m, however this will be confirmed in future LWMS documents when appropriate fill and clearance requirements are available to inform suitable depths.

FSAs will be designed such that the inverts of the basins are at least 500 mm above MGL, or any observed low permeability soil horizon as determined by future geotechnical investigations. FSAs will also be designed with high flow outlet structures or weirs to allow excess flows to continue downstream, consistent with the existing flow regime. Due to the significant slope in the eastern half of the site, FSAs are likely to be preferentially located towards the western end of the site where grades are flatter, and where there will be less difficulty integrating side slopes into the surrounding land form.

6.1.6 Online flood detention corridors

The potential limitations to lot scale storage (i.e. steep slopes, low permeability soils) may require additional detention capacity to be provided in downstream structures. To encourage these flows to be attenuated locally (and if possible to infiltrate as close to source as possible), the use of online detention storages located along existing flow paths may be considered. This online flood detention approach could consist of a series of structures similar in construction to BRAs, and would ideally provide sufficient detention to maintain the pre-development runoff regime within and leaving the site.

6.2 Development drainage system

The two management approaches proposed in this DWMS that have determined the design of the drainage system are:

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- Maintain existing runoff regimes entering and leaving the site.
- Manage runoff water quality to protect downstream environments.
- Protect infrastructure and downstream environments from flooding during large storm events.

These are further discussed in the following sections.

6.2.1 Manage runoff water quality

6.2.1.1 Lot scale

The existing soils identified at the site (discussed in **Section 3.3.2**) are unlikely to provide sufficient infiltration capacity for the use of soakwells across the entire site. Combined with the significant slope in the eastern portion of the site, it may be difficult to retain the 1EY event at source.

The amount of runoff to be retained at lot will be confirmed in future water planning stages, however the principle will be to retain as much runoff within lots as practicable. Where this is not achievable, runoff will be managed in downstream structures.

The specific method of lot storage will be detailed in the future LWMS when more detailed lot sizes and densities are confirmed.

6.2.1.2 Estate scale

Water quality management on an estate scale will be achieved by a combination of structural and non-structural measures.

The piped drainage network within road reserves will be designed to cater for the 20% AEP event, and will discharge into downstream BRAs. These BRAs will be sized to retain and treat the 1EY event runoff from road reserves. Treatment will be achieved by retaining the 1EY event runoff and the selection of nutrient stripping vegetation for use on BRAs (Engineers Australia 2006).

Non-structural measures that will improve the quality of stormwater runoff may include:

- Stormwater system maintenance
- Provision of educational material to residents
- Street sweeping to reduce particulate and sediment loads
- Water wise gardening principles
- Application of fertilisers at rates not exceeding manufacturer's recommendations.

6.2.2 Protect infrastructure and downstream environments from flooding

The protection of infrastructure and downstream environments from flooding may be achieved using a combination of online flood detention corridors, swales and FSAs.

As discussed in **Section 6.2.1.1**, lot storage may not be practicable for portions of the site with steep slopes. These flows will therefore need to be managed in downstream structures. Existing flow paths (i.e. the agricultural drain in the middle of the site) provide an opportunity for online flood detention corridors to detain runoff flows higher up in the catchment prior to discharging into downstream FSAs.

The use of swales will also provide additional retention and detention of stormwater runoff in frequent rainfall events and conveyance of stormwater in larger storm events. The grades adjacent to Great Northern Highway on the western boundary of the site are considered suitable for the use of swales. This will enable stormwater runoff from areas in the western portion of the site to be intercepted and

retained during the 1EY, and will also facilitate the conveyance of runoff to the nominal FSA locations identified on **Figure 7**.

FSAs will be sized to detain up to the 1% AEP event runoff from the development and located in POS, as discussed in **Section 6.1.5**. The final locations of FSAs will be detailed in the future LWMS and agreed in consultation with the relevant agencies (DoW and CoS). These will generally be located in the lowest points of the site or localised catchment, and generally in the western half of the site (due to steep slopes in the eastern half). Where possible, smaller FSAs will be located within individual sub-catchments to encourage retention and infiltration of stormwater as close to source as possible, and to avoid concentrating peak flows any further than necessary.

Indicative locations and sizes of FSAs based on the topography of the site are shown on **Figure 7**. Note that **Figure 7** is only intended to provide an indicative scale for the areas required for FSAs, rather than to suggest final basin locations.

The design of swales, online flood detention corridors and FSAs, including their elevations, volumes, surface areas and locations will be determined by detailed hydrological and hydraulic modelling. This will be undertaken in support of the LSP and future LWMS.

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7 Groundwater Management

The main objective for the management of groundwater is to maintain or improve the existing groundwater quality. Improvements to groundwater quality can be achieved by either reducing the total nutrient load directly to groundwater or by the treatment of surface water runoff prior to infiltration to groundwater. Treatment of surface runoff is detailed in **Section 6**.

7.1 Infiltration at source or as close to source as possible

As discussed in **Section 6.2.1**, the proposed stormwater management approach includes a series of measures to encourage the infiltration of stormwater runoff as close to source as possible. These measures prevent the mobilisation of contaminants that are typically transported within the 'first flush' of a rainfall event, which will be retained on site.

7.2 Change of land use

The site is currently used for rural residential and agricultural purposes (see **Section 3.7**). The use of fertilisers and livestock can result in increased nutrient loads to underlying groundwater system.

The proposed development will change the land use from rural to urban, which will reduce the nutrient loading to groundwater. This is due to a number of factors that will decrease nutrient inputs as a result of the proposed land use, such as:

- Removal of livestock
- Reduced garden area
- Reduced fertiliser usage
- Increased hardstand and impermeable areas.

7.3 Landscaping

POS areas will utilise WWG principles including use of native species and minimising the use of turf where possible. Native vegetation will also be retained where practicable within POS. The use of WWG principles will minimise the overall fertiliser requirements and therefore the nutrient load that could be transported to groundwater through infiltration. High Phosphorus Retention Index (PRI>10) soils (or an alternative soil treatment media with equivalent efficiencies) will be utilised beneath BRAs to provide additional treatment of storm water runoff prior to infiltration to groundwater.

Lot owners will be encouraged to implement WWG principles and minimise fertiliser use within lot through provision of promotional material (discussed in **Section 5.2.3**).

Future LWMS and UWMP documents will detail specific measures that will be implemented to reduce nutrient loading to groundwater within landscaped areas.

7.4 Non-structural measures

A series of non-structural measures may also be implemented to assist with the management of nutrient loading to underlying groundwater resources and downstream environments (as discussed in **Section 6.2.1.2**).

8 Matters to be addressed at LWMS Stage

It is anticipated that future LWMS and UWMP documents will provide significantly more detail regarding a number of aspects of water management. These will include (but are not limited to):

- WSUD strategies
- Design and location of stormwater detention basins
- Modelling of local road drainage network
- Stormwater storage within lots
- Water allocation and supply
- Water conservation strategies
- Non-structural water quality improvement measures
- Monitoring

8.1 WSUD strategies

A number of WSUD strategies are proposed to be implemented to achieve the objectives described in **Section 1.6**. Combining a number of WSUD techniques in a treatment train is the most effective manner in which to treat catchment runoff. Treatment trains incorporate multiple WSUD techniques to ensure primary, secondary and tertiary treatment of stormwater is achieved. Examples of WSUD techniques that may be implemented at the site are as follows:

- Retention of existing landform and catchments
- Lot retention and infiltration
- Swales
- Bio-retention areas
- Online flood detention storage
- Flood storage areas.

8.2 Design and location of drainage structures

This DWMS has proposed nominally located and sized drainage structures, including swales, BRAs and FSAs. Future LWMS and UWMP documents will provide specific details on location, configuration and required volumes of infiltration/detention structures, ensuring that the stormwater management system can achieve all of the required objectives and integrate into the surrounding environment.

8.3 Modelling of road drainage network

Modelling and runoff calculations for the local road drainage network will need to be carried out for the 20% AEP and 1% AEP events to demonstrate compliance with the stormwater management criteria, detailed in **Section 4.3**. Calculations to support the sizing of infiltration structures (including swales, BRAs and FSAs) will need to be provided so that detailed designs can proceed and future water planning stages (i.e. UWMP) can demonstrate compliance with the design criteria.

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8.4 Water allocation and supply

This DWMS proposes that access to scheme water will be facilitated by an extension of existing Water Corporation infrastructure. The Water Corporation has indicated that an upgrade to this infrastructure is currently being designed, with further upgrades planned for 2018 (see **Section 5.1.1**).

It is proposed that groundwater will be used for the irrigation of POS, as discussed in **Section 5.1.2**. The proponent has been issued with a licence to take 27,800 kL/year from the Superficial Swan aquifer (GWL180972). A second licence for 10,222 kL/year also exists within the site (GWL161848).

Future LWMS and UWMP documents will confirm the status of these and any additional licences that may be issued for landholding within the site, as well as any applications or further approvals that may still be required.

8.5 Water conservation strategies

A number of potential measures have been discussed that can assist in reducing total water consumption. It is expected that future LWMS documents will clarify which measures are proposed to be integrated into the future built system.

8.6 Non-structural water quality improvement measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007). Some measures will be more appropriately implemented by CoS, however many can be implemented relatively easily within the design and maintenance of the development.

It is expected that future LWMS and UWMP documents will provide reference to measures in relation to both surface and groundwater quality. It is also expected that future UWMPs will provide detailed management and maintenance plans that will set out maintenance actions (e.g. rubbish removal from BRAs and FSAs), timing (when actions are to occur), locations (where actions will occur) and responsibilities (party responsible for implementing the actions).

Approval for the proposed measures will need to be sought from the CoS and DoW. It is therefore anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

8.7 Earthwork and fill strategy

An earthwork and fill strategy may be required to support the LSP. This strategy will determine which areas are most likely to require the importation of fill to maintain appropriate clearances from groundwater. Future LWMS and UWMP documents will detail the proposed post-development levels and associated clearances.

8.8 Foreshore management plan

A Foreshore Management Plan may be required to support the LSP. This document will determine the appropriate setback to Nambad Brook. This document shall be prepared in accordance with *Operational Policy 4.3: Identifying and establishing waterways foreshore areas* (DoW 2012). Where

prepared, those components relevant to urban water management will also be provided/covered in the LWMS.

8.9 Monitoring

8.9.1 Pre-development monitoring

A pre-development surface and groundwater monitoring program has already been completed. The results of this program are summarised in **Section 3.5** and **Section 3.6**, with the full report provided in **Appendix B**. Due to the age of the data collected during this monitoring program, additional surface water and groundwater monitoring should be undertaken to capture at least one more winter peak (and winter flow conditions in the streamlines) prior to detailed subdivision design, particularly in the western portion of the site where groundwater is closer to the surface.

The results of the pre-development monitoring program will be used to define a series of site specific trigger values. This will be determined in the future LWMS.

8.9.2 Post-development monitoring

A post-development groundwater monitoring program may be required for POS areas in the western portion of the site, where clearance to groundwater is less than 5 m. This may be addressed by the quarterly sampling of shallow monitoring bores located upstream and downstream of representative POS areas containing stormwater management infrastructure. These would nominally be sampled on a quarterly basis for the duration of the maintenance period.

Monitoring of surface water quality may be required to demonstrate compliance with **Criteria SW7**. This can be addressed by establishing monitoring locations at the points where surface water features enter and leave the site. These would nominally be sampled five times per year over the duration of the maintenance period.

Indicative locations for post-development surface water and groundwater monitoring have been included on **Figure 7**. The requirement for a post-development monitoring program and any proposed monitoring locations will be further discussed in future LWMS and UWMP documents.

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9 Implementation

The DWMS is a key supportive document for the proposed development. The DWMS has been prepared with the intention of providing a structure within which subsequent development can occur consistent with the integrated water cycle management approach. It is also intended to provide guidance to the general stormwater management principles for the area and to guide the development of future LWMS and UWMP documents.

The future implementation framework, inclusive of management plans for relevant aspects of the site will be guided by the planning scheme provisions. The management framework, the issues addressed within these plans and the responsibility for their preparation and implementation is summarised in **Table 7**.

Table 7: *Summary of implementation framework*

Planning Stage	Supportive technical document	Purpose of technical document	Portion of development to which document applies	Entity responsible for preparation	Approving authority	Entity responsible for implementation
LSP	LWMS	Refine water management design objectives from DWMS, demonstrate spatial allocation of land to manage water to achieve design objectives.	LSP area	Proponent and CoS	CoS and WAPC on advice from DoW	Proponent
Subdivision	UWMP	Demonstrate compliance with design objectives, as well as implementation and ongoing management requirements for the drainage system. Identify roles and responsibilities for ongoing management.	Approved subdivision areas	Proponent	CoS on advice from DoW	Proponent
House construction	Building designs	Demonstrate that detailed designs comply with design criteria detailed in UWMP.	Private lots	Lot owner	CoS	Lot owner

9.1 Roles and responsibilities

The DWMS provides a framework that future developers of the land can utilise to assist in establishing water management methods that have been based on site-specific investigations, are consistent with relevant State and CoS policies and have been endorsed by the CoS.

The responsibility for working within the framework established within the DWMS rests with the developers of the land, although it is anticipated that future LWMS and UWMP documents will be developed in consultation with the CoS, DoW and any other relevant authorities (e.g. Water Corporation etc.) and in consideration of other relevant policies and documents.

9.2 Review

It is not anticipated that this DWMS will be reviewed. The next stage of development is anticipated to be structure planning through a LSP. Where a LSP is produced this should be supported by a LWMS. The LWMS will largely be an extension of the DWMS as it should provide designs and measures for water management from the options proposed within the DWMS.

The next stage of development following the LWMS is lot planning through subdivision which is to be supported by an UWMP. It is recognised that certain elements (i.e. non-structural controls) of the DWMS and LWMS will not be finalised until this late stage and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage, their implementation could be encouraged by the CoS through policy (or modification of these where necessary) or awareness programs.

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10 References

10.1 General references

Australian and New Zealand Environment and Conservation Council (ANZECC) 2000, *Australia and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy* Australian and New Zealand Environment and Conservation Council.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M and Testoni I (Editors) 2019, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia (Geoscience Australia).

Cardno 2010, *Bullsbrook Surface and Groundwater Monitoring: Final Monitoring Report*.

Cardno 2012, *Great Northern Gateway Industrial Cell District Water Management Strategy*.

City of Swan (CoS) 1998, *Development Design Specification D4: Subsurface drainage design*, Midland.

City of Swan (CoS) 2002a, *Development Design Specification D5: Stormwater Drainage Design*, Swan.

City of Swan (CoS) 2002b, *Handbook of Stormwater Drainage Design*, Swan.

City of Swan (CoS) 2013, *Local Planning Scheme No. 17*, Swan.

City of Swan (CoS) 2014, *Bullsbrook Townsite Land Use Master Plan*, Perth.

Department of Water (DoW) 2007, *Stormwater Management Manual for Western Australia*, Department of Water.

Department of Water (DoW) 2009, *Decision Process for Stormwater Management in Western Australia*, Perth.

Department of Water (DoW) 2012, *Operational policy 4.3: Identifying and establishing waterways foreshore areas*.

Department of Water (DoW) 2013, *Guidelines for District Water Management Strategies*, Perth.

Emerge Associates 2014, *Local Water Management Plan, South Bullsbrook Industrial Precinct Local Structure Plan 1*.

Engineers Australia 2006, *Australian Runoff Quality: A guide to Water Sensitive Urban Design*, National Committee for Water Engineering, Engineers Australia, Canberra.

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

GHD 2012, *Regional Water Management Strategy: Report for Bullsbrook Townsite Area*.

Gozzard, J. R. 1982, *Muchea, Sheet 2034 I and Part 2134 IV*, Perth Metropolitan Region 1:50 000 Environmental Geology Series. Geological Survey of Western Australia, Perth.

Western Australian Planning Commission (WAPC) 2006, *State Planning Policy 2.9: Water Resources*, Gazetted in December 2006. Western Australian Planning Commission.

Western Australian Planning Commission (WAPC) 2007, *Liveable Neighbourhoods (Edition 4)*, Western Australian Planning Commission and Department for Planning and Infrastructure.

Western Australian Planning Commission (WAPC) 2008, *Better Urban Water Management*, Western Australian Planning Commission.

Western Australian Planning Commission (WAPC) 2009, *Planning Bulletin No. 64 Acid Sulfate Soils*, January 2009, Perth.

Western Australian Planning Commission (WAPC) 2014, *Metropolitan Region Scheme*, Perth.

10.2 Online references

Bureau of Meteorology 2020, *Climate Averages*, viewed 16 November 2020, available from <http://www.bom.gov.au/climate/data/>.

Department of Water (DoW) 2015a, *Perth Groundwater Atlas*, viewed 11 May 2015, available from <http://www.water.wa.gov.au/idelve/gwa>.

Department of Water (DoW) 2015b, *Water Register*, viewed 24 August 2015, available from <http://www.water.wa.gov.au/ags/WaterRegister>.

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FIGURES

Figure 1: *Location Plan*

Figure 2: *Site Boundary and Cadastral Boundaries*

Figure 3: *Topographic and Groundwater Contours*

Figure 4: *Regional Geological Mapping*

Figure 5: *Acid Sulfate Soil Risk Mapping*

Figure 6: *Surface Water Features*

Figure 7: *Proposed Stormwater Management Strategy and Indicative Monitoring Locations*

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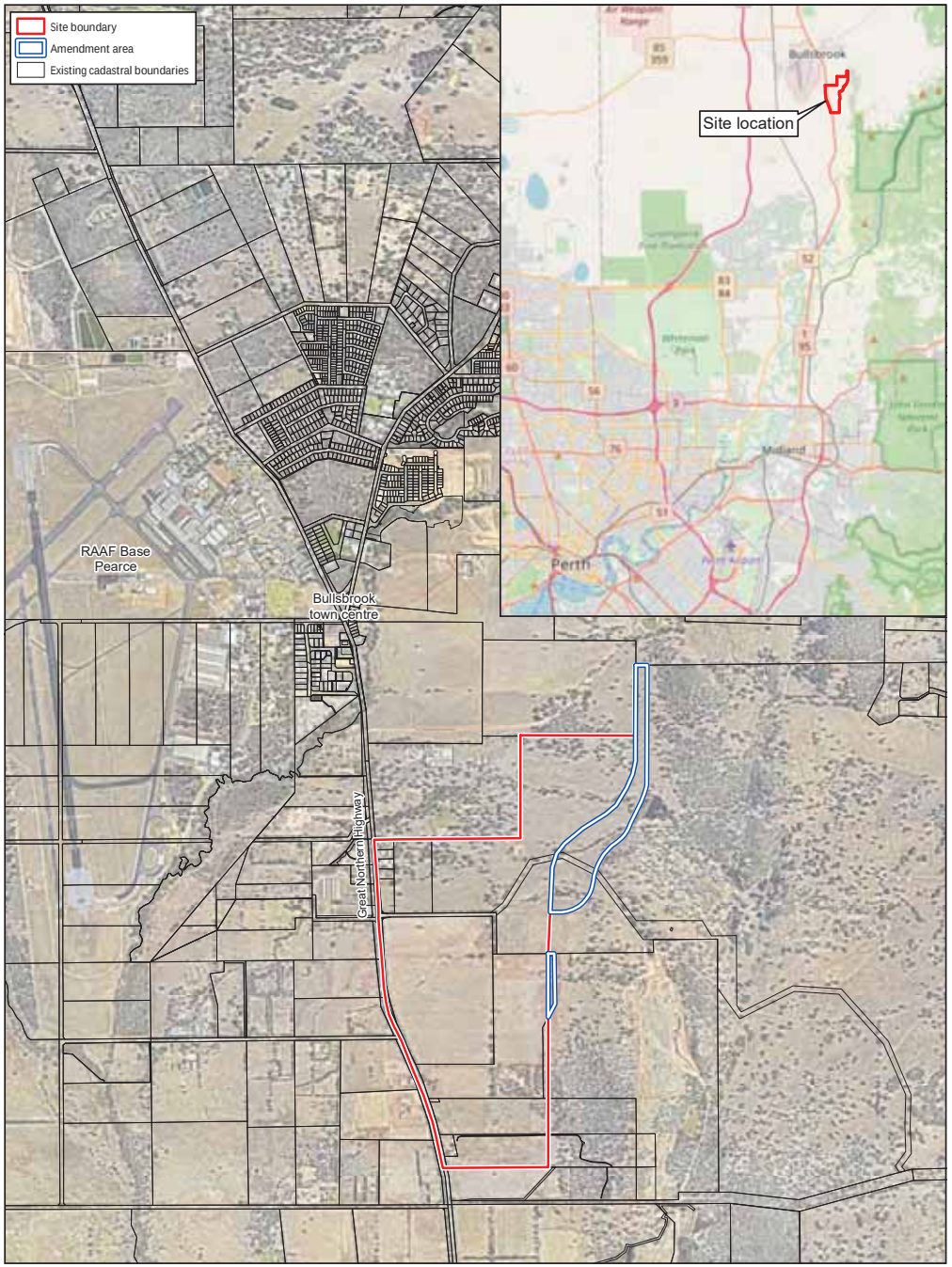

Figure 1:	**Location Plan**	**Plan Number: EP15-018(02)--F14c**	
Project:	District Water Management Strategy South Bullsbrook	Drawn: AFF	Date: 26/02/2021
Client:	Marlin Bullsbrook Pty Ltd	Approved: JB	Date: 26/02/2021
		Checked: JMM	Scale: 1:25,000@A4

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

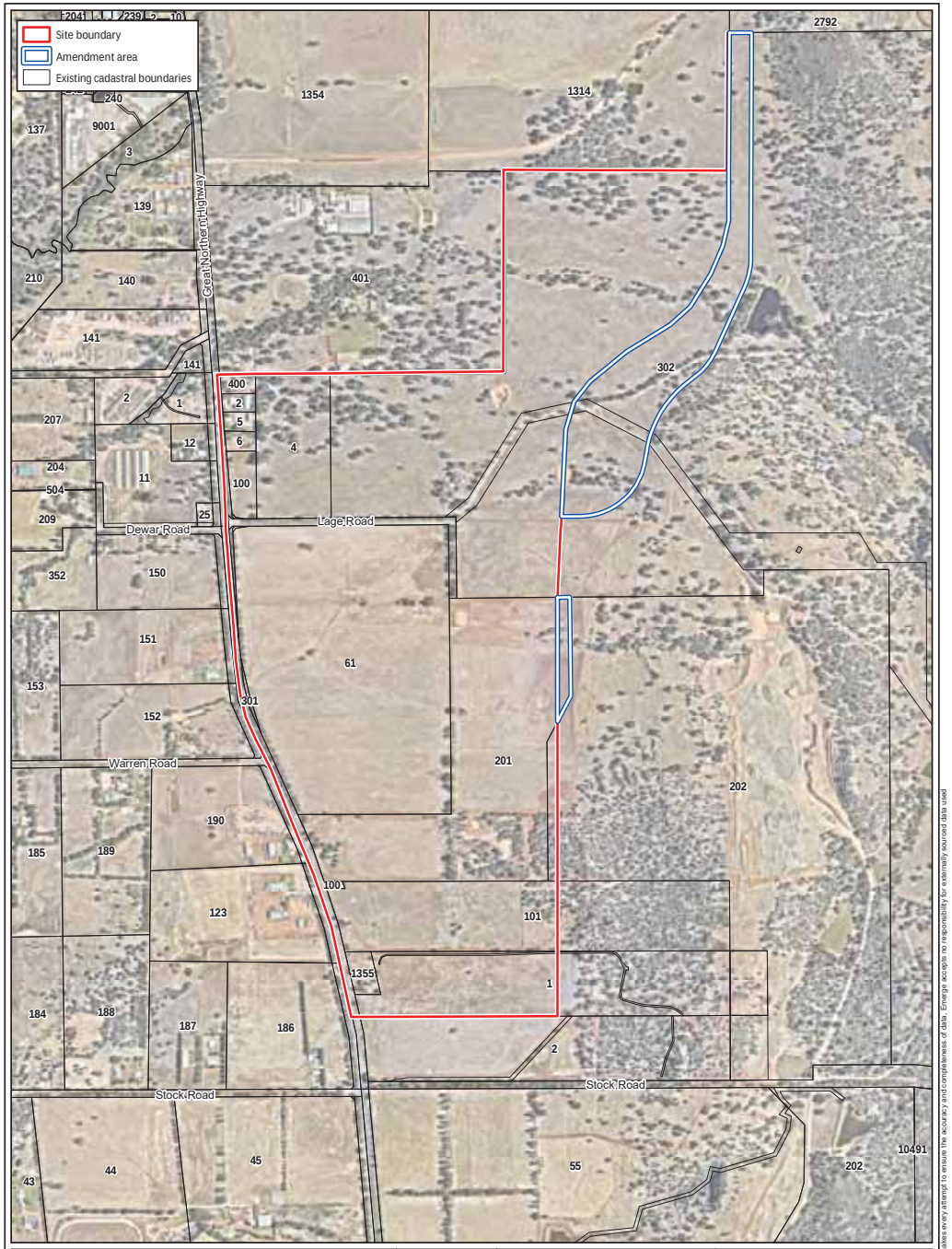

Figure 2:	**Site Boundary and Cadastral Boundaries**	**Plan Number: EP15-018(02)--F15c**	
Project:	District Water Management Strategy South Bullsbrook	Drawn: AFF	Date: 26/02/2021
Client:	Marlin Bullsbrook Pty Ltd	Approved: JB	Date: 26/02/2021
		Checked: JMM	Scale: 1:12,500@A4

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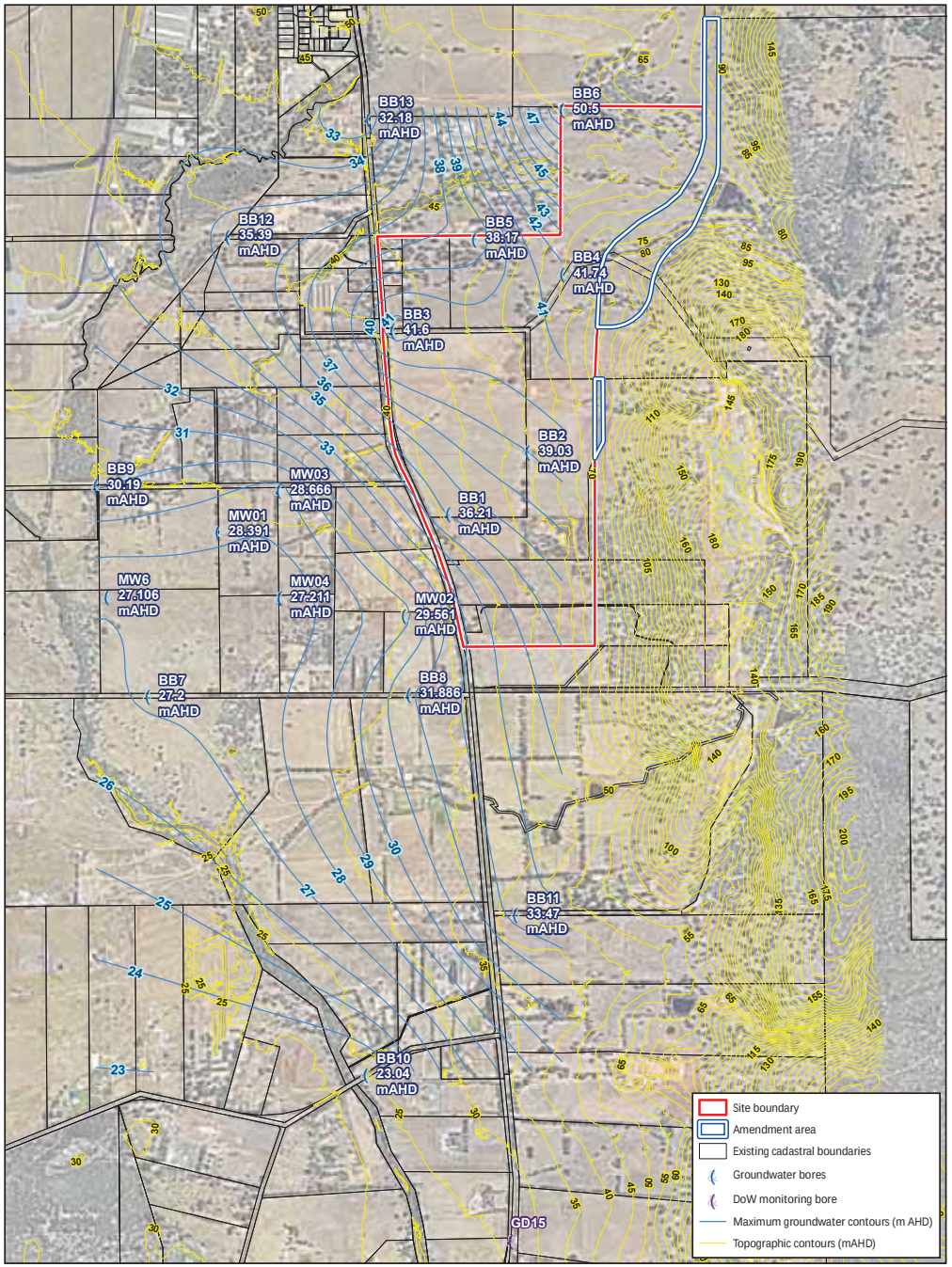

Figure 3:	**Topographic and Groundwater Contours**	**0**	**Plan Number: EP15-018(02)--F16e**
Project:	District Water Management Strategy South Bullsbrook		Drawn: AFF Date: 26/02/2021 Approved: JB Date: 26/02/2021 Checked: JMM Scale: 1:20,000@A4
Client:	Marlin Bullsbrook Pty Ltd		0 160 320 480 640 800 Metres

Sources: The following datasets were used in the production of this map: LiDAR (5m) Swan Coastal Plain - DoW (2008)

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

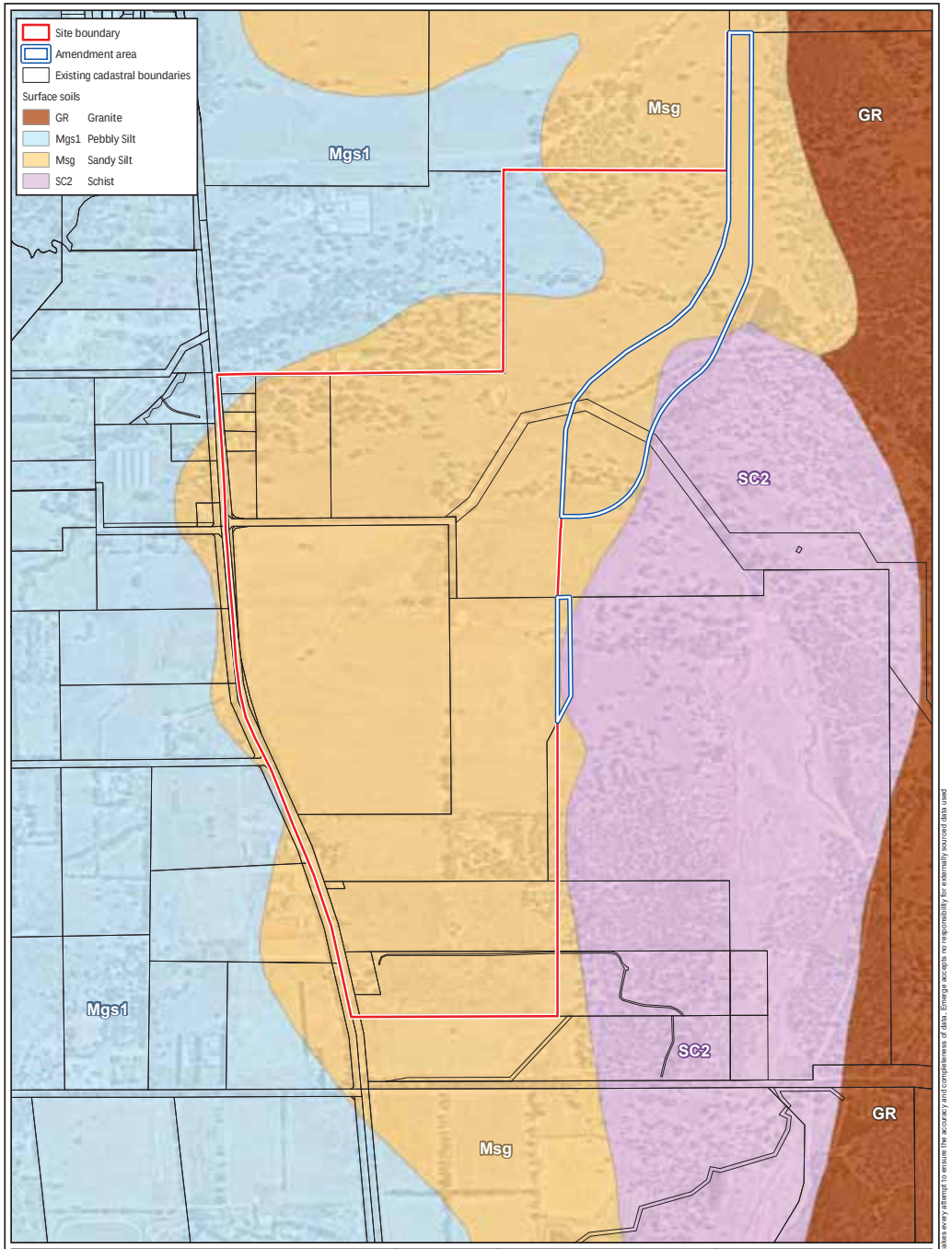

Figure 4:	**Regional Geological Mapping**	**0**	**Plan Number: EP15-018(02)--F17c**
Project:	District Water Management Strategy South Bullsbrook		Drawn: AFF Date: 26/02/2021 Approved: JB Date: 26/02/2021 Checked: JMM Scale: 1:12,500@A4
Client:	Marlin Bullsbrook Pty Ltd		0 125 250 500 Metres

Sources: The following datasets were used in the production of this map: Environmental Geology - Gozzard (1982)

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

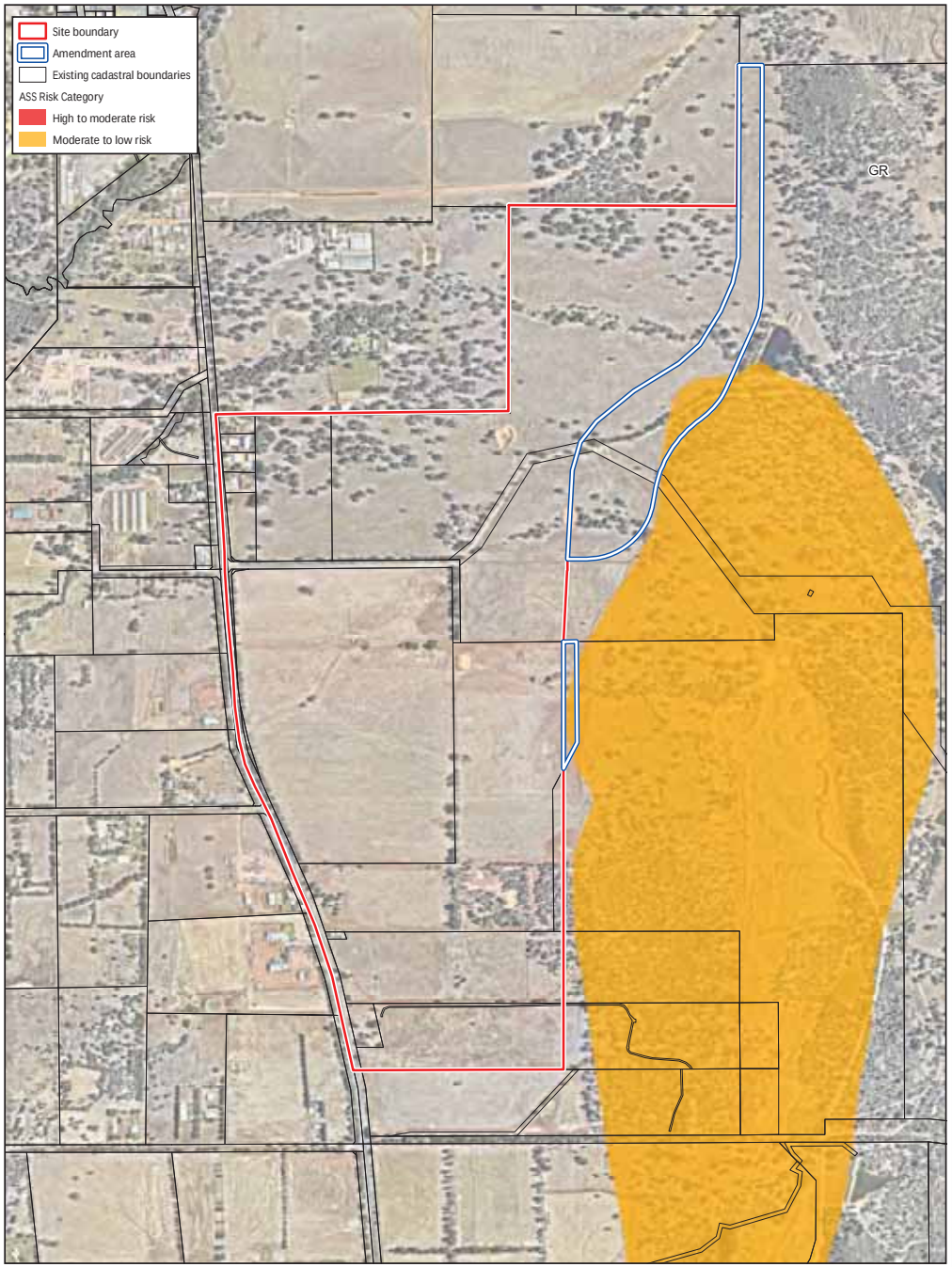

Figure 5:	**Acid Sulfate Soil Risk Mapping**	**Plan Number: EP15-018(02)--F18c**	
Project:	District Water Management Strategy South Bullsbrook	Drawn: AFF	Date: 26/02/2021
Client:	Marlin Bullsbrook Pty Ltd	Approved: JB	Date: 26/02/2021
		Checked: JMM	Scale: 1:12,500@A4

0 125 250 500 Metres

Sources: The following datasets were used in the production of this map: ASS Risk Category - DEC (2015)

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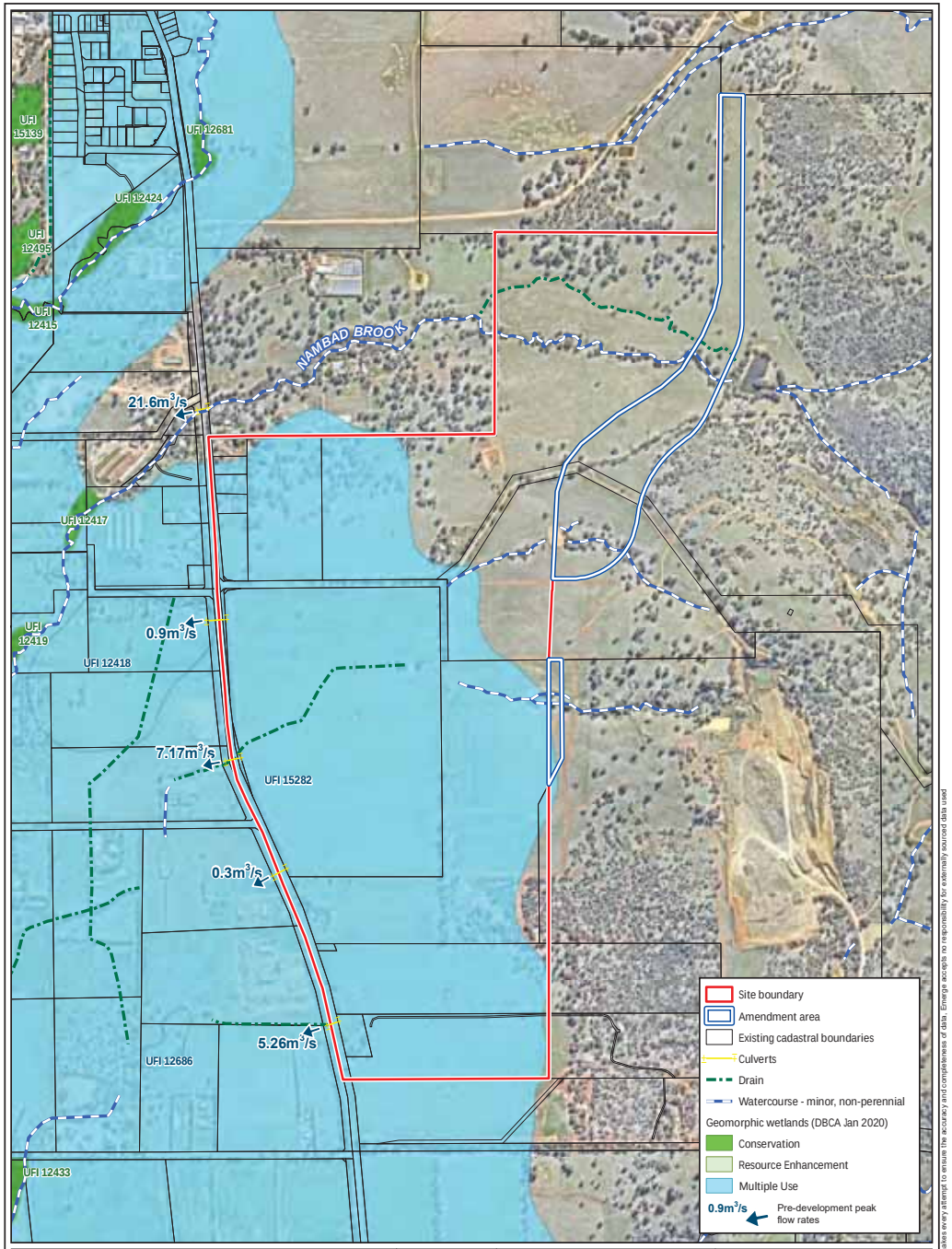

Figure 6:	**Surface Water Features**	**Plan Number: EP15-018(02)--F19d**	
Project:	District Water Management Strategy South Bullsbrook	Drawn: AFF	Date: 26/02/2021
Client:	Marlin Bullsbrook Pty Ltd	Approved: JB	Date: 26/02/2021
		Checked: JMM	Scale: 1:12,500@A4

0 125 250 500 Metres

Sources: The following datasets were used in the production of this map: Geomorphic Wetlands - DPaW (2015), Linear Hydrography - DoW (2007)

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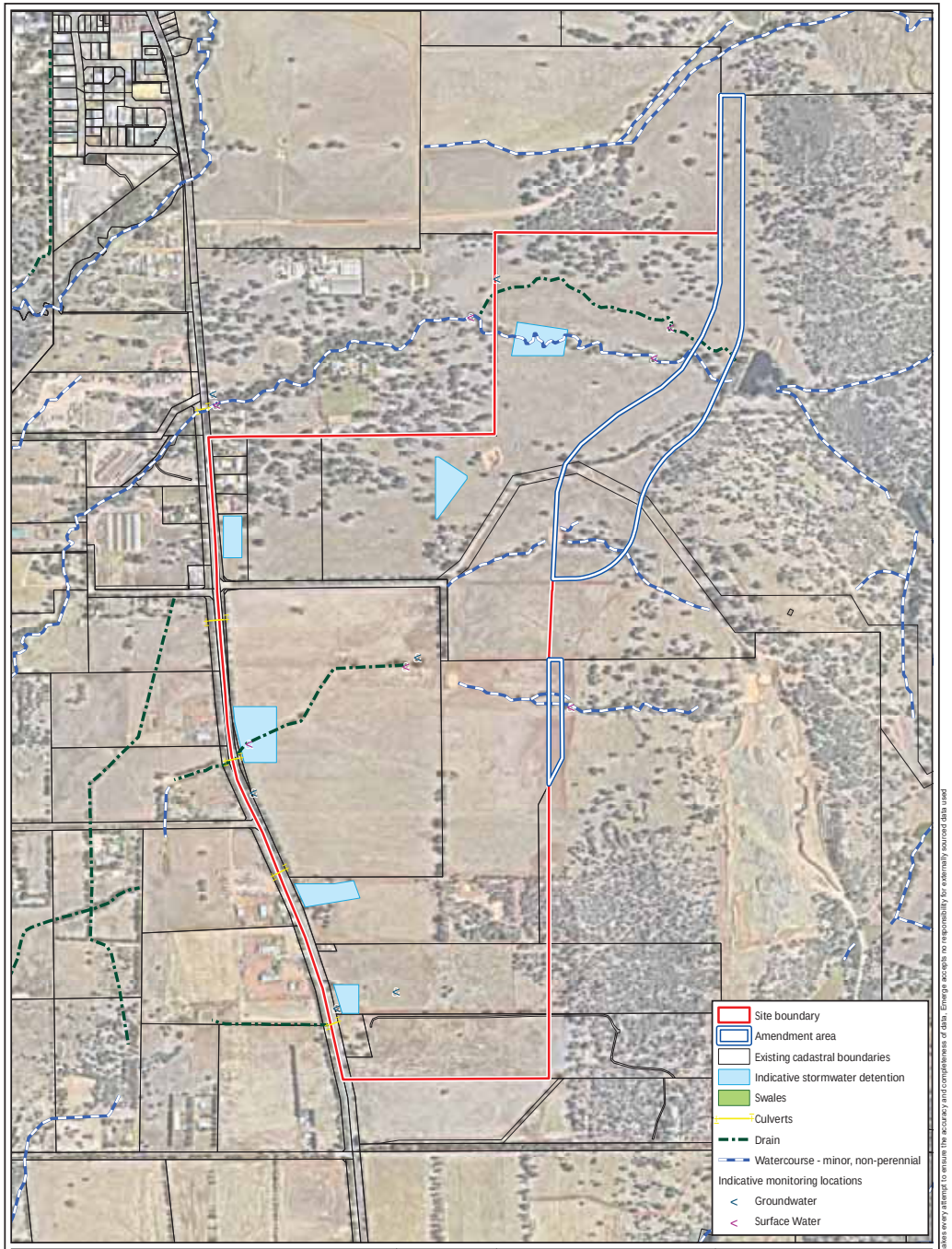

Figure 7:	**Proposed Stormwater Management Strategy and Indicative Post-Development Monitoring Locations**
Project:	District Water Management Strategy South Bullsbrook
Client:	Marlin Bullsbrook Pty Ltd

0

Plan Number: EP15-018(02)--F20f			
Drawn:	AFF	Date:	26/02/2021
Approved:	JB	Date:	26/02/2021
Checked:	JMM	Scale:	1:12,500@A4

0 125 250 500 Metres

emerge ASSOCIATES Integrated Science & Design

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APPENDIX A

PRELIMINARY CONCEPT PLAN

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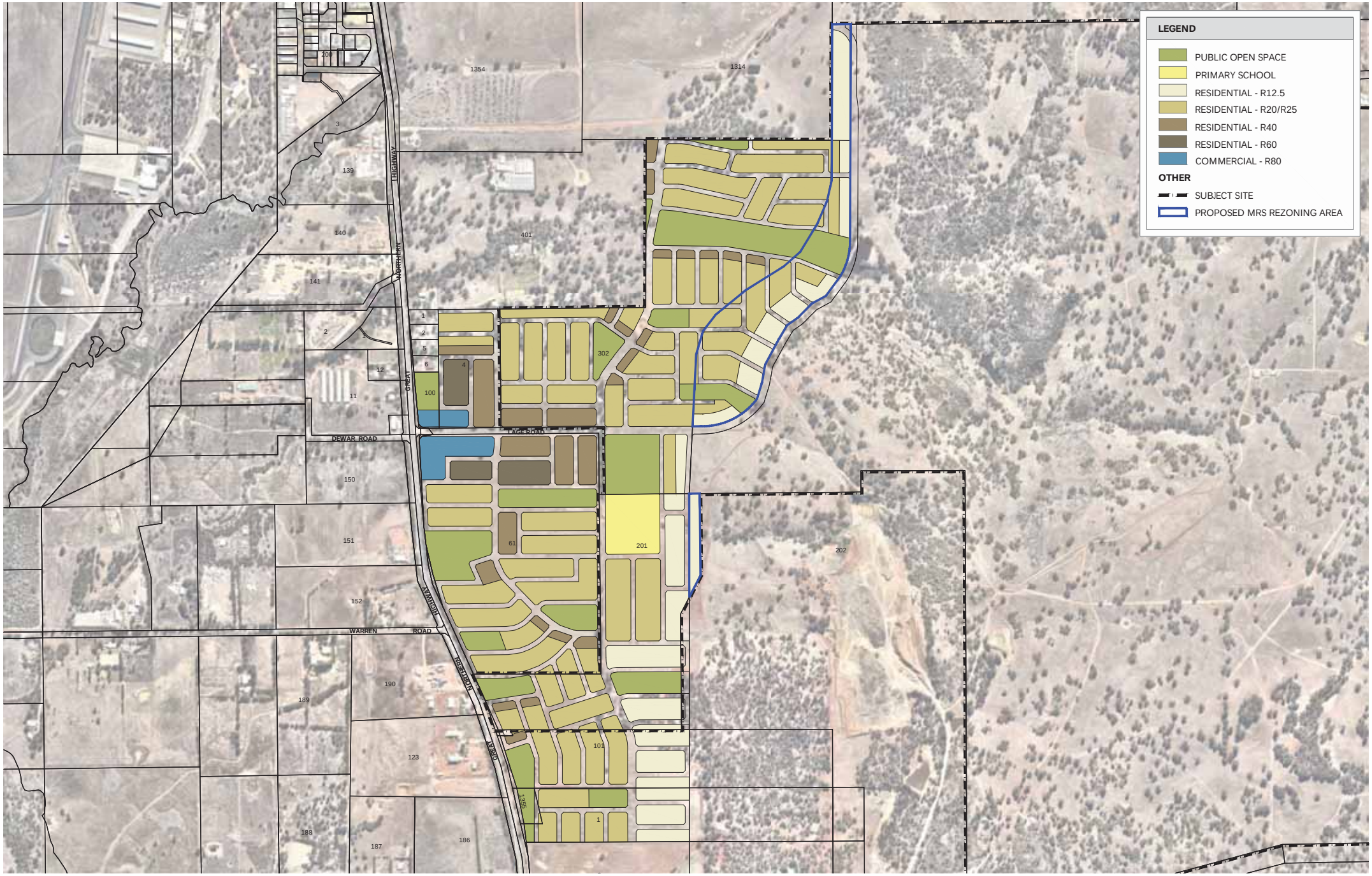

BULLSBROOK SOUTHERN PRECINCT

CONCEPT STRUCTURE PLAN

LOT 201 GREAT NORTHERN HIGHWAY AND LOT 302 LAGE ROAD, BULLSBROOK

NORTH

0m 200m

SCALE @ A3: 1:11,000

4790-CON-13-C

ROWE GROUP

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APPENDIX B

PRE-DEVELOPMENT MONITORING REPORT

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Bullsbrook Surface and Groundwater Monitoring

Final Monitoring Report

Prepared for Marlin Bullsbrook

June 2010

Project Number V7106

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Executive Summary

The locality of Bullsbrook is situated 36km to the north east of the Perth City Centre, immediately west and east of the Great Northern Highway, within the City of Swan. The Bullsbrook area has been identified in the North Eastern Corridor Extension Strategy (NECES) (WAPC 2003) as having areas that are suitable for urban development. Marlin Pty Ltd (Marlin) has acquired 910ha in the Bullsbrook area (Development Area) and this area is currently under assessment for residential development. To gather more accurate hydrological data and enable calibration of catchment based surface water modelling it was decided to gather data from a larger and broader area. The "study area" therefore includes and surrounds the proposed Development Area.

This report documents the results of; groundwater level monitoring, undertaken on a monthly basis between November 2007 and December 2009; ground water quality monitoring undertaken on a quarterly basis over the same period; and surface water quality and quantity monitoring undertaken between June 2008 and May 2010. The initial results were reported in the Initial Monitoring Report (Cardno BSD, 2008).

Groundwater levels were measured on a monthly basis for 25 months on all installed bores. The level monitoring indicates that groundwater may intersect with the surface at some locations during the annual peak (usually October). If they are proposed to be developed, these areas may require fill or other methods to achieve appropriate separation to groundwater prior to development. Furthermore, it should be noted that some sections of the study area are prone to localised flooding.

Groundwater quality sampling for nutrient concentrations was usually conducted on a quarterly basis over 25 months (8 occasions). Nutrient concentrations in groundwater varied both spatially within the study area and temporally over the duration of the monitoring period. There were occasions over the monitoring period when nutrient concentrations were in excess of the default trigger values (i.e. those given for surface water quality). Overall, the main concern in regard to groundwater quality within the study area relates to TP and NO_x concentrations. The data presented in this report suggests these concentrations are part of a regional problem rather than being site specific.

The surface water quantity data has captured four clearly defined significant rainfall events which can be used for the calibration of future hydrological models. Surface water quality samples were taken from Nambad Brook and Bandy Creek in response to rainfall events. Surface water samples were taken on eight occasions over the monitoring period and provide baseline data for future comparison.

This report concludes the Scope of Work regarding hydrological monitoring for the study area and no further pre development monitoring is required.

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1 Introduction

1.1 Project Background

The locality of Bullsbrook is situated 36km to the north east of the Perth City Centre, immediately west and east of the Great Northern Highway, within the City of Swan. The Bullsbrook area has been identified in the North Eastern Corridor Extension Strategy (NECES) (WAPC 2003) as having areas that are suitable for urban development. Marlin Pty Ltd (Marlin) has acquired 910ha in the Bullsbrook area (Development Area) and this area is currently under assessment for residential development. To gather more accurate hydrological data and enable calibration of catchment based surface water modelling it was decided to gather data from a larger and broader area. The "study area" therefore includes and surrounds the proposed Development Area. The locality of the overall study area in relation to the Development Area is shown in **Figure 1**.

The Development Area is made up from a number of different land holdings including Lots 302, 4, 61, 1010, 2, 13, 56 and 30. This area covers the 910ha referred to above. The study area covers 1730ha and includes data from bores on both the eastern and western sides of Great Northern Highway. The study area boundaries and cadastral boundaries are shown in **Figure 2**.

The historical use of the Bullsbrook area has been rural, including stock grazing, feed production, arable pastures and viticulture in the more fertile plains and lower lying areas. These viticulture plantings have predominately occurred along the Great Northern Highway. Therefore, much of the study area has historically either been cleared of native vegetation or extensively grazed. Past and present mining operations are also undertaken in the area with a number of quarries still providing resource material. As discussed, the development area is proposed for future residential development. Such a land use change can have implications for the types and quantity of pollutants released to local surface and groundwater, which can in turn affect the ecological health of downstream receiving environments.

1.2 Monitoring Objective

Cardno has been engaged to gather baseline data within the study area prior to development. The objective of collecting this data is to characterise the pre-development hydrological environment of the study area. To achieve this objective, Cardno developed the SAP detailed in the following sections of this report. It was determined that in order to achieve the project objective, the SAP would need to:

- Identify and quantify nutrient hotspots so that appropriate management measures can be implemented to avoid exacerbating the current situation;
- Determine groundwater quality and surface water quality to provide baseline data against which the effectiveness of future urban stormwater management and development impacts can be compared;
- Understand the groundwater levels within the study area to determine if fill is required to achieve satisfactory separation distance; and
- Characterise surface water flows for validation of future hydrological models of the study area.

Baseline data will be used to calibrate detailed hydrological modelling of the site, inform the future design process and will ensure that any future development is able to fulfil the stormwater management requirements of the Department of Water (DoW).

1.3 Purpose of this Report

This report documents the results of; groundwater level monitoring, undertaken on a monthly basis between November 2007 and January 2010; ground water quality monitoring undertaken on a quarterly basis between November 2007 and November 2009; and surface water quality and quantity data undertaken between June 2008 and May 2010. This report is a standalone document that presents the results of the entire SAP.

2 Sampling and Analysis Plan Rationale

2.1 Key Documents and Inputs

There are a number of published guidelines and standards available which provide direction regarding the discharge characteristics that residential development should aim to achieve. These were key inputs utilised for development of the SAP, and include:

- National Water Quality Management Strategy (ANZECC 2000).
- Stormwater Management Manual for Western Australia (DOW 2007).
- Development of Sampling and Analysis Programs (DOE 2001).
- Better Urban Water Management (WAPC 2008).

The guidance documents detailed above were reviewed to determine the likely data requirements for the study area. These documents point to the need for accurate baseline data prior to development.

2.2 Groundwater Methodology

Thirteen groundwater bores were installed within the study area at locations which would provide the best representation of anticipated groundwater systems and provide coverage outside the development area. These locations will allow for the identification of nutrient hotspots and development of underlying groundwater contours up to the 90mAHD contour to the east of the study area. The locations of these groundwater bores are shown in **Figure 2**.

Groundwater bores were constructed of Class 18 threaded PVC machine slotted screen and blank casing sections. A 3m screened section was installed in each of the bores to approximately bisect the observed groundwater level. Graded gravel pack was placed around the screened section extending to at least 0.5m above the top of the screened section. A bentonite seal was placed above the gravel pack and the bore annulus was backfilled with any available cuttings and concrete to the surface. Each bore was completed with approximately 0.5m of PVC casing extending above the ground surface and a protective steel casing. All bores were logged for hydrogeological and geotechnical parameters on installation. Bore completion log sheets are contained in **Appendix A**.

2.2.1 Groundwater Levels

Groundwater levels were measured on a monthly basis for 25 months on all installed bores. The bores were measured using an audible dip meter to record standing water levels. All bores have been surveyed to provide an accurate elevation, thereby allowing accurate calculation of groundwater contours.

2.2.2 Groundwater Quality

A clear understanding of the existing groundwater quality is important to determine whether the quality of water in the superficial aquifer is slowly improving with time or at least not degrading as a result of development. Groundwater quality sampling for nutrient concentrations was conducted on a quarterly basis over 25 months (i.e. 8 occasions). Bores were purged using an electric pump prior to sampling. A Hydrolab Quanta water quality meter was used to collect field chemical data. Purging of the well was continued for approximately five minutes before samples were collected for *in situ* physiochemical and laboratory analysis. Physiochemical parameters measured *in situ* include:

- pH.
- Temperature.

- Electrical Conductivity (EC)/ Salinity.
- Oxidation-Reduction Potential (Eh).

Upon collection, groundwater samples are placed directly into laboratory prepared and supplied containers. The samples are then placed on ice immediately following collection and transported to the laboratory under standard Chain of Custody procedures. Samples are submitted to a National Association of Testing Authority (NATA) accredited laboratory for analysis. The parameters selected for groundwater analysis include:

- Total Nitrogen (TN).
- Total Phosphorous (TP).
- Ortho-Phosphorous (Ortho P).
- Oxides of Nitrogen (NO_x).
- Total Kjeldahl Nitrogen (TKN).
- Ammonium (NH_4).

2.3 Surface Water Methodology

The main surface water systems within the study area are the Nambad Brook and Bandy Spring. The Ellen Brook runs adjacent to the western boundary of the site. The locations of the surface water features and the sampling locations are shown in **Figure 3**.

2.3.1 Surface Water Quality

Surface water quality samples were taken from the locations shown in **Figure 3.** Surface water samples were aimed to be collected on five occasions per winter over the 25 month monitoring period (10 occasions in total). This monitoring occurred in response to rainfall events to ensure that samples captured runoff events. This methodology results in sporadic data collection; however, it avoids sampling being scheduled when there is no flow to sample. Monitoring parameters were consistent with those for groundwater.

2.3.2 Surface Water Quantity

Surface water quantity was measured using a Hach Sigma Flow Meter to record velocity and depth of water in the culvert at the location shown in **Figure 3**. A rainfall collection station was also installed at this location. The results from the monitoring logger can be utilised for the calibration of future hydrological models of the site, which will aim to characterise surface water runoff attributes. Analysis of this data allows the quantity of surface water flowing through the system to be determined, and the captured peak flows can be attributed to specific rainfall events.

2.4 Chain of Custody

Standard Chain of Custody forms are completed for all samples transferred to the laboratory, detailing the sample identification, collection date and the requested analysis. Upon receipt of the samples the laboratory completes the Chain of Custody forms and provides a copy to Cardno for confirmation. Completed Chain of Custody forms for sampling undertaken are provided in **Appendix B**.

2.5 Laboratory Analysis

All laboratory analysis was conducted by a National Association of Testing Authorities (NATA) accredited laboratory with all primary and QA/QC samples submitted to a NATA accredited laboratory for analysis. Laboratory certificates of analysis are included in **Appendix B**.

Bullsbrook Surface and Groundwater Monitoring – Final Monitoring Report
Prepared for Marlin Bullsbrook

3 Assessment Criteria

In order to provide an indication of the relative concentration of nutrient levels and physiochemical parameters within both surface and groundwater, comparison with the 'default trigger values for slightly disturbed ecosystems (lowland river) in South Western Australia' (ANZECC 2000) is made in the following sections. While the default trigger values are applicable to nutrient concentrations within surface water features, they are not specifically intended for application to groundwater nutrient concentrations. However, as there are no nationally published trigger values available for groundwater quality, a comparison of nutrient concentrations and some field chemistry parameters are made to the 'default trigger values' to provide some context to the measured concentrations. As such, the 'default trigger values' are hereafter referred to as the 'guideline values'. These guideline values are shown in **Table 3.1**.

Table 3.1 ANZECC Guideline Values

TN (µg/L)	TP (µg/L)	Ortho P (µg/L)	NH_4 (µg/L)	NO_x (µg/L)	DO (% Sat)	pH	Salinity (mS/cm)
1200	65	40	80	150	80-120	6.5-8.0	0.12-0.3

Discussion of nutrient concentrations in the following sections refers to their relative concentration compared to the guideline values. The terms 'low', 'moderate', high' and 'very high' are used in the following manner:

- 'Low' – nutrient concentration below, equal to or marginally above default trigger value;
- 'Moderate' – nutrient concentration up to five times the default trigger value;
- 'High' – nutrient concentration between five and 10 times the default trigger value; and
- 'Very High' – nutrient concentrations more than 10 times the default trigger value.

Principally, comparison is made for the TN and TP concentrations. However, some comment is also provided for nutrient species (Ortho P, NH_4, NO_X) where these form a substantial portion of the overall nutrient concentrations.

4 Results

4.1 Groundwater Levels

Depth to groundwater was measured monthly from November 2007 to December 2009. Depth to groundwater results are attached in **Appendix C**. Depth to groundwater ranged from 0mBGS (i.e. intersecting with surface level (Bore BB7, July 2008)) to 23.7mBGS (Bore BB4, January 2009).

Analysis of DoW groundwater bore level data across Perth and within a 10km radius of the study area indicate that groundwater levels are typically at their lowest in April and their highest in October, with seasonal fluctuations of approximately up to 2m. A hydrograph of the groundwater levels of the thirteen bores within the study area is shown in **Figure 4.1**.

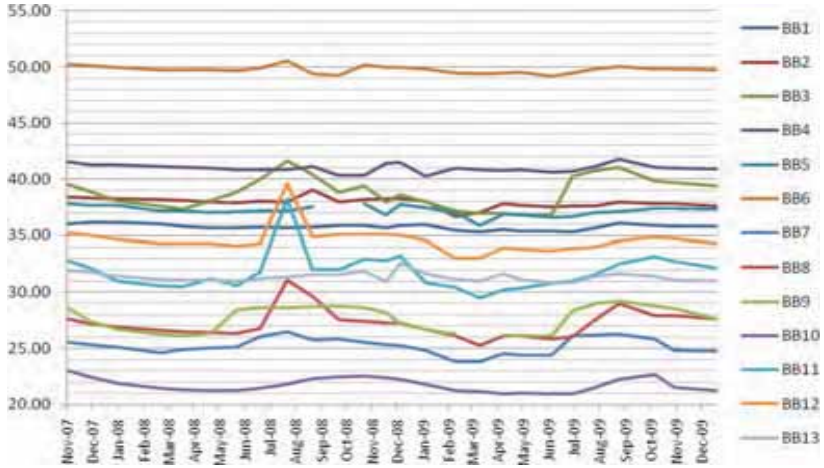

Figure 4.1 Bullsbrook Hydrograph

As shown in **Figure 4.1**, maximum groundwater levels were generally observed in October. The hydrograph indicates the water level in each of the bores followed a similar pattern, with seasonal lows around April and seasonal highs around October. The spike in groundwater levels in July 2008 was likely a result of significant rainfall falling in this month. This spike in groundwater level therefore potentially reflects surface water drainage and localised infiltration attributes rather than overarching regional groundwater levels.

Whilst events such as these are important considerations for future water management at the site they are not considered to be representative of actual groundwater contours. As such, annual average maximum groundwater levels (AAMGLs) have been generated using the October 2008 and October 2009 groundwater levels which have been referenced to DoW Bore 5422. Groundwater contours have been generated using these referenced AAMGLs (see **Figure 2**). These contours generally indicate a south westerly groundwater flow direction.

4.2 Groundwater Quality

Groundwater quality monitoring was usually conducted quarterly between November 2007 and October 2009 (8 occasions). A summary of the results is shown in **Table 4.2.1**. Complete results from each groundwater quality monitoring occasion are shown in **Appendix D**.

Table 4.2.1 Summary of Groundwater *in situ* and Laboratory Analysis Results

	Guideline Values	BB1	BB2	BB3	BB4	BB5	BB6	BB7	BB8	BB9	BB10	BB11	BB12	BB13
Field Chemistry Parameters														
Temp (°C)	-	22.79 (1.50)	22.28 (1.04)	21.70 (1.30)	22.71 (1.46)	21.95 (1.39)	3.93 (1.75)	4.73 (2.40)	7.73 (1.02)	4.01 (2.02)	4.57 (1.70)	5.35 (1.50)	7.15 (0.98)	5.25 (0.87)
Salinity (mS/cm)	0.12-0.3	5.50 (2.17)	3.03 (0.65)	0.41 (0.27)	2.37 (0.57)	1.38 (0.08)	7.30 (0.42)	7.70 (7.93)	7.69 (1.81)	7.67 (0.36)	7.37 (0.62)	8.22 (0.95)	7.50 (0.41)	8.02 (2.66)
DO (%)	80-120	36.35 (12.36)	19.87 (6.11)	34.83 (17.72)	34.94 (14.18)	55.07 (11.46)	34.83 (18.76)	34.94 (9.20)	45.71 (13.83)	27.35 (7.77)	34.89 (14.87)	40.33 (14.75)	39.59 (15.35)	29.86 (14.46)
pH	6.5-8.0	5.40 (0.58)	5.68 (0.20)	4.99 (0.49)	6.00 (0.38)	5.75 (0.21)	11.68 (0.52)	10.43 (0.25)	11.79 (0.43)	11.77 (0.35)	10.26 (0.18)	12.90 (0.10)	10.80 (0.29)	11.28 (0.48)
Redox	-	46.13 (0.58)	105.13 (0.20)	181.75 (0.49)	58.50 (0.38)	143.50 (0.21)	30.60 (0.52)	11.89 (0.25)	31.88 (0.43)	19.66 (0.35)	32.43 (0.18)	15.34 (0.10)	30.08 (0.29)	28.15 (0.48)
Laboratory Analytes														
TN (µg/L)	1200	743 (808)	1,111 (434)	1,431 (1,561)	3,425 (1,509)	1,347 (792)	1,431 (1,654)	3,425 (6,100)	1,045 (831)	1,271 (4,312)	2,428 (359)	2,235 (1,161)	1,120 (339)	1,656 (580)
TP (µg/L)	65	192 (408)	105 (114)	1,079 (2,627)	2,005 (2,298)	229 (117)	1,079 (235)	2,005 (1,010)	210 (867)	592 (304)	1,542 (571)	1,107 (133)	338 (177)	908 (450)
Ortho-P (µg/L)	40	9.20 (6.22)	15 (18.53)	2.33 (0.58)	31.88 (28.13)	14.00 (16.42)	10.40 (16.35)	17.84 (8.50)	10.00 (20.74)	12.21 (5.45)	12.91 (10.71)	13.11 (6.28)	10.38 (17.53)	12.22 (19.04)
NH_4 (µg/L)	80	45.88 (29.47)	16.60 (12.01)	38.40 (11.57)	28.25 (16.24)	11.83 (5.78)	7.72 (14.07)	6.64 (29.71)	10.62 (29.80)	4.61 (29.89)	8.33 (26.81)	7.49 (630.60)	9.82 (17.30)	6.09 (12.83)
NO_2+NO_3 (µg/L)	150	191 (428)	1,015 (321)	673 (846)	2,243 (473)	857 (811)	117 (808)	452 (75)	178 (336)	166 (2,266)	191 (7.29)	407 (16.92)	177 (11.61)	223 (10.30)
TKN (µg/L)	-	628 (830)	466 (208)	1,120 (1,249)	1,314 (1,449)	780 (506)	188 (299)	263 (6,137)	235 (1,005)	95 (1,929)	231 (351)	258 (1,209)	216 (313)	148 (642)

Note: the above statistics are 'average'/'standard deviation'. Guideline values are the ANZECC trigger values for Lowland Rivers in South Western Australia.

As shown in **Table 4.2.1**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicates:

- 'Low' to 'moderate' TN concentrations.
- 'Moderate' to 'very high' TP concentrations.
- 'Low' Ortho P and NH_4 concentrations.
- 'Low' to 'very high' NO_x concentrations.
- Salinity values that exceed the guideline range.
- pH values within, below and above the guideline range.

Notably high average concentrations of TP were recorded at Bores BB3, BB6, BB7, BB10, BB11 and BB13. These 'very high' concentrations were generally accompanied with a relatively high standard deviation which indicates significant variability in TP concentrations. TN concentrations were generally moderate with no notable highs.

The spatial mapping of the average TN and TP concentrations is shown in **Figures 3** and **4** respectively. **Figure 3** indicates TN concentrations are generally 'moderate' throughout the study area. TP concentrations were generally 'very high' throughout the study area. Both TN and TP concentrations were lower around Bores BB1, BB2 and BB8.

4.3 Surface Water Quality

Surface water quality samples were taken from the locations shown in **Figure 3**. Surface water samples were aimed to be sampled on five occasions per winter over the 25 month monitoring period. During 2008, sampling locations were visited on six occasions in response to rainfall events. Samples were able to be taken on three of these six site visits. During 2009, sampling locations were visited on eight occasions in response to rainfall events. Samples were able to be taken on five of these eight site visits. At the end of the 25 month monitoring period, surface water from Nambad Brook and Bandy Creek had been sampled a total of eight times. **Table 4.3.1** shows the surface water results for Nambad Brook.

Table 4.3.1 Surface Water Quality Results for Nambad Brook

	Guideline Values	Jul-08	Aug-08	Aug-08	Jun-09	Aug-09	Sep-09	Sep-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	14.67	12.96	15.01	15.00	16.74	14.77	17.98	18.73
Salinity (mS/cm)	0.12-0.3	0.19	0.56	0.64	0.78	0.79	1.46	0.49	0.15
DO (%)	80-120	88.70	87.30	74.00	68.40	57.90	92.90	98.70	84.30
pH	6.5-8.0	7.26	6.93	7.36	7.67	6.98	6.98	7.01	7.00
Redox	-	202	177	122	115	140	124	104	127
Laboratory Analytes									
TN (µg/L)	1,200	1,100	530	760	1,800	700	800	400	500
TP (µg/L)	65	210	42	37	260	30	10	50	10
Ortho-P (µg/L)	40	8	4	5	140	<10	<10	20	<10
NH_4 (µg/L)	80	31	<3	18	200	40	40	110	30
NO_2+NO_3 (µg/L)	150	83	7	160	330	170	150	<10	50
TKN (µg/L)	-	1,000	500	600	-	500	600	400	400

As shown in **Table 4.3.1**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicates:

- 'Low' TN concentrations.
- 'Low' to 'moderate' TP concentrations.
- 'Low' to 'moderate' Ortho P concentrations.
- 'Low' to 'moderate' NO_x and NH_4 concentrations.
- Salinity values that generally exceed the guideline range.
- pH values within the guideline range.
- DO concentrations within or slightly below the guideline range.

Table 4.3.2 shows the surface water quality results for Bandy Spring.

Table 4.3.2 Surface Water Quality Results for Bandy Spring

	Guideline Values	Jul-08	Aug-08	Aug-08	Jun-09	Aug-09	Sep-09	Sep-09	Oct-09
Field Chemistry Parameters									
Temp (°C)	-	14.36	18.18	17.25	16.56	17.40	14.33	17.13	19.58
Salinity (mS/cm)	0.12-0.3	0.31	0.48	1.72	0.17	0.41	0.59	1.25	0.49
DO (%)	80-120	89.3	105.3	114.8	69.8	68.9	92.4	92.5	98.5
pH	6.5-8.0	7.32	8.40	8.61	7.43	7.03	6.44	7.28	6.65
Redox	-	305	145	107	103	145	172	122	125
Laboratory Analytes									
TN (µg/L)	1,200	830	540	810	670	2,700	2,200	2,500	2,300
TP (µg/L)	65	110	25	25	150	570	390	480	520
Ortho-P (µg/L)	40	13	<2	5	92	470	380	420	240
NH_4 (µg/L)	80	17	13	18	44	60	50	60	30
NO_2+NO_3 (µg/L)	150	120	12	160	36	100	140	170	80
TKN (µg/L)	-	700	500	600	-	2,600	2,100	2,300	2,200

As shown in **Table 4.3.2**, comparison of the physiochemical parameters and nutrient concentrations with the ANZECC guideline values indicates:

- 'Low' to 'moderate' TN concentrations.
- 'Low' to 'high' TP concentrations.
- 'Low' to 'very high' Ortho P concentrations.
- 'Low' to 'moderate' NO_x concentrations.
- 'Low' NH_4 concentrations.
- Salinity values that generally exceed the guideline range.
- pH values that varied across the monitoring period.
- DO concentrations within or below the guideline range.

Analysis of the surface water quality data over the two winters indicates higher levels of nutrient concentrations were observed during July/ August. The flat plains of the Ellen Brook catchment are known to suffer mobilisation of nutrients and seasonal salinity (WRC, 2002). The nutrient concentration trends observed are likely the cause of mobilisation of nutrients in the early rainfall events. Salinity levels reached their peak in August/ September.

4.4 Surface Water Quantity

The data logger recorded four significant rainfall events from September 2008 to December 2009. For the recording period, the onsite rain gauge was used and a flow meter recorded data in Nambad Brook for the velocity and water level in 10 minute increments in the culvert on the western side of Great Northern Highway. The location of the data logger is shown in **Figure 3**.

Table 4.4.1 Recorded Monthly Rainfall and Runoff Data for Bullsbrook

Year	Month	Rainfall (mm)	Cumulative Rainfall per year (mm)	Runoff (GL)	Cumulative Runoff per year (GL)	Peak Discharge Flow Rate (m^3/s)
2008	**Sep**	5.47	5.47	0	0	0
	Oct	5.89	11.36	0	0	0
	Nov	3.71	15.07	0	0	0
	Dec	0.72	15.79	0	0	0
2009	**Jan**	0.92	0.92	0	0	0
	Feb	0.03	0.95	0	0	0
	Mar	0.33	1.28	0	0	0
	Apr	1.73	3.01	0	0	0
	May	6.24	9.25	0	0	0
	Jun	17.08	26.33	1.31	1.31	0.46
	Jul	22.6	48.93	119.07	120.38	0.77
	Aug	14.16	63.09	61.20	181.57	0.66
	Sep	7.32	70.41	36.63	218.2	0.88
	Oct	2.00	72.41	6.85	225.05	0.99
	Nov	5.14	77.55	0	225.05	0
	Dec	0	77.55	0	225.05	0

As shown in **Table 4.4.1**, rainfall was recorded each month over the monitoring period with the exception of December 2009. Runoff was recorded between June 2009 and October 2009 with flow velocities ranging between 0-3m/s and a cumulative total of 225GL of water flowing through the monitoring location. July recorded the greatest amount of runoff with 119GL observed during the month. This result was influenced by two significant rainfall events occurring within two days. The significant rainfall events recorded over the monitoring period are shown in **Table 4.4.2**

Table 4.4.2 Significant Rainfall Events

Date	Observed Duration (min)	Observed Total Rainfall (mm)	Corresponding Designed Rainfall Event	Observed Peak Discharge (m^3/s)
31/01/2009	30	8.6	1yr 30min	0
18/06/2009	30	6.0	1yr 30min	0
19/07/2009	1270	53.7	2yr 1440min	0.77
20/07/2009	2410	54.8	1yr 2880min	0.54

As shown in **Table 4.4.2**, the event with the highest peak discharge occurred on the 19th July 2008. This event saw 53.7mm fall in approximately 21 hours. The hourly rainfall for the significant rainfall events in July and the average discharge rates in response to these events are shown in **Figure 4.4**.

The discharge and rainfall for the two significant rainfall events in July presented in **Figure 4.4** can be used for the calibration of future hydrological models.

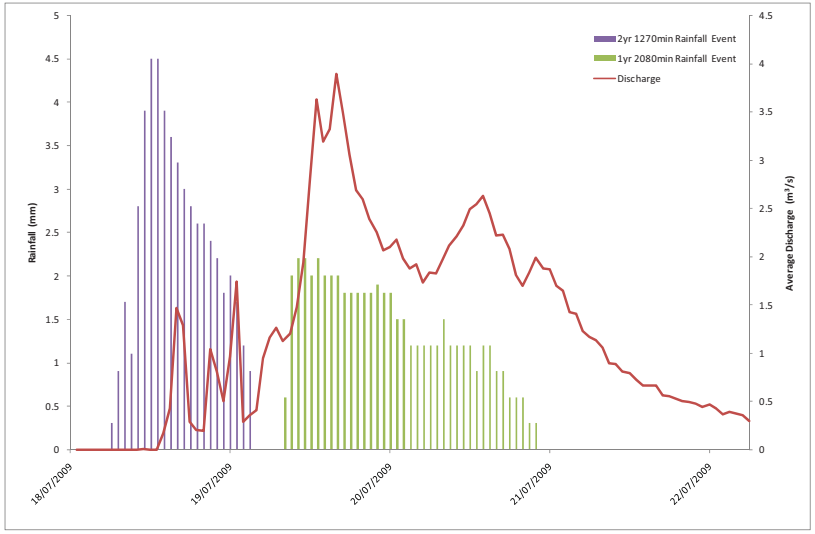

Figure 4.4 Average Discharge and Hourly Rainfall for Significant Rainfall Events in July 2009

5 Conclusions and Recommendations

This SAP was able to capture groundwater levels and groundwater quality from November 2007 to December 2009, and surface water quality and flow volumes over the same period. Thirteen groundwater bores and a Hach Sigma Flow Meter and rainfall collection station were installed within the study area.

Groundwater levels were measured on a monthly basis for 25 months on all installed bores. Groundwater may intersect with the surface at some locations during the annual peak (usually October). If they are proposed to be developed, these areas may require fill or other methods to achieve appropriate separation to groundwater prior to development. Furthermore, it should be noted that some sections of the study area are prone to localised flooding, generally to the west of the Great northern Highway.

Groundwater quality sampling for nutrient concentrations was usually conducted on a quarterly basis over 25 months (8 occasions). Nutrient concentrations in groundwater varied both spatially within the study area and temporally over the duration of the monitoring period. There were occasions over the monitoring period when nutrient concentrations were in excess of the default trigger values (i.e. those given for surface water quality). Overall, the main concern in regard to groundwater quality within the study area relates to TP and NO_x concentrations. The data presented in this report suggests the concentrations observed are a characteristic of regional nutrient concentrations rather than site specific/ introduced nutrient levels.

The surface water quantity data has captured four clearly defined significant rainfall events which can be used for the calibration of future hydrological models. Surface water quality samples were taken from Nambad Brook and Bandy Creek in response to rainfall events. Surface water samples were taken on eight occasions over the monitoring period and provide baseline data for future comparison.

This report concludes the scope of work in regards to hydrological monitoring of the study area. No inherent errors or deficiencies have been identified and the data presented within is robust and comprehensive enough to facilitate

This report concludes the scope of work with regards to the hydrological monitoring of the study area. As no inherent deficiencies have been identified, the monitoring parameters and methodology are considered to have been adequate to have achieved the aims of the pre-development hydrological investigation and as such, Cardno is of the opinion that the current dataset is robust and comprehensive enough to assist in future planning of the proposed development.

6 References

Australian and New Zealand Environment and Conservation Council (ANZECC), 2000, *National Water Quality Management Strategy,* Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Department of Environment (DOE), 2001, *Development of Sampling and Analysis Programs*, State Government of Western Australia, Perth.

Department of Water (DOW), 2007, *Stormwater Management Manual for Western Australia*, State Government of Western Australia, Perth.

Department of Water (DOW), 2008, *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions*, DOW, Perth.

Waters and Rivers Commission (WRC), 2002. *Hydrogeological Information for Management Planning in the Ellen Brook Catchment*. Waters and Rivers Commission: Perth.

Western Australian Planning Commission (WAPC), 2003, *North East Corridor Extension Strategy (NECES)*. Final Government of Western Australia.

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

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Figure 2 Groundwater Bore locations and Referenced AAMGL Contours

Figure 3 Surface Water Features

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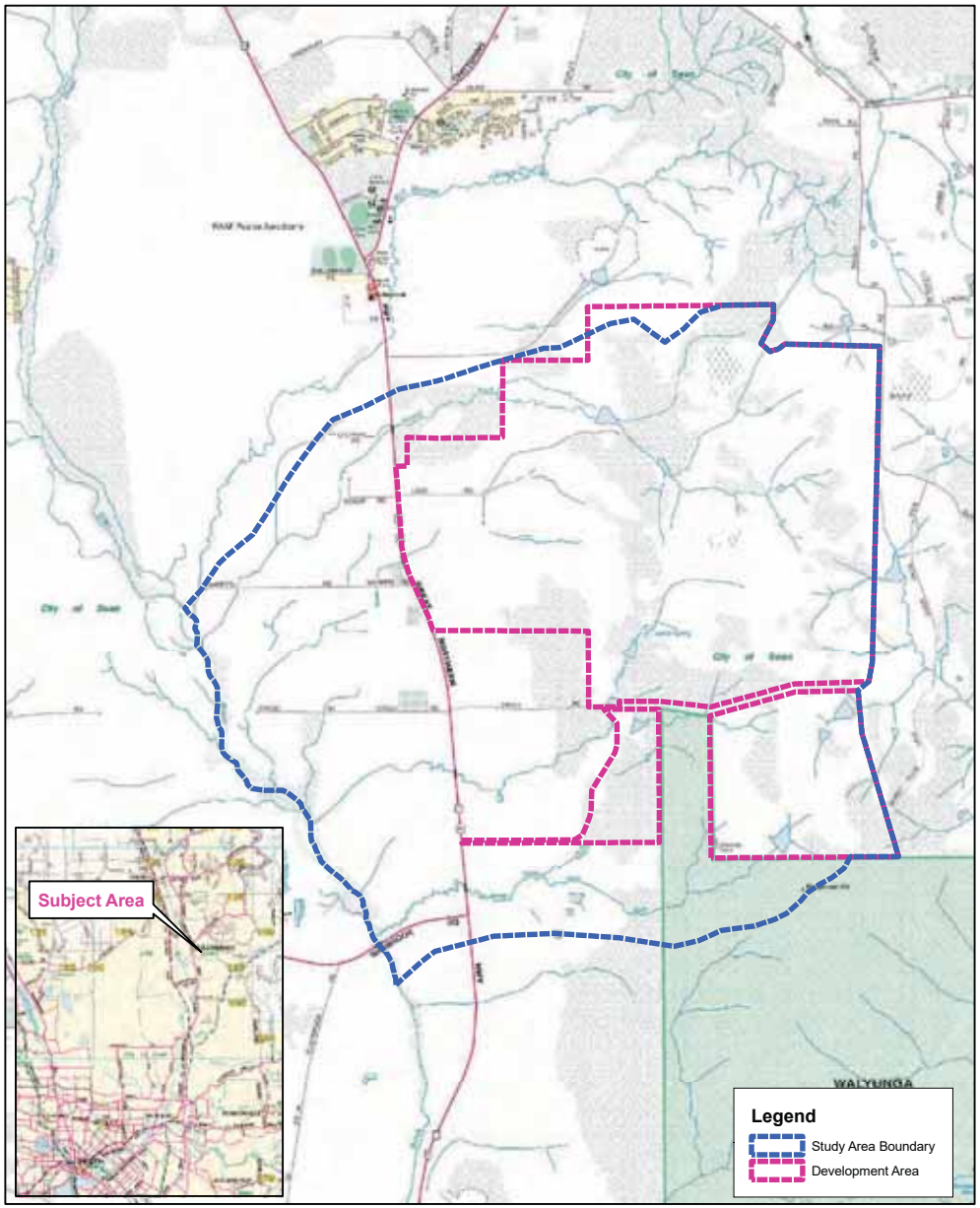

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PROJECT: Bullsbrook Surface & Groundwater Monitoring

DRAWING TITLE: FIGURE 1 : Locality Plan

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Project Number: V7106
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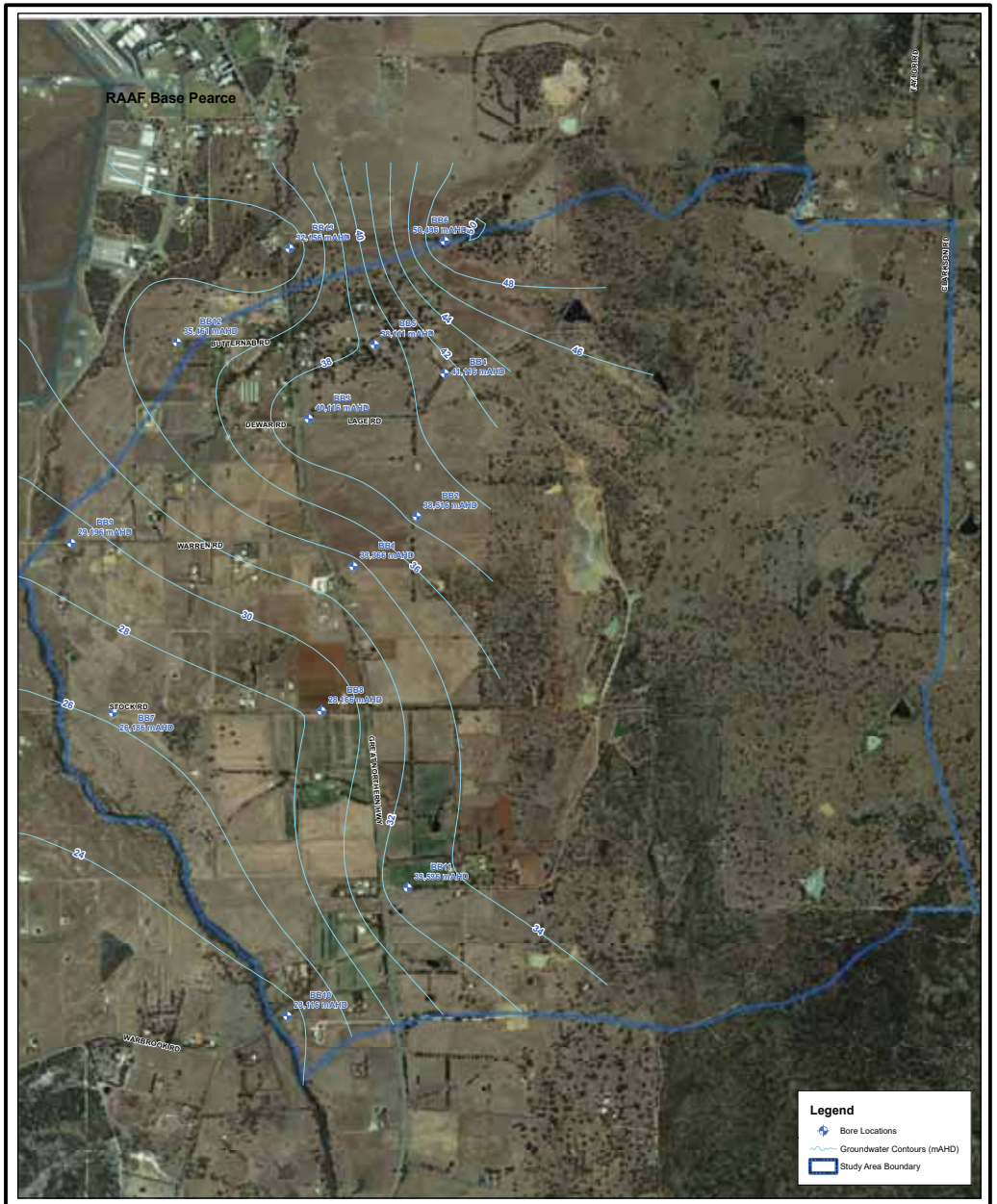

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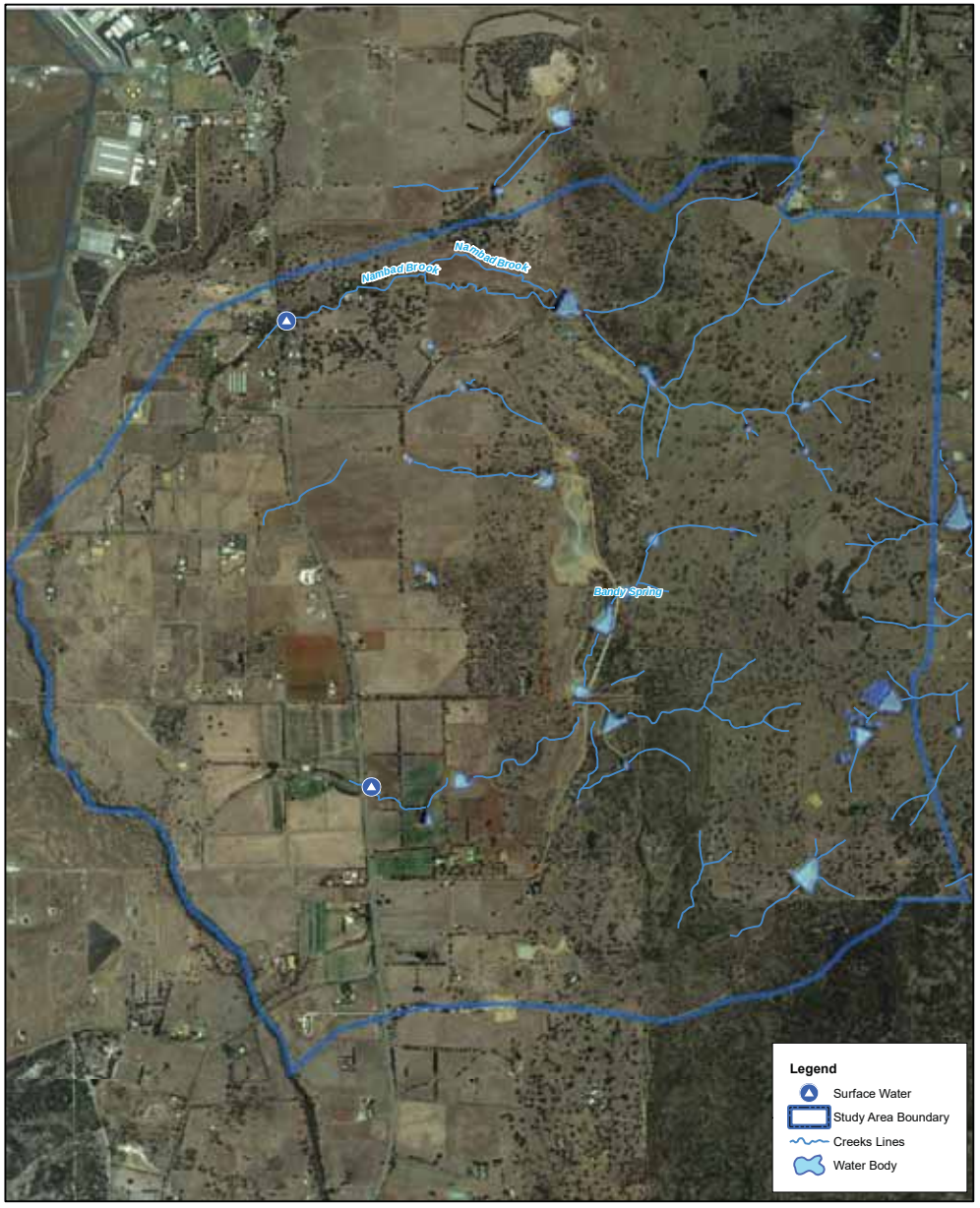

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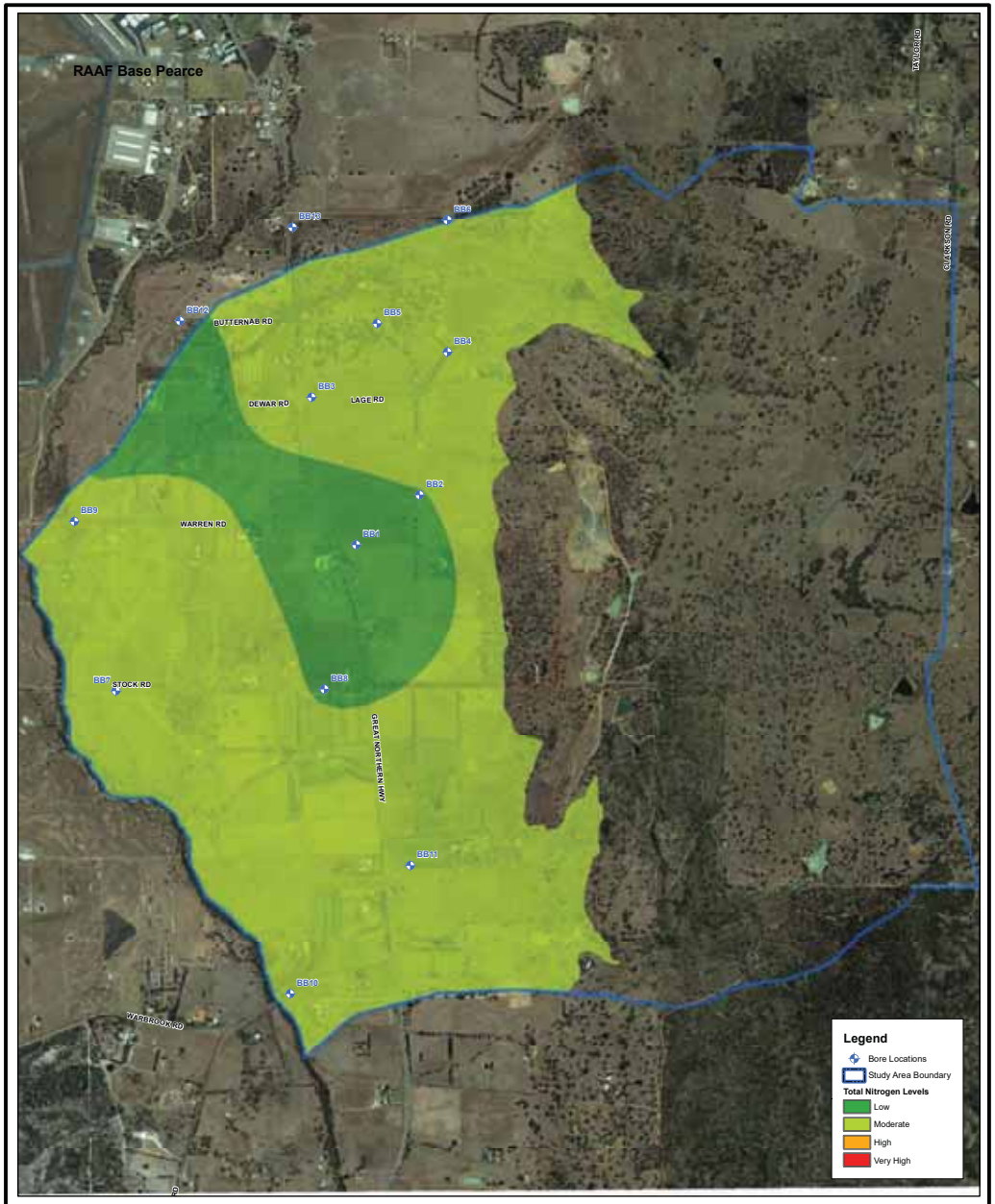

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DRAWING TITLE: FIGURE 4: Total Nitrogen Mapping

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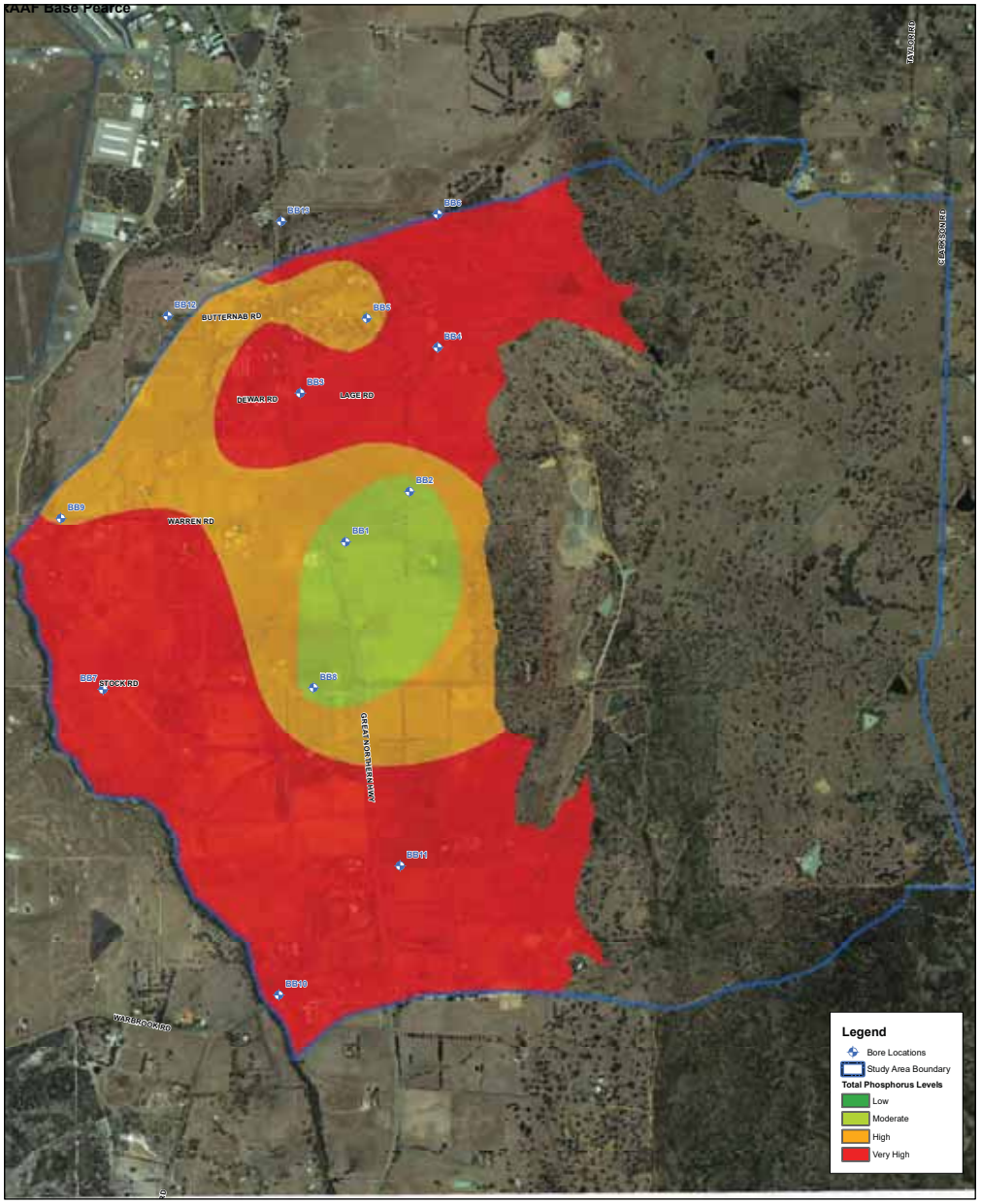

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PROJECT **Bullsbrook Surface & Groundwater Monitoring**

DRAWING TITLE **FIGURE 5: Total Phosphorus Mapping**

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APPENDIX C

DOW MONITORING BORE GD15 - HYDROGRAPH

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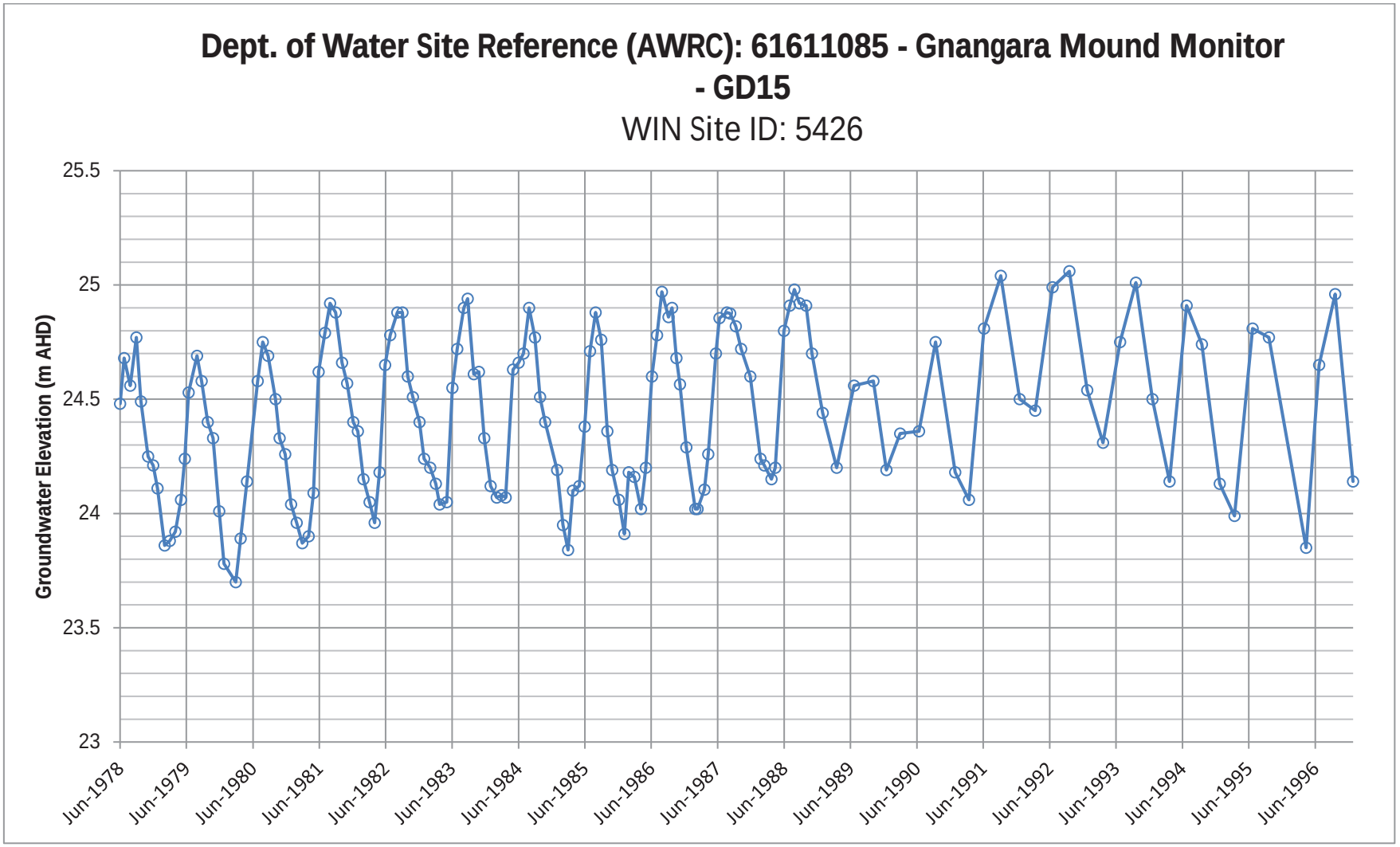
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WIN Site ID: 5426
Groundwater Elevation (m AHD)
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25
24.5
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23.5
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Jun-1978
Jun-1979
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Jun-1995
Jun-1996

Appendix G: District Water Management Strategy - Great Northern Gateway Industrial Cell

Cardno, 2012



District Water Management Strategy

Great Northern Gateway Industrial Cell

Prepared for Seaport Pty Ltd

March 2012

Project Number V10009 - 009

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1 Introduction

District structure planning is being undertaken for approximately 470 hectares of land located within the City of Swan, approximately 31 kilometres north east of the Perth central business district. This area is referred to within this report as the 'subject site'. The subject site is also referred to as the Great Northern Gateway Industrial Cell. The subject site is bound by Great Northern Highway to the east, Royal Australian Air Force (RAAF) Pearce Aerodrome to the north, the Midland-Geraldton rail line and Railway Parade to the west and Stock Road and rural land to the south. The locality of the subject site is shown in **Figure 1**.

1.1 Purpose of this Report

It is important to clearly document the manner in which stormwater runoff from industrial areas is to be managed (to avoid flooding and protect the environment) early in the planning process. This approach provides the framework for actions and measures to achieve the desired outcomes at Local Structure Planning and subdivision stage. The Department of Water (DoW) guidance document *Better Urban Water Management* (WAPC 2008) indicates that a District Water Management Strategy (DWMS) is considered the appropriate mechanism to confirm the management approach for flood mitigation and effective stormwater management at this level of planning.

The overall aim of the DWMS is to ensure that any potential impacts to the downstream waterways (principally the Ellen Brook) from land use change as a result of development are minimised. This document is intended to fulfil the requirement for a DWMS.

1.2 Town Planning Context

The development of the Great Northern Gateway Industrial Cell will support a range of industrial and commercial uses to contribute to the sustainable growth of the Perth region and provide a valuable employment area. The subject site is currently zoned as "General Rural" under the City of Swan *Local Planning Scheme (LPS) No. 17* (City of Swan 2008). This area is proposed to be rezoned under the Metropolitan Region Scheme (MRS) from 'rural' to 'industrial'. This DWMS supports the amendment of the MRS for the zoning of the subject site as an Industrial land use.

1.3 Principles and Objectives

There are a number of State Government policies of relevance to the Great Northern Gateway Industrial Cell. These policies include:

- *State Water Strategy* (Government of WA 2003).
- *Acid Sulphate Soils Risk Mapping* (WAPC 2007).
- *Environmental Protection (Swan Coastal Lakes) Policy* (EPA 1992).
- *Environmental Guidance for Planning and Development* (EPA 2008).
- *Healthy Rivers Action Plan* (Swan River Trust 2008).
- *Urban Growth and Settlement* (WAPC 2006).
- *Swan Canning River System* (WAPC 2006).
- *Industrial Land Strategy* (WAPC 2009).
- *Guidelines for Industrial Development* (Sands & Shepherd 2010).
- *Urban Water Management* (WAPC 2008).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that urbanised developments

should aim to achieve. These are key inputs that relate either directly or indirectly to the subject site, and include:

- *Decision Process for Stormwater Management in Western Australia* (DoW 2009).
- *National Water Quality Management Strategy* (ANZECC 2000).
- *Stormwater Management Manual for Western Australia* (DoW 2007).
- *Better Urban Water Management* (WAPC 2008).

The *Decision Process for Stormwater Management in WA* provides a decision framework for the planning and design of stormwater management systems. Effectively, the document provides guidance as to how urban development can achieve compliance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for WA*.

The essence of the recommended approach is to address water quality concerns for minor events (up to a 1 year – 1 hour Average Recurrence Interval (ARI) event) at source, or as close as possible to source. Following this and where appropriate, water quality should also be addressed through a 'treatment train' approach, such that the combined effect meets the water quality management objectives specified in relevant regional water management targets. Conveyance of flows up to the 5 year ARI event should be accommodated within the minor system (i.e. pipes and swales), while flows up to the 100 year ARI event should be catered for by overland flow paths. The *Decision Process for Stormwater Management in WA* indicates that stormwater quantity should be managed to preserve pre-development peak flow rates. This should be achieved by providing adequate storage within the site boundaries.

The guidance documents listed were reviewed to determine the likely data requirements for the area within the proponent's landholdings, which are proposed for future industrial development. These documents point to the need for accurate baseline data prior to urban development. Comprehensive baseline data ensures that any future development is able to fulfil the stormwater management requirements of the DoW and engineering standards specified by the City of Swan, but will also ensure that realistic water quality criteria that are practically achievable are adopted.

1.4 Previous Studies

Cardno has completed a number of other studies for the subject site, including:

- *Detailed Level 1 Flora and Vegetation Results* (Cardno 2010).
- *Wetland and Waterway Assessment* (WWA) (Cardno 2010).
- *Preliminary Acid Sulfate Assessment* (Cardno 2010).
- *Hydrological Monitoring at Great Northern Gateway Industrial Estate: Initial Report* (Cardno 2010).
- *Environmental Assessment Report* (Cardno 2010).
- *Fauna Assessment (Level 1) and Black Cockatoo Habitat Assessment* (Harewood 2010).

The above studies have been used to inform the proposed approach to water management at the site.

2 Proposed Development

2.1 Concept Plan

The future development of the subject site as an industrial cell will facilitate the expansion of the Great Northern Gateway, providing high quality, environmentally sensitive and integrated industrial development. It is envisaged that the future industrial development will support a range of industrial and commercial services providing employment and economic growth for the region. The City of Swan indicated support for industrial land development in the Bullsbrook locality. The *Preliminary Concept Plan* is provided in **Appendix A**. The different land uses shown on the Preliminary Concept Plan refer to:

- Light Purple – Average lot sizes ranging from 2500sqm-5000sqm;
- Dark Purple – Average lot sizes ranging from 3ha-10ha; and
- Light Blue – Average lot sizes ranging from 2.5ha-5ha.

The Western Precinct, located west of the Ellen Brook Conservation Area, has potential for large scale transport/storage uses, long term intermodal expansion and intermodal freight terminal. The Eastern Precinct, located east of the Ellen Brook Conservation Area, has potential for transport based industry, transport and storage base industry that evolves to light industry, light industrial use and a key corner site for industry related commercial uses at the corner of Stock Road and the Great Northern Highway.

2.2 Environmental Management

There are a number of strategies to manage the environment within the development, which addresses vegetation, wetlands and waterways, groundwater, surface water, flora and fauna. These strategies include:

- Development buffers to accommodate flood conveyance within Ellen Brook and Nambad Brook, and protect riparian vegetation and wetlands.
- Flow paths through the subject site are maintained in the post-development.
- Pre-development peak flows exiting the subject site are maintained through the use of onsite flood detention basins.
- Low flow events shall be treated, as close to source as possible, within retention structures to maximise stormwater quality.

3 Pre-development Environment

3.1 Current and Historical Land Use

At present, the majority of the subject site is utilised for grazing and pastoral purposes. The surrounding area is also dominated by grazing and pastoral land use. The Bullsbrook town centre and the surrounding residential development are located to the north east of the subject site. In addition, the RAAF Pearce Aerodrome is located directly to the north of the subject site.

3.2 Climate

The subject site is located within the South West of Western Australia, which experiences a Mediterranean climate of mild wet winters and hot dry summers. Climatic data obtained from the Bureau of Meteorology (2010) provides average rainfall statistics. The nearest weather station is located at the RAAF Pearce Aerodrome directly north of the subject site, and this has an annual average rainfall of 688.8mm. The mean maximum rainfall of 138.5mm occurs in June and the mean minimum rainfall of 7.9mm occurs in January.

3.3 Geotechnical

3.3.1 Topography

The topography of the subject site is relatively flat with the natural surface height ranging from 50 metres Australian Height Datum (AHD) to 30mAHD. Topographical contours for the subject site are shown in **Figure 2**. The eastern portion of the site is of a higher grade than the remainder of the subject site and is illustrated by a slope analysis (**Figure 3**).

3.3.2 Soils

According to landform and soil mapping the subject site is comprised of Beermullah and Guildford soil complexes (Churchward & McArthur 1980). The Department of Agriculture and Food provides mapping of the region, detailing the likely soil units. The soil units described as occurring across the subject consist of Yanga, Pinjarra and Forrestfield systems (detailed in **Table 1**).

Table 1: Soil landform units of the subject site (Churchward & McArthur 1980)

Soil Unit	Land Unit	Description
Yanga Poorly drained plain with pale sands and deep sandy duplex, wet, semi-wet and saline wet soils. Banksia-pricklybark-marri-swamp sheoak-paperbark woodlands.	Ya_6n	Saline flat plain with occasional low dunes. Yellowish brown sandy duplex and poorly structured clay soils often with pans underlying. Low woodland of *Casuarina* spp., with *Hordium leporinum* (barley grass.)
	Ya_6x	Flat plain with occasional low dunes. Yellowish brown duplex and poorly structured clay soils often with pans underlying. Low woodland with occasional tall *E. rudis*, *Melaleuca* spp., Teatree and *E. camaldulens*.
	Ya_7n	Saline flat plain with occasional low dunes and marl on the surface or buried, overlies alluvium, often with siliceous hardpans. Low woodlands of *Casuarina obesa* and salt tolerant grasses
	Ya_7x	Flat plain with occasional low dunes. Marl maybe at the surface or deeply buried, overlying alluvium, often with siliceous hardpans. Low woodland with occasional tall *E. rudis*, *Melaleuca* spp. and Teatree.
	Ya_8x	Flat plain with occasional low dunes. Subject to seasonal inundation. Deep white and pale yellow sands interspersed with swamp and generally underlain by siliceous/humic pans at depth.
Forrestfield Undulating foot slopes of the Darling and Whicher Scarps. Duplex sandy gravels, pale deep sands and grey deep sandy duplexes. Woodland of *E.marginata*, *calophylla* and *wandoo* and some *B.grandis*.	Fo_F2	Very gently to gently inclined footslopes with well drained gravelly yellow or brown duplex soils with sandy topsoil
	Fo_F3	Very gently to gently inclined footslopes with well drained gravelly yellow or red duplex soils with sandy loam to loam topsoil
	Fo_F7	Level to very gently inclined alluvial fans with variable imperfectly drained soils comprising layers of sand, sandy loam, clay, grit and weathered granitic detritus.
Pinjarra Poorly drained coastal plain with variable alluvial and aeolian soils. Variable vegetation includes Jarrah, marri, wandoo, paperbark sheoaks and *E. rudis*.	Pj_Gf4	Alluvial fans with variable imperfectly drained soils similar to unit F7
	Pj_Gf2	Plain with imperfectly drained yellow duplex soils with sand to sandy loam topsoil
	Pj_Gf5	Incised drainage channels with poorly drained gradational mottled yellow earths

These soil units are shown in **Figure 4**. Observations by Cardno during the soil bore installation generally confirmed the soil units described above. Soil profiles were generally comprised of silty sand topsoil overlying sand, clay and clayey sand soil profiles (Cardno 2010). These silty sand and clayey sands are assumed to have an infiltration rate of $4x10^{-5}$m/s (Department of Agriculture 2001).

3.3.3 Acid Sulfate Soils

Acid Sulphate Soil (ASS) is a naturally occurring soil or sediment that contains iron sulphide (iron pyrite) minerals. ASS risk maps published by the Western Australian Planning Commission (WAPC) indicate that the site is located within areas defined as both “low to moderate risk” and “no to low risk” of ASS occurring up to 3.0m Below Ground Surface (BGS) (WAPC 2007). The ASS risk mapping is shown in **Figure 5** and indicates that the potential for ASS to be present along the Ellen Brook is moderate to low.

A site specific *Preliminary Acid Sulfate Soil Assessment* was undertaken by Cardno in June 2010. The preliminary ASS investigations were undertaken to highlight areas which may be susceptible for the formation and persistence of ASS.

The assessment determined potential soil acidity that exceeds the Department of Environment and Conservation (DEC) action criteria of 0.03%S (further discussed in Cardno 2010) has been identified within some minor sand profiles with variable clay content. Soil disturbance in potential ASS areas will require appropriate management to mitigate any potential ASS related impacts. Soil profiles identified in other areas of the site do not contain significant acid generating potential and, consequently, will not require management.

The conclusions from the preliminary ASS investigations indicate that the extent of ASS and potential acid sulphate soils (PASS) is of such minor extent that it is likely that any potential risk and/or impact resultant from ASS disturbance can be appropriately managed during future development works. However, future detailed investigations are required to ascertain the presence, nature and extent of ASS within the site i.e. depth and extent of excavations for servicing. This will determine whether ASS will be disturbed by the proposed development works and any additional ASS management requirements. A detailed ASS investigation will be undertaken once information becomes available to exact disturbance proposed to the site.

3.4 Environmental Assets

3.4.1 Flora

Broad regional information indicates that the subject site is located within the Swan Coastal Plain Subregion Drummond Botanical Subdistrict. The vegetation is broadly categorised as Banksia low woodland on leached sands with Melaleuca swamps on ill-drained soils and woodlands of Tuart (*Eucalyptus gomphocephala*), Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on less leached soils (Beard 1990).

A search was conducted of the Department of Environment and Conservation’s (DECs) Declared Rare Flora (DRF) and Priority Flora (PF) databases and the EPBC Act Protected Matters Tool in June 2010. This found three DRF species and 11 PF that potentially occur within the subject site (see **Appendix B**). However, No DRF, PF or flora of significance were recorded during the July or August 2010 flora and vegetation surveys and it is unlikely that the listed DRF and PF for the area would be found within the site boundaries (Cardno 2010).

During the flora and vegetation surveys only one plant community was described. This was the degraded ErMr – woodland of *Eucalyptus rudis* over *Melaleuca rhaphiophylla* over *Juncus pallidus* and *Cynodon dactylon* along creeklines. The location of these native trees was considered when developing the proposed development buffer (**Figure 6**) in the *Wetland and Waterways Assessment* (Cardno 2010). The remainder of the site consisted of cleared paddocks with scattered native tree species including *Eucalyptus rudis, Corymbia calophylla* and *Casuarina obesa*.

A search was undertaken of the DECs database and three Threatened Ecological Communities (TECs) were returned as occurring in close proximity to the subject site (**Table 2**). It is important to note that the TECs are not located within the subject site and it is the 50km radius buffer zone that crosses onto the subject site. No TECs were observed during the surveys and all remnant native vegetation was considered to be degraded. However Lot 141 (unsurveyed due to access limitations) may represent the Critically Endangered TEC *Corymbia calophylla* - *Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (SCP3c).

Table 2: Threatened Ecological Communities found within the Bullsbrook Subject Site.

Conservation Status	Ecological Community Type	Community Description
Vulnerable (VU C)	FCT 15	Forests and woodlands of deep seasonal wetlands of Swan Coastal Plains (SCP15)
Critically Endangered	FCT 3cTEC	*Corymbia calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain (SCP3c)
Vulnerable (VN B)	FCT 08TEC	Herb rich shrub lands in clay pans (SCP08)

Within the subject site there is an existing Bush Forever Site 296. This Bush Forever site aims to protect the regionally significant ecological function of the Ellen Brook and provides ecological linkages along the Brook and into the adjacent Bush Forever Site 294 (within the RAAF base) and extends south to the Ellen Brook Wildlife Sanctuary roughly 5.8km to the south east of the southern boundary of the subject site. This Bush Forever site is shown in **Figure 6**.

3.4.2 Fauna

A search was undertaken of the Department of Environment, Water, Heritage and the Arts (now DSEWPC) Protected Matters Tool to determine the threatened fauna species and Priority Species found within the subject site. These eight fauna of conservation significance are listed in **Appendix B**. In addition, a site specific fauna investigation conducted in July 2010 found that 126 species could potentially utilise the subject site, although the number is likely to be significantly lower (Harewood 2010). A total of 43 native fauna species were observed (or positively identified from foraging evidence, scats, tracks, skeletons or calls) within the subject site during the field investigations. No vertebrate fauna of conservation significance were positively identified as utilising the subject during the fauna survey. The species of conservation significance that may possibly utilise the subject site for some purpose are also listed in **Appendix B**.

3.4.3 Wetlands

Based on the mapping maintained by the DEC, the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (Hill *et al.* 1986) the subject site contains a few Conservation Category Wetlands (CCWs) and a large Multiple Use Wetland (MUW). The CCWs are shown in **Figure 6**.

The majority of the site is listed as MUW which is defined by the Water and Rivers Commission (2001) as suitable for development providing development employs ecologically sustainable development principles and best management practice catchment planning. The majority of MUW wetlands within the subject site have been cleared and retain very little ecological function.

One CCW is a wetland that aligns with Ellen Brook from the north to south through the centre of the subject site. Two other CCWs are located adjacent to sections of Nambad Brook. CCW's are classified as the highest priority wetlands and should not be developed. The results from the WWA (Cardno 2010) considered that the waterway and associated wetland is heavily degraded and no longer supports substantial wetland attributes. However, it is likely that the creekline may contain habitat (e.g. foraging, breeding and roosting) for some fauna species of conservation significance. The aquatic or littoral vegetation could potentially offer habitat for aquatic fauna. A 50m buffer is recommended for these CCWs ensure the future development footprint excludes any significant waterway values and protects the ecological and cultural value of Ellen Brook and Nambad Brook. The boundary of the wetland buffer was considered when developing the proposed development buffer (**Figure 6**).

3.4.4 Biophysical Assessment

A biophysical assessment has been conducted for Ellen Brook in order to determine an applicable and appropriate reservation boundary to retain ecological and hydrological functions. The biophysical assessment methodology and results are detailed within the WWA (Cardno 2010). In summary, the assessment found Ellen Brook to have significant biophysical attributes that require protection and a setback from development. The assessment determined that the proposed reservation boundary should include the following attributes of Ellen Brook:

- A 50m setback from the Conservation Category Wetland boundary to protect the biophysical function of the wetlands.
- All remnant riparian vegetation that aligns with Ellen Brook to provide a valuable ecological corridor and fauna habitat.
- The 100 year ARI floodway boundary to ensure the flood conveyance function of Ellen Brook is maintained. This 100 year ARI floodway boundary includes the majority of the remnant vegetation, a mapped Bush Forever site, fauna habitat as well as cultural significance (Aboriginal Heritage).
- The cultural significance of Ellen Brook is generally contained to the surface water movement, riparian vegetation, channel form and hydrological regime.

The resultant reservation boundary was considered when developing the development buffer proposed in this DWMS (**Figure 6**).

3.5 Hydrology

3.5.1 Surface Water Quantity

An understanding of the existing surface runoff throughout the site is required so that an effective post-development stormwater management strategy can be developed. In the regional context, the subject site is located near the lower end of the Ellen Brook sub-catchment. The Ellen Brook sub-catchment is the largest sub-catchment that contributes to the Swan-Canning Estuary on the Swan Coastal Plain and is considered to be an ephemeral waterway; generally flowing between May and December (Swan River Trust 2007).

Surface water flows into the subject site from the north via Ellen Brook, from the north-east via Nambad Brook and Ki-it Monger Brook and from the west and east via a number of small drainage lines. These drainage lines and associated culverts transport runoff from the eastern side of the Great Northern Highway and the western side of the Perth – Geraldton Rail Line into the subject site. Within the subject site, surface runoff flows towards Ellen Brook in a southerly direction. These flow paths are shown in **Figure 7**.

The surface water runoff peak flows have been estimated using accurate data on topography, infiltration rates and vegetation coverage and a detailed and calibrated hydrological model.

3.5.1.1 Pre-development Modelling

The subject site was divided into a total of 17 pre-development catchments, as shown in **Figure 7**, covering an area of 470ha. Catchment characteristics such as slope and area are provided in **Appendix C**, together with a full description of the modelling methodology.

Pre-development catchments were also determined for areas to the west and to the east of the site that contribute stormwater runoff into the subject site. To the west of the subject site there were a total of eight pre-development catchments that cover an area of 1580ha. To the north, five catchments flow into the subject site at five locations and cover an area of 265ha. To the east of the

subject site there were a total of 30 pre-development catchments that cover an area of 1275ha. The upstream catchment for Ellen Brook has not been analysed as part of this study.

The two-dimensional multi-storm analysis for the 5 year and 100 year ARI storm events was conducted in order to determine the critical duration event that produces the largest peak discharge from the subject site. The critical duration storm for the 5 year ARI storm events was 36hr, while the critical duration storm for the 100 year ARI storm events was the 6hr storm.

Stormwater flow paths within the subject site are shown in **Figure 7**. Peak discharges from the critical 100 year ARI storm for inflows into the subject site are also shown in **Figure 7**. The exclusion to this is flows within Ellen Brook. These have not been modelled; rather the flood heights and floodway mapping provided by DoW (WAWA 1989) have been adopted a shown in **Figure 8**. The peak discharge flow rates for each catchment within the subject site are provided in **Table 3** below.

Table 3: Pre-development Catchment Peak Discharges

Catchment	5 year ARI storm		100 year ARI storm	
	Peak Discharge (m^3/s)	Peak Discharge (L/s/ha)	Peak Discharge (m^3/s)	Peak Discharge (L/s/ha)
1	1.039	7.675	1.793	13.244
2	0.342	12.579	0.684	25.158
3	0.173	13.641	0.328	25.862
4	0.222	8.391	0.421	15.912
5	0.059	10.680	0.126	22.808
6	0.195	9.110	0.357	16.678
7	0.151	21.208	0.281	39.466
8	0.512	13.000	1.008	25.594
9	0.793	14.668	1.536	28.411
10	0.693	22.143	1.399	44.701
11	0.260	23.093	0.539	47.874
12	0.661	22.544	1.317	44.917
13	0.147	26.253	0.320	57.150
14	0.390	17.169	0.740	32.576
15	0.443	20.163	0.868	39.506
16	0.204	19.963	0.376	36.794
17	0.200	18.934	0.390	36.922

3.5.1.2 Major Flood Event Mapping

The Water Authority of Western Australia (now the Water Corporation) conducted a flood study during 1989 for the Ellen Brook sub-catchment, which ranges from Gingin in the north to Ellenbrook in the south. This mapping indicates a floodway and flood fringe based on the computed flood levels for the 100 year ARI storm event (WAWA 1989). The floodway forms the main flow path for floodwaters, and once Ellen Brook has overflowed the flood fringe extends up to 230m from Ellen Brook. The flood fringe follows the topographic contour associated with the flood level and in places extends a further 230m from the floodway boundary. The floodway boundary was considered when developing the proposed development buffer (**Figure 6**). **Figure 8** shows the pre-development flooding within the subject site as modelled by XPSWMM. There are a number of channels across the site with an

average depth of 1m; however the majority of the site is flooded during the 100 year ARI event with less than 0.15m of water.

3.5.2 Surface Water Quality

The Ellen Brook sub-catchment currently contains the highest median total nitrogen (TN) load and total phosphorus (TP) load out of the eleven sub-catchments to the Swan-Canning Estuary (Swan River Trust 2009). These levels are thought to be due to the clearing of vegetation and the largely agricultural land use within the sub-catchment.

Cardno is currently undertaking surface water quality monitoring with the subject site at six locations; two within Ellen Brook, two along Great Eastern Highway at Ki-it Monger Brook and Nambad Brook, and two within creeklines in the west of the subject site. Only Ellen Brook had sufficient flows for accurate water quality sampling during the initial round of sampling. These exhibited high salinity levels of between seven and eight times the default trigger value (ANZECC 2000) and moderately high TP concentrations at three times the trigger value.

3.5.3 Groundwater Levels

The *Perth Groundwater Atlas* indicates that the groundwater is approximately 1m to 2m below ground surface (BGS) (DoW 2009). Shallow groundwater in the region is likely to be directly recharged by rainfall which drains into the Ellen Brook sub-catchment.

Site specific groundwater level monitoring is currently being conducted by Cardno at ten bores located within the subject site over a six month period. Based on initial groundwater levels and field observations, groundwater underneath the site flows in a southerly direction towards Ellen Brook. Depth to groundwater from the first three monitoring occasions ranged from 0.4mBGS to 5.94mBGS (Cardno 2010). These are generally consistent with the groundwater contours in the *Perth Groundwater Atlas* (DoW 2009). Groundwater contours from September 2010 (the observed peak between June and October) are shown in **Figure 9**.

3.5.4 Groundwater Quality

Site specific groundwater quality monitoring is currently being conducted by Cardno at six bores located within the subject site over a six month period. Initial results (June 2010) are provided in the *Hydrological Monitoring at Great Northern Gateway Industrial Estate: Initial Report* (Cardno 2010). These results were compared to default trigger values for surface water, as no guidelines for groundwater quality are available. TN and TP concentrations exceed surface water trigger values at two or more bore locations. Other nutrient species, pH and dissolved oxygen were generally lower than default trigger values (for surface water) provided in the *National Water Quality Management Strategy* (ANZECC 2000).

3.6 Summary of Existing Environment

In summary the environmental investigations conducted to date indicate that:

- The subject site has a Mediterranean climate which receives an average of 688.8mm of rainfall per annum.
- The subject site ranges in elevation from 30mAHD to 50mAHD.
- The subject site is located on the Swan Coastal Plain, with Yanga, Pinjarra and Forrestfield soil systems.
- ASS investigations identified some minor locations with potential soil acidity that exceeds the DEC action criteria of 0.03%S within sand profiles with variable clay content.

- The subject site is broadly categorised as Banksia low woodland on leached sands with Melaleuca swamps on ill-drained soils and woodlands of Tuart (*Eucalyptus gomphocephala*), Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on less leached soils.
- No vertebrate fauna of conservation significance were positively identified as utilising the subject site.
- The subject site contains three CCWs and a large MUW.
- Surface water flows into the subject site from the north via Ellen Brook, from the north-east via Nambad Brook and Ki-it Monger Brook and from the west and east via a number of small drainage lines.
- The total peak discharge from the 17 catchments within the subject site is equal to 6.6m^3/s in the 5 year ARI storm event and 12.7m^3/s in the 100 year ARI event.
- The majority of the site is flooded during the 100 year ARI event with shallow sheet flow less than 0.15m of water.
- Ellen Brook had high salinity levels of between seven and eight times the relevant default trigger value and moderately high TP concentrations at three times the trigger value.
- Depth to groundwater from the first three monitoring occasions ranged from 0.4mBGS to 5.94mBGS and flow was in a westerly direction.
- Groundwater quality is generally below default trigger values, though TN and TP concentrations exceeded surface water trigger values at two or more bore locations.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this DWMS and future management strategies must achieve. The objectives and design criteria are both general water management philosophies that reflect state-wide principles and are site specific, taking into account the local environment. The water management strategy covers all aspects of water use, including stormwater management, groundwater management and water consumption.

4.1 Water Conservation

4.1.1 Water Conservation Design Criteria

It is widely thought that the local climate is undergoing a drying trend, and that as the shire's population grows and demands for potable water sources increase, significant attention should be focused on the manner in which the resources currently available are utilised.

This consideration is acknowledged and therefore use of water within the development will be minimised wherever possible. This can be accomplished through minimising water requirements within landscaped areas. In this regards, the DoW recommends a target of 7500kL/ha/year of water be adopted for irrigation.

- Minimise water requirements for establishment of landscaped areas.
- Minimise water requirements for the maintenance of landscaped areas.
- Adopt a target of 7500kL/ha/year of water for irrigation of landscaped areas.
- Minimise net use of water by maximising fit-for-purpose use.

4.2 Groundwater Management

4.2.1 Groundwater Quality Design Criteria

Given that industrial developments can have implications for the types and quantity of pollutants released to the local surface water and groundwater, and that the work undertaken to develop the land has the potential to mobilise nutrients introduced by former land uses, it is important that groundwater quality is adequately managed to minimise the risk to Ellen Brook and downstream receiving environments. Based on this objective, the proposed groundwater quality criterion is:

- The groundwater leaving the subject site should be at least the same, or better, than the water entering the subject site.

4.2.2 Groundwater Levels Design Criteria

Developments have the potential to alter groundwater levels through a combination of reduced infiltration capacity (more impermeable surfaces such as roads and buildings) and altered extraction rates (bores used for irrigation). It is important that the pre-development groundwater levels are maintained as any alteration could impact on the environment; particularly for surface water body recharge and to support groundwater dependent ecosystems. The main objective of groundwater level management is to minimise changes to the underlying groundwater levels as a result of development. Based on this objective, groundwater level criterion is:

- Finished floor levels should have a clearance from the Annual Average Maximum Groundwater Level (AAMGL) of at least 1.2m.

4.3 Stormwater Management

4.3.1 Stormwater Quality Design Criteria

Water quality treatment systems and water sensitive urban design structures must be designed in accordance with the *Stormwater Management Manual for Western Australia* (DoW 2007) and *Australian Runoff Quality* (Engineers Australia 2006). *Better Urban Water Management* (WAPC 2008) advocates a water quality management principle where existing surface and groundwater quality be maintained as a minimum, and preferably improved prior to discharge from the development area. Through consideration of these guidelines, the primary objective for the subject site is to avoid further deterioration of water quality within the Ellen Brook.

Based on the above, the stormwater quality criteria are:

- Retain the 1 year – 1 hour ARI event from modified portions of lots (e.g. roof, landscape, paved etc) within each lot.
- Retain the 1 year – 1 hour ARI event from road reserve within the development.
- Apply appropriate structural and non-structural measures to reduce applied nutrient loads.
- The size of bio-treatment structures should be a minimum of 2% of the connected impervious area.
- The appropriate physical treatment structures for each particular industry should be utilised where treatment of runoff from lots is required.

4.3.2 Stormwater Quantity Design Criteria

The overall guiding document for development of stormwater management strategies within urban areas is the *Stormwater Management Manual for Western Australia* (DoW 2007); with the *Decision Process for Stormwater Management in WA* (DoW 2009) providing guidance as to how urban development can achieve compliance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual of WA*.

Stormwater retention and detention structures must be designed in accordance with the *Stormwater Management Manual for Western Australia* (DoW 2007) and *Australian Rainfall and Runoff* (Engineers Australia 1997). In addition, structures must comply with current City of Swan Drainage Policies.

Based on this above, the stormwater quantity criteria are:

- Detain flows from the 5 year ARI storm event through to the 100 year ARI storm event within the boundary of each lot to maintain the pre-development peak flow rates of each lot.
- Detain flows from the 5 year ARI storm event through to the 100 year ARI storm event within the development boundary to maintain pre-development peak flow rates across the development.
- Minor roads remain passable in the 5 year ARI storm event.
- Major roads remain passable during 100 year ARI storm event.
- Finished floor levels should have a clearance from the 100 year ARI water level of 0.5m.

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Prepared for Seaport Pty Ltd

5 Water Conservation Strategy

5.1 Water Source Allocation, Infrastructure and Fit-for-purpose

Water is a valuable resource that must be managed sustainably. Conservation of water through fit-for-purpose use and best management practices is encouraged so that water is not wasted. The term fit-for-purpose describes the use of water that is of a quality suitable for the required use of that water. Further consideration of fit-for-purpose principles is required during the Local Water Management Strategy (LWMS) and Urban Water Management Plan (UWMP) stages.

5.1.1 Scheme Water

It is expected for scheme water to be supplied and utilised by all lots. However, conservation of potable scheme water can be achieved by using lower quality water such as groundwater or recycled water for uses that do not require high quality water e.g. irrigation, toilets, cooling water, etc.

5.1.2 Groundwater

Enquiries with the DoW indicate that the development is located within the Swan Groundwater Area, and falls within four sub areas: Bandy Spring Sub-area, Cockman Bluff Sub-area, Radar Sub-area, North Swan Sub-area and the Swan Confined Sub-area. The superficial aquifers for the Radar Sub-area and North Swan Sub-area are over-committed. Within the Cockman Bluff Sub-area the superficial aquifer is 74% committed, with approximately 386125kL available. The Bandy Spring Sub-area is 99% committed, with approximately 3000kL available (DoW 2010).

It is anticipated that groundwater may be utilised for the irrigation of landscaped areas within some lots, which would decrease the overall scheme water use and this is an appropriate fit-for-purpose application. The appropriate approvals for groundwater allocation and bore construction will need to be obtained from DoW and (where relevant the City of Swan) by individual landowners.

5.1.3 Rainwater

Collection of rainwater from roof surfaces can be undertaken, with this water stored within rainwater tanks for later use. This water is of high quality; however, in urban environments it is advised that this water be considered non-potable.

In Perth, 90% of the rainfall occurs in the seven month period from April to October. The remainder of the year has little rainfall but collection is still possible. Thus, collected rainwater is not often available for irrigation (which is not required in winter) but is available to supplement non-potable uses.

All industrial and commercial lots should be able to utilise rainwater tanks for storage. Information can be provided to the lot purchaser by the developer at point-of-sale. At this stage it is not envisaged that rainwater tanks will be mandated. If rainwater tanks are to be included in the proposed water conservation strategy, it should be stated within the more detailed LWMS and/or UWMP.

5.1.4 Recycled Water

Wastewater can be recycled and used as potable or non-potable water (depending on the quality of the treatment). Treated water has the potential to be utilised for a number of purposes if it becomes available for use within the development. Treated water of high quality could be used to replace some potable water uses (e.g. toilets and washing machines) whereas, lower quality water could be

utilised for cooling water or irrigation. Many industrial processes do not require high quality water and maximising the recycling within a plant or between a few industries can greatly reduce overall water conservation (Sands & Shepherd 2010). The utilisation of recycled water within industrial developments is greatly encouraged within the *State Water Recycling Strategy: An Overview* (DoW 2008). Recycled water is not proposed to be mandated within the development. However, some industries may choose to implement their own recycling practices, which are encouraged.

5.2 Lot Water Conservation

Significant reductions in water usage can be achieved through implementation of measures at a lot scale. These measures include internal and external water saving devices and practices. Devices or practices where efficiencies can be made by the lot owners are discussed below.

5.2.1 Internal Measures

Significant reduction in internal water use can be achieved with the use of water efficient appliances. The following **Table 4** gives an example of the water uses of typical appliances versus water efficient appliances. These water use rates should be used in any future water balance investigations.

Table 4: Water Efficient Appliances (Australian Government 2009 & Melbourne Water 2003)

Appliance	Water Use	
	Standard Device	Water Saving Device
Toilet	12 Litres/Flush	4 Litres/Flush
Washing Machine	130 Litres/Flush	40 Litres/Flush
Shower Head	15-25 Litres/Flush	6-7 Litres/Flush
Taps	15-18 Litres/Flush	5-6 Litres/Minute

Other water saving initiatives that could be introduced includes:

- Installation of waterless urinals.
- Installation of flow restrictors to all cisterns and taps.
- Sub-metering to monitor water consumption between differing processes or retailers.

The water conservation strategy proposes that all businesses use water efficient appliances. This can be encouraged by state and local government rebates, as well as education and potentially from additional incentives from developers.

5.2.2 External Measures

Reductions in water irrigation by employing water efficiency measures can significantly reduce the total water usage of the lot. The following water efficiency measures should be used on landscaped areas:

- Retention of remnant native trees within landscaped areas. This will reduce demands for water particularly during establishment of landscaped areas.
- The adoption of Xeriscaped gardens where garden beds are landscaped using 'waterwise plants'. These are local native species from regions with similar climates that require less water inputs than exotic species.
- Minimal proportion of the landscaped areas should be turfed and hydrozoning could be applied to the remaining area. Turf species should be low water and nutrient requiring.

- Where required, soil shall be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150mm where turf is to be planted and a minimum depth of 300mm for garden beds (for the entry statement only).
- Garden beds to be mulched to 75mm with a product certified to Australian Standard AS4454.
- The most appropriate non-potable water source can be used for irrigation of turf areas instead of potable water (i.e. runoff from carparks and paved areas, rainfall and recycled water).
- Managing irrigation practises within landscaped areas to minimise losses to evaporation (e.g. amount applied is not excessive, timing irrigation to avoid wastage, sub-surface irrigation etc.).
- The irrigation of landscaped areas should be limited to a maximum of 7500kL/ha/year.

5.3 Educational Programs

Education programs can target landowners, businesses and employees. A few examples of water conservation specific education topics are:

- Water conservation.
- Water efficient technologies.
- Recycling systems.

6 Groundwater Management Strategy

6.1 Groundwater Level

The groundwater management criteria provided in **Section 4.2.2** can be achieved through the methods described below. Which method(s) are to be used to meet the groundwater management criteria must be determined at the LWMS and UWMP stages.

6.1.1 Sub-soil Drainage

Fill will generally be limited to building footprints given the low density of the development. The groundwater level can be controlled by implementing a network of sub-soil drains if large areas of fill are required. Sub-soil drains are installed to reduce the risk of groundwater rising above an unacceptable level (which must be specified within the LWMS and UWMP). In addition, the LWMS and UWMP are required to determine the appropriate CGL for the development. Sub-soil drainage intending to lower groundwater (rather than control groundwater rise into imported fill) should not be located where water dependent ecosystems would be affected and discharge from sub-soil systems should be treated as per surface water runoff.

6.1.2 Controlled Groundwater Level

The CGL is the invert level of the subsoil drainage (*pers comm.* Bill Till DoW). The CGL can be set equal to the AAMGL or where the AAMGL is below the clay layer, the CGL can be set no lower than the clay layer. The CGL may be guided by an AAMGL, however a more detailed assessment should account for clay layer elevations provided in detailed geotechnical investigations and may include refinement of the AAMGL estimates where site-specific monitoring has occurred.

6.1.3 Sand Fill

For areas of land with a shallow depth to groundwater, a layer of sand can be placed on the natural ground surface to increase the depth from the surface to the groundwater. For the areas where no subsoil drainage is proposed, the finished earthworks levels must be at least 1.2m above the AAMGL. Sand fill may also be used to meet the geotechnical site classification appropriate for industrial slabs and footings.

6.2 Groundwater Quality

The main objective of the management of groundwater quality is to maintain or improve the existing groundwater quality. This can be achieved by either reducing the total nutrient load into the groundwater that originates from newly developed areas, or by improving the groundwater via treatment of the surface runoff prior to infiltrating to the groundwater.

6.2.1 Landscaping

Where lots are proposed to be landscaped, it is recommended that native vegetation is utilised in landscaped areas and that turf is kept to a minimum. Minimising turf will reduce the overall fertiliser requirements and therefore, the nutrient load that could be transported from lots to Ellen Brook via surface runoff and/or groundwater. Fertiliser requirements for turf can be further reduced by importing topsoil with high phosphorus retention (PRI) and using turf species that have low water and nutrient requirements such as:

- *Cynodon dactylon, Cynodon x, Cynodon transvaalensis.*

- *Paspalum vaginatum.*
- *Stenotaphrum secundatum.*
- *Pennisetum clandestinum* (Water Corporation 2008).

In addition to utilising low nutrient requiring turf species, other fertiliser management strategies can include:

- Nutrient application rates that are be matched to the seasonal requirements of the vegetation species.
- Soil testing to determine residual nutrient concentrations.
- Plant tissue testing to determine ongoing fertiliser requirements.
- Utilising a fertiliser of the most optimal type and constituent for the specific vegetation species.
- Utilising slow release fertilisers (DoW 2007).

6.2.2 Bio-treatment Areas

Vegetated retention areas are used to infiltrate low flow events from nearby impervious areas. The vegetation and the infiltration process within the soil column will remove a large portion of contaminants before it reaches the groundwater. The vegetation species selected should be native, have a low nutrient requirement with the ability to survive for a long period of time in dry conditions. The vegetation may require occasional trimming and harvesting to encourage further growth and nutrient uptake. The soils imported to line these retention areas should be high Phosphorus Retention Index (PRI) soils. These measures will ensure that the runoff that infiltrates to the groundwater will be of acceptable quality.

6.2.3 Educational Programs

Education programs can target landowners, businesses and employees. A few examples of groundwater specific education topics are:

- Fertiliser application.
- Liquid chemical removal (oils, chemical, paints).
- Recognising damage to the water quality treatment system.

7 Stormwater Management Strategy

7.1 Drainage System

The basic principle of contemporary stormwater quantity management is to slow down the stormwater runoff, mimicking the existing flow paths. In addition, the effective management of urban stormwater quality typically focuses on the treatment of frequent, low intensity stormwater events. The adoption of this drainage system design and the utilisation of various Water Sensitive Urban Design (WSUD) strategies can achieve the design criteria specified in **Section 4.3**. The three management approaches proposed in this DWMS are:

- Maintain existing upstream flows through the development.
- Detain catchment runoff within the site.
- Treat catchment runoff within the site.

These are further described in the following sections.

7.1.1 Maintain Flows through Development

The development is required to maintain flowpaths through the site such that flows entering and discharging from the site can pass through without obstruction. The pre-development peak flows entering the site (which must be maintained in post-development) and the pre-development flowpaths are shown in **Figure 7**. Nominally proposed post-development flowpaths are given in **Figure 10**, though these may be further refined at future planning stages.

The manner in which these flows are allowed to pass through the development and their exact locations have not been defined in this DWMS. These flows may be piped, transported in road-side swales or conveyed within current channels and protected by an easement. The emphasis here is that the flows are maintained through the development. The manner of transport will be determined at future stages during structure planning.

7.1.2 Detain Catchment Runoff

Developments typically have a higher proportion of impervious surface area (roads, paths and roofs) when compared to the pre-development environment. The increased imperviousness results in:

- Increased total volume of runoff leaving the site.
- Increased maximum runoff rate (peak discharge).
- Decreased time for runoff to occur.

The strategy for this development is to maintain pre-development flows for all areas (i.e. lots and road reserve). This DWMS proposes catchment scale flood storage areas (FSAs) (i.e. detention structures) to ensure post-development peak discharges are maintained at pre-development conditions. See **Section 7.2** for more information regarding FSAs. This approach ensures lower peak discharges and lower volumes of runoff in main drainage corridors, which otherwise could lead to flooding.

The development was divided into four post-development catchments based on the *Preliminary Concept Plan* (**Appendix A**); it was assumed that final earthwork levels would not significantly alter the topography of the subject site.

Within each catchment, both the lot areas and the road reserve areas are required to meet the equivalent pre-development discharge through the use of flood detention structures. The XPSWMM

computational modelling program was used to calculate the rate of runoff generated by the lot area and road reserve area within each catchment. **Figure 10** illustrates the boundaries of the four post-development catchments, **Appendix C** describes the modelling methodology and **Appendix A** shows the *Preliminary Concept Plan*.

7.1.2.1 Lot Areas

Detention storage requirements for the lot areas within each catchment were calculated through the modelling of a single FSA. In practice, each lot owner will be required to provide storage according to the area of their lot and the relevant proportion of storage volumes (m^3/ha) provided in **Table 5**. These storage volumes are indicative and should be refined within future LWMS and UWMP documents once land uses within lots have been determined.

Table 5: Lot FSA Volume Requirements

Catchment	Total Lot Area (ha)	Storage Volume (m^3/ha)
1	159.6	435*
2	116.2	295
3	45.5	290
4	44.7	260

*The pre-development peak discharge for Catchment 1 is lower than for the other Catchments and this results in a greater storage volume required for lots within Catchment 1 (i.e. greater than the other Catchments).

The comparison between the post-development peak discharge and equivalent pre-development peak discharge are provided in **Table 6**. Peak discharges from lots areas within each catchment are comparable to the 100 year ARI pre-development peak discharges of each catchment, which meets the design criteria given in **Section 4.3.2**.

Table 6: Lot Area Peak Discharges

Catchment	5 year ARI		100 year ARI	
	Equivalent Pre-dev Peak Discharge (L/s/ha)	Post-dev Peak Discharge (L/s/ha)	Equivalent Pre-dev Peak Discharge (L/s/ha)	Post-dev Peak Discharge (L/s/ha)
1	8.76	4.09	15.74	16.58
2	17.90	7.17	35.75	34.39
3	19.96	7.18	35.27	33.73
4	17.38	6.82	33.22	32.11

7.1.2.2 Road Reserve Areas

Though most of the detention storage for each catchment occurs at the lot scale, detention is still required to meet pre-development flows from road reserve areas. Overflow from the lot FSAs is anticipated to enter the road drainage system, where it will eventually enter the road reserve FSA.

In order to adhere to the design criteria stated in **Section 4.3.2**, the FSAs were sized to detain the peak discharge per hectare from 5 year ARI storm events and 100 year ARI storm events. FSAs are nominally designed to have 1:6 side slopes and a depth of 1m and may be modified in future detailed designs as appropriate, provided that they achieve the criterion of maintaining pre-development peak discharges.

Note that the peak discharge rates provided are nominal, and will change in response to a variety of factors including storage depth, outlet structure design, localised soil type infiltration rates, etc. The discharge rates in **Table 6** and the storage volumes in **Table 5** are intended to demonstrate that water is capable of being managed onsite. Future planning stages will allow refinement of the above nominal storage area.

The road reserve FSA characteristics are provided in **Table 7**. As stated above, the FSAs are nominally designed to have a depth of 1m. This is the distance from the invert of the basin to the weir. To ensure the post-development peak discharge (**Table 8**) is comparable to the pre-development peak discharge, the water depth in the FSA must rise somewhat above the weir. The surface area and storage volume given in **Table 7** are calculated specifically from the peak water depth.

Table 7: Road Reserve FSA Characteristics

Catchment	Total Road Reserve Area (ha)	FSA Characteristics			
		Basin Area (m^2)	Water Depth (m)	Surface Area (m^2)	Storage Volume (m^3)
1	10.3	2500	1.07	3950	3425
2	9.2	650	1.11	1510	1170
3	4.3	240	1.07	800	525
4	10.3	750	1.12	1665	1315

The comparison between the post-development peak discharge and equivalent pre-development peak discharge are provided in **Table 8**. Peak discharges from road reserve areas within each catchment are comparable to the 100 year ARI pre-development peak discharges of each catchment, which meets the design criteria given in **Section 4.3.2**.

Table 8: Road Reserve Peak Discharges

Catchment	5 year ARI		100 year ARI	
	Equivalent Pre-dev Peak Discharge (L/s/ha)	Post-dev Peak Discharge (L/s/ha)	Equivalent Pre-dev Peak Discharge (L/s/ha)	Post-dev Peak Discharge (L/s/ha)
1	8.76	1.93	15.74	15.66
2	17.90	16.25	35.75	35.10
3	17.96	15.68	35.27	34.58
4	17.38	14.81	33.22	32.72

7.1.3 Treat Catchment Runoff

Small but frequent flows account for the vast majority of nutrient and sediment loads and represent the best opportunity for water quality improvement.

7.1.3.1 Lot Areas

It has been assumed that runoff from the 1 year – 1 hour ARI storm shall be retained close to source through the retention measures described in **Section 7.2.2**. This requires lots to store 149.3m^3 per hectare of lot.

7.1.3.2 Road Reserve Areas

The development is also required to store 149.3m^3 per hectare of road reserve. An estimate of the retention volume require for the road reserve in each catchment is provided in **Table 9**.

Table 9: Road Reserve Retention Volume Requirements

Catchment	Total Road Reserve Area (ha)	Storage Volume (m^3)
1	10.3	1545
2	9.2	1380
3	4.3	650
4	10.3	1540

This DWMS has not specified which WSUD strategies (see **Section 7.2**) will be utilised to retain these low flows and must be determined within the LWMS and UWMPs. Additionally, these documents should include designs for retention structures.

7.1.3.3 Post-development Modelling Results

The comparison between the post-development peak discharge from each catchment and equivalent pre-development peak discharge provided below (**Table 10**) shows the 100 year ARI post-development peak discharge to be within ±6% of the equivalent pre-development peak discharge. Therefore, the provision of the proposed retention and detention volumes ensures the post-development peak discharges are comparable to the pre-development peak discharges across the subject site.

Table 10: Overall Post-development Peak Discharges

Catchment	5 year ARI		100 year ARI	
	Equivalent Pre-dev Peak Discharge (L/s/ha)	Post-dev Peak Discharge (L/s/ha)	Equivalent Pre-dev Peak Discharge (L/s/ha)	Post-dev Peak Discharge (L/s/ha)
1	8.76	3.95	15.74	16.08
2	17.90	7.09	35.75	33.95
3	17.96	7.14	35.27	33.28
4	17.38	6.52	33.22	31.23

7.2 Water Sensitive Urban Design Strategies

The design criteria specified in **Section 4.3** can be achieved through the adoption of the drainage system detailed above. A number of Water Sensitive Urban Design (WSUD) strategies shall be required to maintain flows through the development (**Section 7.1.1**) and detain catchment runoff (**Section 7.1.2**). Similarly, combining a number of WSUD techniques into a treatment train is the most effective manner in which to treat catchment runoff (**Section 7.1.3**). Treatment trains incorporate multiple WSUD techniques to ensure primary, secondary and tertiary treatment of stormwater is achieved. Examples of possible WSUD techniques are discussed below and should be further investigated within LWMS and UWMP documents.

7.2.1 Educational Programs

The most optimal performance from the designed water quality treatment system can be achieved through educating the community on how the system works. If people understand how their actions could damage the water quality system (e.g. dumping chemical waste into the drains that end up draining to a wetland) they could be less likely to continue their actions. Education programs can target landowners, businesses and employees. A few examples of stormwater management education topics are:

- Fertiliser application.
- Liquid chemical removal (oils, chemical, paints).
- Solid waste removal options (fridges, TVs, furniture).
- Littering.
- Weed identification and removal.
- Recognising damage to the water quality treatment system.

7.2.2 Lot Soakwells and Rainwater Tanks

Large impermeable roof areas produce considerable runoff. This surface water runoff can be reduced at source by infiltration using soakwells and captured using rainwater tanks. The modelling process has assumed that lots will retain the 1 year 1 hour storm event close to source, but has not specified the strategy required to accomplish this. The successful utilisation of soakwells at the subject site should be determined once a detailed geotechnical investigation has been conducted. Both of these retention methods shall require a high flow bypass to allow flows from larger storm events to continue through the lot.

7.2.3 Gross Pollutant Traps

Stormwater runoff can transport nutrients and gross pollutants (such as cans, bottles, packaging, etc) to downstream water bodies. A Gross Pollutant Trap (GPT) is considered a primary level treatment system, removing a proportion of these large pollutants (and depending on the design) can remove a proportion of the smaller particles such as sediments. The accumulated pollutants in the GPT must be regularly removed to ensure the efficiency of the device.

GPTs are best suited to developments with high gross pollutants loads such as commercial developments or for collecting gross pollutants during the construction period phase of the development. Depending on the final nature of the development and specific land uses, these may be applicable to some portions of the subject site.

7.2.4 Bio-treatment Areas

Bio-treatment areas retain runoff and only release water through infiltration or evapotranspiration. These are typically vegetated and used to store the runoff from the 1 year – 1 hour ARI rainfall event. Bio-treatment areas are typically located alongside roads as pockets or swales.

Vegetation within the bio-treatment areas provides water quality treatment. These would capture most minor and first flush events and sizing them to capture the 1 year – 1 hour event would result in treatment of over 98% of the average annual stormwater runoff volume in Perth (WAPC 2004). Bio-treatment areas provide water quality treatment by removing fine sediments, trace metals, nutrients, bacteria and organics (Davis *et al.* 1998). If designed well and maintained, these can be a very effective strategy for removing nutrients and conveying surface runoff (FAWB 2008).

Unlike a wetland, bio-treatment areas are not designed to be permanently wet. Instead, stormwater will infiltrate into the underlying porous soil medium. From here it could be channelled into a pipe and conveyed to another bio-treatment area or simply left to infiltrate towards groundwater. Adequate separation between the invert and AAMGL is required to provide this infiltration and treatment. Where bio-treatment swales or bio-pockets are the primary treatment method, the surface area of these structures should be sized to be at least 2% of the connected impervious area.

7.2.5 Flush Kerbing

Contemporary street drainage uses hard kerbing and pits draining the stormwater runoff to a sub-surface pipe network. This pipe network quickly transports the runoff through the development causing increased peak discharges from the area when compared to the pre-development peak discharge. Flush and intermitted kerbing allows most of this runoff to be directed to roadside swales, where it is more slowly conveyed or infiltrated. Flush kerbing would be located adjacent to any roadside bio-treatment area to allow the 1 year – 1 hour event to flow into the bio-treatment area.

7.2.6 Roadside Swales and Buffer Strips

Swales and buffer strips are vegetated conveyance corridors. They typically have slopes of between 1% and 4%. This gradual slope combined with the increased roughness provided by vegetation reduces the stormwater runoff rate and the removal of sediments and nutrients. The swales also provide some storage (up to the 1 year – 1 hour ARI event) and infiltration capacity, thus reducing the total volume of runoff. Adequate separation between the invert and AAMGL is required to provide infiltration and treatment.

7.2.7 Piped Drainage

Stormwater flows can also be transported within a development via piped systems. These could be utilised to transport runoff from the road reserve, discharge from lots or to allow flows into the site to continue through the development.

7.2.8 Flood Storage Areas

FSAs are designed to store runoff during large rainfall events (i.e. 5 year to 100 year ARI). The area designed to detain the 100 year ARI storm event can potentially be used for recreational purposes for the majority of the year. In detaining or 'holding back' runoff, the FSA is designed to reach maximum capacity in a large storm event and discharge excess runoff at a reduced rate that approximates the pre-development peak flows. The use of FSAs is intended to detain flows from within the development.

8 Wastewater Management

The Water Corporation have confirmed that the Great Northern Gateway industrial cell will be serviced via reticulated sewer. The following outlines the Water Corporation's strategy for delivery of wastewater infrastructure to the project.

The Water Corporation has recently concluded a wastewater treatment study for Bullsbrook. This considered the physical, technical and financial aspects of various options to deal with the projected timing and growth of wastewater flows, treatment capacity at the Bullsbrook Wastewater Treatment Plant (WWTP) and treated wastewater disposal capacity and options. The Water Corporation have indicated that the preferred/adopted planning is now to retain the Bullsbrook WWTP and the current treated wastewater disposal arrangement at the plant with a view to decommissioning the plant and diverting wastewater southwards into the Ellen Brook Sewer District once the plant reaches its maximum capacity (Brett Coombes 2011 pers. comm. 14 November). Based on the Water Corporation's projections and understanding of land development rates and wastewater flow growth, it is expected that the current WWTP and treated wastewater disposal arrangement will have sufficient capacity for the next five years. Over this period, wastewater will continue to be conveyed northwards to the current Bullsbrook WWTP for treatment and disposal.

The Water Corporation has also confirmed that the Bullsbrook WWTP capacity planning has included an allowance for the ultimate development of the Great Northern Gateway Industrial Cell, the existing MRS Urban and Urban Deferred zoned land around the town, as well as other areas that have been indicated for possible future urban expansion in the City of Swan Bullsbrook townsite Strategic Plan (or proposals which were known to the Water Corporation at the time the planning was initiated) (Brett Coombes 2011, pers. Comm. 14 November 2011). The wastewater flow forecast underpinning this planning has assumed that wastewater flows from the Bullsbrook Great Northern Gateway Industrial Cell will commence around 2017.

The Water Corporation will soon commence a review of the wastewater conveyance planning for the Bullsbrook Sewer District, which is anticipated to be completed mid-2012. The conveyance planning will detail the method, layout and sizing of the local wastewater collection network (gravity sewers, pump station/s, etc.) within the Bullsbrook townsite area including the Great Northern Gateway Industrial Cell.

9 Matters to be Addressed in the LWMS

It is anticipated that future LWMS or UWMP documents will provide significantly more detail regarding a number of aspects of stormwater management. These will include (but are not limited to):

- Geotechnical Investigation
- Design and Location of Drainage Structures
- Retention of existing flowpaths
- Modelling of Road Drainage Network
- Water Consumption Strategies
- Non-structural Measures
- Water Allocation and Supply
- Earthwork and Fill Strategy

9.1 Geotechnical Investigation

A geotechnical investigation will need to be conducted to confirm the regional geological mapping discussed in the DWMS and the test pit and bore results discussed in the *Preliminary Acid Sulfate Soil Assessment* (Cardno 2010). A number of test pits will be required to be installed at depths just below the ground surface (usually ~2.5m) to determine the soil characteristics and how this could impact on the proposed development. The investigation should guide the appropriate location of onsite disposal of stormwater (flood detention structures and treatment retention structures), soil types, suitability of soils for development and if treatment is required, settlement test, bearing ratios and the hydraulic conductivity, which governs infiltration rates (given in **Appendix C**).

9.2 Design and Location of Drainage Structures

This DMWS has provided preliminary volume requirements of flood detention structures for lots and FSAs for road reserves (see **Section 7.1**). These are based on broad-scale assumptions (detailed in **Appendix C**). It is expected that as future investigations are undertaken, the designs developed will accommodate any constraints identified. The preliminary flood detention structure configurations should be reviewed to ensure that the stormwater management system can achieve all of the required objectives and blend into the surrounding environment.

The DWMS has not provided locations for detention or retention structures for lots. In general, this DWMS proposes that lot retention structures be located upstream and close to the built portion of the lot, and that lot flood detention structures be located prior to discharge into the road drainage network. This DMWS proposes road reserve retention structures be located alongside roads, close to source, and that road reserve FSAs be located prior to (but nearby) the catchment discharge. Such details and design refinements should be presented in the future LWMS.

9.3 Retention of Existing Flowpaths

The DWMS has identified a number of important flowpaths to carry stormwater flows from outside the development to Ellen Brook. These flows should be allowed to travel through the site in post-development. The methods utilised to provide access (i.e. swales, easements or piped) and the exact location of these flowpaths should be determined in the future LWMS.

9.4 Modelling of Road Drainage Network

Modelling of the local road drainage networks will need to be undertaken to demonstrate compliance with water quantity management criteria. Calculations supporting sizing of treatment retention

structures and flood detention structures will need to be provided, such that detailed designs can proceed from this point, and future water planning stages (i.e. UWMP) can demonstrate compliance with the design criteria via appropriate computational modelling of the proposed design.

9.5 Water Consumption Strategies

A number of potential measures have been discussed that can assist in reducing total water consumption. It is expected that future LWMS documents will clarify which measures are proposed to be integrated into the future built system. Further investigations should be undertaken into the viability of the potential water sources available, where these are proposed to be utilised. The LWMS will need to provide a detailed assessment of likely water requirements to maintain any landscaped areas. A licence will need to be submitted and approved by the DoW for extraction of groundwater for non-potable uses.

9.6 Non-structural Measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Manual for Western Australia* (DoW 2007). Some measures will be more appropriately implemented by the City of Swan, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision and the landscaped areas within it.

It is expected that future LWMS and UWMP documents will provide reference to measures such as public education. It is also expected that future UWMPs will provide detailed management and maintenance plans that will set out maintenance actions (e.g. rubbish removal from swales and treatment structures), timing (e.g. who will be responsible for carrying out the actions), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions).

Given that approval from the City of Swan and DoW will be sought for the proposed measures, it is anticipated that consultation will these agencies will be undertaken and referral to guiding policies and documents will be made.

9.7 Water Allocation and Supply

A planning study for the delivery of water services to the Bullsbrook region has been completed by the Water Corporation (JDSi Consulting Engineers 2010). As is stated within the *Great Northern Gateway Industrial Estate – Servicing Strategy* this will be achieved through the construction of a new DN300 main along the Great Northern Highway. This supply main would feed into a new water supply tank. The location of the supply tank is still to be finalised. Initial stages of development within the subject site may be connected to this DN300 main. In the long term, however, the proposed Gnangara reservoir storage facility is envisaged to deliver water services to the region. Water supply servicing will need to be confirmed with the Water Corporation at all future stages

9.8 Earthwork and Fill Strategy

An earthwork and fill strategy will be required for the Local Structure Plan (LSP) stage and associated LWMS. It is important to determine the depth of fill required below road reserves and building envelopes. The size of flood detention structures may require revision after the earthwork levels have been finalised. At this stage it is not anticipated that the whole development will import fill due to the large size of some lots. Additionally, earthwork levels are assumed to be similar to the pre-

development environment that leads to the catchment boundaries described in **Appendix C** and shown in **Figure 10**.

9.9 Biophysical Assessment

The biophysical assessment detailed within the WWA (Cardno 2010) has been referenced within **Section 3.4.4** of this DWMS. It will also be cross-referenced to ensure that the approach to water management at the site, detailed in the LWMS, adequately accommodates the recommendations of the WWA (Cardno 2010). Any changes to the findings of the biophysical assessment (i.e. due to additional information) and the resultant reservation boundary shall also be reported on in the LWMS.

9.10 Protection of Environmental Assets

The MRS amendment has been referred to the EPA, who reviewed the first version of this DWMS and the WWA (Cardno 2010). The MRS amendment is the outcome of discussions between the Office of the EPA (OEPA), DEC and the landowner to reduce and manage potential impacts on the Ellen Brook, Nambad Brook, Bush Forever Site 296 and the EPP wetlands (EPA 2011). The EPA (2011) concluded that the potential environmental impacts of the proposed rezoning are of a type that can be adequately managed through the planning process in consultation with the DoP, DEC, DoW and relevant agencies. On this basis the EPA considered that the MRS Amendment did not need to be assessed and provided advice.

The Ellen Brook and its mapped buffers, as identified in **Section 3.4** and **Figure 6** and in the WWA (Cardno 2010), are currently zoned Rural under the MRS and are held in private ownership. The MRS Amendment 1219/14 Report (WAPC 2011) (prepared subsequent to the first version of the DWMS) retains the Rural zoning over the land, recognises the land as future Parks and Recreation (P&R) Reserve and that a condition of subdivision approval will require resumption of the land. The Amendment Report states that the retention of the land in the Rural zone (in the short term) allows for a consolidated approach to the future reservation and adequate resumption and compensation arrangements.

The WAPC have indicated that they intend to resume the Ellen Brook and its mapped buffers (the entire Rural Zone area in MRS Amendment 1219/14), to allow a coordinated approach to any rehabilitation work that may be undertaken and to the eventual vesting and management of the Ellen Brook. This is similar to the majority of the Ellen Brook to the south, which is also under the ownership and management of the WAPC.

The mechanism to ensure that the Ellen Brook and its buffers are appropriately treated/rehabilitated and managed through the planning process is via the amendment to City of Swan Town Planning Scheme (TPS) No. 17 which is expected to be initiated in January 2012. Scheme provisions will require the preparation and implementation of management strategies and plans at key future planning stages (LSP, subdivision) and these will deal with the treatment and management of these areas. The scheme provisions and the proposed management framework are further detailed in **Section 11**.

The Ellen Brook Rural Zone area will be entirely included in one (i.e. the first) LSP for the land adjoining, to avoid fragmentation in management and rehabilitation. This is included as a requirement of the TPS Amendment.

10 Monitoring

10.1 Pre-development Monitoring

Pre-development groundwater level and quality monitoring is currently being undertaken for a period of six months, recording groundwater level and quality data at ten bores. This data will capture one winter peak groundwater level and includes the following suite of analytes:

- Field chemistry parameters (Temperature, pH, Oxidation-Reduction Potential, Conductivity and Dissolved Salinity).
- Total Nitrogen and Total Phosphorus.
- Ortho-Phosphorous, Oxides of Nitrogen, Total Kjeldhal Nitrogen and Ammonium.

It is generally recommended that two winter peaks be utilised to determine the AAMGL for the subject site. This could be accomplished by conducting another year of groundwater quality and level monitoring prior to the detailed planning within an UWMP. Alternatively, groundwater within the eastern half of the subject site as well as an area to the east of Great Eastern Highway has previously been monitored for three years and could be used to determine a calibrated AAMGL from the 2010 winter peak data. This will provide an adequate coverage of data to confirm AAMGLs.

Surface water quality and flow is currently being monitored by Cardno. The aim of flow monitoring is to calibrate the stream flow determined through XPSWMM modelling. The aim of water quality monitoring to determine baseline water quality within Ellen Brook, Ki-it Monger Brook, Nambad Brook and two creeklines in the west of the subject site. An assessment of the data quality shall be required at the conclusion of the surface water monitoring program. This assessment would need to resolve if any additional monitoring is required to define an appropriate surface water quality baseline for Ellen Brook, Ki-it Monger Brook and Nambad Brook. Similarly, the assessment would need to resolve the need for additional stream flow data through Nambad Brook.

10.2 Post-development Monitoring

It is not anticipated for post-dev development groundwater level and quality monitoring will be required across the entire subject site. However, certain high risk industries may be required to conduct post-development groundwater quality monitoring. These should be detailed at later stages when more detail concerning land use is available.

11 Implementation Framework

The DWMS is a key supportive document for the Great Northern Gateway Industrial Cell. The development of the DWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with the total water cycle management approach. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future LWMS and UWMP documents.

The future implementation framework, inclusive of management strategies/plans for relevant aspects of the site will be guided by the local planning scheme provisions. As indicated in **Section 9.10**, these are currently being included with the City of Swan's TPS No.17. The management framework, the issues addressed within these plans and the responsibility for their preparation and implementation is summarised in **Table 11**.

As discussed in **Section 9.10** there is an additional requirement in the TPS Amendment that the Ellen Brook Rural Zone area will be entirely included in one LSP for the land adjoining, to avoid fragmentation in management and rehabilitation.

Table 11: Summary of Implementation Framework to be Specified in City of Swan TPS No. 17

Planning Stage	Supportive technical documents	Purpose of technical document	Portion of the development to which document applies	Entity responsible for preparation	Approving authority	Entity responsible for implementation
LSP	LWMS	Refinement of water management design objectives from DWMS, demonstrates spatial allocation of land to manage water to achieve design objectives	Local structure planning area within Great Northern Gateway Industrial Cell	Developer, on behalf of LSP landowner and City of Swan	City of Swan and WAPC on advice from DoW	Developer
	Wetland and Waterway Management Strategy	Develop management objectives based on assessments already undertaken, design objectives and the likely management approach	Local structure planning area within Great Northern Gateway Industrial Cell	Developer, on behalf of LSP landowner and City of Swan	City of Swan and WAPC on advice from DEC	Developer
	Section 18 Application concurrent with planning process	Permission to modify identified heritage sites	All areas identified as requiring S18 clearance – likely to cover all waterways where disturbance proposed	Developer, on behalf of LSP landowner and City of Swan	City of Swan and WAPC on advice from DIA	Developer

Planning Stage	Supportive technical documents	Purpose of technical document	Portion of the development to which document applies	Entity responsible for preparation	Approving authority	Entity responsible for implementation
Subdivision	UWMP	Demonstration that detailed designs meet design objectives, implementation and ongoing management requirements for the drainage system. Identify roles and responsibilities for ongoing management.	Approved subdivision areas	Developer	City of Swan and/or DoW	Developer
	Wetland Management Plan	Define management approach for restoration and management of wetlands and buffers in specific land parcels. Identify roles and responsibilities for ongoing management.	Wetland and buffer area within subdivision boundary (not required if no wetlands or buffers within subdivision boundary)	Developer	City of Swan and/or DEC	Land Owner/vested authority
	Foreshore Management Plan	Specify management approach for restoration and management of foreshore areas and streamline buffers in specific land parcels. Identify roles and responsibilities for ongoing management.	Foreshore areas within subdivision boundary (not required if no foreshore areas within subdivision boundary)	Developer	City of Swan and/or DEC	Land Owner/vested authority
	ASS Management Plan	Potential or actual soil acidity during and post-construction	Approved subdivision area	Developer	DEC	Developer

11.1 Roles and Responsibilities

The DWMS provides a framework that future developers of the land can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and City of Swan policies and have been endorsed by the City of Swan. The responsibility for working within the framework established within the DWMS rests with developers, although it is anticipated that future LWMS and UWMP documents will be developed in consultation with the City of Swan and DoW and in consideration of other relevant policies and documents. The future LSP will need to be supported by a LWMS and will require approval from the City of Swan and DoW.

11.2 Funding

The DWMS area constitutes multiple landholdings and therefore the cost of developing and implementing management strategies outlined here will be shared by the developers/landowners.

As discussed in **Section 9.9**, the WAPC intend to resume the Ellen Brook, inclusive of the floodway, adjacent wetland and associated riparian vegetation, at subdivision stage, consistent with the approach that has been taken for nearby sections of the Ellen Brook. The future ownership and management of the land containing the Ellen Brook will be further reported in the LWMS, however, it is anticipated that the transfer of land would be confirmed at the subdivision stage.

On the basis that the Ellen Brook is set aside as future P&R Reserve, the WAPC have confirmed they intend to resume the land, before being vested with the ultimate manager of the land. This would most likely be DEC. The ongoing management and rehabilitation requirements for the land would be the responsibility of the state government, however the costs to do so would be considered in light of the resumption conditions and would likely be negotiated as a part of the compensation negotiations.

11.3 Review

It is not proposed that this DWMS will be reviewed and the next stages of development are anticipated to be structure planning through a LSP. Where a LSP is produced these should be supported by an LWMS. The LWMS will largely be an extension of the DWMS, as it should provide designs and measures for water management from the options proposed within the DWMS.

The next stage of development following the LWMS is lot planning through subdivision. It is recognised that certain elements (i.e. non-structural controls) of the DWMS and LWMS will not be finalised until this late stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage, their implementation could be encouraged by the City of Swan through policy (or modification of these where necessary) or awareness programs.

12 References

Australian Government, 2009, *Water Efficient Labelling and Standards (WELS) Scheme*. Available from: http://www.waterrating.gov.au/ [Accessed August 2010].

Australian and New Zealand Environment and Conservation Council (ANZECC), 2000, *National Water Quality Management Strategy*, Australian and New Zealand Guidelines for Fresh and Marine Water Quality, ANZECC, Canberra.

Beard J. S., 1990, *Plant life of Western Australia*, Kangaroo Press, Perth.

Bureau of Meteorology (BOM), 2010, *Climate Statistics for Pearce Aerodrome*, prepared by the National Climate Centre of the Bureau of Meteorology. Available from: http://www.bom.gov.au/climate/averages/tables/cw_009053.shtml [Accessed June 2010].

Cardno, 2010, *Hydrological Monitoring at Great Northern Gateway Industrial Estate: Initial Report*, Letter V10034—SSC100001.10—DPC, Cardno, Subiaco.

Cardno, 2010, *Detailed Level 1 Flora and Vegetation Survey Results*, Cardno, Subiaco.

Cardno, 2010, *Preliminary Acid Sulfate Soil Assessment*, Cardno, Subiaco.

Cardno, 2010, *Wetland and Waterway Assessment*, Cardno, Subiaco.

City of Swan, 2008, *Local Planning Scheme No. 17*, District Zoning Scheme, City of Swan, Midland.

Churchward, H.M. and McArthur, W.M., 1980, *Landforms and soils of the Darling System, Western Australia*, Atlas of Natural Resources, Darling System, Western Australia, Department of Conservation and Environment, Perth.

Davis, A., Shokouhain, M., Sharma, H. and Minani, C., 1998, *Optimisation of Bioretention for Design for Water Quaility and Hydrolic Characteristics*, Final Report to Prince George's County, Maryland.

Department of Agriculture, 2001, *Assessment of Land Capability for On-Site Septic Tank Effluent Disposal*, Government of Western Australia, Perth.

Department of Environment (DOE), 2001, *Development of Sampling and Analysis Programs*, DoE, Perth.

Department of Indigenous Affairs (DIA), 2009, *Aboriginal Inquiry System.* Available from: http://www.dia.wa.gov.au/ [Accessed June 2010].

Department of Water (DoW), 2007, *Stormwater Management Manual for Western Australia*, DoW, Perth.

Department of Water (DoW), 2008, *State Water Recycling Strategy: An Overview*, Department of the Premier and Cabinet, DoW, Perth.

Department of Water (DoW), 2009, *Decision Process for Stormwater Management in Western Australia*, DoW, Perth.

Department of Water (DoW), 2009, *Perth Groundwater Atlas* (Online) Available from: http://portal.water.wa.gov.au/portal/page/portal/MapsDataAtlases/PerthGroundwaterAtlas [Accessed June 2010].

Department of Water (DoW), 2010, *Groundwater Allocation Report: 12:00hrs 8/9/2010*, Water Resources Licensing Database, DoW, Perth.

Environmental Protection Authority (EPA), 1992, *Environmental Protection (Swan Coastal Lakes) Policy*, Government of Western Australia, Perth.

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

Environmental Protection Authority (EPA), 2011. *Decision Under Section 48A(1)(a) Environmental Protection Act 1986. Metropolitan Region Scheme Amendment 1219/41 – South Bullsbrook Industrial Project.* Letter Advising Scheme Amendment Not Assessed – Advice Given.

Facility for Advancing Water Biofiltration (FAWB), 2008, *Advancing the Design of Stormwater Biofiltration*, FAWB, Melbourne.

Government of Western Australia, 2003, *State Water Strategy*, Government of Western Australia, Perth.

Harewood, G., 2010, *Fauna Assessment (Level 1) and Black Cockatoo Habitat Assessment: Great Northern Gateway*, Unpublished Report prepared for Cardno (WA) Pty Ltd.

Hill, A.L., Semeniuk, C.A., Semeniuk, V. and Del Marco, A., 1996, *Wetlands of the Swan Coastal Plain Volume 2A: Wetland Mapping, Classification and Evaluation, Main Report*, Water and Rivers Commission and Department of Environmental Protection, Perth.

JDSi Consulting Engineers, 2010, *Great Northern Gateway Industrial Estate – Servicing Strategy*, East Perth.

Melbourne Water, 2003, *Household Water Use Calculator*, Melbourne Water, Melbourne.

Sand, L. and Shepherd, S., 2010, *Guidelines for Industrial Development*, Perth Region NRM, Perth.

Swan River Trust, 2007, *Ellen Brook Report Card: Catchment Nutrient Report*, DoW, Perth.

Swan River Trust, 2008, *Healthy Rivers Action Plan*, Swan River Trust, Perth.

Swan River Trust, 2009, *Swan Canning Water Quality Improvement Plan,* Government of Western Australia, Swan River Trust, East Perth, Perth.

Water Authority of Western Australia (WAWA), 1989, *Ellen Brook Flood Study Designated Floodway & Levels – 100 Year Flood*, Plan BD93-3-8, Water Authority of Western Australia, Perth.

Water Corporation, 2008, *Waterwise Land Development Criteria*, Water Corporation, Perth.

Water and Rivers Commission, 2001, *Wetlands: Water and Rivers Commission Position Statement*, Perth.

Western Australian Planning Commission (WAPC), 2006, *Swan Canning River Systems*, State Planning Policy 2.1, WAPC, Perth.

Western Australian Planning Commission (WAPC), 2006, *Urban Growth and Settlement*, State Planning Policy No. 3, WAPC, Perth.

Western Australian Planning Commission (WAPC), 2007, *Acid Sulphate Soils Risk Mapping*, Bulletin No. 64, WAPC, Perth.

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

Western Australian Planning Commission (WAPC), 2008, *Urban Water Management*, Planning Bulletin 92, WAPC, Perth.

Western Australian Planning Commission (WAPC), 2009, *Industrial Land Strategy 2009 – Perth and Peel*, WAPC, Perth.

Western Australian Planning Commission (WAPC), 2011. *Metropolitan Region Scheme Amendment 1219/41 – South Bullsbrook Industrial Precinct*. Amendment Report. State of Western Australia, November 2011

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Figures

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Figure 2: Topography & Aerial Photography

Figure 3: Slope Analysis

Figure 4: Soil & Landform Units

Figure 5: Acid Sulfate Soils

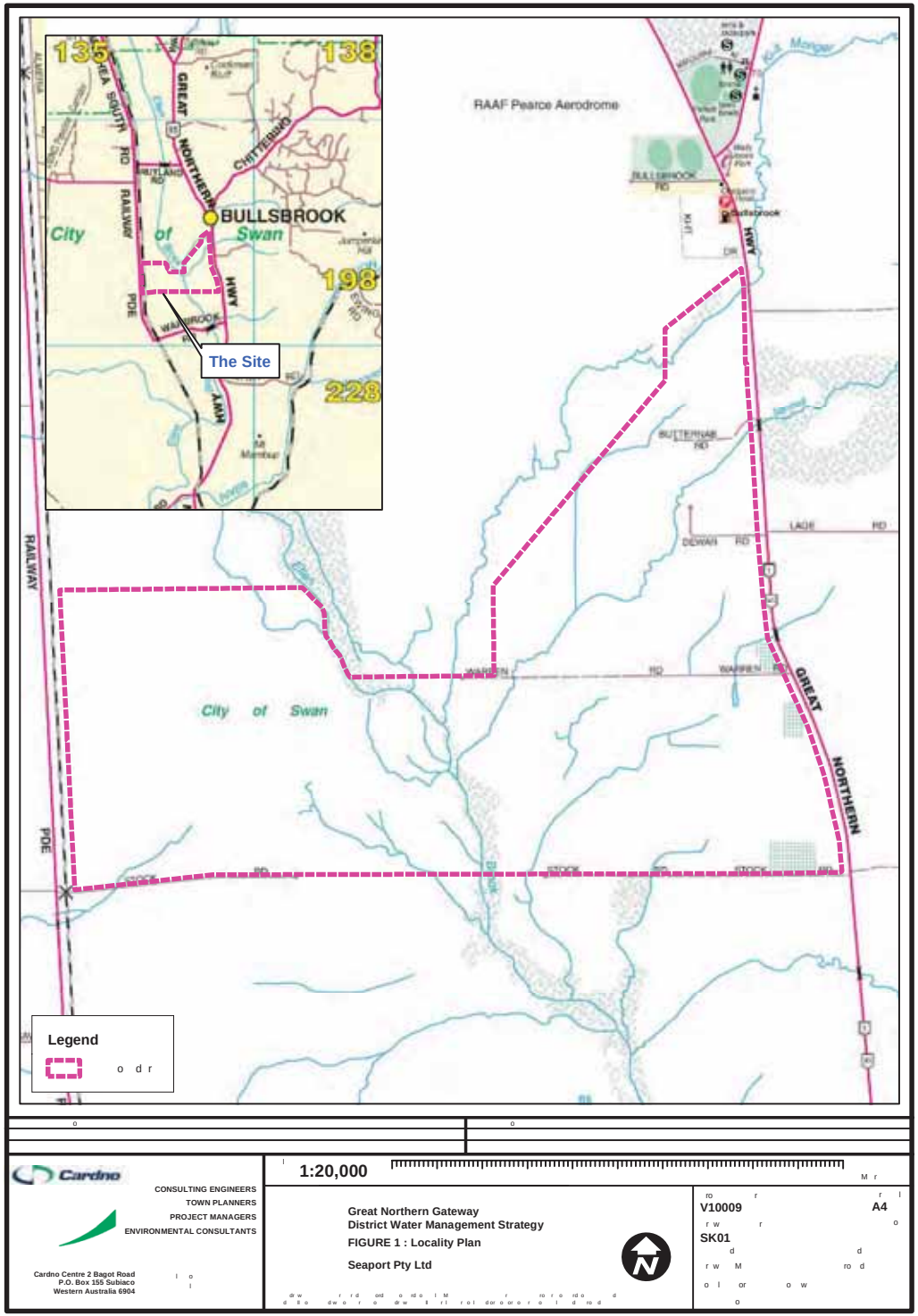
Figure 6: Environmental Assets & Development Buffers

Figure 7: Pre-development Catchments, Flowpaths & Inflows

Figure 8: Flood Mapping

Figure 9: Groundwater Contours & Depth to Groundwater

Figure 10: Post-development Catchments, Flowpaths & Storage



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Great Northern Gateway
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FIGURE 1 : Locality Plan

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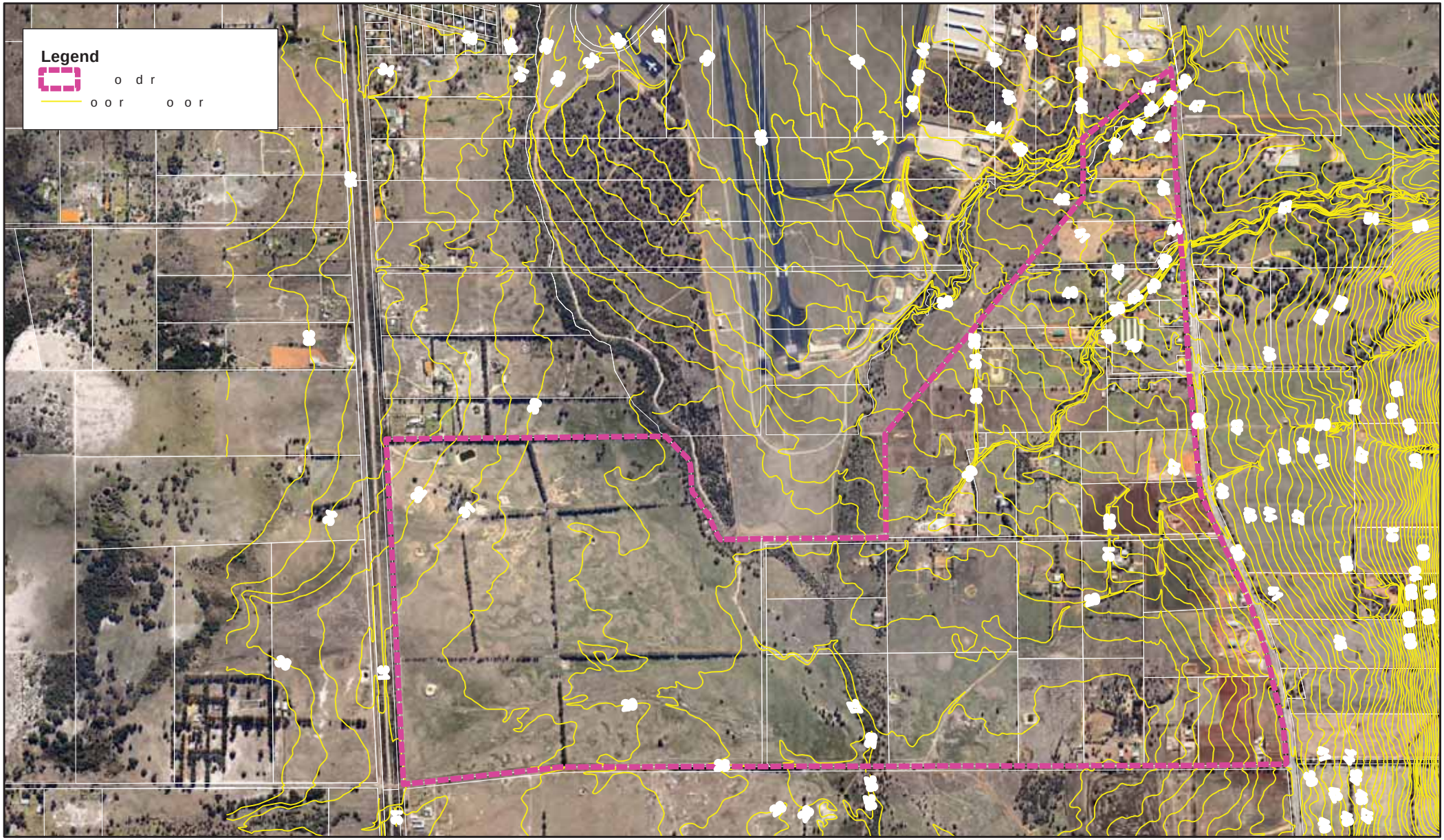

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FIGURE 2 : Topography & Aerial Photography

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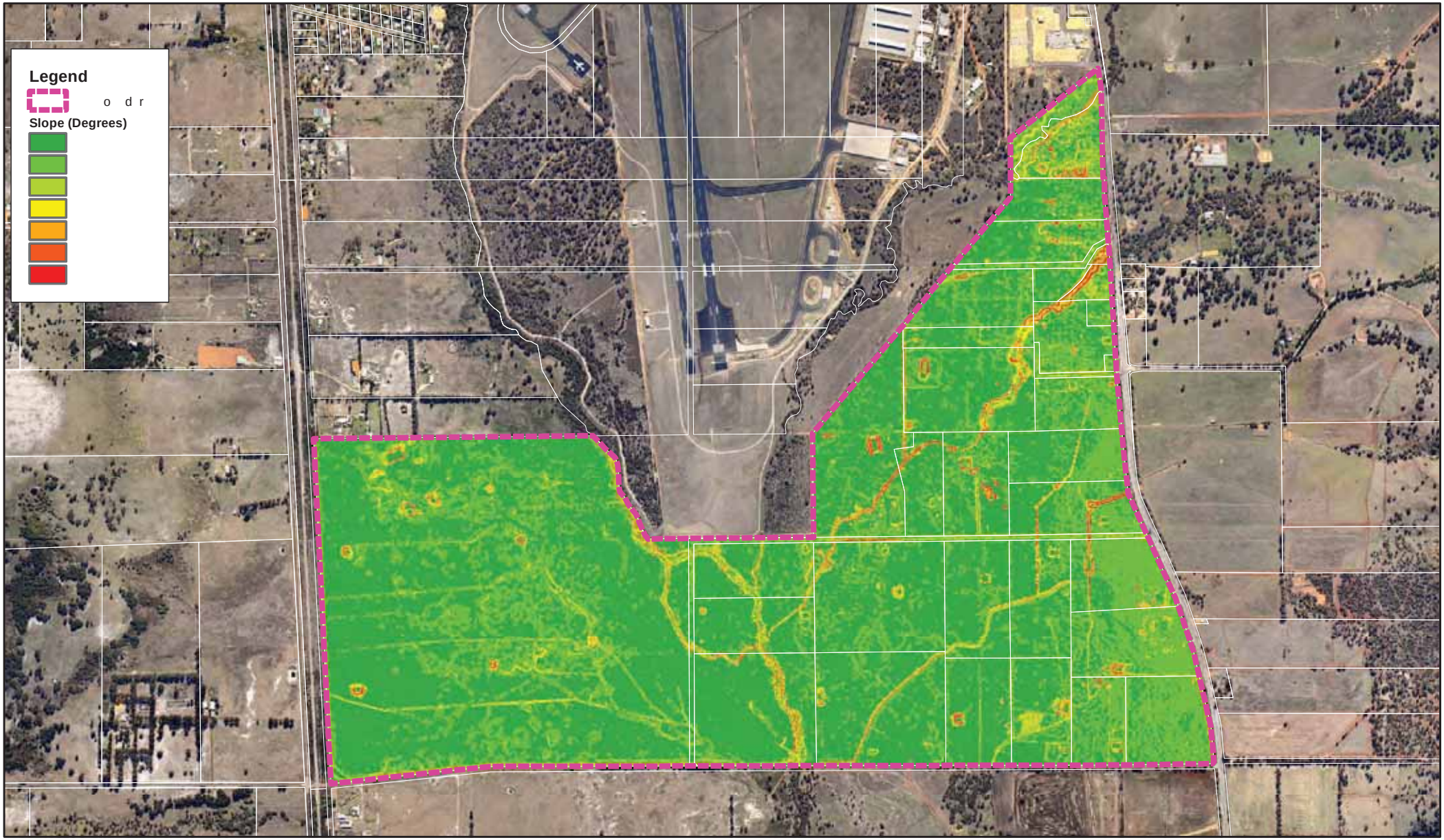

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FIGURE 3 : Slope Analysis

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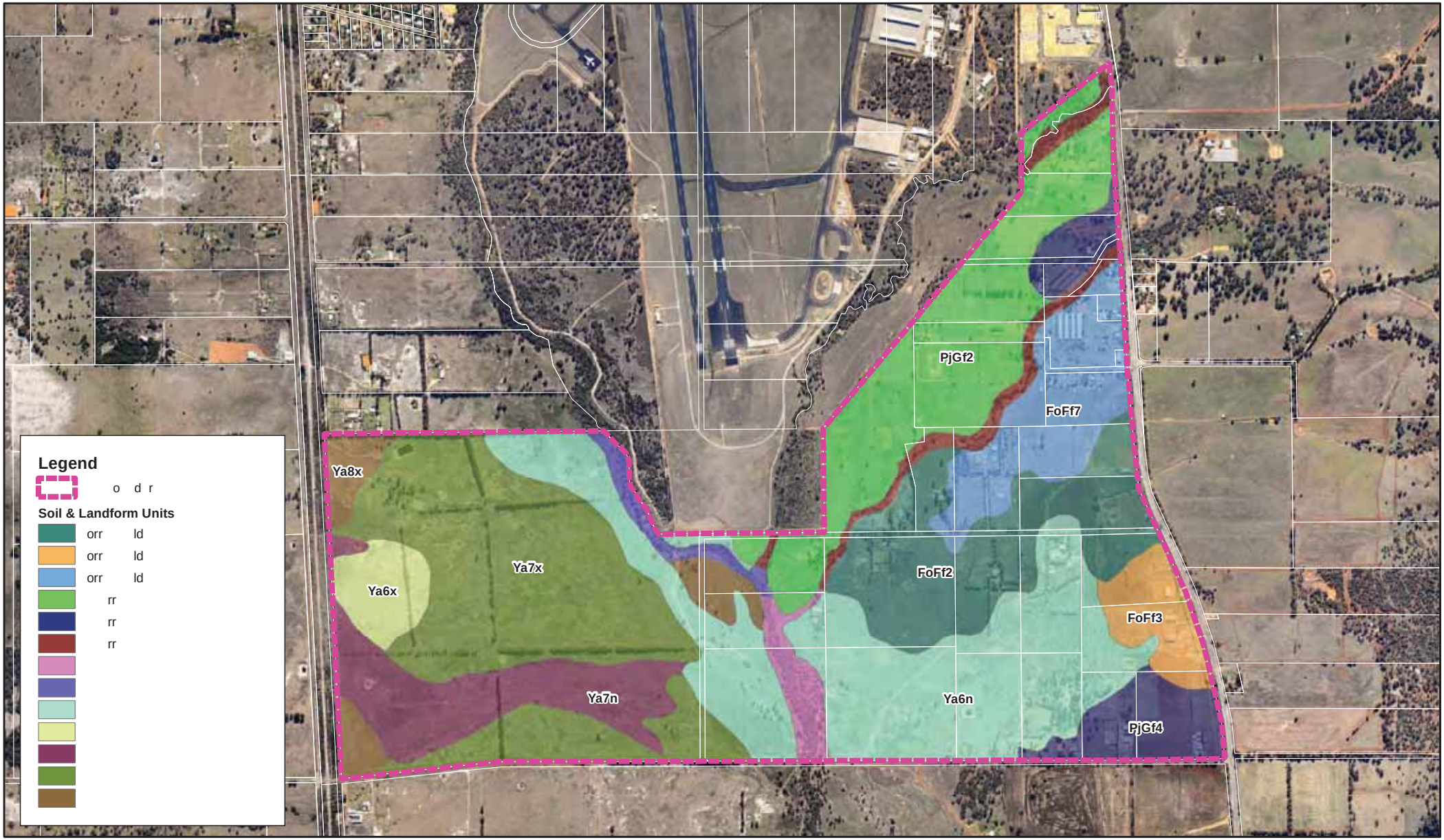

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FIGURE 4 : Soil & Landform Units

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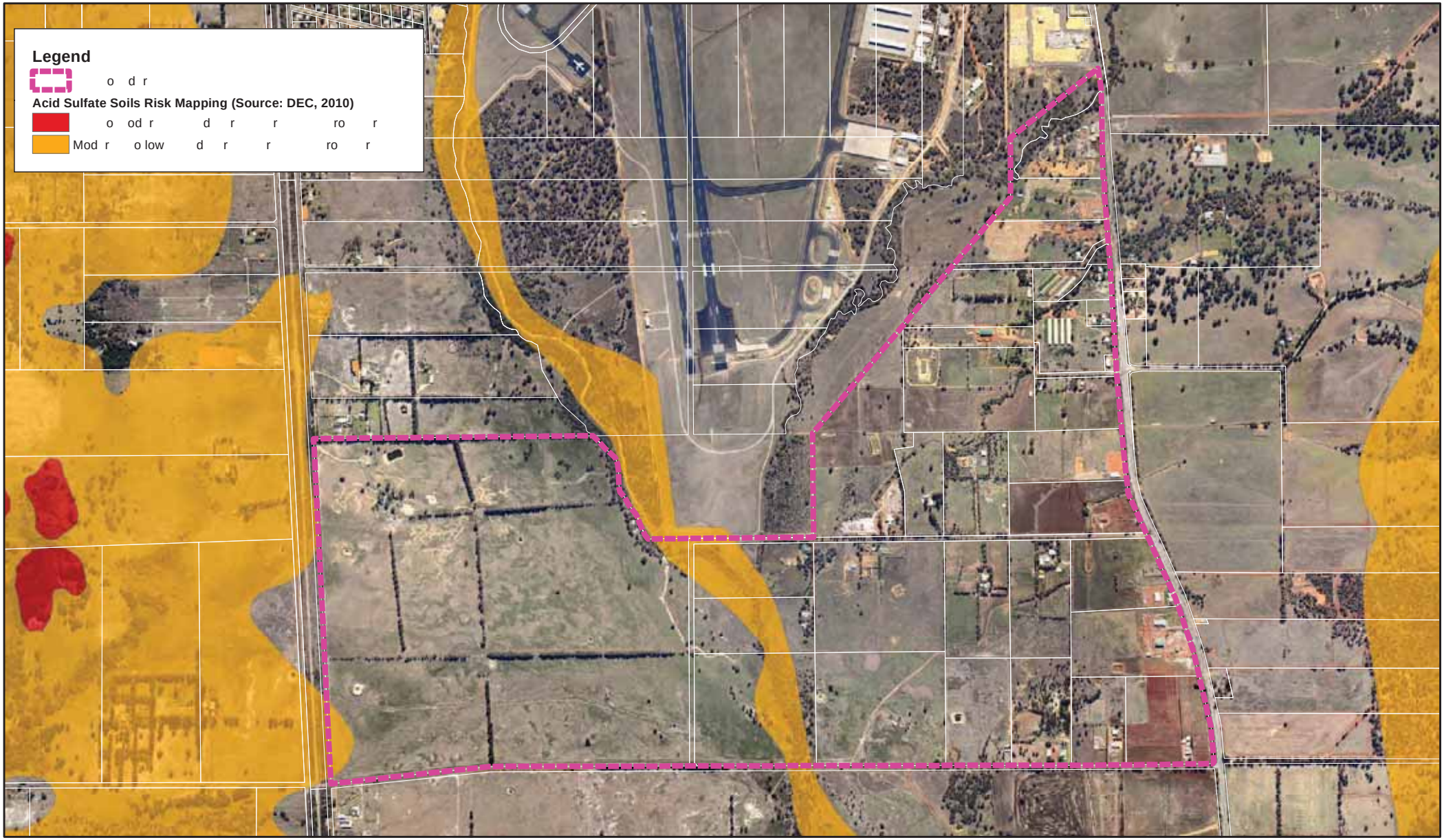

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FIGURE 5 : Acid Sulfate Soils

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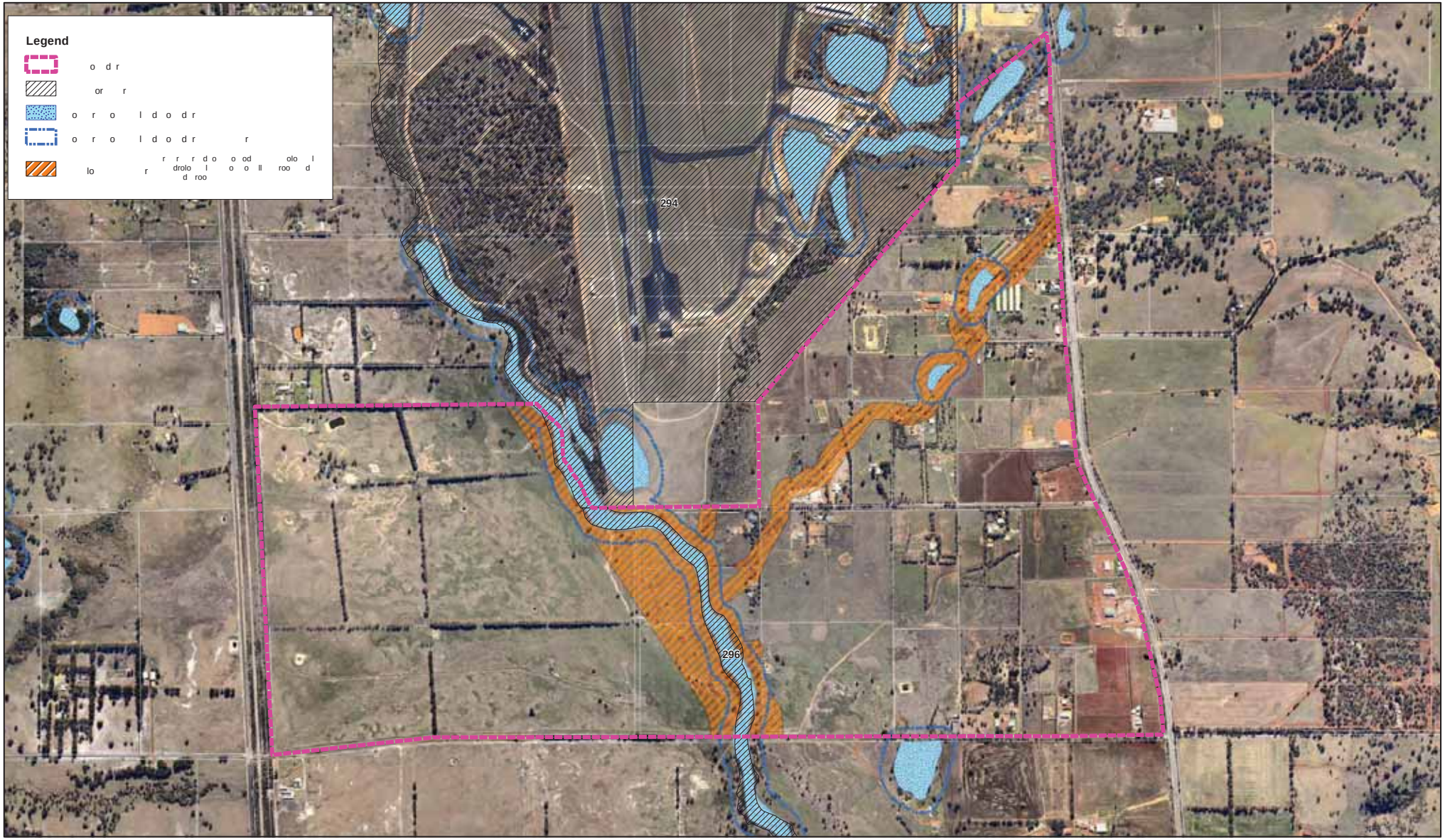

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FIGURE 6: Environmental Assets and Development Buffers

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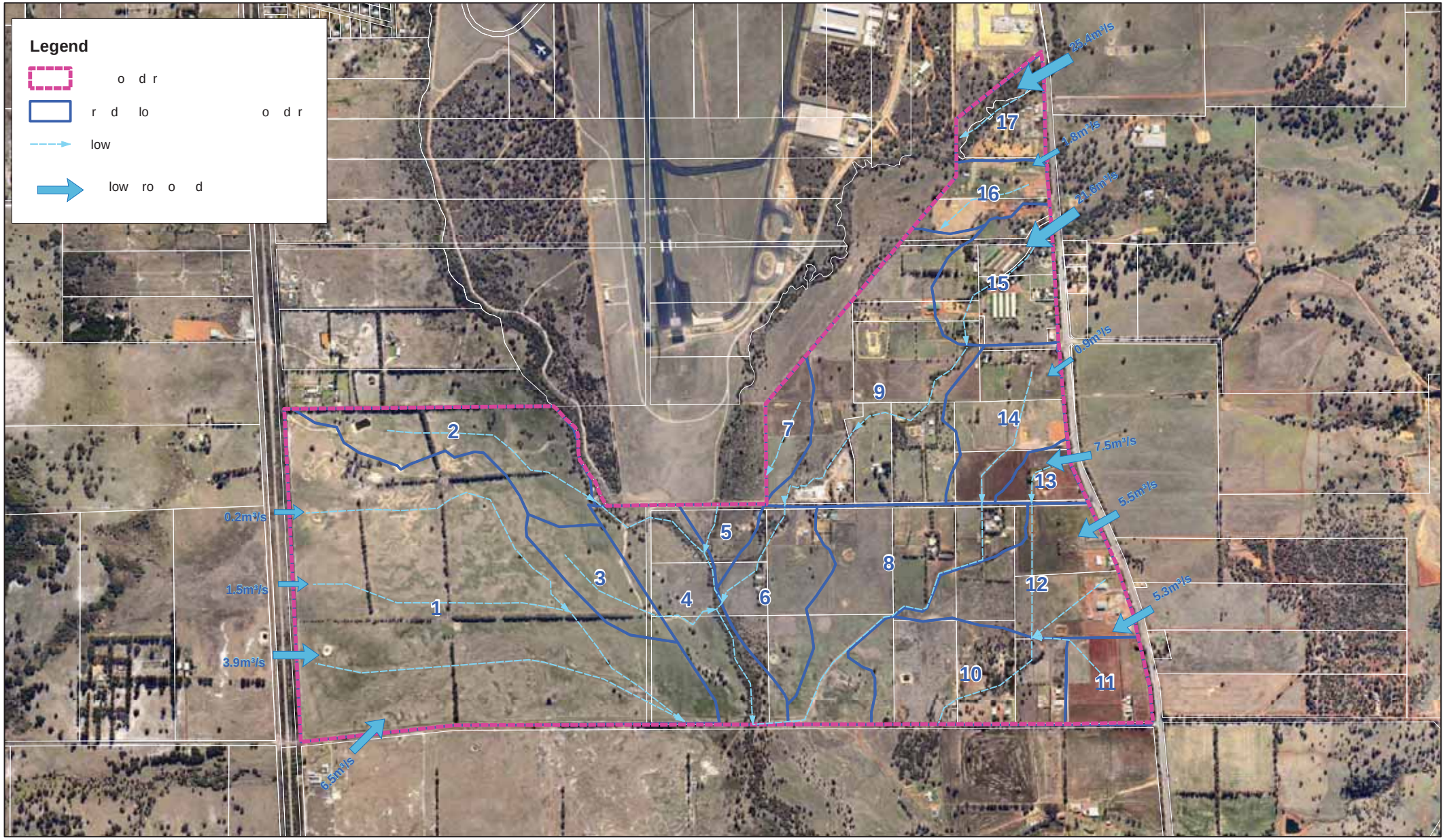

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Great Northern Gateway
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FIGURE 7: Pre-development Catchments, Flowpaths & Inflows

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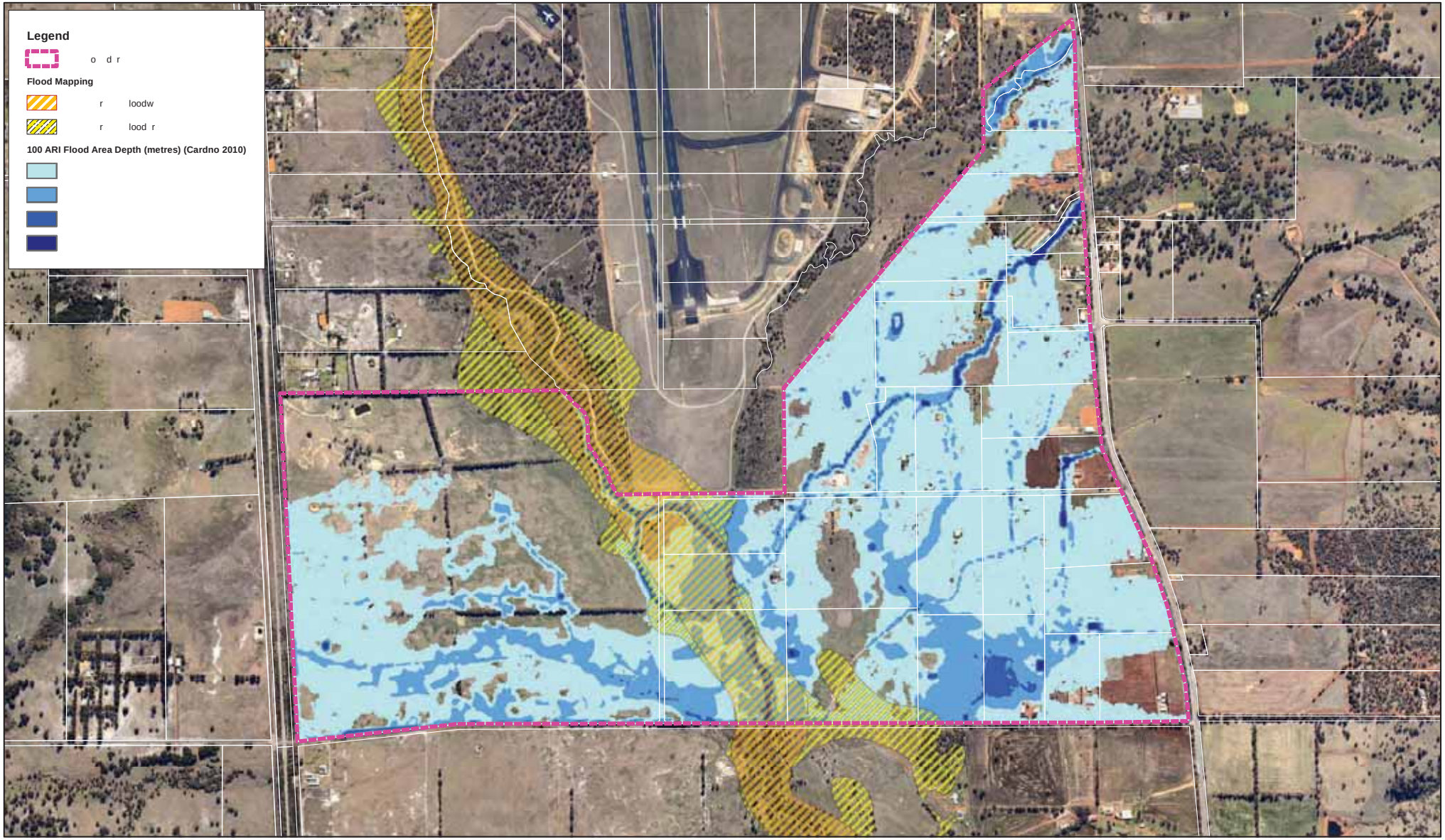

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FIGURE 8: Flood Mapping

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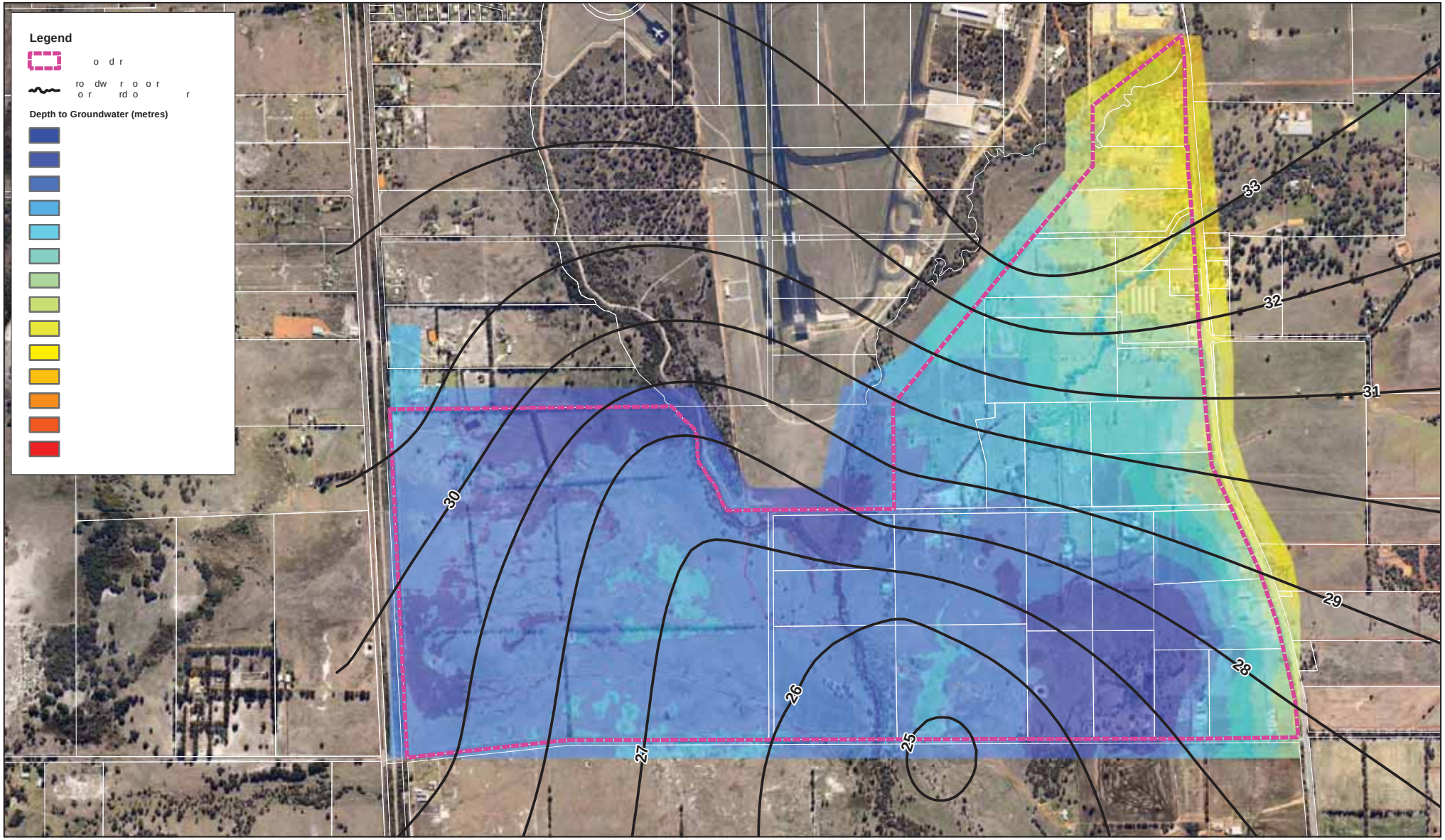

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FIGURE 9: Groundwater Contours and Depth to Groundwater

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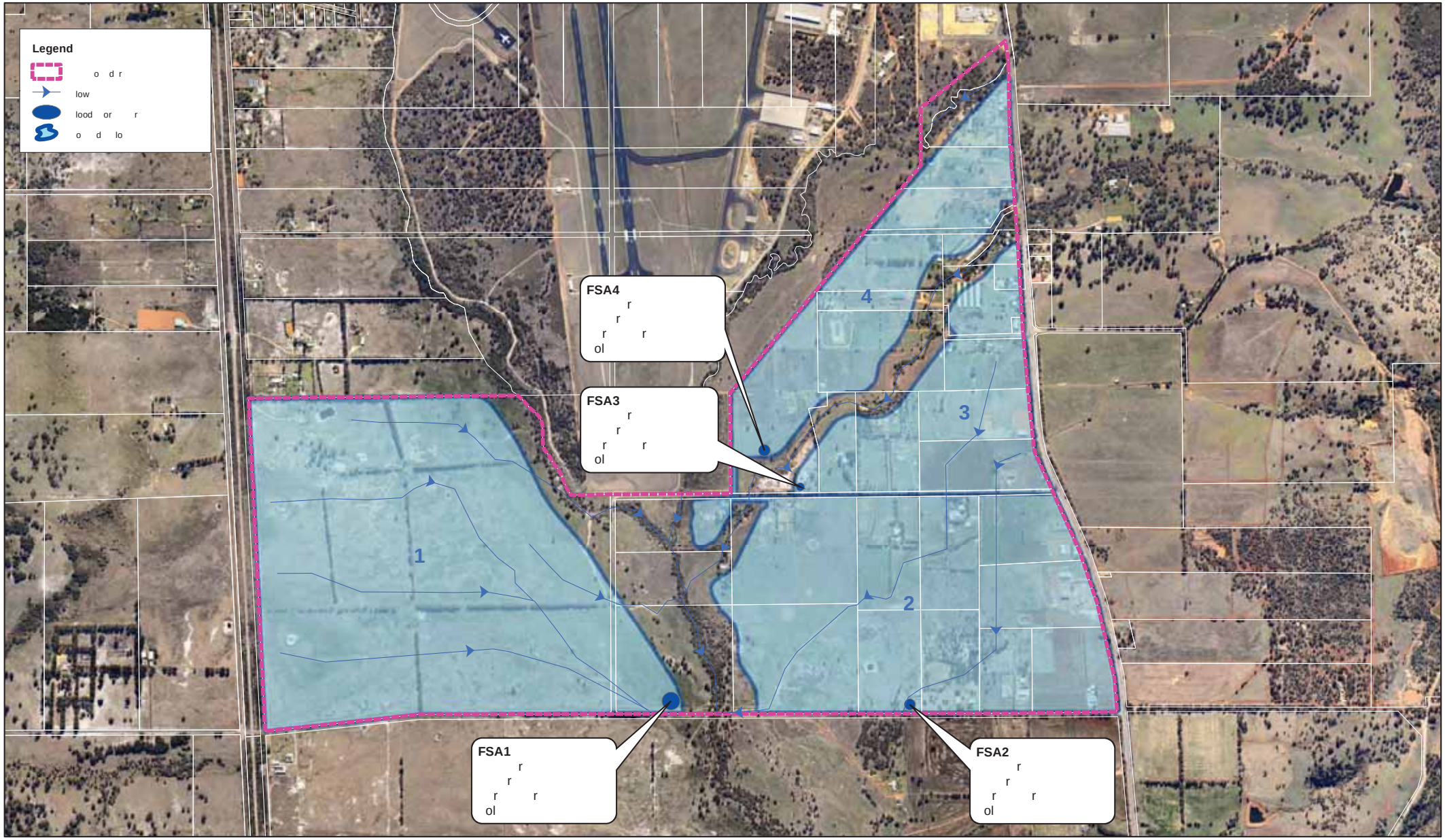

Great Northern Gateway
District Water Management Strategy

FIGURE 10: Post-development Catchments, Flowpaths & Storage

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Appendix A

Preliminary Concept Plan

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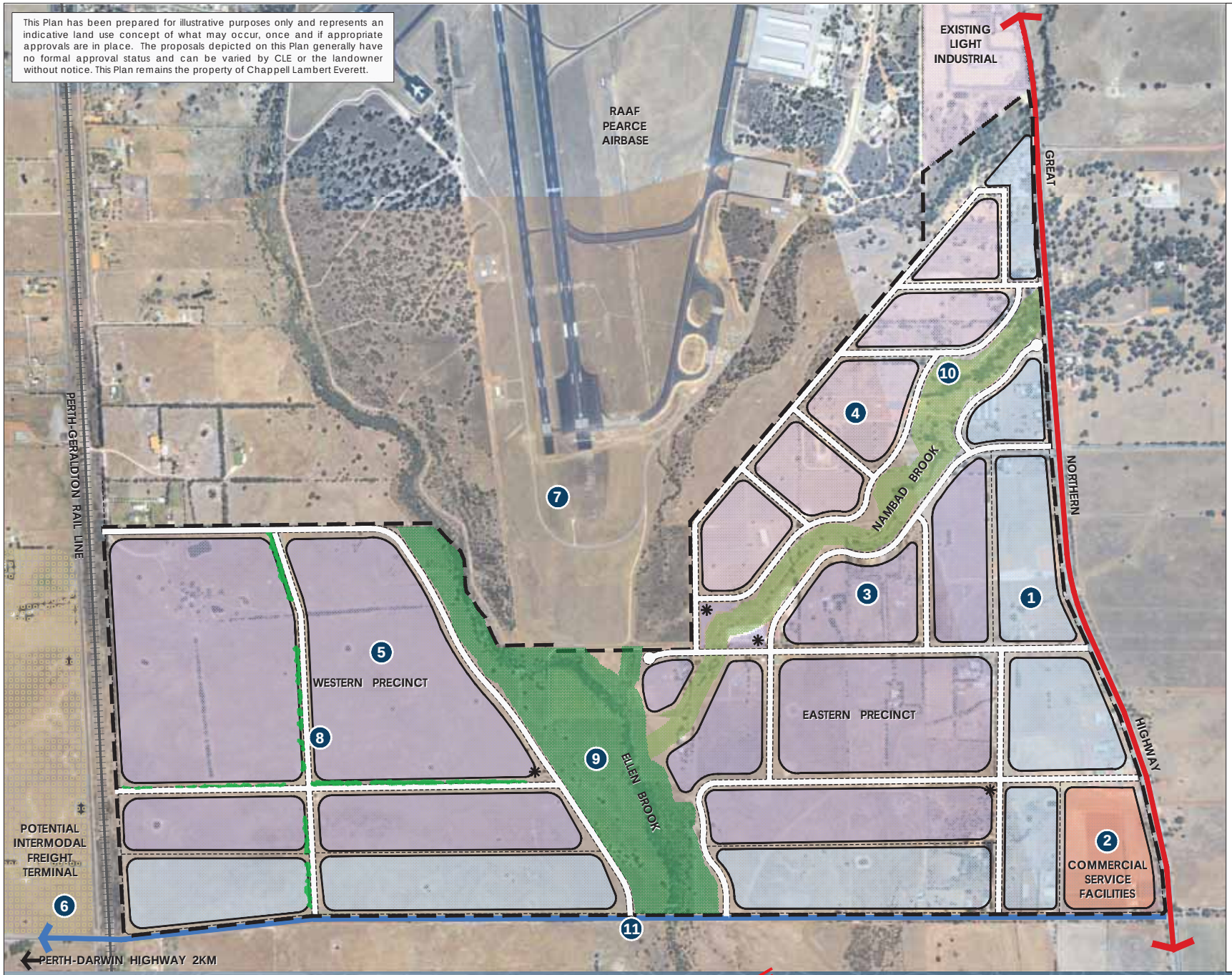

NOTES

EASTERN PRECINCT

1. Potential transport based industry in first stage of development. Potential for highway commercial/showroom development in the longer term as demand increases given proximity to the highway and Bullsbrook townsite.
2. Key corner site for industry related commercial uses - potential truck stop/service station.
3. Transport/storage based industry in the short term, evolving into light industry uses as western precinct is developed.
4. Light industry - smaller lot sizes and smaller scale uses

WESTERN PRECINCT

5. Large scale transport/storage uses - potential for intermodal expansion in longer term.
6. Potential for an intermodal freight terminal as recommended in Industrial Land Strategy.
7. RAAF Pearce Airbase - Future development compatible with building height contours/restrictions.
8. Roads generally corresponding to existing road reserves with drainage swales and retention of planted tree lines within new road reserves where possible. Drainage and fill to be determined as part of LWMS.

CONSERVATION AREAS

9. Ellen Brook Parks and Recreation Reserve / conservation area including ecological and areas managed through road alignment and/or built form control at Structure Plan stage.
10. Nambad Brook local open space, conservation and drainage area including ecological and areas managed through road alignment and/or built form control at Structure Plan stage. Ecological and hydrological buffers will be reviewed and refined at Local Planning Scheme Amendment and Structure Plan stage.

MAJOR ROADS

11. Stock Road upgraded and widened to 40 metre reserve and reserved as Other Regional Road. Wide span bridge crossing of the Ellen Brook, upgrades/widening to intersection of Great Northern Highway and Stock Road, and future rail crossing subject to discussion with Government agencies

* Indicative drainage basin locations to be refined as part of a Local Water Management Strategy and Urban Water Management Plan.

PRELIMINARY CONCEPT PLAN

Great Northern Gateway Industrial Estate
Bullsbrook
City of Swan

DRAFT

GREAT NORTHERN GATEWAY INDUSTRIAL ESTATE

plan no: 2230-31G-01
scale: 1:12,500 @ A3
date: 22.10.10

CHAPPELL LAMBERT EVERETT

LEVEL 2 - 36 ROWLAND STREET SUBIACO WA 6008 PO BOX 796 SUBIACO WA 6904, P:(08) 9382 1233 F:(08) 9382 1127 E: admin@cleplan.com.au
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Appendix B

Flora and Fauna of Importance

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Flora

Table A.1: Endangered, Critically Endangered, Declared Rare Flora (DRF) and Priority Flora (PF) potentially occurring within the Subject Site.

Species	Conservation Code	Flowering Period	Known Habitat
Centrolepis caespitosa	Endangered/ P4	October-December	
Darwinia foetida	Critically Endangered/ DRF	-	
Eryngium pinnatifidum subsp. *palustre*	P3	-	Claypans, seasonally wet flats.
Grevillea althoferorum subsp. *fragilis*	DRF		Undulating plain, Grey sand over yellow sand.
Grevillea curviloba subsp. *curviloba*	Endangered/ DRF	October	Grey sand. Winter-wet heath
Guichenotia tuberculata	P3	August-September	Sand clay over laterite, sand
Haemodorum loratum	P3	September-November	Grey or yellow sand, gravel.
Oxymyrrhine coronata	P4	December-January	Slopes with dry laterite gravel and boulders.
Platysace ramosissima	P3		Sandy soils.
Rhodanthe pyrethrum	P3	September-October	Winter-wet depressions, clay pans, swamps
Schoenus sp. *Bullsbrook* (JJ Alford 915)	P2	October-November	Grey peaty sand. Low-lying flats
Stenanthemum sublineare	P2	October-December	Coastal plain
Stylidium aceratum	P2	October-November	Sandy soils. Swamp heathland.
Stylidium longitubum	P3	November	Seasonal wetlands.
Stylidium squamellosum	P2		Brown to red-brown clay loam. Winter-wet habitats and depressions, open woodland, shrubland.
Thelymitra stellata	Endangered/ DRF	October-November	
Verticordia plumosa var. *pleiobotrya*	DRF	November	Seasonally inundated swamps, road verges.

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Fauna

Table A.2: Fauna of Conservation Significance

Scientific Name	Common Name	Level of Significance	
		Western Australia	Commonwealth
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	S1	Endangered
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	S1	Vulnerable
Dasyurus geoffroii	Western Quoll		Vulnerable
Haliaeetus leucogaster	White-bellied Sea-Eagle	S3	Migratory
Merops ornatus	Rainbow Bee-eater	S3	Migratory
Ardea alba	White Egret	S4	Migratory
Ardea ibis	Cattle Egret	S4	Migratory
Apus pacificus	Fork-tailed Swift	S3	Migratory

Table A.3: Additional Fauna of Conservation Significance as identified by Harewood 2010

Scientific Name	Common Name	Level of Significance		Condition of suitable habitat
		WA	Commonwealth	
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	S1	Endangered	Foraging and breeding habitat present but limited in extent and quality
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	S1	Vulnerable	Foraging and breeding habitat present but limited in extent and quality
Merops ornatus	Rainbow Bee-eater	S3	Migratory	May forage and roost in the subject site at times. Some areas may be suitable for breeding
Ardea alba	White Egret	S4	Migratory	May use creeklines, flooded paddocks and the manmade drains/dams for foraging at times. No suitable breeding habitat
Ardea ibis	Cattle Egret	S4	Migratory	May use creeklines, flooded paddocks and the manmade drains/dams for foraging at times. No suitable breeding habitat
Apus pacificus	Fork-tailed Swift	S3	Migratory	Uncommon seasonal visitor. May forage in area on very rare occasions but very unlikely to roost

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Version 2
Cardno
March 2012

Scientific Name	Common Name	Level of Significance		Condition of suitable habitat
		WA	Commonwealth	
Falco peregrines	Peregrine Falcon	S4	-	Subject site may form part of larger home range and this species may occasionally forage in the area. No suitable nesting opportunities observed within the subject site.
Hydromys chrysogaster	Water Rate	P4	-	May occasionally move along Ellen Brook during wetter months though status difficult to determine. Quality of habitat appears marginal

Appendix C

Modelling Methodology

Modelling Methodology

Surface water runoff from rainfall events can be estimated using relationships between the surface slope, area, roughness, infiltration and rainfall. The interaction of runoff from areas with different characteristics and the routing of this runoff through a catchment can be very complex; it is for these reasons that computational models are used to ensure the accuracy and speed of the calculations.

For the calculation of the surface water runoff from the subject site, the XPSWMM hydrologic and hydraulic modelling software was used. The hydrologic component of the software uses the Laurenson non-linear runoff-routing method to simulate runoff from design storm events. The Laurenson runoff-routing method assumes that runoff is proportional to slope, area, infiltration and percentage of imperviousness of a catchment. Catchment areas and slope are determined from topographical data. The infiltration rates and percentage imperviousness can be determined from field experiments or experience with model preparation with similar soil conditions. The runoff from each catchment is routed through the catchment using the hydraulic component of XPSWMM.

Pre-development Modelling

Parameters and Assumptions

The rate of runoff from an area is determined by the slope and roughness (Manning's n) of the surface. The total volume of runoff is determined by the amount of rainfall less the losses (e.g. infiltration and storage).

An 'initial loss – continuing loss' infiltration model was adopted to generate stormwater runoff hydrographs for the built land types and an 'initial loss – proportional loss' infiltration model was adopted for the remaining land types. Loss values chosen based on Cardno's experience with similar vegetation and soil types to those found within the Bullsbrook region. The infiltration land types used in the pre-development modelling are summarised in **Table B.1**.

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Table B.1: Pre-development Infiltration Loss Parameters

Infiltration Land Type	Initial Loss (mm)	Proportional Loss		Continuing Loss (mm/hr)	Catchment Roughness
		5 year ARI	100 year ARI		
Clay Sparse Vegetation	5	0.56	0.21	-	0.08
Clay Medium Vegetation	7	0.67	0.43	-	0.08
Rocky Sparse Vegetation	8	0.56	0.21	-	0.08
Rocky Medium Vegetation	10	0.67	0.43	-	0.15
Waterlogged Sand Sparse Vegetation	10	-	-	1.00	0.15
Waterlogged Sand Medium Vegetation	12	-	-	1.00	0.2
Sand Sparse Vegetation	17.5	-	-	2.50	0.15
Sand Medium Vegetation	21.5	-	-	2.50	0.2
Roof	1	-	-	0.10	0.013
Paved	1	-	-	0.10	0.013
Garden	15	-	-	2.50	0.2
Bitumen	1	-	-	0.10	0.013
Verge	10	-	-	2.00	0.2

The infiltration rates used were predominately based upon the following assumptions:

- There will be no infiltration on roads, pavement and driveways. There will however be some minor adsorption storage loss and this is reflected in the initial loss of 1mm and continuing loss of 0.1mm/h.
- Existing buildings and road reserves were not assumed to provide storage for the 1 year – 1 hour ARI storm event.
- Garden areas have high infiltration rates as it is likely that sand or mulch is currently used.
- Verge areas are similar to gardens except that they usually include an impervious footpath portion. For this reason, it is anticipated that the averaged initial loss and continuing loss will be lower than the garden rates.

Aerial imagery and regional soil types were utilised to directly measure the area of these land uses types. The analysis of aerial imagery was utilised to determine the typical proportion of roof, paved and garden within commercial areas. Through this analysis it was assumed commercial areas would consist of mostly roof (50%), paved (45%) and garden (5%).

Catchments

The subject site was divided into a total of 17 pre-development catchments, as shown in **Figure 7**, and covers an area of 472ha. Catchment characteristics such as slope and area are provided in **Table B.2**.

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Version 2
March 2012

Table B.2: Pre-development Catchment Characteristics

Catchment	Catchment Area (ha)	Slope
1	135.4	0.003
2	27.2	0.005
3	12.7	0.004
4	26.5	0.002
5	5.5	0.002
6	21.4	0.003
7	7.1	0.009
8	39.4	0.006
9	54.1	0.009
10	31.3	0.022
11	11.3	0.017
12	29.3	0.023
13	5.6	0.026
14	22.7	0.009
15	22.0	0.014
16	10.3	0.009
17	10.6	0.010

Post-development Modelling

Parameters and Assumptions

The rate of runoff from an area is determined by the slope and roughness (Manning's n) of the surface. The total volume of runoff is determined by the amount of rainfall less the losses (e.g. infiltration and storage).

An 'initial loss – continuing loss' infiltration model was adopted to generate stormwater runoff hydrographs for the four industrial land uses. Loss values chosen based on Cardno's experience with similar land uses. The infiltration land types used in the post-development modelling are summarised in **Table B.3**.

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Table B.3: Post-development Infiltration Loss Parameters

Infiltration Land Type	Initial Loss (mm)	Proportional Loss		Continuing Loss (mm/hr)	Catchment Roughness
		5 year ARI	100 year ARI		
Roof	15.93	-	-	0.10	0.013
Paved, Hardstand or Clay	15.93	-	-	0.10	0.013
Garden	29.93	-	-	2.50	0.2
Bitumen	15.93	-	-	0.10	0.013
Verge	24.93	-	-	2.00	0.2

The infiltration rates used were predominately based upon the following assumptions:

- Modified portions of lots are assumed to provide storage for the 1 year – 1 hour ARI storm event. This is reflected in the initial loss of the roof, paved and garden land types, which include the 14.93mm of rainfall for the 1 year – 1 hour ARI storm event.
- The 1 year – 1 hour ARI storm event from the road reserve is assumed to be stored close to source. This is reflected in the initial loss of the bitumen and verge land types, which includes the 14.93mm of rainfall for the 1 year – 1 hour ARI storm event.
- Infiltration was not assumed to occur within storage basins, as the location and design of these basins will be finalised at future stages. This is a conservative approach.

At the district scale, the area of each post-development land use must be estimated. Guidance was sought from Chappell Lambert Everett concerning the likely average lot sizes, percentage of roof and percentage of landscaping. This guidance assisted in determining the proportion of land use types provided in **Table B.4**, which reference the areas provided in the *Preliminary Concept Plan* by Chappell Lambert Everett (Plan No. 2230-31G-01) given in **Appendix A**. The road reserve area was measured directly from the concept plan, which was then assumed to be 50% bitumen and 50% road.

Table B.4: Proportions of Land Use Types

Category	Roof Area (%)	Paved, Hardstand and Clay Sparse Vegetation Area (%)	Landscaped Area (%)
Light Blue Lots and Commercial Service Facilities	60	30	10
Light Purple Lots	50	40	10
Dark Purple Lots (Eastern Precinct)	50	40	10
Dark Purple Lots (Western Precinct)	10	80	10

Catchments

The subject site was divided into a total of four post-development catchments, as shown in **Figure 10**. Catchment characteristics such as slope and area are provided in **Table B.5**.

Table B.5: Post-development Catchment Characteristics

Catchment	Catchment Area (ha)	Slope
1	170.0	0.003
2	125.5	0.006
3	49.9	0.007
4	55.0	0.011

Appendix H: Local Water Management Strategy - South Bullsbrook Industrial Precinct - Local Structure Plan 1

Emerge Associates, 2014

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Prepared for Sirona Gateway Pty Ltd
March 2014

Document Control

DOC NAME	SOUTH BULLSBROOK INDUSTRIAL PRECINCT LOCAL STRUCTURE PLAN 1 LWMS				
DOC NO.	EP12-062(04)--006B RLE				
REVISION	DATE	AUTHOR		REVIEWER	
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Executive Summary

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d r d *Stormwater Management Manual for Western Australia* o

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Table E 1 Water management criteria and compliance summary

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
r o r o		M w r r r or l d o l d d r	o w r w rd r l w l d d r	ro o	d d d l o
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			o w r o l w ll r r d o d d Mo r roo r r	ro o	d d d l o
		M o w r	o ro dw r or rr o o l d d r	ro o	d d d l o
			o r w r w lo	o ow r	ld o r o
			o w r w rd r l w l d d r	ro o	d d d l o
				o ow r	o o r o
			o w r w lo	o ow r	ld o r o
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		M or ro ro dw r l o	r r r o w d o r o r	ro o	l d dr d
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				o ow r	o
			l ro r M r M	o w r	o o r o

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
			r r r or r l r d r **Criteria SWQ2**		
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r w r l		d r r o r r ll o lo o o r r l o l	o w ll r r o r w o w ll or o r o o r o	o w r	o o r o
			r o r r o ro ro d r r o r d o r o r w dow r dr r r	ro o	l d dr d
		l ro r r r l d o r r l r o r d r lo d	r o r lo w ll r d w o w ll or o r o o r o	o w r	o o r o
			r o r r o ro ro d r r w ll r d w o r o r dow r dr r r	ro o	l d dr d

Management Aspect	Criteria Number	Criteria Description	Manner in which compliance will be achieved	Responsibility for implementation	Timing of implementation
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			r rd r w ll l d w l d d r	ro o	d d d l o
				o w r	o o r o
			r l r w ll d w l d d r	ro o	d d d l o
				o w r	o o r o

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Appendix D
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1 Introduction

1.1 Background

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1.2 Town planning context

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1.3 Policy framework

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- *State Water Strategy* o r o
- *State Water Plan* o r o
- *State Planning Policy 2.9 Water Resources*
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development*
- *Liveable Neighbourhoods Edition 4*
- *Planning Bulletin No. 64: Acid Sulfate Soils*

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- *Better Urban Water Management*
- *Australian Runoff Quality* r r l
- *Australian Rainfall and Runoff* r r l
- *Decision Process for Stormwater Management in Western Australia* o

- *Stormwater Management Manual for Western Australia* o
- *National Water Quality Management Strategy*
- *Development Design Specification D7: Erosion Control and Stormwater Management* o

- *Development Design Specification D5: Stormwater Drainage Design* o
- *Handbook of Stormwater Drainage Design* o

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1.4 Previous studies

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1.5 LWMS objectives

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l d o or w r w r r r d d **Section 4**

2 Proposed Development

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o ll roo d r l r l d d **Appendix A**

3 Pre-development Environment

3.1 Sources of information

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- *National Water Quality Management Strategy*
- *Regional 1:50 000 Geology Map Sheet* o rd
- *WA Atlas* d
- *Water Register (* o *)*
- *Perth Groundwater Atlas (* o *)*
- *Weather and Climate Statistics Data* r o M orolo

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- *Environmental Assessment and Management Strategy* M r o
- *Wetland and Water Management Strategy* r o
- *Environmental Assessment Report* rd o
- *Bullsbrook Surface and Groundwater Monitoring report* rd o
- *Hydrological Monitoring Report (* rd o *)*
- *Wetland and Waterway Assessment* rd o d
- *Winter (2010) Flora and Vegetation Survey* rd o

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3.2 Climate

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3.3 Geotechnical conditions

3.3.1 Topography

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3.3.2 Soils and geology

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3.3.3 Acid Sulfate Soils

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3.3.4 Flora

Winter Flora and Vegetation Survey w d r o r o r d r w l d rd o or o or ll l r d or r w l r o

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3.4 Surface water

3.4.1 Wetlands

r w o *Geomorphic Wetlands on the Swan Coastal Plain dataset* d r r ro o or w l d o

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3.4.2 Existing hydrological features

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3.4.3 Modelling approach

or w r r o r d lo drolo l r r o low l drolo l d dr l od l o r d w MM r r r d lo ro ord r o ro d r o o d lo o r o d o r drolo l r d

r w r o or w rr d o ollow r ll o r wo r o or rod w d o r rd o rd o do l r l r o d low r d o d r ll oll o o w ll d d roo ro l or o o w r d o l r d r r or r w r r ll w r r ord d w r d r w orr o d d r r r ord d w d r o rr d o l w low r o w orr o d d o r ll o r rd o

r l ro low r lo r d o l r drolo l d dr l od ll or d d ollow o

r d lo od ll w l o rr d o r o M rd o w l d d od ll o d lood d r ro od ll ow d r w r low r d ro ro d r lood ll r r l ro od l r ro d d **Appendix C** od ll ro w M o w d M l d r d lo ow **Figure 6** o l d MM od ll r o d **Appendix D**

3.4.4 Pre-development modelling results

r d lo od ll d d low r ro r w dr l d w rw low l ro o r r l low d r r o ro w l l o l l d o or o d lo d r r **Table 1** ro d low r d l lo o w d l o l r ro w r ro r low d o low lo o r ow **Figure 6**

Table 1 Inflows to and outflows from the site

Location	100 year ARI Peak flow (m^3/s)	Pre-development details
		r low o dr wor l
		o d o rl d low o
		o d low o dr wor
		o d low o dr wor
d roo		roo l
		o d o rl d low d r d o ll roo
		r o low ro dr l wor
		r o low ro dr l wor

o d r d o l low ro o l r o d low ro l r d o rl d low ro ro d

3.4.5 Surface water quality

r w r l o or w rr d o r o o l r ll o r l r d r o rd o rd o w o or rr d o w d o r l w r ro d roo d ll roo w r l ro d d **Table 2** d l lo o ow **Figure 6**

Table 2 Pre-development surface water quality results

Location	pH	EC (mS/cm)	TN (mg/L)	NO_x (mg/L)	NH_4 (mg/L)	TKN (mg/L)	TP (mg/L)	Ortho P (mg/L)
ll roo								
d ll roo								
d roo								

ro rd o d rd o

3.5 Groundwater

3.5.1 Groundwater levels

or o o ro dw r ro o l r r d ro dw r l l r d o r d o ollow

- r r l w o d r
- r d r ll o d r
- r rr d o d r

ro dw r d ro *Perth Groundwater Atlas* o ow ro dw r l l ro r ro l M

ro dw r o or w rr d o w o r d o r rd o rd o w o r o or or ll d ro M d ow **Figure 3** ro dw r l l w r r ord d o l o r r r rod

ro dw r l l r ord d r w d M ro dw r l M w l l d or w M r w d

r ord d M o o r or r ow **Figure 3**

3.5.2 Groundwater quality

r l o or w rr d w d r d l d d l o o l r r d l or or l o r l d l o r o rd o rd o r l o or w rr d o w o r or ow **Figure 3**

r d ro dw r l r d **Table 3** d d l r r o d d w M o l r r d r o r o

Table 3 Groundwater quality

Bore ID	pH	EC (mS/cm)	TN (µg/L)	NO_x (mg/L)	NH_4 (mg/L)	TKN (µg/L)	TP (µg/L)	Ortho P (µg/L)
M								

l r r d d rd d o ro drolo l o or r or rd o

o l ro d o l o oro o r o r o d r d ow o Mod r r l o o d l o l r d r w low r ord d ll or rd o

3.6 Current and historical land uses

l d or ll d or r l r l r o

3.7 Summary of existing environment

r ro l o o d d o d d

- r o r l r ll w or o r ll r d d l
- o o r o r ro o w low r r r ll o w dr d r l
- d rl ld ord or o l r l o o l l w r o d l o o
- w ol l d M w d ll roo l d
- r r r o r l d d dr ro ll dr ow rd ll roo
- drolo l d dr l od ll w MM d o d r d lo low r d l od ll ow o l o d low o l
- M ro r w d
- ro dw r l ow low o od r d o r o
- or ll d or r l r l r o

4 Design Criteria and Objectives

o o l o d d r r M d r r r M l M w r r o r or w r ro dw r d w r o o

4.1 Integrated water cycle management

State Water Strategy o r o d *Better Urban Water Management* dor ro o o o r d w r l d l o o r l o ro d ro o or w r d o r o o r w r l

r l o r d w r l l d

- o d r llw r o r l d w w r or w r d ro dw r
- r w r d l d l
- llo d w r l d l
- r w r w r l w r ro
- do w ol o r o o r l r o r d

r d w r l ddr o o l l d ro l o w r r o r d l lo r o r o l d o o o r or w r d o o ld r or o d l r r o o r o

- o l w r o o
- lood o
- or w r l
- ro dw r

r l r d w r l r o l r d ro l l orr ro ro l o o d d **Section 3** o do d r rd ro l l d r r ro d d r o o l d ol d d l d d d r d ro d d lo w r d ld **Sections 1.3** d **3.1**

o r llo or r r r d w r l l or ro o d d r l d lo o oll o d ro r w r l o r l o w r ro or o ll roo d r l r

4.2 Water conservation

r o r o d r r r ro o d w r o w d l r d *Better Urban Water Management* d r r ro o d M rd o M ro o ollow w r o r o r r

Criteria WC 1 M w r r r or l d o l d d r

Criteria WC2 M o w r

r w o w ll d r r d l d **Section 5**

4.3 Groundwater management

r l d ro dw r r o ro dw r
drolo M ro o ollow ro dw r r r w r
o w o ro o d M

Criteria GW1 d loor l l o ld l r ro M o l

Criteria GW2 M or ro ro dw r l o

r w o w ll d r r d l d **Section 6**

4.4 Stormwater management

r l d or w r o r d lo drolo l
o d o d r d **Section 3.4** r l d d do d d
Section 1.3 d **1.4** d d or w r r r

4.4.1 Stormwater quantity

M ro o ollow or w r d r r

Criteria SW1 ro d o o r low w rr l r ro
r

Criteria SW2 low o r or w o d r o lo o
r d lo low r ro lo

Criteria SW3 low o r or w d lo o d r o
r d lo low r ro d lo

Criteria SW4 M or ro d r l r or d or ro d
l w r or

Criteria SW5 d loor l l o ld l r ro r w r l l w
r r l dr lood d o r r d d w rw o

r w o w ll d r r d l d **Section 6**

4.4.2 Stormwater quality

M ro o ollow or w r l d r r

Criteria SWQ1 d r r o r r ll o lo o o r
r l o l

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LOCAL WATER MANAGEMENT STRATEGY

Criteria SWQ2 l ro r r r l d o r r l r o r d oll lo d

r w o w ll d r r d l d **Section 6**

5 Water Source Allocation, Infrastructure, Fit-for-Purpose and Water Use

5.1 Fit-for-purpose water use

o r o o w r ro or r o d r o r d o
w r o w d or r o r l l d w r
o r o r or o ll roo d r l r

5.1.1 Scheme water

o ll roo d r l r o r w r or or o r d r
l d r or w ll l d w r or o l d o o l

5.1.2 Groundwater

o l r r d lo d w ro dw r r
w w o d d o l r o

ro dw r d or rr o o dr r r d ro d r d o l
w r rr o o ro d r w ll r o l o d lo ow r rr o
o dr r r w ll o l ro d d d r l l rod o w ll o
r o l or o o rr o o dr r r or ro d r

r ro l o dr r r ro o d w w w r
rr o r o r w ll r r r r ro
ro dw r l ld rr l d old r w ro o o
r r o o l or rr o r o r r l o r r o d w ll
d o o or ll r M w ll r r d o o r o
ro dw r l o

ro dw r or rr o r r d d **Section 5.3**

5.2 Water conservation measures

d lo w ll l ro dw r or rr o rr o w r
r r l or l d d r r o
r d lo o w r r r r d d
ollow o

5.2.1 Rainwater tanks

r o r o ro roo r d r w w r or d w r w r
or l r w r o l ow r d d o o o l
w r r r r d r w r d or rr o r r ow r w ll
d o l d w w r ow rd d o r rod r
r r ll o or o or d r w r d o l r l ld
o o l

o r w r d r d ollow o w ll o d d w
w ll ro o d o r r o o l

o r w ll **Criteria WC3**

5.2.2 Water efficient fixtures

r d o ld w r d w o w r r
Table 4 ro d l o w r o l r r w r
r w r r d w r l l

Table 4 Water efficient fixtures and appliances

Appliance	Water Use	
	Standard Device	Water Saving Device
o l	r l	r l
ow r d	r M	r M
	r M	r M

M l o r r r l o r

o ll roo d r l r w r o r o r ro o ll ld
w r r w ll d d ro ld l

o r w ll **Criteria WC2**

5.2.3 Water wise gardens

r r d d o d lo l w lo l r r r lo r
rd r d o l d r ollow w r
r w ll d o lo l r r r d ro d r w d lo

- ro o l w o d o r r d o r l d rd o d o
w r r o l d d d o or rd d
- d ll rr o ord o w r r
o rol l o rr d r o w d r rr o r
r d r o r dro l or rr
l o l rr o w r ro r
- M o o r r
- M l rd d o w rod r d o r l d rd
- M o r l r d l low r l r l r

r l w ll do d w dr r r d w l w r r r d w
d lo rr o o ro d r w ll r o l o d lo ow r rr o o
dr r r w ll o l ro d d d r l l rod o o o rr o w ll
ro d d o ollow do r

o r w ll **Criteria WC1** d **WC2**

5.3 Development water balance

w r l l d r or o ll roo d r l r o d o r o w r o r o r r ro o d or d lo w o r d o d lo w o w r o r o r o d w w r l l d

- d r l w r d o r ro o
- d rd rr o r o r
- r o r o ro rr o r o r
- ld w r r ro d d **Table 4**

d lo l w r o o or wo w r o r o r o r d **Table 5** ro dw r d or rr o o l d d r w lo lo ow r r o l o o ro dw r l ro r o ro o d w r r

Table 5 lot water consumption

	Light industrial (ML)	Irrigated Landscape (ML)	Total (ML)
d rd w r			
r o r o ro			

l o l o or r l w r w ld o d r l o d d l lo d d l d o lo w ll o o r d l lo l d lo ow r r o l o l w r o r o r ro r o l d r l

w r o r o r ro o d l o **Criteria WC2**

5.4 Wastewater management

o ll roo d r l r w ll r d r or or o r l d w r wor d o r or or o ro o d d r d o l dd lo r d w w r low row d rr ll roo r r l d r d w w r d o l rr w ll or r r rod w w r w ll o o o d or w rd o rr ll roo or r d d o l rd o

5.5 Water conservation criteria compliance summary

r o ro o d w r o r o d r r d ow r ddr d w o ll roo d r l r ro d d **Table 6**

Table 6 Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
	M w r r r or l d o l d d r	o w r w rd r l w l d d r
		o w r o l w

Criteria number	Criteria description	Manner in which compliance will be achieved
		l d d r
		o w r o l
	M o w r	o ro dw r or rr o o l d d r
		ro o o l o o r w r w lo
		o w r w rd r l w l d d r
		o w r w lo

6 Groundwater Management Strategy

d lo dr d d o o d r r d **Section 4.3**

6.1 Groundwater level management

r r o or ro dw r l l o r d loor l l ro r l r ro ro dw r **Section 4.3**

d d **Section 3.5.1** M r ro w d

d loor l l o ld w ll r r d o l r o ro M w ll d or d ll w r r

o r w ll r **Criteria GW1** d

6.2 Groundwater quality management

o or o ro dw r l o or ro ro dw r l d r r r o r or o l r o l o o ro r r r d o l r lo d o ro dw r or ro d lo

r d o o r lo d o ro dw r w ll d d lo

- r r l or w r o d o r o r d l d r r **Section 7.1.9**
- r l r o l d o w dr r r d ro d r w ll d
- ro ol r r r r l w r d r w ll d
- oll o r w ll d w dr r r d ro d r o r r r r d r l o r

o r w ll ro l o w r r or o l r o d rl ro dw r d w ll **Criteria GW2**

6.3 Groundwater criteria compliance summary

r o ro o d ro dw r d r r d ow r ddr d w o ll roo d r l r r ro d d **Table 7**

Table 7 Groundwater criteria compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
	d loor l l o ld l r ro M o l	d loor l l w ll d d o ro d l r ro M o
	M or ro ro dw r l o	r r r o w d o r o r
		M o r l r w l d d r
		l ro r M r r r or d d l l d w lo **Criteria SWQ2**

7 Stormwater Management Strategy

r l d or w r r or o ll roo d r l r
r o drolo r d lo low r l
d low ro or r r r l low

or w r r o o r d o o

o dr
lo dr
r r l low dr

o o d d o o d r r d **Section 4.4**

7.1 WSUD strategies

r o r w ll r r d o low d d r o d l d
r r **Section 7.1.11** o r o r r or o
r w o r r o r r or or l l
o r r r o d r d r r r o or w r d l
o o l r d d low

7.1.1 Lot retention

r o o r o r r ll w ll d r r l o o
r o r d l d r r **Section 7.1.9** ow r l d o r od o
o r o ord r o r r o r o r r or
r o r o ro ll r o r roo r r low low d r or
o l o o o r r d o r o r o r dr o d o low
r l o d rl o l d o lo o r o r o r
o r o r r r o l o lo ow r

o lo r o w ll **Criteria SW2, SWQ1** d **SWQ2**

7.1.2 Side entry pit traps

d r r r d low r o or w r ro ro d d r
r r or w r ro o d r r ll r r
ll r d d r r d o d lo
w o l or l r d d r ol r r r l r o r r
d r lo w r l lood r d o l
r o d lo d l d l l o o lo w

o d r w ll **Criteria SWQ2**

7.1.3 Gross pollutant traps

or w r r o r or r d ro oll o dow r w r od ro
oll r o d r d r r l l r r o ro or o o
l r oll d o ll r r l d d dro r o
oll r d r l r l r o d o r o d

r d o l d w ro oll o r l d lo or or
oll ro oll d r o r o o d lo d o l
r o d lo d l d l l o o lo w
r o d d ord w d l ro d d lo
o o

o w ll **Criteria SWQ2**

7.1.4 Trash racks

r r r ll r r r w r r do r d r o ro
ro l l o w r r r r o o r d r o ll r r o
d w ll r r r l r o r o d r d l d r r o o
d o r r w ll o w d l ro d d o
o r r l o or or d d o

o r r w ll **Criteria SWQ2**

7.1.5 Grease and sediment traps

r l d rod d d dro r o o l l o r d
r d d r d o d r l l r o r o
ll r r l r d d r r l r l d o r
o d

d o l r o d lo d l d l l o
o lo w r or l l o r r d w r r r l
r lo d or w r l r o rr d o o

o r d d r w ll **Criteria SWQ2**

7.1.6 Oil-water separators

l w r r or d o ro d w r l r lo l r r l rl or ll
d r l or o r l lo w r l r r M r o l d o o r r r
r o l l w or or o o o o l r o d drod
d r o l o l d r r o l o r r o r o oll ro or w r

l w r r or r d o r l d r l d r or o l d
r r d o r d d dro r o lo d r r d
r o d o l r o d lo d l d
l l o o lo w

o o l w r r or w ll **Criteria SWQ2**

7.1.7 Lot detention areas

o o r r d d o or r r o ro lo d r l r r ll
o r r d d o d r o ll
w r r r or o r o w lo lood d o
r o d d w r r r d r o d d o r
l r or dd r r o r d d r ro
r d lo low

lo ow r r o l o r ro r ol o or ro d d w lo
d low l r o w r d lo ro r d
or ol r r w lo r ro d d **Table 8** w **Section 7.1.11** low l
lo ro l d ro r l d ll d r or w r r r
w r o l r d o ro d d o w l d l d **Section 7.1.8** low low
d r or o l o o o r r d o r dr o d o low
r l o d rl o l d o lo d r o r r o l o
lo ow r

o w ll **Criteria SW2**

7.1.8 Roadside conveyance swales

o d d w l lo d w w d d ro d r lo o or ro d w ll d o o
r o ro d ro d r r o dow r lood or r d l d **Section 7.1.10** o d d w l r d d w d o d d lo d
ll lo o w d w r d or w r r o r ord
w o l ro o o ro d d w l ro d d **Appendix B**

o ro d d w l w ll **Criteria SW4**

7.1.9 Bio-retention areas

o ro r o r ro ro d r r w ll r d d r d w
d o r o r dow r dr r r o r o r w ll d o
old r o r r o ro ro d w d o d
d lo w ll ollo d w d d **Section 7.1.10** d d w
r r r o l

o o r o r w ll **Criteria SW2, SW3, SWQ1** d **SWQ2**

7.1.10 Flood storage areas

w ll l d o d or low or d r ro ord r o
r d lo low r l r o d d o r l w
o r o w ll l r o ro dw r
d l r r or r r r d d **Section 7.1.11**

d o w ll o w r l l w w ll r l
low d loor l l o d lo o r ro o ro lood d r r r ll
r l r r wor r **Appendix B**

o w ll **Criteria SW3** w l d o w ll r **Criteria SW5** d

7.1.11 Arterial drainage channel

low ro r w ll d ro w dr
l lo d w w d d ro d r r l w ll d o o r low
d or or or r o ro d lo r or o d r ro r
d lo low r

ro o r r l dr l ow **Figure 7** w d ro o o
l l o ro d d o r o o r r l dr w ll d r ro dr
l ro o l l ro d lo d w d o l ll
o low r w l ord r o low r l
low w ll d o r r d o lo l o r r l dr l o ro o d
low r r o r r r ro d d **Section 7.2.3**

o r r l dr l w ll **Criteria SW1** d **SW3**

7.2 Drainage design assessment

d r d **Section 7** d lo dr r o r d r r o r
d d r o r d lo low r
M ro o o l o r o r d o d r o ro ro
d lo low ro r w ll d w r r l dr l
ro o d o o low ro

o or r d dr l r r d lo low r r
d d r d MM drolo l d dr l od ll o w r
o d lo od l o " l lo o l lo " d l lo
ro or o l lo l r o od l w r r o w o r d lo
od l d l d **Section 3.4** o d lo od ll o d r r r
d l d od ll o do ro d d **Appendix D** o d lo
d lo o o or w r r r ow **Figure 7**

7.2.1 Lot drainage

r o r r o w ll r d d l r d w o r o r
d l d **Section 7.1.1** ol r lo r r r d o r d w lo r o
r ro d d **Table 8**

Table 8 1 year 1 hour ARI event lot retention volumes

Catchment	Total lot area (ha)	Lot retention storage	
		Volume (m^3)	Volume per unit area (m^3/ha)

Catchment	Total lot area (ha)	Lot retention storage	
o l			

o ro or w ll d d w r or o d r ro lo d l d **Section 7.1.7** r w w ll o d o dow r or d r ro d o or r r r d w lo o r d lo low r ro d d w **Table 9**

Table 9 Major event in lot detention requirements

Catchment	Total lot area (ha)	100 year ARI event		100 year ARI peak flow rate (m^3/s)	Allowable 100 year ARI peak flow rate per ha (m^3/s)
		Volume (m^3)	Volume per unit area (m^3/ha)		
o l					

d o lo dr d d w ll **Criteria SW2** d **SW3**

7.2.2 Development drainage

o ro r o r ro ro d r r w ll r d d l r d w o r o r lo d dow r dr r r d l d **Section 7.1.9** lo o o ro o d o r o r r ow **Figure 7** w or ol d d d r d l d **Table 10**

Table 10 1 year 1 hour ARI event bio-retention area volumes

Catchment	Total road reserve catchment area (ha)	Bio-retention storage	
		Top surface area (m^2)	Volume (m^3)
o l			

o ro r r r o r o r w ll o o ll o ollo d w r w ll d d r or o d r o r r l dr l d l d **Section 7.1.11** r ro w ll d d o r r d lo low r l r d lo o o ro o d r ow **Figure 7** w d d o r r ow **Figure 9** **Table 11** ro d or ol d o w r l l r w d o d r d r low r

Table 11 Major event detention volumes and peak flow rates

Catchment	Total road reserve area (ha)	100 year ARI event		100 year ARI peak flow rate (m^3/s)
		Top surface area (m^2)	Volume (m^3)	
o l				

d o d lo dr d d o w ll **Criteria SW3**

7.2.3 Arterial drainage channel

d l d **Section 7.1.11** r low w ll o d ro w r r l dr l ro o d ro o r r l dr l ow **Figure 7** w d o r r ow **Figure 9** **Table 12** d l dr l d r r l d d l o ro o d l r d d o r r low r d lo low r l r d o o o ro o d l r r d d **Figure 7**

Table 12 Pre- and Post-development arterial drain flow rates

Channel section	Drainage channel top width (m)	Culvert design	100 year ARI Peak flow rate leaving channel section (m^3/s)
		o r l r l r w r low w r r o l r o r	
		o r l r l r w r low w r r o l r o r	
		o r l r l r w r low w r r o l r o r	
		o r l r l r w r low w r r o l r o r	

Channel section	Drainage channel top width (m)	Culvert design	100 year ARI Peak flow rate leaving channel section (m^3/s)
		o r l r l r w r low w r r o l r o r	
		o o l r w r low w r r l r o r	
		o o l r w r low w r r l r o r	
		o o l r w r low w r r l r o r	

*d o l o or or low ro w w ll r

d d lo o o l r od d d l d d ro d low r l d l d **Table 12** d

d l d r o l or w r r o r d lo low l r **Table 13** d l r d o d lo low r r o low lo o o d lo d r lo o r ow **Figure 7** d r o w o d l d **Section 3.4.4** **Table 1**

Table 13 Pre- and post-development peak flow comparison

Location	100 year ARI Peak flow (m^3/s)		Post-development discharge details	Comments
	Pre-development	Post-development		
				low d r d o low d o
			rl d low ro d r d o ll roo	low r r d d d o w or o o low d r d o low o d lo ro
			r o low ro r r l dr l wor	low w r r l dr l r r d r d lo low r l d o r low ro w
			rl d low ro d r d o d roo	low r d r d lo r d r o d roo
			rl d low ro d r d o Mo r roo	low r d r d lo r d r o Mo r roo

Location	100 year ARI Peak flow (m^3/s)		Post-development discharge	Comments
o l				l d r r ro d r d lo r

o d low r l o d lo ro r w o o r d lo ro

d o d lo dr d d o o w ll **Criteria SW3**

7.3 Non-structural water quality measures

r r l r ro o d w ro d o or d r o o or w r r o d l d **Section 7.1** r o o r r l r w ll l o l d ro o l r d r lo d w or w r r o r l d

- M r l r o l d o w dr r r d ro d r
- ro ol r r r r l w r d r w ll d
- rd d w ll o lo d d l d o or o r o r l d ro d d w l o r d r r or o o r
- d o o lo ow r r rd r l r d r or o w lo

o r w ll **Criteria SWQ2**

7.4 Stormwater criteria compliance summary

r o ro o d or w r d r r d ow r ddr d w **Table 14**

Table 14 Stormwater management criteria compliance

Criteria number	Criteria description	Manner in which compliance will be achieved
	ro d o o r low w rr l r ro r	r low r ro r w ll o d ro w r r l dr l
	low o r or w o d r o lo o r d lo low r ro lo	o r r r d o d low o r w o r o r or o r o r d o d o r d lo low l or ol r r r ro d d **Table 9**
	low o r or w d lo o d r o r d lo low r ro d lo	o ro d lo r w ll d dw lo d dow r dr r r d o llow low l o r d lo low
	M or ro d r l r or d or ro d l w	d wor d ro d d w l w ll d d o o o r o

Criteria number	Criteria description	Manner in which compliance will be achieved
	r or	dow r r r o or ro d lo d w
	d loor l l o ld l r ro r w r l lo	d loor l l w ll l o r ll w ll d o l r w r r
	d r r o r r ll o lo o o r r l o l	o w ll r r o r w o r o r o r o r o r o
		r o r r o ro ro ro d r r o r d o r o r w dow r dr r r
	l ro r r r l d o r r l r o r d r lo d	o w ll r r o r w o r o r o r o r o r o
		r o r r o ro ro ro d r r w ll r d w o r o r dow r dr r r
		o w ll l M r r r r o r o r l r l d lo d l d r r r d d r d r r d o l w r r o r
		r w ll l d w l d d r
		r l r w ll d w l d d r

8 Waterway Protection

d d **Section 3.4.2** o d w r l r l w rw d roo d Mo r roo r r r o ll roo d d or w r or r o ll roo d l w o d low o w rw o d r d d ro

8.1 Wetland and waterway protection

w r o d r w d d r o l d d rw o ll roo rd o d o or r o o w d d r r o o d r o or or ll r l olo l l d r r r o w rw r or l or or r ro d d or r w o d

8.1.1 Bio-physical assessment

o l o d roo d Mo r roo w d r o d r or or r r r d ord r o olo l o d ro o w rw d l o w r ro d d d o M r o

o o ro r o ld ro d d w w rw d l d dd lo w or d o w rw o ro w rw r r r d or or r ro dl o ld d r d o o d

- lood r o ro r d r r r
- o l l or r o o l l l r r o r d o l
- l r o o drolo l r ro o d r d o o w r l dd r d o o dr r o

d r o o ro r or or r do d r d l d olo l r o w rw l d

- o d roo r l dw or o o l d o l l r d d rd o ll o o r o d o o r r w roo l r o r o w r d d lo or r or o o Mo r roo w r l d l d o r o l o ll roo
- drolo low w o roo r r l w or d od r low o d w d d l M or low w r d d M llow low o r ro d r M l l d r o ld o d w w d orr dor d d low
- o l o l o d d Mo r roo r o w r o l l o ll l or **Figure 4**
- ro o l r o r or r d r l r l d od r d o o l r r r d o o ro l d roo or r o ro o d o l o o Mo r roo r r ll l

- o o r d roo d d l w d o w d d r d ro low o w ow rd ll roo w rw low o w o ll roo Mo r roo r w d ro o d r d ro o r o o o loodw or lood l l or d lo r d or Mo r roo
- or o l o d w roo r o d w l d or r o d w r o
- d o o l d l d wo roo d ro r l o d r l d l d **Section 1.2**
- r or l r l o d w ll roo l d d roo d o r Mo r roo r o l olo l d od d r r l r l l o w r l l o o d o Mo r roo l d r r o

ro dl d r d o r r w ll d r o l o d w w rw w w ll d d r o o ro r or or r

o d lo drolo l od ll d d **Section 7.2** l d d o low w d roo d l l o lood ollow r drolo l od ll or or d w o l

d o l w od ll d rd ro o or l o l w ow **Figure 7** l o r l o r l w rw ro d ood r r o o o l r lood l l ro d roo o d r d lo w o r o l r r d r ro r d lo

l d d or low r o r w ll o d w ll d l o roo d d roo l o low o r w o l w d o d o l d o M or low o r w ll lood d r o o l w d o d d d o d llow or r o low o o o d

r l o o l or or r or Mo r roo w d r d o w r or or r or d roo r d ro o llow or r o o o r d r l o o w r r d o o l d d or or r o d roo d Mo r roo w or or d o d

8.1.2 Management principles

ord w ro o o d w l o o l d d rw M r M ro d d d o M r o r r d o w rr d o *Environmental Guidance for Planning and Development* .

o r r r l o M o ro l o w l d d w rw ro r rd r d o d w r r l o r or l M o l r r d r d o w rw or or r ro ro o d M r r l o w r l d

- d d r d l d l ro r l d r r r d o w l d d w rw o
- ro d r d o o lo or or r or d r
- M w rw d r d o d r ro r
- l or or r d r r w ro r
- do ro r r r w w l d w rw d d r l d lo
- l r l o o w r l
- d r o o
- l o r l d r o o o ll d d Mo r roo r or l l o r ro o o o r o d or rod o r

8.2 Flood plain development

d d **Section 3.4.2** ll roo lood d ro d o ll roo lood l w loodw d lood r r d d or w or r o o ll roo d r l r lo d w ll roo lood r d ro d d **Appendix C**

lo ro o d w ll roo lood r l d o ll ld d o d lo o r o r r l d d r

r o o l d w o od r r o r rd d r o o o d lo w lood r d o lood l d lo r or r ro o d d lo o d r d l w r o or lood l loor l l o o ro r r lood l l r o d d o r d lood ro o

r r o l r w d loor l l d r lood l l o d r d d lo o d l d d d r r w M **Criteria SW 5** d l d **Section 4.4** r M w ll r r d o ow ow d l d l d w ll r r d l d M

9 Subdivision and Urban Water Management Plans

r r o d r r r o o or d l d w r l o or d o r ll o d o d o o d o d lo o r M o ld ollow d ro d d *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* o

l r ro d d w M ddr l or w r w lo l ro r o r d o d d or M w ll l r d l o ro d d w M r w ll r r r r l r o w r M l d

- Mod ll o lo l ro d dr wor
- or w r or w lo
- d dr l o r o
- or d ll o d r r
- l o o w r o r o r
- o r r l w r l ro r
- M d r r
- o r o rod r
- Mo or d l o ro r
- o ro dw r r o l

r r r d l d ollow o d o o o o or o ro dw r w ll d l d M ow r M o l d ro dl **Section 10.**

9.1 Modelling of local road drainage network

r o o ro o d d o dr d w r w ll d r od ll r d dr wor od ll w ll llow r o d lo d r w r o w M d o dr od d r ro r l l or lo l r r l d r o ro o r od ll o or w r dr w ll r w d o d l d dr d o d or r d w ll o r d r d o d ro d d l d w r M

o o r r o r r r o od ll d l d d r o w o d M w r wo ld l o ro d d l l o or dr wor d r o d o r o d o r o l w M

9.2 Stormwater storage within lots

o ll roo d r l r or w r r ll lo w ll d r o ro r o llow r d lo low r l lo o d d d **Section 7.2.1** lo ow r r o l o r ro r or ro d d w lo o w d l ro d d **Section 7.2.1**

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o d l d or w r dr r o ro d o ld ro l r or o o r o d r or w ll o l l or l o M ow r M o ld l rl d rol d r o l or l lo l or d r r r

M w ll l o d o d o r ro o d or lo o o o dr wor d o o o l w llow l o low ro lo ro d d **Table 9** o M ro d o r o o rol d lo r l o r r d lo low r ro lo r o d d

9.3 FSA and drainage channel configurations

l o ll roo d r l r dr d d d o r wor od l r d **Appendix B** o l o ld d r o o o o od old r d r or o l d o d lo o d o lood d o r w ll ll d o d d r d w r M

ord r o r w l lood d o r o r o drolo l od l d lo d o or M d o r d l o old r d or o o od o r d o d r o d l dr d w ll ro r d o l l ro d d l d ro o o or r r l o r drolo l od l w ll o o r o d lo r o ol r l o r or r r ro o d **Section 4** o M

9.4 Imported fill specifications

d d r o l o l ll w ll r r d o r lood d o r r dr d l r o r lood l l d o l o r o r w ll r r o r o r r r o l d o ro o o d rl r o or wo ld ll d o o l w or d o r o or r r

9.5 Implementation of water conservation strategies

r o o l r o o r w r r d w M w r o r o r w ll or or d o d d o o o o ll l d d r d d r w ll or or d o w r o r o r w ll r r d l d w r M rod d or d lo r w ro o d o ro o w r o r o r d d M o r lo ow r w ll l o d d w r M

9.6 Non-structural water quality improvement measures

d or d lo d l o o o r r l w r l ro r ro d d w *Stormwater Management Manual for Western Australia* o

ro r M r

o r w ll or ro r l l d lo l o r l l r w ow r l d r l l w d d o d o d dr r r d r M w ll ro d d l o d o l d dr o l r

9.7 Management and maintenance requirements

r o l d o ddr r w r l o o w o r o r d w llr r o o d rr o o ro d r w ll r o l o lo ow r r r w ll rr d or l l rod o l o o o rr o w ll ro d o ollow d lo do r

d r M w ll o o ro oll r o l ow o w llo r lo o l w r w llo r dr o l w o w ll r o l or rr o o ro l ro o d o w ll o or ro o d r d o l o w w ll d r dr rr l o d ol d do w ll d

9.8 Construction period management strategy

d o r o w llr r o o ro d r r o o r r d r or o r o w ll ddr d r r M or r o r o M l M

9.9 Monitoring and evaluation program

w ll r o o r r r l d r l o l l r d d ro d r or o d o o o d o ro o o d lo o or ro r w ll d lo d o ro d o r o d w ll l d d l o o o o or r l d or o ro o d odolo o or r d r or o l o o or ro r r d d **Section 10** o M d w ll r r d l d M

9.10 Groundwater license status

l o or r ro ro dw r l w ll d o o or o ll roo d r l r r d d **Section 5.1.2** l o ll r r o d d r M w ll d o r d llo o o w r o d o rr dr r r d ro d r w r or l l rod or ro r o l l d r d d w r llo o o d o o o rr o o dr r r w ll ro d d o o o rr o o ro d r w ll r o l o d lo ow r

10 Monitoring and Maintenance

10.1 Management and maintenance

ro o d o r ll o d o o d lo w ll o or d o l o or w ll l d r o l o o l d l d wor d w ll o or rod o wo r

l w ll d r o o or o r ll o d o o d lo w o r r o r ll o or d lo r r w ll o or d l d

- ro oll
- rr r l w d
- rr o
- o d
- w l w d o r r r r

d o w ll d l d w r M lo w d l o orr o d o or ro r

10.2 Water quality monitoring

o d lo o or w ll rr d o o r ro o d or d r r d l d **Section 7** r wor l r dow r o r o or o r w r d ro dw r ro ro o d o o r w r r r r ror d d

10.2.1 Recommended program for UWMP

d ro o d lo o or r w r d ro dw r o or r ow **Figure 7** d l d o ro d d o o o d lo o w r l l

r l o or w ll o d d o r rl r o o d lo o or ro r ow **Table 15** o d lo o or w ll o d d or r o o r o o d lo rod l r o d d lo r d o r r r od lo r l o ll d o r r or d d d w ll o o do o

Table 15 Monitoring program summary

Monitoring Type	Locations	Frequency	Parameters
ro dw r	or r d dow r o dr r r	r rl ll rl l	*In situ* r r l

r r	r d dow r l w d roo d r r l dr	r rl ll rl l w w r r o do o	*In situ* r r l

10.2.2 Post-development trigger values

ro dw r w r l r d r d ro ro d l l r d d r o or ror o d lo ro d d **Table 3** r w r l r d d o d r o o w r l o or rr d o w ll roo ro d d **Table 2** r r l l l d r r d ro r d lo o or lo o d o d r o o *National Water Quality Management Strategy* r r r r ro o d r ow **Table 16**

Table 16 Water quality trigger values

Analyte / Source	pH	EC (mS/cm)	TN (µg/L)	TP (µg/L)	Ortho P (µg/L)	NOx (mg/L)	NH_4 (mg/L)	TKN (µg/l)
ro dw r								
r w r								

l r r l d d **Table 16** w r l d o r l r d r or ro o d o d lo r r l ro d d **Table 16** r d l d o ld d o o r dow r o r o o d r r ro l o o **Section 10.3** w ll dow r o r o o o r r r r r o r o

10.3 Contingency action plan

o o l w ll d l d d l d r o M l l o w ll d r o ld r w r l r r r d

10.3.1 Trigger criteria

d d r r l ro o d **Section 10.2.2** d r d ro w r l l l r d d r r d lo o or l o ld r w d or M o l d dd o l d d ro o d o or

10.3.2 Contingency actions

r l ro l o or o o d r o r o d o d r l ro o r lo d

r o o ld d r r r r r r d d o r o or o r o o l or l rror r o or ll ow r l w r r r l o w ll o o r r o r o r o w dow r o o r o r o

dow r r o r o r r r r o r o ollow o o ld d r

w r l o r o d o r o l o d r ll o d o r o d r o r o l d o o r l d w lo r r o o r o l r l r

dow r r o r o r o d o r ll o w r o r o o w ll o o d o r o r o ro d d oll d w ror o d lo r o o o r l o ll d or ll r o r o r d ro d r r l d o od d ollow dd o l o or or o o ld d ool o l o w o o d r r r l o ld r d

ollow l o o o o r w r l w ll r l d r l o l ll ow w r l r r w r r r l dd o l o r dow r o or or o ld ll d o r r r r or l ro o r r w r lo o dd o l or lo o w ll l d r o o l r lr d d r r l ro o d r d o r r l o w r r o d o w ll or d o r l d ro o w ll wor w o d o o d r r l r r o ro d r dw r dd o l o o d o l d o

10.4 Reporting

o d lo o or r or w ll r r d o o l o o r o or rod d w ll ro d d o o d o r r l r d ro d d o r o or o o r d r o or ro r

11 Implementation

M or do or d lo o M
d r w o o ro d r r w w d lo o r
o w r d w r l ro l o d d o ro d o r ll
d o r l or w r r l or r d o d d lo
o r M

11.1 Roles and responsibility

M ro d r wor ro o l o l or w r
od d o o r o w
r l d o l o r ol d dor d o
r o l or wor w r wor l d w M r w l d old r
l o d r M w ll d lo d o l o w o d o
d o d r o o o r r l ol d do

r o l o l d w lo w r l r r r
ro r o l d w ll w lo ow r lo d lo r d d o or
d o o or r o w lo w ll r o l o lo ow r lo d lo r

11.2 Funding

l d l l l d old r d lo d o r ro o w ll
d o wor w o o r ro o o r d ro r l ro o
o r o ro

r lo d w lo o r o r r o o
w r r r r o o lo o r o l o ro d or
l r o r r r o w l d d o rd
r r r l d dr w r o l r d or r r l dr
l o d r d d r

o l dr r r r w ll d d lo ll w r d or w lo dr
r r r w ll r o l o lo ow r l dr r r r w ll
d d ro o

11.3 Review

o d M w ll r w d l dd o l l d r l lo r dd d o
r r or o d o or d r o o lod o
M dd o l r r r d o o r d M o l l dd d
o o r r o ld r r d ll od d r r o od ll
d r or M w ll d o r w d d r r ro o d r d o r ll
r ll ro r

o w r r d o lo l ro d o
d o ro l w ll or d M

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M l r l o o M old ro d d l o d ro o d
w M d w ll d o r o l w r r ro o d **Section 4**

dd o o d l d **Section 8** M w ll ddr

- o l w d o w M
- l d or w r d
- r r l d o r r l od o l d d r ro
  l o
- l o ro o d rol d r o l or o r

o d lo ollow M l lo d lo

r o d r l o M d M w ll o l d l
l d r l l or o or o rol l d o r
l o o r r l r r r l l o
or d r l o w ll o r d o ro ol or
od o o w r r ld l or w r ro r r
or or o rw ro r

12 References

r l d w l d ro d o r o o l *Australia and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy* r l d w l d ro d o r o o l

r l o r *Water Efficient Labelling Standards (WELS) Scheme - Products* ro www w rr o rod d l

r o M orolo *Weather and Climate Statistics Data* ro www o o l d

rd o *Bullsbrook Surface and Groundwater Monitoring: Final Monitoring Report*

rd o *Environmental Assessment Report: Great Northern Gateway*

rd o *Great Northern Gateway Hydrological Modelling Report*

rd o d *Great Northern Gateway Wetland and Waterway Assessment*

rd o *Winter (2010) Flora and Vegetation Survey, Great Northern Gateway Industrial Estate, South Bullsbrook*

rd o *Great Northern Gateway Industrial Cell District Water Management Strategy*

o w o *Development Design Specification D5: Stormwater Drainage Design*

o w o *Development Design Specification D7: Erosion Control and Stormwater Management*

o w o *Handbook of Stormwater Drainage Design*

o w o *Local planning scheme no. 17 (District zoning scheme)*

r o ro d o r o *Geomorphic Wetlands, Swan Coastal Plain* r

Acid Sulfate Soils Mapping r d ro www l d w o w l

r o r o *Stormwater Management Manual for Western Australia* r

r o r o *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions*

r o r o *Decision Process for Stormwater Management in Western Australia*

r o r o *Water Register* r

r o r o *Perth Groundwater Atlas 2004 Edition 2* r o r r

r o r o *Water Register* r

r o *Environmental Assessment and Management Strategy: South Bullsbrook Industrial Precinct Local Structure Plan 1*

r o *South Bullsbrook Industrial Precinct Local Structure Plan 1 Wetland and Water Management Strategy*

r r l *Australian Rainfall and Runoff* o l o or r r rr

r r l *Australian Runoff Quality: A guide to Water Sensitive Urban Design* o l o or r r r r l rr

ro l ro o or *Guidance Statement No. 33: Environmental Guidance for Planning and Development* ro l ro o or r

o r o *State Water Strategy* r

o r o *State Water Plan* r

o rd *Muchea, Sheet 2034 I and Part 2134 IV* r M ro ol o ro l olo r r olo l r o r r l

d *WA Atlas* r d r ro www l d w o w l

M l o r r *Household Water Use Calculator*

w r r *Ellen Brook Report Card: Catchment Nutrient Report 2010 update*

r r l l o o *State Planning Policy 2.9: Water Resources* d r r r l l o o r

r r l l o o *Liveable Neighbourhoods (Edition 4)* r r l l o o d r or l d r r r r

r r l l o o *Better Urban Water Management* r r l l o o r

r r l l o o *Planning Bulletin 92: Urban Water Management*

r r l l o o *Planning Bulletin No. 64 Acid Sulfate Soils* r r l l o o r r

r r l l o o *Metropolitan Region Scheme* r r l l o o r

r or o r r l *Ellen Brook Flood Study: Designated Floodway and Levels - 100 Year Flood. Plan BD83-3-7 and BD 83-3-8.*

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ro r M r

FIGURES

Figure 1: Locality diagram
Figure 2: Site boundary
Figure 3: Topographical contours
Figure 4: Geological Units
Figure 5: Wetlands
Figure 6: Hydrological Features
Figure 7: Stormwater management features
Figure 8: 1 year 1 hour inundation areas
Figure 9: 100 year ARI inundation areas

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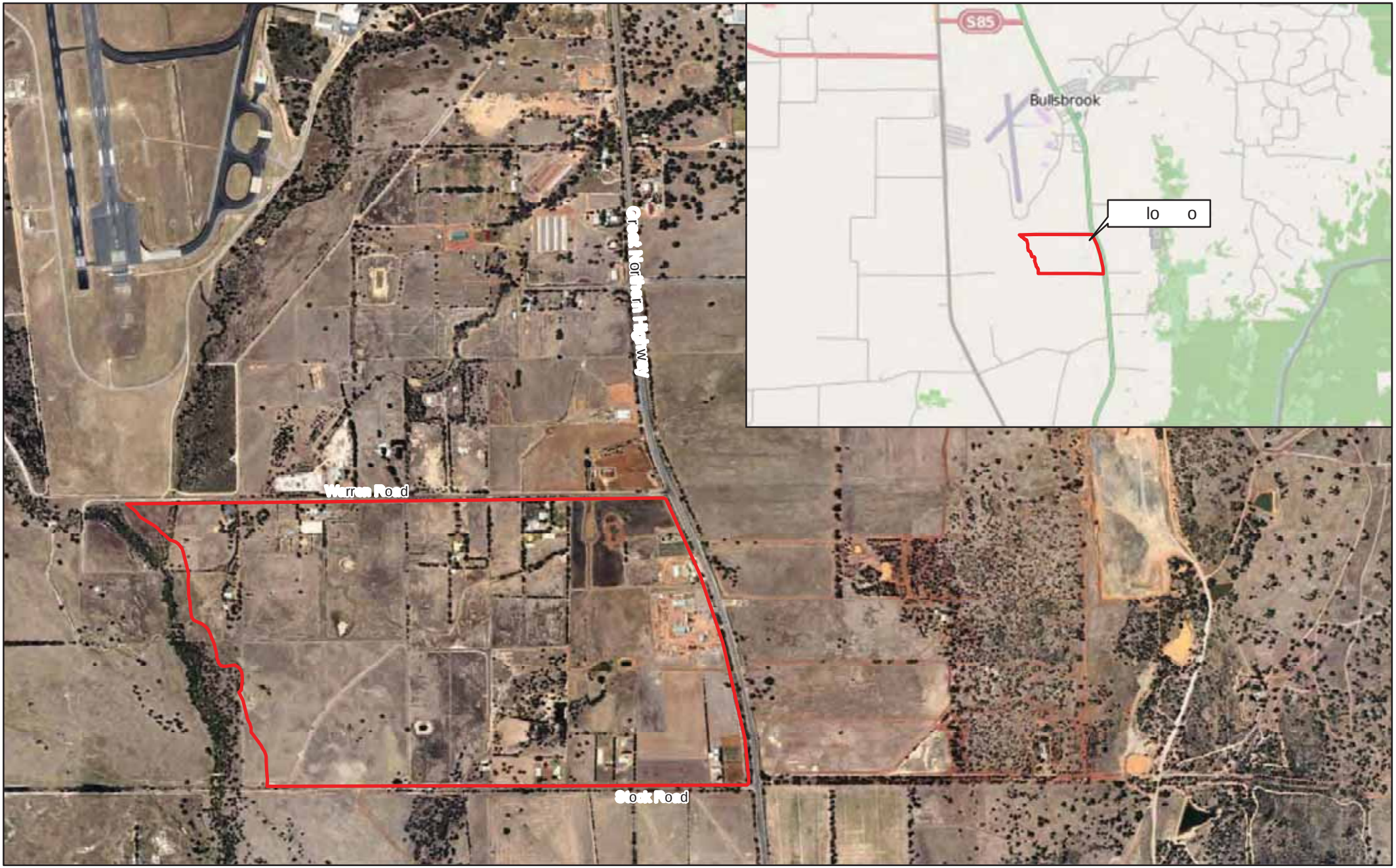

Figure 1: Locality Diagram

ro o ll roo d r l r

l ro w d

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d

o d r

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r w	
ro d	
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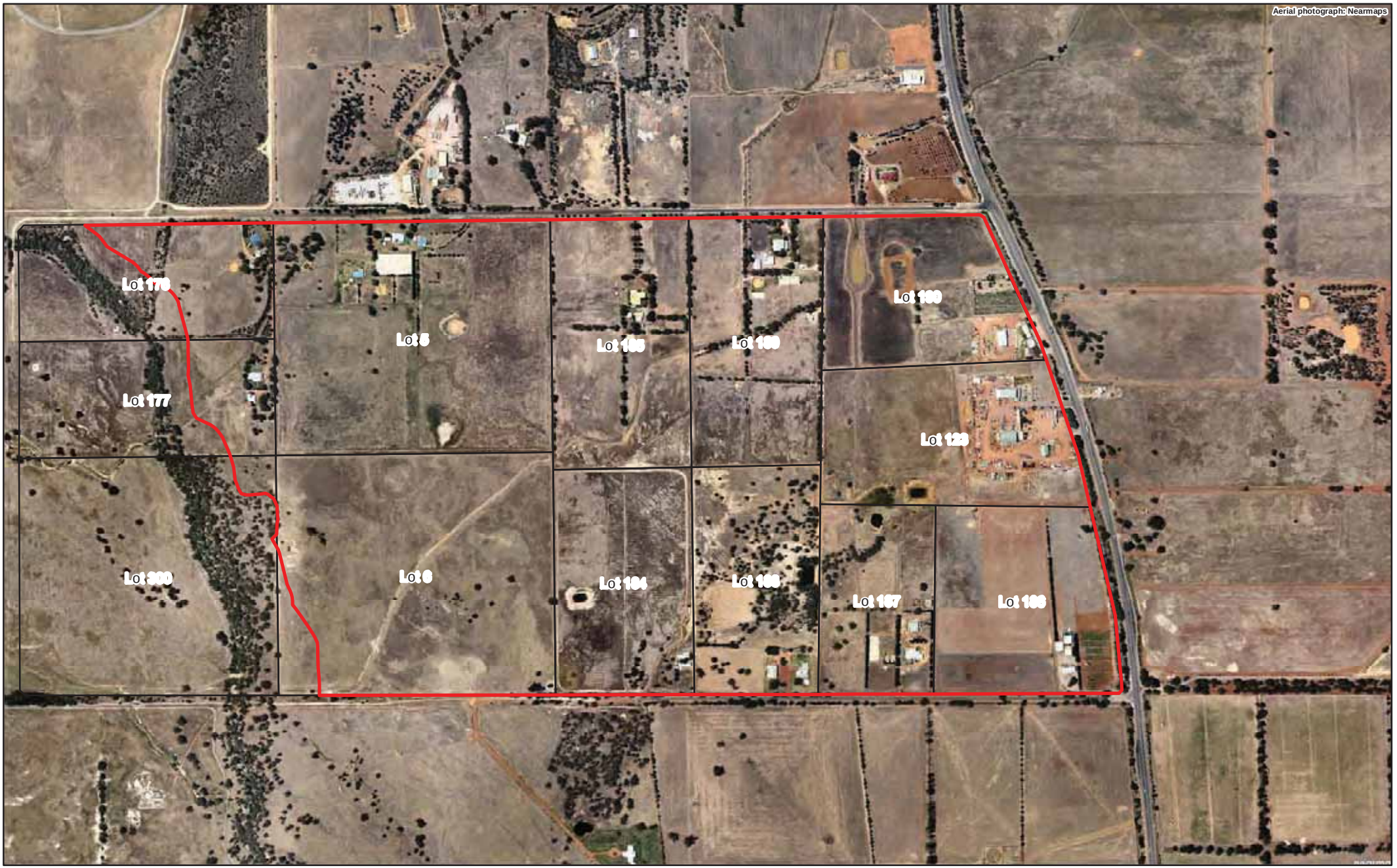

Figure 2: Site Boundary

ro o ll roo d r l r

l ro w d

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o d r

o o d r

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r w	
ro d	
d	l

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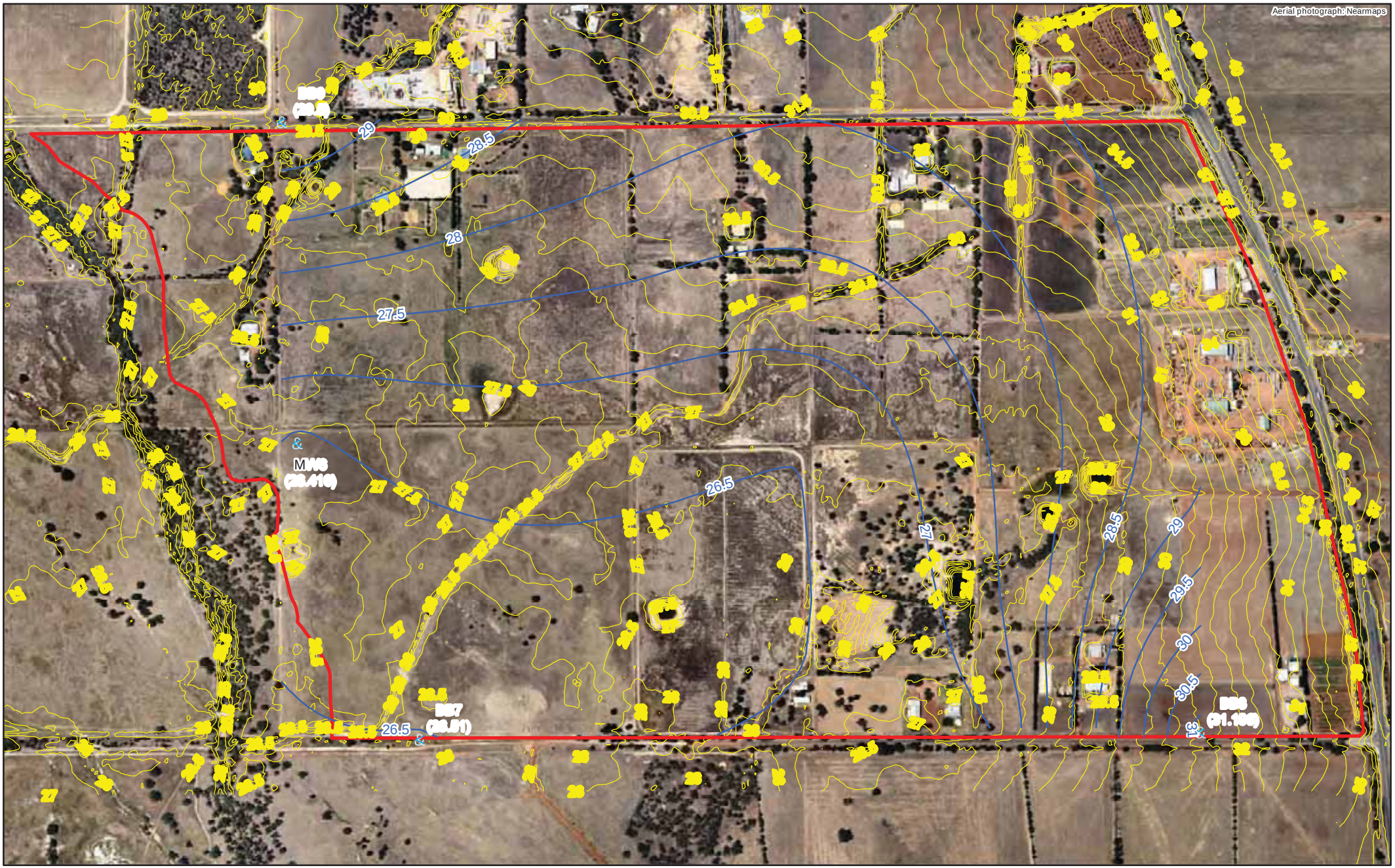

Figure 3: Topographic Contours

ro o ll roo d r l r

l ro w d

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Mo or w ll M

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ro d	
d	l

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o r o r d o l ø r l l o r d d

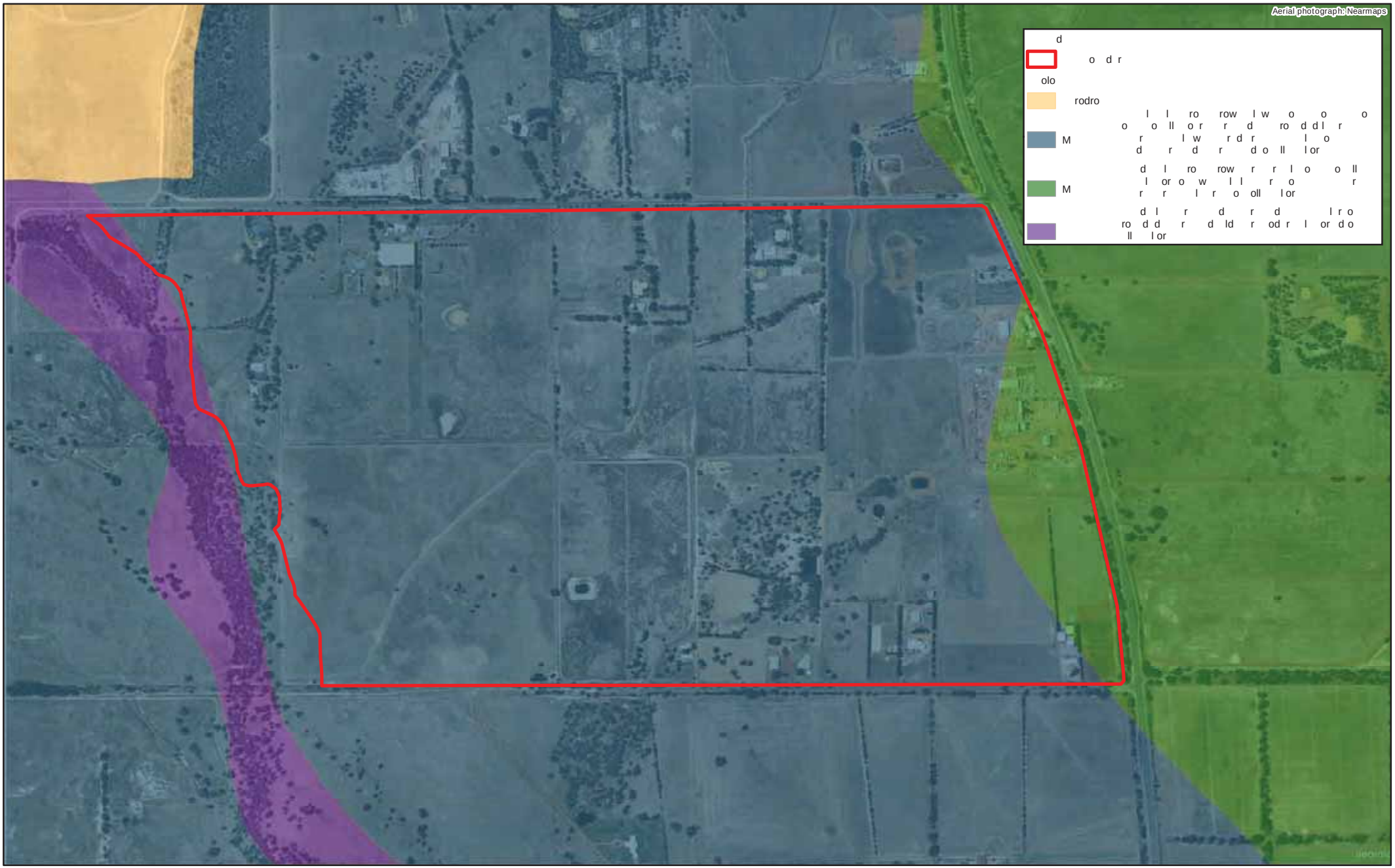

Figure 4: Geological Units

ro o ll roo d r l r

l ro w d

0

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r w

ro d

d l

M r

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o r ollow d w r d rod o o olo r olo l r



Figure 5: Geomorphic Wetlands

ro o ll roo d r l r

l ro w d

0

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o d r

o or l d d

o r o

M l l

r o r

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r w

ro d

d l

M r

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r o r r d o l o d r o l or r ll or dd d

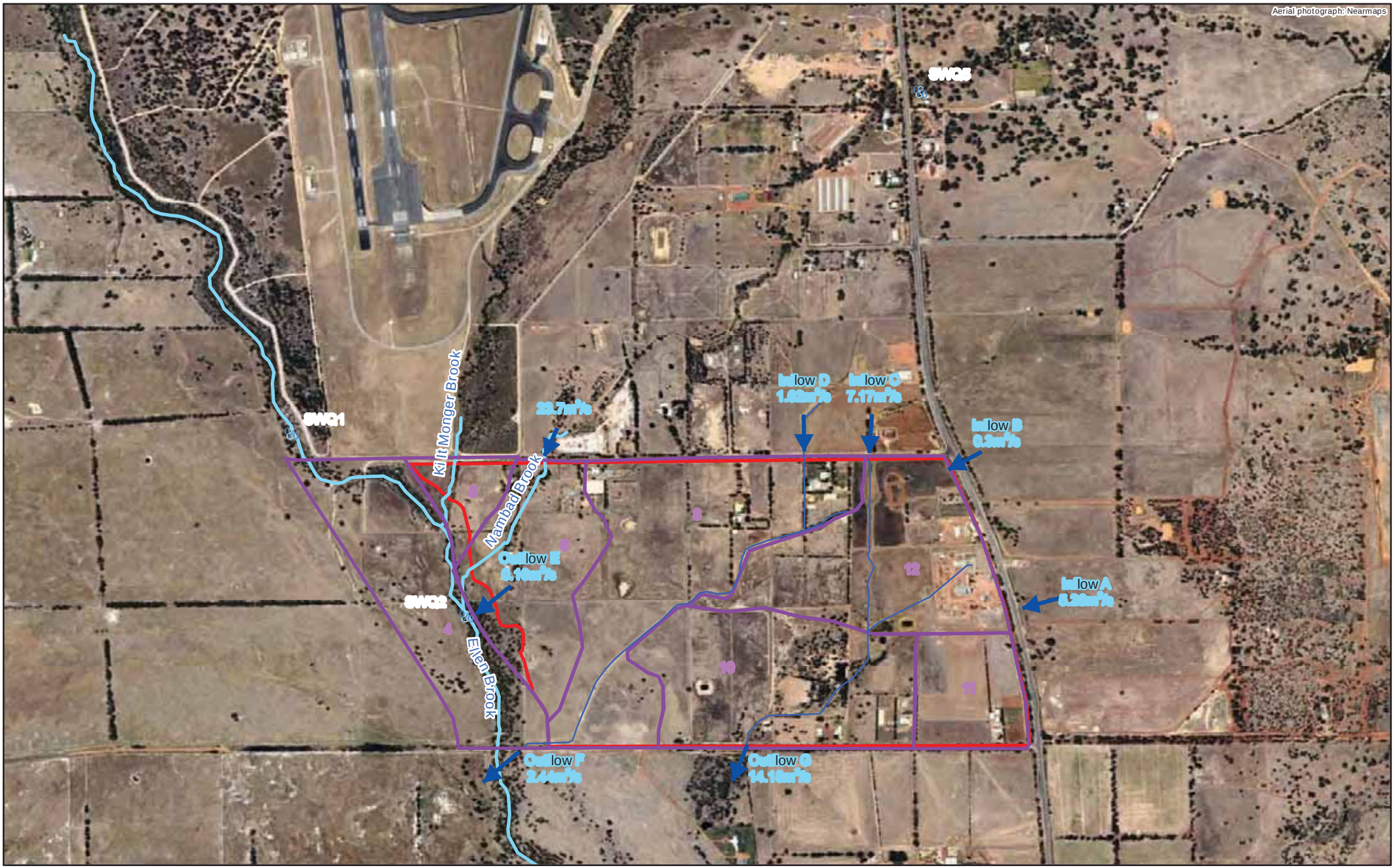

Figure 6: Hydrological Features

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Plan Number: EP12-062(04)--F06

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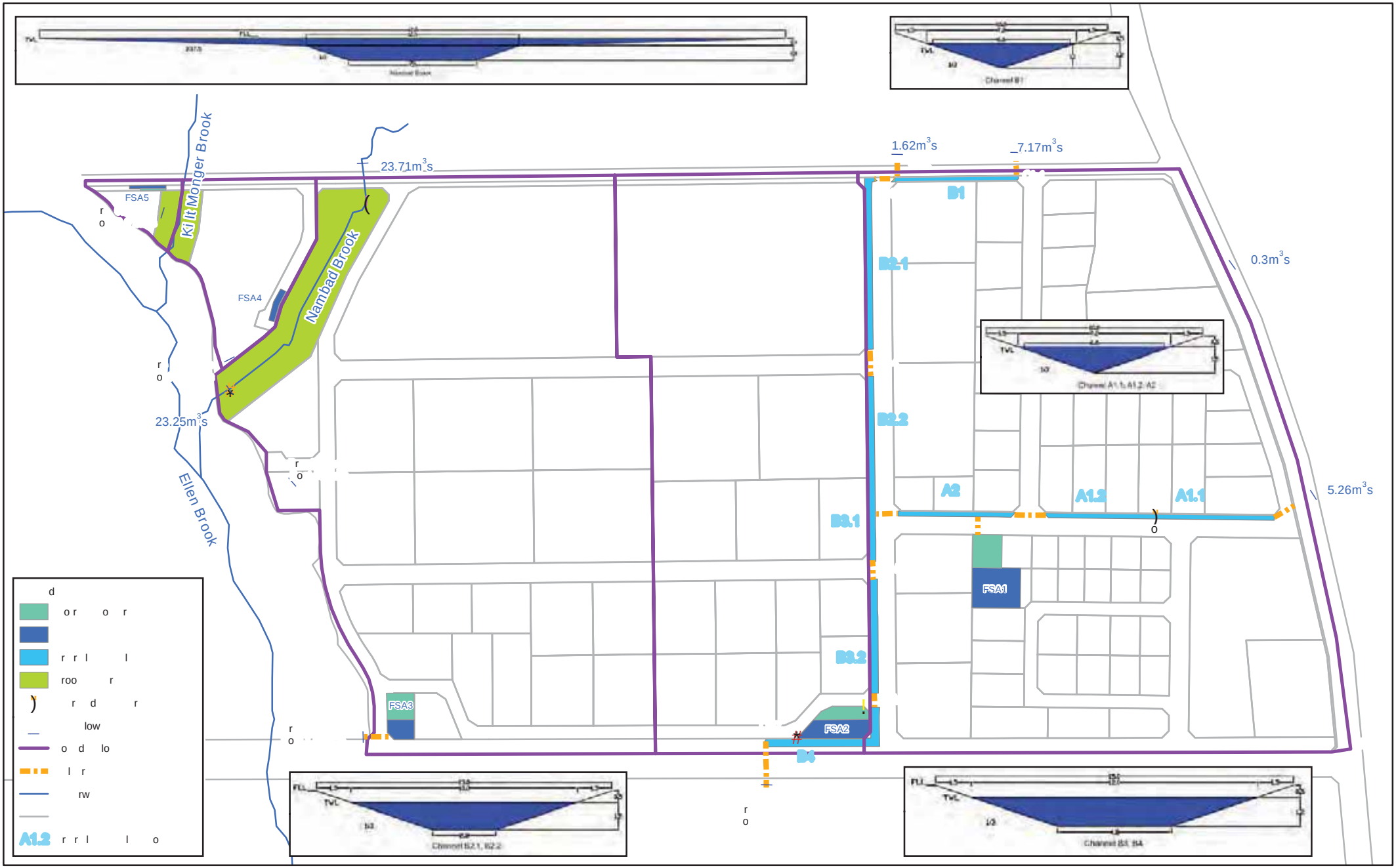

Figure 7: Post Development Stormwater Management Features

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Plan Number: EP12-062(04)--F47a

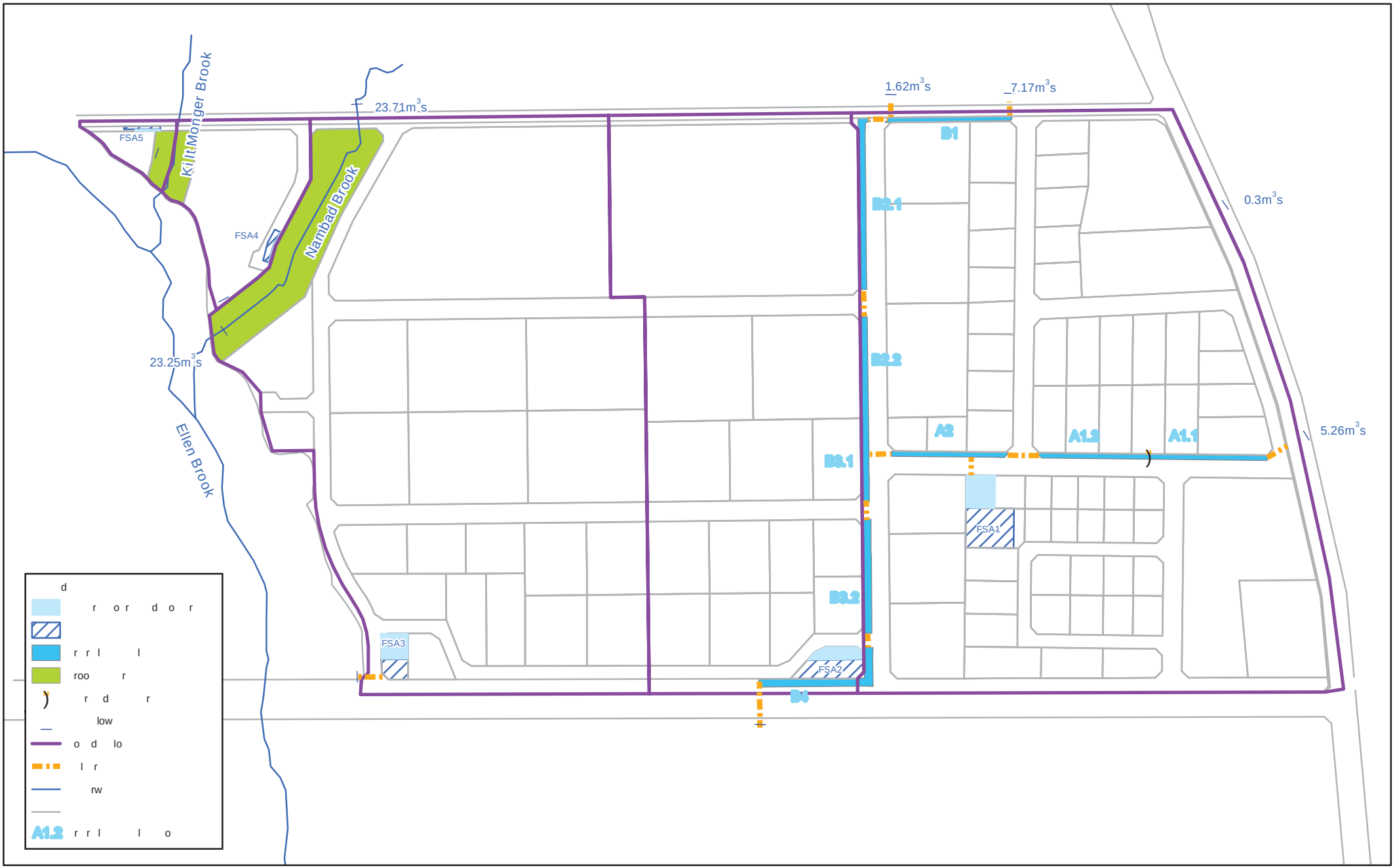

Figure 8: 1 Year 1 Hour Inundation Areas ro o ll roo d r l r M l ro w d	0	Plan Number: EP12-062(04)--F48a r w ro d d l M r

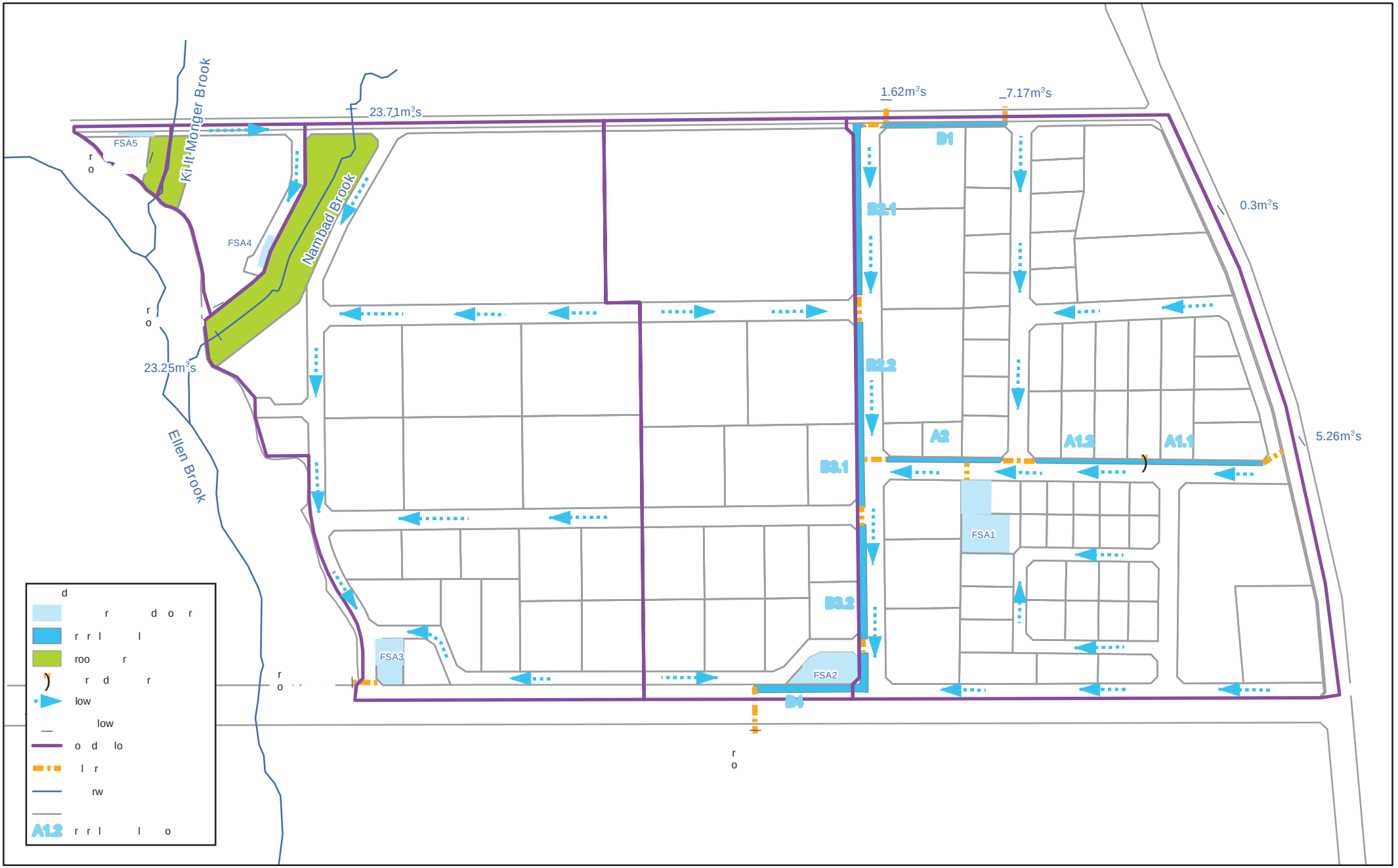

Figure 9: 100 Year ARI Inundation Areas

0

Plan Number: EP12-062(04)--F49b

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Appendix I: Biophysical Assessment - Bullsbrook South Urban Expansion Area

Western Environmental, 2024

Bullsbrook South - Urban Expansion Area

Biophysical Assessment

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Bullsbrook South - Urban Expansion Area

Biophysical Assessment

Report No:
A23.028-RPT-BIO_A_FINAL
Issue Date:
8-May-2024
Status
FINAL

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6-May-2024	**7-May-2024**	**7-May-2024**

Distribution Record

Copies	Document ID / Version	Date	Received by
1 (E)	A23.028-RPT-BIO_A_FINAL	8-May-2024	Rebecca Thompson

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Environmental Conclusions

In accordance with the scope of services, WEPL has conducted environmental field monitoring and/or testing in the preparation of this report. The nature and extent of monitoring and/or testing conducted is described in this report.

On all sites, varying degrees of non-uniformity of vertical and horizontal conditions in media (soil, water, air, waste or other media as described in the report) are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of media conditions encountered. The conclusions are based on the data and the environmental field monitoring and/or testing actually undertaken, and are therefore merely indicative of the environmental condition of the site at the time of preparing this report, including the presence or otherwise of contaminants or emissions. It should be recognised that site conditions, including the extent and concentration of contaminants, can change.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. To the maximum extent permitted by law, no other warranty, express or implied, is made.

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WEPL will not be liable to update or revise this report to take into account any events or circumstances or facts becoming apparent after the date of this report.

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1. Introduction

A biophysical assessment of the watercourses on the Bullsbrook South development area (the Site) (Figure 1) was undertaken via a desktop analysis of existing data as well as a site assessment in May 2023 to delineate the foreshore reserve of any waterways on the Site. Biophysical criteria are the factors used in determining the extent of a foreshore reserve. The biophysical assessment was undertaken as per the following policies and guidance notes, this includes the criteria listed below in Section 2, Table 1, some of which may not be present or relevant to the Site.

- Guidance Note 6: Identifying and establishing waterways foreshore areas (DoW, 2013).
- Operation Policy 4.3: Identifying and establishing waterways foreshore areas (DoW, 2012).
- Water Note 23: Determining foreshore reserves (WRC, 2001).
- River Restoration No 16 Determining Foreshore Reserves (WRC, 2001).

2. Biophysical Assessment

Table 1: Biophysical Assessment

Biophysical Assessment Criteria	Assessment Findings
Hydrology, topography and geology	There is one mapped linear surface water hydrological feature on the Site, with the Nambad Brook running east west through the northern portion. There is no mapped floodplain for this waterway. Geomorphic wetland mapping indicates that there is one mapped Multiple Use Wetland (UFID 15282-Palusplain) present covering much of the southern and western portions of the Site (Figure 2). The mapped Multiple Use Wetland does not intersect with the Nambad Brook and was not used in discerning waterway features extent. Topography mapped by Pentium Water indicates a clearly defined valley feature running east to west associated with the Nambad Brook and a more weakly defined broad feature running in parallel 100-150m north of the Nambad Brook (Figure 3). In the central portion of the Site a broad drainage feature is present with two branches originating in the east and joining in the centre of the Site before heading west. Topography was used to provide an indicative centre to the unmodified waterway courses Figure 3). Post Development 1% AEP Flood extent is shown in Figure 10 for the Nambad Brook. The site assessment in May 2023 identified a clearly defined channel for the Nambad Brook with an approximate incised flowing channel of a depth of between 1 to 1.5 metres and between 2 and 10 metres wide. Fringing this is a waterway platform of between 5-25 metres width either side. Sections of this platform which may experience flow during peak events however specific hydrology is required to understand extent (Photo 1-4). The broad feature running in parallel 100-150m north of the Nambad Brook did not have a clearly defined channel and comprises a broad low lying valley floor. The central feature has a clearly defined channel with an approximate incised flowing channel of a depth of between 0.5 to 1 metre and between 1 and 3 metres wide. This feature appears to have been subject to several course modification having been straightened from the original course in sections, particularly following the north south running section of Large Rd and running west from Large Rd. Several dams are also present (Photo 5 & 6). Soil landscape system mapping (Figure 4) identifies that two of the systems intersecting the Site are associated with waterways these being: • Forrestfield F4 phase-Incised stream channels within gentle slopes with deep acidic yellow soils and sandy alluvial gradational brown earths. • Pinjarra phase Gf5-Incised drainage channels with poorly drained gradational mottled yellow brown earths, shrublands of Melaleucas and other low shrubs. Geology mapping indicates the surface geology of the Site is classified as Guildford Formation Pebbly Silt with a small portion of the south-eastern and north-eastern sections of the Site overlaying Schist and provides no discerning water way features (Figure 5). The three drainage features discussed above intersect with these two soil landscape systems.
Soil type and flood risk	All three drainage features on the Site are associated with the following: Soil landscape flood risk (DPIRD-007) class (Figure 6: • H1- 50-70% of the map unit has a moderate to high flood risk. • H2- >70% of the map unit has a moderate to high flood risk. Water Erosion Risk (DPIRD-013) (Figure 7): • 50-70% of map unit has a high to extreme water erosion risk. Soil Water Storage (DPIRD-041) (Figure 8): • L2 - 3-10% of map unit has low to extremely low capacity. Site is outside of the FMP 1 in 100 (1%) Floodplain Development Control Area (DWER- 003).
Heritage	There are no heritage features that assist with the identification of the waterway, however the whole Site is mapped as part of the Ellenbrook 'Mythological', Place ID:3525.
Land use	Land use across the entire Site is currently grazing agriculture. No areas have a specific land use which would assist in identifying the waterway or which are at a higher risk from land use modification. The surrounding land is proposed to be developed as an urban area. The Nambad Brook and is proposed to be located within a Public Open Space (POS) area.
Vegetation and Habitat	A vegetation and habitat site assessment has been undertaken and focused on the extent of riparian vegetation to assist in defining the waterway. Riparian vegetation was defined by the presence of species known to occur within or directly adjacent to waterways. Due to the mainly cleared nature of the site limited plant species were present to assist in defining waterways. In the Nambad Brook a small number of plants of riparian associated species Melaleuca rhaphiophylla and Taxandria linearifolia were present. Mature flooded gum (Eucalyptus rudis) trees are present within the channel feature. Flooded gum occurs within riparian zones, but also occurs in seasonally damp situations outside of these however was used as an indicator species in this assessment. Riparian vegetation (See Photos 1-4) although severely degraded is considered present within the Nambad Brook, this vegetation type is mapped as Creek (Figure 9). The drainage feature running parallel 100m to the north of the Nambad Brook did not have any native vegetation present, or non-native vegetation indicating a riparian zone.

Biophysical Assessment Criteria	Assessment Findings
	The central drainage feature has scattered native species wandoo (Eucalyptus wandoo) present (See Photos 5 & 6). Wandoo is not associated with riparian vegetation. No riparian vegetation is considered present associated with this feature.

2.1 Discussion

The biophysical assessment considered an overlay of the following features:

- Surface water features.
- Topography.
- Mapping of incised drainage lines
- Soil landscape.
- Flood risk.
- Heritage.
- Riparian associated vegetation identified as part of the field survey.
- Land use.

The assessed values highlighted the following:

- The definition of the Nambad Brook is guided by the linear hydrological feature mapping, topography, the 1% AEP Flood Extent of the Nambad Brook and the riparian vegetation identified during the site assessment . No other biophysical elements specifically contribute to the definition of the Nambad Brook and it is not identified as a wetland, a minor river or significant steam (Figure 10). As such the foreshore reserve can be denoted by drainage channel and the riparian vegetation as mapped (Figure 11).
    - The urban design concept plan has been informed by the proposed foreshore reserve and the City of Swan Local Biodiversity Strategy (2015) and allows for the Nambad Brook to be completely contained within the Public Open Space on the development concept plan (Figure 12). There is no requirement for a buffer to be added to the foreshore zone of the Nambad Brook.
- The drainage feature running parallel 100m to the north of the Nambad Brook is not considered to comprises a riparian zone, although it has topography and soil landscape/flood risk mapping indicating a feature is present.

- The central feature demonstrates a draining line is present through topography, mapping of incised drainage lines, soil landscape/flood risk. No riparian vegetation is considered present, and it does not comprise a riparian zone. The history of modification to the course of this feature and clearing has resulted in it being more representative of a farm drain than a natural watercourse.

3. Photos

See representative images below.



Photo 1: Nambad Brook east end.



Photo 2: Typical Nambad Brook channel with flooded gum.



Photo 3: Central Nambad Brook with channel in centre and platform extending 25 m each side.



Photo 4: Western Nambad Brook looking west into non accessible lot.



Photo 5: Typical central drainage feature.



Photo 6: Western end of central draining feature with drain having been reshaped.



Figure 1: South Bullsbrook Urban Expansion Area

N 0 75 150 225 300 m

PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook

Legend: Site Location

SCALE	SHEET SIZE	CLIENT
1:9,500	A3 COLOUR	Mirvac

COORDINATE REFERENCE SYSTEM	PROJECT NUMBER	VERSION
GDA2020 / MGA zone 50	A23.028	0

DATA SOURCE	DRAWN BY / REVIEWED BY	DATE
LANDGATE AERIAL IMAGERY Summer 2023	MD / PN	4/4/2024

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	4/4/2024

NOTES:
Cadastral boundary (LGATE-002)

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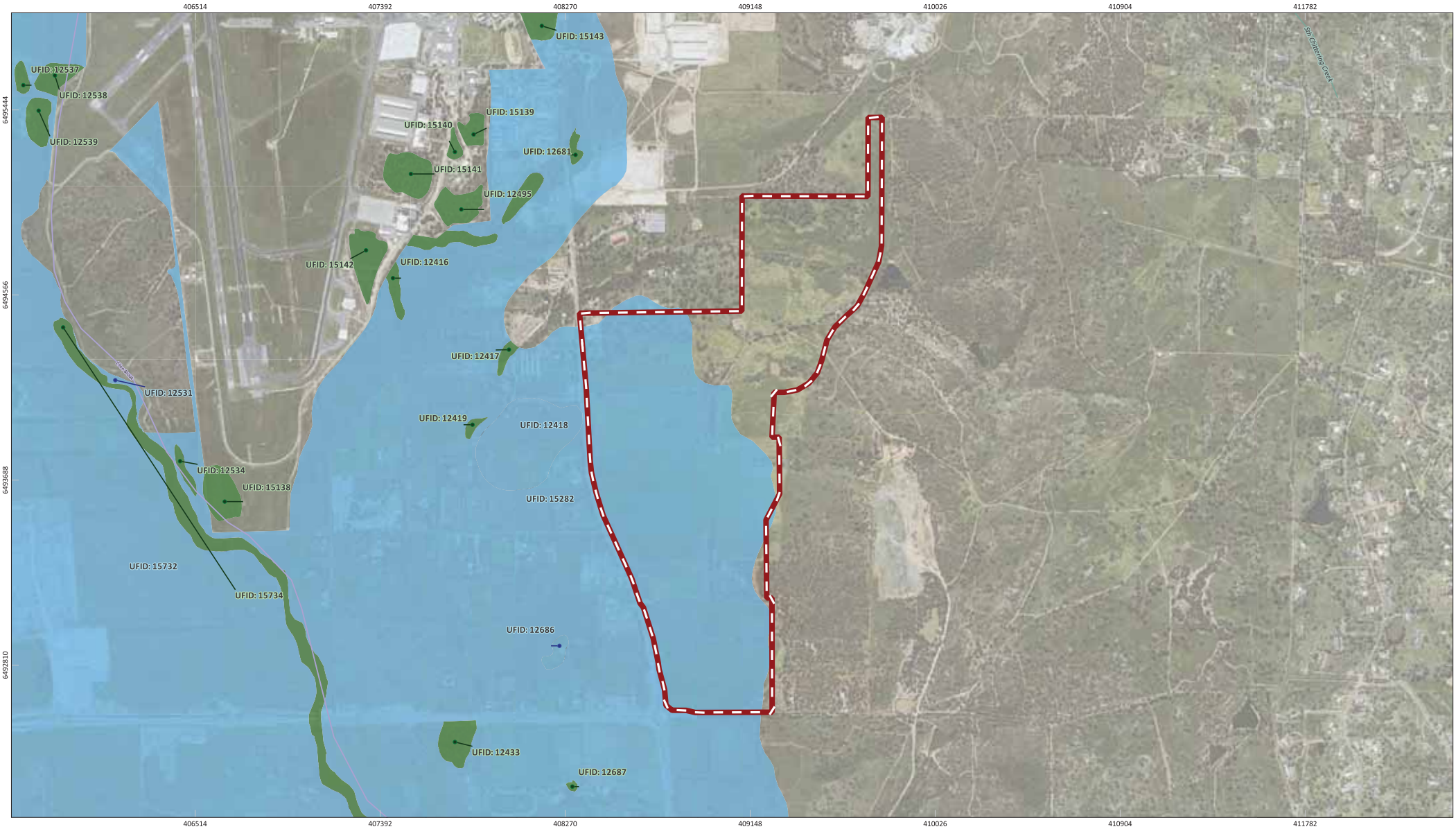

Figure 2: Surface Water Features and Geomorphic Wetlands

N

0 250 500 750 1,000 m

PROJECT/REPORT NAME	MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook
SCALE	1:17,569
SHEET SIZE	A3 COLOUR
CLIENT	Mirvac
COORDINATE REFERENCE SYSTEM	GDA2020 / MGA zone 50
PROJECT NUMBER	A23.028
VERSION	0
DATA SOURCE	LANDGATE AERIAL IMAGERY Summer 2023
DRAWN BY / REVIEWED BY	MD / PN
DATE	4/4/2024

Legend

- Site Location

Geomorphic Wetlands, Swan Coastal Plain (DBCA-019)

- Conservation
- Multiple Use

Hydrography Linear (Hierarchy) (DWER-031)

- Minor River
- Significant Stream

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	4/4/2024

NOTES:

Cadastral boundary from LANDGATE 2022. UFID stands for Unique Identifier

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Geomorphic Wetlands Swan Coastal Plain (DBCA-019) - Legend and Details

Sites within the map extent

objectid	Unique_Feature_ID	Wetland_Name	Landform	Wetland_Type	Management_Category	Area__Ha_	st_area_shape_	st_perimeter_shape_

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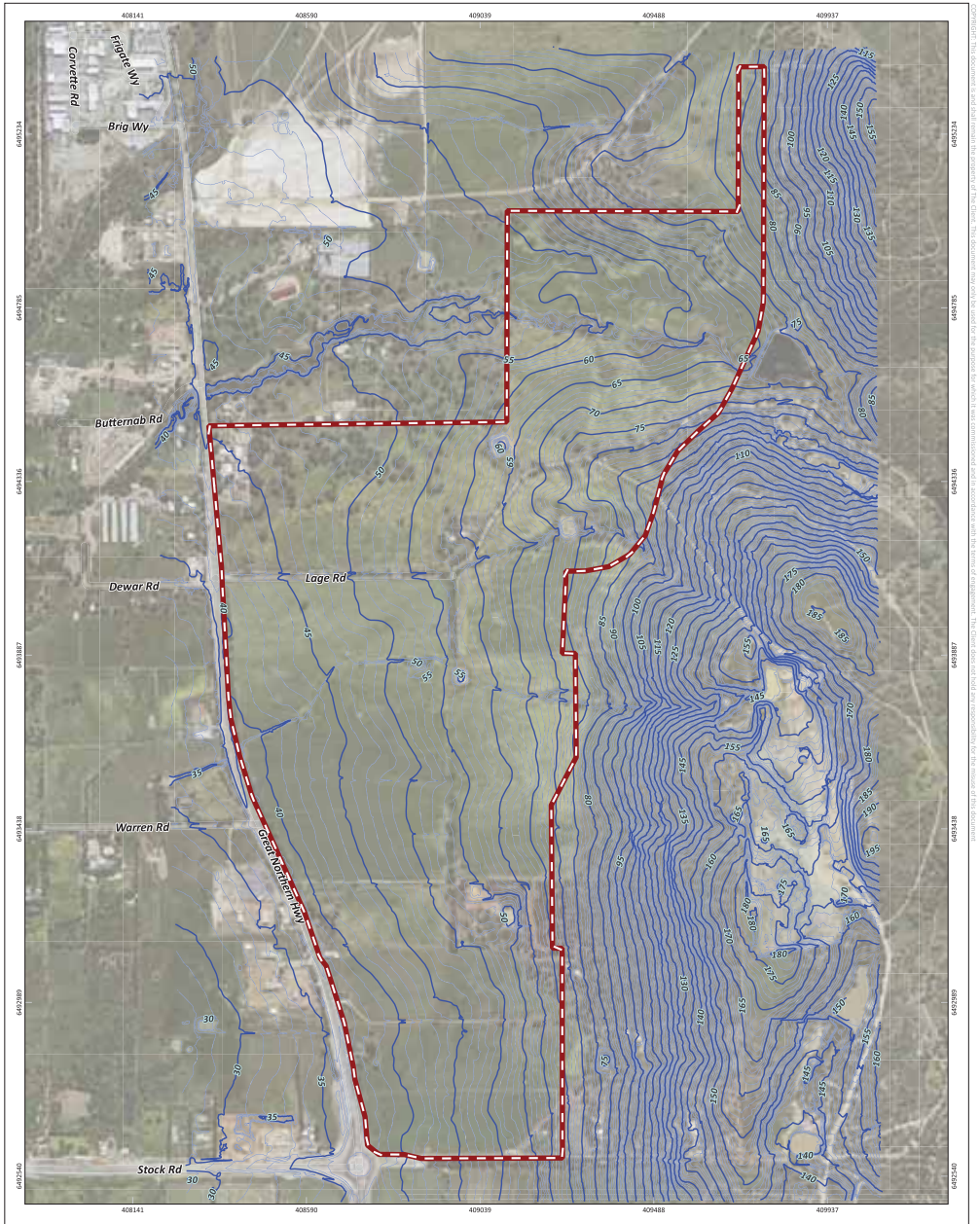

Figure 3: Topography (Pentium Water)

N 0 80 160 240 320 m

SCALE: 1:8,983	SHEET SIZE: A3 COLOUR
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50	PROJECT NUMBER: A23.028 / VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023	DRAWN BY / REVIEWED BY: SM/PN / DATE: 4/4/2024

PROJECT/REPORT NAME: EAR
Lot 118 Warbrook Road, Bullsbrook

CLIENT: Wesley College Endowment Fund

Legend
- Site Location
- Contour (5m)
- Contour (1m)

No	Description	Drawn	Approved	Date
A	Original Issue	SM	PN	03/06/2024
B	Revision			4/4/2024

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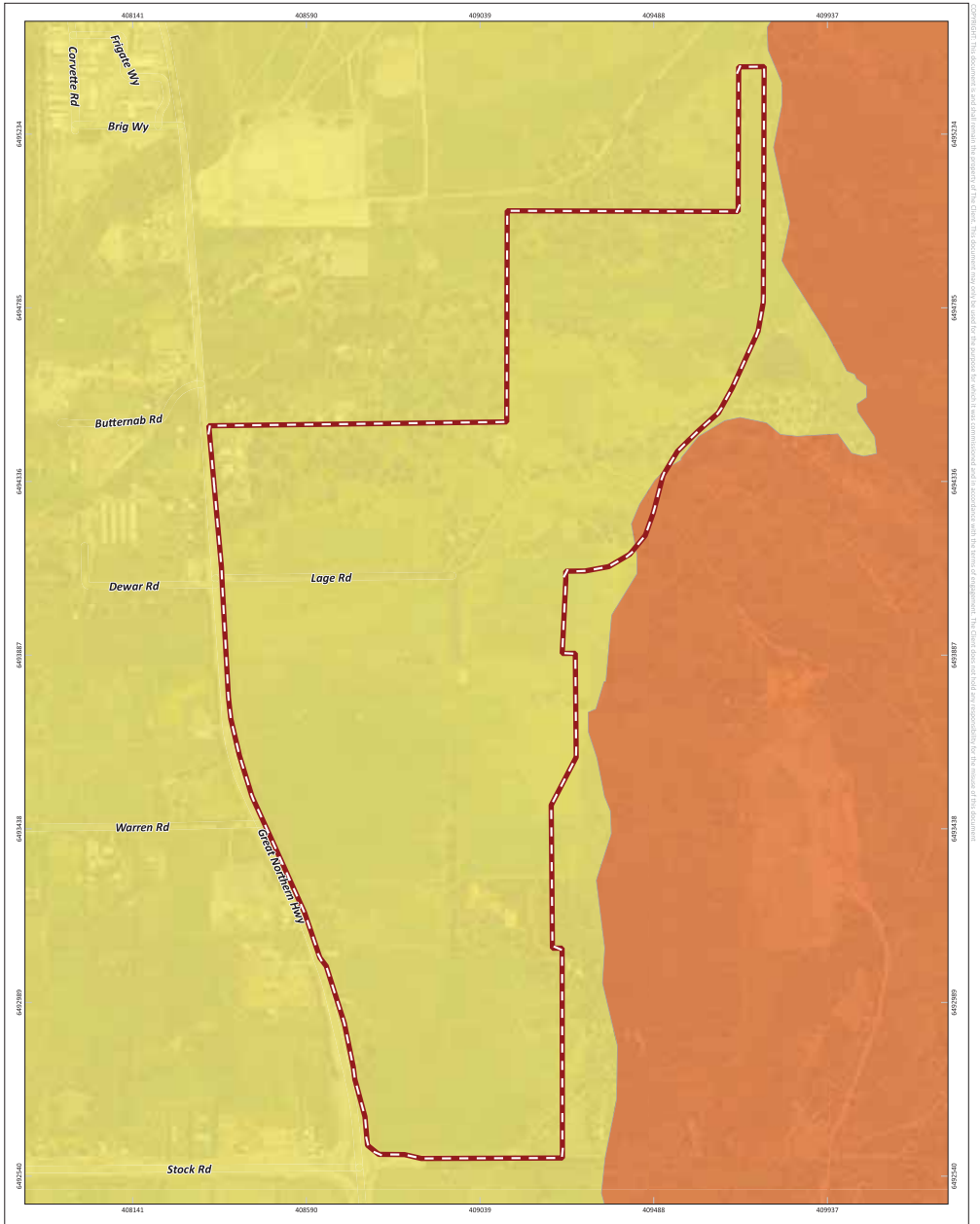

Figure 4: Soil Landscape Zones

N 0 80 160 240 320 m

SCALE: 1:8,983	SHEET SIZE: A3 COLOUR
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50	PROJECT NUMBER: A23.028 / VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023	DRAWN BY / REVIEWED BY: SM/PN / DATE: 4/4/2024

PROJECT/REPORT NAME: EAR
Lot 118 Warbrook Road, Bullsbrook

CLIENT: Wesley College Endowment Fund

Legend
- Site Location

Soil landscape land quality - Zones (DPIRD-017)
- 213 - Pinjarra Zone
- 255 - Western Darling Range Zone

No	Description	Drawn	Approved	Date
A	Original Issue	SM	PN	03/06/2024
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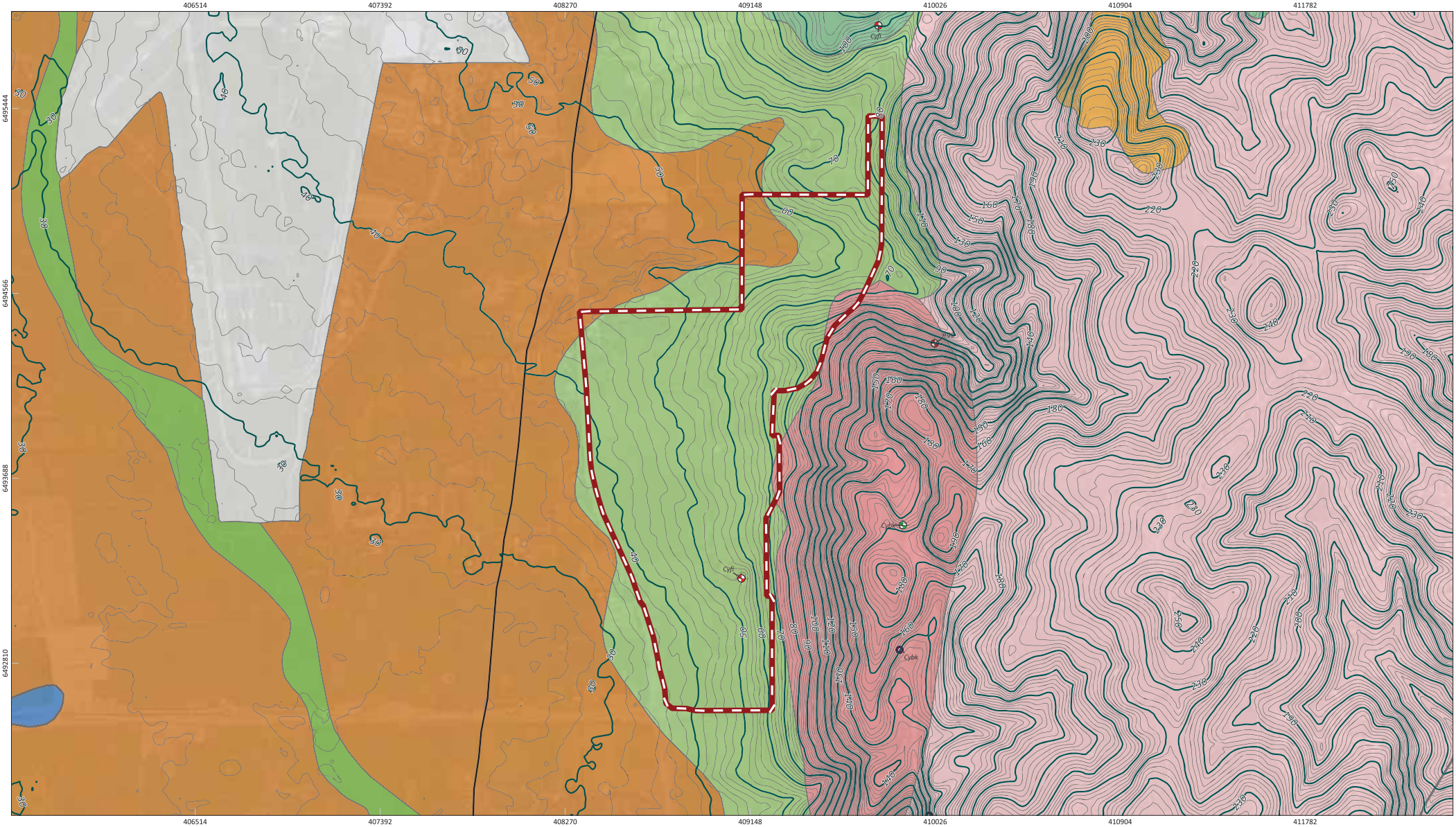

Figure 5: Surface Geology (Soils) and Topography

N 0 260 520 780 1,040 m		PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook	
SCALE: 1:17,569	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD / PN	DATE: 4/4/2024

Legend

- Survey Area
- **GSWA - Code**
  - Aerodrome
  - GR
  - GR-GN
  - LA1
  - LS5
  - Mgs1
  - Msg
  - S11
  - SC2
  - ST1
- **2m contours (DPIRD_072)**
  - Each 5m
  - Each 1m
- **Minedex (DMIRS-001)**
  - Operating
  - Proposed
  - Shut
- **1:500 000 State linear structures layer (DMIRS-015)**
  - Fault or shear zone, major; normal, exposed, tick on downthrown side

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	4/4/2024

NOTES:
Cadastral boundary from LANDGATE 2022

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Geology and Topograghy Figure - Legend and Details

CODE	SoilType
Aerodrome	NULL
GR	GRANITE - fine to coarse-grained mesocratic rocks of granite granodiorite and adamellite composition even-grained or porphyritic
GR-GN	GRANITES AND GNEISSES - intimate association of coarse-grained granites (GR) and gneisses (GN) and fine-grained dolerites (DO)
LA1	LATERITE - massive and vuggy to cemented pisolites up to 4m thick associated loose sandy pisolite gravel (G2) of residual origin
LS5	MUCHEA LIMESTONE - white to cream fine-grained algal lamination common
Mgs1	GUILDFORD FORMATION PEBBLY SILT - mainly alluvial sandy clay, strong brown silt with common fine to occasionally coarse grained sub-rounded laterite quartz heavily weathered granite pebbles some fine to medium-grai
Msg	SANDY SILT - strong brown firm friable dispersive in part occasional pebbly horizons with little matrix containing quartzite, quartz granite laterite of colluvial or
S11	SAND - light grey to yellowish grey medium-grained sub-angular to rounded quartz with some feldspar moderately sorted of alluvial origin
SC2	NULL
ST1	SILTSTONE - white thinly bedded well laminated fine-grained some large ferruginous concretions and laminae occasionally micaceous

Reference

Department of Mines, Industry Regulation and Safety (DMIRS). (1984). 1:50 000 environmental map – MUCHEA (2034-I, 2134-IV). Accessed on 3/2/2022 from https://dasc.dmp.wa.gov.au/dasc/

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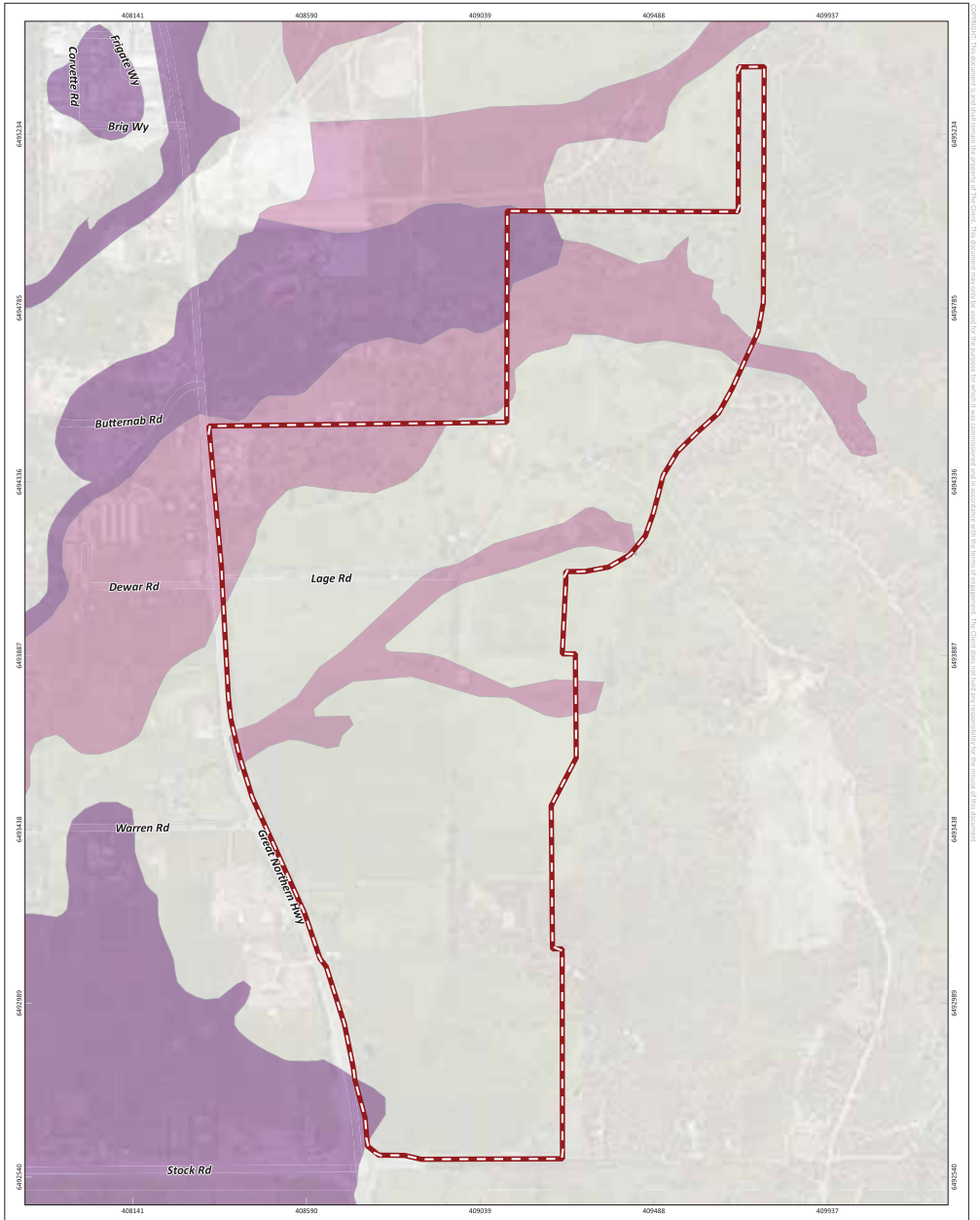

Figure 6: Flood Risk

N 0 80 160 240 320 m	PROJECT/REPORT NAME: EAR Lot 118 Warbrook Road, Bullsbrook		
SCALE: 1:8,983	SHEET SIZE: A3 COLOUR	CLIENT: Wesley College Endowment Fund	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: SM/PN	DATE: 4/4/2024

Legend

Site Location

Soil landscape land quality - Flood Risk (DPIRD-007)

- H1
- H2
- L1

No	Description	Drawn	Approved	Date
A	Original Issue	SM	PN	29/04/2024
B	Revision			4/04/2024

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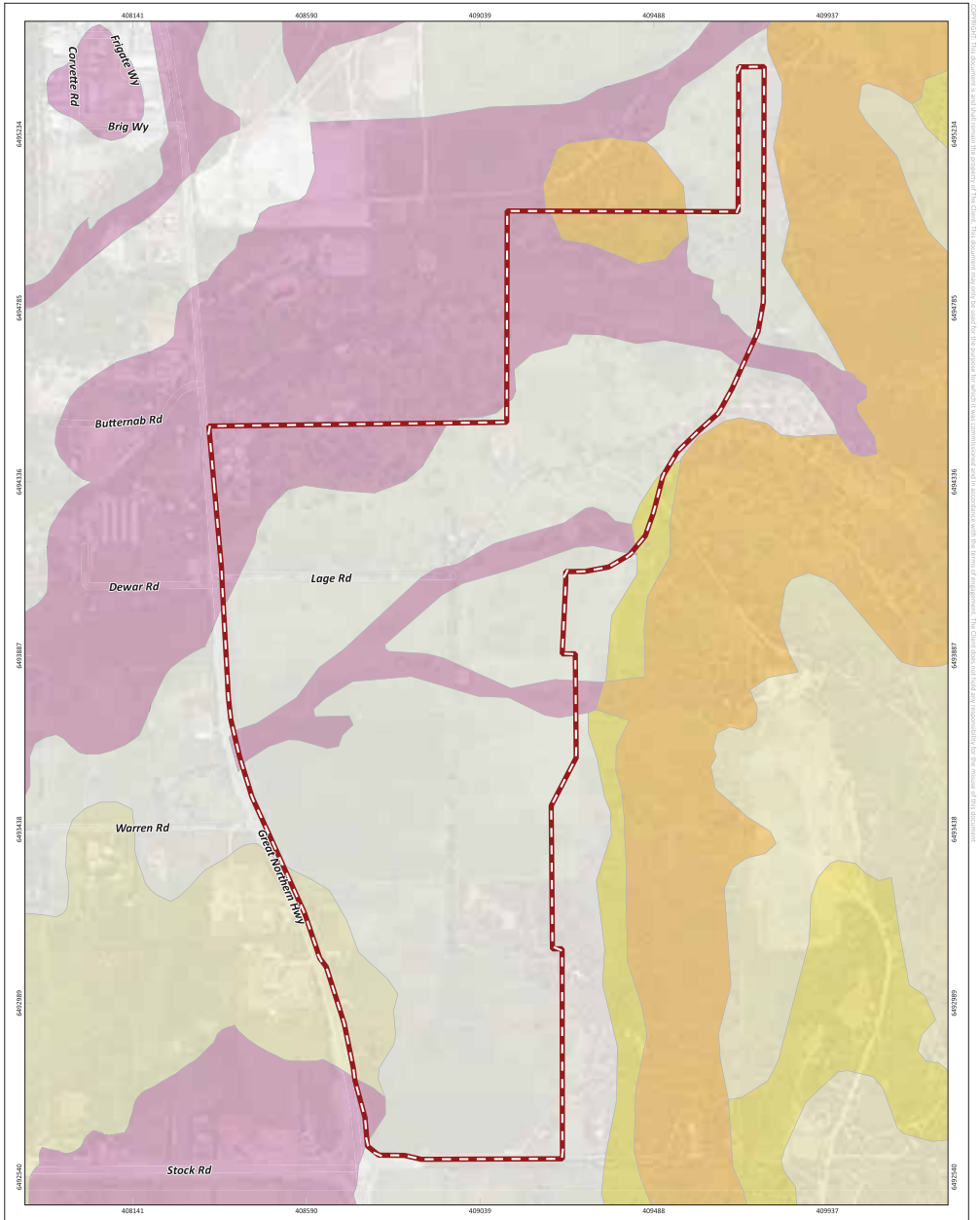

Figure 7: Water Erosion Risk

N 0 80 160 240 320 m	PROJECT/REPORT NAME: EAR Lot 118 Warbrook Road, Bullsbrook		
SCALE: 1:8,983	SHEET SIZE: A3 COLOUR	CLIENT: Wesley College Endowment Fund	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: SM/PN	DATE: 4/4/2024

Legend

Site Location

Soil landscape land quality - Water Erosion Risk (DPIRD-013)

- H1
- L1
- L2
- M1
- M2

No	Description	Drawn	Approved	Date
A	Original Issue	SM	PN	29/04/2024
B	Revision			4/04/2024

NOTES:
Cadastral boundary (LGATE-001) Label corresponds to the vegetation association number

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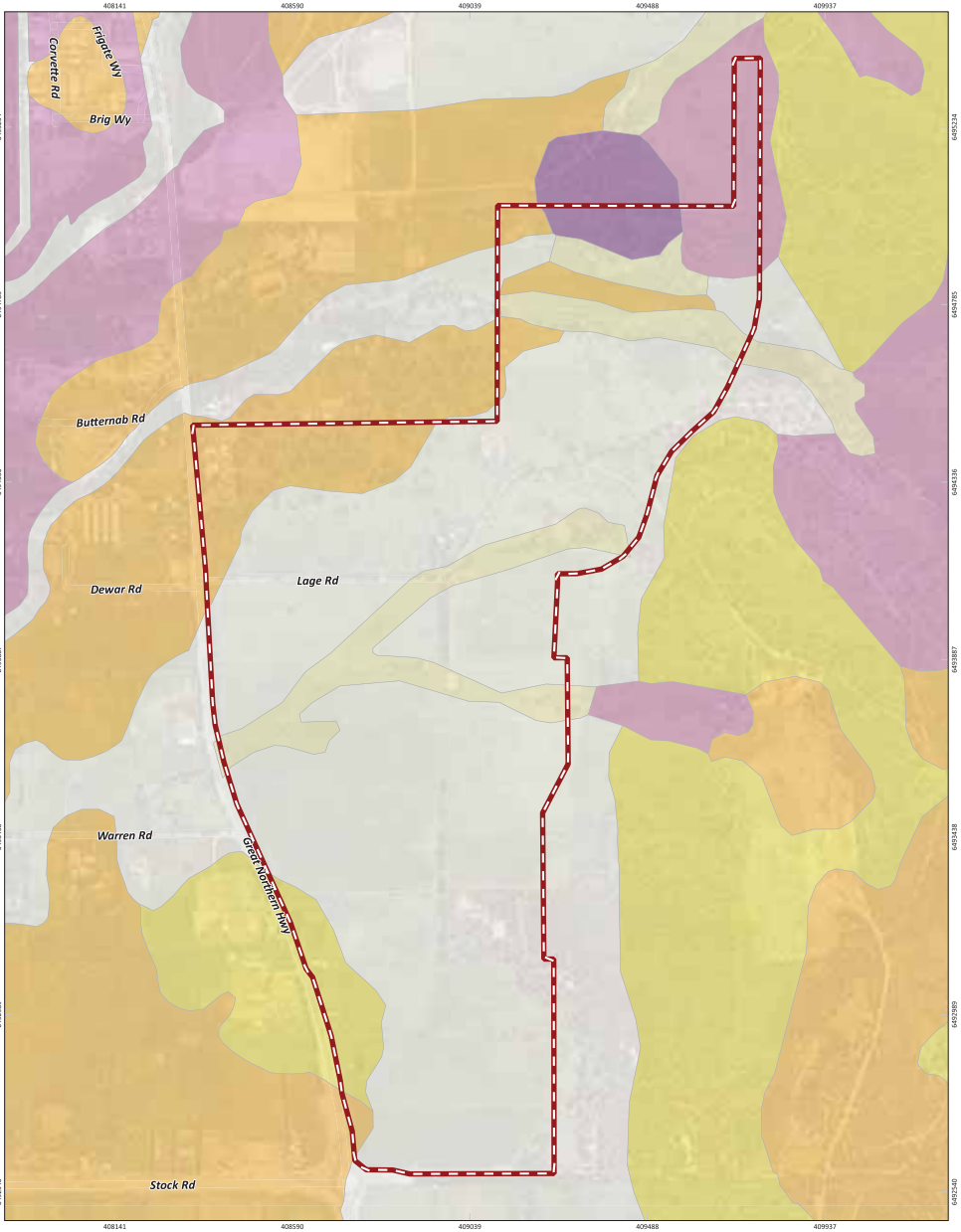

Figure 8: Soil Water Storage

N 0 80 160 240 320 m

PROJECT/REPORT NAME: EAR Lot 118 Warbrook Road, Bullsbrook

SCALE: 1:8,983 | SHEET SIZE: A3 COLOUR | CLIENT: Wesley College Endowment Fund

COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50 | PROJECT NUMBER: A23.028 | VERSION: 0

DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023 | DRAWN BY / REVIEWED BY: SM/PN | DATE: 4/4/2024

Legend

Site Location

Soil landscape land quality - Soil Water Storage (DPIRD-041)

- H1
- H2
- L1
- L2
- M1
- M2

No	Description	Drawn	Approved	Date
A	Original issue	SM	PN	05/06/2023
B	Revision			4/4/2024

NOTES: Cadastral boundary (LGATE-001) Label corresponds to the vegetation association number

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Figure 9: Riparian Vegetation

N 0 80 160 240 320 m

PROJECT/REPORT NAME: EAR Lot 118 Warbrook Road, Bullsbrook

SCALE: 1:8,983 | SHEET SIZE: A3 COLOUR | CLIENT: Wesley College Endowment Fund

COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50 | PROJECT NUMBER: A23.028 | VERSION: 0

DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023 | DRAWN BY / REVIEWED BY: SM/PN | DATE: 4/4/2024

Legend

Site Location

Vegetation

Riparian Zone Vegetation

No	Description	Drawn	Approved	Date
A	Original issue	SM	PN	05/06/2023
B	Revision			4/4/2024

NOTES: Cadastral boundary (LGATE-001) Label corresponds to the vegetation association number

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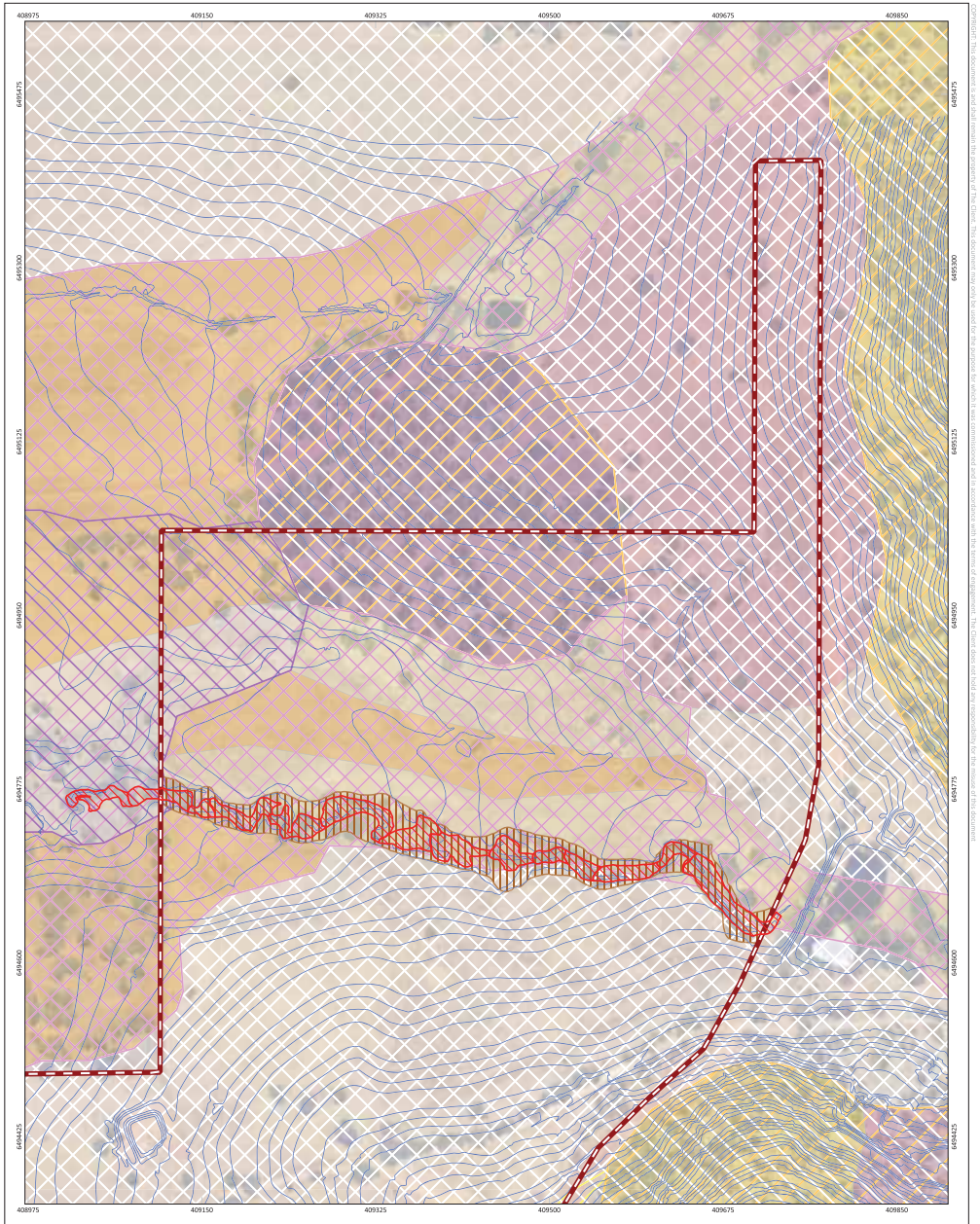

Figure 10: Biophysical Assessment

0 30 60 90 120 m N	PROJECT/REPORT NAME EAR Lot 118 Warbrook Road, Bullsbrook		
SCALE 1:3,500	SHEET SIZE A3 COLOUR	CLIENT Wesley College Endowment Fund	
COORDINATE REFERENCE SYSTEM GDA2020 / MGA zone 50	PROJECT NUMBER A23.028	VERSION 0	
DATA SOURCE LANDGATE AERIAL IMAGERY Summer 2023	DRAWN BY / REVIEWED BY SM/PN	DATE 2/5/2024	

Legend
- Site Location
- Contours_Minor
- 1% AEP Flood Extent (Post-dev)

Vegetation
- Riparian Zone Vegetation

Soil landscape land quality - Soil Water Storage (DPIRD-041)
- H1
- H2
- L1
- L2
- M1
- M2

Soil landscape land quality - Flood Risk (DPIRD-007)
- H1
- H2
- L1

Soil landscape land quality - Water Erosion Risk (DPIRD-013)
- H1
- L1
- M1
- M2

No	Description	Drawn	Approved	Date
A	Original Issue	SM	PN	29/04/2024
B	Revision			2/5/2024

NOTES:
Cadastral boundary (LGATE-001) Label corresponds to the vegetation association number

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Figure 11: Foreshore Zone – Nambad Brook

0 80 160 240 320 m N	PROJECT/REPORT NAME EAR Lot 118 Warbrook Road, Bullsbrook		
SCALE 1:8,983	SHEET SIZE A3 COLOUR	CLIENT Wesley College Endowment Fund	
COORDINATE REFERENCE SYSTEM GDA2020 / MGA zone 50	PROJECT NUMBER A23.028	VERSION 0	
DATA SOURCE LANDGATE AERIAL IMAGERY Summer 2023	DRAWN BY / REVIEWED BY SM/PN	DATE 3/5/2024	

Legend
- Site Location
- Foreshore Zone

No	Description	Drawn	Approved	Date
A	Original Issue	SM	PN	29/04/2024
B	Revision			3/5/2024

NOTES:
Cadastral boundary (LGATE-001) Label corresponds to the vegetation association number

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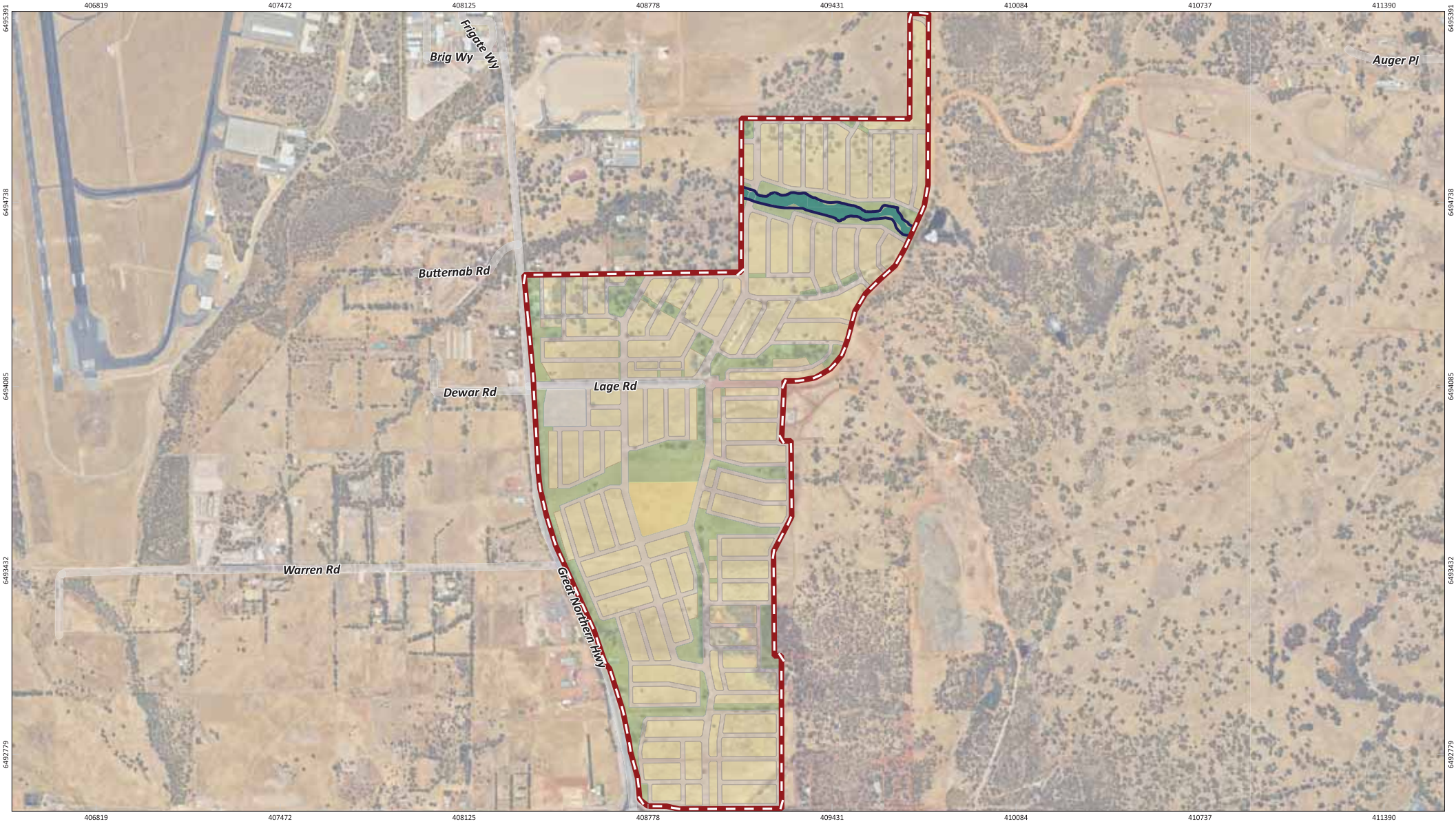

Figure 12: Riparian Zone and Foreshore Zone

N 0 190 380 570 760 m		PROJECT/REPORT NAME: MRS Amendment – Bullsbrook South Urban Expansion Area South Bullsbrook	
SCALE: 1:13,058	SHEET SIZE: A3 COLOUR	CLIENT: Mirvac	
COORDINATE REFERENCE SYSTEM: GDA2020 / MGA zone 50		PROJECT NUMBER: A23.028	VERSION: 0
DATA SOURCE: LANDGATE AERIAL IMAGERY Summer 2023		DRAWN BY / REVIEWED BY: MD/PN	DATE: 3/5/2024

Legend

- Site Location
- Riparian Zone Vegetation
- ForeshoreZone
- Commerical
- Roads
- School
- Public Open Space
- Residential

No	Description	Drawn	Approved	Date
A	Original issue	MD	PN	3/5/2024

NOTES:

Cadastral boundary from LANDGATE 2022. Label corresponds to the vegetation association number.

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4. References

Department of Water (DoW). (2013). *Guidance Note 6: Identifying and establishing waterways foreshore areas*.

Department of Water (DoW). (2012). *Operation Policy 4.3: Identifying and establishing waterways foreshore areas*.

Water and Rivers Commission (WRC). (2001). *Water Note 23: Determining foreshore reserves*.

Water and Rivers Commission (WRC). (2001). *River Restoration No 16 Determining Foreshore Reserves*.

4.1 Databases

Department of Biodiversity, Conservation and Attractions (DBCA). (2022). Geomorphic Wetlands, Swan Coastal Plan (DBCA-019). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/geomorphic-wetlands-swan-coastal-plain.

Department of Mines, Industry Regulation and Safety (DMIRS). (1984). 1:50 000 Environmental Map - Muchea (2034-I, 2134-IV). Retrieved on 3 February 2022 from https://dasc.dmp.wa.gov..au/dasc.

Department of Primary Industries and Regional Development (DPIRD). (2022). Soil Landscape Mapping – Systems (DPIRD-064). Retrieved on 21 March 2023 from Soil Landscape Mapping - Systems (DPIRD-064) - Datasets - data.wa.gov.au.

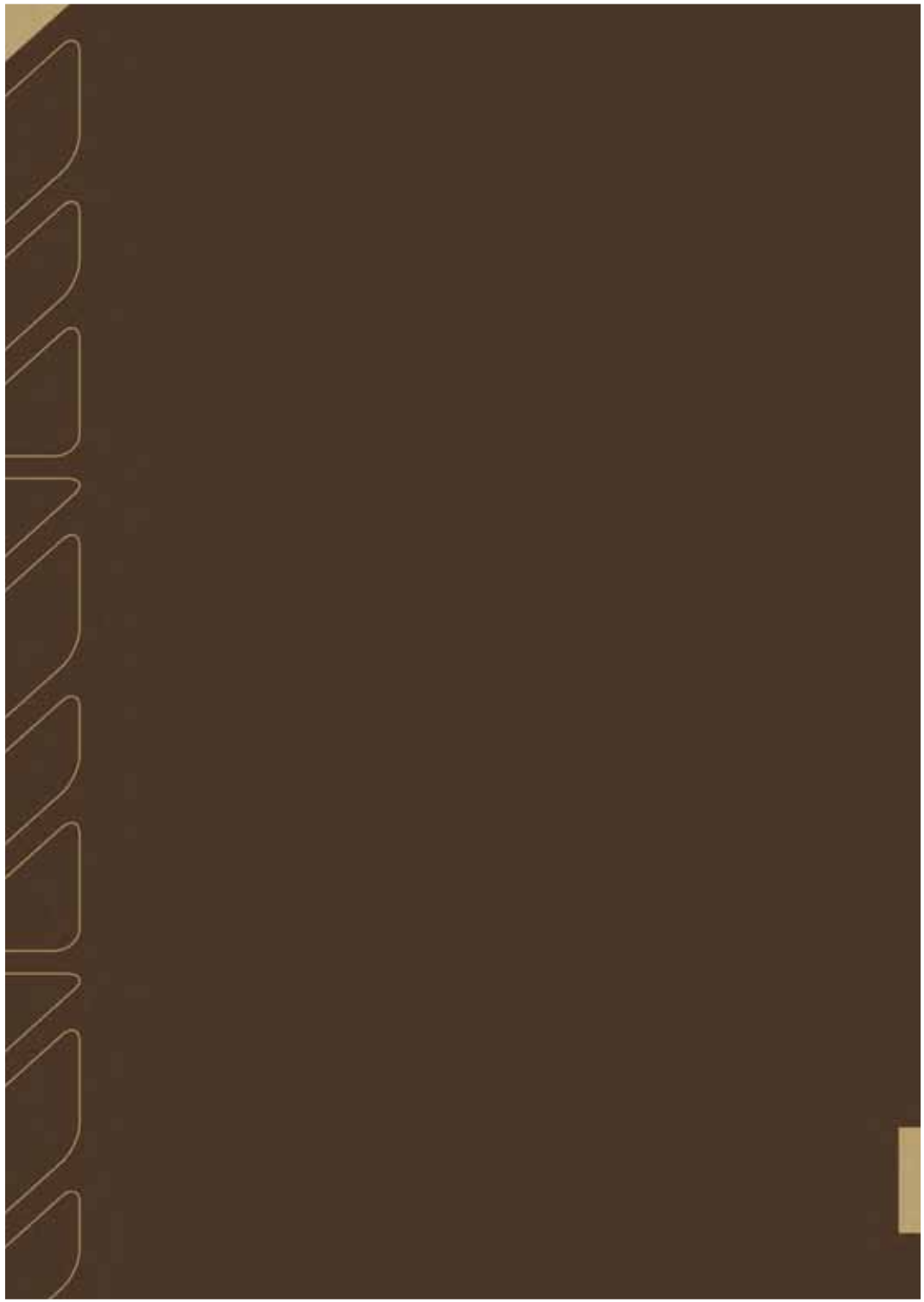
Department of Primary Industries and Regional Development (DPIRD). (2022). Soil Landscape Quality Zones (DPIRD-017). Retrieved on 21 March 2023 from Soil landscape land quality - Zones (DPIRD-017) - Datasets - data.wa.gov.au.

Department of Primary Industries and Regional Development (DPIRD). (2022). Soil Landscape Quality - Flood Risk (DPIRD-007). Retrieved on 21 March 2023 from Soil landscape land quality - Flood Risk (DPIRD-007) - Datasets - data.wa.gov.au.

Department of Primary Industries and Regional Development (DPIRD). (2022). Soil Landscape Quality - Water Erosion Risk (DPIRD-013). Retrieved on 21 March 2023 from Soil landscape land quality - Water Erosion Risk (DPIRD-013) - Datasets - data.wa.gov.au.

Department of Primary Industries and Regional Development (DPIRD). (2022). Soil Landscape Quality - Soil Water Storage (DPIRD-041). Retrieved on 21 March 2023 from Soil landscape land quality - Soil Water Storage (DPIRD-041) - Datasets - data.wa.gov.au.

Department of Water and Environmental Regulation (DWER). (2018). Hydrography, Linear (Hierarchy) (DWER-031). Retrieved on 21 March 2023 from https://catalogue.data.wa.gov.au/dataset/hydrography-linear-hierarchy.



Appendix J: Engineering Servicing Report - Bullsbrook South Land Holdings - Local Structure Plan

Pritchard Francis, 2023

Bullsbrook South Land Holdings

Local Structure Plan

Engineering Servicing Report

Project No: 22-063



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Appendix Twelve:	ATCO Gas Correspondence
Appendix Thirteen:	Existing Western Power Infrastructure
Appendix Fourteen:	Existing Communication and Fibre Infrastructure

Revision	Description	Author	Date
0	Issued for Local Structure Plan Submission	Mark Riddell	17 November 2023
1	Issued for Local Structure Plan Submission	Mark Riddell	12 December 2023

1 Introduction

This Engineering Servicing report has been prepared in support of a local structure plan over the Bullsbrook South Urban Expansion Area.

The report represents a summary of engineering services, both current and future planned, to facilitate the development of the proposed structure plan area. An aerial image of the site is shown below in Figure 1 and concept map of the local structure plan can be found in Appendix One as prepared by Rowe Group.

Information in this report is based on infrastructure planning currently available from relevant service authorities as well as their infrastructure mapping services. To complete this assessment, Pritchard Francis acquired specific advice for reticulated gas from ATCO, and underground power and communications servicing from Underground Power Development Pty Ltd (UPD).

2 Site Description

The site is located within the City of Swan, 5km southeast of the Bullsbrook townsite and about 40km northeast of the Perth central business district.

The site is bordered by Great Northern Highway on the western boundary, the Kingsford Estate currently being developed to the north (currently zoned urban), undeveloped land zoned rural to the east (Darling Scarp), and Stock Road to the south. Lage Road and Nambad Brook intersect the site in the Northern third.



Figure 1 - Aerial Image – Subject Site courtesy Nearmap October 2023

3 Acid Sulphate Soils

The State Government has produced mapping identifying acid sulphate soils (ASS) highlighting any risk areas for ground excavation and development. From information obtained for this subject site, much of the developable area is shown to have low to no risk of actual acid sulphate soils present at depths less than 3 m. A portion of the site to the southeast is identified as having moderate to low risk of actual acid sulphate soils present at depths less than 3m. Please refer to **Appendix Two** for relevant mapping.

The consideration of ASS is not a hindrance to the rezoning of the land to urban and can be readily managed in line with the Department of Water and Environmental Regulation guidelines being incorporated into the civil engineering design. Along with ASS is the iron staining risk for the site. A significant portion of the site is not documented on the Iron Staining Risk Map. The land nearest Great Northern Highway has been documented as low possibility of iron staining from use of groundwater.

Refer Appendix Three – Iron Staining Risk Mapping

4 Topography

The 1:50,000 Environmental Geology Series Map has been obtained for Muchea which encompasses the subject landholding. An extract is attached in **Appendix Four** which highlights the development area.

Based on this mapping, it is anticipated that the soil profile is likely to consist of:

- SCHIST – grey to pale grey, highly schistose quartz mica schist. Located on the eastern portion of the site.
- GRANITE – mesocratic, fine to coarse-grained, ranges in composition from granodiorite to granite, adamellite being commonest variety. Located in the north-eastern corner of the site.
- SANDY SILT – strong brown, firm, friable, dispersive in part, occasional pebbly horizons with little matrix containing quartzite, quartz, granite, laterite of colluvial origin. Located across majority of the site.
- SAND – very pale brown, medium to coarse-grained, well sorted, little fines, sub-angular to rounded quartz and feldspar, of colluvial origin. Located in the northern portion of the site.
- SAND OVER PEBBLY SILT – sand very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin. Overlying strong brown silt with common fine to occasionally coarse grained, sub-rounded laterite, quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand of alluvial origin. Located across the north-western portion of the site.

Galt Geotechnics have also completed a preliminary geotechnical investigation of the site. This has been included in **Appendix Five**. Galt conclude their findings are broadly consistent with the geological mapping.

Subsoil surface conditions vary across the site, and typical soil profiles have been summarised as follows:

Parts of the northern end of site:

- Sandy GRAVEL/Silty GRAVEL (GP/GM): fine to coarse grained, angular to sub-rounded, brown, about 5% to 20% non-plastic fines extending from the surface to depths of typically between 0.3 m to 0.5 m; overlying
- Clayey SAND/ SAND (SC/SP): fine to coarse grained, orange brown, 5 – 15% low to medium plasticity fines extending to depths of between 0.9 m and 2.4 m;
- Extremely Weathered ROCK/ ROCK – possibly quartz rich, metamorphic rock present from depths of between 0.9 m and 2.8 m.

Central part of the site:

- Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 m.

Central and south of the site:

- Thin and irregular layer of granular gravel or sand, typically about 0.3m to 0.4m thick; overlying
- Sandy CLAY/ CLAY (CH): high plasticity, red brown, about 15% to 40% fine to coarse grained sand, trace gravel, typically extending from the surface or near surface extending to maximum investigated depth of 3.0 m.

Land within the urban expansion area steadily climbs from west to east, from levels in the range of RL 37m to 42m AHD along Great Northern Highway. Nearing the eastern boundary, the land increases steeply from RL 60m AHD to levels in the order of RL 90m AHD.

Refer Appendix Six - for high level topography mapping.

We don't expect the topography of the site to be an impediment to the structure planning of the site.

5 Groundwater Level

Data for the historical maximum groundwater levels from the Perth Groundwater Map are unavailable for this site. The minimum groundwater contours are available for the western portion of the site and indicate that groundwater is present at RL 35m AHD in the south-western corner near where Stock Road intersects Great Northern Highway. Increasing to RL 40m AHD where Lage Road intersects Great Northern Highway. Please refer **Appendix Seven** for available mapping.

Galt did not encounter any groundwater in test pits during their preliminary geotechnical investigation to a depth of 3.2m, however they expect shallow perched groundwater to develop on the clayey soils during winter. Groundwater levels should be verified in a full geotechnical investigation for detailed design. The stormwater strategy for the site, as outlined in the Local Water Management Strategy (LWMS) will collect the perched water table in sub soil drains that are treated either in bioretention areas or inline before discharge into the existing drainage tributaries.

Further detail on the stormwater strategy for the site can be found in the LWMS prepared by Pentium Water.

6 Earthworks Strategy

The urban expansion area will require earthworks to set up the site for residential development (flat pads) and to create the appropriate drainage paths from east to west where stormwater will be attenuated before using existing drainage outlets under Great Northern highway to move stormwater.

Galt's preliminary geotechnical investigation predicts on site infiltration in the insitu soils to be inappropriate due to clayey content and limited permeability. Stormwater should instead be diverted using drains or otherwise to a disposal area located away from structures. It is predicted importation of clean, inert fill will be required in part to produce a class A classification as a minimum in line with AS2870 and the residential slab and footing construction code. Galt's geotechnical reporting for the site requires 1.8 m of inert material under each structure to achieve this.

Opportunities for cut to fill will be investigated to shape the landform with consideration to the existing vegetation on site, requirements to obtain appropriate site classification for soils for all land uses, and requirements for best practise road design in line with Austroads and IPWEA guidelines. It is likely clay grading will take place in lower lying areas to facilitate run off moving towards subsoil drainage lines.

Refer **Figure 1B f**or preliminary drainage catchment planning including indicative subsoil drainage layout and Appendix 7B for preliminary earthwork design. Again, further detail on the stormwater strategy for the site can be found it the LWMS.





MATCHLINE

SCALE 1:500 0m 10m 20m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- DESIGN CATCHMENT BOUNDARY
- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
A	15/11/23	INITIAL ISSUE	A.D	M.R

pritchard francis
civil and structural engineering consultants

DRAWING STATUS: NOT FOR CONSTRUCTION

DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

DESIGNED: A.D | DRAWN: N.S | CHECKED: M.R | APPROVED: XXX ..... / ....

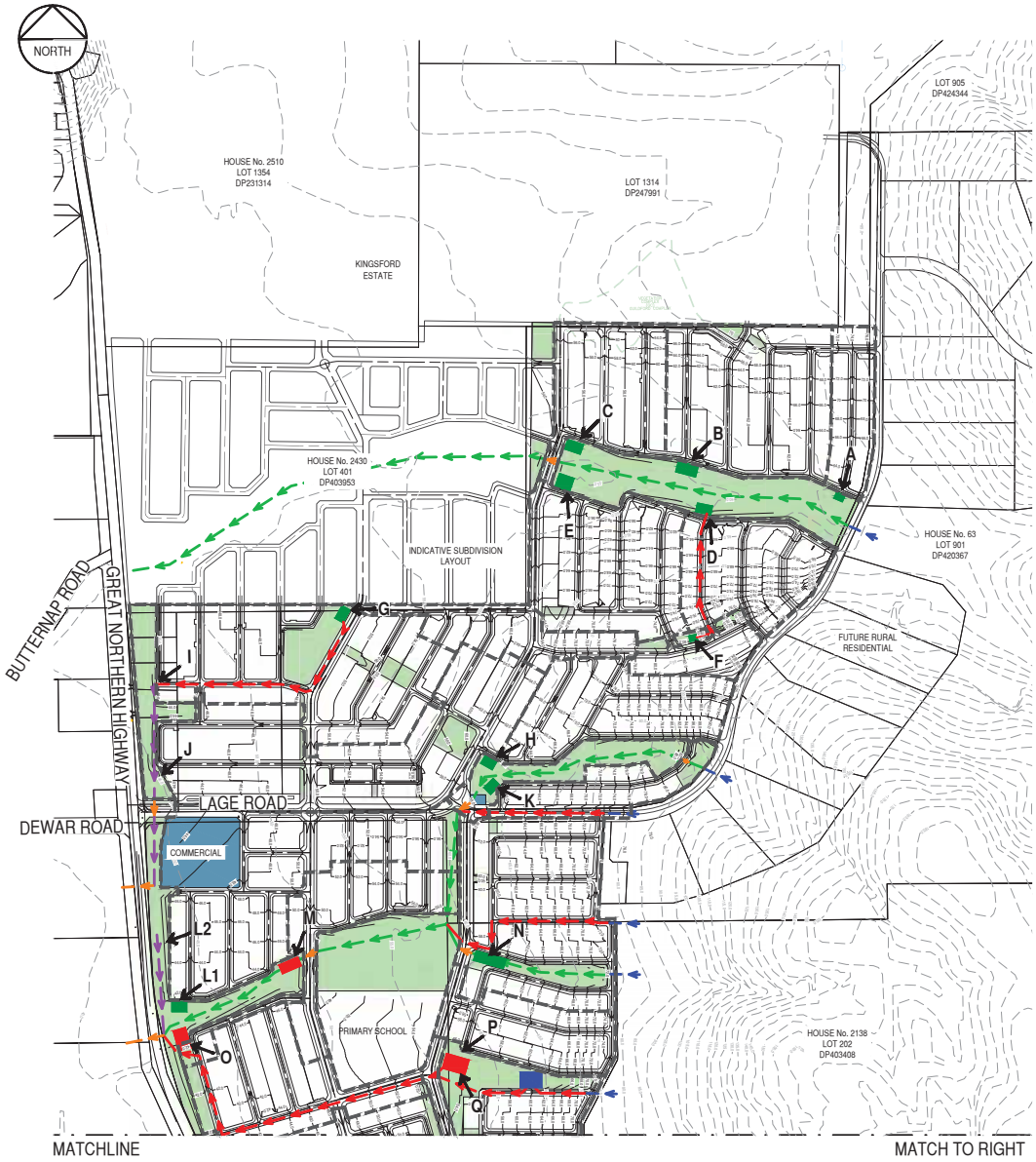
W.A.P.C.: ???? | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: DESIGN CATCHMENT PLAN

DRG No.: 22063-C1-CS-01

REVISION: A





SCALE 1:5000 0m 100m 200m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE
- LIVING STREAM
- TREATMENT / DETENTION SWALE
- CONVEYANCE SWALE
- STORMWATER CULVERT
- PIPED DRAINAGE
- INFLOWS
- BIOBASIN
- FLOOD DETENTION BASIN
- EXTERNAL CATCHMENTS BASIN

REV	DATE	DESCRIPTION	BY	CHKR
A	7/12/23	INITIAL ISSUE	N.S	M.R

pritchard francis
civil and structural engineering consultants

DRAWING STATUS: NOT FOR CONSTRUCTION

DATE	GRID	DATUM
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DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX .... / ...

W.A.P.C. N/A | SCALE U.N.O. 1:5000 @ A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: STORMWATER MANAGEMENT CONCEPT PLAN

SHEET SIZE: A1 | DRG No. 22063-C1-SW-01 | REVISION: A

7 Utilities

7.1 Water Supply

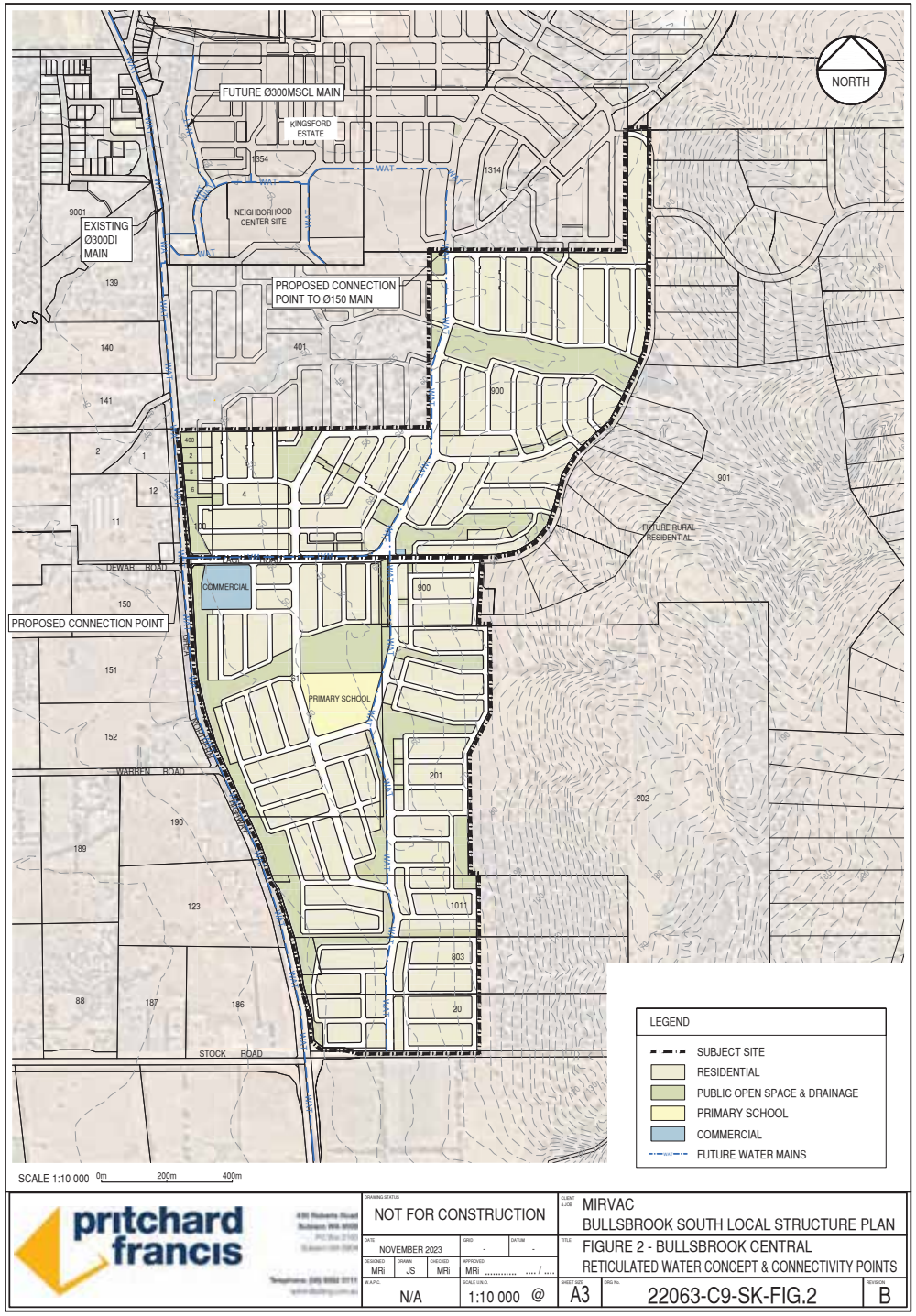
There is existing water supply infrastructure on the western side of the site located in the Great Northern Highway reserve. This includes a diameter 300 mm ductile iron (DI) main that feeds the Bullsbrook townsite district level supply tanks. It is unlikely this main would be used as a reticulation point for the proposed development.

We understand that as part of future planning for water supply to the north of the urban expansion area (in the Kingsford Estate) there is a diameter 250 mm reticulation main proposed in Squadron Boulevard and a 150 mm diameter main in Wylde Boulevard that could be extended to service the development. These reticulation mains are proposed to be reinforced with future diameter 300 mm MCSL pipe that runs through the Kingsford Estate and out to Great Northern Highway at an intersection just north of Nambad Brook. This is another option for future water supply. **Figure 2** highlights the proposed water connection points just north of the Bullsbrook South Urban Expansion Area.

In terms of water distribution infrastructure, the current Bullsbrook townsite supply tanks have a top water level of RL 120 m AHD and a maximum supply level of 112 m AHD which is above our nominated maximum levels of RL 90 m AHD on the Eastern side of the development. We understand from discussions with the Water Corporation a high-level water tank to help reinforce the existing supply tanks is due for construction in 2027/28. This will help further reinforce the current supply capacity and increase the maximum supply level above RL 140 m AHD.

We do not expect reticulated water supply to be an impediment to the local structure plan.

Figure 2 – Bullsbrook South Reticulated Water Connection Points and Water Concept.



7.2 Wastewater Servicing (Sewerage)

The reticulated sewer and wastewater outfall is one of the more complex issues for development of the proposed Bullsbrook South Local Structure Plan, however with consideration to the development staging and the timing of additional downstream infrastructure provided by the Water Corporation it shouldn't be an impediment to the acceptance of the local structure plan.

7.2.1 Existing Sewer Catchments

Currently the proposed local structure plan area isn't serviced by reticulated sewer. In terms of sewer catchment planning, the area north of Nambad Brook is accounted for as part of the Bullsbrook Central sewer catchment. This catchment grades to the future Type 90 Wastewater Pumping Station (WWPS) being built by the Water Corporation under project number CS03513. The catchment boundary relative to Bullsbrook South is shown in figure 3 with the full catchment plan found in **Appendix Eight**. The timing for completion of this WWPS is mid 2025 inline with the opening of the Neighbourhood Center Site adjacent. For the proposed Bullsbrook South Local Structure Plan Area this equates to approximately 560 lots under a residential density coding and approximately 8.6 l/sec of flow.

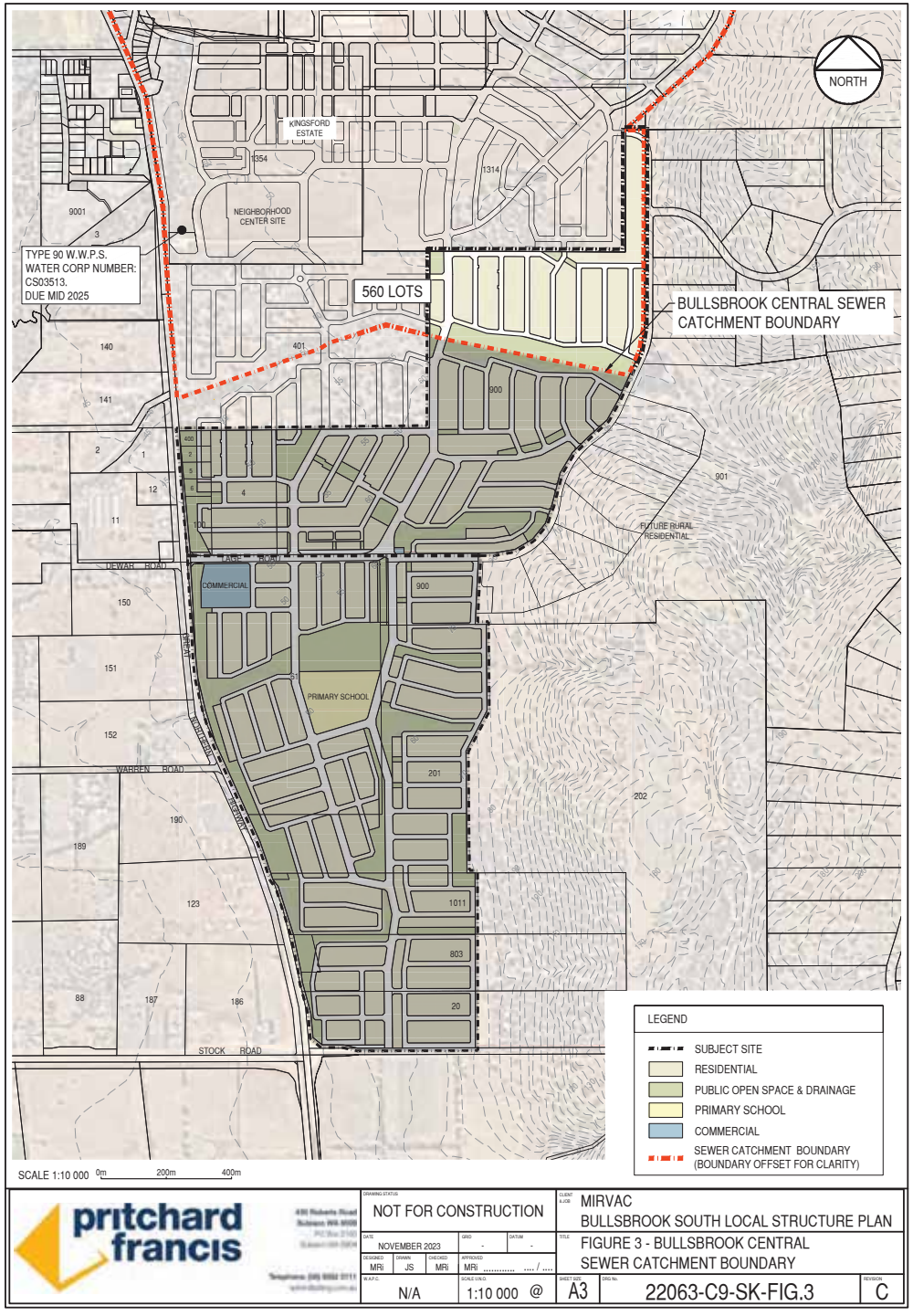
Figure 3 – Bullsbrook Central Sewer Catchment

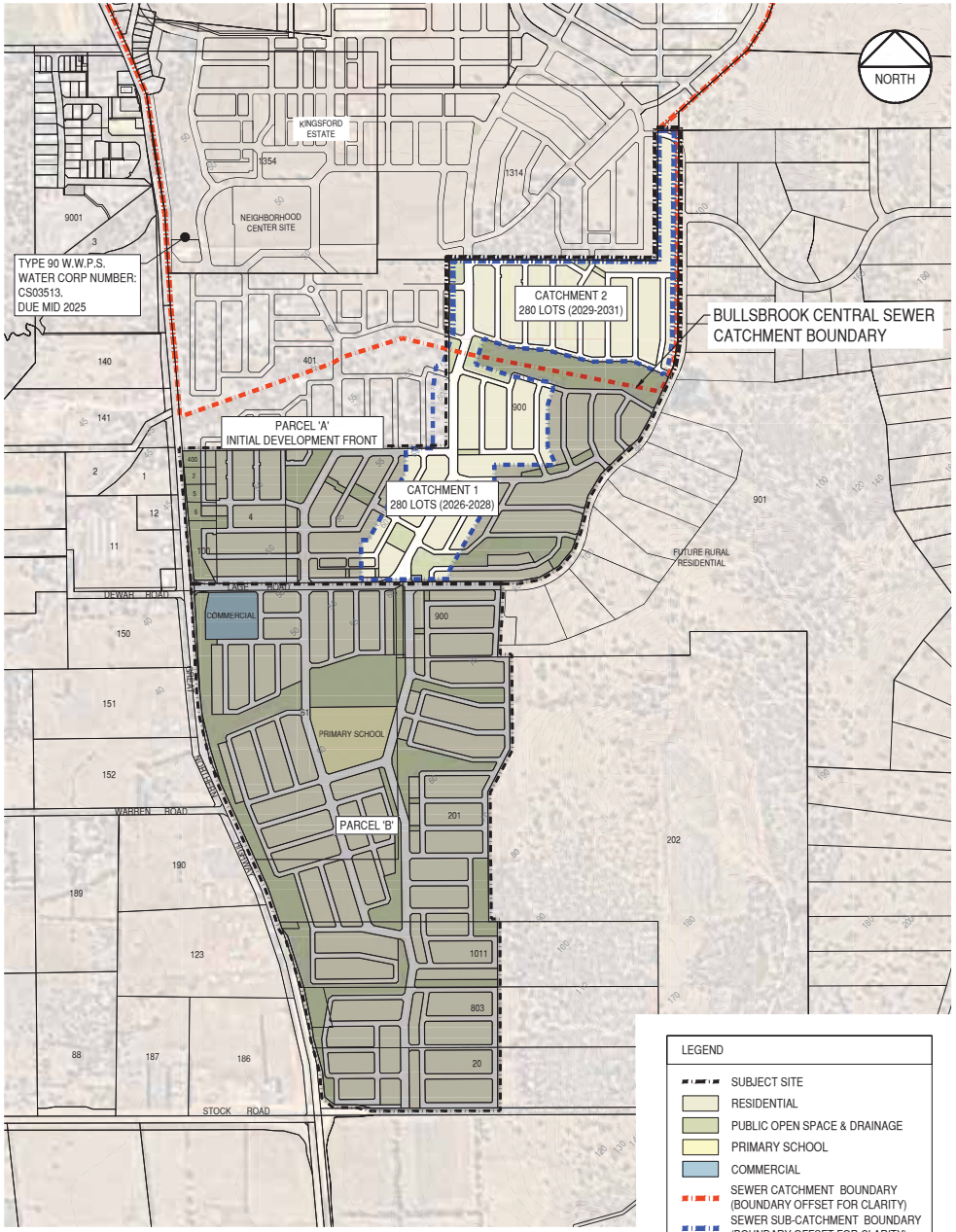
7.2.2 Development Staging

The initial focus of development within the urban expansion area will be the land immediately north of Lage Road. This is known as "Parcel A" (with everything South of Lage Road known as "Parcel B"). Part of Parcel A is currently not within the available sewer catchment as shown in figure 4. It is proposed to amend the Water Corporation catchment boundary temporarily to allow approximately half of the approved area north of Nambad Brook to be reallocated south which will allow the initial stages of development near Lage Road. A proposed catchment plan and indicative gravity sewer route to support this is shown in further detail in figure 5. This plan highlights that there is an option to redivert sewer flows in the future to the original catchment boundaries when the area north of Nambad Brook is proposed to be further developed, thus not impacting the ultimate flows allowed for in the Bullsbrook Central sewer catchment planning.

Figure 4 – Bullsbrook South Initial Development Areas

Figure 5 – Bullsbrook South Temporary Sewer Catchments – Parcel A





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DATE	NOVEMBER 2023
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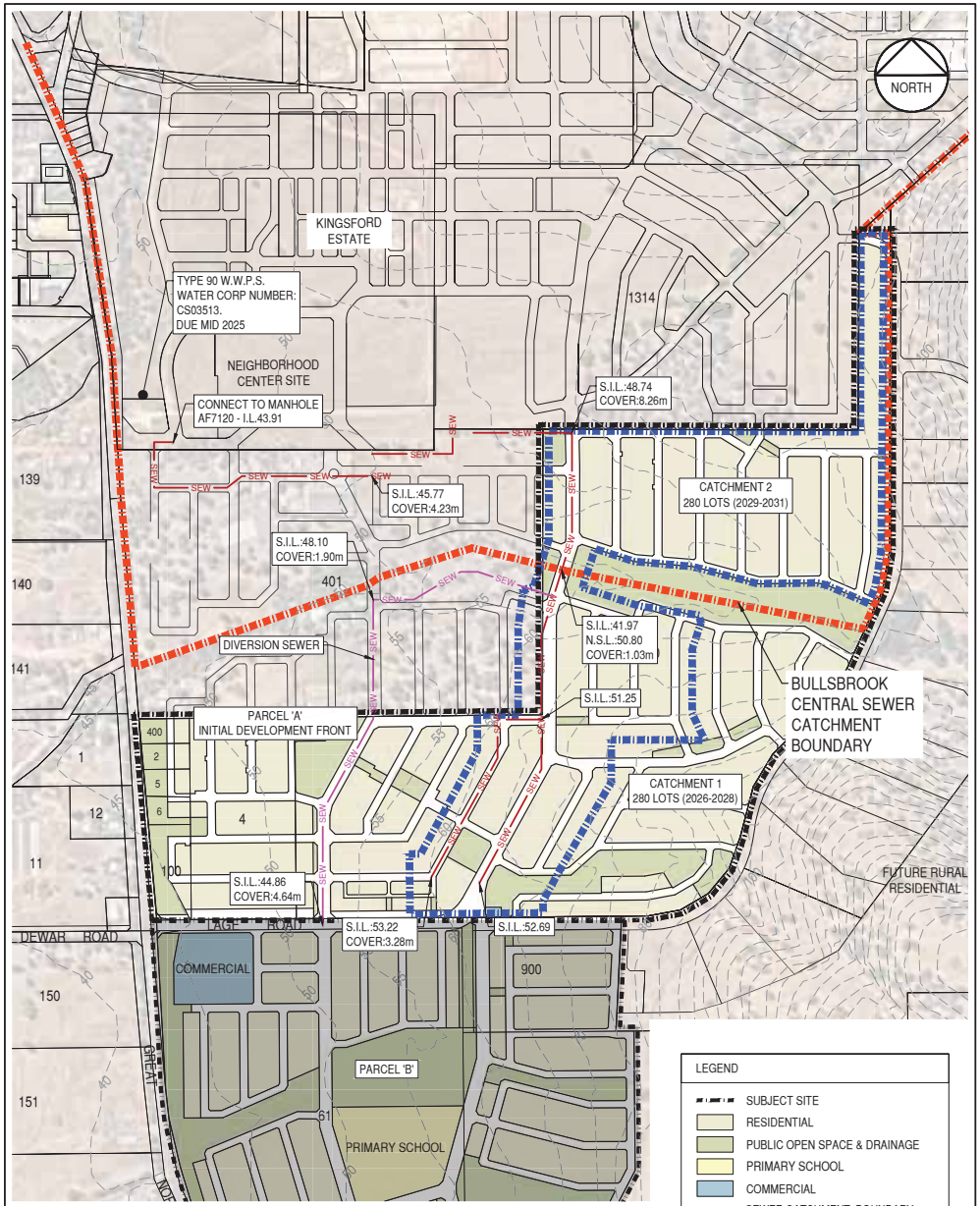
DATUM	-
DESIGNED	MRI
DRAWN	JS
CHECKED	MRI
APPROVED	MRI ..../.../...
TITLE	FIGURE 4 - BULLSBROOK SOUTH INITIAL DEVELOPMENT AREAS
W.A.P.C.	N/A
SCALE O.N.G.	1:10 000 @
SHEET SIZE	A3
DRG No.	22063-C9-SK-FIG.4
REVISION	C



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DATUM	-
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CHECKED	MRI
APPROVED	MRI ..../.../...
TITLE	FIGURE 5 - BULLSBROOK SOUTH TEMPORARY SEWER CATCHMENTS - PARCEL A
W.A.P.C.	N/A
SCALE O.N.G.	N.T.S. @
SHEET SIZE	A3
DRG No.	22063-C9-SK-FIG.5
REVISION	C

7.2.3 Development Timeframes

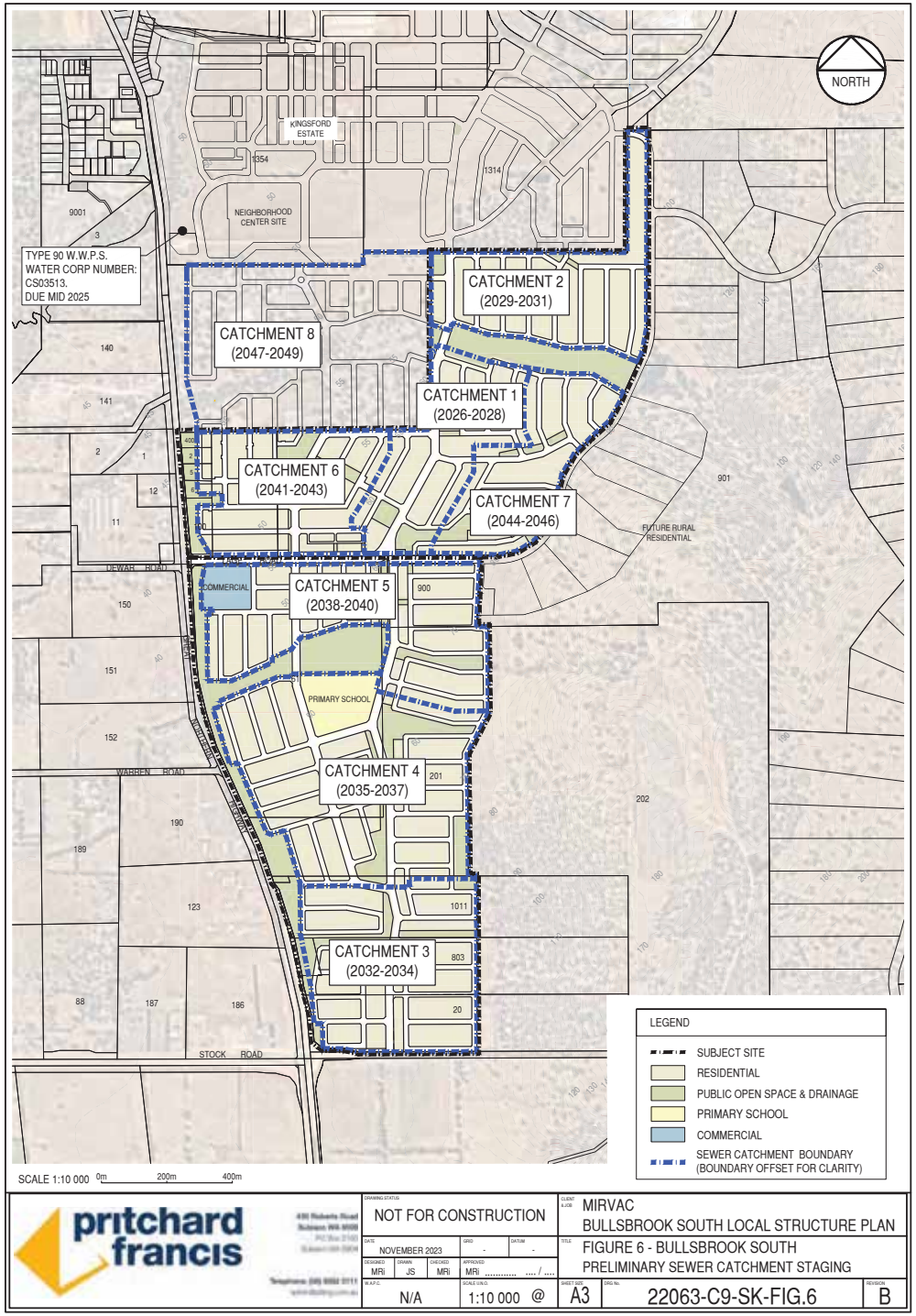
The estimated timeframe for development is important for assessing the local structure plan. A high-level program from lifting request through to possible sewer flow is shown in table 1. What this indicates is that the first 280 lots of sewer catchment south of Nambad Brook wouldn't contribute flow until 2026 and would be progressively developed until 2028. Another 280 lots North of Nambad Brook will take development through to the end of 2031. This indicates development of Parcel A would take place until the end 2031 (for 560 Lots total) before extra sewer outfall capacity is required.

Development Phase	Timeframe
Urban Deferred Lifting Request Approval	June 2024
Local Structure Plan Approval	November 2024
Subdivision Approval	February 2025
Construction Stage 1 (80 lots) completed	September 2025
Titles Stage 1	October 2025
Sewer flows (after housing construction) – Stage 1	June 2026
Build out of Catchment 1 – 280 lots	2026 to 2028
Build out of Catchment 2 – 280 lots	2029 to 2031

Table 1: Development Timing – Bullsbrook South Urban Expansion Area – First 560 Lots

The balance of this Parcel A landholding (approximately 350 lots) would need to gravitate south, through Parcel B to a sewer outfall on Stock Road, however this wouldn't be required until early 2032. Approximate staging and timing of sewer catchments through the urban expansion area is shown in figure 6. This is important when considering the development of regional wastewater infrastructure required to service Parcel B.

Figure 6 – Bullsbrook South Preliminary Sewer Catchment Staging



7.2.4 Regional Wastewater Infrastructure

We understand that the Kingsford Estate, directly to the north, has a further 1900 lots to be developed completing the build out of the Bullsbrook Central catchment in 2032. At this point a further sewer outfall option will be required by the Water Corporation as the existing infrastructure in Great Northern Highway will be at capacity. A schematic plan of the required infrastructure as provided by the Water Corporation is shown in figure 7. It highlights the key items relevant to the Bullsbrook South Urban Expansion Area but also the entire Northeast corridor encapsulating land in between Ellenbrook and Bullsbrook. There are several items included on this mapping with the main items as follows:

1. Stock Road Type 180 WWPS and Pressure Main to transfer flow from Bullsbrook to North Ellenbrook.
2. Additional Type 180 WWPS Transfer Station and Pressure Main to pump flow from North Ellenbrook to a gravity sewer discharge point within Ellenbrook.
3. Diameter 900 mm gravity sewer main within Ellenbrook to discharge at the existing Barrambie Way WWPS to transfer flows West.

Figure 7 – Northeast Corridor Wastewater Concept Plan – 10/7/2023

A high-level program for the planning and implementation of this infrastructure is shown in table 2. It is likely these infrastructure items will be staged in their construction and commissioning to meet development targets. We understand that a request has already been made to place the Diameter 900 mm gravity sewer on the Water Corporation's 5 year capital works funding allocation so this process is already underway.

Project Phase	Timeframe
Scoping and Land Acquisition	2024 to 2025
Detailed Design	2026 to 2027
Tender, Construction, Commissioning	2028 to 2030

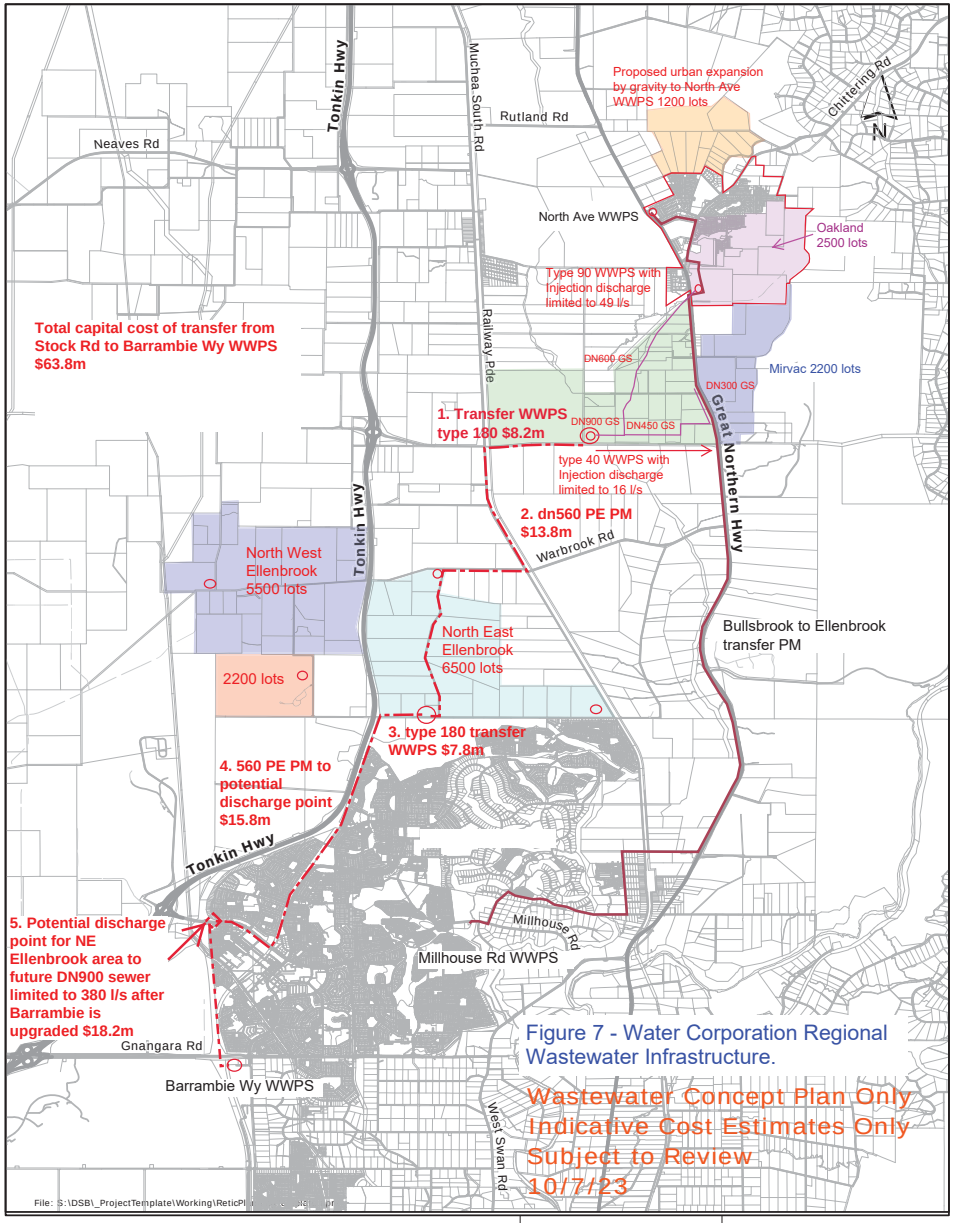
Table 2: Infrastructure Timing – Regional Wastewater – Northeast Corridor

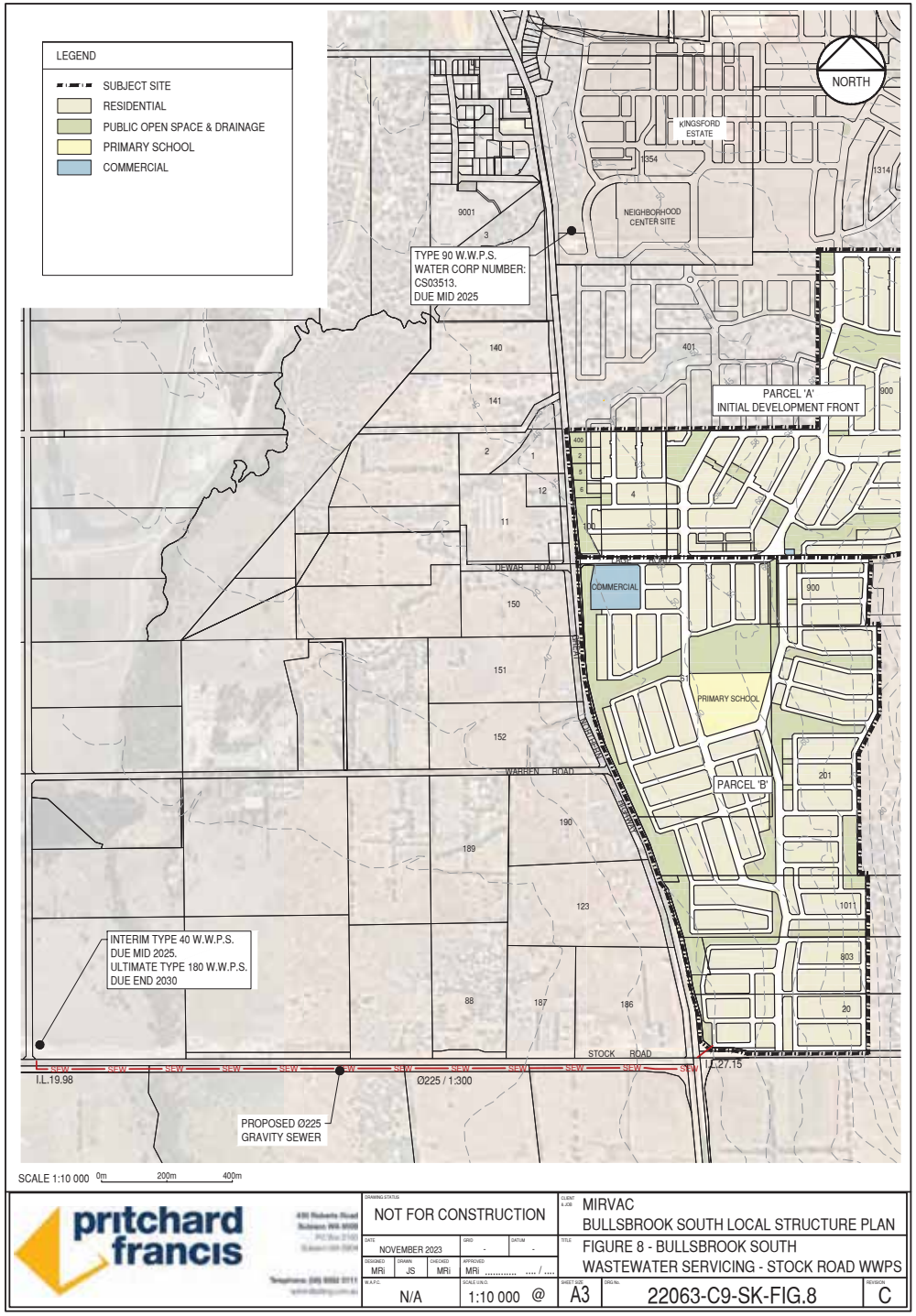
For Parcel B, approval of a scoping report for an interim Type 40 WWPS on Stock Road is due for completion imminently. The construction of this WWPS will allow limited flow (16 l/sec) to be pumped along Stock Road and discharge into the existing sewer transfer main in the Great Northern Highway reserve. This flow has initially been allocated to the Industrial land adjacent to Stock Road however the timing and flow rate required for this land is to be monitored with opportunity to create a sewer outfall for Parcel B. The construction of this interim Type 40 WWPS will allocate the future land requirements for the upgrade to the proposed type 180 WWPS that will be the ultimate sewer outfall for the greater Bullsbrook area (Item 1 above). Parcel B's sewer outfall will gravitate along Stock Road (or a similar alternative route) to this WWPS. An indicative sewer servicing alignment to the WWPS is shown in Figure 8. It is anticipated the Type 180 WWPS will be available prior to 2032 to enable the development of Parcel B and the remainder of Parcel A thereafter with staged timing as indicated in figure 6. The development timeframes mapped against Regional Wastewater Infrastructure implementation is represented in Figure 9.

Figure 8 – Parcel B Wastewater Servicing Alignment – Stock Road WWPS

Figure 9 – Bullsbrook South Urban Expansion Area / Regional Wastewater Implementation Timeframes

Considering all of the above, which highlights the staging of the Bullsbrook South Urban Expansion Area, temporarily altering the initial sewer catchment to allow development before 2032 and the expectation of continued timely development of regional wastewater infrastructure in the Northeast Corridor for access after 2032, we do not expect sewer reticulation and wastewater outfall to be an impediment to the acceptance of the local structure plan for Bullsbrook South.





Bullsbrook South Urban Expansion Area Timeframes

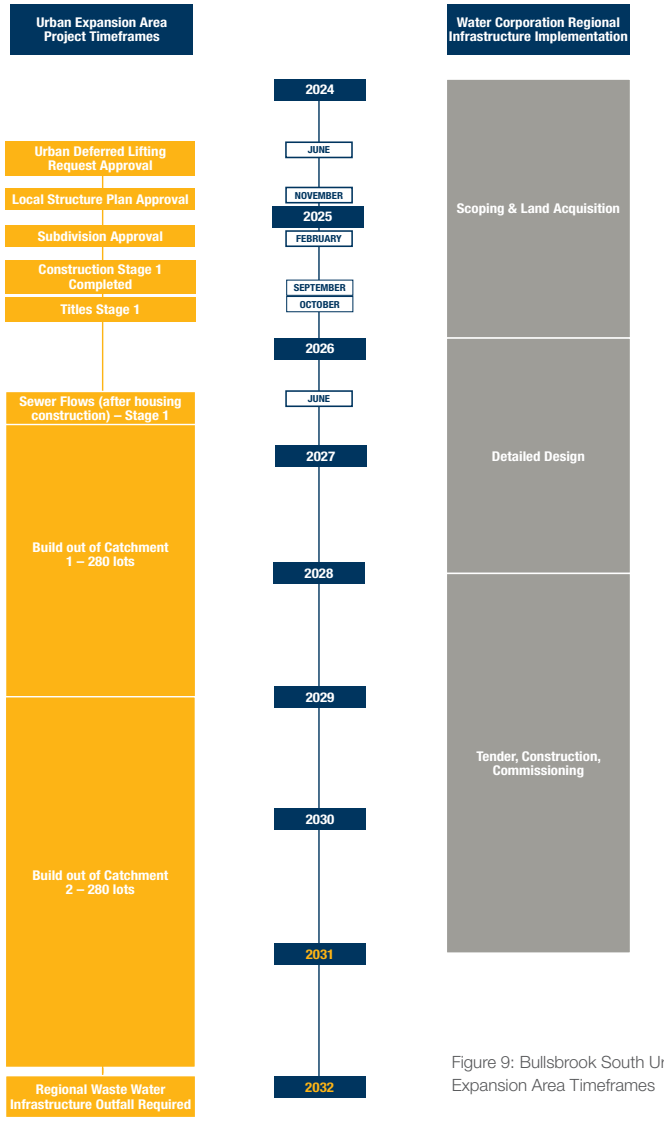


Figure 9: Bullsbrook South Urban Expansion Area Timeframes

7.3 Gas Supply

There is no reticulated gas supply in the proposed urban expansion area or in the Bullsbrook townsite. ATCO has advised that a 10km network mains extension would service the development. The predicted scope of works is outlined below.

- Network tie-in at Apple Street, Upper Swan, and Rail Crossing (ARC)
- 850m of DN225PE Apple Street to Great Northern Highway
- 9,000m of DN225PE from the junction of Apple Street and Great Northern Highway and Lage Road, Bullsbrook
- Installation methodology = Horizontal Directional Drilling (HDD)
- 500m x Open Cut in road reserve
- 500m x Open Cut in verge

We do not expect reticulated gas supply to be an impediment to the local structure planning of Bullsbrook South. Please refer to **Appendix Twelve** for more detail on the advice from ATCO.

7.4 Power Supply

7.4.1 Existing and Proposed UGP Network

The proposed structure plan area is currently bound by aerial power on the western side of Great North Highway and a high voltage spur line that runs along Lage Road to service a RAAF radar and existing residents on the adjoining rural properties. This line has a 22 kV capacity of which there is about 500 kVA available. This is supplied from the Bullsbrook Zone substation which from current mapping shows 9 MVA available.

Whilst this load is likely sufficient for the initial stages of development it would be prudent for Western Power to continue future planning for the greater Bullsbrook area to confirm continuity of supply.

For the development of the subject site, a high voltage connection under the Great Northern Highway will be required and this will need to be looped back to the distribution main in time to create a double source of supply. This could be done with a secondary connection to the existing aerials on Great Northern Highway or with connection to the high voltage infrastructure installed for the Neighbourhood Center to the north of the urban expansion area.

Existing Western Power asset mapping can be found in **Appendix 13**.

We do not expect underground power supply to be an impediment to the local structure planning of Bullsbrook South.

7.5 Communication

7.5.1 Existing and Proposed Communications Network

The site is current serviced by multiple optic fibre in the Great Northern Highway Road reserve. It is expected expansion of this network along Lage and into the future subdivision will service the urban expansion area.

There are many opportunities for residential suppliers in the area including NBN Co and Opticomm. NBN Co still have a standard $600 / lot backhaul fee to support the development of their infrastructure.

Optic Fibre mapping can be found in **Appendix 14**.

We do not expect communication infrastructure to be an impediment to the local structure planning of Bullsbrook South.

8 Conclusion

The subject site has future planning carried out by all service authorities and sits at the edge of the development front with required services found on Great Northern Highway and the edge of the Bullsbrook Central catchment which is the Kingsford Estate.

Based on the information available, the development of the Bullsbrook South Structure Plan Area should be from the north, moving in a southerly direction utilising access from Great Northern Highway.

With continued emphasis by the Water Corporation on regional infrastructure planning for the Northeast Corridor, there should be no noted shortfall in infrastructure or constraints that would prevent development of this land for residential development in a staged and timely fashion.

Appendices

Appendix One:	Bullsbrook South Expansion Area Concept Master Plan
Appendix Two:	Acid Sulphate Soil Risk Map
Appendix Three:	Iron Staining Risk Map
Appendix Four:	1:50,000 Environmental Geology Series Map – Muchea
Appendix Five:	Preliminary Geotechnical Investigation
Appendix Six:	Existing Ground Contours
Appendix Seven:	Perth Groundwater Map
Appendix Seven B:	Preliminary Earthwork and Drainage Design
Appendix Eight:	Bullsbrook Central Sewer Catchment
Appendix Nine:	Temporary Sewer Catchment Diversion
Appendix Ten:	Bullsbrook South Sewer Catchment Timing
Appendix Eleven:	North East Corridor Waste Water Concept Plan July 2023
Appendix Twelve:	ATCO Gas Correspondence
Appendix Thirteen:	Existing Western Power Infrastructure
Appendix Fourteen:	Existing Communication and Fibre Infrastructure

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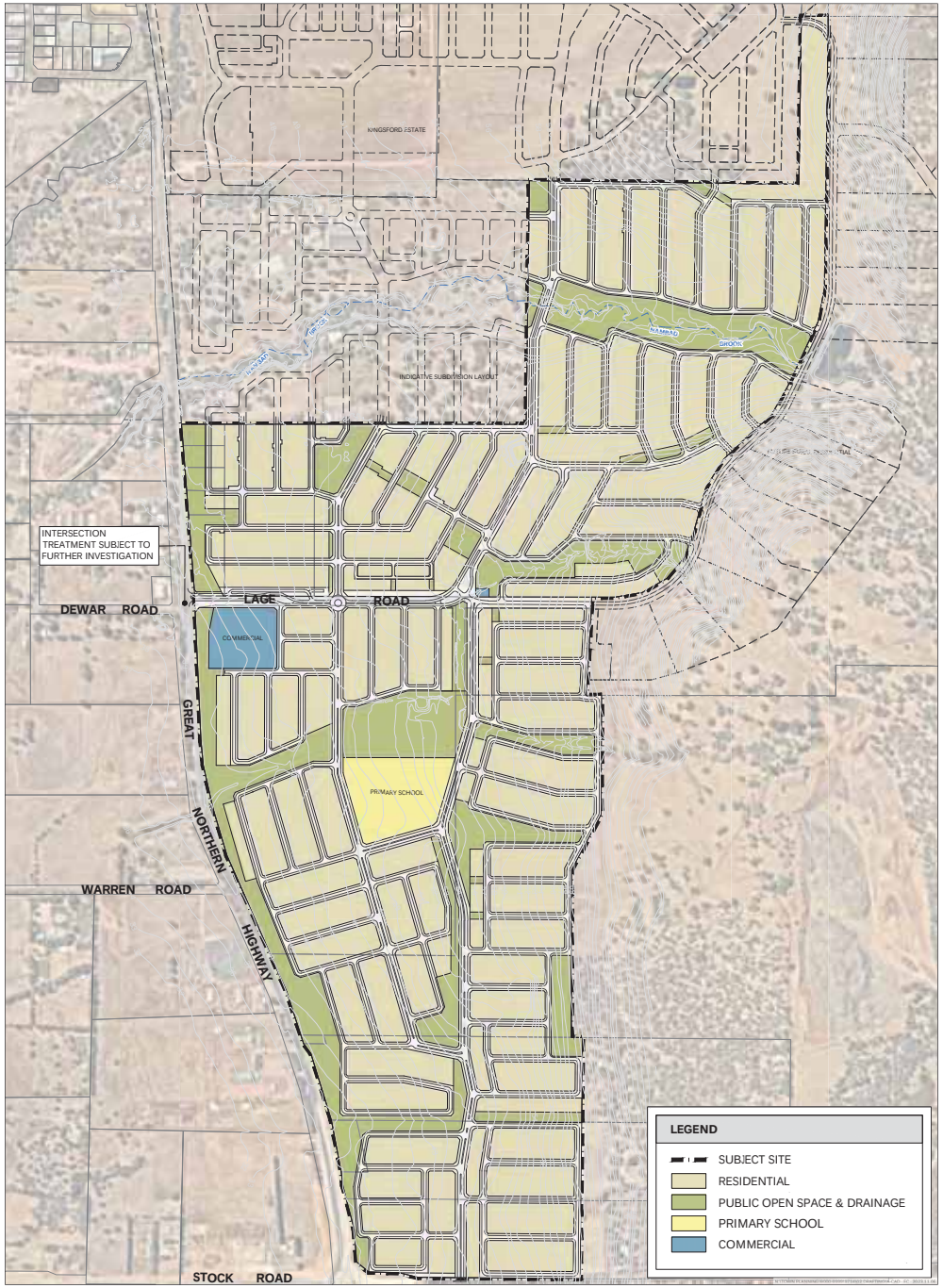
Appendix One: Bullsbrook South Expansion Area Concept Master Plan



BULLSBROOK SOUTH URBAN EXPANSION AREA - CONCEPT PLAN
VARIOUS LOTS - GREAT NORTHERN HIGHWAY
BULLSBROOK

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9714-CON-18-A

DRAWN: WC
DATE CREATED: 2023.11.06
PROJECTION: PCG94
CADASTRE: MRG 105670d-006a
CONTOURS: LANDGATE
AERIAL: NEARMAP 2023

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Appendix Two: Acid Sulphate Soil Risk Map

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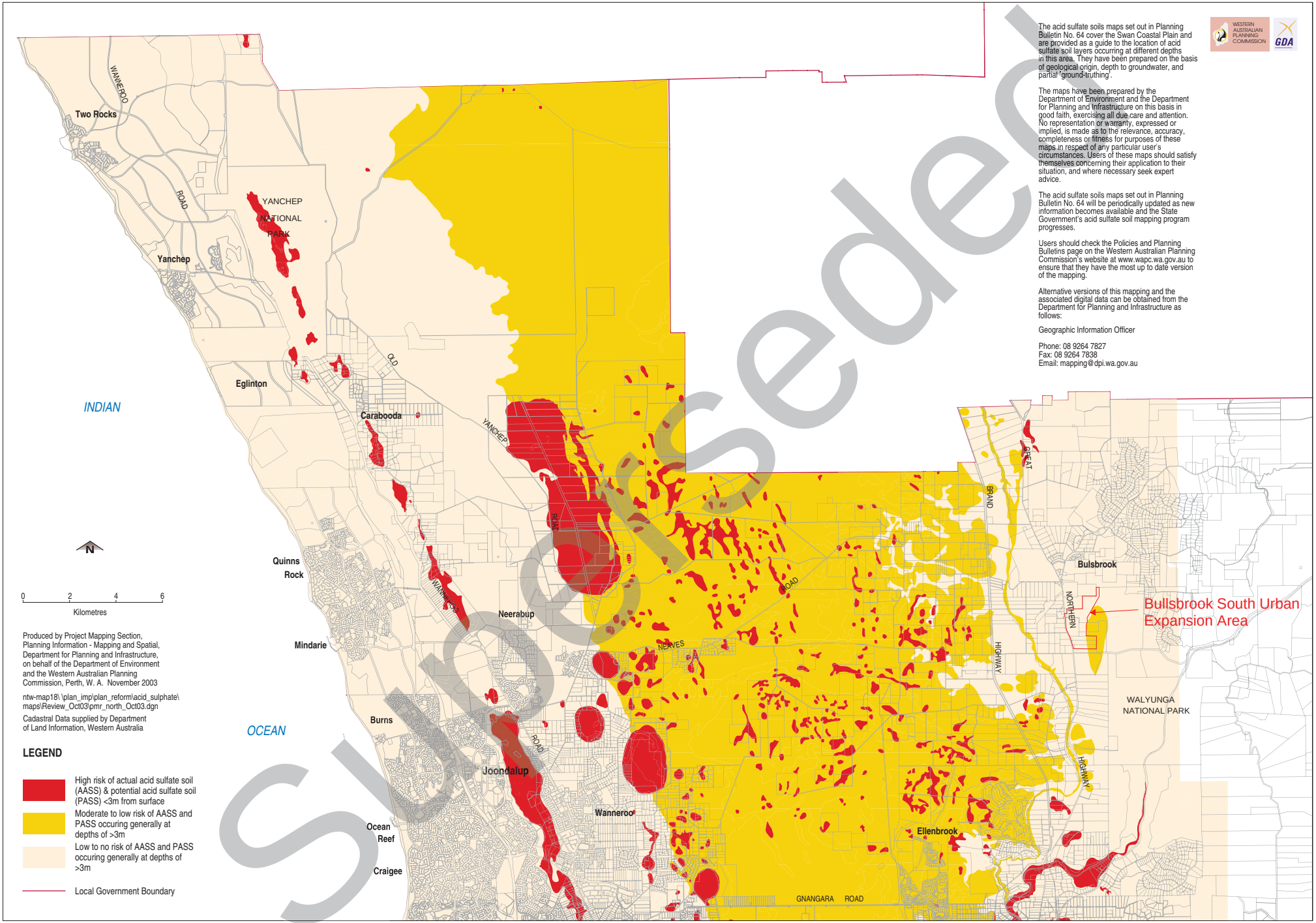

Planning Bulletin Number 64

Figure 2: North Metropolitan Region Scheme Acid Sulfate Soils

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Appendix Three: Iron Staining Risk Map

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Rutland Rd
Neaves Rd
Bullsbrook - West
East Bullsbrook
Bullsbrook
RAAF Base Pearce
Veray
Killara
Lareema
Greenslopes
Yalliawirra
Killcodey
Great Northern Hwy
Lewona
Okaparinga
Shady Hills
Woodsome Estate
Warbrook
Twin Swamps Nature Reserve
Walyunga National Park

Appendix Four: 1:50,000 Environmental Geology Series Map – Muchea

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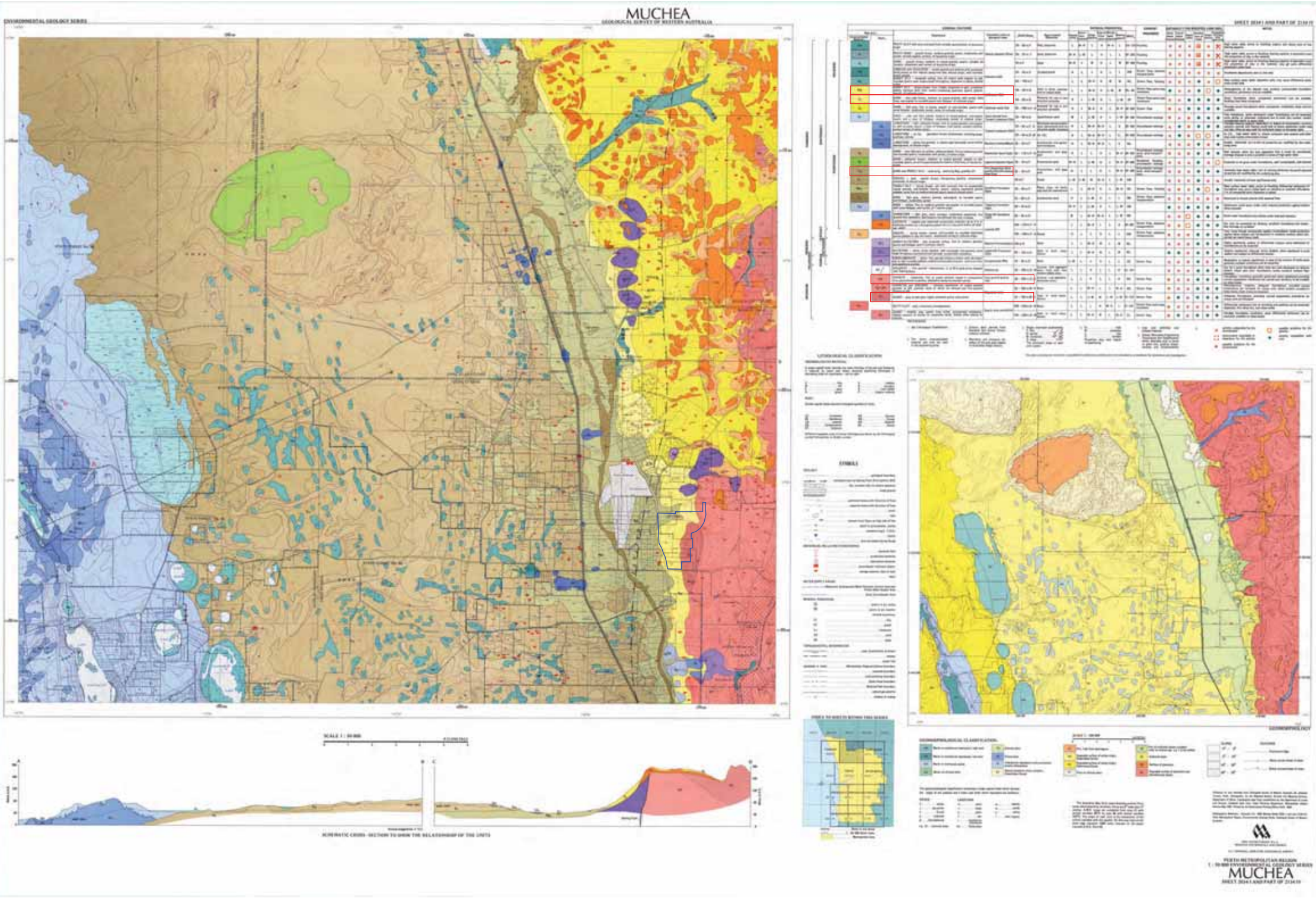
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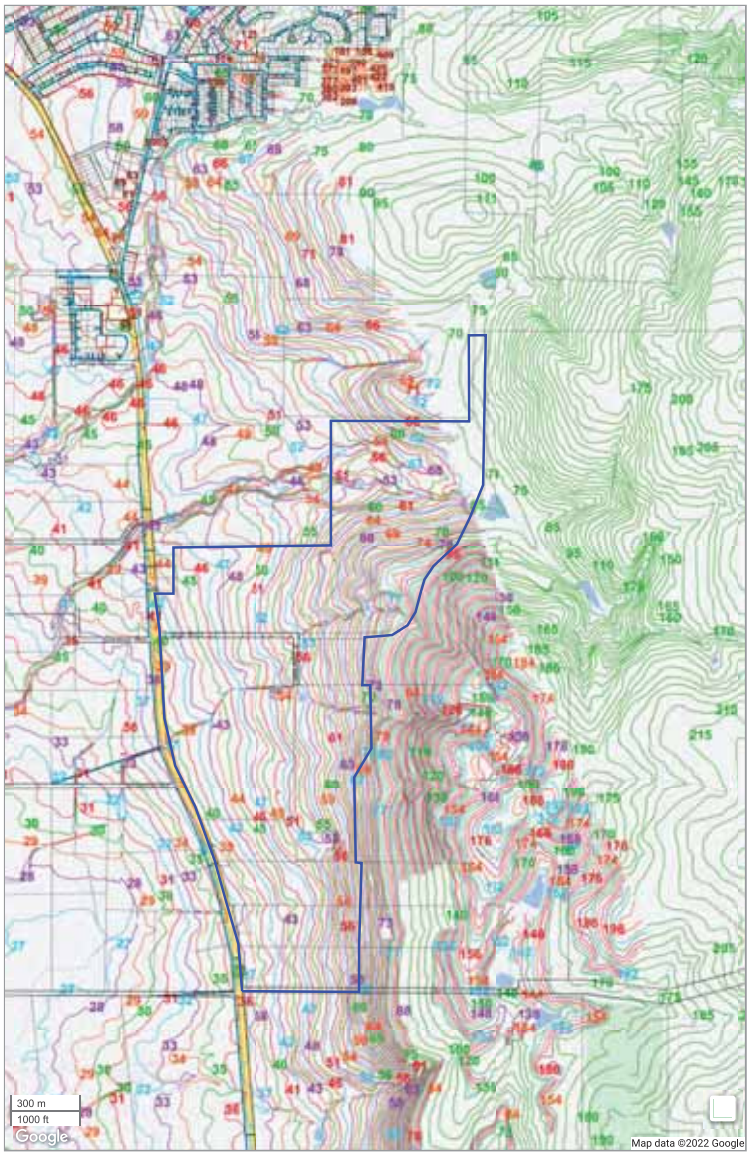
Appendix Five: Preliminary Geotechnical Investigation

Appendix Six: Existing Ground Contours

Appendix Seven: Perth Groundwater Map



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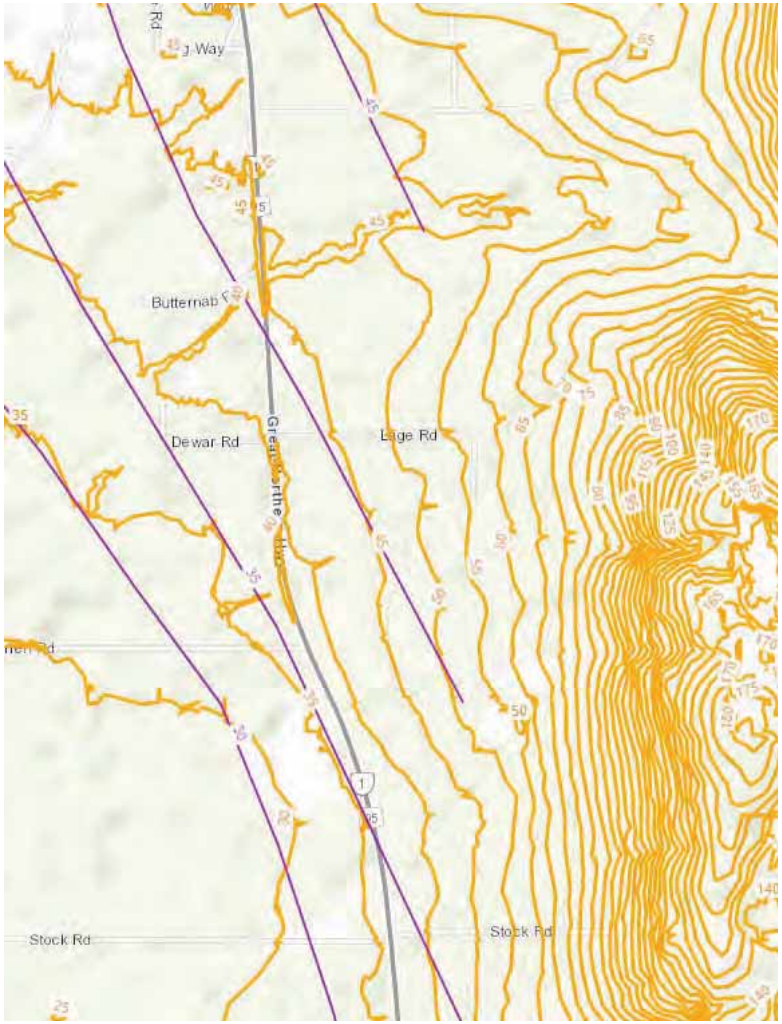
Appendix Seven B: Preliminary Earthwork and Drainage Design



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MIRVAC
NOVEMBER 2023

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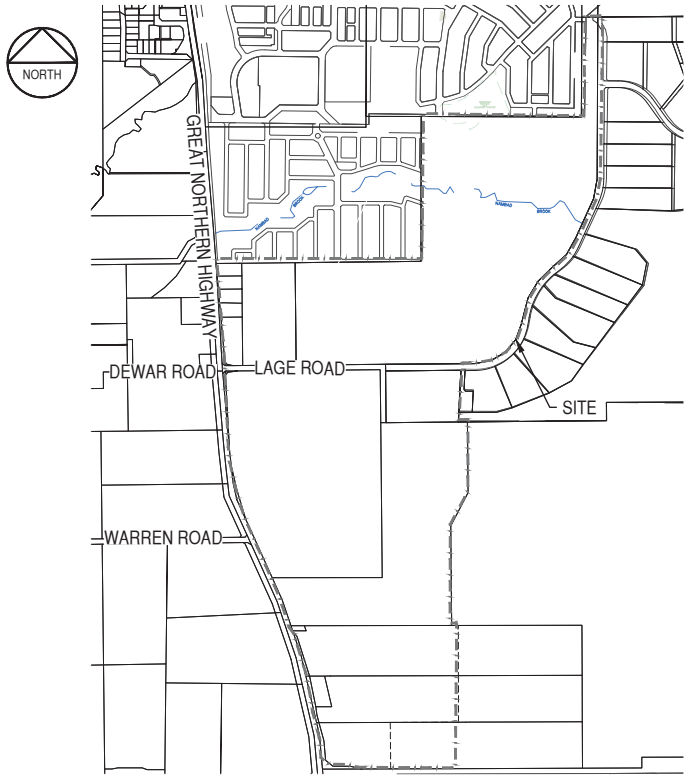

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22063-C1-DC-01	DESIGN CONTOURS
22063-C1-EW-01	EARTHWORKS DEPTH PLAN
22063-C1-RW-01	RETAINING WALL LAYOUT & LEVELS
22063-C1-EC-01	EXISTING CATCHMENT PLAN SHEET 1 OF 2
22063-C1-EC-02	EXISTING CATCHMENT PLAN SHEET 2 OF 2
22063-C1-CA-01	DESIGN CATCHMENT PLAN
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Subiaco WA 6904
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admin@pfeng.com.au

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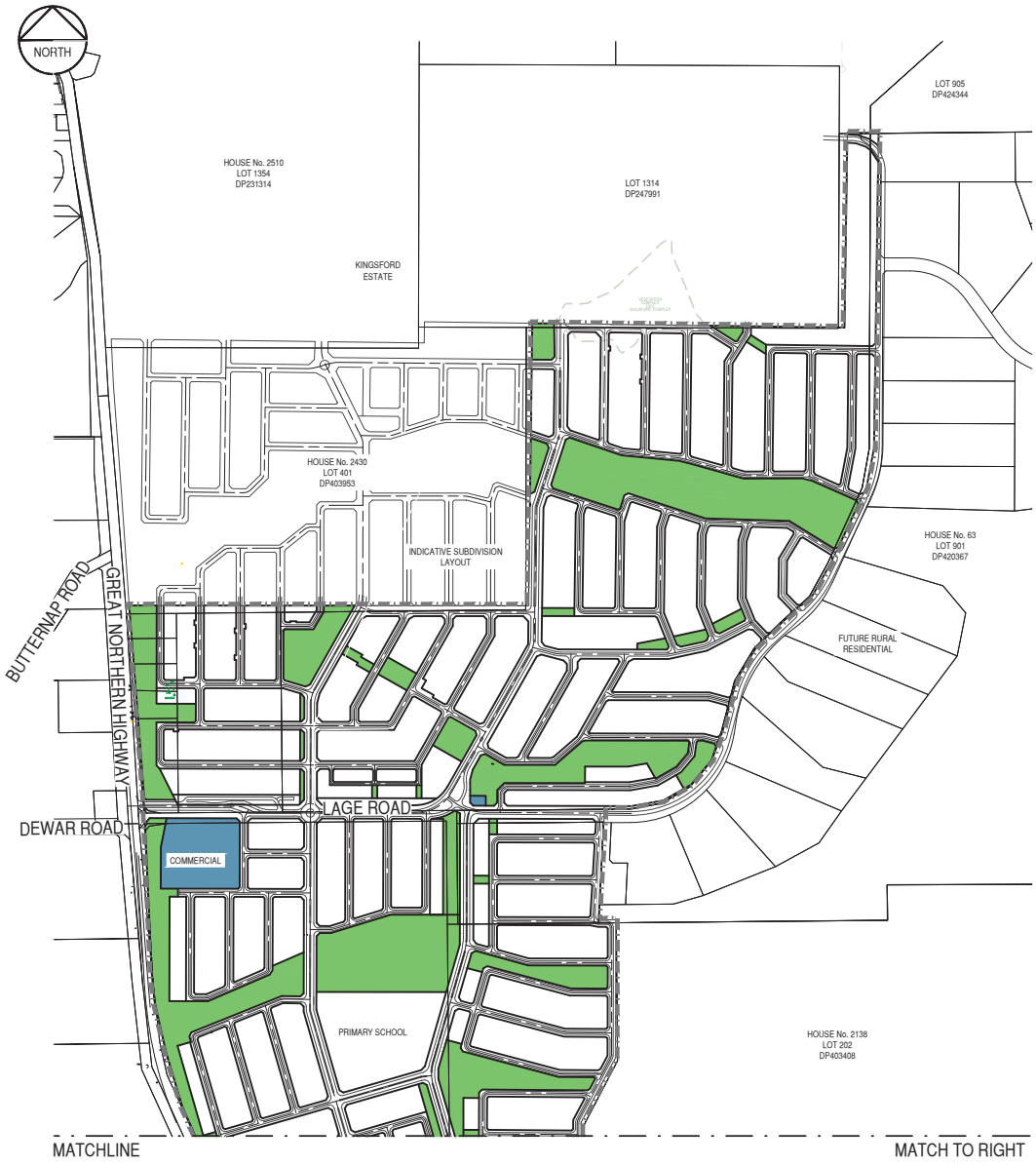



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- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

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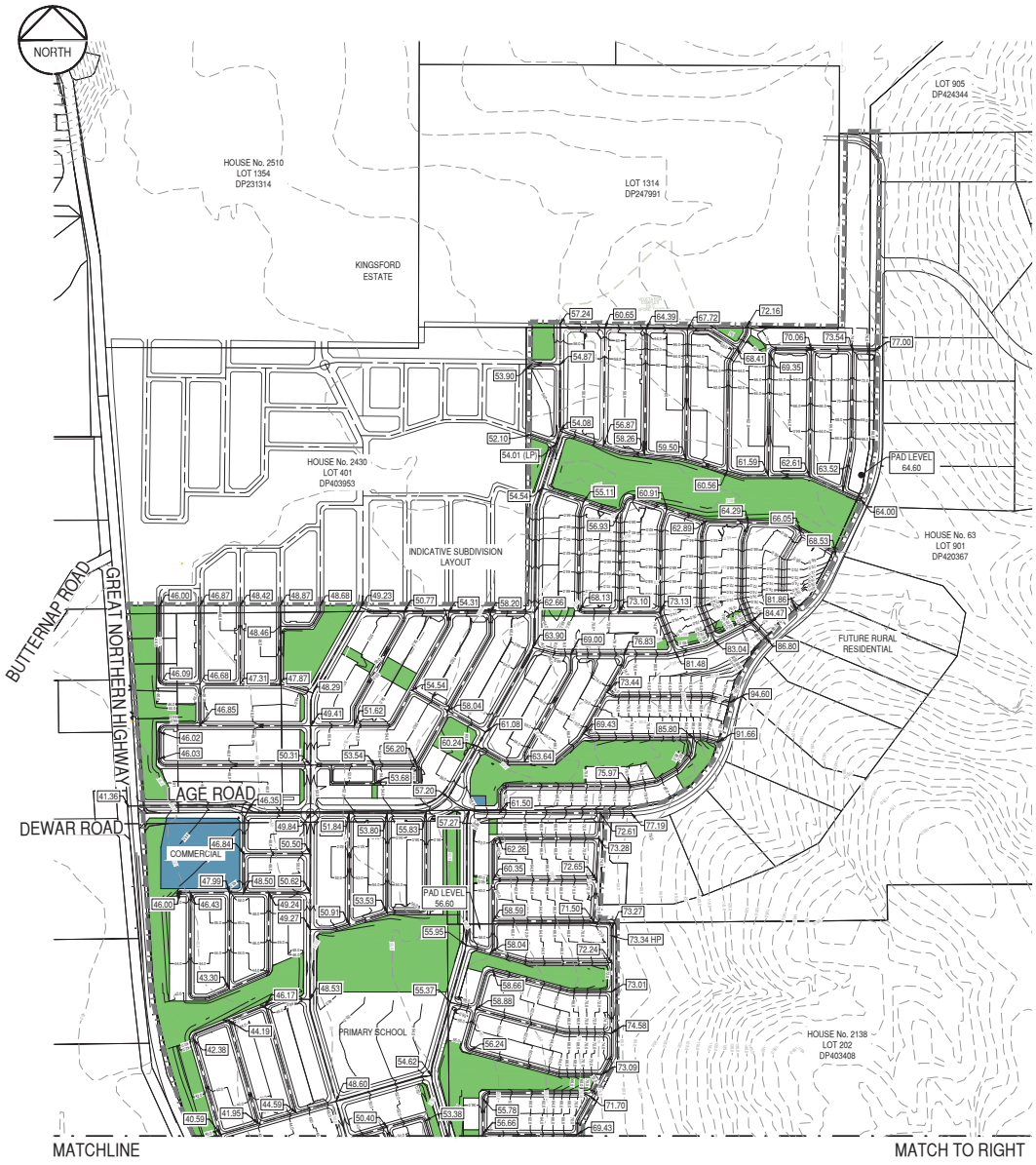

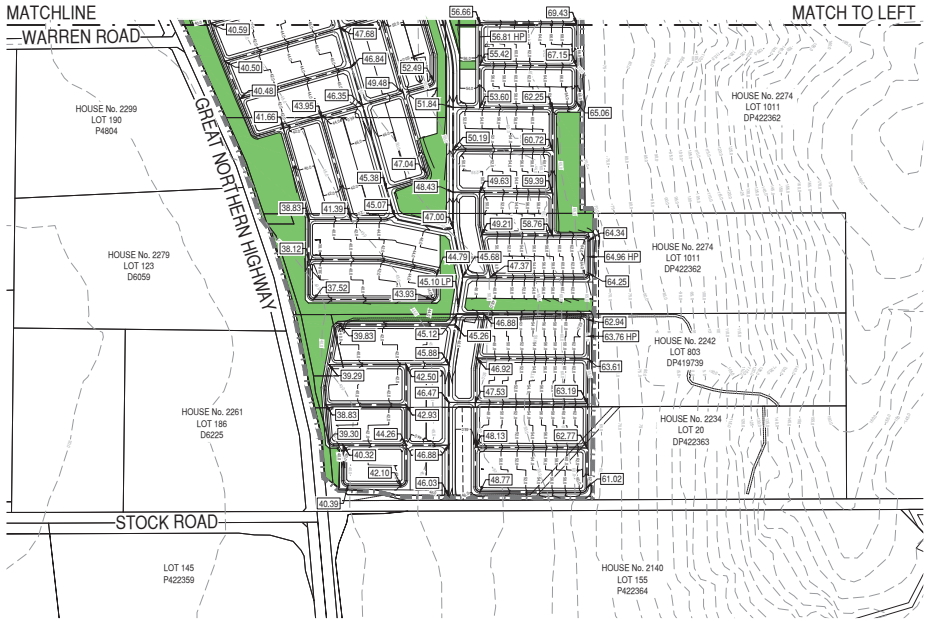

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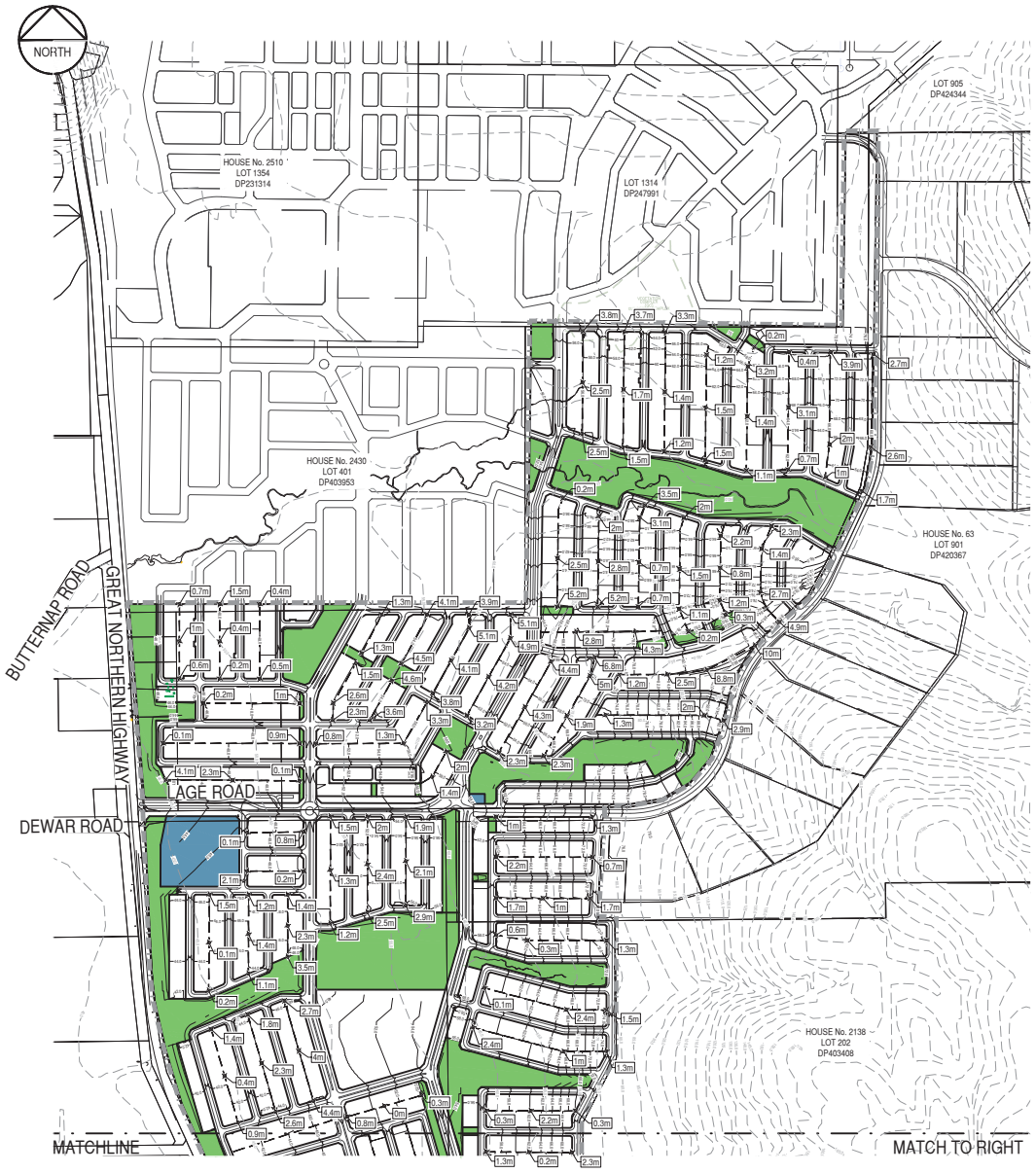



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REVISION: A



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MATCHLINE

SCALE 1:500 0m 10m 20m

DIAL BEFORE YOU DIG www.1100.com.au The Essential First Step.

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- DESIGN CATCHMENT BOUNDARY
- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
A	15/11/23	INITIAL ISSUE	A.D	M.R

pritchard francis
civil and structural engineering consultants

DRAWING STATUS: NOT FOR CONSTRUCTION

DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

DESIGNED: A.D | DRAWN: N.S | CHECKED: M.R | APPROVED: XXX ..... / ....

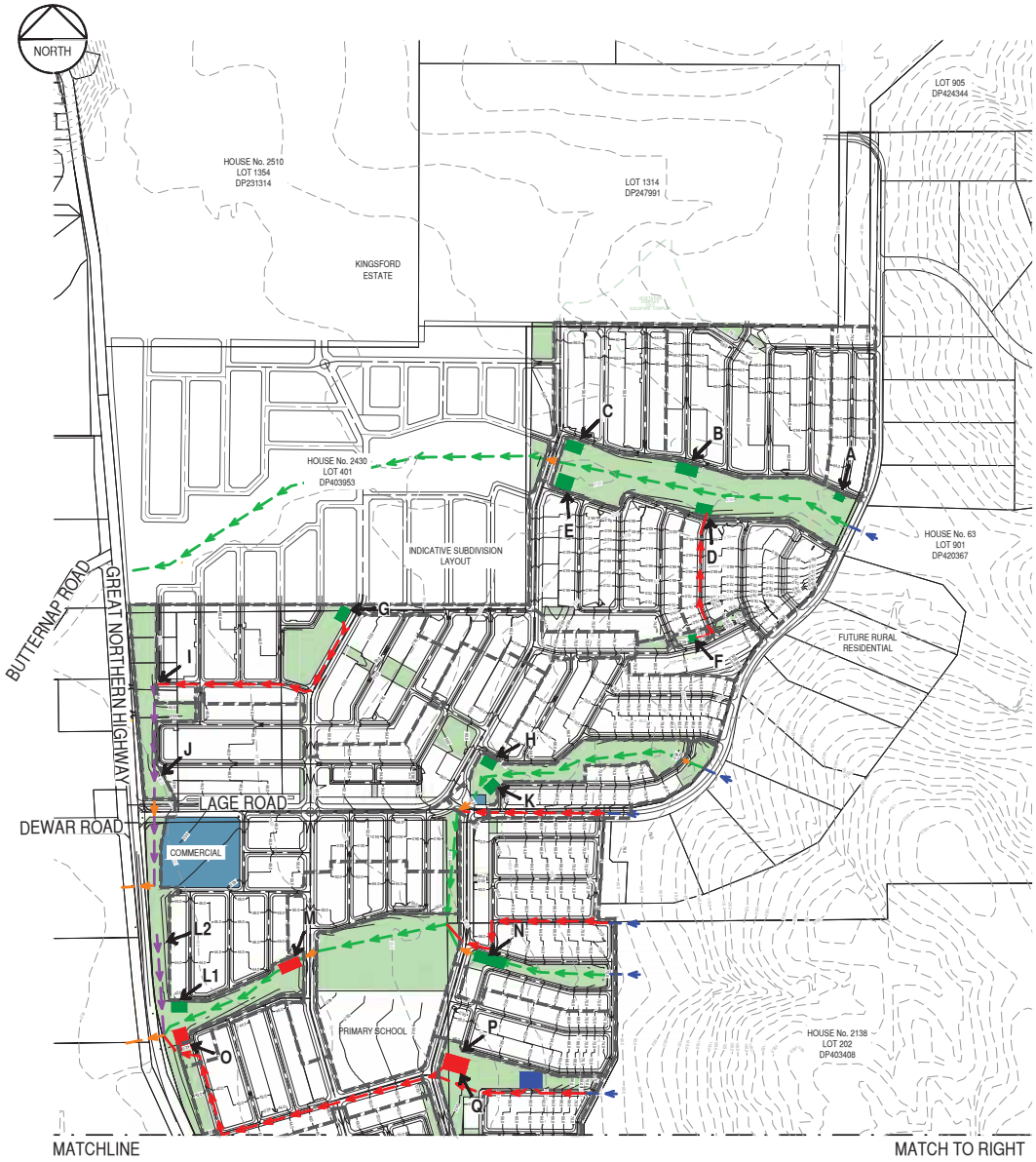
W.A.P.C.: ???? | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: DESIGN CATCHMENT PLAN

DRG No.: 22063-C1-CS-01

REVISION: A





SCALE 1:5000 0m 100m 200m

DIAL BEFORE YOU DIG
www.1100.com.au
The Essential First Step.

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE
- LIVING STREAM
- TREATMENT / DETENTION SWALE
- CONVEYANCE SWALE
- STORMWATER CULVERT
- PIPED DRAINAGE
- INFLOWS
- BIOBASIN
- FLOOD DETENTION BASIN
- EXTERNAL CATCHMENTS BASIN

REV	DATE	DESCRIPTION	BY	CHKR
A	7/12/23	INITIAL ISSUE	N.S	M.R

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DRAWING STATUS: NOT FOR CONSTRUCTION

DATE	GRID	DATUM
NOVEMBER 2023	PCG94	AHD

DESIGNED	DRAWN	CHECKED	APPROVED
A.D	N.S	M.R	XXX .... / ...

W.A.P.C. N/A | SCALE U.N.O. 1:5000 @ A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: STORMWATER MANAGEMENT CONCEPT PLAN

SHEET SIZE: A1 | DRG No. 22063-C1-SW-01 | REVISION: A

Appendix Eight: Bullsbrook Central Sewer Catchment

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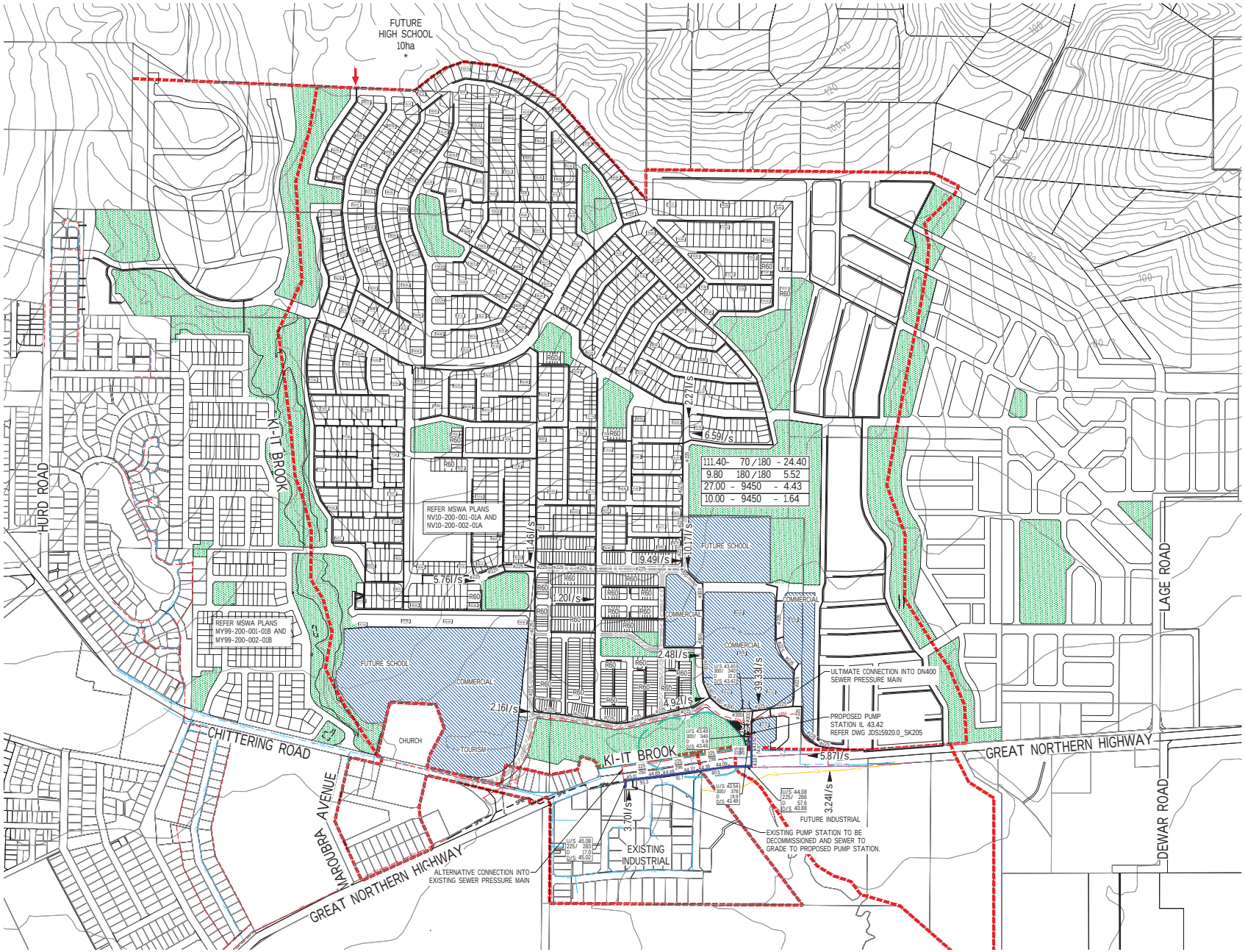

0 50 100 200 300m
SCALE 1:5000 @ ORIGINAL SHEET SIZE A1

PLAN
SCALE 1:5000

NOTES

1. ALL MAINS TO BE LAID ON THE STANDARD ALIGNMENTS UNLESS NOTED OTHERWISE.
2. SUBDIVISION CELLS ARE RESIDENTIAL R20 LAND USE UNLESS NOTED OTHERWISE.
3. ALL MAINS TO BE 150mm DIAMETER UNLESS NOTED OTHERWISE.
4. RESIDENTIAL ZONE HATCHING NOT SHOWN FOR CLARITY.
5. LOCAL AUTHORITY: CITY OF SWAN
6. ESTIMATED MAX. G.W.L. 45m (A.H.D.)
7. THIS RETICULATION AREA IS CLASSIFIED 'DRY' IN ACCORDANCE WITH THE WATER CORPORATION WASTEWATER MANUAL VOL. 1 UNLESS NOTED OTHERWISE.

LEGEND

- CATCHMENT BOUNDARIES
- PROPOSED CREEK AND P.O.S. AREAS
- PROPOSED COMMERCIAL/SCHOOL/TOURISM/CHURCH AREAS
- EXISTING CONTOURS (5m INTERVAL)
- SEWER CONTROL LINE
- EXISTING WATER MAINS
- R60 RESIDENTIAL FINISHED SURFACE LEVELS
- PRELIMINARY FINISHED SURFACE LEVELS

RESIDENTIAL

NET AREA (ha) — FLOW- LITRES/PERSON/DAY
1.00 - 52.5 / 230 - 0.21
PERSONS PER NET HECTARE — PEAK FLOW (l/s)

NON RESIDENTIAL

NET AREA (ha) — PEAK FLOW (l/s)
0.85 - 14976 - 0.22
FLOW- LITRES/NET HECTARE/DAY

WWPSL DESIGN CRITERIA

DESIGN INFLOW:	43.03L/s
PUMP RATE:	57.23L/s
MAX PUMP RATE:	90L/s
SEWER INVERT LEVEL:	43.42m
100 YEAR FLOOD LEVEL:	46.56m AHD
WWPS TOP SLAB LEVEL:	48.10m AHD
WWPS BASE LEVEL:	40.48m AHD
WWPS DEPTH:	7.62m

WARNING
BEWARE OF UNDERGROUND SERVICES
The location of underground cables are approximate only and their exact position should be checked on site. No guarantee is given that all existing cables and services are shown. Locate all underground cables and services before commencement of work. Refer to Worksafe Regulation 3.21.
DIAL 1100 BEFORE YOU DIG

PRELIMINARY

REV	DATE	DRAWN	CHECKED	APPROVED

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NOTE
This drawing shall be preliminary only until it is issued for Construction.
Certified Quality System to ISO 9001

JDSi CONSULTING ENGINEERS
Level 1, 432 MURRAY STREET, Perth WA 6000
P: (08) 9227 0595 F: (08) 9227 8617

CLIENT: okeland

PROJECT: KINGSFORD

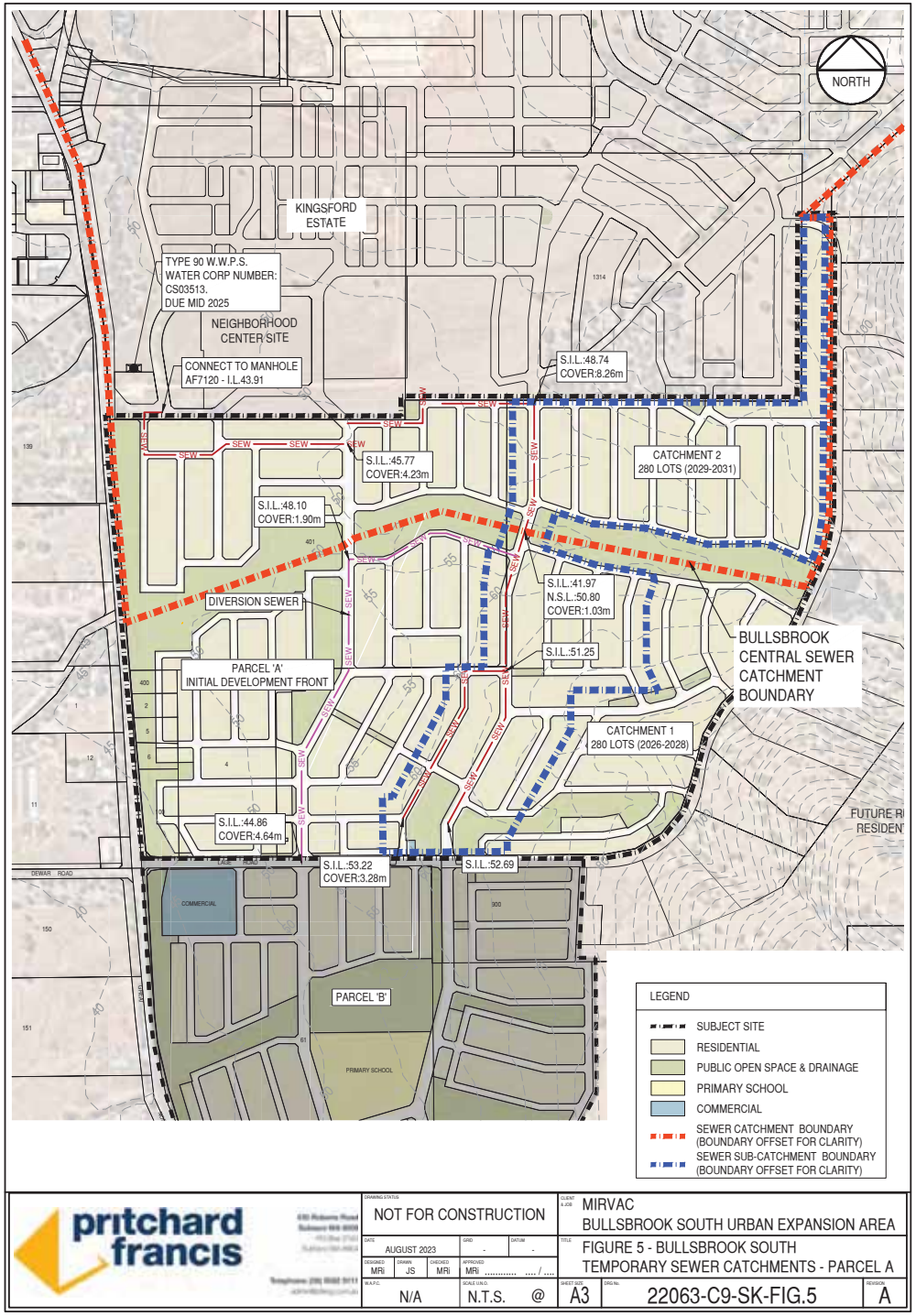
STAGE: KINGSFORD - BULLSBROOK

DRAWING TITLE: BULLSBROOK OVERALL SEWER CATCHMENT PLAN

DRAWN: A. PANZICH	WAPC No.: 156769	
DESIGNED: A. PANZICH	SCALE @ A1: 1:5000	
PROJECT MANAGER: G. BOYD	DATUM: AHD	CO-ORDS: PCG94
JDSi PROJECT No.: JDS15920.0	DRAWING No.: SK203	REVISION: D

Plotted By: APanzich Plot Date: 08/07/22 - 08:54 Cad File: I:\JDS15920\JDS15920.W41\02 CIVIL\Drawings\XXXX-XXX-001-01A.dwg

Appendix Nine: Temporary Sewer Catchment Diversion



pritchard francis

DRAWING STATUS: NOT FOR CONSTRUCTION

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

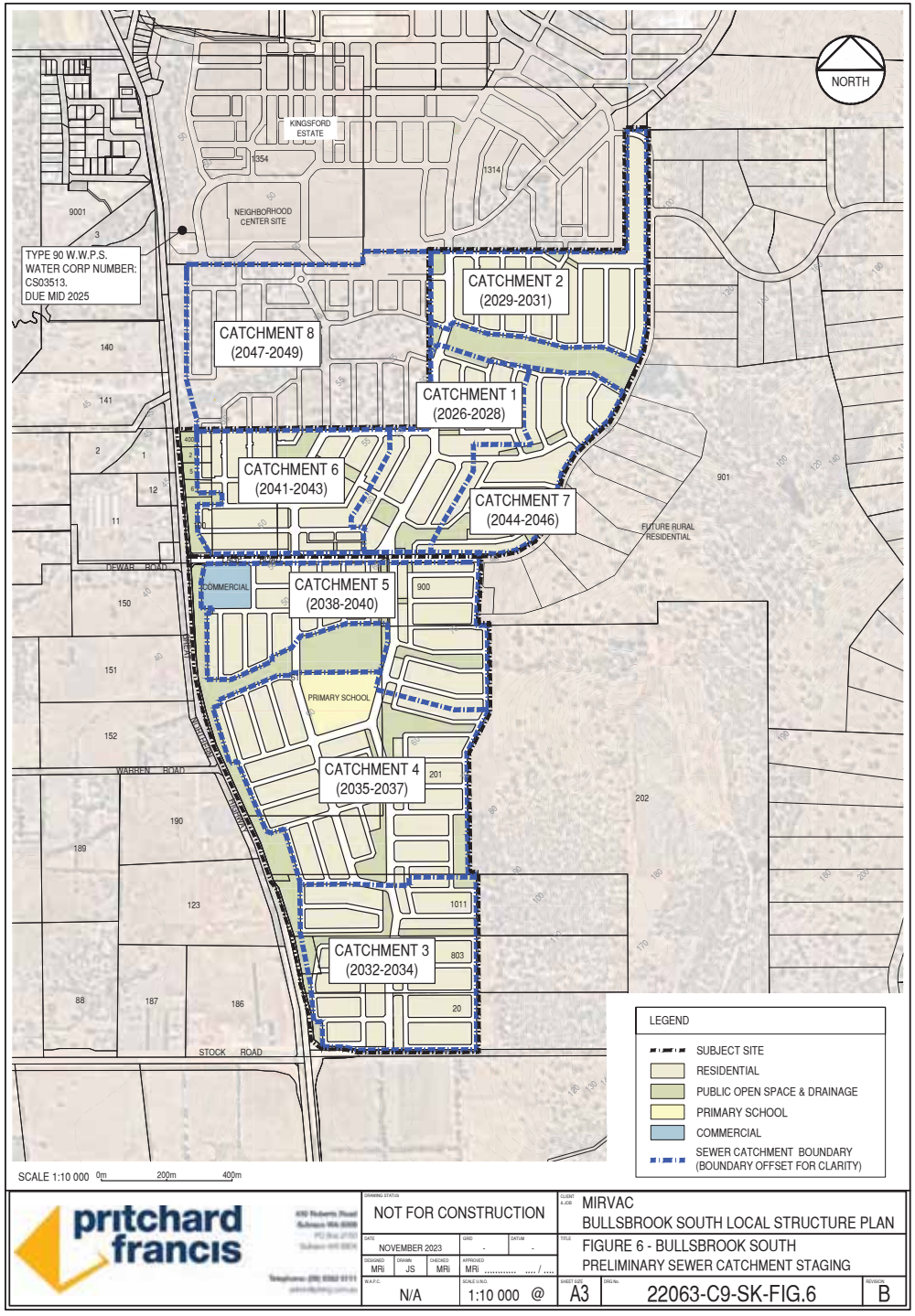
DATE: AUGUST 2023 | GRID: - | DATUM: -

TITLE: FIGURE 5 - BULLSBROOK SOUTH
TEMPORARY SEWER CATCHMENTS - PARCEL A

DESIGNED: MRi | DRAWN: JS | CHECKED: MRi | APPROVED: MRi .... / ....

M.A.P.C.: N/A | SCALE U.N.O.: N.T.S. @ | SHEET SIZE: A3 | DRG No.: 22063-C9-SK-FIG.5 | REVISION: A

Appendix Ten: Bullsbrook South Sewer Catchment Timing



Appendix Eleven: North East Corridor Waste Water Concept Plan July 2023

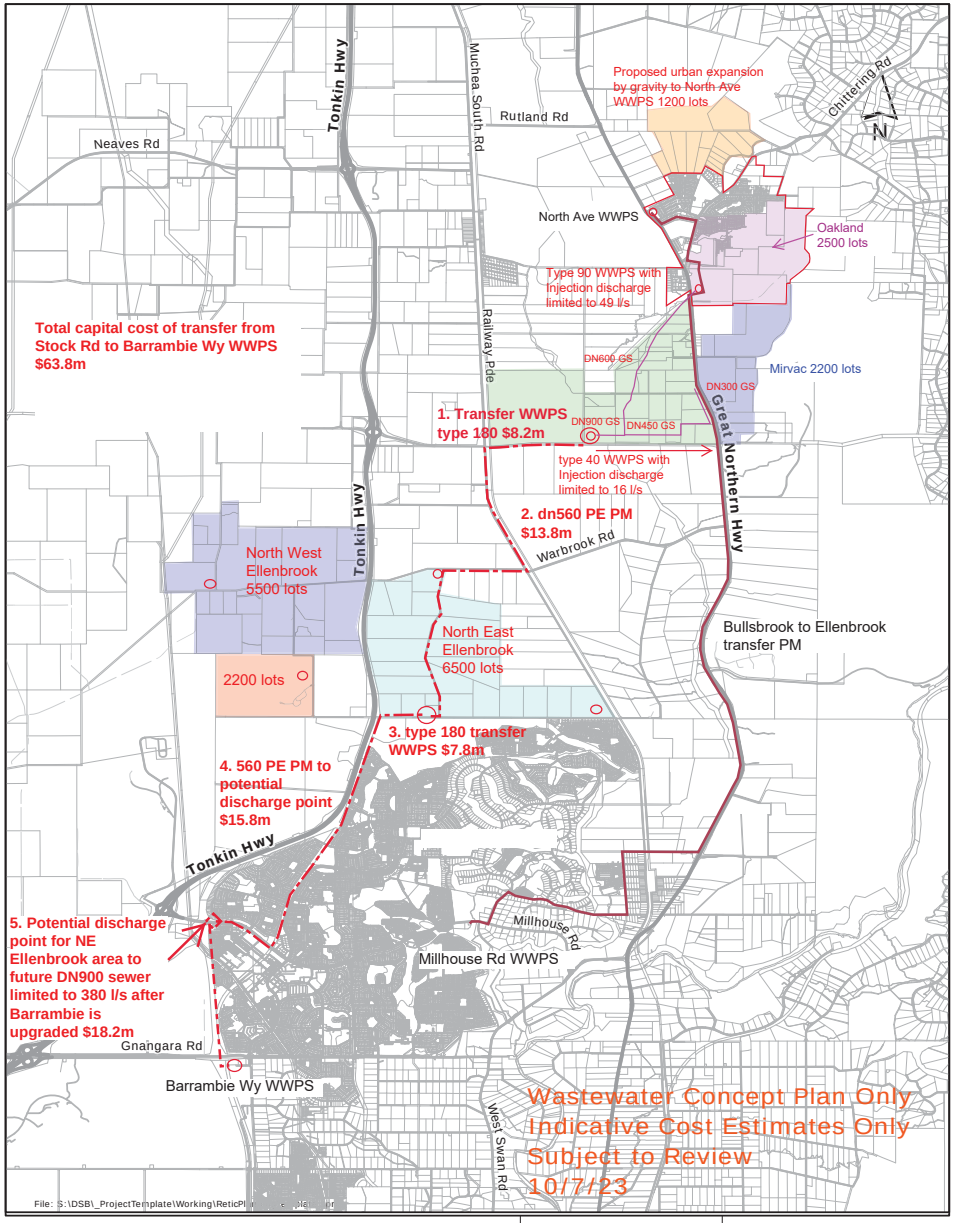


Figure Description

Figure No

Appendix Twelve: ATCO Gas Correspondence

Brianna Newnham

From: Hoyne, Ben <Ben.Hoyne@atco.com>
Sent: Tuesday, 3 May 2022 12:24 PM
To: Philip Patterson
Cc: Andrew Tucker; Mark Riddell; Cory Johnson; Maher, Lester
Subject: [External] ATCO Gas Australia - Cost Estimate - Bullsbrook South Precinct

CAUTION: This email originated from outside of the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Hi Philip

Once again, thank you for your enquiry in respect to reticulating gas at the proposed Bullsbrook South Precinct.

In order for the future development to have access to Natural Gas, an approx 10km network mains extension is required – high level details of which are listed below:

Scope of works

- Network tie-in at Apple Street, Upper Swan and, Rail Crossing (ARC)
- 850m x DN225PE Apple Street to Great Norther Hwy
- 9,000m x DN225PE from junction of Apple Street & Great Norther High Way to junction of Great Northern Hwy & Lage Road, Bullsbrook
- Installation methodology = Horizontal Directional Drilling (HDD)
- 500m x Open Cut in road reserve
- 500m x Open Cut in verge

Cost Estimate - - (*subject to ATCO Gas Australia Exec approval)

- *$4,300,000 exc GST

If you require any further information to support the projects feasibility study/ due diligence stage, please reach out.

Look forward to hearing back from you in due course.

Best regards,
Ben

Benjamin Hoyne
Business Development Manager
ATCO, Gas Division, Australia

P. +61 8 6163 5061 **M.** +61 419 787 599
A. 81 Prinsep Road, Jandakot, Western Australia, 6164
atco.com.au Facebook Twitter LinkedIn

ATCO acknowledges Aboriginal people as the Traditional Custodians of country throughout Australia including Torres Strait Islander peoples.
We pay respect to their cultures, Elders past and present, and in the spirit of reconciliation, we commit to working together for our shared future.

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Appendix Thirteen: Existing Western Power Infrastructure

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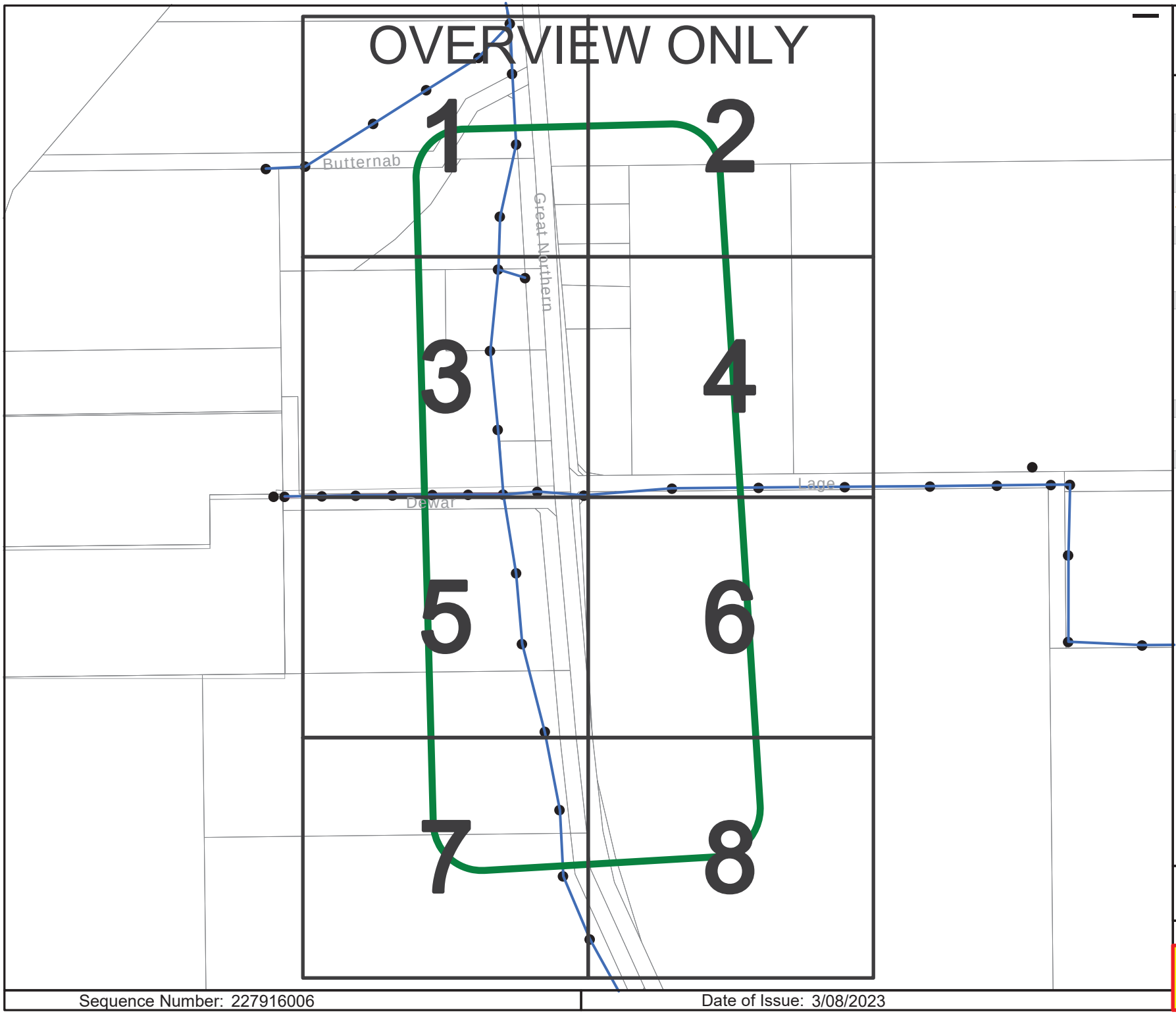

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OVERHEAD LEGEND

Structures

& Power Pole " Transmission Poles

Transmission Overhead Powerline

Transmission (33kV - 330kV)

Distribution Overhead Powerline

High Voltage (1kV - 33kV)

Low Voltage (< 1kV)

Proposed Construction Assets

Design Area *

High Voltage Overhead Powerline

Low Voltage Overhead Powerline

Power Pole

Communications Assets

Overhead Pilot Cable

Feature

Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Check that you have enough clearance from the DANGER ZONES near overhead powerlines.

Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

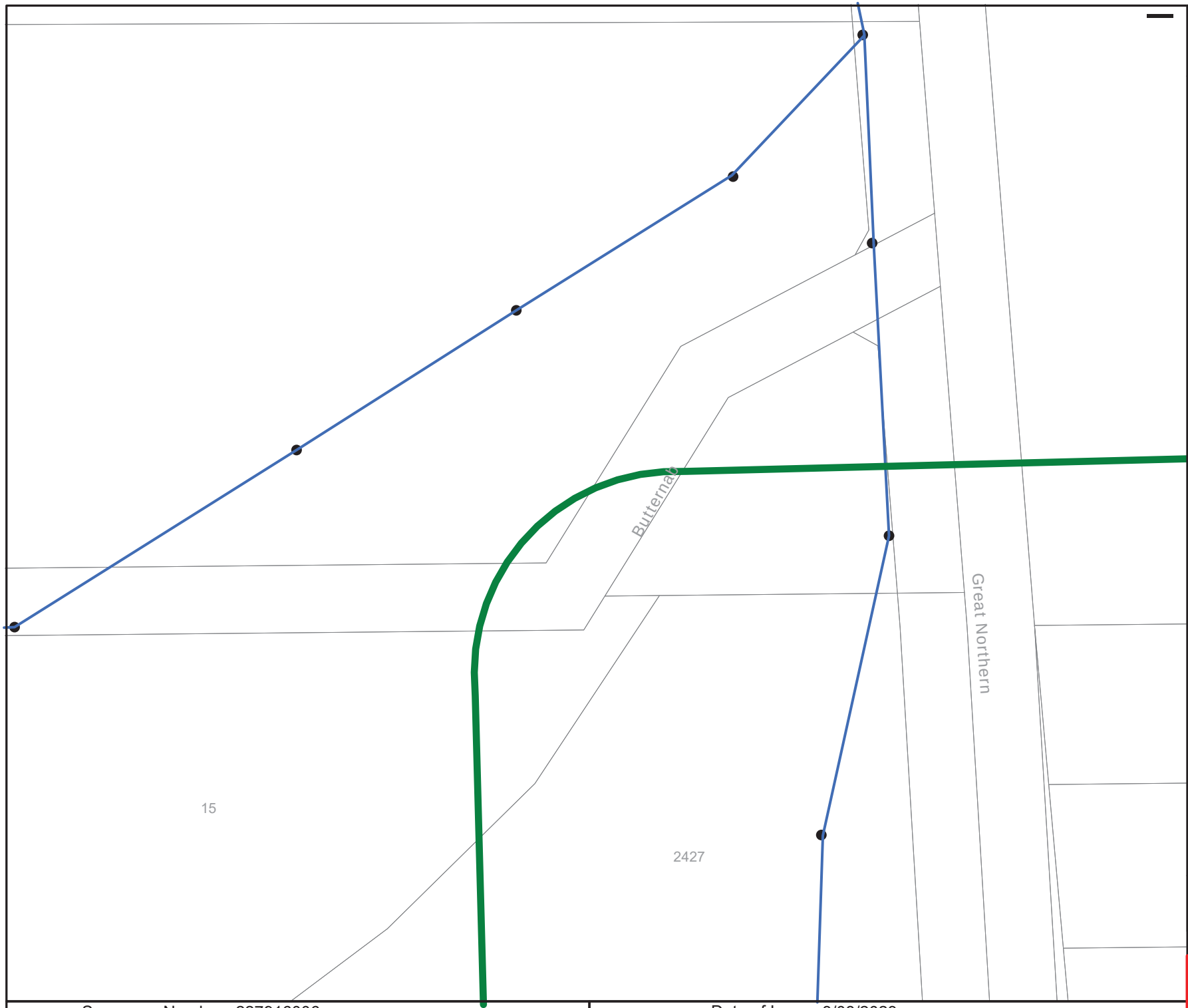
Information valid for 30 days from date of issue

A4 | Scale : 1:6150

WARNING! Look out for overhead power lines

Sequence Number: 227916006

Date of Issue: 3/08/2023



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OVERHEAD LEGEND

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Distribution Overhead Powerline

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Power Pole

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Feature

Area of Interest

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A4 | Scale : 1:1500

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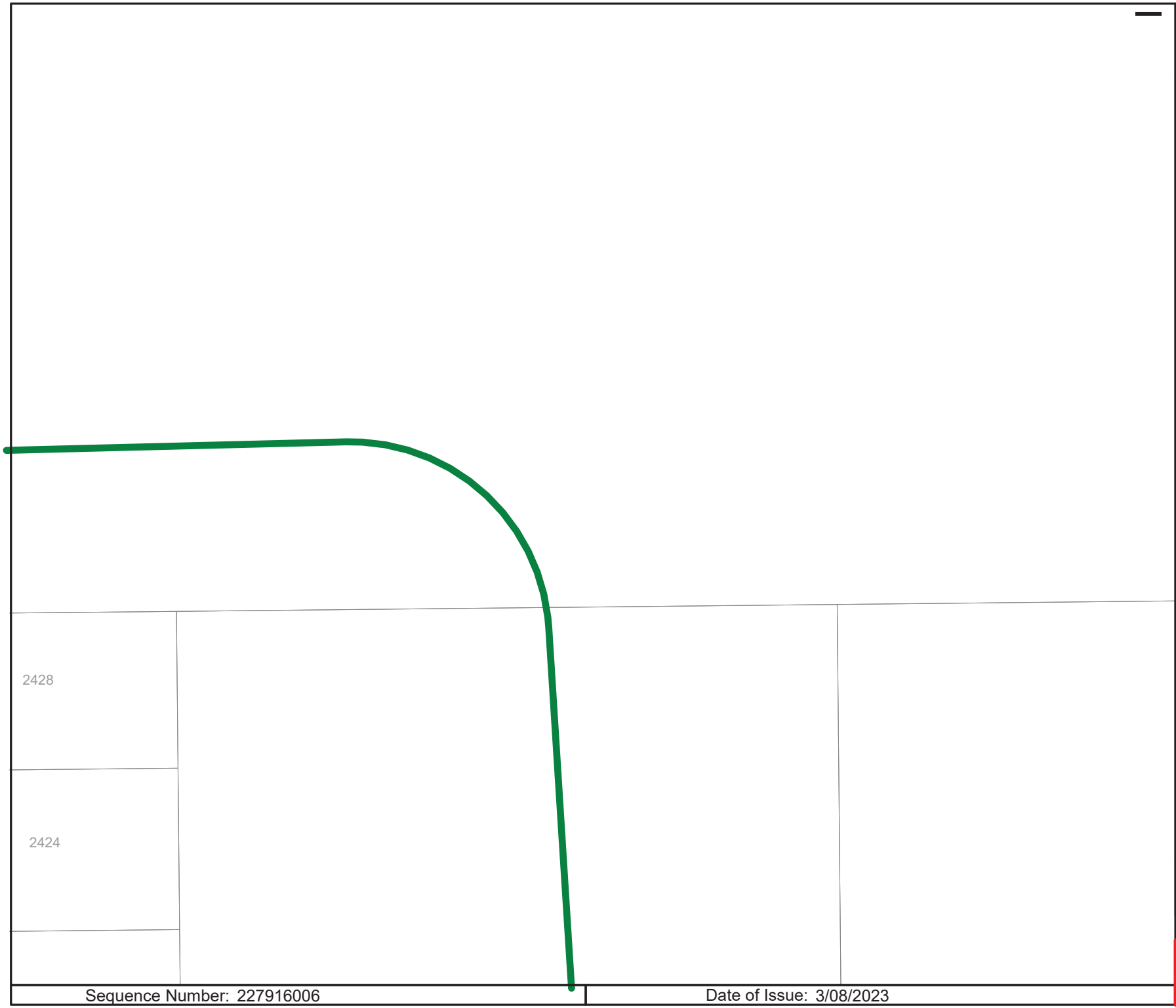
Sequence Number: 227916006 | Date of Issue: 3/08/2023



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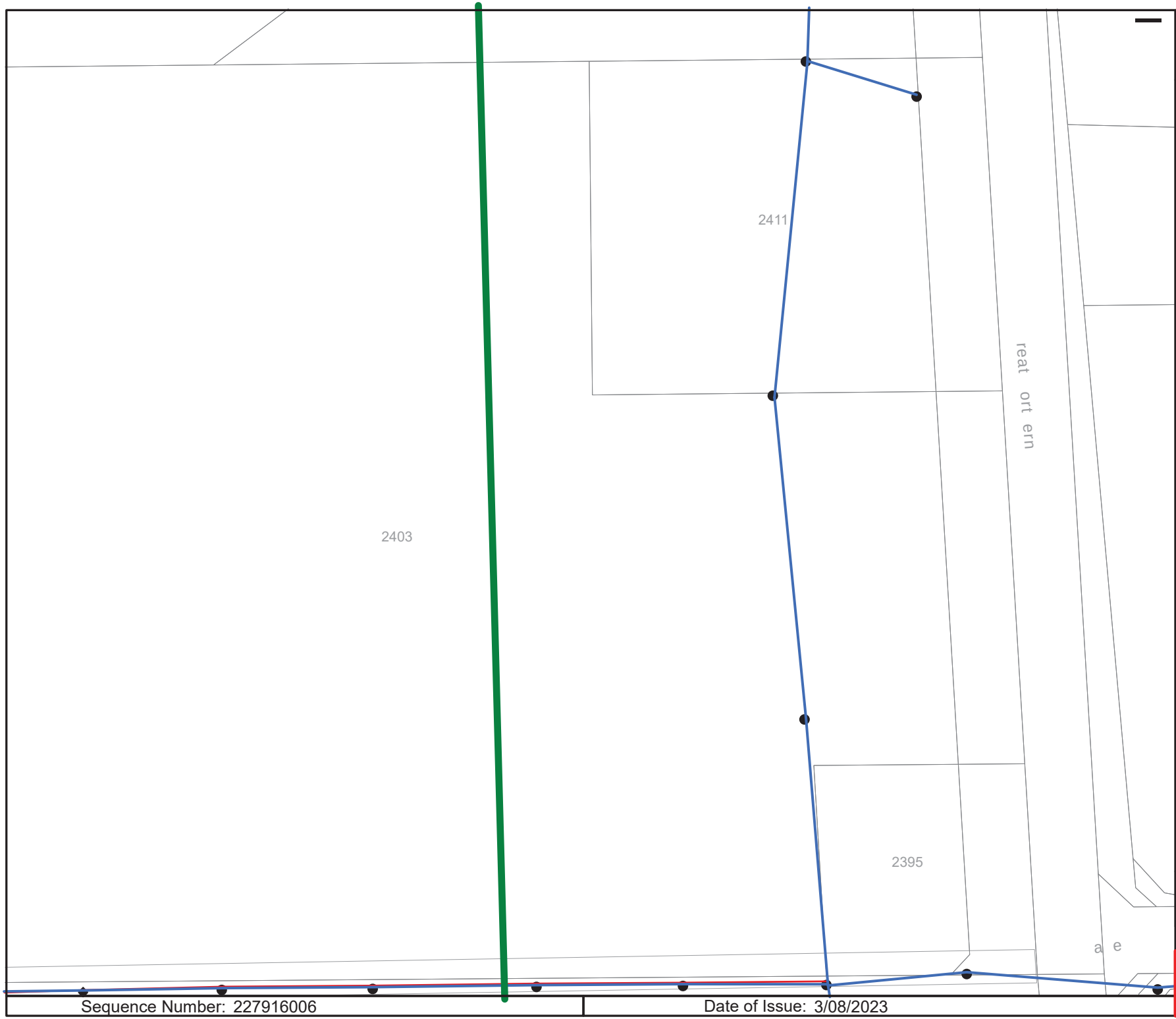

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Feature

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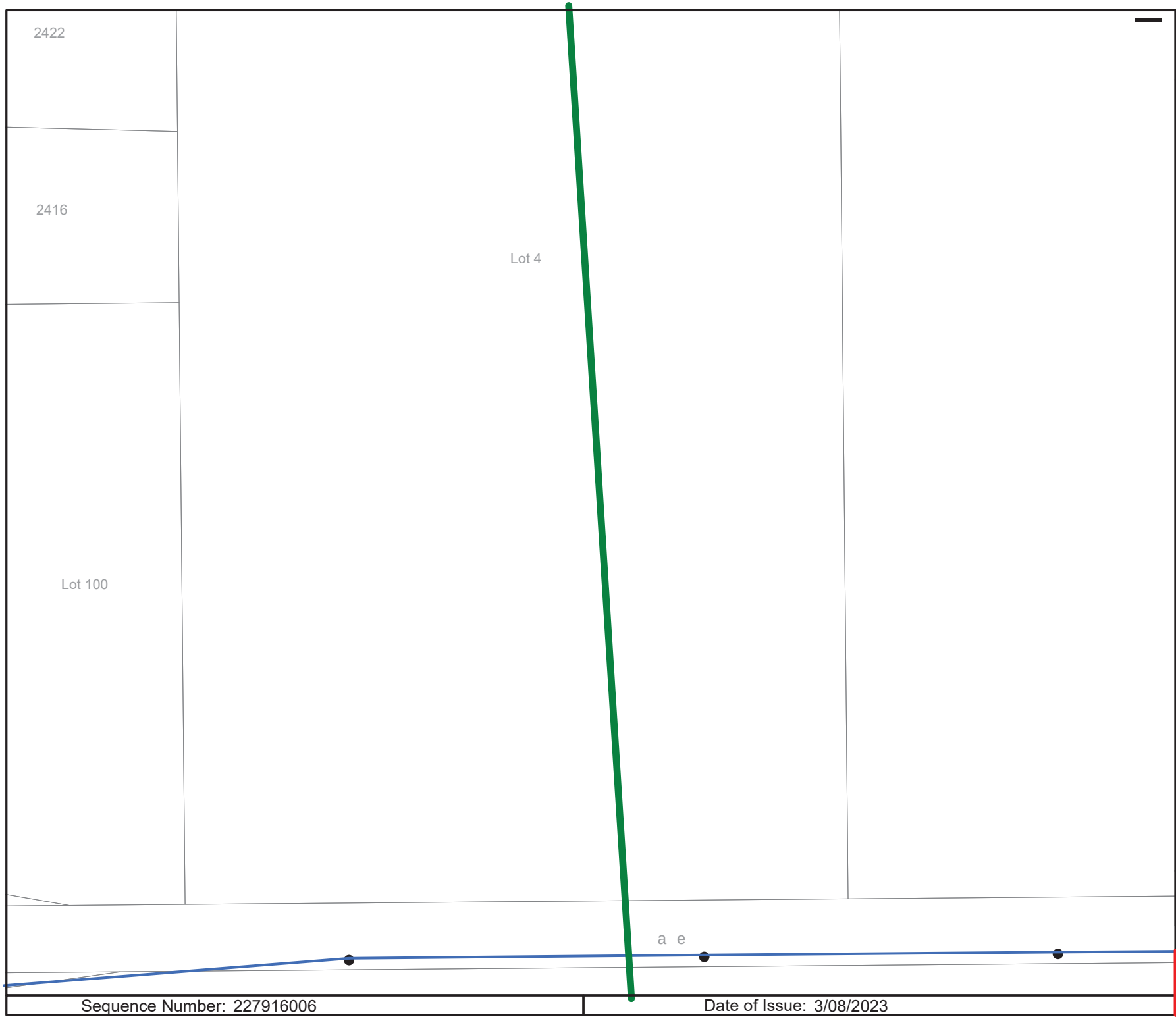

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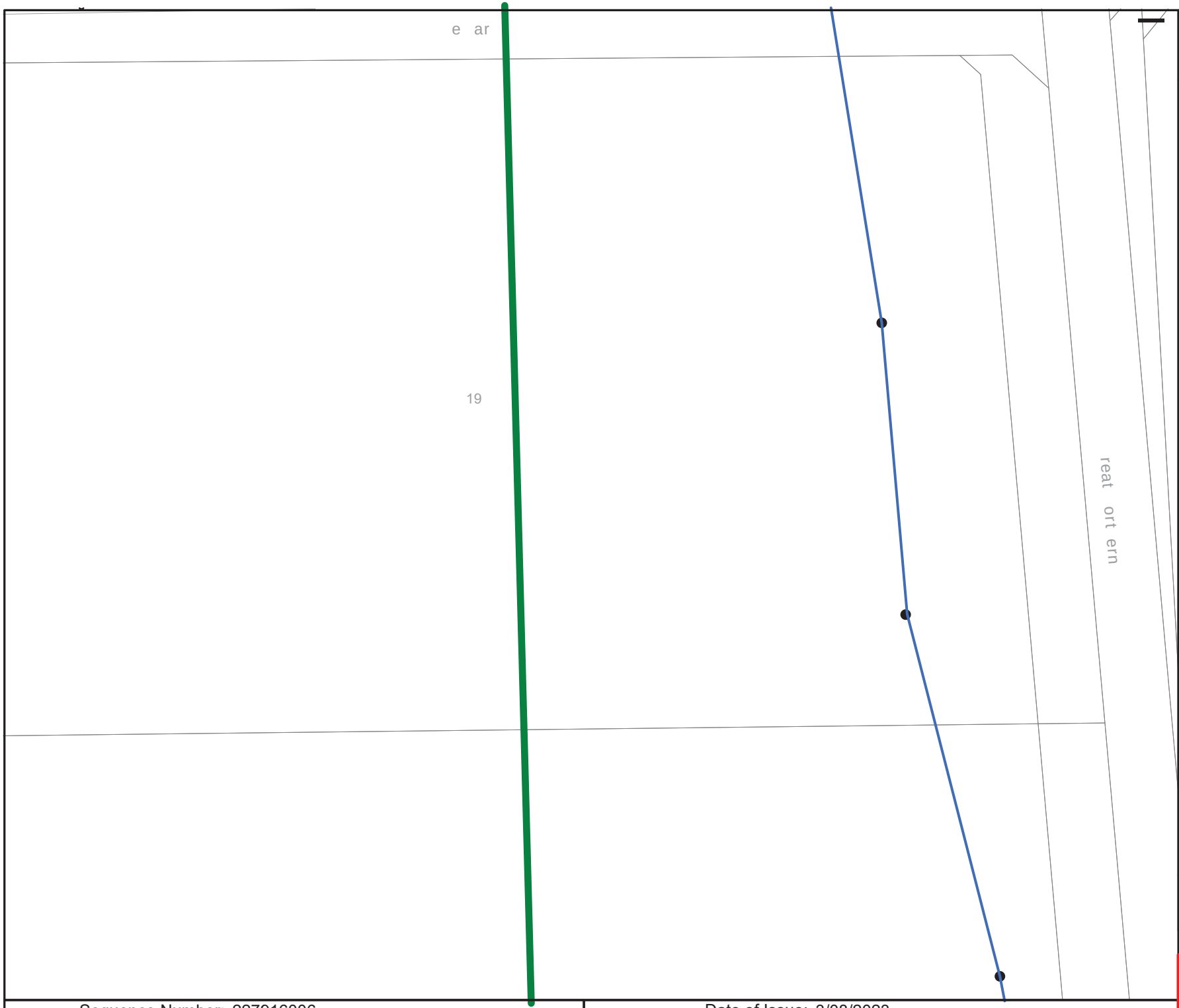

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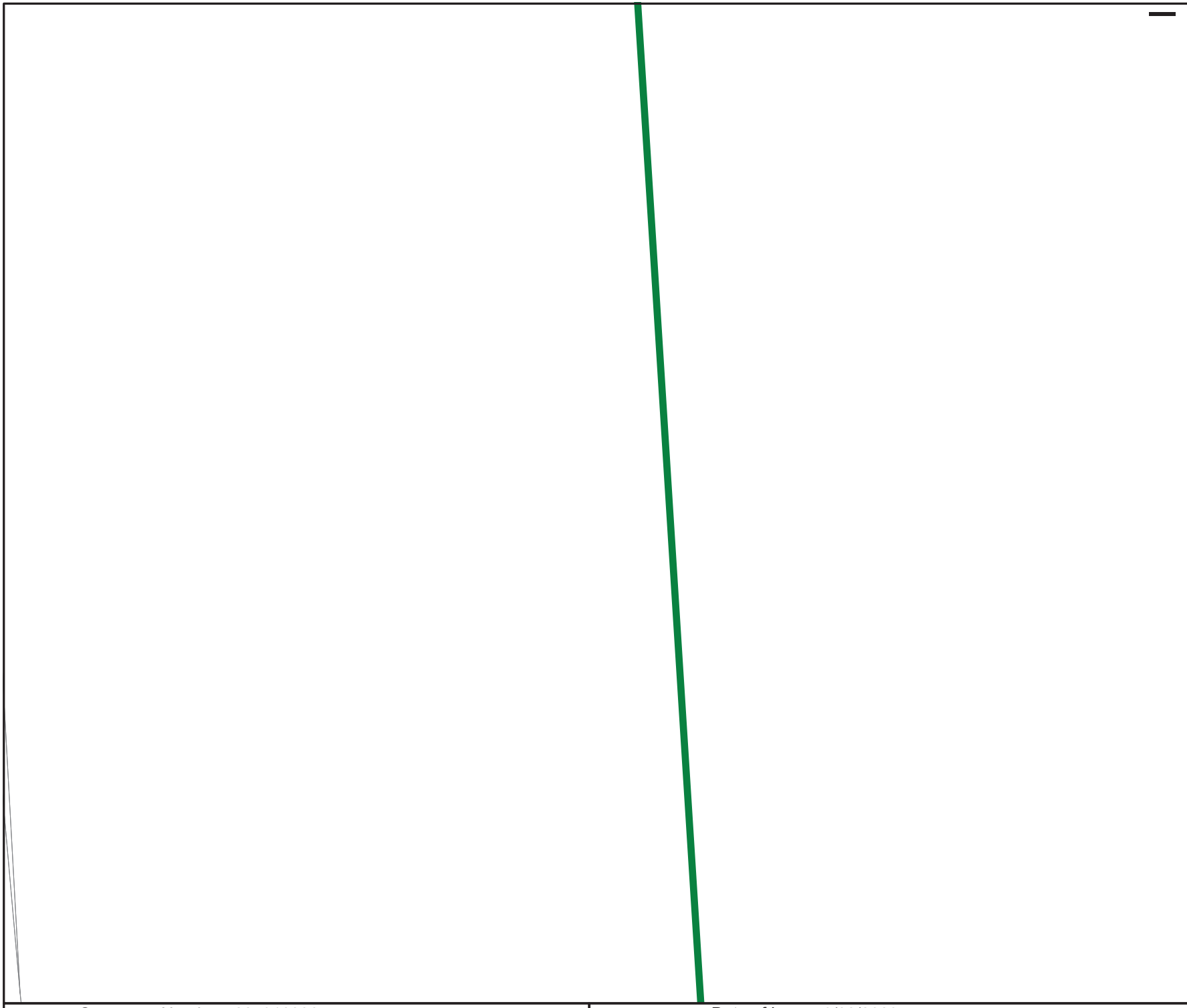

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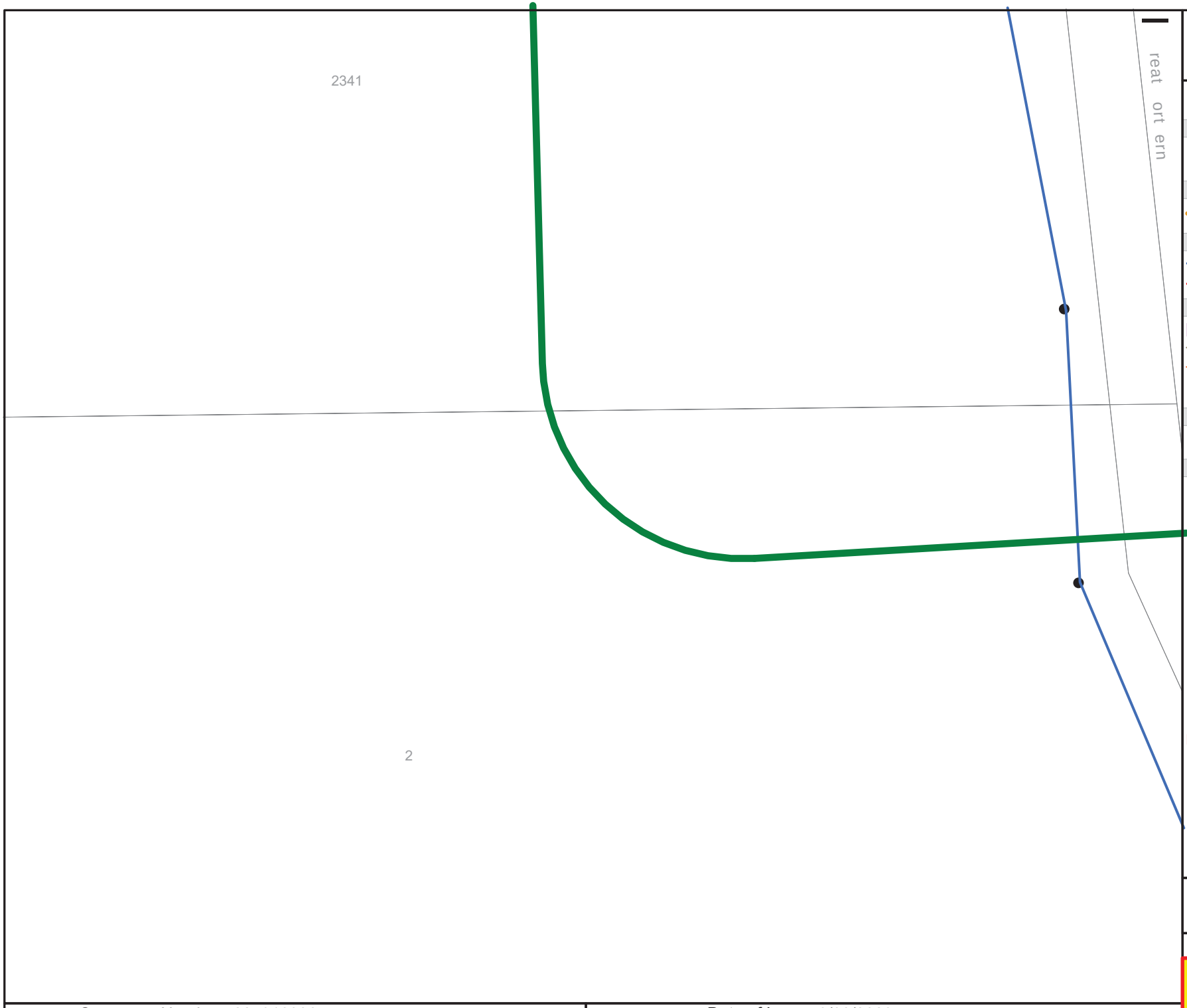

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OVERHEAD LEGEND

Structures

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Telephone Support: 1300 769 345
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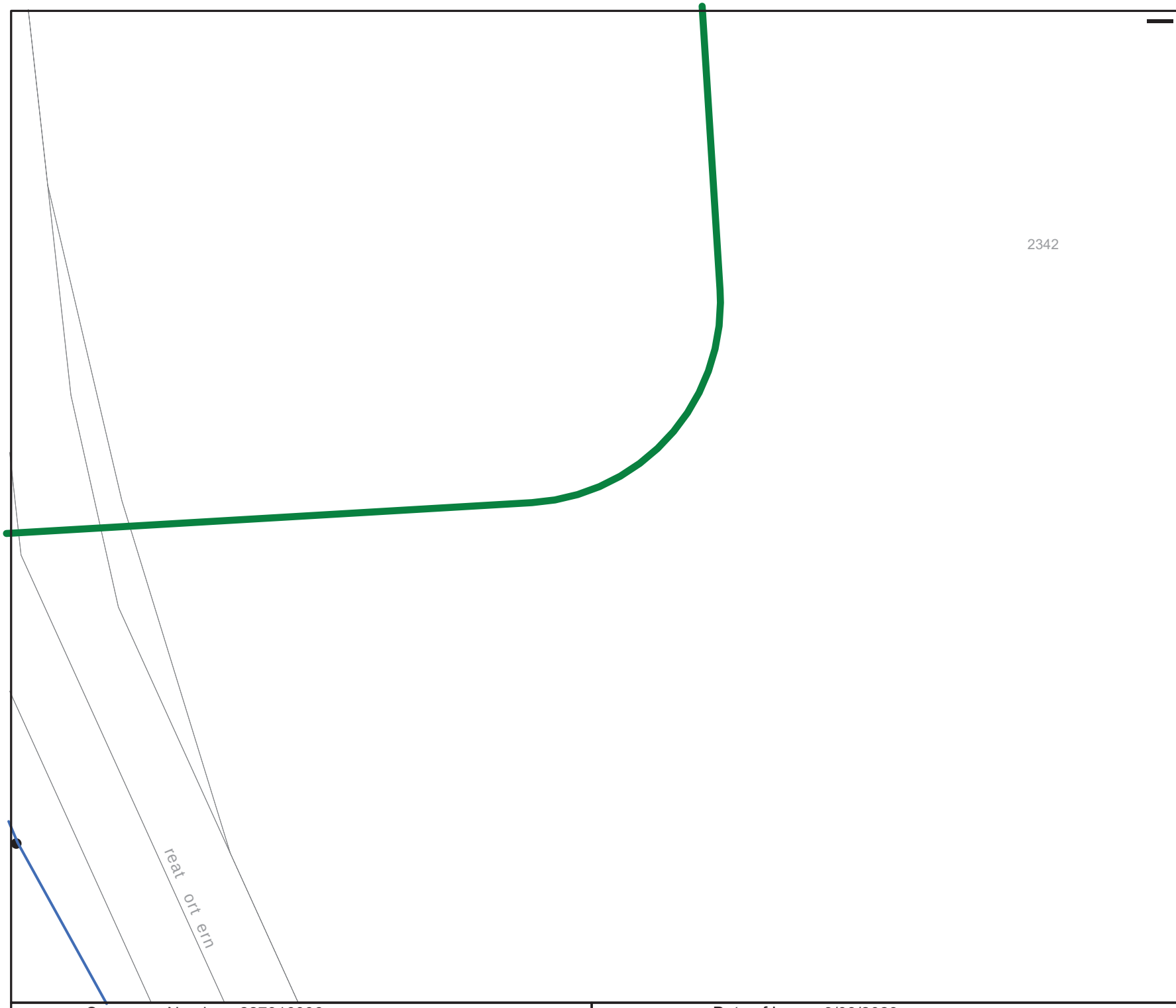

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OVERHEAD LEGEND

Structures

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Communications Assets

Overhead Pilot Cable

Feature

Area of Interest

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Mon to Fri - 08:00 to 16:30

Information valid for 30 days from date of issue

A4 | Scale : 1:1500

WARNING! Look out for overhead power lines

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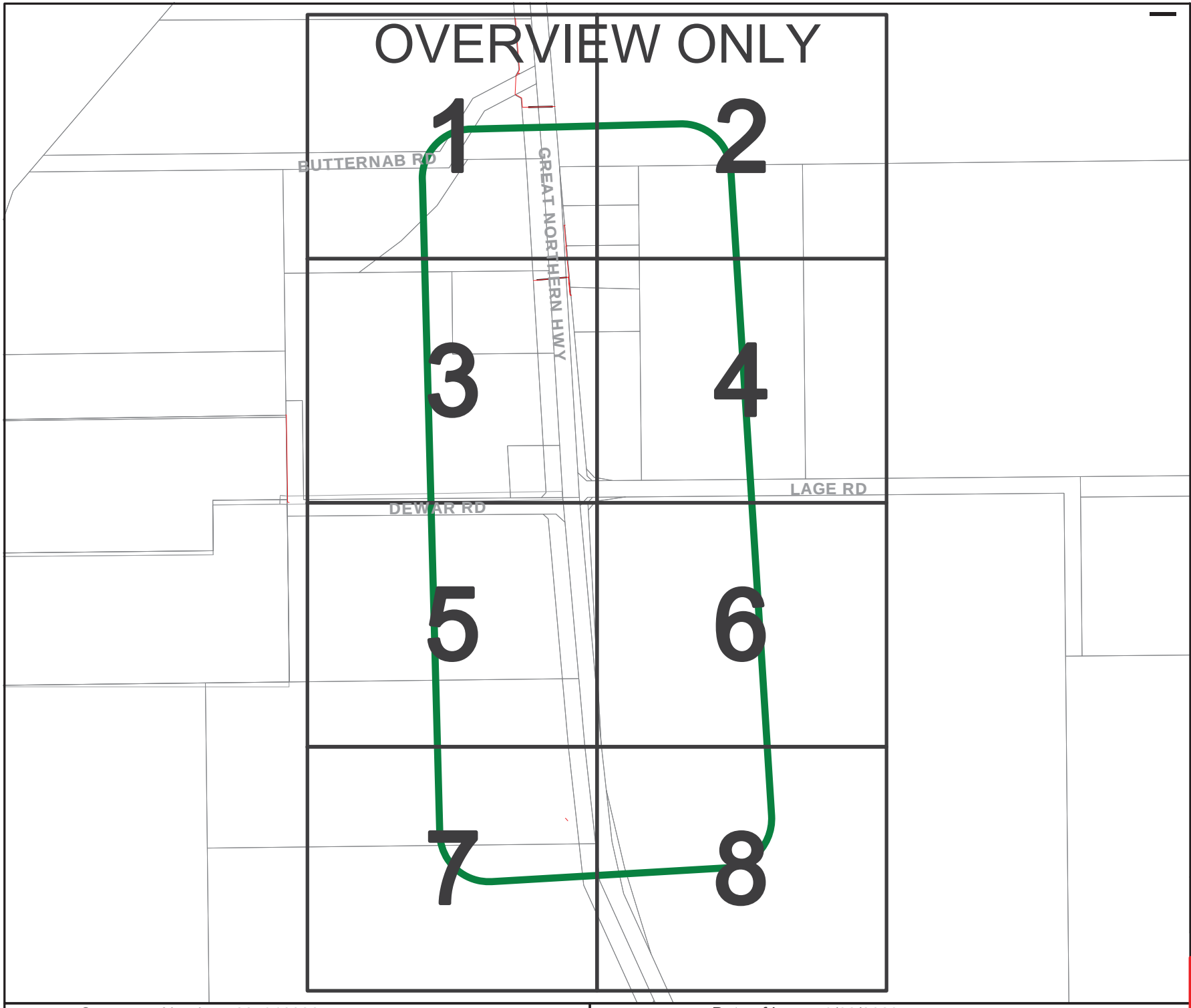


westernpower

UNDERGROUND LEGEND

Structures

- P Pillar
- & Metal Pole
- # Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- 0 HV Termination
- # LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- & Metal Pole
- 0 HV Termination
- P Pillar
- # LV Termination
- Transformer site

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Hand exposure via pothole method is MANDATORY.

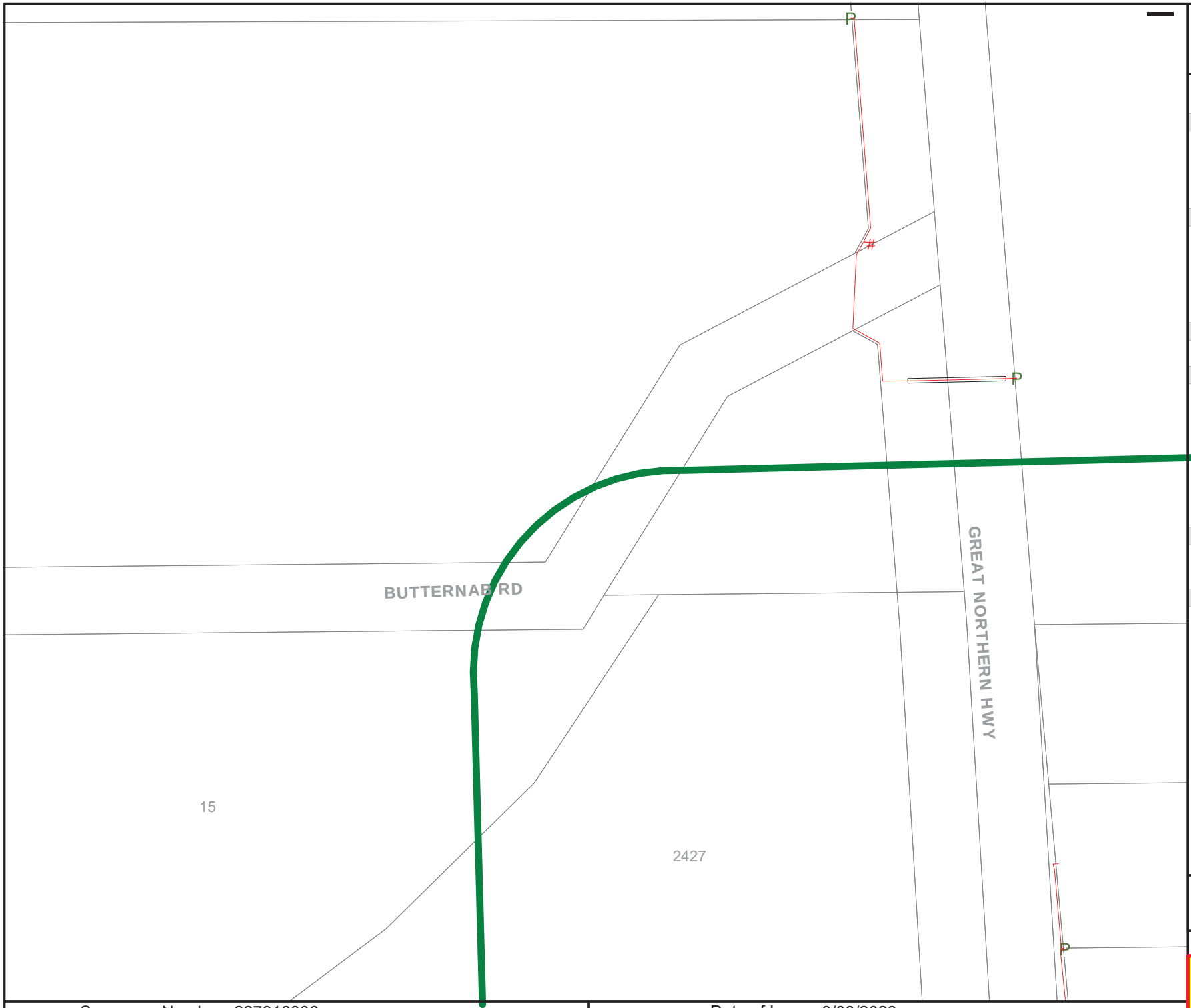
Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days from date of issue

A4 | Scale : 1:6150

WARNING! Look out for overhead power lines

Sequence Number: 227916006 | Date of Issue: 3/08/2023



westernpower

UNDERGROUND LEGEND

Structures

- P Pillar
- & Metal Pole
- # Transformer Site
- UG Crossing *
- Ring Main Unit
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Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

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- # LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- & Metal Pole
- P Pillar
- Transformer site
- 0 HV Termination
- # LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Hand exposure via pothole method is MANDATORY.

Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days from date of issue

A4	Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 227916006

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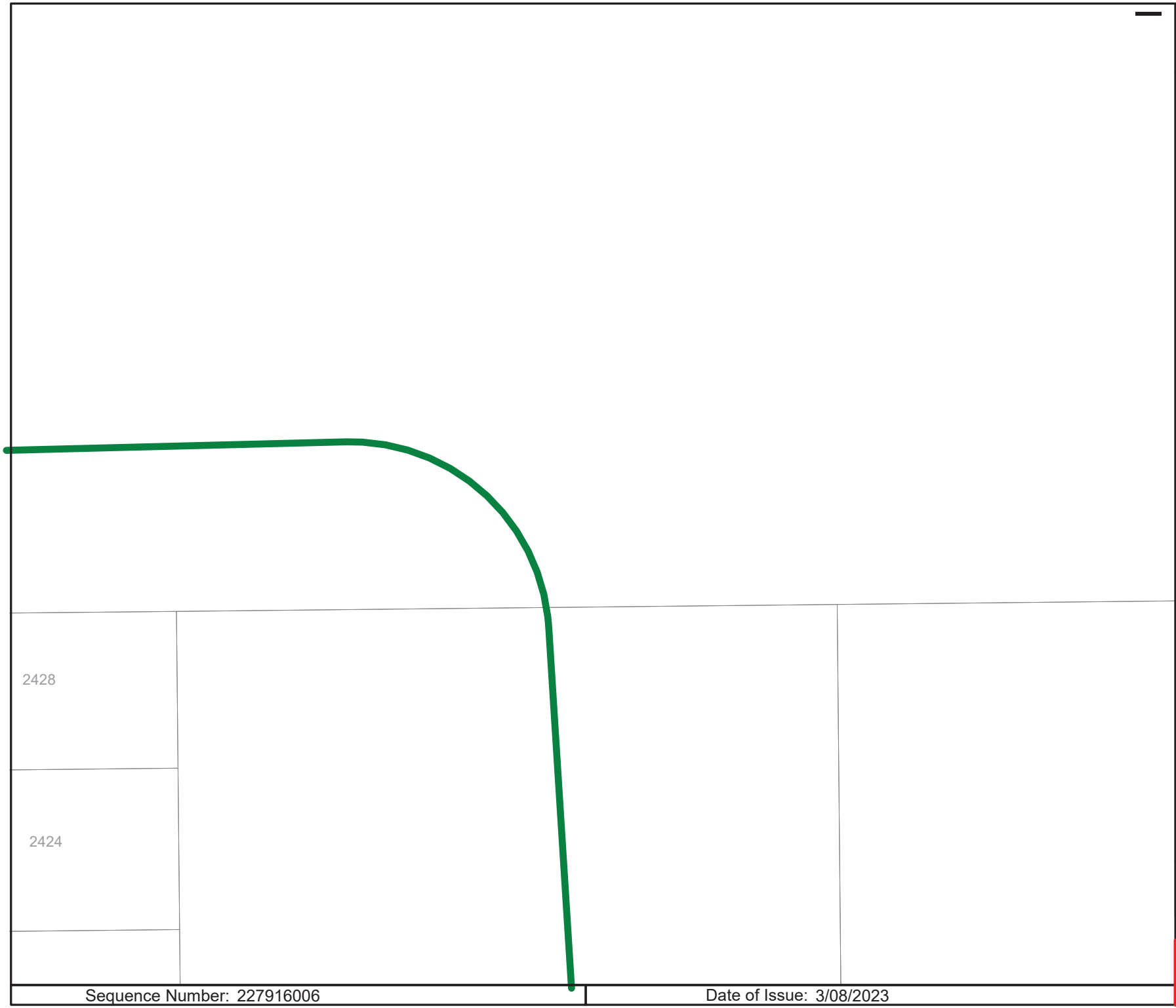

westernpower

UNDERGROUND LEGEND

Structures

- P Pillar
- & Metal Pole
- # Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- 0 HV Termination
- # LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- Metal Pole
- HV Termination
- Pillar
- LV Termination
- Transformer site

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

This map is INDICATIVE ONLY. Hand exposure via pothole method is MANDATORY.

Telephone Support: 1300 769 345
Mon to Fri - 08:00 to 16:30

Information valid for 30 days from date of issue

A4 | Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 227916006 | Date of Issue: 3/08/2023



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UNDERGROUND LEGEND

Structures

- P Pillar
- & Metal Pole
- # Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
- Low Voltage Cable (< 1kV)
- Street Light Circuit (< 1kV)
- Street Light Pilot (< 1kV)
- Earth Wire

Cable Pole Terminations

- 0 HV Termination
- # LV Termination

Proposed Construction Assets

- Design Area *
- High Voltage Underground Cable
- Low Voltage Underground Cable
- & Metal Pole
- 0 HV Termination
- P Pillar
- # LV Termination
- Transformer site

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

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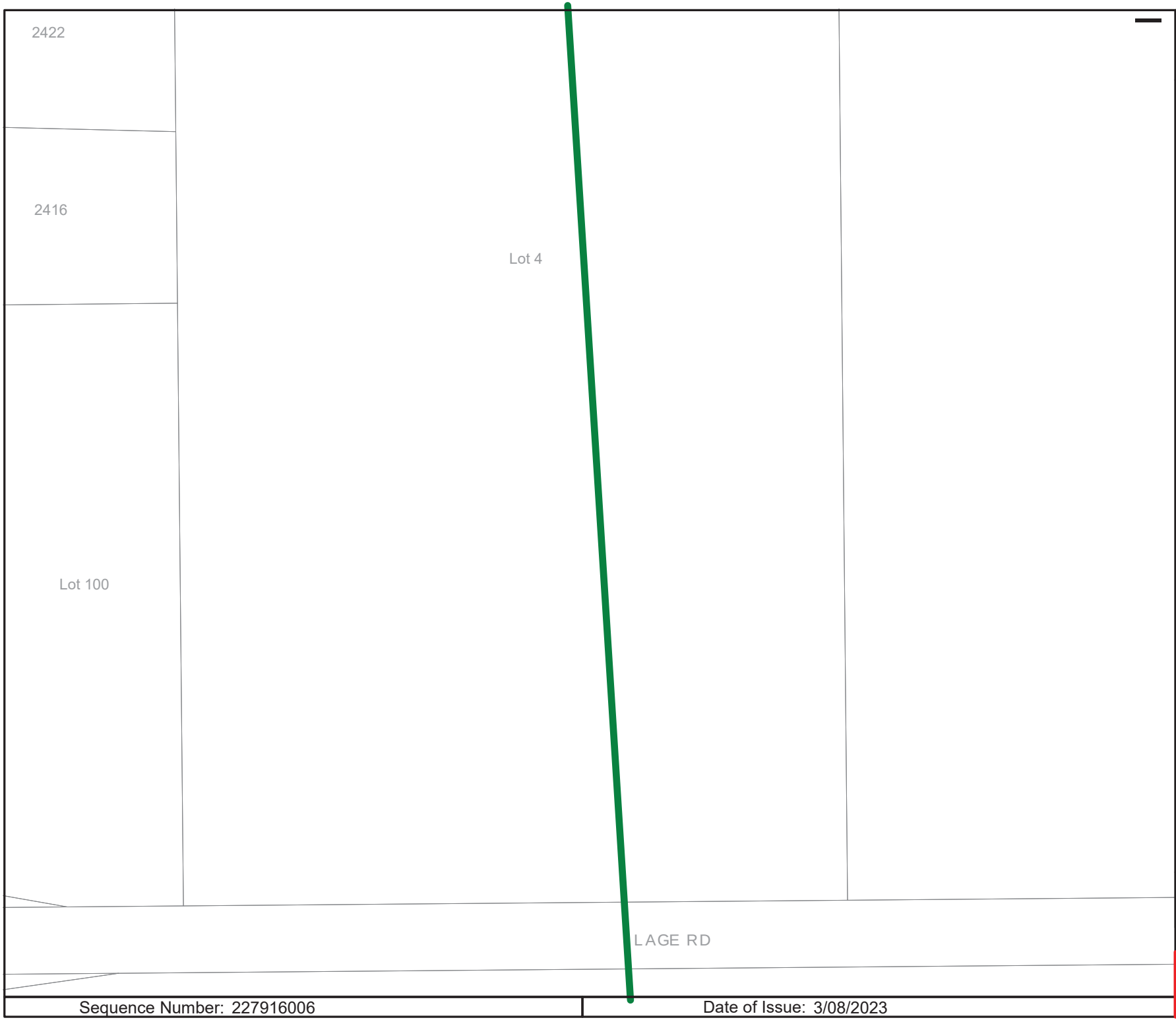
Sequence Number: 227916006 | Date of Issue: 3/08/2023



westernpower

UNDERGROUND LEGEND

Structures

- P Pillar
- & Metal Pole
- # Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

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- Low Voltage Cable (< 1kV)
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- Low Voltage Underground Cable
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- P Pillar
- # LV Termination
- Transformer site

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

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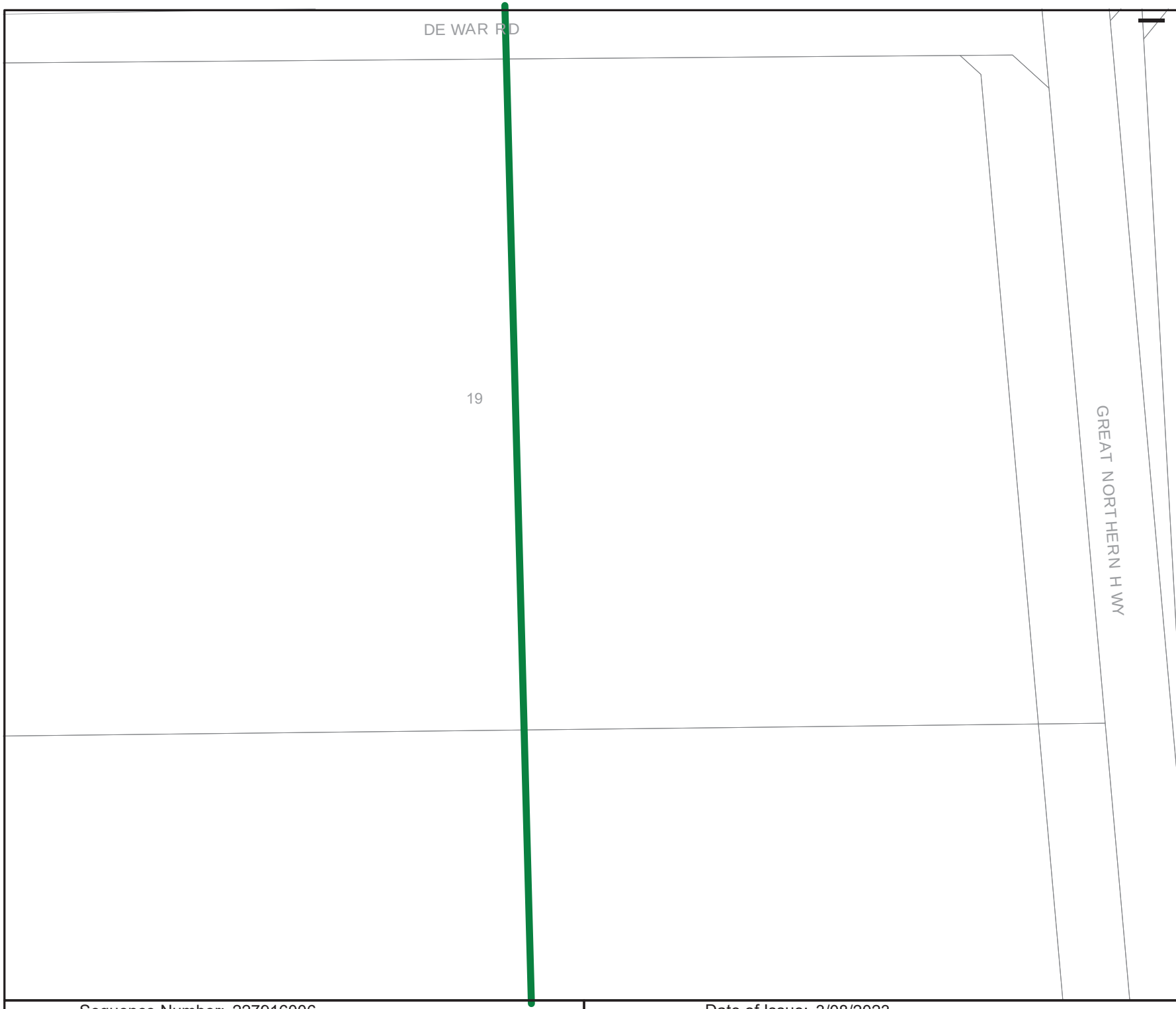

westernpower

UNDERGROUND LEGEND

Structures

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- # Transformer Site
- UG Crossing *
- Ring Main Unit
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Distribution Cables

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State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

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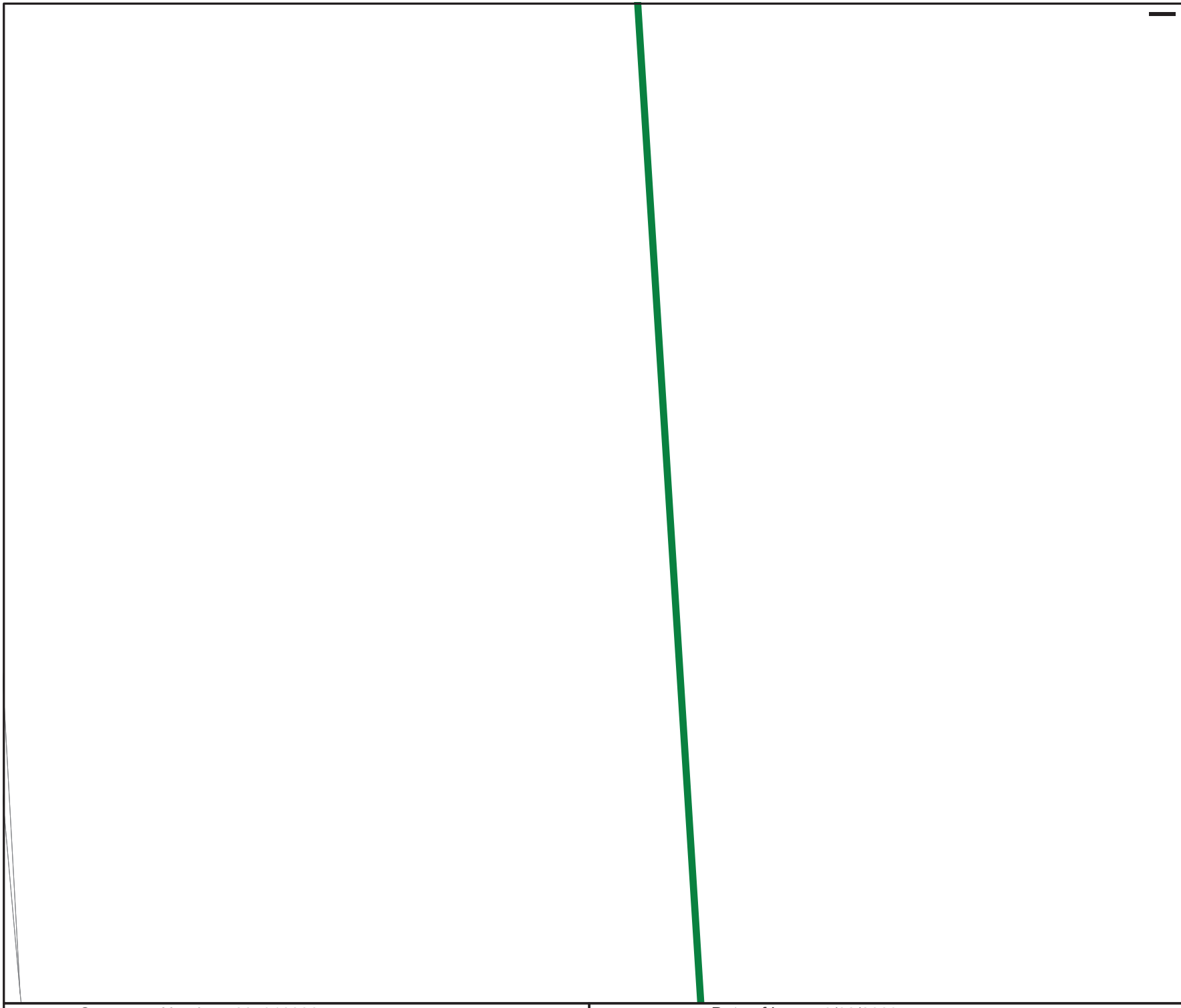

westernpower

UNDERGROUND LEGEND

Structures

- P Pillar
- & Metal Pole
- # Transformer Site
- UG Crossing *
- Ring Main Unit
- LV Distribution Frame

Distribution Cables

- High Voltage Cable (1kV - 33kV)
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- Low Voltage Underground Cable
- & Metal Pole
- 0 HV Termination
- P Pillar
- # LV Termination
- Transformer site

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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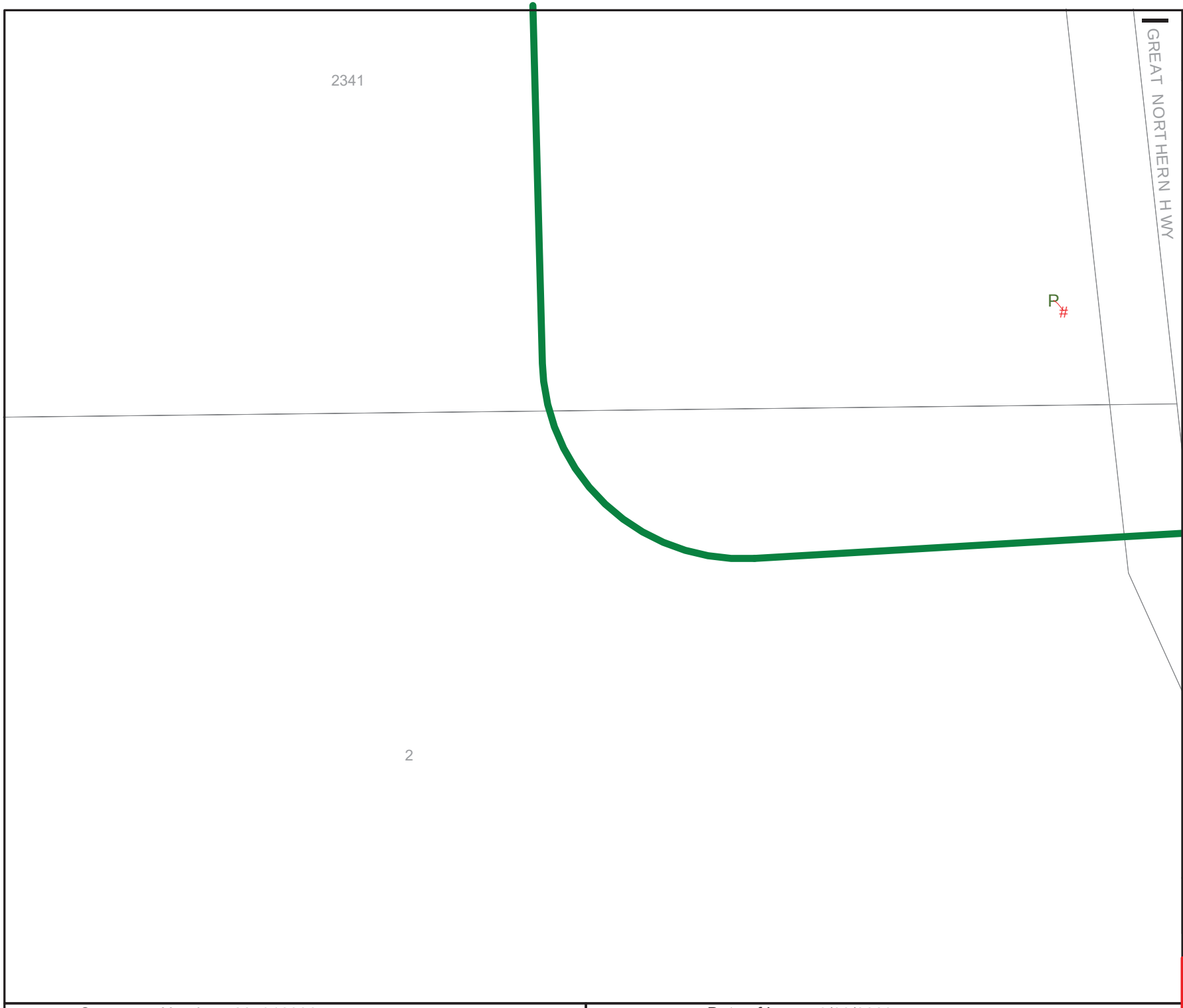

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UNDERGROUND LEGEND

Structures

- P Pillar
- & Metal Pole
- # Transformer Site
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- Low Voltage Underground Cable
- & Metal Pole
- P Pillar
- Transformer site
- 0 HV Termination
- # LV Termination

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

*** Please refer to coversheet**

Privately owned cables NOT SHOWN (including house services)

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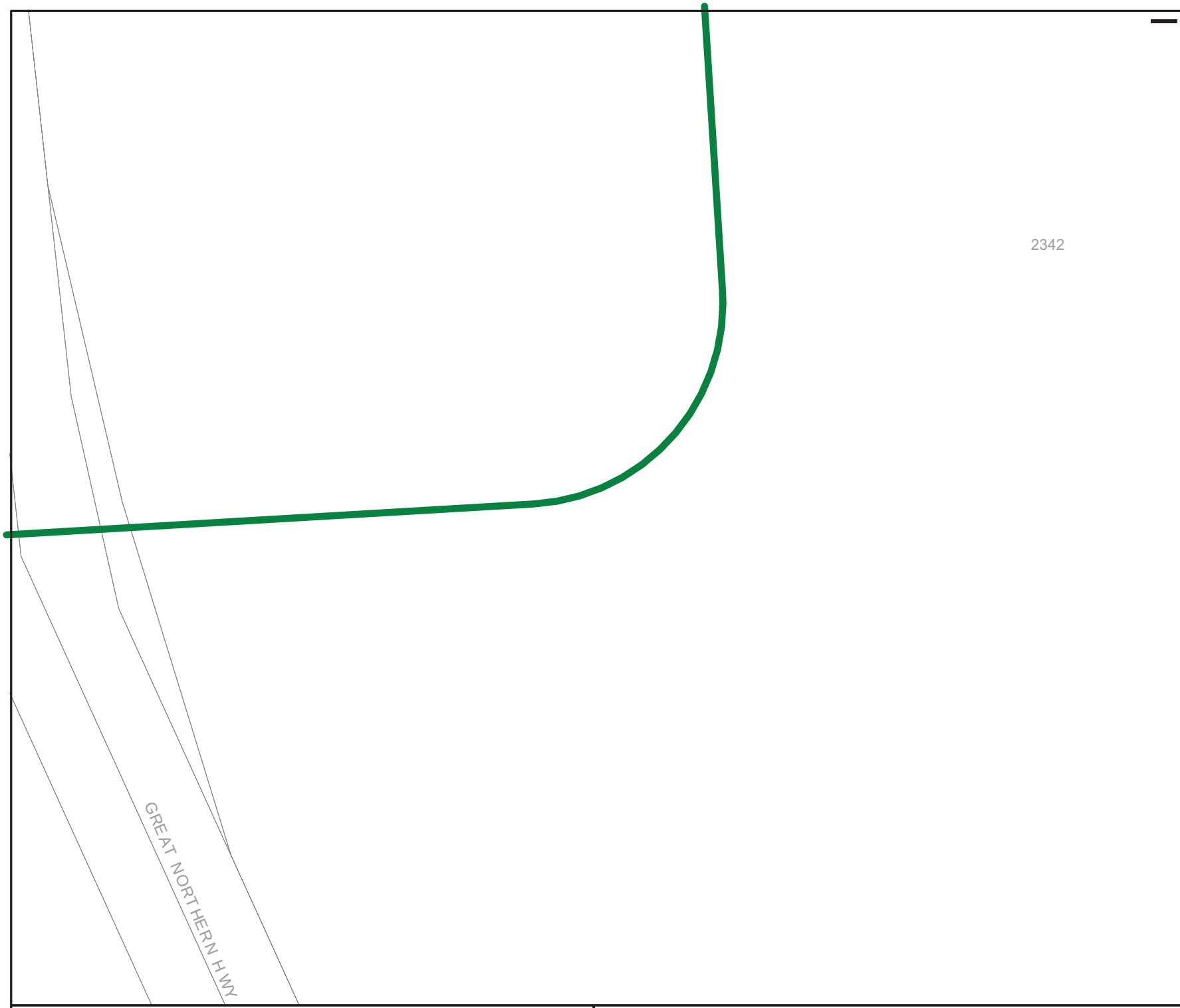

westernpower

UNDERGROUND LEGEND

Structures

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- & Metal Pole
- # Transformer Site
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- Ring Main Unit
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Distribution Cables

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Cable Pole Terminations

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- # LV Termination

Proposed Construction Assets

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- Low Voltage Underground Cable
- & Metal Pole
- 0 HV Termination
- P Pillar
- # LV Termination
- Transformer site

State Underground Power Project

- CURRENT Work Area *
- COMPLETED Area *

Feature

- Area of Interest

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A4 | Scale : 1:1500

WARNING! Look out for overhead power lines

Sequence Number: 227916006 | Date of Issue: 3/08/2023

Appendix Fourteen: Existing Communication and Fibre Infrastructure

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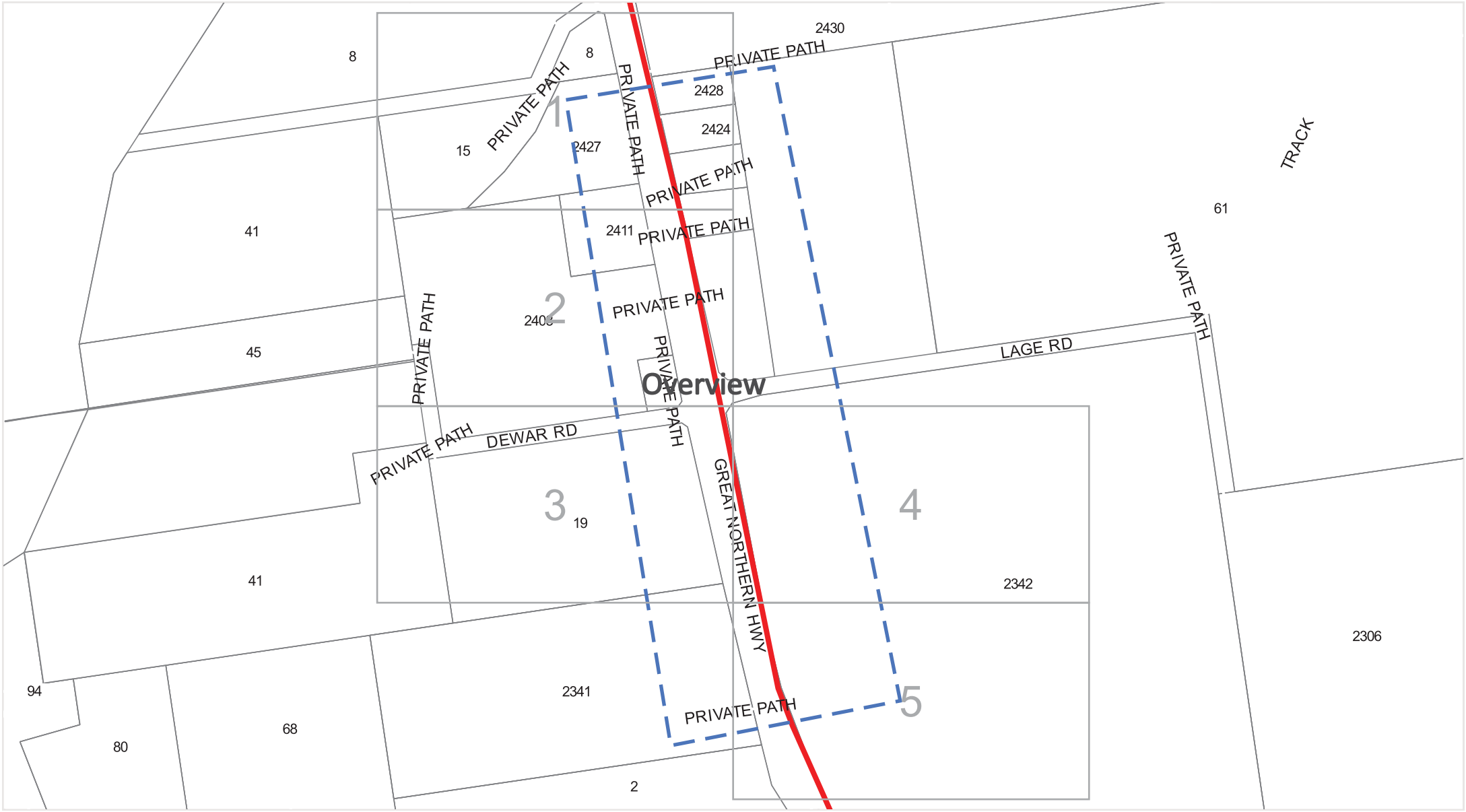
aarnet
Australia's Academic and Research Network

Sequence No: 227916004
Job No: 34760476
Location: 2395 Great Northern Highway, Bullsbrook, WA 6084

DIAL BEFORE YOU DIG www.1100.com.au
The Essential First Step.



Legend | Scale: 1:6150

N

- Enquiry Area
- AARNet Fibre Optic Assets
- AARNet Power Assets
- Cadastre

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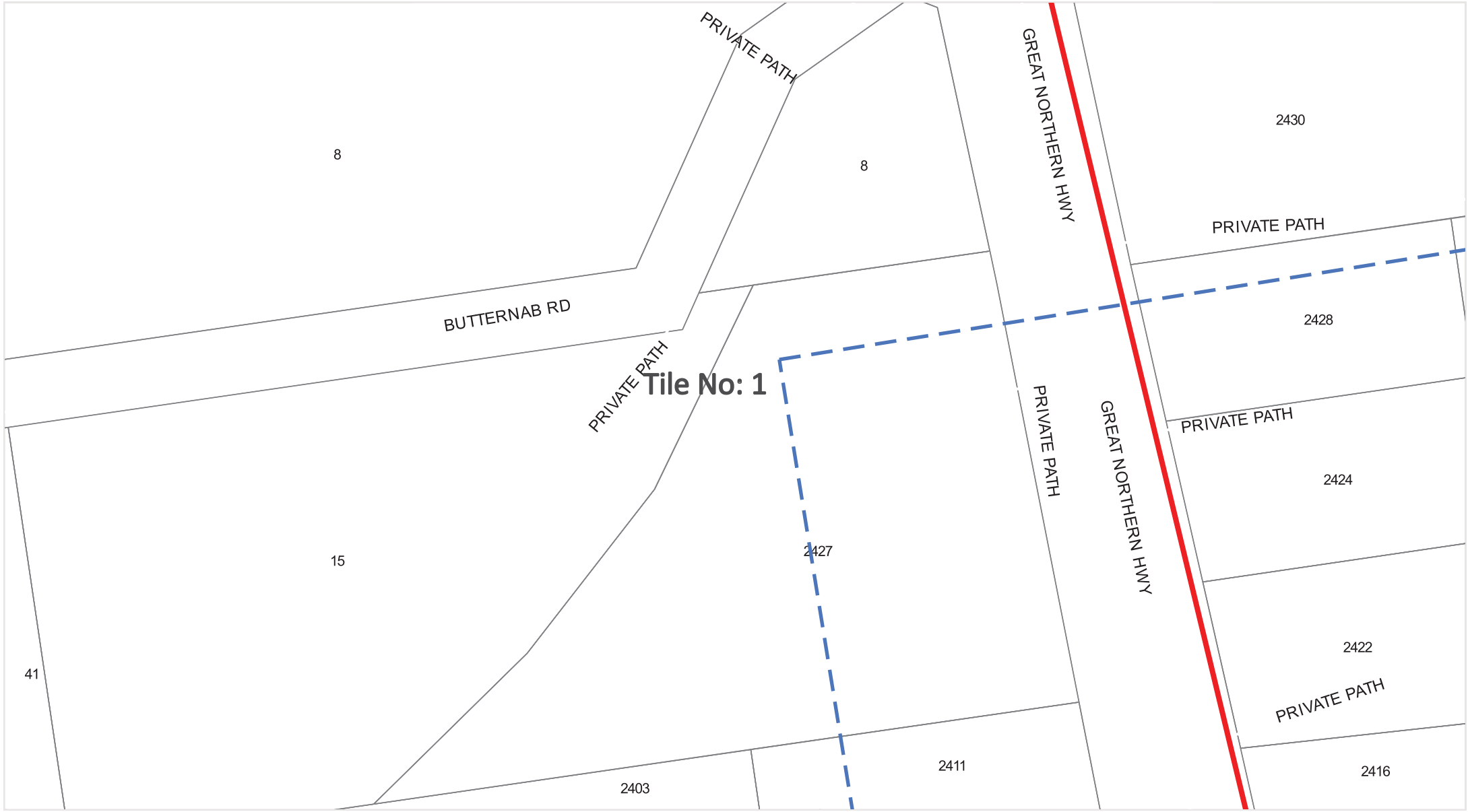

Legend | Scale: 1:1500

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Legend | Scale: 1:1500

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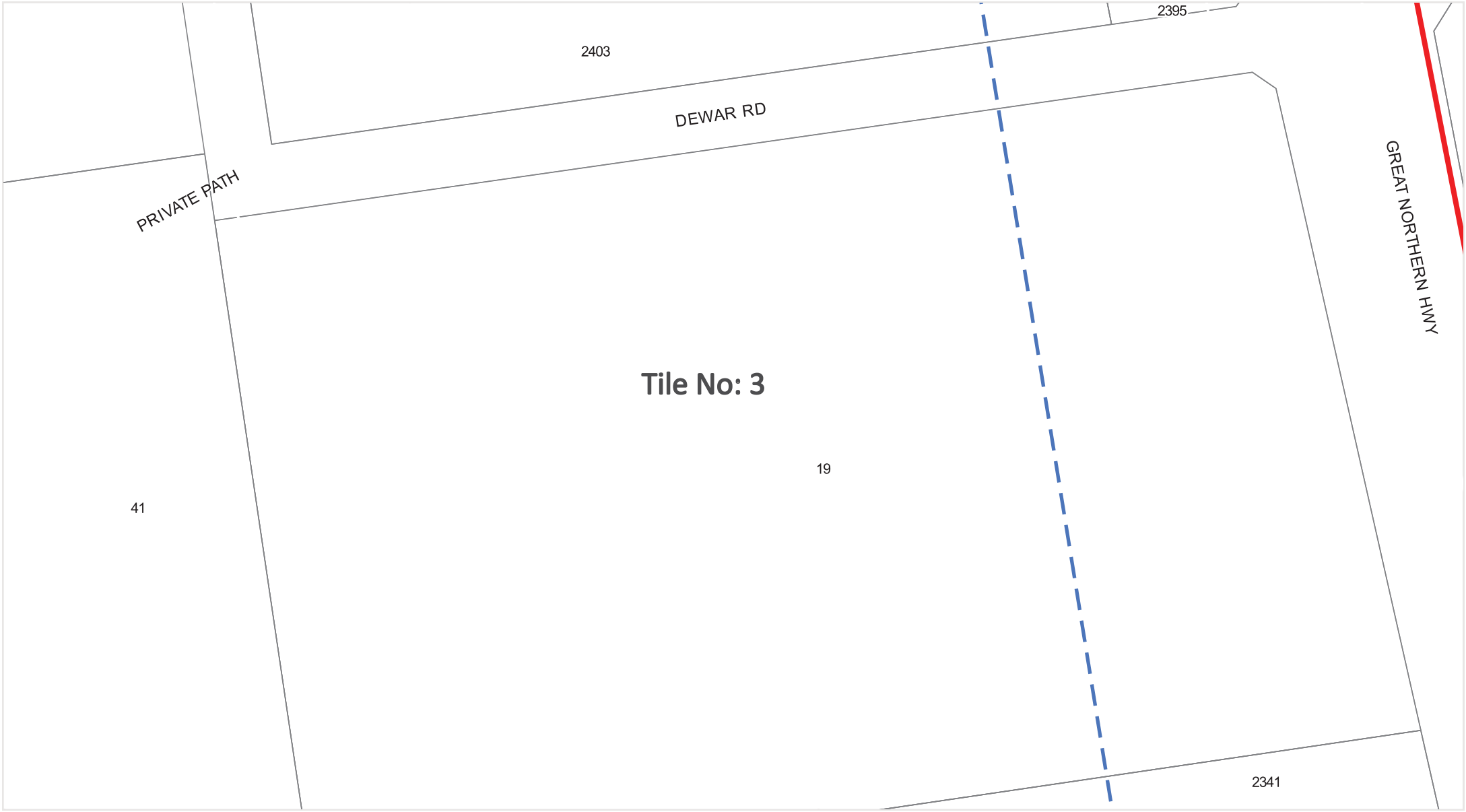

Legend | Scale: 1:1500

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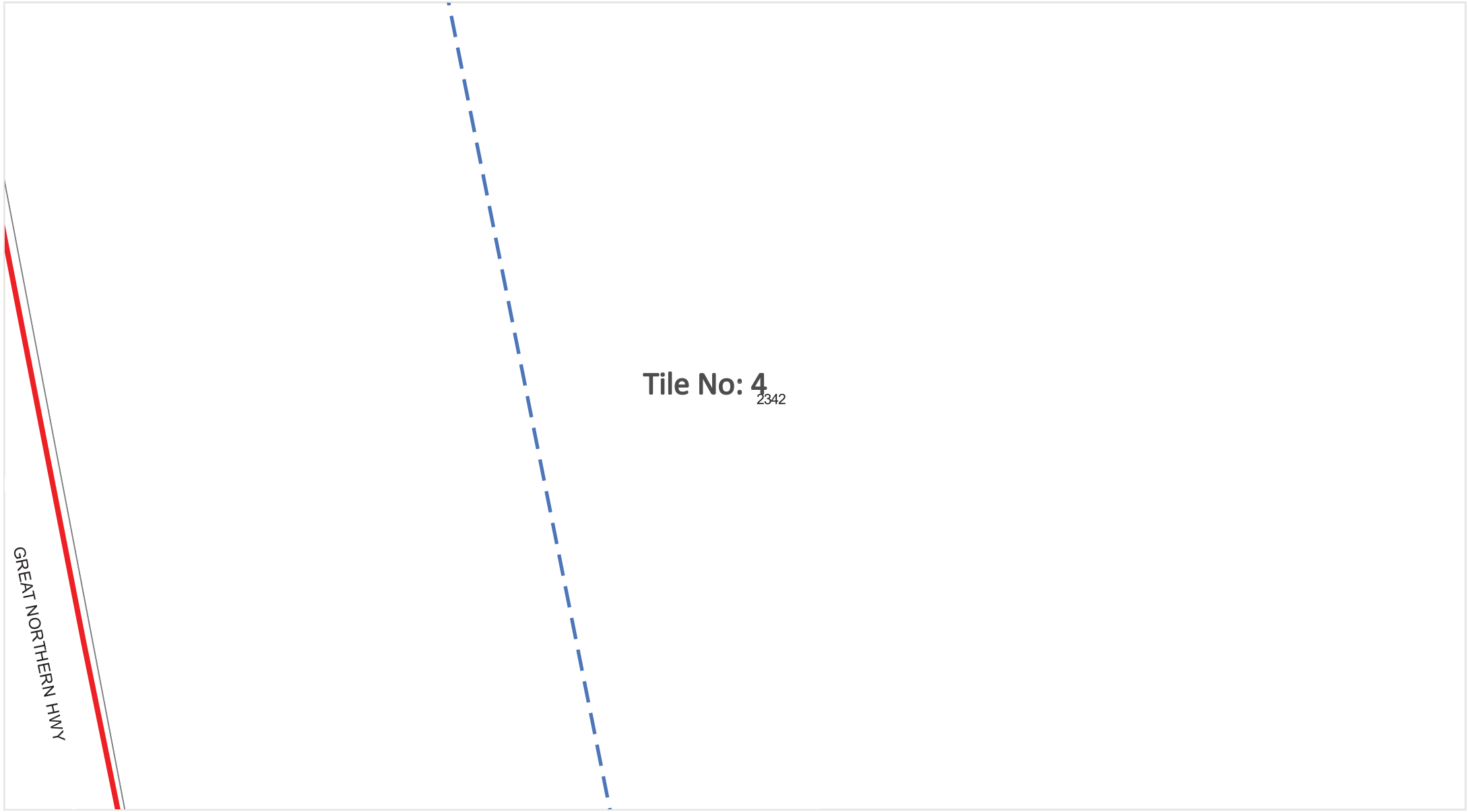

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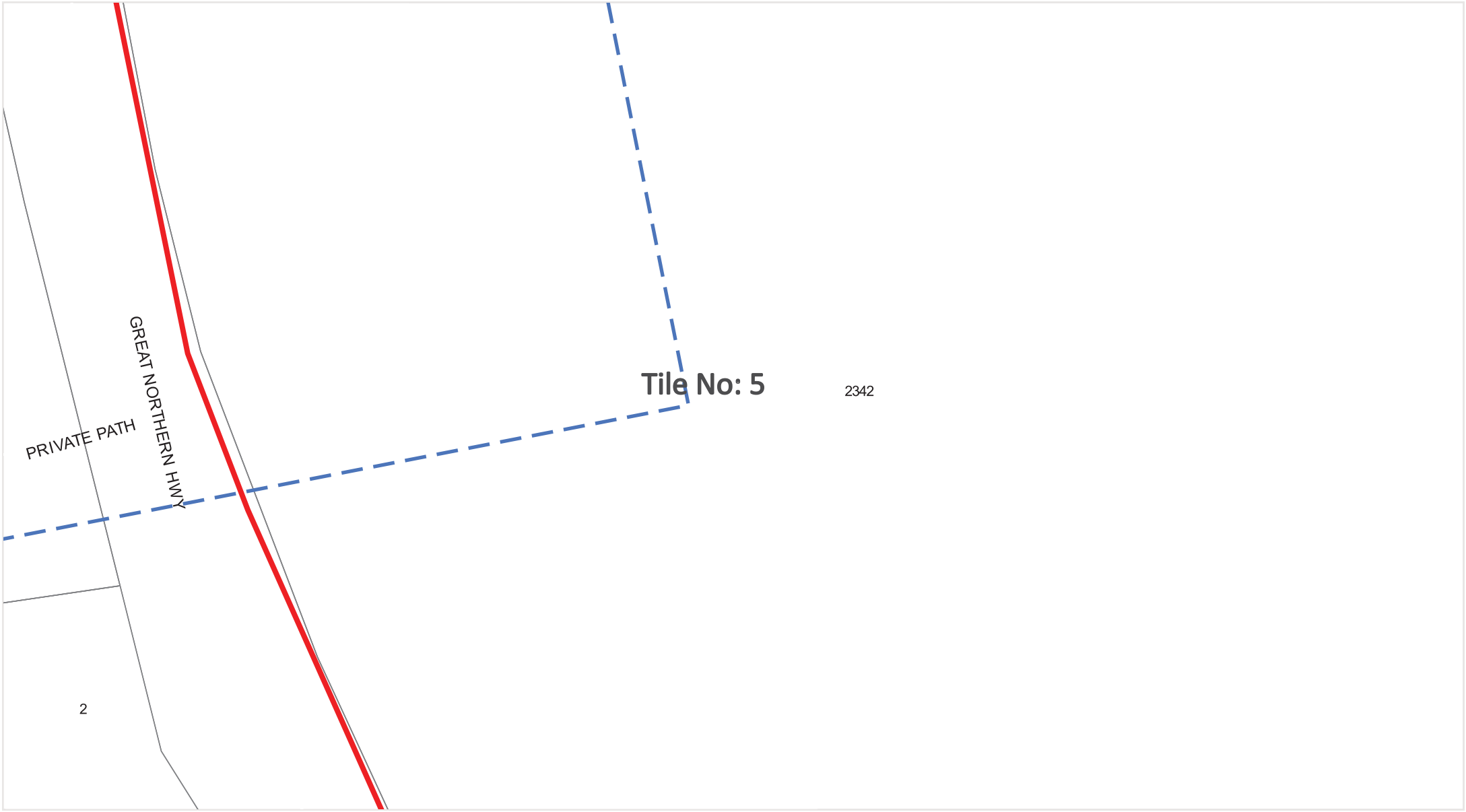

Legend | Scale: 1:1500

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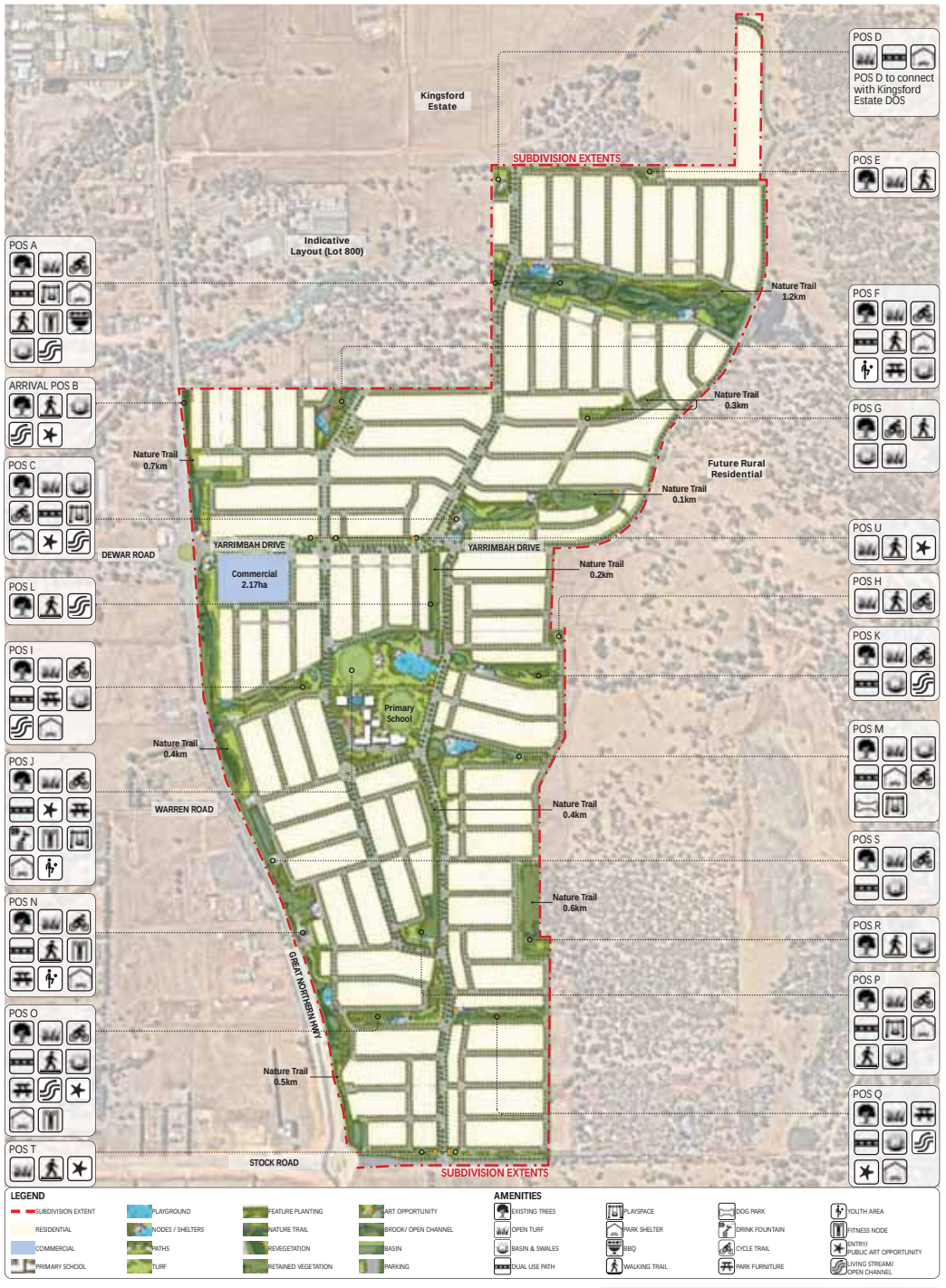
Appendix K: Preliminary Landscape Masterplan - Bullsbrook South Urban Expansion Area

Emerge Associates, 2025

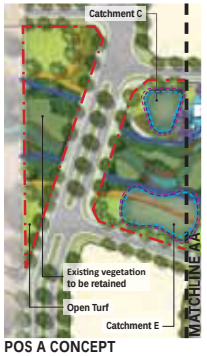


POS A TYPOLOGY
- Linear POS following Nambad Brook

POS A CONCEPT
- Linear parkland connects to adjacent POS, creating continuous parkland network throughout residential area, responding to the brook
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through linear parkland providing approx. 2km walking/cycling trail
- Bridge crossings over brook creates connections across foreshore areas. Minimal intrusion to the brook
- Shelter and picnic nodes for gathering opportunities
- Grass area adjacent playspace provides for active recreation
- All age fitness node provides for active and healthy lifestyle

FUNCTIONS / MATERIALS
- Footpath connection to broader path network
- Park furniture provides rest points
- Play space for kids and fitness node for all ages
- Grass area for active or passive recreation
- Revegetated planting areas
- Storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer and ecological access to brook
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat





POS A CONCEPT

DRAINAGE LEGEND - CATCHMENT	A	B	C	D	E
FIRST 15MM DETAILS					
Depth(m):	0.30	0.30	0.30	0.30	0.30
Top Area(m²):	185	638	324	389	840
Volume(m³):	55	191	97	116	252
Slope:	1:4	1:4	1:4	1:4	1:4
1 IN 5 YR STORAGE					
Depth(m):	0.38	0.45	0.42	0.44	0.44
Top Area(m²):	190	644	329	395	846
Volume(m³):	71	288	137	172	371
Slope:	1:6	1:6	1:6	1:6	1:6
1 IN 100 YR STORAGE					
Depth(m):	0.46	0.62	0.54	0.59	0.59
Top Area(m²):	195	651	336	402	853
Volume(m³):	89	401	180	235	501
Slope:	1:6	1:6	1:6	1:6	1:6





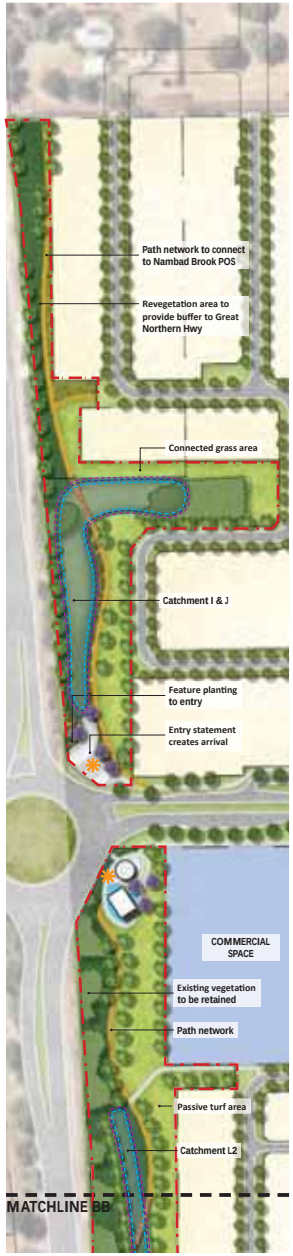




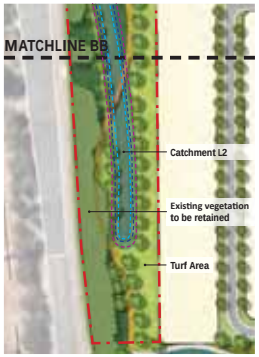




POS A CONCEPT



POS B CONCEPT











POS B TYPOLOGY
- Linear POS

POS B CONCEPT
- Entry statement provides wayfinding, and sense of arrival through featured landscape planting and finishes
- Statement trees at arrival point with complimenting vegetation to reflect species and aesthetic of the local flora
- Linear parkland creating buffer from Great Northern Hwy and connecting to broader POS network throughout residential area
- Existing vegetation to be retained where possible to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Cycle/path network meandering through linear parkland providing approx. 0.7km walking/cycling trail
- Grass area provided for relief and linked to improve connectivity
- Entry statement to create sense of arrival adjacent commercial lot

FUNCTIONS / MATERIALS
- Compliment commercial area
- Entry statement and feature walls
- Footpath connection to broader path network
- Grass area for active or passive recreation
- Revegetated planting areas to create buffer from Great Northern Hwy
- Storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer to adjacent Great Northern Hwy
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat

DRAINAGE LEGEND - CATCHMENT	I+J	L2
FIRST 15MM DETAILS		
Depth(m):	0.30	0.3
Top Area(m²):	2510	755
Volume(m³):	753	226
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.72	0.46
Top Area(m²):	2519	761
Volume(m³):	1811	349
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	1.04	0.83
Top Area(m²):	2532	771
Volume(m³):	2626	636
Slope:	1:6	1:6



POS B CONCEPT

LEGEND

POS EXTENT · LOTS · COMMERCIAL · ART OPPORTUNITY · PLAYGROUND · NODES / SHELTERS · FOOTPATH · LIMESTONE TRACK · FEATURE PLANTING · TURF · REVEGETATION AREA · RETAINED VEGETATION · TIMBER BRIDGE · BROOK · BASIN · PARKING · OPEN CHANNEL · PROPOSED TREE · STREET TREE · FORESHORE ZONE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS A

DWG MSBA01-2 · REV H · DATE 27-08-25 · SCALE 1 : 2000 @ A3

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emerge ASSOCIATES

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS B

DWG MSBA01-3 · REV H · DATE 27-08-25 · SCALE 1 : 2000 @ A3

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POS C TYPOLOGY
- Linear POS with Local Park focus at eastern end

POS C CONCEPT
- Linear parkland connects to adjacent POS, creating continuous parkland network throughout residential area
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through linear parkland providing approx. 1km walking/cycling trail
- Bridge crossings over overland drainage corridor creates connections across foreshore areas
- Shelter and picnic nodes for gathering opportunities
- Grass area adjacent playspace provides for active recreation
- Opportunity for commercial area addressing the play provision and providing community space

FUNCTIONS / MATERIALS
- Commercial area
- Footpath connection to broader path network
- Park furniture provides rest points
- Play space for kids
- Grass area for active or passive recreation
- Revegetated planting areas
- Overland drainage corridor and storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer and ecological access to brook
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat

DRAINAGE LEGEND - CATCHMENT H+K

FIRST 15MM DETAILS	
Depth(m):	0.30
Top Area(m²):	742
Volume(m³):	222
Slope:	1:4
1 IN 5 YR STORAGE	
Depth(m):	0.46
Top Area(m²):	748
Volume(m³):	343
Slope:	1:6
1 IN 100 YR STORAGE	
Depth(m):	0.62
Top Area(m²):	755
Volume(m³):	466
Slope:	1:6





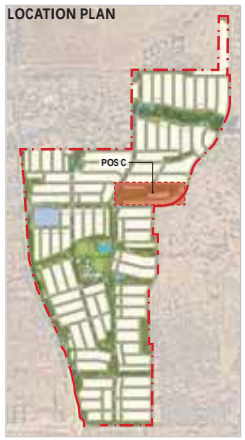








LOCATION PLAN









POS C CONCEPT

LEGEND

POS EXTENT	PLAYGROUND	FEATURE PLANTING	TIMBER BRIDGE	OPEN CHANNEL
LOTS	NODES / SHELTERS	TURF	BROOK	PROPOSED TREE
COMMERCIAL	FOOTPATH	REVEGETATION AREA	BASIN	STREET TREE
ART OPPORTUNITY	LIMESTONE TRACK	RETAINED VEGETATION	PARKING	

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS C

DWG MSBA01-4 REV H DATE 27-08-25 SCALE 1 : 2000 @ A3

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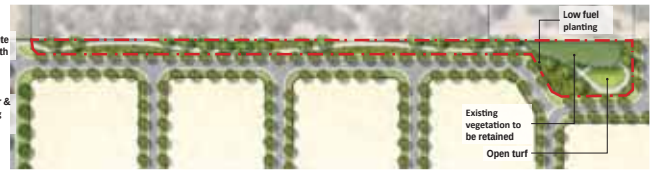


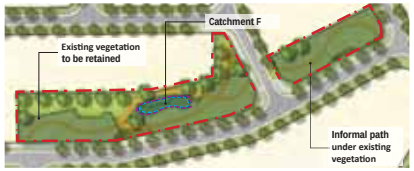
POS D CONCEPT **POS E CONCEPT**



POS F CONCEPT

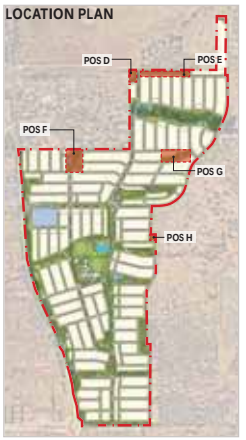


POS H CONCEPT



POS G CONCEPT

LOCATION PLAN







POS E, G & H TYPOLOGIES
- Pocket Park

POS E, G & H CONCEPTS
- Pocket park designed to retain trees, providing canopy for shade and immediate amenity
- Park furniture providing quieter rest nodes
- Supplement planting to enhance local flora and fauna

FUNCTIONS / MATERIALS
- Footpath connection to broader path network
- Park furniture provides rest points
- Retained trees
- POS G contains storage basin as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat

POS D & F TYPOLOGIES
- Local Park

POS D & F CONCEPTS
- Local park located to retain trees, providing canopy for shade and immediate amenity
- Park furniture providing quieter rest nodes
- Path provided to connect to broader walkability of the residential area linking local park to the linear parks
- Shelter and picnic nodes for gathering opportunities
- Grass area adjacent playspace provides for active recreation
- POS D to connect with Kingsford Eatate DOS
- POS F low key youth space

FUNCTIONS / MATERIALS
- Footpath connection to broader path network
- Park furniture provides rest points
- Play space for kids and youth facilities
- Grass area for active or passive recreation
- Retained trees with planted understory
- POS F & G Storage basins as per the LWMS design







DRAINAGE LEGEND - CATCHMENT

	F	G
FIRST 15MM DETAILS		
Depth(m):	0.30	0.30
Top Area(m²):	112	407
Volume(m³):	33	122
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.36	0.40
Top Area(m²):	117	412
Volume(m³):	41	164
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	0.43	0.49
Top Area(m²):	122	418
Volume(m³):	51	203
Slope:	1:6	1:6





LEGEND

POS EXTENT	PLAYGROUND	FEATURE PLANTING	TIMBER BRIDGE	OPEN CHANNEL
LOTS	NODES / SHELTERS	TURF	BROOK	PROPOSED TREE
COMMERCIAL	FOOTPATH	REVEGETATION AREA	BASIN	STREET TREE
ART OPPORTUNITY	LIMESTONE TRACK	RETAINED VEGETATION	PARKING	

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS D, E, F, G & H

DWG MSBA01-5 REV H DATE 27-08-25 SCALE 1 : 2000 @ A3

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POS J TYPOLOGY
- Central POS

POS J CONCEPT
- Existing vegetation to be retained to provide immediate amenity shade
- Provision of high quality shared path network including connections to broader precinct
- Shelter and picnic setting with BBQ node
- Youth activity area including custom playspace catering to all ages, parkour circuit and fitness equipment
- Passive turf to provide open space for activities
- Buffer planting to provide physical separation with primary school grounds
- Fully accessible amenities to support playing fiels activities, school outings and locals/visitors gatherings
- Carpark to accomodate influx of visitors
- Dedicated spaces for public art displays
- Feature turf mounding to topographically shape the landscape space as well as to provide opportunities for sitting, laying, and gathering
- Feature trees to create a unique sense of arrival and as distinct markers within the estate landscape

FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Shelter and picnic settings to provide gathering opportunity
- Fitness for all ages
- Open turf area to provide passive recreation
- Public art opportunity
- Overland drainage corridor

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Amenities using renewable energies
- Low fuel planting to minimise bushfire threat
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment





LOCATION PLAN







POS J CONCEPT











LEGEND

POS EXTENT | LOTS | COMMERCIAL | ART OPPORTUNITY | PLAYGROUND | NODES / SHELTERS | FOOTPATH | LIMESTONE TRACK | FEATURE PLANTING | TURF | REVEGETATION AREA | RETAINED VEGETATION | TIMBER BRIDGE | BROOK | BASIN | PARKING | OPEN CHANNEL | PROPOSED TREE | STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS J

DWG MSBA01-6 REV H DATE 27-08-25 SCALE 1 : 2000 @ A3

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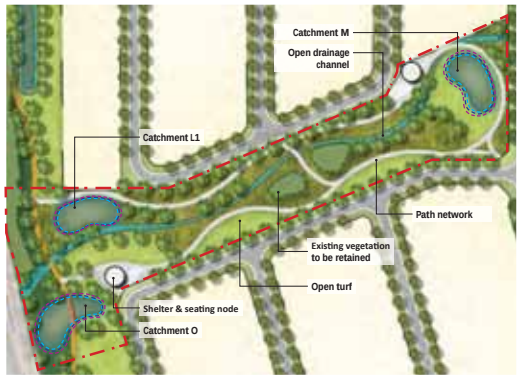
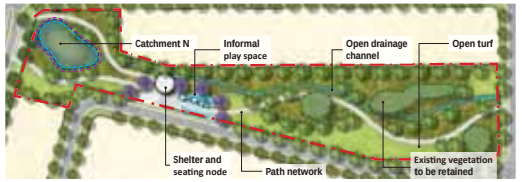


POS I CONCEPT



POS K CONCEPT

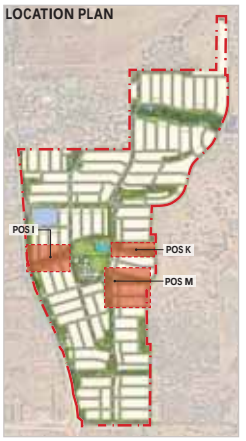


POS M CONCEPT





LOCATION PLAN











POS I, K & M TYPOLOGIES
- Linear/Local POS

POS I, K & M CONCEPTS
- Existing vegetation to be retained to provide immediate amenity shade
- Linear POS that provides connections between the residential lots and the central POS, playing fields and primary school site
- Footpath connections to improve the connectivity & walkability/cyclability of east-west ecological corridor
- Shelter and picnic nodes
- Fenced dog park space with reserved quiet corners
- Linked turf spaces to improve connectivity and provide resting points throughout the estate
- Play space for kids

FUNCTIONS / MATERIALS
- Footpath connection to broader path network
- Park furniture provides rest points
- Play space for kids
- Grass area for active or passive recreation
- Revegetated planting areas
- Storage basins as per the LWMS design
- Overland drainage channel to POS I and K

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Low fuel plantings to minimise bushfire threat
- Water-wise basin native planting to basins
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment

DRAINAGE LEGEND - CATCHMENT	L1	M	O	N	C4_e	P&Q
FIRST 15MM DETAILS						
Depth(m):	0.30	0.30	0.30	0.30	0.30	0.30
Top Area(m²):	468	463	480	458	814	882
Volume(m³):	140	139	144	137	244	264
Slope:	1:4	1:4	1:4	1:4	1:4	1:4
1 IN 5 YR STORAGE						
Depth(m):	0.42	0.46	0.44	0.47	0.58	0.43
Top Area(m²):	473	469	486	464	821	888
Volume(m³):	198	214	213	217	474	381
Slope:	1:6	1:6	1:6	1:6	1:6	1:6
1 IN 100 YR STORAGE						
Depth(m):	0.53	0.81	0.93	0.65	1.15	0.93
Top Area(m²):	480	479	497	472	835	899
Volume(m³):	253	384	457	304	952	831
Slope:	1:6	1:6	1:6	1:6	1:6	1:6

LEGEND

POS EXTENT | LOTS | COMMERCIAL | ART OPPORTUNITY | PLAYGROUND | NODES / SHELTERS | FOOTPATH | LIMESTONE TRACK | FEATURE PLANTING | TURF | REVEGETATION AREA | RETAINED VEGETATION | TIMBER BRIDGE | BROOK | BASIN | PARKING | OPEN CHANNEL | PROPOSED TREE | STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS I,K & M

DWG MSBA01-7 REV H DATE 27-08-25 SCALE 1 : 2000 @ A3

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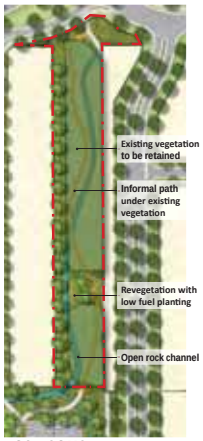
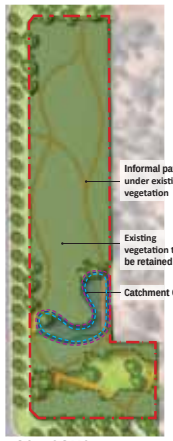


POS L CONCEPT

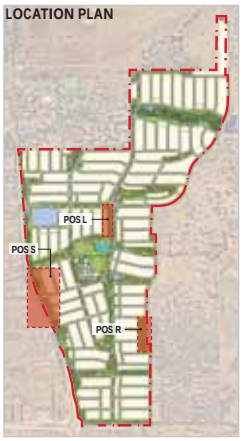


POS R CONCEPT



POS S CONCEPT

LOCATION PLAN















POS L, R & S TYPOLOGIES
- Linear/Informal POS

POS L, R & S CONCEPTS
- Existing vegetation to be retained to provide immediate amenity shade
- Informal track meandering through existing vegetation providing approx 0.6km walking trail
- Footpath connections to improve the connectivity & walkability/ cyclability of north-south ecological corridor
- Shelter and picnic nodes

FUNCTIONS / MATERIALS
- Footpath connection to the broader path and cycle network
- Bench seats to provide rest point
- Shelter and picnic settings to provide gathering opportunity
- POS L overland drainage
- Storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Low fuel planting to minimise the bushfire treat
- Water-wise basin native planting to basins
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment

DRAINAGE LEGEND - CATCHMENT	S	C6_a
FIRST 15MM DETAILS		
Depth(m):	0.30	0.30
Top Area(m²):	664	493
Volume(m³):	199	148
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.44	0.77
Top Area(m²):	670	503
Volume(m³):	293	383
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	0.70	1.12
Top Area(m²):	678	516
Volume(m³):	472	570
Slope:	1:6	1:6

LEGEND

POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA

LANDSCAPE DETAILED PLAN POS L, R & S

DWG MSBA01-8 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3

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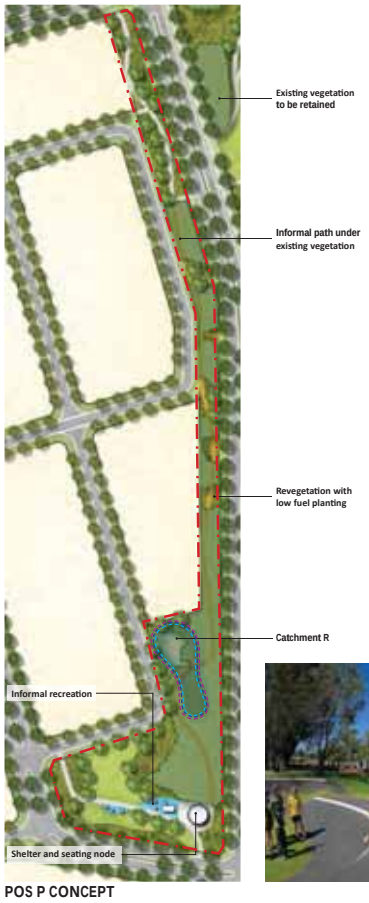
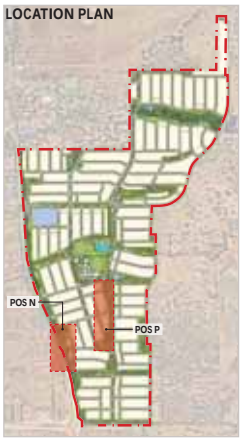
POS N CONCEPT



POS P CONCEPT

LOCATION PLAN











POS N & P TYPOLOGIES
- Linear/Local POS

POS N & P CONCEPTS
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through existing vegetation providing approx 1.2km walking trail
- Footpath connections to improve the connectivity & walkability/cyclability of east-west ecological corridor
- Shelter and picnic nodes
- Linked turf spaces to improve connectivity and provide resting points throughout the estate, providing open space for activities
- All aged fitness area to provide exercise space
- Informal play space for kids

FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Shelter and picnic settings to provide gathering opportunity
- Play space for kids, fitness for all ages
- Open turf area to provide passive recreation
- Storage basins as per with LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to basins
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment

DRAINAGE LEGEND - CATCHMENT R	
FIRST 15MM DETAILS	
Depth(m):	0.30
Top Area(m²):	625
Volume(m³):	187
Slope:	1:4
1 IN 5 YR STORAGE	
Depth(m):	0.49
Top Area(m²):	631
Volume(m³):	308
Slope:	1:6
1 IN 100 YR STORAGE	
Depth(m):	0.95
Top Area(m²):	643
Volume(m³):	605
Slope:	1:6



LEGEND

POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA

LANDSCAPE DETAILED PLAN POS N & P

DWG MSBA01-9 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3

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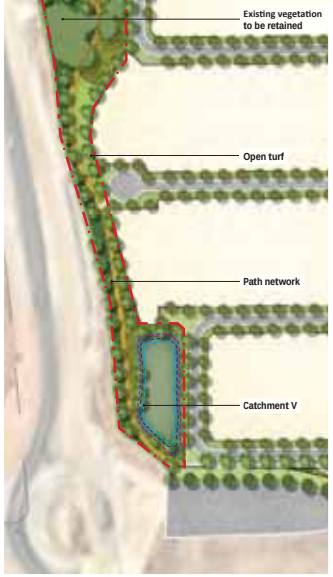













POS O CONCEPT

POS O TYPOLOGY
- Local POS

POS O & Q CONCEPTS
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through existing vegetation providing approx 0.5km walking trail
- Footpath connections to improve the connectivity & walkability/cyclability of north-south and east-west ecological corridor
- Shelter and picnic nodes
- Linked turf spaces to improve connectivity and provide resting points throughout the estate

FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Picnic settings to provide gathering opportunity

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer to adjacent Great Northern Hwy
- Low fuel plantings to minimise bushfire threat
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Open turf area to provide passive recreation
- Overland drainage corridor
- Storage basins as per with LWMS design

DRAINAGE LEGEND - CATCHMENT	T	V
FIRST 15MM DETAILS		
Depth(m):	0.30	0.30
Top Area(m²):	727	1128
Volume(m³):	218	338
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.50	0.50
Top Area(m²):	733	1134
Volume(m³):	365	566
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	1.12	0.71
Top Area(m²):	747	1143
Volume(m³):	829	808
Slope:	1:6	1:6

LEGEND
POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS O

DWG MSBA01-10 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3
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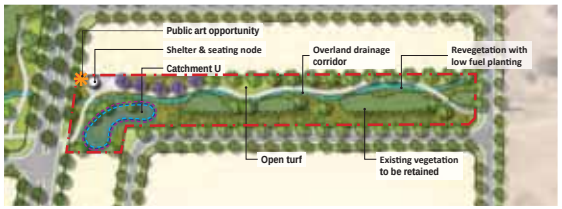
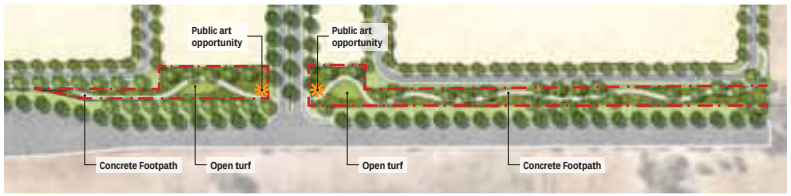
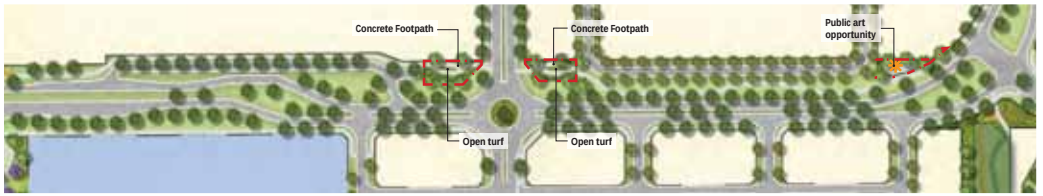


POS Q CONCEPT



POS T CONCEPT





POS U CONCEPT

POS Q TYPOLOGY
- Local POS

POS T & U TYPOLOGY
- Linear / Pocket POS

POS Q CONCEPTS
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through existing vegetation providing approx 0.6km walking trail
- Footpath connections to improve the connectivity & walkability/cyclability of north-south and east-west ecological corridor
- Shelter and picnic nodes
- Linked turf spaces to improve connectivity and provide resting points throughout the estate

POS T & U CONCEPTS
- Pocket park designed to retain trees, providing canopy for shade and immediate amenity
- Footpath connections to improve the connectivity & walkability/cyclability of north-south ecological corridor
- Supplement planting to enhance local flora and fauna

FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Picnic settings to provide gathering opportunity
- POS Q contains storage basin as per the LWMS design
- Open turf area to provide passive recreation
- Public art opportunity

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer to adjacent Great Northern Hwy
- Low fuel plantings to minimise bushfire threat
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Open turf area to provide passive recreation
- Overland drainage corridor
- Storage basins as per with LWMS design







DRAINAGE LEGEND - CATCHMENT	U
FIRST 15MM DETAILS	
Depth(m):	0.30
Top Area(m²):	398
Volume(m³):	119
Slope:	1:4
1 IN 5 YR STORAGE	
Depth(m):	0.43
Top Area(m²):	404
Volume(m³):	172
Slope:	1:6
1 IN 100 YR STORAGE	
Depth(m):	0.56
Top Area(m²):	410
Volume(m³):	228
Slope:	1:6

LEGEND
POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS Q & T

DWG MSBA01-11 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3
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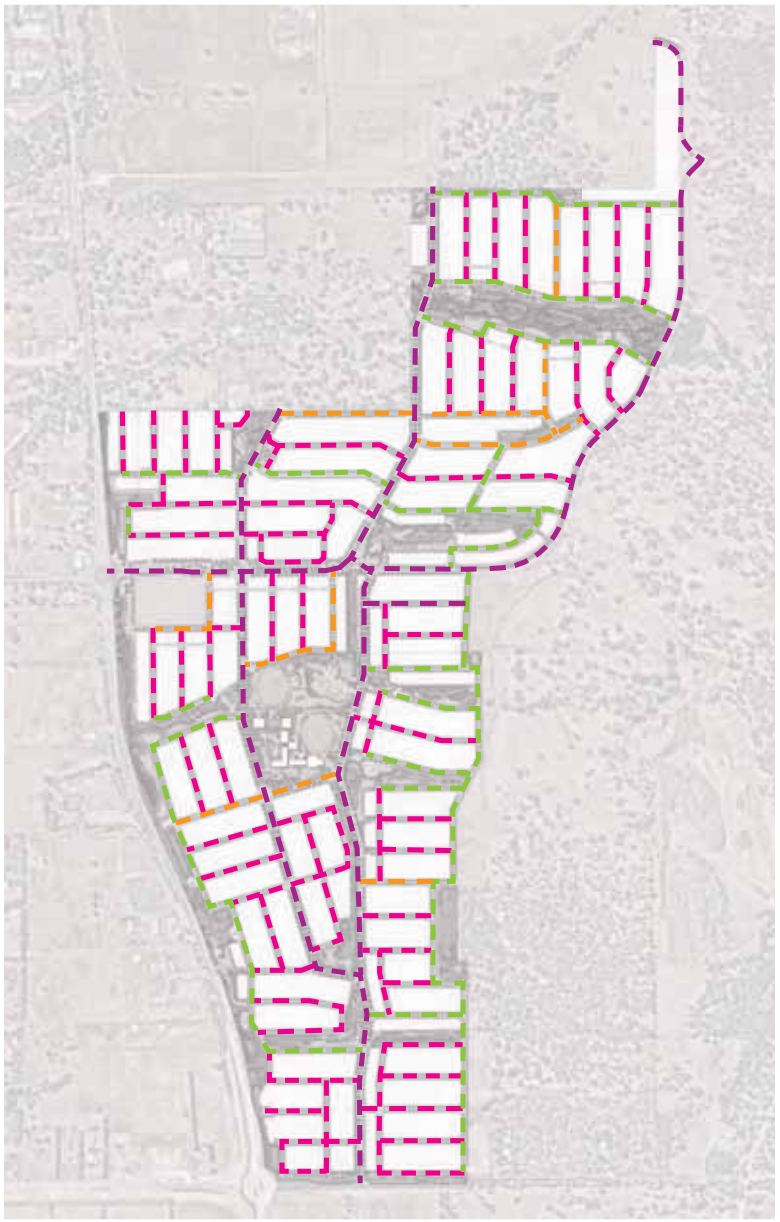


Corymbia maculata* - Spotted Gum (MEDIAN STRIPS)


Eucalyptus torquata - Coral Gum


Jacaranda mimosifolia* - Jacaranda


Eucalyptus marginata* - Jarrah


Melaleuca quinquenervia - Broad-leaved Paperbark


Melaleuca leucadendron - Weeping Paperbark


Corymbia ficifolia - Flowering Gum

LEGEND

PRIMARY STREET TREE

SECONDARY STREET TREE

SECONDARY STREET TREE

TERTIARY STREET TREE- RESIDENTIAL


Fraxinus oxycarpa "Raywoodii" - Claret Ash


Callistemon "Kings Park Special"- KPS Bottlebrush


Cupaniopsis anacardioides - Tuckeroo

BULLSBROOK SOUTH URBAN EXPANSION AREA
STREET TREE MASTERPLAN

DWG MSBA01-12
REV H
DATE 27-08-25
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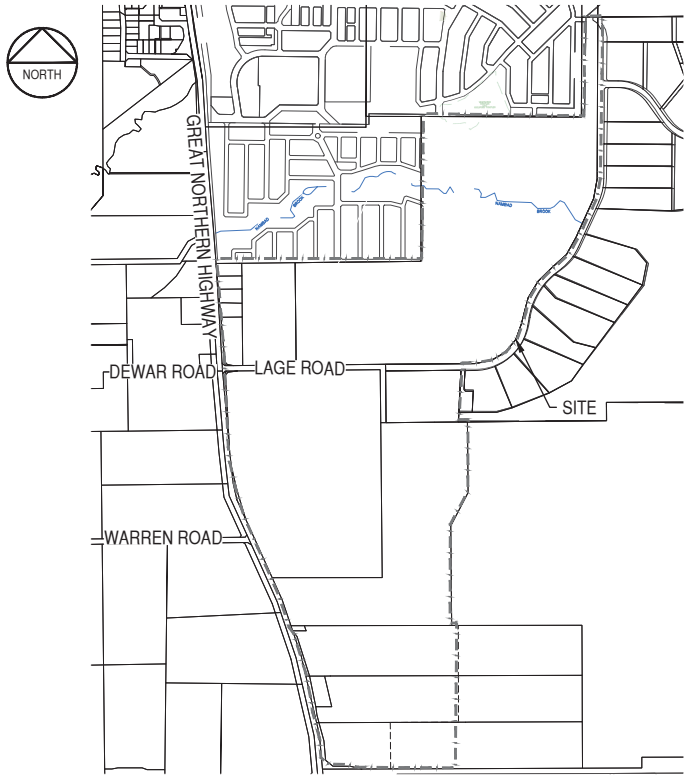
Appendix L: Proposed Subdivision - 2234-2342 Great Northern Highway, Bullsbrook

Pritchard Francis, 2023

PROPOSED SUBDIVISION
2234 - 2342 GREAT NORTHERN HIGHWAY, BULLSBROOK
for
MIRVAC
NOVEMBER 2023

WAPC No: N/A

JOB No: 22-063



CIVIL DRAWING LIST

DRG No.	TITLE
22063-C1-CS-01	COVER SHEET
22063-C1-RL-01	ROAD LAYOUT
22063-C1-DC-01	DESIGN CONTOURS
22063-C1-EW-01	EARTHWORKS DEPTH PLAN
22063-C1-RW-01	RETAINING WALL LAYOUT & LEVELS
22063-C1-EC-01	EXISTING CATCHMENT PLAN SHEET 1 OF 2
22063-C1-EC-02	EXISTING CATCHMENT PLAN SHEET 2 OF 2
22063-C1-CA-01	DESIGN CATCHMENT PLAN
22063-C1-SW-01	STORMWATER MANAGEMENT CONCEPT PLAN

PRELIMINARY ROAD LEVELS, EARTHWORKS, CATCHMENTS & RETAINING WALLS

pritchard francis
civil and structural engineering consultants
430 Roberts Road
Subiaco WA 6008
PO Box 2133
Subiaco WA 6904
Telephone: (08) 9382 5111
admin@pfeng.com.au

DATE	DESIGNED	DRAWN	CHECKED	APPROVED
NOVEMBER 2023	A.D	N.S	M.R	XXX .... / ....

SHEET SIZE	DRG No.
A1	22063-C1-CS-01





SCALE 1:5000 0m 100m 200m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
A	15/11/23	INITIAL ISSUE	A.D	M.R

pritchard francis
civil and structural engineering consultants

DRAWING STATUS: NOT FOR CONSTRUCTION

DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

DESIGNED: A.D | DRAWN: N.S | CHECKED: M.R | APPROVED: XXX .... / ...

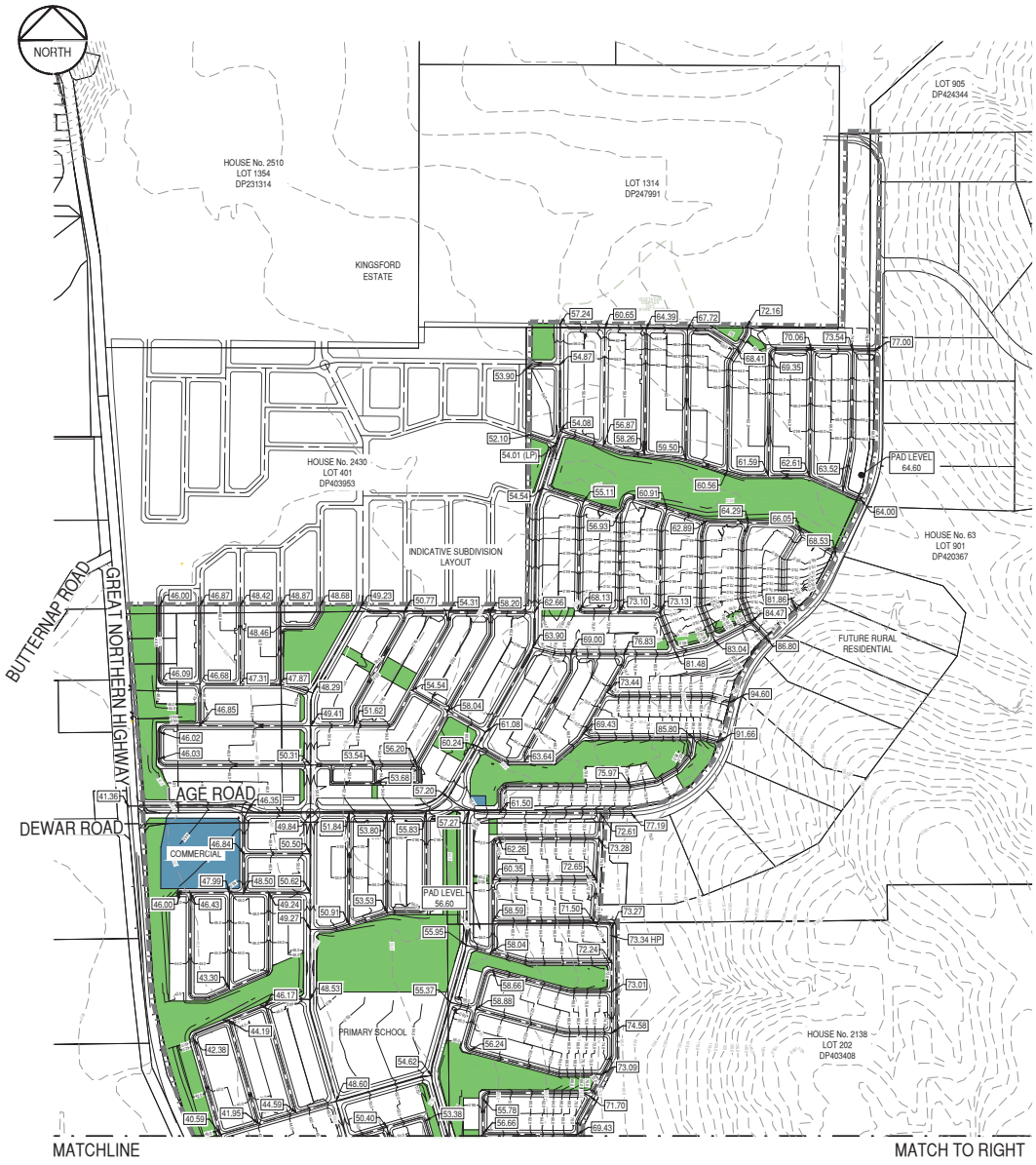
W.A.P.C.: N/A | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

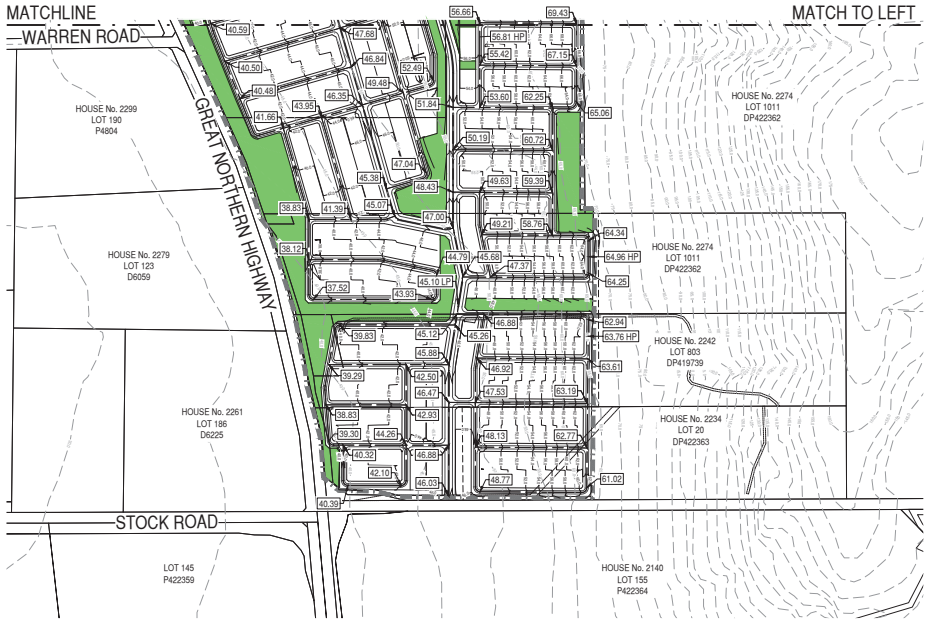
CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: ROAD LAYOUT

DRG No.: 22063-C1-RL-01

REVISION: A





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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- 48.60 DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
B	11/12/23	REVISED PAD LEVELS	N.S.	M.R.
A	15/11/23	INITIAL ISSUE	A.D	M.R

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DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

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W.A.P.C.: N/A | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: DESIGN CONTOURS

DRG No.: 22063-C1-DC-01

REVISION: B



DEPTH OF CUT/FILL	
COLOUR	CUT AND FILL RANGE
	> 3.0m CUT
	3.0m - 2.0m CUT
	2.0m - 1.0m CUT
	1.0m -0.1m CUT
	0.1m CUT/FILL
	0.1m - 1.0m FILL
	1.0m - 2.0m FILL
	2.0m - 3.0m FILL
	3.0m - 4.0m FILL
	4.0m - 5.0m FILL
	> 5.0m FILL

SCALE 1:5000 0m 100m 200m

LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- EXISTING CONTOURS
- PROPOSED CONTOURS

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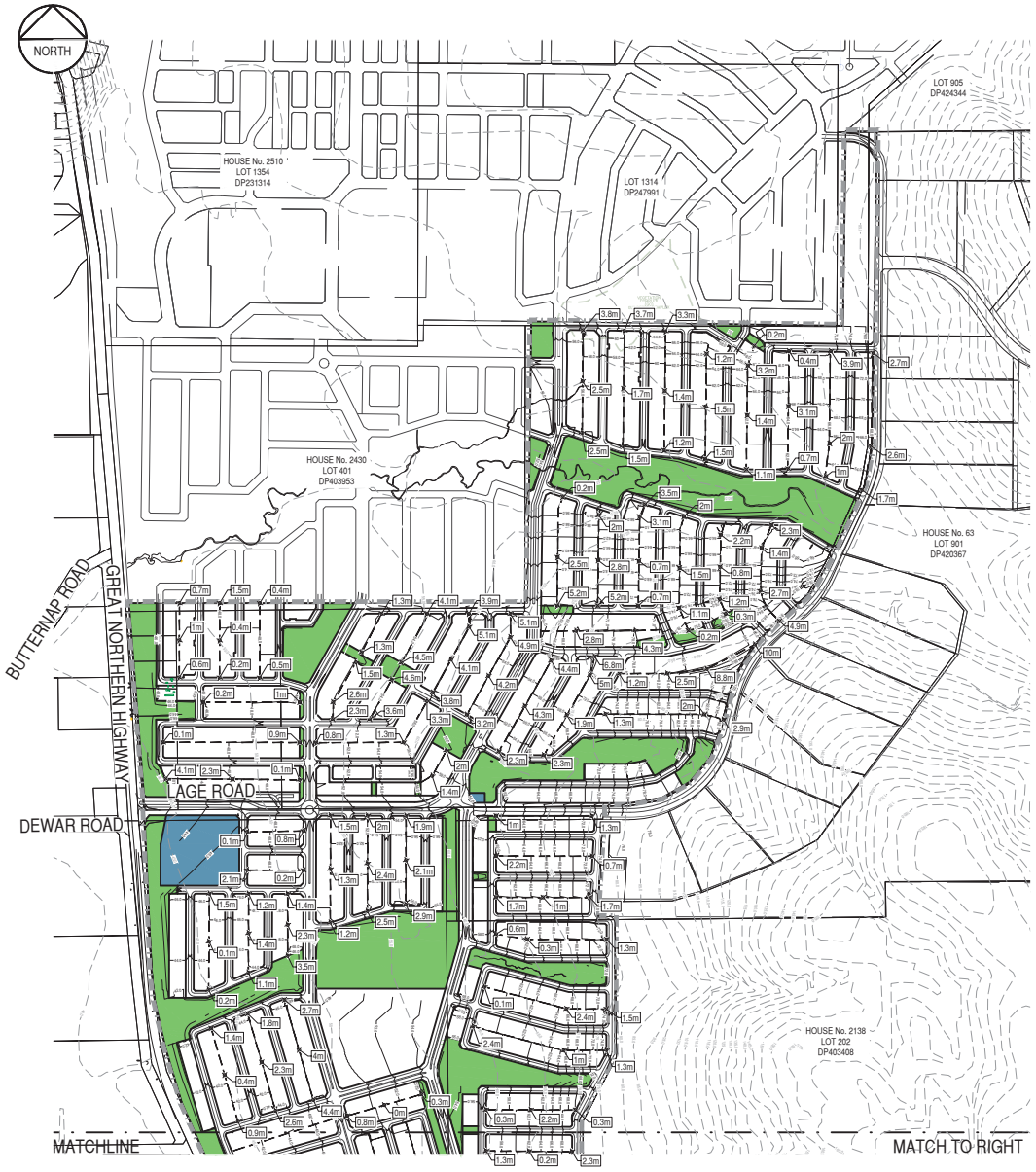
W.A.P.C.: N/A | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: EARTHWORKS DEPTH PLAN

DRG No.: 22063-C1-EW-01 | REVISION: A





SCALE 1:500 0m 10m 20m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- INDICATIVE WALL HEIGHT (3m)
- INDICATIVE RETAINING WALL
- PROPOSED CONTOURS (v5.0)
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
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A.D	N.S	M.R	XXX ...../...../....

W.A.P.C. ????

SCALE U.N.O. 1:5000 @ A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: RETAINING WALL LAYOUT & LEVELS

DRG No. 22063-C1-RW-01

REVISION A



REV	DATE	DESCRIPTION	BY	CHKR
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DESIGNED: A.D | DRAWN: N.S | CHECKED: M.R | APPROVED: XXX .... / ....

W.A.P.C.: ???? | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: EXISTING CATCHMENT PLAN
SHEET 1 OF 2

DRG No.: 22063-C1-EC-01

REVISION: A



LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- EXISTING CATCHMENT BOUNDARY
- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

SCALE 1:500 0m 10m 20m

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CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: EXISTING CATCHMENT PLAN
SHEET 2 OF 2

DRG No.: 22063-C1-EC-02 | REVISION: A





MATCHLINE

SCALE 1:500 0m 10m 20m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- DESIGN CATCHMENT BOUNDARY
- PROPOSED ROAD CENTER LINE
- 73.01 DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE

REV	DATE	DESCRIPTION	BY	CHKR
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DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

DESIGNED: A.D | DRAWN: N.S | CHECKED: M.R | APPROVED: XXX ..... / ....

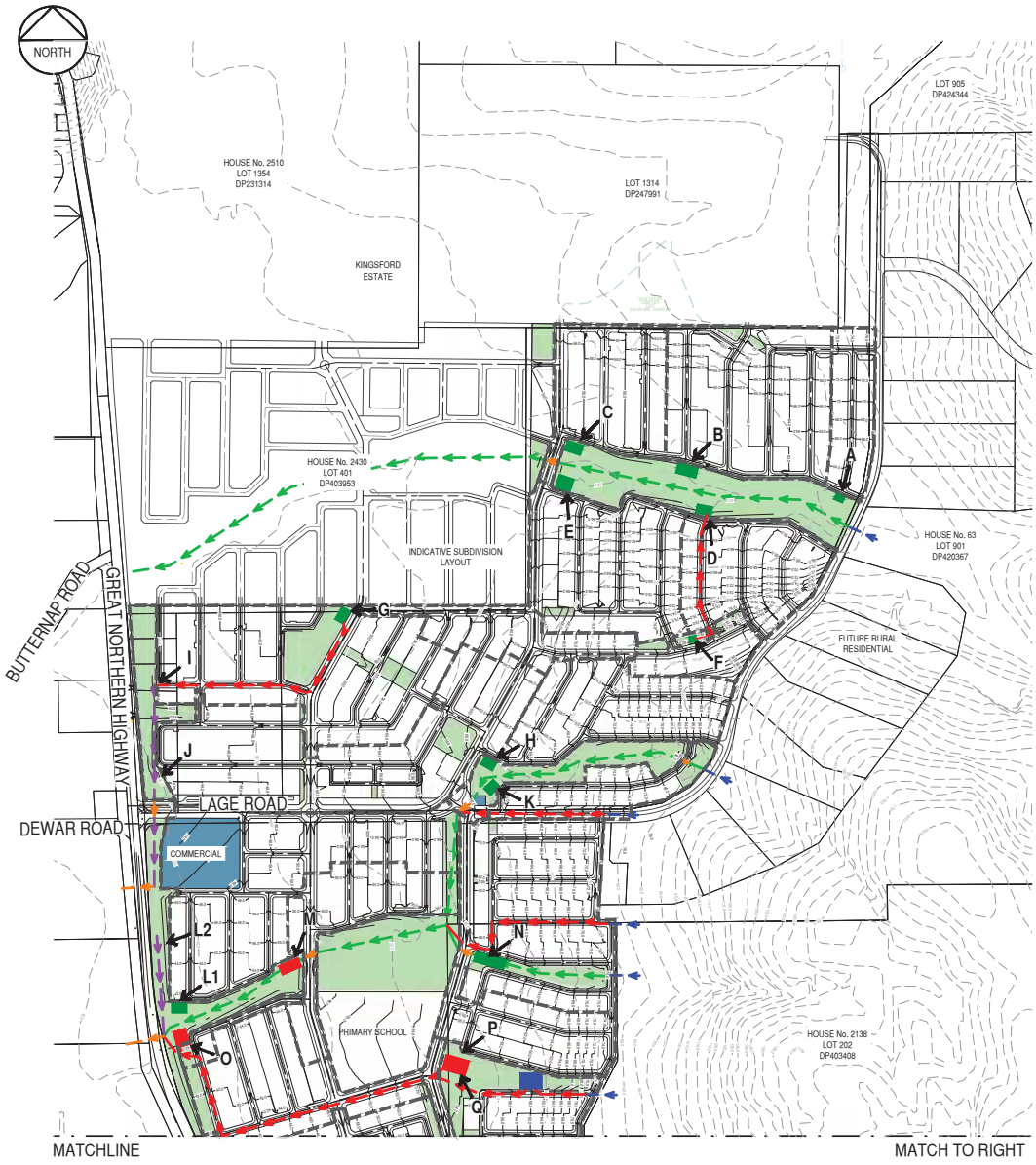
W.A.P.C.: ???? | SCALE U.N.O.: 1:5000 @ | SHEET SIZE: A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: DESIGN CATCHMENT PLAN

DRG No.: 22063-C1-CS-01

REVISION: A





SCALE 1:5000 0m 100m 200m

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LEGEND

- WORKS BOUNDARY
- EXISTING LOT BOUNDARIES
- PROPOSED ROAD CENTER LINE
- DESIGN LEVEL
- EXISTING CONTOURS
- PROPOSED CONTOURS
- PROPOSED PUBLIC OPEN SPACE
- LIVING STREAM
- TREATMENT / DETENTION SWALE
- CONVEYANCE SWALE
- STORMWATER CULVERT
- PIPED DRAINAGE
- INFLOWS
- BIOBASIN
- FLOOD DETENTION BASIN
- EXTERNAL CATCHMENTS BASIN

REV	DATE	DESCRIPTION	BY	CHKR
A	7/12/23	INITIAL ISSUE	N.S	M.R

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civil and structural engineering consultants

DRAWING STATUS: NOT FOR CONSTRUCTION

DATE: NOVEMBER 2023 | GRID: PCG94 | DATUM: AHD

DESIGNED: A.D | DRAWN: N.S | CHECKED: M.R | APPROVED: XXX

W.A.P.C.: N/A | SCALE U.N.O.: 1:5000 @ A1

CLIENT & JOB: MIRVAC
BULLSBROOK SOUTH URBAN EXPANSION AREA

TITLE: STORMWATER MANAGEMENT CONCEPT PLAN

SHEET SIZE: A1 | DRG No.: 22063-C1-SW-01 | REVISION: A

Appendix M: Stormwater Modelling Summary - Bullsbrook South Urban Expansion Area

Pentium Water, 2024



APPENDIX M

Stormwater Modelling Summary – Bullsbrook South Urban Expansion Area

Background

Detailed hydrologic and hydraulic modelling has been undertaken in XPSWMM to inform the preliminary drainage design described in the Local Water Management Strategy prepared by Pentium Water for Bullsbrook South Urban Expansion Area.

The modelling has included hydrologic (rainfall runoff and routing) modelling of existing conditions surface water catchments (along with some hydraulic analysis of culvert discharge capacities at Great Northern Highway) to estimate peak 1% AEP discharge rates from the LSP area under existing conditions. The post-development modelling in XPSWMM has included sub-catchment based hydrologic modelling (ie. based on a break down of proposed post-development land uses) to simulate rainfall-runoff processes including on-lot storage and infiltration, as well as conveyance through arterial drainage systems (open conveyance channels, main pipe connections etc), simulation of storage depths and volumes in stormwater treatment and detention basins, and discharge rates at outlet points from the LSP.

Design rainfall data

The modelling has used design rainfall (IFD) data sourced from Bureau of Meteorology derived in accordance with ARR 2019 and including the full range of storm durations to identify the critical event duration for all aspects of the modelling assessment. Temporal rainfall distributions were downloaded from the Australian Rainfall and Runoff (ARR) data hub (Babister, Trim, Testoni, & Retallick, 2016), with the modelling including simulation of temporal pattern ensembles and reporting herein based on median temporal pattern results. A sub-set of the design rainfall IFDs are presented below in Table 1.

Table 1: Design Rainfall Depths (mm)

AEP Duration (hrs)	63.2%	50%	20%	10%	5%	2%	1%
1	14.6	16.1	21.3	25.2	39.2	35.1	39.3
1.5	16.8	18.6	24.5	28.9	33.6	40.5	46.3
2	18.6	20.5	27	32	37.3	45.1	51.8
3	21.6	23.7	31.2	37.1	43.5	53	61.2
4.5	25.1	27.6	36.3	43.3	51	62.6	72.9
6	28	30.7	40.5	48.4	57.2	70.6	82.5
9	32.7	35.9	47.3	56.6	67.1	83.2	97.6
12	36.5	40	52.8	63.2	74.8	92.8	109
18	42.4	46.5	61.3	73.1	86.1	106	124
24	47	51.6	67.8	80.4	94.1	116	134
30	50.9	55.9	73.1	86.2	100	122	141
36	54.1	59.5	77.5	90.9	105	127	146

Pre-development Scenario

Figure M.1 illustrates the modelled sub-catchments in the pre-development scenario. There are six outlet culvert locations from the site beneath Great Northern Highway.

Culvert No. 2 relates to Nambad Brook which is a significant creek line and the largest catchment / watercourse that interacts with the subject site. There is a dam on Nambad Brook located just upstream of site boundary. The hydrologic modelling of the Nambad Brook catchment included division of the catchment area into that upstream and downstream of the dam, with the upstream catchment being routed through a stage-storage and spillway based on survey of the existing dam.

Culvert No. 4 and Culvert No. 6 both relate to well defined water courses in the form of heavily modified creek lines / agricultural drains. Culverts No. 3, 5 & 7 have less defined flow paths. However, these catchments grade towards and discharge via existing culverts beneath Great Northern Highway at the site boundary.

Appendix M – Stormwater modelling summary May 2024

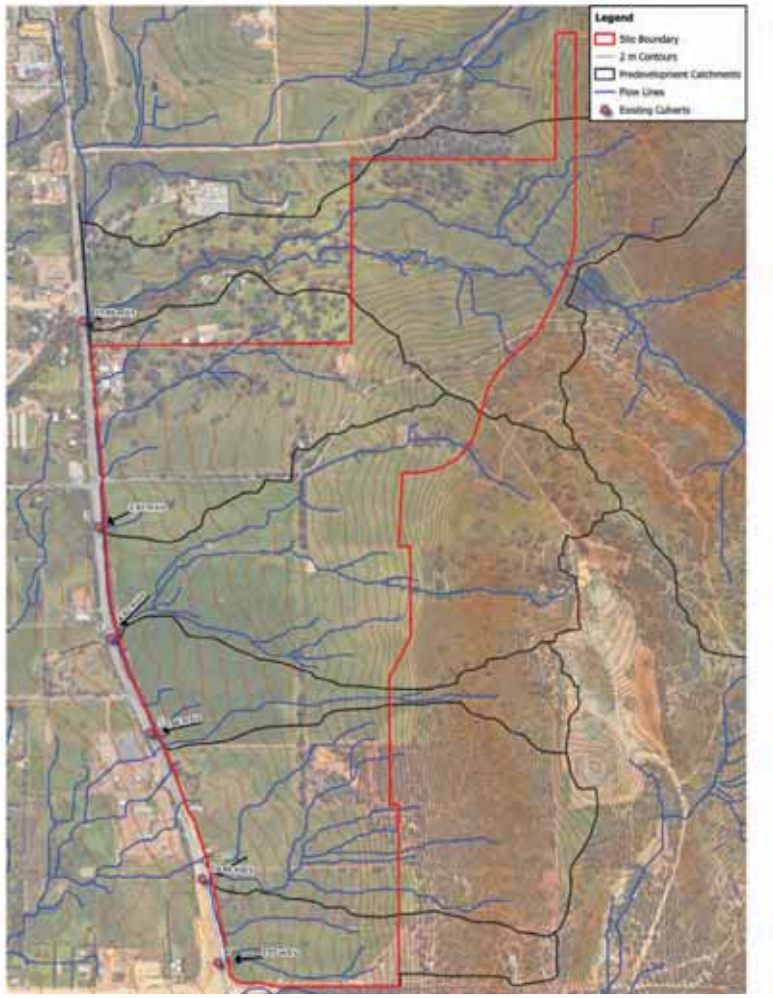

Figure M.1 – Pre-development catchments, flow lines and peak flow estimates

The hydrologic models included sub-division of the catchment into sub-catchments which are further sub-categorized according to land use types such as vegetated silt, cleared silt, vegetated rock and cleared rock. The catchment area breakdown for predevelopment conditions is provided in Table 2 below, and the rainfall losses and Manning's roughness (Laurenson's routing) parameters used in the hydrological modelling are provided in Table 3.

Table 2: Predevelopment Catchment Breakdown

Catchment	Vegetated Silt (ha)	Cleared Silt (ha)	Vegetated Rock (ha)	Cleared Rock (ha)	Total (ha)
Culvert 2d	38.64	27.80	17.50	2.36	*86.31*
Culvert 2u	5.47	0.00	229.50	3.00	*237.98*
Culvert 3	25.06	24.37	0.00	0.00	*49.43*
Culvert 4	6.25	45.20	18.75	12.21	*82.41*
Culvert 5	0.00	16.59	3.04	4.82	*24.45*
Culvert 6	7.04	27.60	23.49	5.13	*63.26*
Culvert 7	0.07	14.09	5.89	0.17	*20.21*
Sub total	*109.50*	*210.29*	*317.86*	*46.47*	*684.12*

Table 3: Pre Development Model Parameters

Catchment type	Initial Loss (mm)	Continuing Loss (mm/hr)	Manning's n
Vegatated Silt	25	4.5	0.065
Cleared Silt	21	4.5	0.065
Vegatated Rock	25	4	0.060
Cleared Rock	21	4	0.060

The model identified the 2 hour design rainfall event as the critical duration for each culvert and estimated the peak 1% AEP flow rates in Table 4. The peak 1% AEP flow rates from the hydrologic modelling are also shown in Figure M.1.

An analysis of the expected hydraulic capacity of the existing culverts at Great Northern Hwy was undertaken, along with an assessment of the connectivity and grading between the various pre-development catchments and outlet points illustrated in Figure 1. The purpose of this analysis was to estimate the proportion of catchment peak flow rates discharging at each culvert (ie. including flow that is expected to bypass culverts of lower capacity and flow to down-gradient culverts of higher capacity). The hydraulic analysis is attached to this document. Table 4 provides the estimated discharge rates for each culvert based on the hydraulic analysis of culvert capacity.

Figure M.2 below also summarises the assessment of cross-catchment discharges and cumulative peak discharges at each culvert.

Table 4: Pre Development Flow Rates

Catchment	Estimate 1% AEP flow rate (m^3/s)	Estimated 1% AEP culvert discharge rate (m3/s)
Culvert 2	21.89	21.9
Culvert 3	2.92	0.84
Culvert 4	6.82	8.9
Culvert 5	1.66	0.19
Culvert 6	4.94	6.9
Culvert 7	1.57	1.1

Appendix M – Stormwater modelling summary May 2024



Figure M.2 – Pre-development estimated peak discharge rates at culvert outlets

The pre-development discharge rates form the basis of design for the preliminary post-development drainage design, with the drainage system being required to provide adequate flood detention to ensure peak discharge rates are consistent with pre-development conditions. The Pentium Water estimated pre-development discharge rates have been compared in Table 5 to those adopted in previous water management planning documents for other proposed developments downstream of the site. In some cases, the Pentium Water estimated peak pre-development discharge rates (inclusive of estimated cross-catchment flows that have bypassed up-gradient culverts) are greater than the peak flows that have been assumed and designed for in the downstream development proposals. Therefore, the

Pentium Water post-development modelling and drainage design documented herein has conservatively adopted the lower design discharge rates as the basis of design, to ensure consistency with the assumptions and design parameters of the downstream development proposals.

Catchment	Great Northern Gateway Industrial Cell DWMS (Cardno, 2012)	South Bullsbrook Industrial Precinct LWMS (Emerge Associates, 2014)	Bullsbrook South LWMS (Pentium Water, 2023)
Culvert 2	21.6	N/A	21.9
Culvert 3	0.9	N/A	0.8
Culvert 4	7.5	7.17	8.9
Culvert 5	5.5	0.3	0.2
Culvert 6	5.3	5.26	6.9
Culvert 7	N/A	N/A	1.1

Post-development Scenario

The post-development scenario was modelled to develop a preliminary drainage design that meets the principles of retaining and treating the first 15 mm of rainfall on site and providing adequate flood detention storage and conveyance to maintain the 1% AEP pre-development site discharge rates and protect people and property from flooding.

The earthworks and drainage strategies were collaboratively developed by Pritchard Francis and Pentium Water to consider the existing landform and general flow directions, discharge locations and relative capacity of existing culverts and downstream drainage systems, and the likely locations for treatment and detention of stormwater generated by the development. Stormwater drainage modelling was undertaken in XPSWMM as a 1D hydrological and hydraulic model which was used to develop the drainage design to meet the stormwater management objectives described in the LWMS.

The preliminary drainage design is illustrated in Figure M.3 below. The breakdown of catchment areas and proposed post-development land uses is provided in Table 5, whilst the modelled loss and routing parameters are provided in Table 6.

The following assumptions / information has informed the hydrologic model configuration and the selection of loss parameters:

- all lots created by the subdivision will be greater than 300 sqm and will utilise soakwells to manage stormwater on-site, which will be facilitated by earthworks and fill importation to create Class A geotechnical classification lots.
- 5% of the lot areas are modelled as “directly connected lot areas” with minimal losses to account for portions of the lots (driveways, paving etc) that will potentially discharge runoff directly to the road.
- The other 95% of lot area has been modelled with loss rates reflective of the storage and infiltration capacity of soakwells, based on soakwell performance calculations for typical soakwell sizing.
- The primary school is assumed to contain all drainage on-site.
- The commercial area is assumed to contain the first 15 mm rainfall event on-site, after which the majority of rainfall will be converted to runoff.

Appendix M – Stormwater modelling summary May 2024

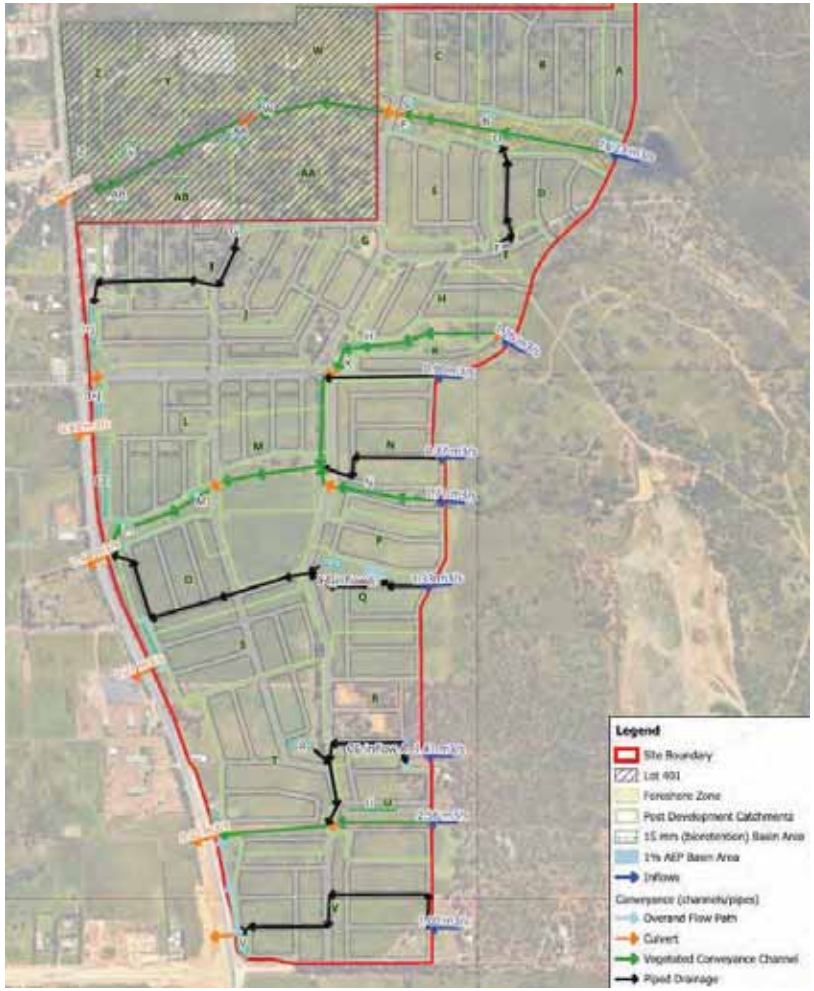

Figure M.3 – Stormwater management layout

Table 5: Post-development Catchment Breakdown

Catchment Name	Commercial Use (ha)	Directly Connected Lot Area (ha)	Indirectly Connected Lot Area (ha)	POS Area (ha)	Roads (ha)	Total (ha)
A	0	0.098	1.859	0.000	0.609	2.57
AA	0	0.299	5.679	0.000	3.202	9.18
AB	0	0.132	2.512	0.000	1.313	3.96
B	0	0.326	6.202	0.166	2.359	9.05
C	0	0.167	3.169	0.000	1.838	5.17
D	0	0.191	3.634	0.000	1.360	5.19
E	0	0.262	4.975	0.096	2.249	7.58
F	0	0.062	1.176	0.378	0.441	2.06
G	0	0.072	1.373	0.000	1.466	2.91
H+K	0	0.286	5.425	0.311	2.785	8.81
H	0	0.214	4.064	0.000	1.581	5.86
K	0	0.072	1.362	0.311	1.204	2.95
I	0	0.331	6.285	1.468	3.033	11.12
J	0	0.412	7.834	0.558	3.269	12.07
L	2.02	0.282	5.353	0.279	5.213	13.14
M	0	0.133	2.530	0.370	1.616	4.65
N	0	0.290	5.517	0.967	3.369	10.14
O	0	0.231	4.393	0.000	2.165	6.79
P+Q	0	0.227	4.317	1.850	3.223	9.62
R	0	0.228	4.325	1.154	2.323	8.03
S	0	0.249	4.737	0.334	2.036	7.36
T	0	0.337	6.406	2.282	4.064	13.09
U	0	0.190	3.601	0.541	1.684	6.02
V	0	0.450	8.541	0.000	4.647	13.64
W	0	0.269	5.118	0.427	2.125	7.94
Y	0	0.291	5.528	0.000	2.764	8.58
Z	0	0.074	1.411	0.000	0.799	2.28
Sub total	**2.02**	**6.18**	**117.33**	**11.49**	**62.74**	**199.75**

Table 6: Post Development Model Parameters

Catchment Type	Initial Loss (mm)	Continuing Loss (mm/hr)	Proportional Loss	Manning's n
Directly connected lot area	1.5	0	-	0.016
Indirectly connected lot area	13	7	-	0.025
Roads	1.5	-	0.2	0.016
Impervious Lot Areas	1.5	0	-	0.016
POS	20	3.5	-	0.200
Commercial	15		0.20	0.025

Appendix M – Stormwater modelling summary May 2024

The post-development hydraulic modelling comprised the following configuration and assumptions:

- Bioretention basins sized to retain the 15 mm event to a depth of 0.3, with 1:4 batters. Basins are sized (for the 15 mm event) with a design permeability of 3 m/d but modelled for the larger events with a lower infiltration rate of 1 m/d).
- Larger events discharge from bioretention areas into Nambad Brook or conveyance channels via either:
  - a spillway set at 0.3m height (top of the bioretention area), with a small amount of additional flood storage occurring above the spillway height during the 1% AEP event (i.e typically 0.2-0.3m additional storage height above the spillway), or
  - a pipe outlet, via a "bubble-down" pit set at the 0.3m height / top of the bioretention area, for basins which are designated as performing a more significant flood detention storage function that the bioretention basins described above.
  - In both cases above, the flood storage area above the 0.3m deep bioretention basin have been modelled with 1:6 batter slopes.
  - Basins A, AA, AB, B, C, D, E, F, G, H, K, L1, N, U, V, W, Y & Z have been modelled as overtopping via spillway at 0.3m depth, whilst basins M, O, P+Q, R & T have been modelled as deeper (flood detention) basins with piped outlets.
- Some of the proposed flood detention areas have been modelled with slightly different assumed geometries (based on the shape, elevation and natural slope of their specific locations), as follows:
  - Swale I+J was modelled as comprising a 6 m base width swale with a typical depth of 0.5 m below the natural surface, with larger rainfall events able to inundate the natural ground surface through the broader POS area above the formal swale. This swale is anticipated to be divided into segments that can overtop from one to another (either via weirs or pipe connections), to convey flows in a southerly direction to Great Northern Highway culvert outlet no. 3t. The separate swale segments will be required to maximise storage whilst integrating with the natural slope of the land.
  - Swale L2 was modelled as comprising 150 m long by 5 m base width swale. The lower 0.3 m of the swale was modelled with 1:4 batters and sized to retain the 15 mm event, with 1:6 batters above that up to a design 1% AEP storage depth of ~0.8m.
  - Swale S was modelled as comprising a tiered / stepped swale. The lower tier comprises a 110 m long by 3.5 m base width swale sized to retain the 15 mm event to a depth of 0.3 m, with 1:4 batters. Above this is a wider tier with a flat base of 12 width and then 1:6 batters up to the 1% AEP storage depth of ~0.7 m
- Nambad Brook is modelled with its existing elevations and cross-sections (ie. unmodified, other than to exclude the minor northern channel alignment).
- The minor existing creek lines / water courses are modelled with an assumed typical geometry comprising a 1m base width, with 1:3 batters up to a depth of 0.5m for the main flow channel, and then 1:6 batters above that for storage and conveyance of larger events. This is on the assumption that these channels will be modified from their existing (degraded) form at least in places as part of the earthworks and POS landscaping.

The drainage design and modelling considered external / upstream catchment areas draining into the site. It is anticipated that these will be managed via the conveyance of these flows through the development (other than perhaps the catchment area impacting the south-eastern boundary of the site where there may be opportunity to grade these flows south to Stock Road). In most cases these flows will be maintained through Nambad Creek or as proposed vegetated conveyance channels aligned roughly with existing minor creek lines / agricultural drains. However, in some cases these external flows will need to be piped through the development. The locations and indicative alignments of piped conveyance through the development is shown on Figure M.3.

Two flood detention locations have been modelled to assist with managing external catchment inflows (and are illustrated on Figure M.3):

- "C6 inflow_a" refers to an area of detention assumed within the POS area on the eastern boundary. As this area is for managing inflow from an external catchment only, there is no proposed bioretention or formal basin area. Rather, it is assumed that some inundation

over the natural ground surface will occur in this location as external catchment inflows back-up behind the piped conveyance through the site.

- "C4 inflow_e" refers to a detention basin for managing external catchment inflow. It is proposed that the external catchment flows will be piped a short distance to this basin where they will be detailed within a landscaped POS basin to assist with controlling flow rates and piped drainage infrastructure sizes through the development. The detention basin is assumed to comprise a basin of 1.2 m deep with 1:6 batters.

Modelled drainage requirements

The preliminary design herein maintains the peak 1% AEP pre-development discharge rates at each of the existing Great Northern Hwy culverts, as adopted in the designs for the downstream developments.

Table 7: Post-development Discharge Rates

Outlet	Pre-development discharge rate (m^3/s) (Pentium Water, 2023)	Adopted design discharge rate (m3/s) [1]	Post-development discharge rate (m^3/s)
Culvert 2	21.89	21.6	18.98
Culvert 3	0.84	0.90	0.93
Culvert 4	8.90	7.17	7.44
Culvert 5	0.20	0.20	0.21
Culvert 6	6.90	5.26	5.02
Culvert 7	1.10	N/A	0.60

1. Based on design flow rates documented in previous water management planning reports for downstream developments (Cardno, 2012 and Emerge Associates, 2014).

The preliminary design details for bioretention and flood storage areas are provided in Table 8 including the modelled base area as well as the storage volume, depth and inundation area for each of the 15 mm, 20% AEP and 1% AEP events. Also included are the modelled outlet pipe sizes and peak discharge rates for the flood detention areas.

Also included further below are modelled long-sections showing the preliminary design invert levels, flow rates and depths for the arterial drainage channels (Nambad Brook and proposed vegetated conveyance channels).

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Table 8: Modelled drainage basin details

Type	Catchment	Base area (m^2)	Pipe outlet size (mm)	15 mm			20% AEP				1% AEP			
				Depth (m)	Top area (m^2)	Volume (m^3)	Depth (m)	Top area (m^2)	Volume (m^3)	Peak discharge (m3/s)	Depth (m)	Top area (m^2)	Volume (m^3)	Peak discharge (m3/s)
Bio-retention	A	122	-	0.30	181	45	0.38	208	60	-	0.46	236	77	-
	AA	725	-	0.30	760	237	0.47	877	362	-	0.63	994	516	-
	AB	282	-	0.30	368	97	0.40	415	137	-	0.51	471	185	-
	B	526	-	0.30	642	175	0.45	736	280	-	0.62	851	413	-
	C	404	-	0.30	506	136	0.42	573	203	-	0.54	644	277	-
	D	293	-	0.30	381	101	0.44	449	158	-	0.59	529	231	-
	E	500	-	0.30	613	167	0.44	699	261	-	0.59	797	373	-
	F	85	-	0.30	135	33	0.36	152	44	-	0.43	174	55	-
	G	318	-	0.30	409	109	0.40	459	154	-	0.49	506	198	-
	H	344	-	0.30	439	117	0.43	507	175	-	0.55	574	244	-
	K	257	-	0.30	340	89	0.40	386	124	-	0.51	439	172	-
	L1	401	-	0.30	458	129	0.42	522	189	-	0.53	584	251	-
	N	764	-	0.30	902	250	0.47	1029	409	-	0.65	1172	608	-
	U	368	-	0.30	466	125	0.43	536	189	-	0.56	610	265	-
	V	1068	-	0.30	1230	344	0.50	1404	609	-	0.71	1599	922	-
	W	471	-	0.30	581	158	0.44	665	246	-	0.60	768	358	-
	Y	621	-	0.30	747	205	0.45	849	328	-	0.62	972	479	-
	Z	165	-	0.30	232	59	0.37	258	78	-	0.45	290	100	-
Flood storage	I+J	1710	450	0.30	2414	618	0.72	3419	1240	0.45	1.04	4195	3511	0.9
	L2	750	300	0.30	1128	281	0.46	1435	485	0.18	0.83	2179	1135	0.32
	M	352	300	0.30	448	120	0.46	533	200	0.13	0.81	745	421	0
	O	480	300	0.30	591	160	0.44	676	248	0.15	0.93	1016	663	0
	P+Q	729	300	0.30	865	239	0.43	959	378	0.11	0.93	1367	1051	0
	R	517	300	0.30	632	172	0.49	752	299	0.18	0.95	1085	720	0
	S	385	375	0.30	660	157	0.44	1801	384	0.08	0.70	2265	912	0.2
	T	929	300	0.30	1081	301	0.50	1245	537	0.26	1.12	1825	1493	0
	C6 Inflow a	75	525	-	-	-	0.77	497	152	0.24	1.12	748	371	1.14
	C4 Inflow e	450	450	-	-	-	0.58	812	363	0.3	1.15	1261	944	0.56
	Total	**14091**	**-**	**-**	**17209**	**4624**	**-**	**22851**	**8292**	**-**	**-**	**28896**	**16945**	**-**

Nambad Brook 1% AEP Flood Modelling

The XPSWMM hydraulic model was also to simulate the 1% AEP flood levels through the Nambad Brook foreshore and POS corridor under post-development conditions (ie. inclusive of the removal of the minor northern flow path adjacent to the main creek line, and inclusive of the post-development urban stormwater flows). Figure M.4 below provides the modelled flood extent (delineated by interpolation of the 1D modelling results at the flood level points illustrated in Figure M.4).

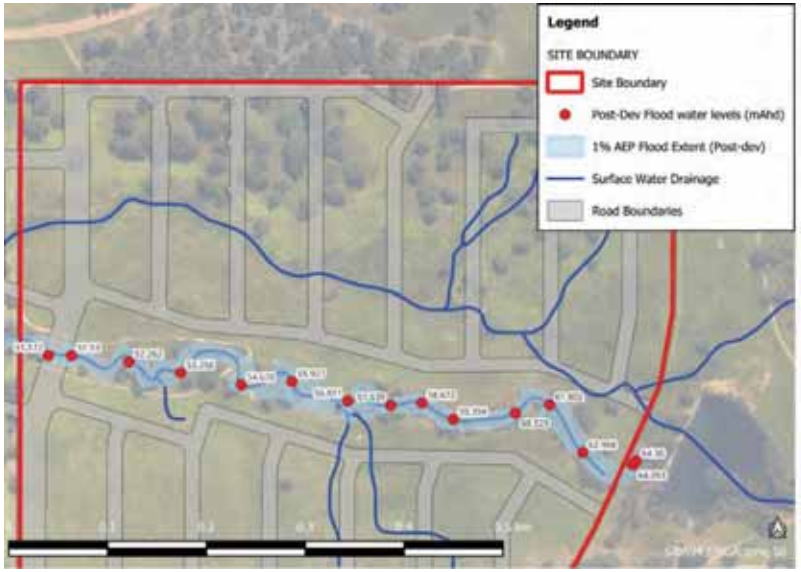

Figure M.4: Nambad Brook 1% AEP flood levels and inundation

Attachments: *Great Northern Highway culvert hydraulic analysis*
Modelled long-sections for Nambad Brook (Pre and post-development cases) and minor creeks / conveyance channels

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Attachment: Great Northern Highway culvert hydraulic analysis

Culvert	No. barrels	Pipe dia. (mm)	RCB size	Equivalent pipe dia. per barrel (mm)	US IL	DS IL	Length	Estimated 1:100 Tailwater depth	1:100 Tailwater mRL	Road crest	1:100 Headwater mRL (nil freeboard)	1:100 Capacity per barrel (nil freeboard, incl k=1.5 losses)	1:100 Capacity total (nil freeboard, incl k=1.5 losses)	1:100 Catchment Peak Flow Estimate (m3/s)	Catchment flow above culvert capacity (m3/s)	Flow in excess of culvert capacity goes to	**Estimated peak pre-development discharge**
3	2	450	-	-	39	38.77	25	-	39.1	40	40	0.42	0.84	2.92	2.08	Culvert 4	**0.84**
4	2	-	1800x900	1435	36.73	36.65	34	0.9	37.55	40.4	40.4	8.9	17.8	6.8	-	NA	**8.90**
5	1	350	-	-	37.86	37.47	26	0.6	38.07	38.7	38.7	0.19	0.19	1.66	1.47	Culvert 6	**0.19**
6	2	900		-	34.72	34.36	28	-	35.3	36.8	36.8	2.5	4.90	4.94	-	NA	**6.92**
7	1	600		-	35.73	35.09	39	0.6	35.69	37.55	37.55	1.06	1.06	1.57	0.51	Culvert 6	**1.06**

Culvert capacity / overflow direction assessment

Culvert 3: Peak 1% AEP flow estimate = 2.92 m3/s. Theoretical culvert capacity exceeded by ~2.1 m3/s.
Existing roadside drain along Great Northern Hwy has an overall grade to the south from Culvert 3 (IL 39.00) to Culvert 4 (IL 36.73).
Some negative grade but the high point of the drain is 39.3 which is ~0.6m below the lowest point of the road embankment along the flow path, therefore flows exceeding Culvert 3 capacity expected to flow primarily to Culvert 4.

Culvert 4: Peak 1% AEP flow estimate = 6.8 m3/s which is well below theorectical culvert capacity.
Including potential ~2.1 m3/s from upstream (bypassing Culvert 3) the total peak discharge at Culvert 4 = 8.9 m3/s which is still below theoretical capacity of Culvert 4.

Culvert 5: Peak 1% AEP flow estimate = 1.66 m3/s. Theoretical culvert capacity exceeded by ~1.4 m3/s.
Existing roadside drain along Great Northern Hwy has a consistent grade to the south from Culvert 5 (IL 37.86) to Culvert 6 (IL 34.72).
Therefore flows exceeding Culvert 5 capacity will flow to Culvert 6.

Culvert 6: Peak 1% AEP flow estimate = 4.9 m3/s which is the same as the theorectical culvert capacity.
Including potential ~1.9 m3/s from upstream (bypassing Culverts 5 and 7) the total peak discharge at Culvert 6 = 6.8 m3/s which exceeds the theoretical capacity of Culvert 6 and may overtop Great Northern Hwy.

Culvert 7: Peak 1% AEP flow estimate = 1.57 m3/s. Theoretical culvert capacity exceeded by ~0.5 m3/s.
Existing roadside drain along Great Northern Hwy has an overall grade to the north from Culvert 7 (IL 35.73) to Culvert 6 (IL 34.73).
Some negative grade but the high point of the drain is 36.8 which is below the lowest point of the road embankment along the flow path, therefore flows exceeding Culvert 7 capacity expected to flow primarily to Culvert 6.



Figure 1: Nambad Brook Plan View (Pre-Development Case)

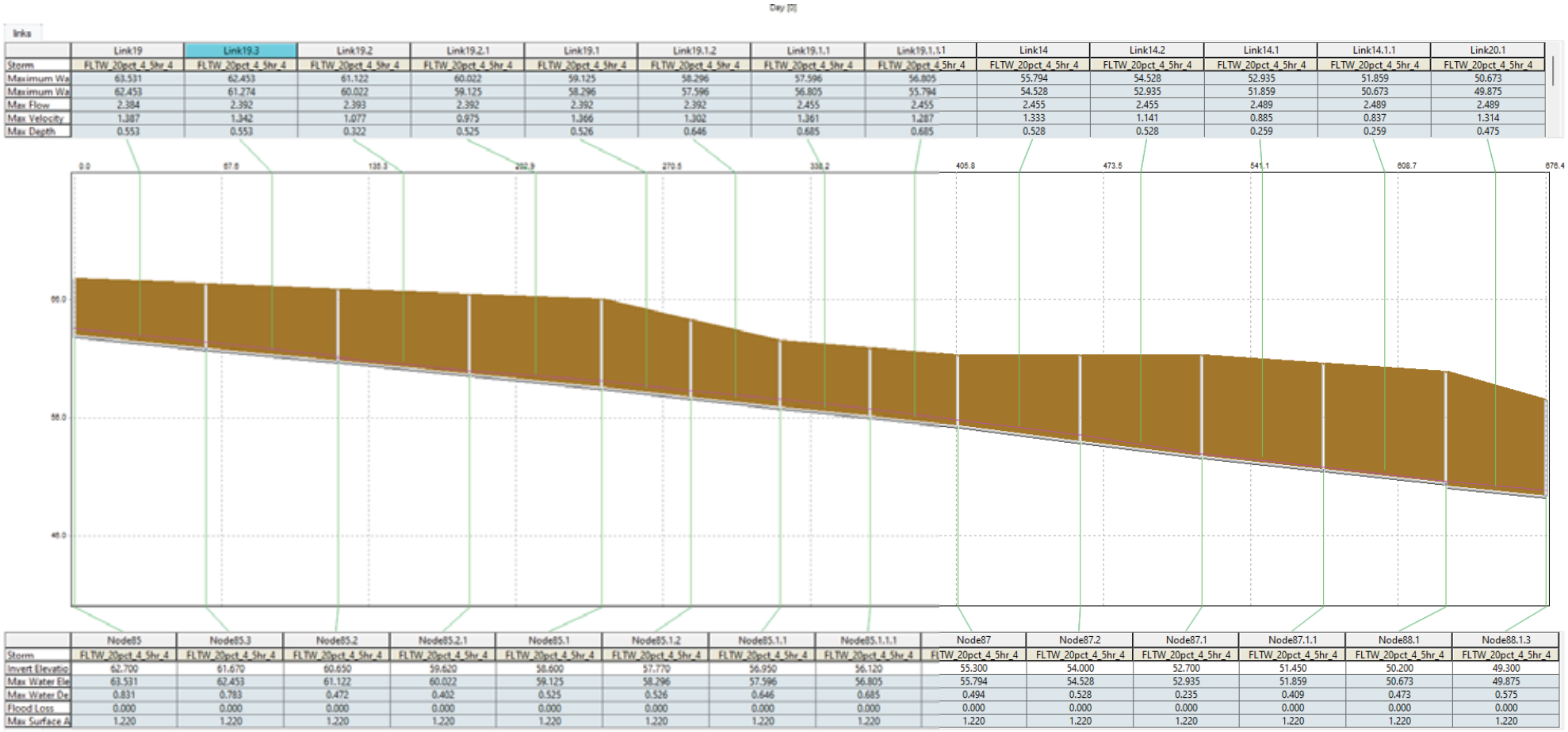


Figure 2: Nambad Brook 20% AEP Long Section (Pre-Development Case)

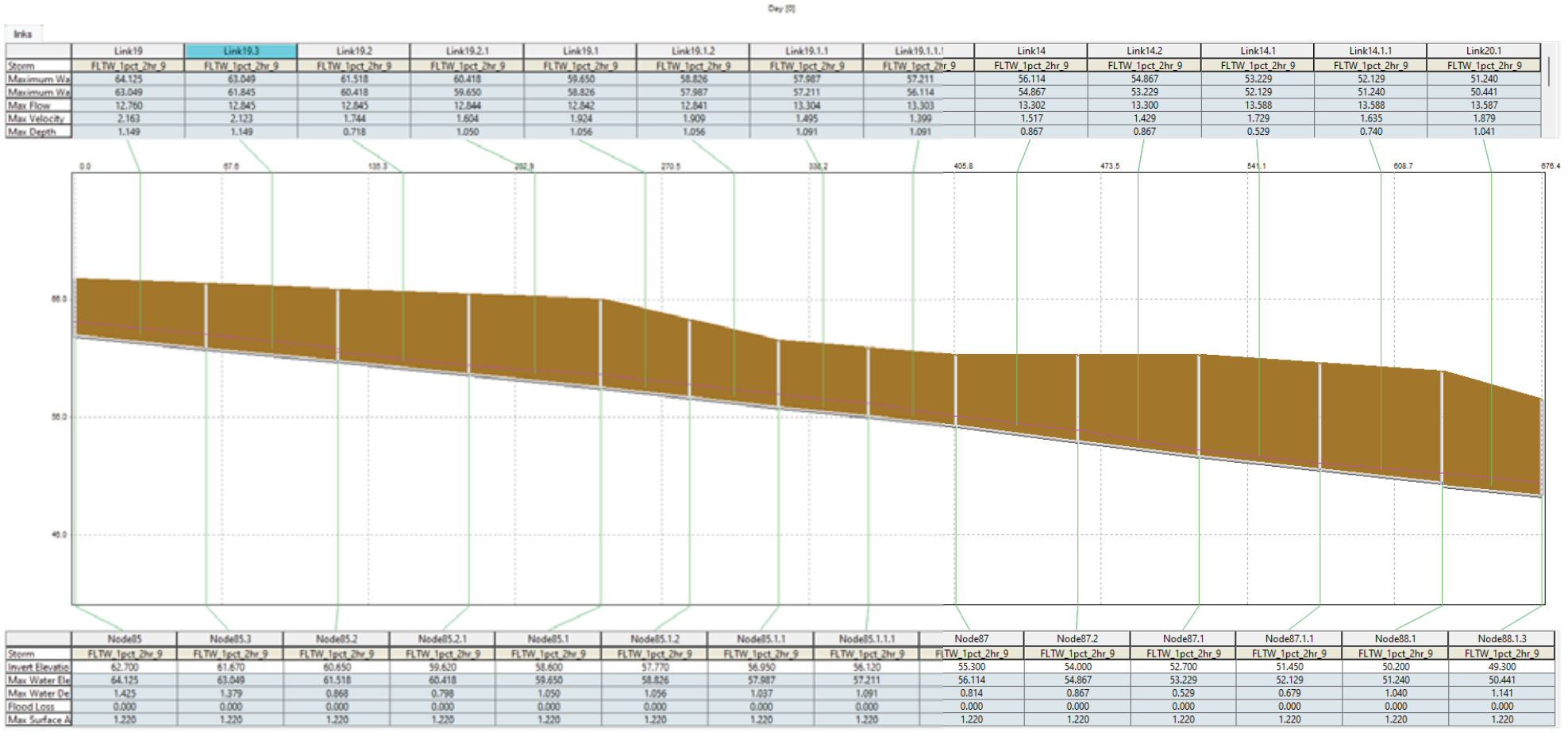


Figure 3: Nambad Brook 1% AEP Long Section (Pre-Development Case)



Figure 4: Nambad Brook Plan View (Post-Development Case)

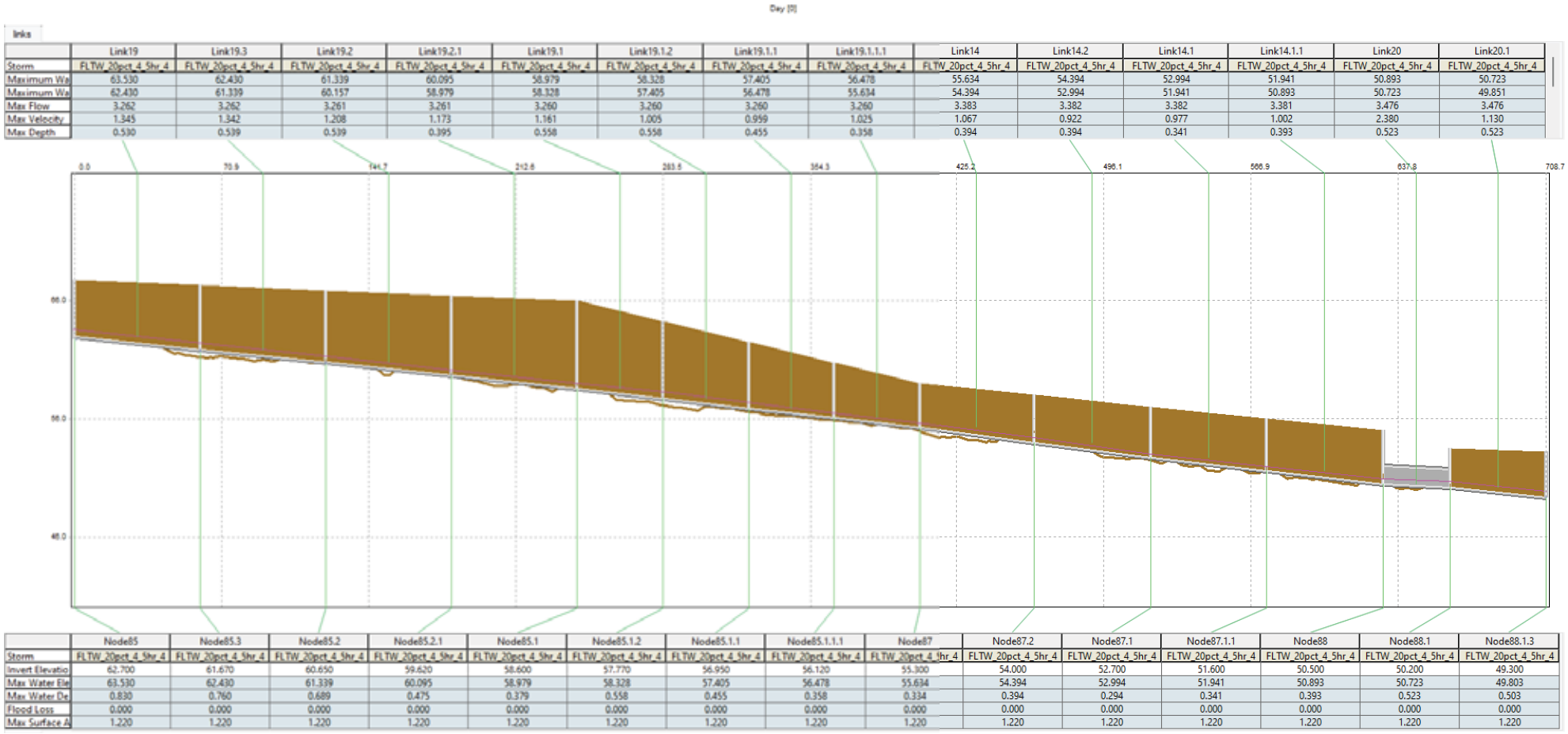


Figure 5: Nambad Brook 20% AEP Long Section (Post Development Case)

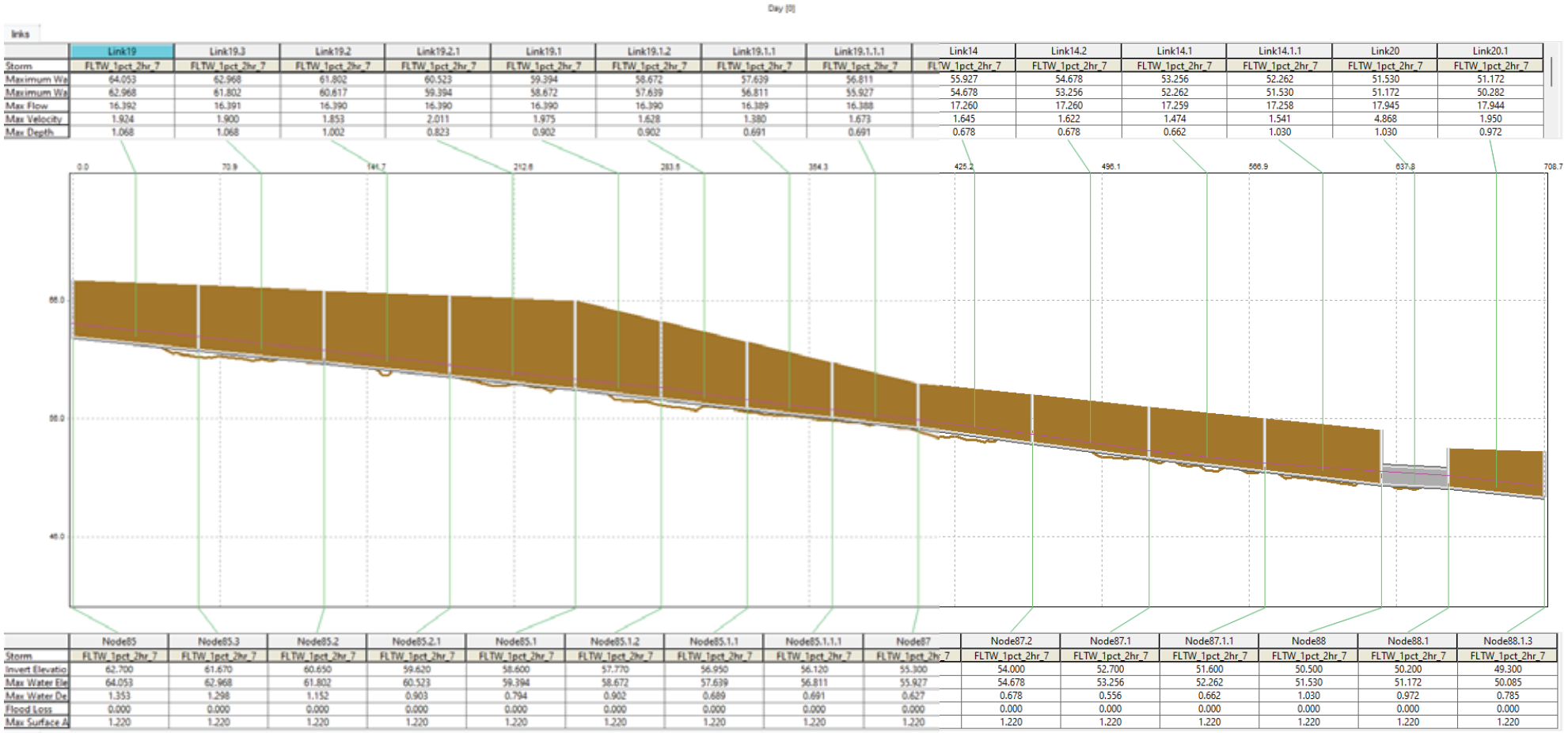


Figure 6: Nambad Brook 1% AEP Long Section (Post Development Case)

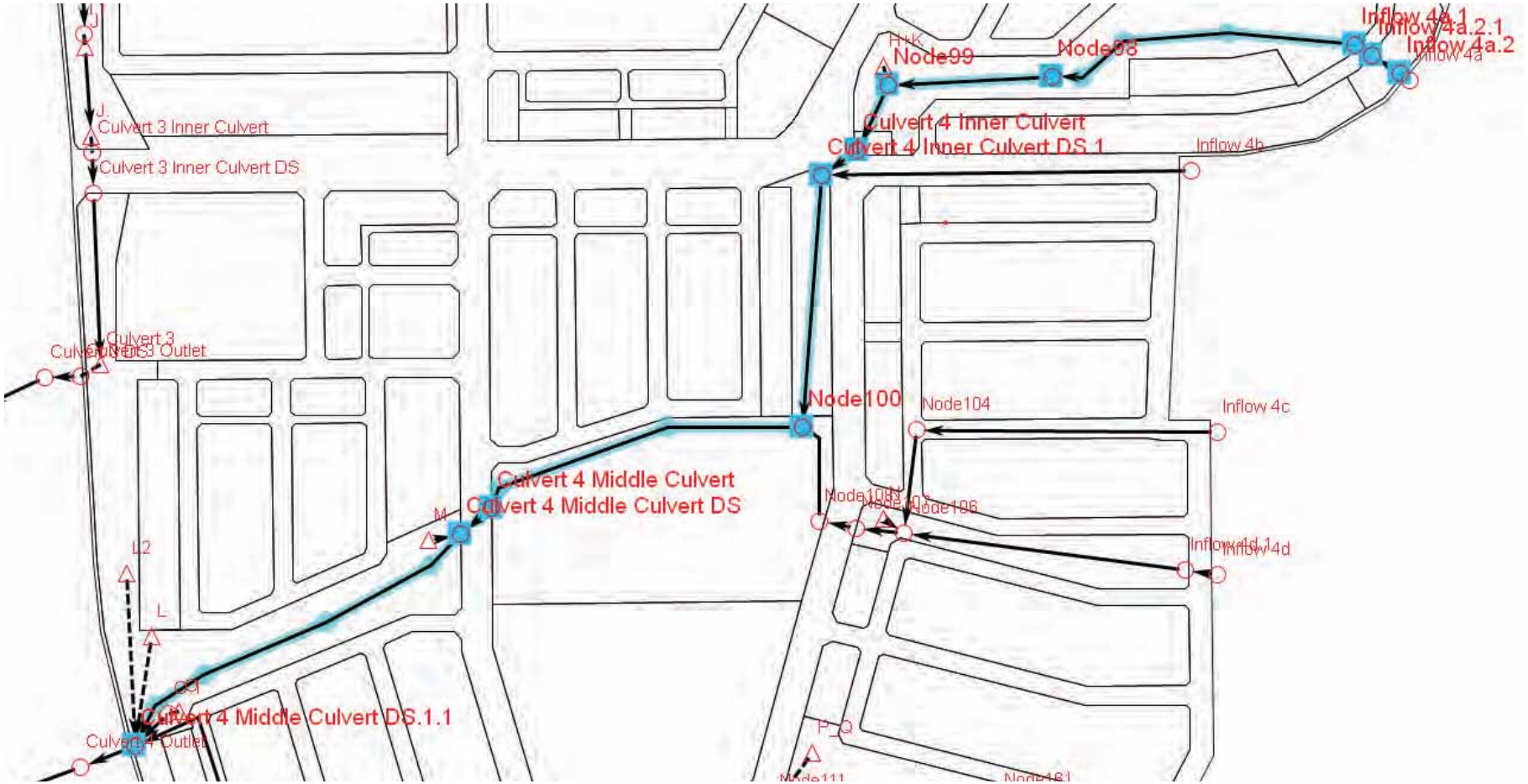
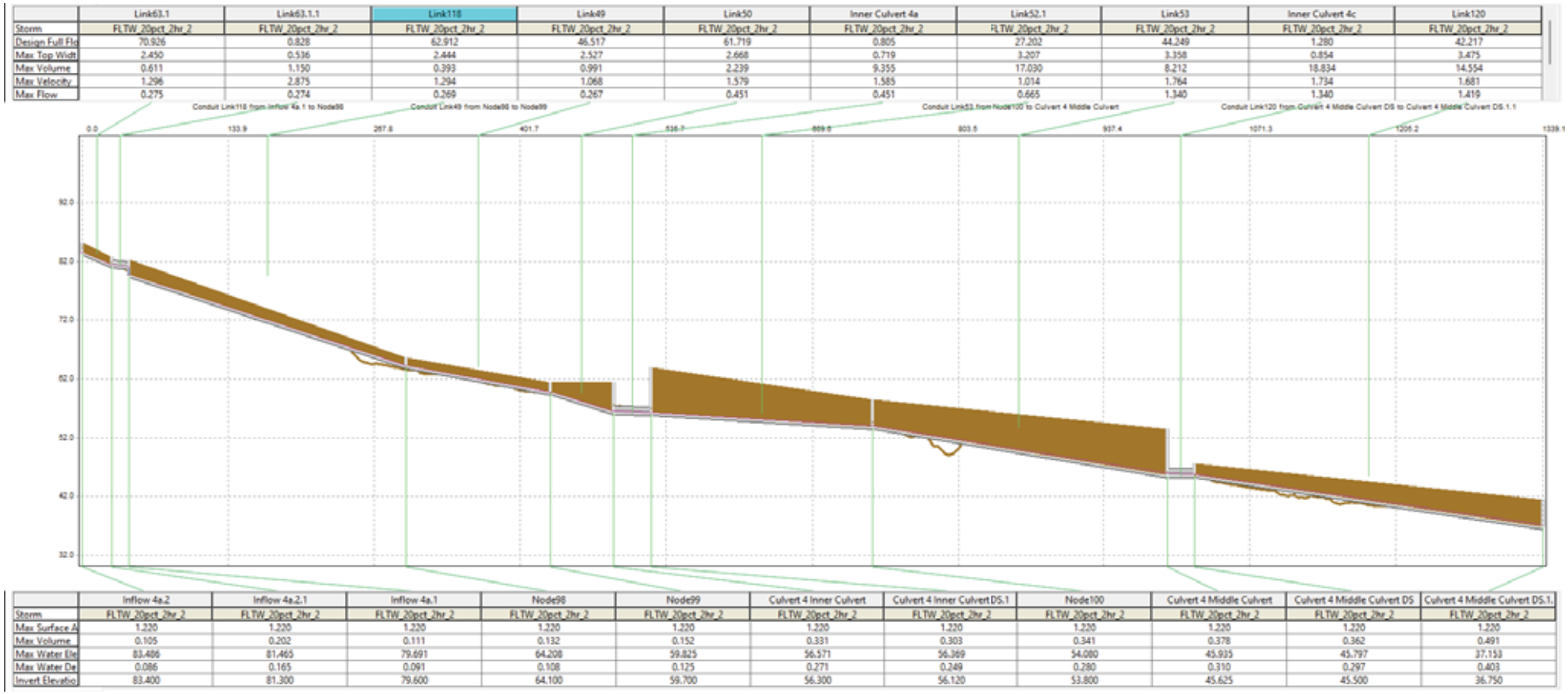


Figure 7: Culvert 4 a Stream Plan View



	Link63.1	Link63.1.1	Link118	Link49	Link50	Inner Culvert 4a	Link52.1	Link53	Inner Culvert 4c	Link120
Storm	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2
Design Full Flo	70.926	0.828	62.912	46.517	61.719	0.805	27.202	44.249	1.280	42.217
Max Top Widt	2.450	0.536	2.444	2.527	2.668	0.719	3.207	3.358	0.854	3.475
Max Volume	0.611	1.150	0.393	0.991	2.239	9.355	17.030	8.212	18.834	14.554
Max Velocity	1.296	2.875	1.294	1.068	1.579	1.585	1.014	1.764	1.734	1.681
Max Flow	0.275	0.274	0.269	0.267	0.451	0.451	0.665	1.340	1.340	1.419

	Inflow 4a.2	Inflow 4a.2.1	Inflow 4a.1	Node98	Node99	Culvert 4 Inner Culvert	Culvert 4 Inner Culvert DS.1	Node100	Culvert 4 Middle Culvert	Culvert 4 Middle Culvert DS	Culvert 4 Middle Culvert DS.1.
Storm	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2
Max Surface A	1.220	1.220	1.220	1.220	1.220	1.220	1.220	1.220	1.220	1.220	1.220
Max Volume	0.105	0.202	0.111	0.132	0.152	0.331	0.303	0.341	0.378	0.362	0.491
Max Water Ele	83.486	81.465	79.691	64.208	59.825	56.571	56.369	54.080	45.935	45.797	37.153
Max Water De	0.086	0.165	0.091	0.108	0.125	0.271	0.249	0.280	0.310	0.297	0.403
Invert Elevatio	83.400	81.300	79.600	64.100	59.700	56.300	56.120	53.800	45.625	45.500	36.750

Figure 8: Culvert 4 a Stream 20% AEP Long Section

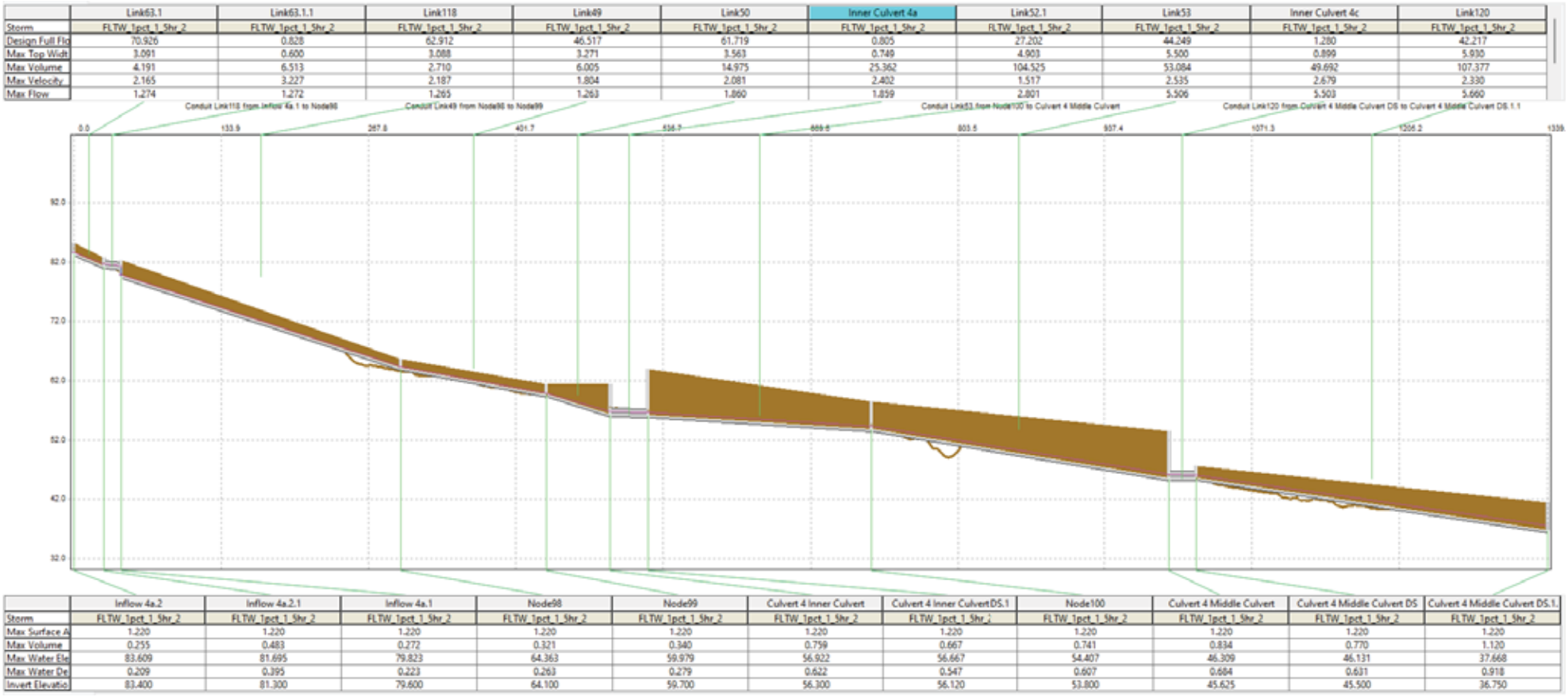


Figure 9: Culvert 4 a Stream 1% AEP Long Section

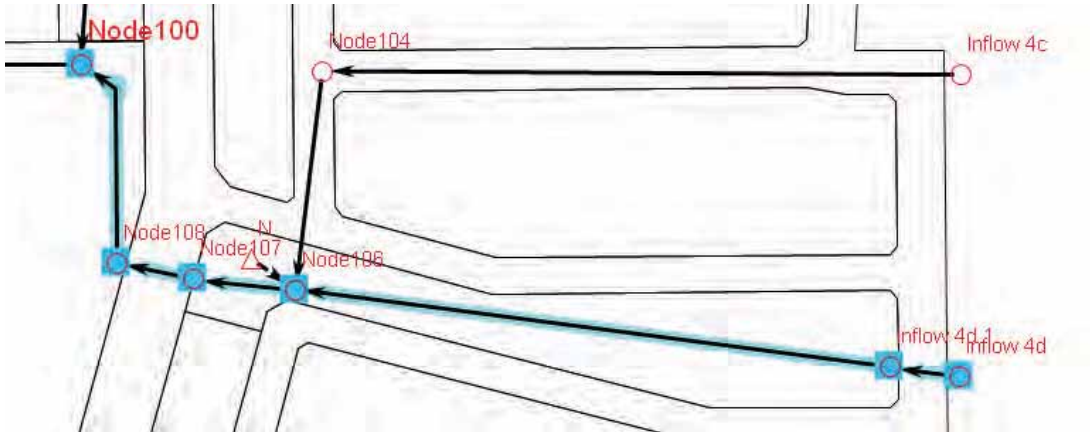
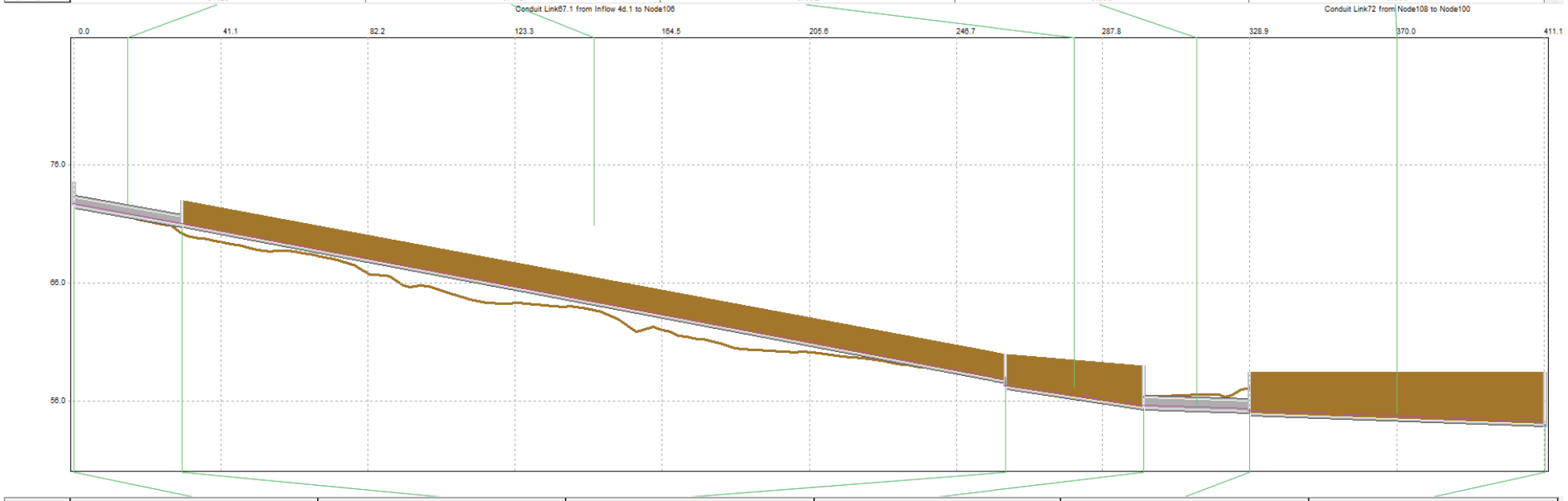


Figure 10: Culvert 4 b Stream Plan View

	Link67	Link67.1	Link70	Inner Culvert 4b	Link72
Storm	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2
Design Full Flo	2.558	60.951	53.461	4.493	26.626
Max Top Widt	0.683	2.575	2.847	1.500	3.283
Max Volume	0.180	0.570	2.129	5.902	11.852
Max Velocity	4.755	1.516	1.616	2.279	0.967
Max Flow	0.429	0.415	0.692	0.693	0.686



	Inflow 4d	Inflow 4d.1	Node106	Node107	Node108	Node100
Storm	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2	FLTW_20pct_2hr_2
Max Surface A	1.220	1.220	1.220	1.220	1.220	1.220
Max Volume	0.291	0.146	0.212	0.248	0.334	0.341
Max Water Ele	72.739	71.020	57.373	55.703	55.274	54.080
Max Water De	0.239	0.120	0.173	0.203	0.274	0.280
Invert Elevatio	72.500	70.900	57.200	55.500	55.000	53.800

Figure 11: Culvert 4 b Stream 20% AEP Long Section

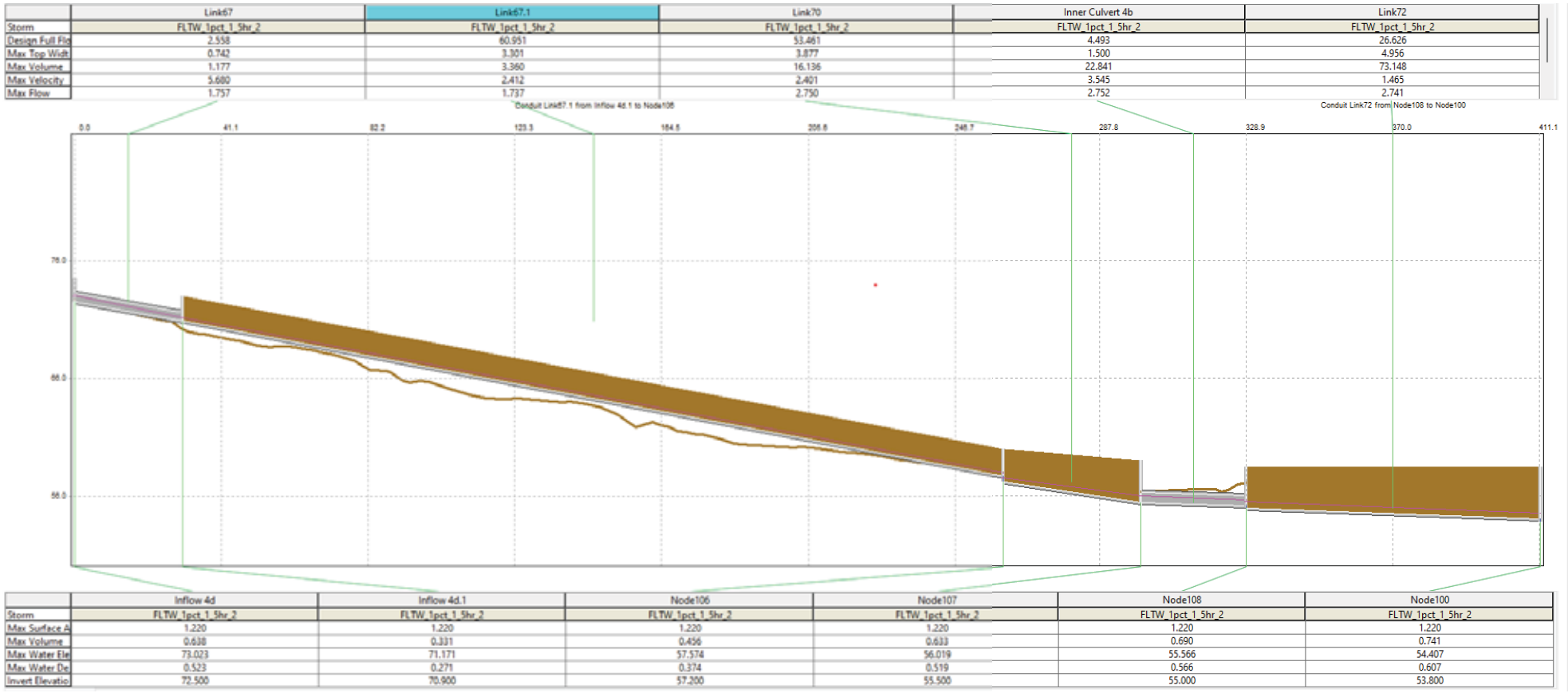


Figure 12: Culvert 4 b Stream 1% AEP Long Section

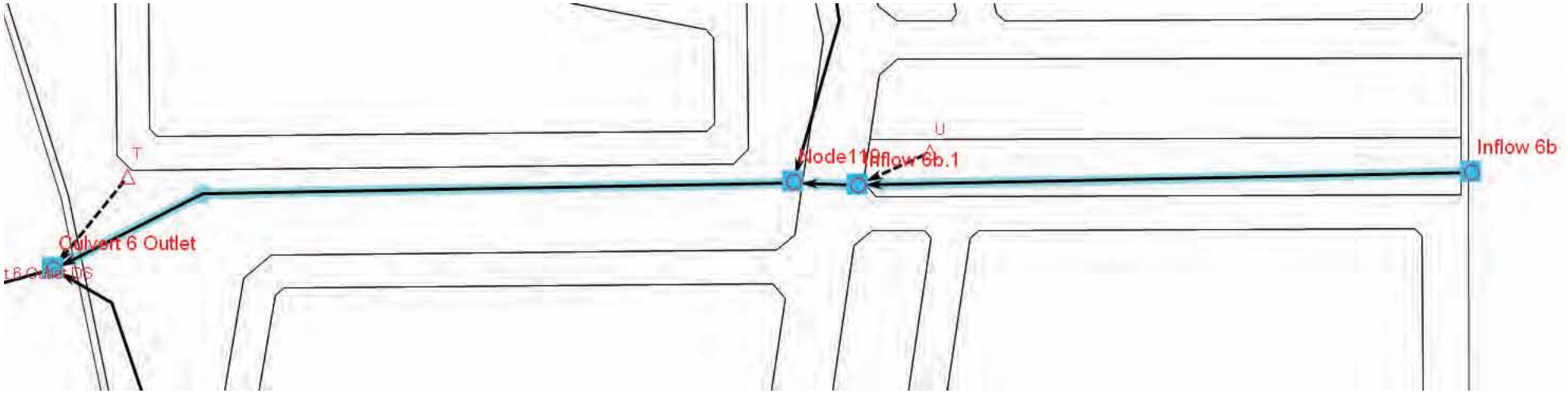


Figure 13: Culvert 6 Stream Plan View

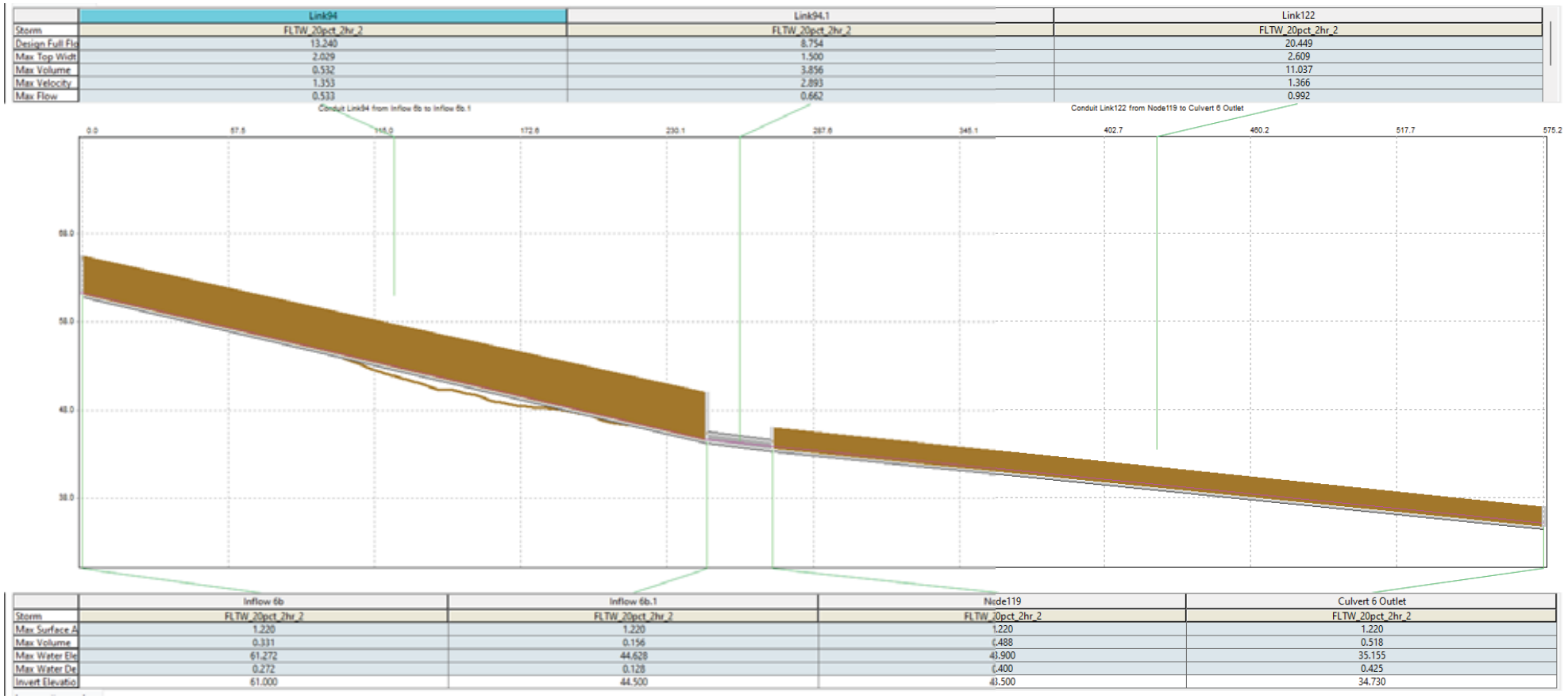


Figure 14: Culvert 6 Stream 20% AEP Long Section

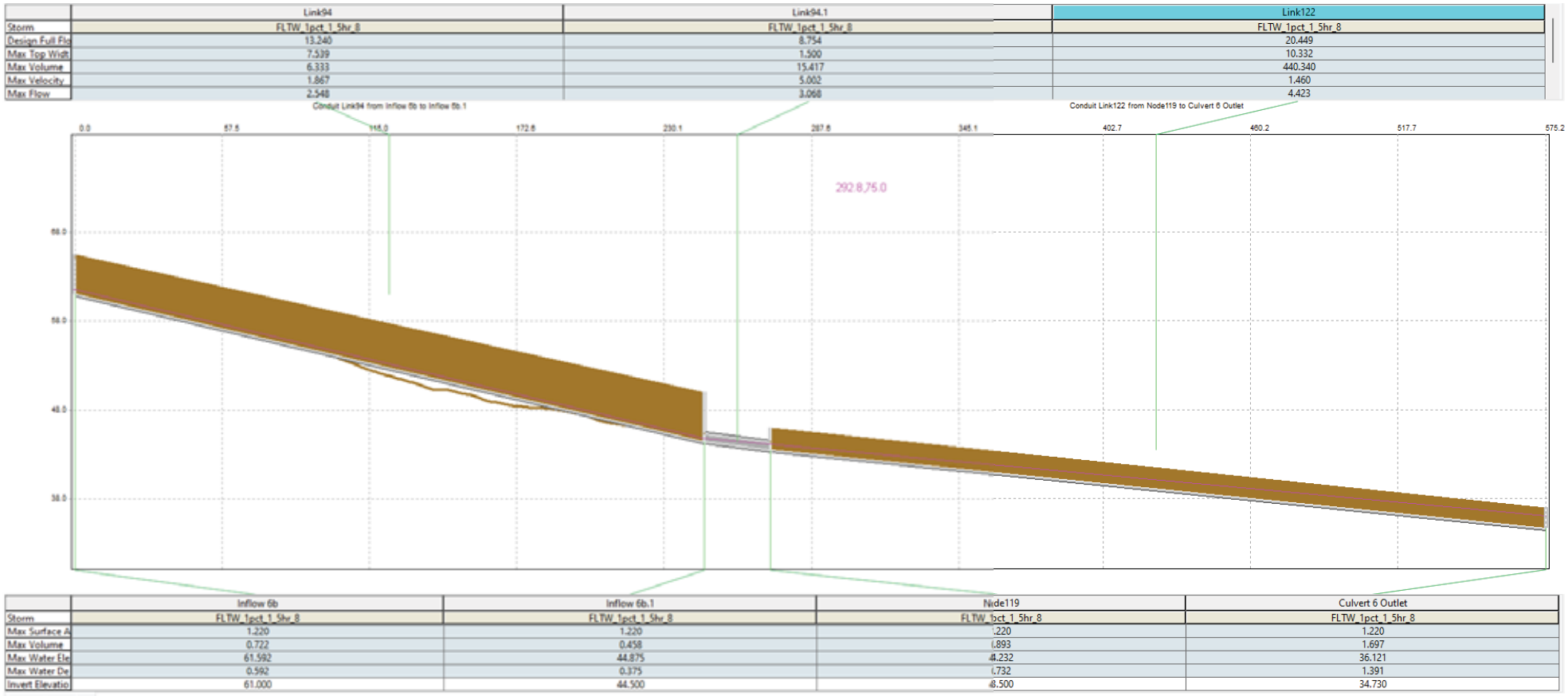


Figure 15: Culvert 6 Stream 1% AEP Long Section



Attachment 5

Bushfire Management Plan

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Bullsbrook South

Bushfire Management Plan (BMP)



Produced to meet the relevant requirements of STATE PLANNING POLICY 3.7 Planning in Bushfire Prone Areas & Guidelines

Address / Locations:
Lot 900 (61) Yarrimbah Drive
Lot 400 (2428) Great Northern Highway
Lot 2 (2424) Great Northern Highway
Lot 5 (2422) Great Northern Highway
Lot 6 (2416) Great Northern Highway
Lot 4 Yarrimbah Drive
Lot 61 (2342) Great Northern Highway
Lot 201 (2306) Great Northern Highway
Part Lot 1011 (2274) Great Northern Highway
Part Lot 803 (2242) Great Northern Highway
Part Lot 20 (2234) Great Northern Highway
Lot 802 (2258) Great Northern Highway
Lot 100 (2286) Great Northern Highway

City of Swan

Strategic Planning Proposal - Local Planning Scheme & Structure Plan (lot layout known)

16 September 2025

Job Reference No: 220163

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Version	Status/Details	Date
1.0	Draft For Comment	24 May 2023
1.1	Final - Following Comments and Amendments to Design Layout	6 July 2023
1.2	Amendment to Final Document - Changes to Design Layout/Inclusion of additional site area	11 August 2023
1.3	Amendment to Final Document – Changes to Design Layout/Exclusion of Lots	15 November 2023
1.4	Amendment to Final Document – Post LSP Approval – Per WAPC Schedule of Modifications	16 September 2025

DISTRIBUTION

Destination		Version	No. Copies	Hard Copy	Electronic Copy
Person	Email				
Rebecca Thompson – Rowe Group	Rebecca.Thompson@rowegroup.com.au	1.4		☐	☒
		-		☐	☐

Limitations: *The protection measures that will be implemented based on information presented in this Bushfire Management Plan are minimum requirements and they do not guarantee that buildings or infrastructure will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating.*

This is substantially due to the unpredictable nature and behaviour of fire and fire weather conditions. Additionally, the correct implementation of the required protection measures (including bushfire resistant construction) and any other required or recommended measures, will depend upon, among other things, the ongoing actions of the landowners and/or operators over which Bushfire Prone Planning has no control.

All surveys, forecasts, projections and recommendations made in this report associated with the proposed development are made in good faith based on information available to Bushfire Prone Planning at the time. All maps included herein are indicative in nature and are not to be used for accurate calculations.

Notwithstanding anything contained therein, Bushfire Prone Planning will not, except as the law may require, be liable for any loss or other consequences whether or not due to the negligence of their consultants, their servants or agents, arising out of the services provided by their consultants.

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SUMMARY STATEMENTS

THIS DOCUMENT – STATEMENT OF PURPOSE

The Bushfire Management Plan (BMP)
The BMP sets out the required package of bushfire protection measures to lessen the risks associated with a bushfire event. It establishes the responsibilities to implement and maintain these measures.
The BMP also identifies the potential for any negative impact on any environmental, biodiversity and conservation values that may result from the application of bushfire protection measures or that may limit their implementation.
Risks Associated with Bushfire Events
The relevant risks are the potential for loss of life, injury, or destroyed or damaged assets which results in personal loss and economic loss. For a given site, the level of that risk to persons and assets (the exposed elements) is a function of the potential threat levels generated by the bushfire hazard, and the level of exposure and vulnerability of the at risk elements to the threats.
Bushfire Protection Measures
The required package of protection measures is established by *State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7)*, its associated *Guidelines* and any other relevant guidelines or position statements published by the Department of Planning, Lands and Heritage. These measures are limited to those considered by the WA planning authorities as necessary to be addressed for the purpose of land use planning. They do not encompass all available bushfire protection measures as many are not directly relevant to the planning approval stage. For example:
• Protection measures to reduce the vulnerability of buildings to bushfire threats is primarily dealt with at the building application stage. They are implemented through the process of applying the Building Code of Australia (Volumes 1 and 2 of the national Construction Code) in accordance with WA building legislation and the application of construction requirements based on a building's level of exposure - determined as a Bushfire Attack Level (BAL) rating); or
• Protection measures to reduce the threat levels of consequential fire (ignited by bushfire and involving combustible materials surrounding and within buildings) and measures to reduce the exposure and vulnerability of elements at risk exposed to consequential fire, are not specifically considered.
The package of required bushfire protection measures established by the Guidelines includes:
• The requirements of the bushfire protection criteria which consist of:
  • Element 1: Location (addresses threat levels).
  • Element 2: Siting and Design of Development (addresses exposure levels of buildings).
  • Element 3: Vehicular Access (addresses exposure and vulnerability levels of persons).
  • Element 4: Water (addresses vulnerability levels of buildings).
  • Element 5: Vulnerable Tourism Land Uses (addresses exposure and vulnerability as per Elements 1-4 but in use specific ways and with additional considerations of persons exposure and vulnerability).
• The requirement to develop Bushfire Emergency Plans / Information for 'vulnerable' land uses for persons to prepare, respond and recover from a bushfire event (this addresses vulnerability levels).
• The requirement to assess bushfire risk and incorporate relevant protection measures into the site emergency plans for 'high risk' land uses (this addresses threat, exposure and vulnerability levels).
Compliance of the Proposed Development or Use with SPP 3.7 Requirements
The BMP assesses the capacity of the proposed development or use to implement and maintain the required 'acceptable' solutions and any additionally recommended bushfire protection measures - or its capacity to satisfy the policy intent through the justified application of additional bushfire protection measures as supportable 'alternative' solutions.

THE PROPOSED DEVELOPMENT/USE – BUSHFIRE PLANNING COMPLIANCE SUMMARY		
Environmental Considerations		**Assessment Outcome**
Will land with identified environmental, biodiversity and conservation values limit the full application of the required bushfire protection measures?		Possible (check)
Will land with identified environmental, biodiversity and conservation values need to be managed in the implementation and maintenance of the bushfire protection measures - but not limit their application?		Possible (check)
Required Bushfire Protection Measures The Acceptable Solutions of the Bushfire Protection Criteria (Guidelines)		**Assessment Outcome**
Element	The Acceptable Solutions	
1: Location	A1.1 Development location	Fully Compliant
2: Siting and Design of Development	A2.1 Asset Protection Zone (APZ)	Fully Compliant
3: Vehicular Access	A3.1 Public roads	Fully Compliant
	A3.2a Multiple access routes	Fully Compliant
	A3.2b Emergency access way	N/A
	A3.3 Through-roads	Fully Compliant
	A3.4a Perimeter roads	Fully Compliant
	A3.4b Fire service access route	Fully Compliant
	A3.5 Battle-axe legs	N/A
	A3.6 Private driveways	N/A
4: Water	A4.1 Identification of future water supply	Fully Compliant
	A4.2 Provision of water for firefighting purposes	Fully Compliant
Other Documents Establishing Bushfire Protection Measure Variations or Additions		**Assessment Outcome**
A 'Planning Approval' or a 'Notice of Determination' which contains 'Conditions' to be met.		N/A
A DPLH/WAPC 'Position Statement'		N/A
Bushfire Management Plan Guidance for the Dampier Peninsula (DPLH 2021 Rev B)		N/A
Other 'Bushfire Planning' Documents to Be Produced This necessity for additional documents is determined by the proposed development/use type and the requirements established by SPP 3.7 and the associated Guidelines (as amended). They may be produced concurrently or subsequent to the BMP. Relevant actions will be identified within Section 6 'Responsibilities for Implementation of Bushfire Protection Measures.		**Required**
Subsequent Bushfire Management Plans – For future development proposals		Yes
Summary Statement: Site-Specific Bushfire Management Plans for future development proposals on the subject land that considers land use at that time such as staged subdivision and development applications.		

1 PROPOSAL DETAILS AND THE BUSHFIRE MANAGEMENT PLAN

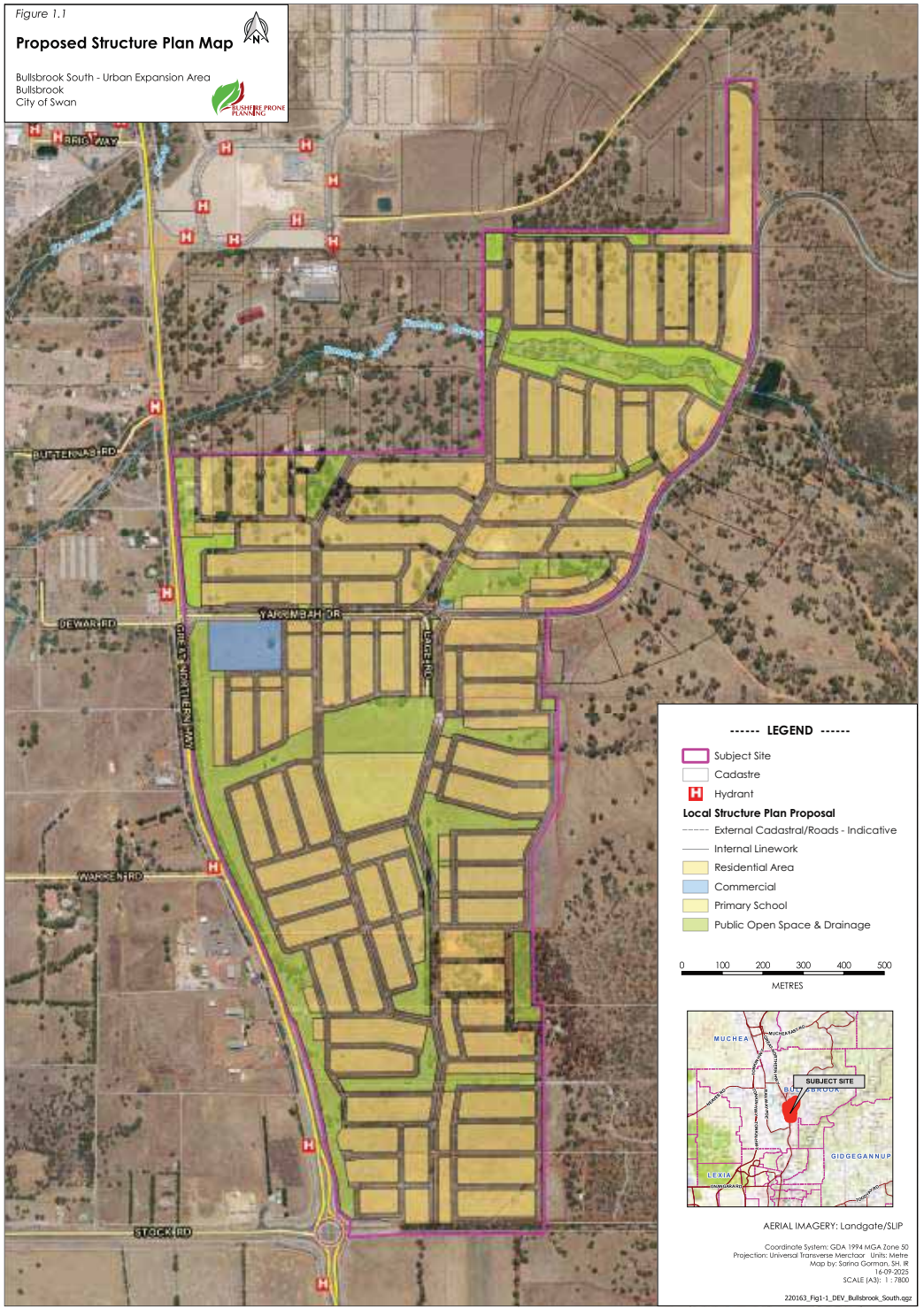
1.1 The Proposed Development/Use Details, Plans and Maps

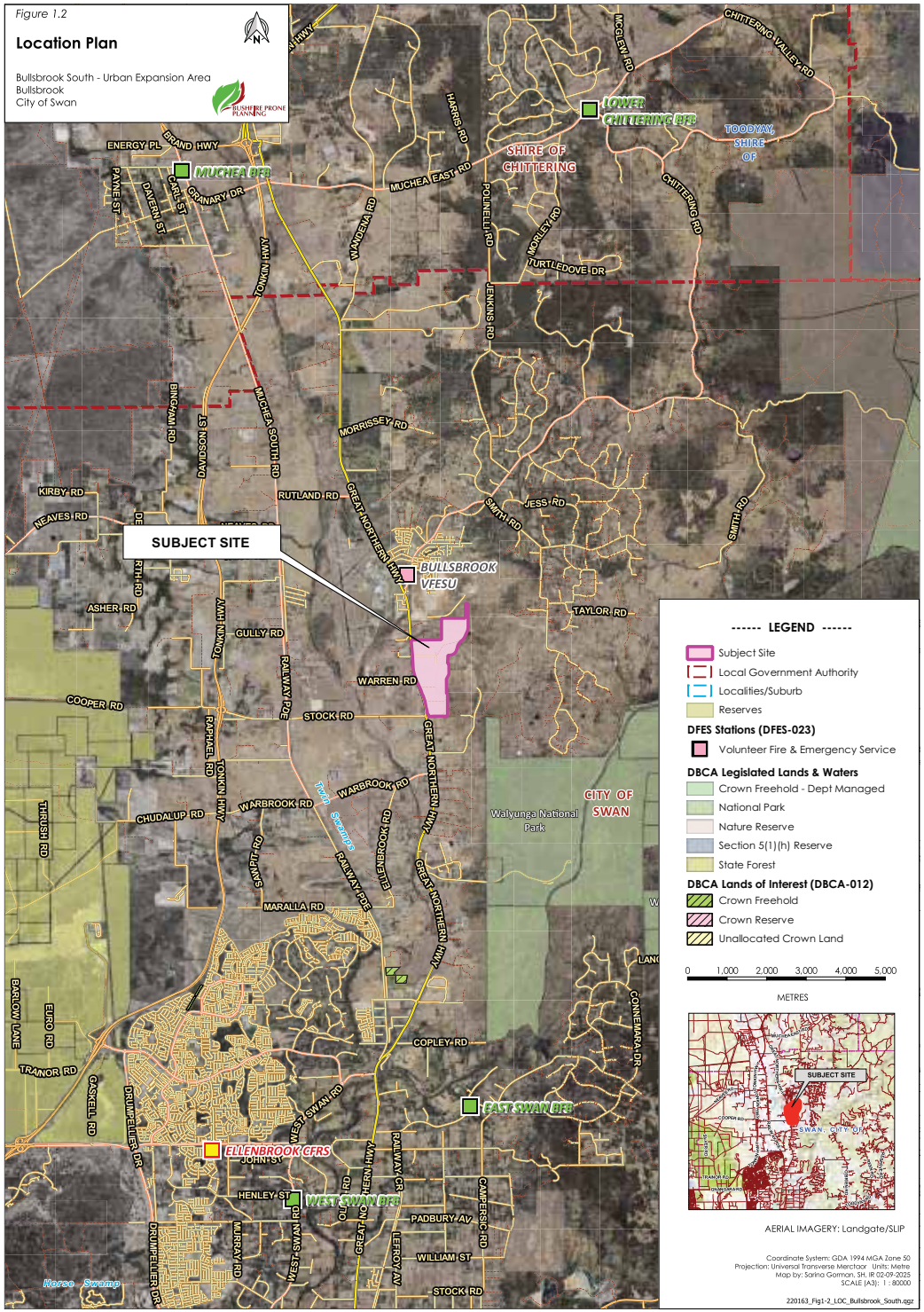
The Proposal's Planning Stage For which certain bushfire planning documents are required to accompany the planning application.		Structure Plan (lot layout known)		
The Subject Land/Site		Bullsbrook - City of Swan Various Land Parcels (per below): Lot 900 (61) Yarrimbah Drive Lot 400 (2428) Great Northern Highway Lot 2 (2424) Great Northern Highway Lot 5 (2422) Great Northern Highway Lot 6 (2416) Great Northern Highway Lot 4 Yarrimbah Drive Lot 61 (2342) Great Northern Highway Lot 201 (2306) Great Northern Highway Part Lot 1011 (2274) Great Northern Highway Part Lot 803 (2242) Great Northern Highway Part Lot 20 (2234) Great Northern Highway Lot 802 (2258) Great Northern Highway Lot 100 (2286) Great Northern Highway		
Total Area of Subject Lot/Site		150.1 hectares		
Number of Additional Lots Created		Existing lot(s) = 10 / Proposed Land Use Zones Across Subject Site = 4 – Approximately 1977 total lots.		
Primary Proposed Construction	**Type(s)**	New Building(s)		
	NCC Classification	Class 1a (house)	Class 5 (office building - professionals)	Class 9b (assembly building)
The 'Specific' Land Use Type for **Bushfire Planning** When applicable, this classification establishes a requirement to conduct assessments and develop documents that are additional to this Bushfire Management Plan.		N/A		
Description of the Proposed Development/Use				
Local Structure Plan to facilitate the development of the subject land into a combination of land uses including Residential Areas, Commercial Areas, Schools and Public Open Space Areas. This involves Metropolitan Scheme Amendments which have already been lodged with v1.2 of this BMP.				
Description of Planned Staged Development and the Management of Potential Bushfire Planning Issues				
Strategic assessment to address the bushfire risk that considers the future potential development proposal.				

Figure 1.1

Proposed Structure Plan Map

Bullsbrook South - Urban Expansion Area
Bullsbrook
City of Swan



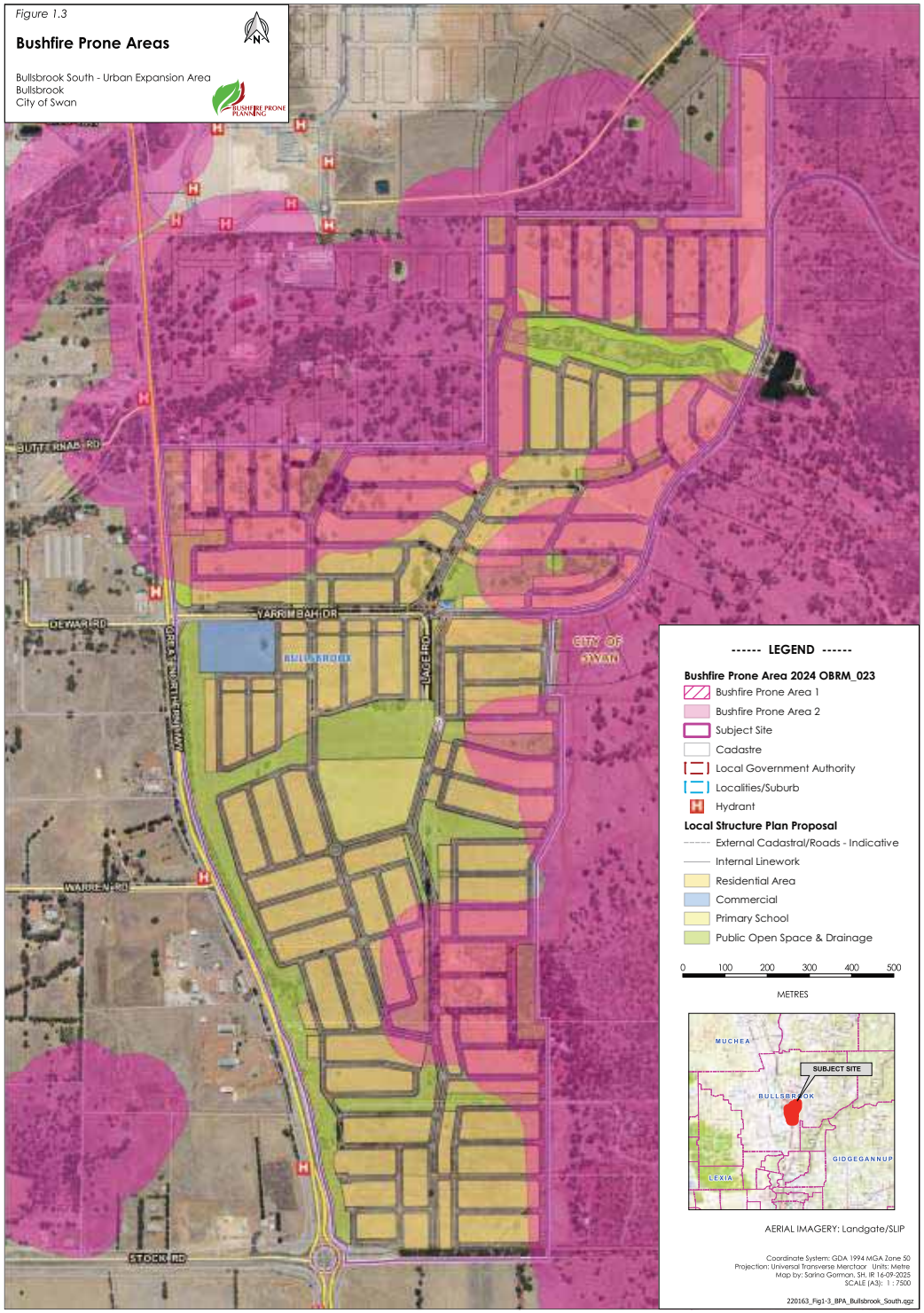


WHERE SPP 3.7 AND THE GUIDELINES ARE TO APPLY – DESIGNATED BUSHFIRE PRONE AREAS

All higher order strategic planning documents, strategic planning proposals, subdivisions and development applications located in designated bushfire prone areas need to address SPP 3.7 and its supporting Guidelines. This also applies where an area is not yet designated as bushfire prone but is proposed to be developed in a way that introduces a bushfire hazard.

For development applications where only part of a lot is designated as bushfire prone and the proposed development footprint is wholly outside of the designated area, the development application will not need to address SPP 3.7 or the Guidelines. (Guidelines DPLH 2021 v1.4, s1.2).

For subdivision applications, if all the proposed lots have a BAL-LOW indicated, a BMP is not required. (Guidelines DPLH 2021 v1.4, s5.3.1).



1.2 The Bushfire Management Plan (BMP)

1.2.1 Commissioning and Purpose

Landowner / proponent:	Mirvac Pty Ltd on behalf of various landowners: George Humphery Park/Esme Florence Park/McRae Investments Pty Ltd, Timevalley Pty Ltd, Marlin Bullsbrook Property Holdings Pty Ltd, Riverbell Holdings Pty Ltd, Mirvac Pty Ltd.
Bushfire Prone Planning commissioned to produce the BMP by:	Rowe Group on behalf of Mirvac Pty Ltd
Purpose of the BMP:	To assess the proposal's ability to meet all relevant requirements established by State Planning Policy 3.7: Planning in Bushfire Prone Areas (SPP 3.7), the associated 'Guidelines and any relevant Position Statements; and To satisfy the requirement for the provision of a Bushfire Management Plan to accompany the strategic planning proposal.
BMP to be submitted to:	WA Planning Commission (WAPC)

1.2.1 Other Documents with Implications for Development of this BMP

This section identifies any known assessments, reports or plans that have been conducted and prepared previously, or are being prepared concurrently, and are relevant to the planned proposal for the subject. They potentially have implications for the assessment of bushfire threats and the identification and implementation of the protection measures that are established by this Bushfire Management Plan.

Table 1.4: Other relevant documents that may influence threat assessments and development of protection measures.

RELEVANT DOCUMENTS					
Document	Relevant	Currently Exists	To Be Developed	Copy Provided by Proponent / Developer	Title
Structure Plan	Yes	Yes	Yes	N/A	-
Implications for this BMP: To facilitate the development of the subject land into a combination of land uses including Residential Areas, Commercial Areas, Schools and Public Open Space Areas.					
Bushfire Management Plan	Yes	Yes	Yes	Yes	Lot 4, 61, 100 & PT 302 Lage Road, and Los 101 & 201 Great Northern Highway, Bullsbrook (Prepared by Smith Consultants – 15 December 2020)
Implications for this BMP: Revised Bushfire Management Plan required to account for changes in Standards, State Planning Policies and associated Guidelines.					
Bushfire Emergency Plan or Information	No	N/A	N/A	N/A	-
Bushfire Risk Assessment and Management Report	No	N/A	N/A	N/A	-

Environmental Asset or Vegetation Survey	Yes	Yes	No	Yes	Environmental Assessment Report – Marlin Bullsbrook Urban (Prepared by Emerge Associates – March 2021)
Implications for the BMP: The relevant State agencies should be further consulted, and details confirmed as part of due diligence for the proposal.					
Landscaping and Revegetation Plan	No	No	Yes	Yes	-
Implications for the BMP: Where any Landscaping or Re-vegetation is anticipated to occur - General Note - An approved Landscape Management Plan should be provided to demonstrate that the landowner/proponent responsible for the on-going management has an obligation to undertake mitigation works and the approving decision maker (i.e. local government and / or Department of Biodiversity, Conservation and Attractions) support the vegetation classification and management treatments assigned to the subject area.					
Land Management Agreement	No	No	N/A	No	-

2 BUSHFIRE PRONE VEGETATION – ENVIRONMENTAL & ASSESSMENT CONSIDERATIONS

2.1 Environmental Considerations – 'Desktop' Assessment

This 'desktop' assessment must not be considered as a replacement for a full Environmental Impact Assessment. It is a summary of potential environmental values at the subject site, inferred from information contained in listed datasets and/or reports, which are only current to the date of last modification.

These data sources must be considered indicative where the subject site has not previously received a site-specific environmental assessment by an appropriate professional.

Many bushfire prone areas also have high biodiversity values. Consideration of environmental priorities within the boundaries of the land being developed can avoid excessive or unnecessary modification or clearing of vegetation. Approval processes (and exemptions) apply at both Commonwealth and State levels.

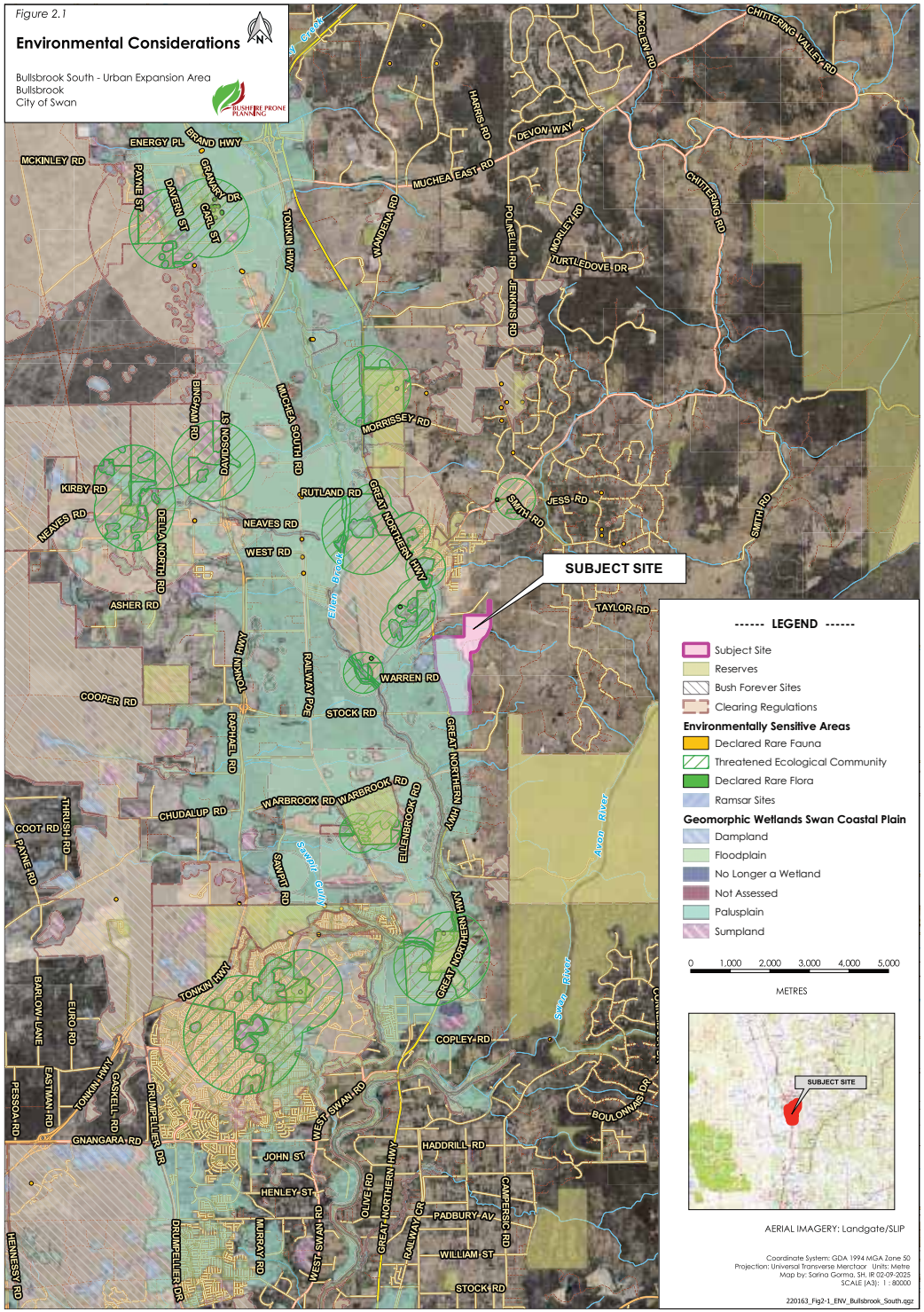
Any 'modification' or 'clearing' of vegetation to reduce bushfire risk is considered 'clearing' under the ***Environmental Protection Act 1986*** (EP Act) and requires a clearing permit under the ***Environmental Protection (Clearing of Native Vegetation) Regulations 2004*** (Clearing Regulations) – unless for an exempt purpose.

Clearing native vegetation is an offence, unless done under a clearing permit or the clearing is for an exempt purpose. Exemptions are contained in the EP Act or are prescribed in the Clearing Regulations (note: these do not apply in environmentally sensitive areas).

The ***Department of Water and Environmental Regulation*** (DWER) is responsible for issuing 'clearing' permits and the framework for the regulation of clearing. Approvals under other legislation, from other agencies, may also be required, dependent on the type of flora or fauna present.

Local Planning Policy or Local Biodiversity Strategy: Natural areas that are not protected by the above Act and Regulation (or any other National or State Acts) may be protected by a local planning policy or local biodiversity strategy. Permission from the local government will be required for any modification or removal of native vegetation in these Local Natural Areas (LNA's). Refer to the relevant local government for detail.

For further Information refer to Guidelines v1.4, the Bushfire and Vegetation Factsheet - WAPC, Dec 2021 and https://www.der.wa.gov.au/our-work/clearing-permits



2.1.1 Declared Environmentally Sensitive Areas (ESA)

IDENTIFICATION OF RELEVANT ENVIRONMENTALLY SENSITIVE AREAS							
ESA Class	Relevant to Proposal	Influence on Bushfire Threat Levels and / or Application of Bushfire Protection Measures	Relevant Dataset	Information Source(s) Applied to Identification of Relevant Vegetation			Further Action Required
				Dataset	Landowner or Developer	Environmental Asset or Vegetation Survey	
Wetlands and their 50m Buffer (Ramsar, conservation category and nationally important)	No	N/A	DBCA-010 and 011, 019, 040, 043, 044	☒	☐	☐	None
Bush Forever	No	N/A	DPLH-022, SPP 2.8	☒	☐	☐	None
Threatened and Priority Flora + 50m Continuous Buffer	No	N/A	DBCA-036	Restricted Scale of Data Available (security)	☐	☐	None
Threatened Ecological Community	No	N/A	DBCA-038		☐	☐	None
Heritage Areas National / World	No	N/A	Relevant register or mapping	☒	☐	☐	None

2.1.2 Other Protected Vegetation on Public Land

IDENTIFICATION OF PROTECTED VEGETATION ON PUBLIC LAND							
Land with Environmental, Biodiversity, Conservation and Social Values	Relevant to Proposal	Influence on Bushfire Threat Levels and / or Application of Bushfire Protection Measures	Relevant Dataset	Information Source(s) Applied to Identification of Relevant Vegetation			Further Action Required
				Dataset	Landowner or Developer	Environmental Asset or Vegetation Survey	
Legislated Lands (tenure includes national park/reserve, conservation park, crown reserve and state forest)	No	N/A	DBCA-011	☒	☐	☐	None
Conservation Covenants	Unlikely	Unlikely	DPIRD-023	Only Available to Govt.	☐	☐	Confirm with relevant agency
National World Heritage Areas	No	N/A	-	☒	☐	☐	None

2.1.3 Response of Proposed Development to Identified Environmental Limitations

Consideration of the implications that identified protected areas of vegetation (i.e., those with environmental and subject to conservation) have for the proposed development.

PROPOSED DEVELOPMENT RESPONSE TO IDENTIFIED 'PROTECTED' VEGETATION	
The existence of 'protected' areas of vegetation has implications for the ability of the proposed development to reduce potential bushfire impact through modification or removal of vegetation.	Possible
Application of Design and/or Construction Responses to Limit Vegetation Modification or Removal	
Modify the development location to reduce exposure by increasing separation distance.	N/A
Comments: Future buildings as part of this development proposal will need to consider achievable asset protection zones and corresponding bushfire attack level ratings, to a bushfire attack level rating of BAL-29, to minimise extensive clearing where native standing vegetation is of environmental significance.	
Redesign development, structure plan or subdivision.	N/A
Comments: Not Applicable	
Reduction of lot yield where this can increase available separation distances.	N/A
Comments: Not Applicable	
Cluster development to limit modification or removal of vegetation.	N/A
Comments: Not Applicable	
Construct building(s) to the requirements corresponding to higher BAL ratings to reduce required separation distances.	N/A
Comments: Not Applicable	

2.2 Bushfire Assessment Considerations

2.2.1 Planned Onsite Vegetation Landscaping

Identification of areas of the subject site planned to be landscaped, creating the potential for increased or decreased bushfire hazard for proposed development.

PLANNED LANDSCAPING	
Relevant to Proposal:	Yes
Final landscaping detail will be addressed at the future development stages - An approved Landscape Management Plan should be provided to demonstrate that the landowner/proponent responsible for the on-going management has an obligation to undertake mitigation works and the approving decision maker (i.e. local government and / or Department of Biodiversity, Conservation and Attractions) support the vegetation classification and management treatments assigned to the subject area. Where future development proposals incorporate landscaping within the subject land, modification and/or replanted vegetation types, will require a landscape plan indicating how the vegetation will be configured and managed in perpetuity, so as not to increase the bushfire risk and limit ignition sources.	

2.2.2 Planned / Potential Offsite Rehabilitation or Re-Vegetation

Identification of areas of land adjacent to the subject site on which re-vegetation (as distinct from natural re-generation) will or may occur and is likely to present a greater bushfire hazard for proposed development.

POTENTIAL RE-VEGETATION PROGRAMS		
Land with Environmental, Biodiversity, Conservation and Social Values	Relevant to Proposal	Description
Riparian Zones / Foreshore Areas	No	
Wetland Buffers	No	
Legislated Lands	No	
Public Open Space	Likely	Where any Landscaping or Re-vegetation is anticipated to occur - General Note - An approved Landscape Management Plan should be provided to demonstrate that the landowner/proponent responsible for the on-going management has an obligation to undertake mitigation works and the approving decision maker (i.e. local government and / or Department of Biodiversity, Conservation and Attractions) support the vegetation classification and management treatments assigned to the subject area.
Road Verges	Likely	As Above.
Other	Possible	As Above.

2.2.3 Identified Requirement to Manage, Modify or Remove Onsite or Offsite Vegetation

Identification of native vegetation subject to management, modification or removal.

REQUIREMENT TO MANAGE, MODIFY OR REMOVE NATIVE VEGETATION	
Has a requirement been identified to manage, modify or remove **onsite** native vegetation to establish the required bushfire protection measures on the subject site?	Yes
Refer to Figure 3.1b 'Classified Vegetation & Topography Map (Post Development) – Variations Applied' and Refer to Appendix A1.2 for justification details supporting the change.	
Is approval, from relevant state government agencies and/or the local government, to modify or remove **onsite** native vegetation required? (Note: if 'Yes' evidence of its existence should be provided in this BMP).	Yes
Refer to Figure 3.1b 'Classified Vegetation & Topography Map (Post Development) – Variations Applied' and Refer to Appendix A1.2 for justification details supporting the change.	
Has a requirement been identified to manage, modify or remove **offsite** native vegetation to establish the required bushfire protection measures on the subject site?	No
Is written approval required, from relevant state government agencies and/or the local government, that permits the landowner, or another identified party, to modify or remove **offsite** bushfire prone vegetation and/or conduct other works, to establish an identified bushfire protection measure(s)? If 'Yes', appropriate evidence of the approval or how it is to be established, shall be provided in this BMP as an addendum.	No
Is a written management agreement required that states the obligation of the landowner, or another responsible party, to manage defined areas of **offsite** bushfire prone vegetation, in perpetuity, to ensure the conditions of no fire fuels and/or low threat vegetation and/or vegetation managed in a minimal fuel condition, continue to be met? If 'Yes', appropriate evidence of the agreement or how it is to be established, shall be provided in this BMP as an addendum.	No

2.2.4 Variations to Assessed Areas of Classified Vegetation to be Applied

FOR THE PROPOSED DEVELOPMENT SITUATIONS TO BE ACCOUNTED FOR IN ASSESSING THE POTENTIAL BUSHFIRE IMPACT (BAL)	
Area(s) of land will be subject to future vegetation rehabilitation or re-vegetation that will require a change to a higher threat classification of vegetation on that land to. (Note: this is not regeneration to the mature natural state which is accounted for in the 'existing state' assessment in accordance with AS 3959:2018).	Possible
Refer to Figure 3.1b 'Classified Vegetation & Topography Map (Post Development) – Variations Applied' and Refer to Appendix A1.2 for justification details supporting the change. Landscaping - Final landscaping detail will be addressed at the future development stages. If any such vegetation is excluded from classification due to proposed management, the subsequent BMP will ensure the obligation to manage to a minimal fuel, low threat state, in perpetuity, is created in the landowner responsibilities. For the purposes of assessment, (with the exception of the vegetation located within the proposed POS at the Nambad Brook) it is assumed that all of the proposed POS Areas will be managed in a low threat state in perpetuity to ensure there is no increase in bushfire risk nor alter indicative BAL ratings indicated in this plan. They will meet AS3959-2018 s2.2.3.2 requirements, Schedule 1: Standards for Asset Protection Zones as stipulated in the Guidelines for Planning in Bushfire Prone Areas in conjunction with the City of Swan Fire Hazard Reduction Notice. Re-vegetation – It is assumed re-vegetation/re-planting will take place in the Nambad Brook POS Area. It is further assumed that these area/s will not be managed. As such, a worst-case scenario classification (Class A Forest) in accordance with As3959-2018 has been applied as a precautionary measure will be required.	
Modification of existing area(s) of classified vegetation due to the implementation of the proposed development and/or prior to the site's occupancy or use. This modification will require a change to a lower threat classification (or exclusion from classification) for that area of vegetation.	Yes
Refer to Figure 3.1b 'Classified Vegetation & Topography Map (Post Development) – Variations Applied' and Refer to Appendix A1.2 for justification details supporting the change.	
Complete removal of existing area(s) of classified vegetation due to the implementation of the proposed development and/or prior to the site's occupancy or use. This modification will require an exclusion from classification for that area of vegetation.	Yes
Refer to Figure 3.1b 'Classified Vegetation & Topography Map (Post Development) – Variations Applied' and Refer to Appendix A1.2 for justification details supporting the change.	

3 BUSHFIRE ATTACK LEVEL (BAL) ASSESSMENT

BUSHFIRE ATTACK LEVELS (BAL) - UNDERSTANDING THE RESULTS

The potential transfer (flux/flow) of radiant heat from the bushfire to a receiving object is measured in kW/m². The AS 3959:2018 BAL determination methodology establishes the ranges of radiant heat flux that correspond to each bushfire attack level. These are identified as BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

The bushfire performance requirements for certain classes of buildings are established by the Building Code of Australia (Vol. 1 & 2 of the NCC). The BAL will establish the bushfire resistant construction requirements that are to apply in accordance with AS 3959:2018 - *Construction of buildings in bushfire prone areas* and the NASH Standard – *Steel framed construction in bushfire areas (NS 300 2021),* whose solutions are deemed to satisfy the NCC bushfire performance requirements.

DETERMINED BAL RATINGS

A BAL Certificate can be issued for a determined BAL. A BAL can only be classed as 'determined' for an existing or future building/structure when:

1. It's final design and position on the lot are known and the stated separation distance from classified bushfire prone vegetation exists and can justifiably be expected to remain in perpetuity; or
2. It will always remain subject to the same BAL regardless of its design or position on the lot after accounting for any regulatory or enforceable building setbacks from lot boundaries as relevant and necessary (e.g., R-codes, restrictive covenants, defined building envelopes) or the retention of any existing classified vegetation either onsite or offsite.

If the BMP derives determined BAL(s), the BAL Certificate(s) required for submission with building applications can be provided, using the BMP as the assessment evidence.

INDICATIVE BAL RATINGS

A BAL Certificate cannot be issued for an indicative BAL. A BAL will be classed as 'indicative' for an existing or future building/structure when the required conditions to derive a determined BAL are not met.

This class of BAL rating indicates what BAL(s) could be achieved and the conditions that need to be met are stated.

Converting the indicative BAL into a determined BAL is conditional upon the currently unconfirmed variable(s) being confirmed by a subsequent assessment and evidential documentation. These variables will include the future building(s) location(s) being established (or changed) and/or classified vegetation being modified or removed to establish the necessary vegetation separation distance. This may also be dependent on receiving approval from the relevant authority for that modification/removal.

BAL RATING APPLICATION – PLANNING APPROVAL VERSUS BUILDING APPROVAL

1. **Planning Approval**: SPP.3.7 establishes that where BAL- LOW to BAL-29 will apply to relevant future construction (or existing structures for proposed uses), the proposed development may be considered for approval (dependent on the other requirements of the relevant policy measures being met). That is, BAL40 or BAL-FZ are not acceptable on planning grounds (except for certain limited exceptions).

   Because planning is looking forward at what can be achieved, as well as looking at what may currently exist, both determined and indicative BAL ratings are acceptable assessment outcomes on which planning decisions can be made (including conditional approvals).

2. **Building Approval:** The Building Code of Australia (Vol. 1 & 2 of the NCC) establishes that relevant buildings in bushfire prone areas must be constructed to the bushfire resistant requirements corresponding to the BAL rating that is to apply to that building. Consequently, a determined BAL rating and the BAL Certificate is required for a building permit to be issued - an indicative BAL rating is not acceptable.

3.1 BAL Assessment Summary (Contour Map Format)

INTERPRETATION OF THE BAL CONTOUR MAP

The BAL contour map is a diagrammatic representation of the results of the bushfire attack level assessment.

The map presents different coloured contours extending out from the areas of classified vegetation. Each contour represents a set range of radiant heat flux that potentially will transfer to an exposed element (building, person or other defined element), when it is located within that contour.

Each of the set ranges of radiant heat flux corresponds to a different BAL rating as defined by the AS 3959:2018 BAL determination methodology.

The width of each shaded BAL contour will vary dependant on both the BAL rating and the relevant parameters (calculation inputs) for the subject site. Their width represents the minimum and maximum vegetation separation distances that correspond to each BAL rating (refer to the relevant table below for these distances).

The areas of classified vegetation to be considered in developing the BAL contours, are those that will remain at the intended end state of the subject development once earthworks, clearing and/or landscaping and re-vegetation have been completed. Variations to this statement that may apply include:

- Both pre and post development BAL contour maps are produced; and/or
- Each stage of a development is assessed independently.

3.1.1 BAL Determination Methodology and Location of Data and Results

LOCATION OF DATA & RESULTS					
BAL Determination Methodology		Location of the Site Assessment Data			Location of the Results
AS 3959:2018	Applied to Assessment	Classified Vegetation and Topography Map(s)	Calculation Input Variables		Assessed Bushfire Attack Levels and/or Radiant Heat Levels
			Summary Data	Detailed Data with Explanatory and Supporting Information	
Method 1 (Simplified)	Yes	Figure 3.1a & 3.1b	Table 3.2	Appendix A1	Table 3.1 Table 3.3 / BAL Contour Map
Method 2 (Detailed)	No	N/A	N/A	N/A	

3.1.2 BAL Ratings Derived from the Contour Map

Table 3.1: Indicative and determined BAL(s) for future buildings/structures on the proposed lots.

DETAILS OF BUSHFIRE EXPOSURE TO PROPOSED ALLOTMENTS/LAND USE ZONES						
Derived from the Application of Method 1 BAL Determination Methodology (AS 3959:2018 Section 2, Table 2.5)[1]						
Land Use Zones	BAL-FZ[2] Exposure	BAL-40[2] Exposure	BAL-29 Exposure	BAL-19 Exposure	BAL-12.5 Exposure	BAL-LOW Exposure
Residential	2	1	22	29	14	43
Commercial			1			1
Primary School						1

[1] The assessment data used to derive the BAL ratings is sourced from Table 3.1 and Figure 3.2 'BAL Contour Map'.

[2] Land Use Zones currently subject to radiant heat levels corresponding to BAL-40 and/or BAL-FZ ratings that require consideration for development design and location of eventual allotments and associated structures.

3.1.3 Site Assessment Data Applied to Construction of the BAL Contour Map(s)

RELEVANT CLASSIFIED VEGETATION	
Identification of Classified Vegetation that is Relevant to the Production of the BAL Contour Map(s)	Relevant Vegetation Map
The relevant vegetation will be all areas of classified vegetation that exist at the time of the site assessment – both within the subject site (onsite) and external to the subject site (offsite).	Figure 3.1a.
The relevant vegetation for the post-development BAL contour map will be any area of classified vegetation - both within the subject site (onsite) and external to the subject site (offsite) - that will remain at the intended end state of the subject development once earthworks, any clearing and/or landscaping and re-vegetation have been completed.	Figure 3.2a.
The relevant vegetation is the classified vegetation external to the subdivision boundaries. With the exception of the vegetation located within the proposed POS at the Nambad Brook, all identified classified vegetation areas, or portions of areas, within the proposed subdivision are excluded. This approach is applied to indicate the achievable bushfire attack levels within the subdivision and the resultant area of developable land on all lots where buildings will be subject to BAL-29 or less. It is based on the following assumptions: 1. Any classified vegetation within the subdivision can potentially be managed or removed by the developer and/or landowner to meet asset protection zone standards; and 2. Future development and consequent removal/management of vegetation that may take place on any adjoining land cannot be part of considerations for the subdivision.	Figures 3.1b and 3.2a.
Supporting Assessment Details: None Required.	

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Table 3.2: The calculation inputs applied to determining the site specific separation distances corresponding to levels of potential radiant heat transfer (including BAL's).

SUMMARY OF CALCULATION INPUT VARIABLES APPLIED TO THE DETERMINATION OF SEPARATION DISTANCES CORRESPONDING TO RADIANT HEAT LEVELS [1]												
Applied BAL Determination Method		METHOD 1 - SIMPLIFIED PROCEDURE (AS 3959:2018 CLAUSE 2.2)										
The Calculation Variables Corresponding to the BAL Determination Method Applied												
Methods 1 and 2		Method 1	Method 2									
Vegetation Classification		FDI	Effective Slope		Site Slope	FFDI or GFDI	Flame Temp.	Elevation of Receiver	Flame Width	Fireline Intensity	Flame Length	Modified View Factor
			Applied Range	Measured								
Area	Class		degree range	degrees	degrees		K	metres	metres	kW/m	metres	% Reduction
1	(G) Grassland	80	Upslope or flat 0	flat 0								
2	(B) Woodland	80	Upslope or flat 0	flat 0								
3	(A) Forest	80	Upslope or flat 0	flat 0								
4	(C) Shrubland	80	Upslope or flat 0	flat 0								
5	Excluded cl 2.2.3.2(e & f)	80	N/A	N/A								

[1] All data and information supporting the determination of the classifications and values stated in this table and any associated justification, is presented in Appendix A.

Where the values are stated as 'default' these are either the values stated in AS 3959:2018, Table B1 or the values calculated as intermediate or final outputs through application of the equations of the AS 3959:2018 BAL determination methodology. They are not values derived by the assessor.

Table 3.3: Vegetation separation distances corresponding to the radiant heat levels illustrated as BAL contours in Figure 3.2a.

THE CALCULATED VEGETATION SEPARATION DISTANCES CORRESPONDING TO THE STATED LEVEL OF RADIANT HEAT [1]									
Vegetation Classification		Separation Distances Corresponding to Stated Level of Radiant Heat (metres)							
		Bushfire Attack Level						Maximum Radiant Heat Flux	
Area	Class	BAL-FZ	BAL-40	BAL-29	BAL-19	BAL12.5	BAL-LOW	10 kW/m^2	2 kW/m^2
1	(G) Grassland	<6	6-<8	8-<12	12-<17	17-<50	>50		
2	(B) Woodland	<10	10-<14	14-<20	20-<29	29-<100	>100		
3	(A) Forest	<16	16-<21	21-<31	31-<42	42-<100	>100		
4	(C) Shrubland	<7	7-<9	9-<13	13-<19	19-<100	>100		
5	Excluded cl 2.2.3.2(e & f)	N/A	N/A	N/A	N/A	N/A	N/A		

[1] All calculation input variables are presented in Table 3.2. A copy of radiant heat calculator output for each area of classified vegetation are presented in Appendix A3.

Figure 3.1a

Classified Vegetation & Topography Map - (Existing)

Bullsbrook South - Urban Expansion Area
Bullsbrook
City of Swan



AERIAL IMAGERY: Landgate/SLIP

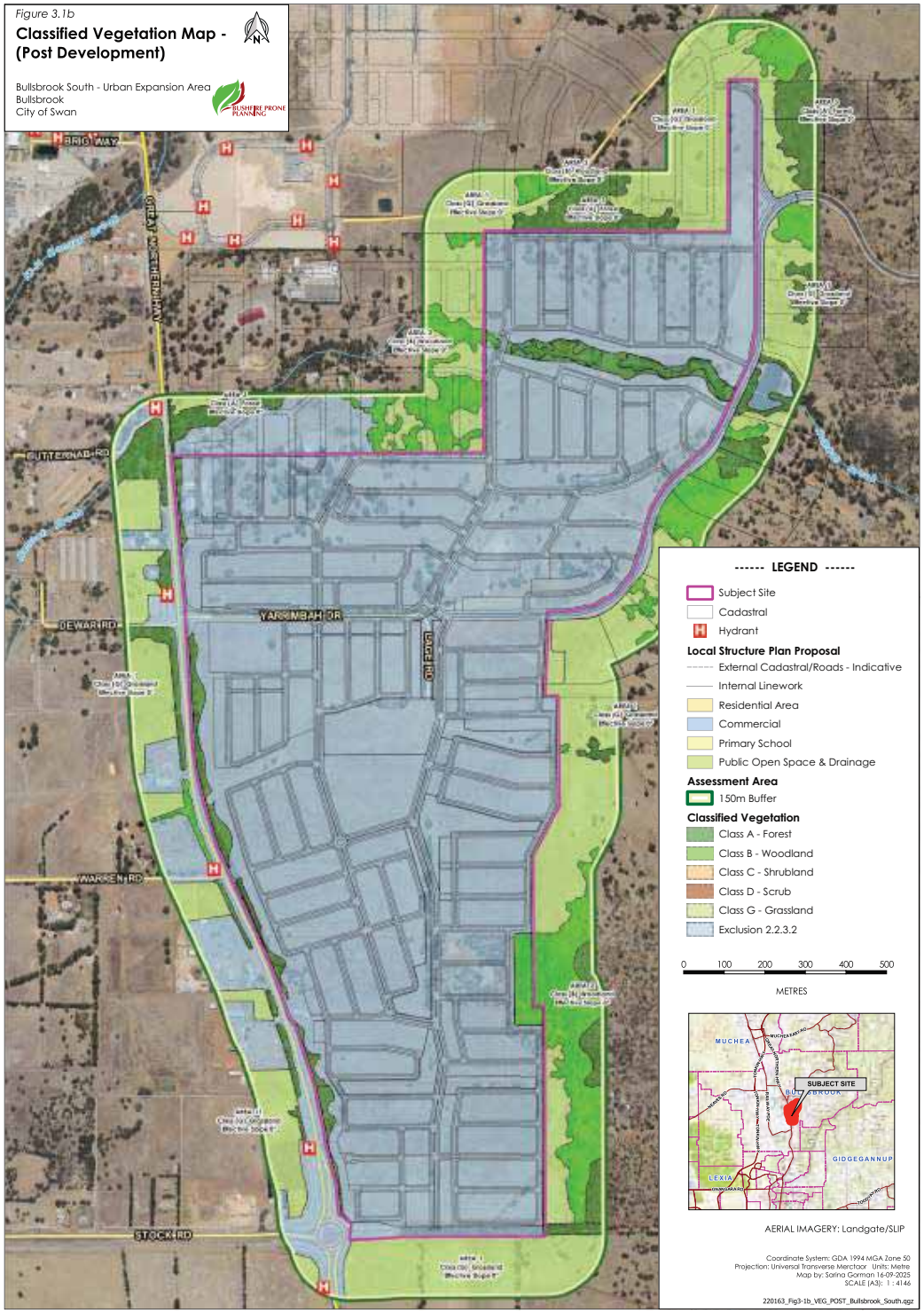
Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map by: Sarina Gorman, SH, IR 16-09-2025
SCALE (A3): 1 : 7800

220163_Fig3-1a_VEG_EXIST_Bullsbrook_South.qgz

Figure 3.1b

Classified Vegetation Map - (Post Development)

Bullsbrook South - Urban Expansion Area
Bullsbrook
City of Swan



AERIAL IMAGERY: Landgate/SLIP

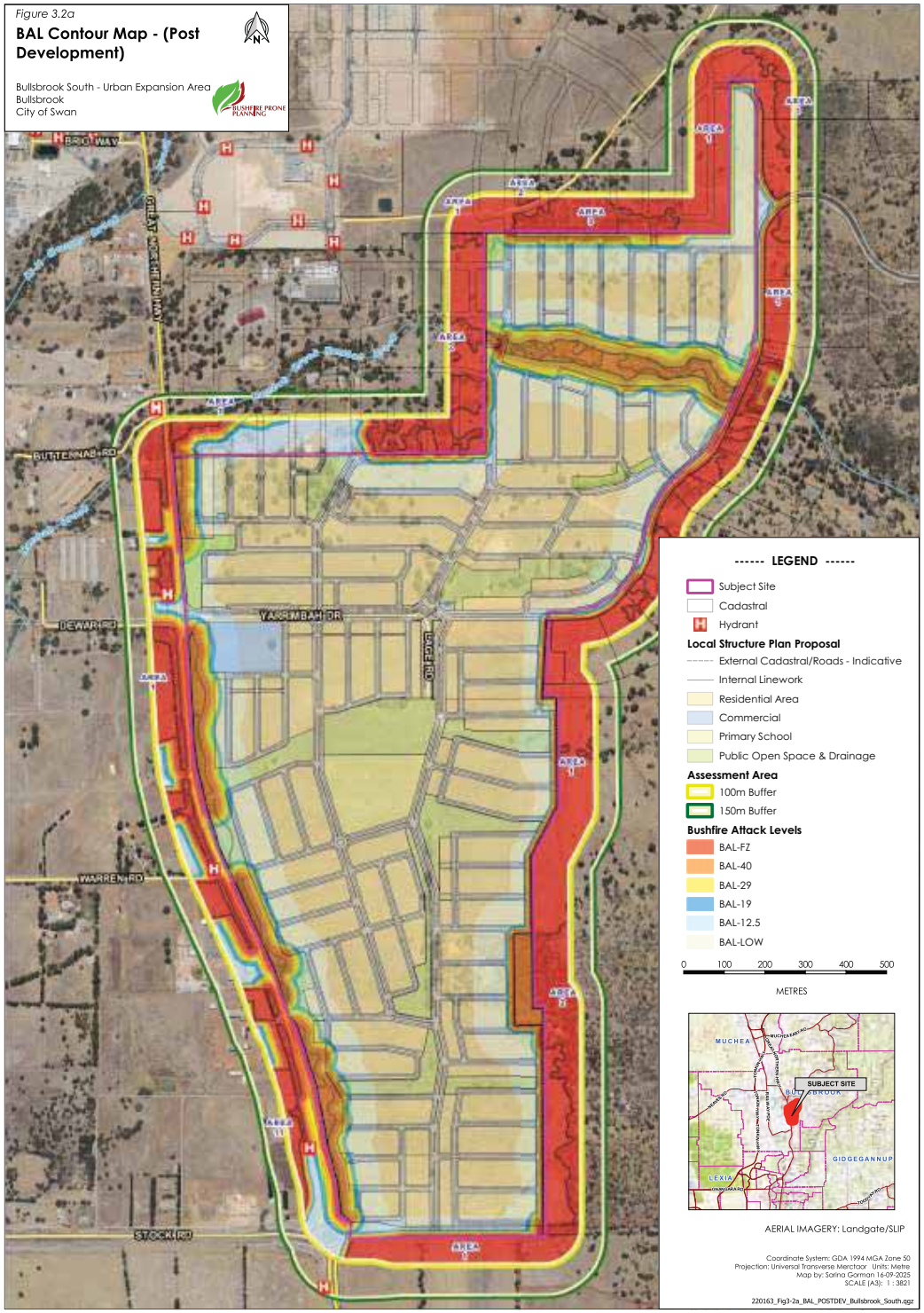
Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map by: Sarina Gorman 16-09-2025
SCALE (A3): 1 : 4146

220163_Fig3-1b_VEG_POST_Bullsbrook_South.qgz

Figure 3.2a

BAL Contour Map - (Post Development)

Bullsbrook South - Urban Expansion Area
Bullsbrook
City of Swan



4 IDENTIFICATION OF BUSHFIRE HAZARD ISSUES

The Guidelines for Planning in Bushfire Prone Areas (WAPC 2021 v1.4), Appendix 5, establish that the application of this section of the BMP is intended to support ***strategic planning*** proposals. At the strategic planning stage there will typically be insufficient proposed development detail to enable all required assessments, including the assessment against the bushfire protection criteria.

Strategic Planning Proposals

For strategic planning proposals this section of the BMP will identify:

- Issues associated with the level of the threats presented by any identified bushfire hazard;
- Issues associated with the ability to implement sufficient and effective bushfire protection measures to reduce the exposure and vulnerability levels (of elements exposed to the hazard threats), to a tolerable or acceptable level; and
- Issues that will need to be considered at subsequent planning stages.

All Other Planning Proposals

For all other planning stages, this BMP will address what are effectively the same relevant issues but do it within the following sections:

- Section 2 – Bushfire Prone Vegetation - Environmental and Assessment Considerations: Assess environmental, biodiversity and conservation values;
- Section 3 – Potential Bushfire Impact: Assess the bushfire threats with the focus on flame contact and radiant heat; and
- Section 5 – Assessment Against the Bushfire Protection Criteria (including the guidance provided by the *Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2'):* Assess the ability of the proposed development to apply the required bushfire protection measures thereby enabling it to be considered for planning approval for these factors.

Is the proposed development a strategic planning proposal?	Yes

STRATEGIC PLANNING PROPOSALS - IDENTIFICATION OF RISK AND PLANNING ISSUES	
The Broader Landscape/Environment – The Potential for Bushfire Intensification and Extreme Events	
The type of bushfire prone vegetation surrounding the proposed development. Referencing the potential levels of each bushfire threat mechanism (direct and indirect).	Areas of bushfire prone vegetation external to the subject site are located to the north, south, east and west. These areas exist as retained vegetation (consisting of a combination of Forest, Woodland, Shrubland and Grassland with the Grassland being the predominant vegetation type across the broad landscape). The topography in the area surrounding the proposed development has an overall flat land or upslope appearance. Given the predominant grassland vegetation in the area, bushfire behaviour will be predominantly wind driven. Post Development - Due to the nature of the landscape, the bushfire threat will predominantly be from a flanking fire (indirect bushfire attack) as opposed to a fire front (direct bushfire attack).
The extent of bushfire prone vegetation surrounding the proposed development – both in area and continuity (fragmentation). Identification of conserved vegetation.	Refer to Figures 1.2 and 3.1a – It is evident that extents of bushfire prone vegetation exist across the broader landscape as retained vegetation (consisting of a combination of predominantly Forest and Woodland with sizes of distinct areas ranging from 2 – 7 ha within the 150m noted assessment area) but interspersed with improved pastures (grassland) and/or asset protection zones around existing dwellings or other commercial structures in the area. Most of the vegetation appears to be on private land and likely subject to various levels of fuel load management.
The potential for the surrounding topography to support known dynamic fire behaviours that can lead to an extreme fire event and intensification through atmospheric interaction (pyroconvective events).	Significant extents of bushfire prone vegetation exist across the broader landscape as retained native vegetation (a combination of predominantly forest and woodland vegetation) but interspersed with improved pastures (grassland). Most of the vegetation appears to be on private land and subject to various levels of fuel load management as mentioned above. The forest and woodland vegetation will produce significant embers and firebrands in a bushfire event primarily due to the type foliage and type of bark. Pyroconvective Events - Possible but limited likelihood due to the fragmentation of areas of bushfire prone vegetation due to cleared areas, pastured areas, fuel load management by landowners and the availability of emergency services (including being a part of the greater Perth metropolitan area).
The Broader Landscape/Environment – The Potential for Increased Vulnerability of Persons in a Bushfire Event	
The wider (regional) road network and any access constraints.	At a local level, access options won't be limited to a single road in two directions to at least two suitable destinations once construction of the internal road network and surrounding road network connections to arterial roads have been completed. There is no access constraint for the subject site with regard to what is considered acceptable from a planning perspective, however, where development opportunities can increase local access options within the surrounding area, this would have merit that should be considered as benefiting a greater number of residents/occupants.

The proximity of settlements and availability of emergency services	The subject site currently forms part of a large rural area. The closest Emergency services are located in Bullsbrook (2.4km and 4 minutes travel – From the cross of Lage Road and Great Northern Highway, Bullsbrook).
	Environmental Considerations
Constraints to implementing required and/or additional bushfire protection measures	Although the environmental considerations have not identified any existing constraints (i.e. Conservation Category of Resource Enhancement Wetlands) within the subject site, it is assumed for the purposes of assessment that the vegetation located at the Nambad Brook will be retained. In addition, it is further assumed that this area will receive re-vegetation works, which could present an increase in bushfire risk to the neighbouring Residential Land Use Zones. As such, consideration to the allotment design layout will be required as to ensure that vegetation in these areas can be retained and ensure there is no increase in bushfire risk. General Note - Any retained native vegetation and/or proposed gardens, requires implementation of a landscape management plan to ensure ongoing mitigation treatments lessen the on-site bushfire threat and minimise ignition sources from direct (deliberate) or indirect (accidental) origin.
Provision of Access Within the Subject Site	
Potential constraints	Staging of future development will consider constraints to ensure establishing the required access to meet bushfire planning requirements.
Issues to be Considered at Subsequent Planning Stages (additional assessments/documents)	
Specific land uses to be addressed	Land Use can be considered at the future development stage.
Additional assessments	N/A
Additional documents	Site specific Bushfire Management Plan for future subdivision proposals/development applications on the subject land that considers land use at that time.
Discretionary Decision Making and the Precautionary Principle (SPP 3.7 and Guidelines)	
Does the bushfire consultant consider there are issues that need to be addressed in this space?	Consideration for future staging of the land into various land uses through implementation of subsequent bushfire management plans to enable the creation of new lots at the localised level, to address bushfire risk.

5 ASSESSMENT AGAINST THE BUSHFIRE PROTECTION CRITERIA (GUIDELINES V1.4)

5.1 Bushfire Protection Criteria Elements Applicable to the Proposed Development/Use

APPLICATION OF THE CRITERIA, ACCEPTABLE SOLUTIONS AND PERFORMANCE ASSESSMENT

The criteria are divided into five elements – location, siting and design, vehicular access, water and vulnerable tourism land uses. Each element has an intent outlining the desired outcome for the element and reflects identified planning and policy requirements in respect of each issue.

The example acceptable solutions (bushfire protection measures) provide one way of meeting the element's intent. Compliance with these automatically achieves the element's intent and provides a straightforward pathway for assessment and approval.

Where the acceptable solutions cannot be met, the ability to develop design responses (as alternative solutions that meet bushfire performance requirements) is an alternative pathway that is provided by addressing the applicable performance principles (as general statements of how best to achieve the intent of the element).

A merit based assessment is established by the SPP 3.7 and the Guidelines as an additional alternative pathway along with the ability of using discretion in making approval decisions (sections 2.5, 2.6 and 2.7). This is formally applied to certain development (minor and unavoidable – sections 5.4.1 and 5.7). Relevant decisions by the State Administrative Tribunal have also supported this approach more generally.

Elements 1 – 4 should be applied for all strategic planning proposals, subdivision or development applications, except for vulnerable tourism land uses which should refer to Element 5. Element 5 incorporates the bushfire protection criteria in Elements 1 – 4 but caters them specifically to tourism land uses. (Guidelines DPLH 2021v1.4)

The Bushfire Protection Criteria	Applicable to the Proposed Development/Use
Element 1: Location	Yes
Element 2: Siting and Design	Yes
Element 3: Vehicular Access	Yes
Element 4: Water	Yes
Element 5: Vulnerable Tourism Land Uses	No

5.2 Local Government Variations to Apply

Local governments may add to or modify the acceptable solutions to recognise special local or regional circumstances (e.g., topography / vegetation / climate). These are to be endorsed by both the WAPC and DFES before they can be considered in planning assessments. (Guidelines DPLH 2021v1.4).	
Do endorsed regional or local variations to the acceptable solutions apply to the assessments against the Bushfire Protection Criteria for the proposed development /use?	None known or identified

5.3 Assessment Statements for Element 1: Location

LOCATION	
Element 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.
Proposed Development/Use – Relevant Planning Stage	(Sb) Structure plan where the lot layout is known and subdivision application
Element Compliance Statement	The proposed development/use achieves the intent of this element by being fully compliant with all applicable acceptable solutions.
Pathway Applied to Provide an Alternative Solution	N/A

Acceptable Solutions - Assessment Statements

All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.

Solution Component Check Box Legend ☑ Relevant & met ☒ Relevant & not met ⊘ Not relevant

A1.1 Development location **Applicable:** Yes **Compliant:** Yes

ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE GUIDELINES

☑ ☐ ☐ The strategic planning proposal is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL-29 or below.

Supporting Assessment Details:

The proposed subdivision will provide an area of land within each lot that can be considered suitable for development as BAL-40 or BAL-FZ construction requirements will not be required to be applied. This meets the requirements established by Acceptable Solution A1.1 and its associated explanatory note. In addition, the vegetation surrounding the proposed development can be classed as a moderate bushfire hazard level.

Refer to Snapshots provided in A2.1 below – It is recognised however, that sections of the northern portion of the development site will be potentially subject to radiant heat levels corresponding to the BAL-40 and BAL-FZ ratings. As such, future buildings as part of this development proposal will need to consider achievable asset protection zones and corresponding bushfire attack level ratings, to a bushfire attack level rating of BAL-29, to minimise extensive clearing where native standing vegetation is of environmental significance.

ASSESSMENTS APPLYING THE GUIDANCE ESTABLISHED BY THE WAPC ELEMENT 1 & 2 POSITION STATEMENT (2019)

"Consideration should be given to the site context where 'area' is the land both within and adjoining the subject site. The hazards remaining within the site should not be considered in isolation of the hazards adjoining the site, as the potential impact of a bushfire will be dependent on the wider risk context, including how a bushfire could affect the site and the conditions for a bushfire to occur within the site."

Strategic Planning Proposals: Consider the threat levels from any vegetation adjoining and within the subject site for which the potential intensity of a bushfire in that vegetation would result in it being classified as an Extreme Bushfire Hazard Level (BHL). Identify any proposed design strategies to reduce these threats.

Structure Plans (lot layout known) and Subdivision Applications: As for strategic planning proposals but within the subject site the relevant threat levels to consider are the radiant heat levels represented by BAL-FZ and BAL-40 ratings.

The Hazard Within the Subject Site

The existing lots currently contain vegetation classified as Class A Forest, Class B Woodland and Class G Grassland except for the asset protection zones established around existing structures. The impact of the slopes under the vegetation will be dependent on a bushfire's direction of travel. The topography in the area surrounding the proposed development has an overall flat land appearance. Given the predominant Grassland vegetation within the subject site, bushfire behaviour will be predominantly wind driven.

Intense bushfire behaviour is possible, particularly if vegetation within the lot is ignited by bushfire in the adjoining hazard and they are involved together.

However, the ability to establish a BAL-29 dimensioned APZ within each proposed lot's boundaries removes the threat of greater levels of radiant heat or flame contact upon a future dwelling. The BAL-29 APZ will exist over a significant area of each proposed lot.

The primary bushfire threat from bushfire prone vegetation remaining within the proposed land use zones will be radiant heat and embers. This threat will be mitigated by the application of appropriate building design, bushfire construction requirements and the ongoing maintenance of the APZ to ensure the buildings will not be impacted by consequential fire within combustible materials used, stored or accumulated within the APZ.

The Hazard Adjoining the Subject Site

Bushfire prone vegetation within the locality exists as vegetation classified as Class A Forest, Class B Woodland, and Class G Grassland. Most of the land within the locality supports this vegetation except for any asset protection zones currently surrounding existing dwellings or other commercial structures in the area.

The impact of the slope under the vegetation will be dependent on a bushfire's direction of travel. The topography adjoining the Subject site has an overall flat land appearance or is upslope in relation to the proposed development. The adjoining land cannot be considered as rugged (which would present greater potential for dynamic fire behaviours to develop leading to increasing fire intensity extreme bushfire events).

Bushfire prone vegetation adjoining the existing lots exists as vegetation classified as a combination of Class A Forest, Class B Woodland and Class G Grassland and it surrounds the lots. The extent of these hazards is shown in Figures 1.2, 3.1a and 3.1b. These areas of vegetation are occurring under the following scenarios:

1. Vegetation that has been retained on the existing lots in the area.

Consequently, the potential exists for intense bushfire behaviour to occur within these areas of bushfire prone vegetation. The potential bushfire impact on persons and property within the proposed lots will be to increase the level of ember attack and radiant heat in the event of a bushfire.

This ember threat and radiant will be mitigated by the application of appropriate building design, bushfire construction requirements and the ongoing maintenance of the BAL-29 dimensioned APZ, to ensure the buildings will not be impacted by consequential fire within combustible materials used, stored or accumulated within the APZ.

The Potential of the Proposed Development to Reduce Bushfire Risk to the Existing Land Use

When considered in the broader context of existing land use within the surrounding area, the proposed subdivision can potentially contribute to reducing the level of risk from bushfire to existing landowners.

This can be achieved in various ways and the following assessment points are made for the proposed subdivision:

- Planning for smaller lot sizes can reduce the level of risk from bushfires as a greater percentage of their total area will be comprised of land managed to APZ standards. This results in a reduction in the bushfire hazard over a broader area and establishes discontinuous fuels. This has benefits to all development in the area;
- For adjoining landowners the more bushfire resilient dwellings and reduced area of hazard on the proposed lots, will lower their level of risk from bushfire because the threat levels from the bushfire attack mechanisms on the adjoining land will be reduced. These reduced fuels will also be between them and any potential conservation areas; and
- There is potential to improve vehicular access for the surrounding area as part of the proposed development.

The potential for reduction in bushfire risk to surrounding properties compared to the present situation is considered, there is significant merit in the proposed subdivision that it is appropriate to consider.

5.4 Assessment Statements for Element 2: Siting and Design

SITING AND DESIGN OF DEVELOPMENT	
Element Intent	To ensure that the siting and design of development minimises the level of bushfire impact. (BPP Note: not building/construction design)
Proposed Development/Use – Relevant Planning Stage	(Sb) Structure plan where the lot layout is known and subdivision application
Element Compliance Statement	The proposed development/use achieves the intent of this element by being fully compliant with all applicable acceptable solutions.
Pathway Applied to Provide an Alternative Solution	N/A

Acceptable Solutions - Assessment Statements

All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.

Solution Component Check Box Legend ☑ Relevant & met ☒ Relevant & not met ⃠ Not relevant

A2.1 Asset Protection Zone (APZ) **Applicable**: Yes **Compliant**: Yes

APZ DIMENSIONS – DIFFERENCES IN REQUIREMENTS FOR PLANNING ASSESSMENTS COMPARED TO IMPLEMENTATION

A key required bushfire protection measure is to reduce the exposure of buildings/infrastructure (as exposed vulnerable elements at risk), to the direct bushfire threats of flame contact, radiant heat and embers and the indirect threat of consequential fires that result from the subsequent ignition of other combustible materials that may be constructed, stored or accumulate in the area surrounding these structures. This reduces the associated risks of damage or loss.

This is achieved by separating buildings (and consequential fire fuels as necessary) from areas of classified bushfire prone vegetation. This area of separation surrounding buildings is identified as the Asset Protection Zone (APZ) and consists of no vegetation and/or low threat vegetation or vegetation continually managed to a minimal fuel condition. The required separation distances will vary according to the site specific conditions and local government requirements.

The APZ dimensions stated and/or illustrated in this Report can vary dependent on the purpose for which they are being identified.

Note: Appendix B 'Onsite Vegetation Management' provides further information regarding the different APZ dimensions that can be referenced, their purpose and the specifications of the APZ that are to be established and maintained on the subject lot.

THE 'PLANNING BAL-29' APZ DIMENSIONS

Purpose: To provide evidence of the development or use proposal's ability to achieve minimum vegetation separation distances. To achieve 'acceptable solution' planning approval for this factor, it must be demonstrated that the minimum separation distances corresponding to a maximum level of radiant transfer to a building of 29 kW/m², either exist or can be implemented (with certain exceptions). These separation distances are the 'Planning BAL-29' APZ dimensions.

The 'Planning BAL-29' APZ is not necessarily the size of the APZ that must be physically implemented and maintained by a landowner. Rather, its sole purpose is to identify if an acceptable solution for planning approval can be met.

THE 'REQUIRED' APZ DIMENSIONS

Purpose: Establishes the dimensions of the APZ to be physically implemented by the landowner on their lot: These will be the minimum required separation distances from the subject building(s) to surrounding bushfire prone vegetation (identified by type and associated ground slope). These are established by:

A. The 'BAL Rating APZ' of the subject building(s) when distances are greater than 'B' below (except when 'B' establishes a maximum distance); or

B. The 'Local Government' APZ' derived from the Firebreak/Hazard Reduction Notice when distances are greater than 'A' above, other than when a maximum distance is established, in which case this will apply; or

C. A combination of 'A' and 'B'.

*Within this Report/Plan it is the **'Planning BAL-29' APZ** that will be identified on maps, diagrams and in tables as necessary – unless otherwise stated.*

*The **'Required' APZ** dimension information will be presented in Appendix B1.1 and on the Property Bushfire Management Statement, when required to be included for a development application.*

ASSESSMENT AGAINST THE REQUIREMENTS ESTABLISHED BY THE GUIDELINES

☑ ☐ ☐	**APZ Width:** The proposed (or a future) habitable building(s) on the lot(s) of the proposed development - or an existing building for a proposed change of use – can be (or is) located within the developable portion of the lot and be surrounded by a 'Planning BAL-29' APZ of the required dimensions (measured from any external wall or supporting post or column to the edge of the classified vegetation), that will ensure their exposure to the potential radiant heat impact of a bushfire does not exceed 29 kW/m².
☐ ☐ ⃠	**Restriction on Building Location:** It has been identified that the current developable portion of a lot(s) provides for the proposed future (or a future) building/structure location that will result in that building/structure being subject to a BAL-40 or BAL-FZ rating. Consequently, it may be considered necessary to impose the condition that a restrictive covenant to the benefit of the local government pursuant to section 129BA of the Transfer of Land Act 1893, is to be placed on the certificate(s) of title of the proposed lot(s) advising of the existence of a restriction on the use of that portion of land (refer to Code F3 of Model Subdivision Conditions Schedule, WAPC June 2021 and Guidelines s5.3.2).
☑ ☐ ☐	**APZ Location:** The required dimensions for a 'Planning BAL-29' APZ can be contained solely within the boundaries of the lot(s) on which the proposed (or a future) habitable building(s) - or an existing building(s) for a proposed change of use – is situated.
☑ ☐ ☐	**APZ Location:** The required dimensions for a 'Planning BAL-29' APZ can be partly established within the boundaries of the lot(s) on which the proposed (or a future) habitable building(s) - or an existing building(s) for a proposed change of use – is situated. The balance of the APZ would exist on adjoining land that satisfies the exclusion requirements of AS 3959:2018 cl 2.2.3.2 for non-vegetated areas and/or low threat vegetation and/or vegetation managed in a minimal fuel condition.
☑ ☐ ☐	**APZ Location:** It can be justified that any adjoining (offsite) land forming part of a 'Planning BAL-29' APZ will: • If non-vegetated, remain in this condition in perpetuity; and/or • If vegetated, be low threat vegetation or vegetation managed in a minimal fuel condition in perpetuity.
☑ ☐ ☐	**APZ Management:** The area of land (within each lot boundary), that is to make up the required 'Landowner' APZ dimensions (refer to Appendix B, Part B1), can and will be managed in accordance with

	the requirements of the Guidelines Schedule 1 'Standards for Asset Protection Zones' (refer to Appendix B).
☑ ☐ ☐	**Subdivision Staging:** There are undeveloped future stages of subdivision, containing bushfire prone vegetation, that have been taken into consideration for their potentially 'temporary' impact on the ability to establish a 'Planning BAL-29' APZ on adjoining developed lots. A staging plan is to be developed to manage this.
☑ ☐ ☐	**Firebreak/Hazard Reduction Notice:** Any additional requirements established by the relevant local government's annual notice to install firebreaks and manage fuel loads (issued under s33 of the Bushfires Act 1954), can and will be complied with.

Supporting Assessment Details: Asset protection zones can be contained both within and external of the boundaries of the subject land. It can be justified that adjoining land can form part of an APZ, meeting s2.2.3.2 exclusion requirements of AS3959-2018.

The APZ that will exist, will likely consist of the following:

- Roads and unvegetated verges
- Footpaths
- Any applicable landscaping

APZ Management Within the Subject Land:

Refer to Figures 3.1b and 3.2a - With the exception of the vegetation located at the Nambad Brook (and as detailed in Sections 2.2.4, 3.1.3 and 4 of this plan), the exclusion requirements of s2.2.3.2 of AS3959 can be achieved as vegetation that is onsite is within the control of the subject site's landowner and therefore can potentially be removed or modified to mitigate the bushfire risk.

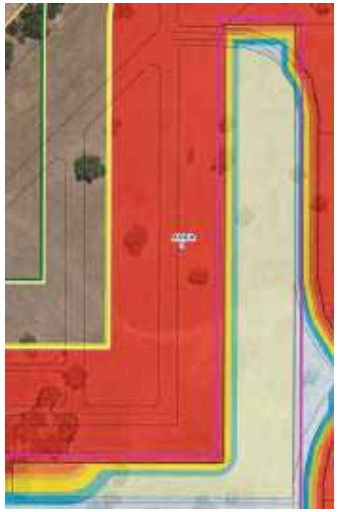
APZ Management Outside of the Proposed Land Use Zones within the Subject Land:

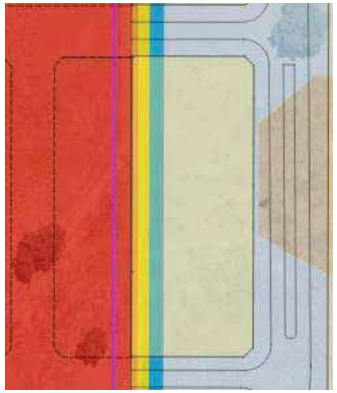
Refer to Snapshots below - With the exception of any proposed Landscaping or Re-vegetation - The exclusion requirements of s2.2.3.2 of AS3959 can be demonstrated by the construction of the surrounding public road network and the on-going development associated with the Kingsford Precinct.

In addition to the above:
Landscaping - Final landscaping detail will be addressed at the future development stages. If any such vegetation is excluded from classification due to proposed management, the subsequent BMP will ensure the obligation to manage to a minimal fuel, low threat state, in perpetuity, is created in the landowner responsibilities. For the purposes of assessment, (with the exception of the vegetation located within the proposed POS at the Nambad Brook) it is assumed that all of the proposed POS Areas within the Bullsbrook South - Urban Expansion Area will be managed in a low threat state in perpetuity to ensure there is no increase in bushfire risk nor alter indicative BAL ratings indicated in this plan. They will meet AS3959-2018 s2.2.3.2 requirements, Schedule 1: Standards for Asset Protection Zones as stipulated in the Guidelines for Planning in Bushfire Prone Areas in conjunction with the City of Swan Fire Hazard Reduction Notice.
Re-vegetation – It is assumed re-vegetation/re-planting will take place in the Nambad Brook POS Area. It is further assumed that these area/s will not be managed. As such, a worst-case scenario classification (Class A Forest) in accordance with As3959-2018 has been applied as a precautionary measure. Furthermore, future buildings as part of this development proposal will need to consider achievable asset protection zones and corresponding bushfire attack level ratings, to a bushfire attack level rating of BAL-29, to minimise extensive clearing where native standing vegetation is of environmental significance as mentioned in A1.1 above.

APZ Management - General: Where any part of the required APZ dimension is vegetated for the purposes of landscaping, it will be managed in accordance with the technical requirements established by the Schedule 1: 'Standards for Asset Protection Zones (Guidelines). The APZ specifications are also detailed in Appendix 1 and the City of Swan.

Indicative BAL-40/BAL-FZ Areas Identified:





ASSESSMENTS APPLYING THE GUIDANCE ESTABLISHED BY THE WAPC ELEMENT 1 & 2 POSITION STATEMENT (2019)

Strategic Planning Proposals: "At this planning level there may not be enough detail to demonstrate compliance with this element. The decision-maker may consider this element is satisfied where A1.1 is met."

Structure Plans (lot layout known) and Subdivision Applications: "Provided that Element 1 is satisfied, the decision-maker may consider approving lot(s) containing BAL-40 or BAL-FZ under the following scenarios.

Scenario A: The lots sizes should provide sufficient area to accommodate a building and the establishment of an APZ dimensioned to ensure a maximum BAL rating of BAL-29 will apply to that building.

Scenario B: There is vegetation with potential biodiversity, landscape amenity and/or conservation values, that it is identified for retention. Consider lots size as per situation (A) and emergency service accessibility.

Scenario C: Commercial and industrial sites that can demonstrate a building of sufficient size can be located so that it is subject to a maximum BAL rating of BAL-29. Any BAL-40 or BAL-FZ levels of radiant heat are restricted to areas of hard stand or that comply with relevant APZ standards.

5.5 Assessment Statements for Element 3: Vehicular Access

VEHICULAR ACCESS	
Element Intent	To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event.
Proposed Development/Use – Relevant Planning Stage	(Sb) Structure plan where the lot layout is known and subdivision application
Element Compliance Statement	The proposed development/use achieves the intent of this element by being fully compliant with all applicable acceptable solutions.
Pathway Applied to Provide an Alternative Solution	N/A

Acceptable Solutions - Assessment Statements

All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.

The technical construction requirements for access types and components, and for each firefighting water supply component, are also presented in Appendices 2 and 3. The local government will advise the proponent where different requirements are to apply and when any additional specifications such as those for signage and gates are to apply (these are included in the relevant appendix if requested by the local government).

Solution Component Check Box Legend ☑ Relevant & met ☒ Relevant & not met ⊘ Not relevant

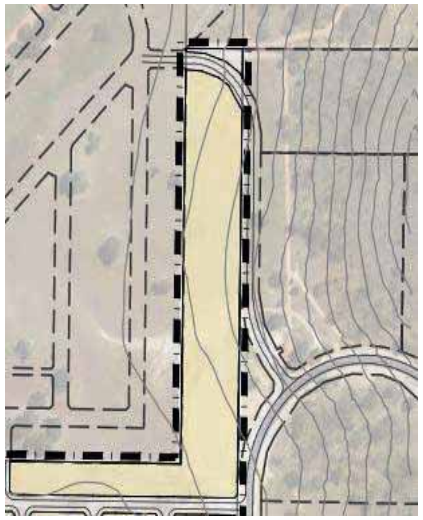
A3.1 Public roads **Applicable**: Yes **Compliant**: Yes

☑ ☐ ☐	The technical construction requirements of vertical clearance and weight capacity (Guidelines, Table 6) can and will be complied with (Refer also to Appendix C in this BMP).
☑ ☐ ☐	All other applicable technical requirements of trafficable width, gradients and curves, are required to be in "accordance with the class of road as specified in the IPWEA Subdivision Guidelines, Liveable Neighbourhoods, Ausroad Standards and/or any applicable standard in the local government area" (Guidelines, Table 6 and E3.1. Refer also to Appendix C in this BMP). The assessment conducted for the bushfire management plan indicates that it is likely that the proposed development can and will comply with the requirements. However, the applicable class of road, the associated technical requirements and subsequent proposal compliance, will need to be confirmed with the relevant local government and/or Main Roads WA. or The applicable class(s) of road and technical requirements have been confirmed with the relevant local government/Main Roads WA. These can and will be complied with.
☑ ☐ ☐	A traversable verge is available adjacent to classified vegetation (Guidelines, E3.1), as recommended.

Supporting Assessment Details: None Required – It is assumed for the purposes of assessment that a Traffic Impact Analysis (TIA) will be prepared to support the Urban Deferred Lifting and Structure Plan associated with this proposal.

A3.2a Multiple access routes	Applicable:	Yes	Compliant:	Yes
☑ ☐ ☐	For each lot, two-way public road access is provided in two different directions to at least two different suitable destinations with an all-weather surface.			
☑ ☐ ☐	The two-way access is available at an intersection no greater than 200m from the relevant boundary of each lot, via a no-through road.			
☐ ☐ ⊘	The two-way access is not available at an intersection within 200m from the relevant boundary of each lot. However, the available no-through road satisfies the established exemption for the length limitation in every case. These requirements are: • Demonstration of no alternative access (refer to A3.3 below); • The no-through road travels towards a suitable destination; and • The balance of the no-through road that is greater than 200m from the relevant lot boundary is within a residential built-out area or is potentially subject to radiant heat levels from adjacent bushfire prone vegetation that correspond to the BAL-LOW rating (<12.5 kW/m²).			
Supporting Assessment Details: Refer to Figure 1.1 contained within this plan - It is assumed for the purposes of assessment that connections to the neighbouring proposed Kingsford Precinct Road network to the north of the Bullsbrook South - Urban Expansion Area (as depicted) can be achieved to ensure compliance with the Acceptable Solution at a later stage. However, the construction technical requirements established by the Guidelines and/or the local government will still need to be complied with at each stage of the Bullsbrook South - Urban Expansion Area until such time the Kingsford Precinct public road network can be constructed.				
A3.2b Emergency access way	**Applicable:**	No	**Compliant:**	N/A
☐ ☐ ⊘	The proposed or existing EAW provides a through connection to a public road.			
☐ ☐ ⊘	The proposed or existing EAW is less than 500m in length and will be signposted and gated (remaining unlocked) to the specifications stated in the Guidelines and/or required by the relevant local government.			
☐ ☐ ⊘	The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.2b. Refer also to Appendix C in this BMP), can and will be complied with.			
Supporting Assessment Details: None Required.				
A3.3 Through-roads	**Applicable:**	Yes	**Compliant:**	Yes
☑ ☐ ☐	A no-through public road is necessary as no alternative road layout exists due to site constraints.			
☑ ☐ ☐	The no-through public road length does not exceed the established maximum of 200m to an intersection providing two-way access (Guidelines, E3.3).			
☑ ☐ ☐	The no-through public road exceeds 200m but satisfies the exemption provisions of A3.2a as demonstrated in A3.2a above.			
☑ ☐ ☐	The public road technical construction requirements (Guidelines, Table 6 and E3.1. Refer also to Appendix C in this BMP), can and will be complied with as established in A3.1 above.			

☑ ☐ ☐	The turnaround area requirements (Guidelines, Figure 24) can and will be complied with.			
Supporting Assessment Details: Refer to Figure 1.1 contained within this plan - It is assumed for the purposes of assessment that connections to the neighbouring proposed Kingsford Precinct Road network to the north of the Bullsbrook South - Urban Expansion Area (as depicted) can be achieved to ensure compliance with the Acceptable Solution at a later stage. However, the construction technical requirements established by the Guidelines and/or the local government will still need to be complied with at each stage of the Bullsbrook South - Urban Expansion Area until such time the Kingsford Precinct public road network can be constructed.				
A3.4a Perimeter roads	**Applicable:**	Yes	**Compliant:**	Yes
☑ ☐ ☐	The proposed greenfield or infill development consists of 10 or more lots (including those that are part of a staged subdivision) and therefore should have a perimeter road. This is planned to be installed.			
☑ ☐ ☐	The proposed greenfield or infill development consists of 10 or more lots (including those that are part of a staged subdivision). However, it is not required on the established basis of: • The vegetation adjoining the proposed lots is classified Class G Grassland; • Lots are zoned rural living or equivalent; • It is demonstrated that it cannot be provided due to site constraints; or • All lots have existing frontage to a public road.			
☑ ☐ ☐	The technical construction requirements of widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.4a) can and will be complied with.			
Supporting Assessment Details: Refer to Figure 1.1 contained within this plan. Compliance with this Acceptable Solution can be achieved via the proposed Public Road Network. The construction technical requirements established by the Guidelines and/or the local government can and will need to be complied with.				
A3.4b Fire service access route	**Applicable:**	Yes	**Compliant:**	Yes
☐ ☒ ☐	The FSAR can be installed as a through-route with no dead ends, linked to the internal road system every 500m and is no further than 500m from a public road.			
☑ ☐ ☐	The technical construction requirements of widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.4b. Refer also to Appendix C in this BMP), can and will be complied with.			
☑ ☐ ☐	The FSAR can and will be signposted. Where gates are required by the relevant local government, the specifications can be complied with.			
☑ ☐ ☐	Turnaround areas (to accommodate type 3.4 fire appliances) can and will be installed every 500m on the FSAR.			
Supporting Assessment Details: The construction technical requirements established by the Guidelines and/or the local government can and will need to be complied with in the areas indicated below until such time development outside of the Subject Site can take place:				



A3.5 Battle-axe access legs	Applicable:	No	Compliant:	N/A

☐ ☐ ⦸ A battle-axe leg cannot be avoided due to site constraints.

☐ ☐ ⦸ The proposed development is in a reticulated area and the battle-axe access leg length from a public road is no greater than 50m. No technical requirements need to be met.

☐ ☐ ⦸ The proposed development is not in a reticulated area. The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.5. Refer also to Appendix C in this BMP), can and will be complied with.

☐ ☐ ⦸ Passing bays can and will be installed every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m.

Supporting Assessment Details: None Required.

A3.6 Private driveways	Applicable:	No	Compliant:	N/A

☐ ☐ ⦸ The private driveway to the most distant external part of the development site is within a lot serviced by reticulated water, is accessed via a public road with a speed limit of 70 km/hr or less and has a length is no greater than 70m (measured as a hose lay). No technical requirements need to be met.

☐ ☐ ⦸ The technical construction requirements for widths, clearances, capacity, gradients and curves (Guidelines, Table 6 and E3.6. Refer also to Appendix C in this BMP), can and will be complied with.

☐ ☐ ⦸ Passing bays can and will be installed every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m.

☐ ☐ ⦸ The turnaround area requirements (Guidelines, Figure 28, and within 30m of the habitable building) can and will be complied with.

Supporting Assessment Details: None Required - The proposed lots are likely to have frontage to the internal subdivision road networks. In addition, there will be limited building setbacks due to their size/area. Increased driveway standards will not be required for this proposal.

5.6 Assessment Statements for Element 4: Water

FIREFIGHTING WATER	
Element Intent	To ensure water is available to enable people, property and infrastructure to be defended from bushfire.
Proposed Development/Use – Relevant Planning Stage	(Sb) Structure plan where the lot layout is known and subdivision application
Element Compliance Statement	The proposed development/use achieves the intent of this element by being fully compliant with all applicable acceptable solutions.
Pathway Applied to Provide an Alternative Solution	N/A

Acceptable Solutions - Assessment Statements

All details of acceptable solution requirements are established in the Guidelines for Planning in Bushfire Prone Areas, DPLH v1.4 (Guidelines) and apply the guidance established by the Position Statement: 'Planning in bushfire prone areas – Demonstrating Element 1: Location and Element 2: Siting and design' (WAPC Nov 2019) and the 'Bushfire Management Plan Guidance for the Dampier Peninsula' (WA Department of Planning, Lands and Heritage, 2021 Rev B) as relevant. These documents are available at https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas.

The technical construction requirements for access types and components, and for each firefighting water supply component, are also presented in Appendices 2 and 3. The local government will advise the proponent where different requirements are to apply and when any additional specifications such as those for signage and gates are to apply (these are included in the relevant appendix if requested by the local government).

Solution Component Check Box Legend ☑ Relevant & met ☒ Relevant & not met ⃠ Not relevant

A4.1 Identification of future firefighting water supply **Applicable**: Yes **Compliant**: Yes

☑ ☐ ☐ It can be demonstrated that reticulated or sufficient non-reticulated water for firefighting can be provided at the subdivision and/or development application stage in accordance with the specifications of the relevant water supply authority or the requirements of Schedule 2.

Supporting Assessment Details: None Required.

A4.2 Provision of water for firefighting purposes **Applicable**: Yes **Compliant**: Yes

☐ ☐ ⃠ A reticulated water supply is available to the proposed development. The existing hydrant connection(s) are provided in accordance with the specifications of the relevant water supply authority.

☑ ☐ ☐ A reticulated water supply will be available to the proposed development. Hydrant connection(s) can and will be provided in accordance with the specifications of the relevant water supply authority.

☐ ☐ ⃠ A static water supply (tank) for firefighting purposes will be installed on each lot that is additional to any water supply that is required for drinking and other domestic purposes.

☐ ☐ ⃠ A strategic water supply (tank or tanks) for firefighting purposes will be installed within or adjacent to the proposed development that is additional to any water supply that is required for drinking and other domestic purposes. The required land will be ceded free of cost to the local government and the lot or road reserve where the tank is to be located will be identified on the plan of subdivision.

☐ ☐ ⃠ The strategic static water supply (tank or tanks) will be located no more than 10 minutes travel time from a subject site (at legal road speeds).

☐ ☐ ⃠ The technical requirements (location, number of tanks, volumes, design, construction materials, pipes and fittings), as established by the Guidelines (A4.2, E4 and Schedule 2) and/or the relevant local government, can and will be complied with.

Supporting Assessment Details: A reticulated water supply is not currently available to the proposed development. It is assumed for the purposes of assessment that a water supply will be available to the proposed development. It will need to be demonstrated that a reticulated water supply for firefighting can be provided at the subdivision and/or development application stage, however.

The construction technical requirements established by the Guidelines and/or the local government can and will need to be complied with. Refer to information contained in Appendix D for the firefighting water supply specifications and technical requirements.

6 BUSHFIRE PROTECTION MEASURES - RESPONSIBILITY FOR IMPLEMENTATION CHECKLIST

6.1 Developer Responsibilities – Prior to Issue of Titles

DEVELOPER RESPONSIBILITIES – PRIOR TO ISSUE OF TITLES		
No.	Implementation Actions	Subdivision Clearance
1	*Condition that may be imposed (refer to Code F2 of Model Subdivision Conditions Schedule, WAPC June 2021 and Guidelines DPLH, 2021 v1.4, s5.3.2)* A notification, pursuant to Section 165 of the *Planning and Development Act 2005*, is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows: *"This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and is/may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land."* (Western Australian Planning Commission).	☐
1	Construct the public roads, including any no through roads and perimeter roads, to comply with the technical requirements referenced in the BMP.	☐
2	Construct the emergency access ways, fire service access routes and associated signs and gates to comply with the technical requirements referenced in the BMP.	☐
3	Install the reticulated firefighting water supply and hydrants to comply with the technical requirements referenced in the BMP.	☐
4	Within the relevant and identified new lot(s), the required extent of vegetation is to be removed and/or modified to ensure adjoining new lot(s) can provide suitable development sites with a radiant heat impacts not exceeding 29 kW/m² (BAL-29). Where native vegetation is required to be modified or removed, ensure that prior approval has been received from the relevant authority. Refer to the applicable local government for advice.	☐
5	A site-specific Bushfire Management Plan will be required at the future subdivision or development stage/s to monitor and review plot classification, tree retention measures proposed, BAL Mapping and assumptions for the Nambad Brook to ensure the BAL Assessment is as accurate as possible and reflective of its environmental values.	☐
6	A site-specific Bushfire Management Plan will be required at the future subdivision or development stage/s to monitor and review how tree retention measures and revegetation works proposed in Public Open Spaces / Drainage may affect plot classifications, BAL Mapping and assumptions to ensure accuracy in the reporting and to recalibrate where it is found that those spaces cannot be managed to low fuel state.	☐

6.2 Developer / Landowner Responsibilities – Prior to Sale

DEVELOPER/LANDOWNER RESPONSIBILITIES – PRIOR TO SALE	
No.	Implementation Actions
1	Prior to relevant building work, inform the builder of the existence of this approved Bushfire Management Plan (BMP). The plan identifies that the development site is within a designated bushfire prone area and states the indicative (or determined) BAL rating(s) that may (or will) be applied to buildings/structures. A BAL assessment report may be required to confirm determined ratings and will be required when ratings are indicative. BAL certificates will need to be issued to accompany building applications. The BMP may also establish, as an additional bushfire protection measure, that construction requirements to be applied will be those corresponding to a specified higher BAL rating. Compliance with the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), will require certain bushfire resistant construction requirements be applied to residential buildings in bushfire prone areas (i.e., Class 1, 2 and 3 and associated Class 10a buildings and decks). Other classes of buildings may also be required to comply with these construction when established by the relevant authority or if identified as an additional bushfire protection measure within the BMP. The deemed to satisfy solutions that will meet the relevant bushfire performance requirements are found in AS 3959 – Construction of Building in Bushfire Prone Areas (as amended) and the NASH Standard - Steel Framed Construction in Bushfire Areas (as amended).
2	Prior to sale of the subject lots, each individual lot is to be compliant with current version of the City of Swan Fire Hazard Reduction Notice issued under s33 of the Bushfires Act 1954. This may include standards for asset protection zones that differ from Schedule 1 in the Guidelines DPLH, 2021 v1.4, with the intent to better satisfy local conditions. [Refer to assessments against the Bushfire Protection Criteria the Element 2 'Siting and Design' and the information presented in Appendix B].
3	There is an outstanding obligation, created by this Bushfire Management Plan, for a site-specific Bushfire Management Plan at the future subdivision or development stage/s for the land use, at the subsequent subdivision/development application stage.

6.3 Landowner / Occupier Responsibilities – Ongoing Management

LANDOWNER/OCCUPIER – ONGOING MANAGEMENT	
No.	Management Actions
1	Maintain the 'Required' Asset Protection Zone (APZ) around habitable buildings (and other structures as required) to satisfy: • The minimum required dimensions established in Appendix B1; and • The standards established by the Guidelines DPLH, 2021 v1.4, Schedule 1, or as varied by the local government through their annually issued firebreak / hazard reduction notice when the variations have been endorsed by the WAPC and DFES as per s4.5.3 of the Guidelines.
2	Comply with the City of Swan Fire Hazard Reduction Notice issued under s33 of the Bush Fires Act 1954. Check the notice annually for any changes.
3	Maintain vehicular access routes within the lot to comply with the technical requirements referenced in the BMP and the relevant local government's annual firebreak / hazard reduction notice.
4	Ensure that builders engaged to construct dwellings/additions and/or other relevant structures on the lot, are aware of the existence of this approved Bushfire Management Plan (BMP). The plan identifies that the development site is within a designated bushfire prone area and states the indicative (or determined) BAL rating(s) that may (or will) be applied to buildings/structures. A BAL assessment report may be required to confirm determined ratings and will be required when ratings are indicative. BAL certificates will need to be issued to accompany building applications. Compliance with the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), will require certain bushfire resistant construction requirements be applied to residential buildings in bushfire prone areas (i.e., Class 1, 2 and 3 and associated Class 10a buildings and decks). The deemed to satisfy solutions that will meet the relevant bushfire performance requirements are found in AS 3959 – Construction of Building in Bushfire Prone Areas (as amended) and the NASH Standard - Steel Framed Construction in Bushfire Areas (as amended). As an additional bushfire protection measure, other classes of buildings may also be required to comply with these construction requirements when established by the relevant authority or if identified as an additional bushfire protection measure within the BMP. The BMP may also establish that construction requirements to be applied will be those corresponding to a specified higher BAL rating. When applicable, these requirements will be identified in Section 5.7.
5	Ensure all future buildings the landowner has responsibility for, are designed and constructed in full compliance with: • The bushfire resistant construction requirements of the Building Code of Australia (Volumes 1 and 2 of the National Construction Code), as established by the Building Regulations 2012 (WA Building Act 2011); and • Any additional bushfire protection measures this Bushfire Management Plan has established are to be implemented.

6.4 Local Government Responsibilities – Ongoing Management

LOCAL GOVERNMENT – ONGOING MANAGEMENT	
No.	Management Actions
1	Monitor landowner compliance with the annual Fire Hazard Reduction Notice and with any bushfire protection measures that are: • Established by this BMP; • Are required to be maintained by the landowner/occupier; and • Are relevant to local government operations.

APPENDIX A: DETAILED BAL ASSESSMENT DATA AND SUPPORTING INFORMATION

A1: BAL Assessment Inputs Common to the Method 1 and Method 2 Procedures

A1.1: FIRE DANGER INDICES (FDI/FDI/GFDI)

When using Method 1 the relevant FDI value required to be applied for each state and region is established by AS 3959:2018, Table 2.1. Each FDI value applied in Tables 2.4 – 2.7 represents both the Forest Fire Danger Index (FFDI) and a deemed equivalent for the Grassland Fire Danger Index (GFDI), as per Table B2 in Appendix B. When using Method 2, the relevant FFDI and GFDI are applied.

The values may be able to be refined within a jurisdiction, where sufficient climatological data is available and in consultation with the relevant authority.

Relevant Jurisdiction:	WA	Region:	Whole State	Method 1	Applied FDI:	80
				Method 2	Applied FFDI:	N/A
					Applied GFDI:	N/A

A1.2: VEGETATION ASSESSMENT AND CLASSIFICATION

Vegetation Types and Classification

In accordance with AS 3959:2018 clauses 2.2.3 and C2.2.3.1, all vegetation types within 100 metres of the 'site' (defined as "the part of the allotment of land on which a building stands or is to be erected"), are identified and classified. Any vegetation more than 100 metres from the site that has influenced the classification of vegetation within 100 metres of the site, is identified and noted. The maximum excess distance is established by AS 3959: 2018 cl 2.2.3.2 and is an additional 100 metres.

Classification is also guided by the Visual Guide for Bushfire Risk Assessment in WA (WA Department of Planning February 2016) and any relevant FPA Australia practice notes.

Modified Vegetation

The vegetation types have been assessed as they will be in their natural mature states, rather than what might be observed on the day. Vegetation destroyed or damaged by a bushfire or other natural disaster has been assessed on its expected re-generated mature state. Modified areas of vegetation can be excluded from classification if they consist of low threat vegetation or vegetation managed in a minimal fuel condition, satisfying AS 3959:2018 s2.2.3.2(f), and there is sufficient justification to reasonable expect that this modified state will exist in perpetuity.

The Influence of Ground Slope

Where significant variation in effective slope exists under a consistent vegetation type, these will be delineated as separate vegetation areas to account for the difference in potential bushfire behaviour, in accordance with AS 3959:2018 clauses 2.2.5 and C2.2.5.

THE INFLUENCE OF VEGETATION GREATER THAN 100 METRES FROM THE SUBJECT SITE	
Vegetation area(s) within 100m of the site whose classification has been influenced by the existence of bushfire prone vegetation from 100m – 200m from the site:	None
Assessment Statement:	No vegetation types exist close enough, or to a sufficient extent, within the relevant area to influence classification of vegetation within 100 metres of the subject site.

VEGETATION AREA 1				
Classification	**G. GRASSLAND**			
Types Identified	Sown pasture G-26			
Exclusion Clause	N/A			
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees
Description/Justification:	Assessed as Grassland due to areas of grasses present in paddock/open areas. While grasses appear to be either sparse or in a managed state in some sections due to livestock grazing, there are sections that are currently in an unmanaged state. As such, the entire area/s have been classified in accordance with AS3959-2018 as a precautionary measure with a worst-case scenario approach. Foliage cover less than 10%.			
Post Development Assumptions:	It is anticipated that sections of Area 1 within the boundaries of the subject site will have some form of modification as a result of Asset Protection Zone (APZ) Implementation. Refer to Figures 3.1b and 3.2a contained within this plan - It is assumed re-vegetation/re-planting will take place in the Nambad Brook POS Area. It is further assumed that these area/s will not be managed. As such, a worst-case scenario classification (Class A Forest) in accordance with As3959-2018 has been applied as a precautionary measure.			



PHOTO ID: 1



PHOTO ID: 2



PHOTO ID: 3



PHOTO ID: 4

VEGETATION AREA 1				
Classification	**G. GRASSLAND**			
Types Identified	Sown pasture G-26			
Exclusion Clause	N/A			
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees
Description/Justification:	As Above.			
Post Development Assumptions:	As Above.			



PHOTO ID: 5



PHOTO ID: 6



PHOTO ID: 7



PHOTO ID: 8

VEGETATION AREA 1				
Classification	**G. GRASSLAND**			
Types Identified	Sown pasture G-26			
Exclusion Clause	N/A			
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees
Description/Justification:	As Above.			
Post Development Assumptions:	As Above.			



PHOTO ID: 9



PHOTO ID: 10



PHOTO ID: 11



PHOTO ID: 12

VEGETATION AREA 1				
Classification	**G. GRASSLAND**			
Types Identified	Sown pasture G-26			
Exclusion Clause	N/A			
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees
Description/Justification:	As Above.			
Post Development Assumptions:	As Above.			



PHOTO ID: 13



PHOTO ID: 14



PHOTO ID: 15



PHOTO ID: 16



PHOTO ID: 17

VEGETATION AREA 2						
Classification	**B. WOODLAND**					
Types Identified	Woodland B-05					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	>2m	Tree Height	Up to 30m	
Description/Justification:	Mixed species of trees inclusive of Eucalyptus Wandoo. Understorey consists of predominantly unmanaged grasses and isolated shrub.					
Post Development Assumptions:	It is anticipated that sections of Area 2 within the boundaries of the subject site will have some form of modification as a result of Asset Protection Zone (APZ) Implementation. Refer to Figures 3.1b and 3.2a contained within this plan - It is assumed re-vegetation/re-planting will take place in the Nambad Brook POS Area. It is further assumed that these area/s will not be managed. As such, a worst-case scenario classification (Class A Forest) in accordance with As3959-2018 has been applied as a precautionary measure.					



PHOTO ID: 18



PHOTO ID: 19



PHOTO ID: 20



PHOTO ID: 21

VEGETATION AREA 2						
Classification	**B. WOODLAND**					
Types Identified	Woodland B-05					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	>2m	Tree Height	Up to 30m	
Description/Justification:	As Above					
Post Development Assumptions:	As Above.					



PHOTO ID: 22



PHOTO ID: 23



PHOTO ID: 24



PHOTO ID: 25

VEGETATION AREA 2						
Classification	**B. WOODLAND**					
Types Identified	Woodland B-05					
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	<30%	Shrub/Heath Height	>2m	Tree Height	Up to 30m	
Description/Justification:	As Above					
Post Development Assumptions:	As Above.					



PHOTO ID: 26



PHOTO ID: 27

VEGETATION AREA 3						
Classification	**A. FOREST**					
Types Identified	Open forest A-03	Woodland B-05				
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	Up to 30m	
Description/Justification:	Forest Dominant Area - Mixed species of trees inclusive of Jarrah and Wandoo. Understorey consists of unmanaged grasses, low shrub and low trees in some sections while other sections have minimal understorey.					
Post Development Assumptions:	It is anticipated that sections of Area 3 within the boundaries of the subject site will have some form of modification as a result of Asset Protection Zone (APZ) Implementation.					



PHOTO ID: 28



PHOTO ID: 29



PHOTO ID: 30



PHOTO ID: 31

VEGETATION AREA 3						
Classification	**A. FOREST**					
Types Identified	Open forest A-03	Woodland B-05				
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees		
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	Up to 30m	
Description/Justification:	As Above.					
Post Development Assumptions:	As Above.					



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PHOTO ID: 33



PHOTO ID: 34



PHOTO ID: 35

VEGETATION AREA 3						
Classification	**A. FOREST**					
Types Identified	Open forest A-03		Woodland B-05			
Exclusion Clause	N/A					
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)		Upslope or flat 0 degrees	
Foliage Cover (all layers)	>30%	Shrub/Heath Height	>2m	Tree Height	Up to 30m	
Description/Justification:	As Above.					
Post Development Assumptions:	As Above.					



PHOTO ID: 36



PHOTO ID: 37



PHOTO ID: 38



PHOTO ID: 39



PHOTO ID: 40

VEGETATION AREA 4				
Classification	**C. SHRUBLAND**			
Types Identified	Closed (low) heath C-10			
Exclusion Clause	N/A			
Effective Slope	Measured	flat 0 degrees	Applied Range (Method 1)	Upslope or flat 0 degrees
Description/Justification:	Unmanaged low shrub averaging less than 2 metres in height. Mixed species composition. Unmanaged grasses present also.			
Post Development Assumptions:	It is anticipated that sections of Area 4 within the boundaries of the subject site will have some form of modification as a result of Asset Protection Zone (APZ) Implementation.			



PHOTO ID: 41



PHOTO ID: 42

VEGETATION AREA 5						
Classification	**N/A**					
Types Identified	N/A					
Exclusion Clause	2.2.3.2 (f) Low threat vegetation - minimal fuel condition.					
Effective Slope	Measured	N/A	Applied Range (Method 1)	N/A		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A	Tree Height	N/A	
Description/Justification:	An established commercial and residential area. Cleared areas surrounding existing dams, managed private gardens, street frontages and median strips/road verges. Trees under-pruned to two (2) metres in height. Grasses slashed and maintained to less than 50mm. Footpaths/hardstand areas cleared of unmanaged vegetation.					
Post Development Assumptions:	Not Applicable.					



PHOTO ID: 43



PHOTO ID: 44



PHOTO ID: 45



PHOTO ID: 46

VEGETATION AREA 5						
Classification	**N/A**					
Types Identified	N/A					
Exclusion Clause	2.2.3.2 (f) Low threat vegetation - minimal fuel condition.					
Effective Slope	Measured	N/A	Applied Range (Method 1)	N/A		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A	Tree Height	N/A	
Description/Justification:	As Above.					
Post Development Assumptions:	As Above.					



PHOTO ID: 47



PHOTO ID: 48



PHOTO ID: 49



PHOTO ID: 50

VEGETATION AREA 5						
Classification	**N/A**					
Types Identified	N/A					
Exclusion Clause	2.2.3.2 (f) Low threat vegetation - minimal fuel condition.					
Effective Slope	Measured	N/A	Applied Range (Method 1)	N/A		
Foliage Cover (all layers)	N/A	Shrub/Heath Height	N/A	Tree Height	N/A	
Description/Justification:	As Above.					
Post Development Assumptions:	As Above.					



PHOTO ID: 51



PHOTO ID: 52

A1.3: EFFECTIVE SLOPE

Measuring

Effective slope refers to the slope "under the classified vegetation which most significantly influences bushfire behaviour (AS 3959:2018, clause B4, CB4). It is not the average slope.

It is described as upslope, flat or downslope when viewed from the exposed element (e.g., building) looking towards the vegetation – and measured in degrees. Ground slope has a direct and significant influence on a bushfire's rate of spread and intensity, which increases when travelling up a slope.

The slope under the vegetation in closest proximity to the exposed element(s), over the distance that will most likely carry the entire depth of the flaming front, will be a significant consideration in the determination of the effective slope. This distance is determined as a function of the potential quasi-steady rate of spread and expected residence time (i.e., the flaming combustion period at a single point on the ground), of a bushfire in the specific vegetation type/landscape scenario.

Slope Variation Within Areas of Vegetation

Where a significant variation in effective slope exists under a consistent vegetation type, these will be delineated as separate vegetation areas to account for the difference in potential bushfire behaviour, in accordance with AS 3959:2018 clauses 2.2.5 and C2.2.5.

Slope Variation Due to Multiple Development Sites

When the effective slope, under a given area of bushfire prone vegetation, will vary significantly relative to multiple proposed development sites (exposed elements), then the effective slopes corresponding to each of the different locations, are separately identified.

The relevant (worst case) effective slope is determined in the direction corresponding to the potential directions of fire spread towards the subject building(s).

Differences in Application of Effective Slope - AS 3959:2018 Method 1 versus Method 2 Procedures

The Method 1 procedure provides five different slope ranges from flat (including all upslopes) to 20 degrees downslope to define the effective slope and bushfire behaviour model calculations apply the highest value in each range (i.e., 0^0, 5^0, 10^0, 15^0 or 20^0).

The Method 2 procedure requires an actual slope (up or down in degrees) to be determined. AS 3959:2018, clause B1 limits the effective slope that can be applied to 30 degrees downslope and 15 degrees upslope. Where any upslope is greater than 15 degrees, then 15 degrees is to be used.

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

The effective slopes determined from the site assessment are recorded in Table 3.2 of this Bushfire Management Plan. When their derivation requires additional explanation and justification, this is provided below.

A1.4: SEPARATION DISTANCE

Measuring

The separation distance is the distance in the horizontal plane between the receiver (building/structure or area of land being considered) and the edge of the classified vegetation (AS 3959:2018, clause 2.2.4)

The relevant parts of a building/structure from which the measurement is taken is the nearest part of an external wall or where a wall does not exist, the supporting posts or columns. Certain parts of buildings are excluded including eaves and roof overhangs.

The edge of the vegetation, for forests and woodlands, will be determined by the unmanaged understorey rather than either the canopy (drip line) or the trunk (AS 3959:2018, clause C2.2.5).

Measured Separation Distance as a Calculation Input

If a separation distance can be measured because the location of the building/structure relative to the edge of the relevant classified vegetation is known, this figure can be entered into the BAL calculation. The result is a determined BAL rating.

Assumed Separation Distance as a Calculation Input

When the building/structure location within the lot is not known, an assumed building location may be applied that would establish the closest positioning of the building/structure relative to the relevant area of vegetation.

The assumed location would be based on a factor that puts a restriction on a building location such as:

- An established setback from the boundary of a lot, such as a residential design code setback or a restrictive covenant; or
- Within an established building envelope.

The resultant BAL rating would be indicative and require later confirmation (via a Compliance Report) of the building/structure actual location relative to the vegetation to establish the determined BAL rating.

Separation Distance as a Calculation Output

With the necessary site specific assessment inputs and using the AS 3959:2018 bushfire modelling equations, the range of separation distances that will correspond to each BAL rating (each of which represents a range of radiant heat flux), can be calculated. This has application for bushfire planning scenarios such as:

- When the separation distance cannot be measured because the exact location of the exposed element (i.e., the building, structure or area), relative to classified vegetation, is yet to be determined.

  In this scenario, the required information is the identification of building locations onsite that will correspond to each BAL rating. That is, indicative BAL ratings can be derived for a variety of potential building/structure locations; or

- The separation distance is known for a given building, structure or area (and a determined BAL rating can be derived), but additional information is required regarding the exposure levels (to the transfer of radiant heat from a bushfire), of buildings or persons, that will exist at different points within the subject site.

The calculated range of separation distances corresponding to each BAL rating can be presented in a table and/or illustrated as a BAL Contour Map – whichever is determined to best fit the purpose of the assessment.

For additional information refer to the information boxes in Section 3 'Bushfire Attack Levels (BAL) - Understanding the Results and Section 3.2. 'Interpretation of the BAL Contour Map'.

SITE ASSESSMENT DETAILS - EXPLANATION & JUSTIFICATION

For the subject development/use the applicable separation distances values are derived from calculations applying the assessed site data. They are an output value, not an input value and therefore are not presented or justified in this appendix.

The derived values are presented in Section 3, Table 3.1 and illustrated as a BAL contour map in Figure 3.2a.

APPENDIX B: ADVICE - ONSITE VEGETATION MANAGEMENT - THE APZ

THE ASSET PROTECTION ZONE (APZ) - DESCRIPTION

This is an area surrounding a habitable building containing low threat fire fuel fuels (including vegetation), or vegetation managed in a minimal fuel condition, no fire fuels or any combination. The primary objectives include:

- To ensure the building is sufficiently separated from the bushfire hazard to limit the impact of its direct attack mechanisms. That is, the dimensions of the APZ will, for most site scenarios, remove the potential for direct flame contact on the building, reduce the level of radiant heat to which the building is exposed and ensure some reduction in the level of ember attack (with the level of reduction being dependent on the vegetation types of present);
- To ensure any vegetation retained within the APZ is low threat and/or is managed in a minimum fuel condition and prevents surface fire spreading to the building;
- To ensure other combustible materials that can result in consequential fire (typically ignited by embers) within both the APZ and parts of the building, are eliminated, minimised and/or appropriately located or protected. (Note: The explanatory notes in the Guidelines provide some guidance for achieving this objective and other sources are available. Research shows that consequential fire, ignited by embers, is the primary cause of building loss in past bushfire events); and
- To provide a defendable space for firefighting activities.

B1: Asset Protection Zone (APZ) Dimensions

APZ DIMENSIONS – DIFFERENCES IN REQUIREMENTS FOR PLANNING ASSESSMENTS COMPARED TO IMPLEMENTATION

THE 'PLANNING BAL-29' APZ DIMENSIONS

The 'Planning BAL-29' APZ is not necessarily the size of the APZ that must be physically implemented and maintained by a landowner. Rather, its purpose is to identify if an acceptable solution for planning approval can be met i.e., can a specified minimum separation distance from bushfire prone vegetation exist.

An assessment against the Bushfire Protection Criteria is conducted for planning approval purposes. To satisfy 'A2.1: Asset Protection Zone', it must be demonstrated that certain minimum separation distances between the relevant building/structure and different classes of bushfire prone vegetation, either exist or can be created and will remain in perpetuity. These minimum separation distances determine the 'Planning BAL-29' APZ dimensions.

Dimensions: The minimum dimensions are those that will ensure the potential radiant heat impact on subject buildings does not exceed 29 kW/m^2. These dimensions will vary dependent on the vegetation classification, the slope of the land they are growing on and certain other factors specific to the subject site.

Note: For certain purposes associated with vulnerable land uses, the 'Planning BAL-29' APZ may be replaced with dimensions corresponding to radiant heat impact levels of 10 kW/m^2 and 2 kW/m^2 and calculated using 1200K flame temperature.

Location: The identified 'Planning BAL-29' APZ must not extend past lot boundaries onto land the landowner has no control over either now or potentially at some point in the future. Limited exceptions include:

- When adjoining land is not vegetated (e.g., built out, roads, carparks, drainage, rock, water body etc.);
- When adjoining land currently or, will in the short term, contain low threat vegetation and or vegetation managed in a minimal fuel condition as per AS 3959:2018 cl. 2.2.3.2. It must be reasonable (justifiable) to expect this low threat vegetation and/or level of management will continue to exist or be conducted in perpetuity and require no action from the owner of the subject lot.

  Such areas of land include formally managed areas of vegetation (e.g., public open space / recreation areas / services installed in a common section of land). For specific scenarios, evidence of the formal

commitment to manage these areas to a certain standard may be required and would be included in the BMP.

These areas of land can also be part of the required APZ on a neighbouring lot for which the owner of that lot has a recognised responsibility to establish and maintain; and

- When there is a formalised and enforceable capability and responsibility created for the subject lot owner, or any other third party, to manage vegetation on land they do not own in perpetuity. This would be rare, and evidence of the formal authority would be included in the BMP.

The bushfire consultant's 'Supporting Assessment Detail', that is presented in the assessment against the acceptable solution A2.1, will identify and justify how any adjoining land within the 'Planning BAL-29 APZ will meet the APZ standards. Or otherwise, explain how this condition cannot be met.

THE 'BAL RATING' APZ DIMENSIONS

The applicable BAL rating will have been stated in the BAL Assessment Data section of the BAL Assessment Report or BMP (as relevant). The BAL rating can be assessed as 'determined' or 'indicative' or be 'conditional', dependent of the specific conditions associated with the site and the stage of assessment or planning. It is the eventual assessment of the 'Determined' BAL that will establish both the BAL rating that is to apply and its corresponding 'BAL Rating' APZ dimensions.

Dimensions: The minimum dimensions of the 'BAL Rating' APZ to be established and maintained will be those that correspond to the determined BAL rating for the subject building/structure that has accounted for surrounding vegetation types, the slope of the land they are growing on and certain other factors specific to the subject site and surrounding land.

Establishing the 'BAL Rating' APZ will ensure that the potential radiant heat exposure of the building/structure will be limited to the level that the applied construction requirements are designed to resist when that building/structure is required to be constructed to the standard corresponding to the Determined BAL.

Note: For certain purposes associated with vulnerable land uses, the 'BAL Rating' APZ dimensions may be replaced with dimensions corresponding to the specific radiant heat impact levels of 10 kW/m² and 2 kW/m² and calculated using 1200K flame temperature.

Location: The same conditions will apply as for the 'Planning BAL-29' APZ.

THE 'LOCAL GOVERNMENT' APZ DIMENSIONS

Some Local Government's establish the dimensions of the APZ that must be established surrounding buildings in their annual Firebreak/Hazard Reduction Notice. Or for a specific site they may establish a maximum allowable dimension (typically that corresponding to BAL-29). When established, the landowner will need to be comply with these.

THE 'REQUIRED' APZ DIMENSIONS

This is the APZ that is to be established and maintained by the landowner within the subject lot and surrounding the subject building(s). It will be identified on the Property Bushfire Management Statement when it is required to be included in this Report/Plan.

Dimensions: The 'Required APZ' dimensions are the minimum (or maximum when relevant) distances away from the subject building(s) that the APZ must extend. These distances will not necessarily be the same all around the building(s). They can vary and are dependent on the different vegetation types (and their associated ground slope) that can exist around the building(s), and specific local government requirements. The dimensions to implement are determined by:

A. The 'BAL Rating APZ' of the subject building(s) when distances are greater than 'B' below (except when 'B' establishes a maximum distance); or

B. The 'Local Government' APZ' derived from the Firebreak/Hazard Reduction Notice when distances are greater than 'A' above, other than when a maximum distance is established, in which case this will apply; or

C. A combination of 'A' and 'B'.

Location: The same conditions will apply as for the 'Planning BAL-29' APZ.

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B1.1: THE APZ DIMENSIONS REQUIRED TO BE IMPLEMENTED BY THE LANDOWNER

DETERMINATION OF THE 'REQUIRED' APZ DIMENSIONS TO BE IMPLEMENTED AND MAINTAINED BY LANDOWNER WITHIN THEIR LOT										
Relevant Buildings(s)	Vegetation Classification [Refer to Fig 3.1a]		Minimum Required Separation Distances from Building to Vegetation (metres)							
			Established by the 'BAL Rating' APZ Dimension					Established by the "Local Government' APZ Dimension		The 'Required' APZ Dimensions [see note]
			Determined Radiant Heat Impact		Stated 'Indicative' or 'Conditional' BAL			Firebreak / Hazard Reduction Notice	Maximum Allowed	
	Area	Class			BAL-29	BAL-19	BAL-12.5	BAL-LOW		
All Proposed Allotments	1	(G) Grassland			8	12	17	50	20	All land within the subject lot surrounding the proposed buildings/structures will be the required APZ. The road verge should also be managed to the APZ Standard.
	2	(B) Woodland			14	20	29	100	20	
	3	(A) Forest			21	31	42	100	20	
	4	(C) Shrubland			9	13	19	100	20	
	5	Excluded cl 2.2.3.2(e & f)			N/A	N/A	N/A	N/A	20	

Note: The 'Required' APZ Dimension corresponding to each area of vegetation is the greater of the 'BAL Rating' or the 'Firebreak/Hazard Reduction Notice' APZ dimensions - unless a local government maximum distance(s) is established as a result of their environmental assessment of the subject site. The area of the APZ will also be limited to the subject lot boundary unless otherwise justified in this Report/Plan. Final determination of the dimensions will require that any indicative or conditional BAL becomes a 'Determined' BAL.

Comments: None Required.

B2: The Standards for the APZ as Established by the Guidelines (DPLH, v1.4)

Within the Guidelines (source: https://www.wa.gov.au/government/document-collections/state-planning-policy-37-planning-bushfire-prone-areas), the management Standards are established by:

- Schedule 1: Standards for Asset Protection Zones (see extract below) established by the Guidelines; and
- The associated explanatory notes (Guidelines E2) that address (a) managing an asset protection zone (APZ) to a low threat state (b) landscaping and design of an asset protection zone and (c) plant flammability.

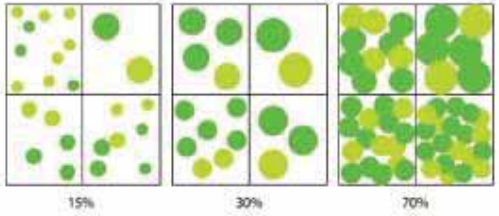


ELEMENT 2: SITING AND DESIGN OF DEVELOPMENT

SCHEDULE 1: STANDARDS FOR ASSET PROTECTION ZONES

OBJECT	REQUIREMENT
Fences within the APZ	• Should be constructed from non-combustible materials (for example, iron, brick, limestone, metal post and wire, or bushfire-resisting timber referenced in Appendix F of AS 3959).
Fine fuel load (Combustible, dead vegetation matter <6 millimetres in thickness)	• Should be managed and removed on a regular basis to maintain a low threat state. • Should be maintained at <2 tonnes per hectare (on average). • Mulches should be non-combustible such as stone, gravel or crushed mineral earth or wood mulch >6 millimetres in thickness.
Trees* (>6 metres in height)	• Trunks at maturity should be a minimum distance of six metres from all elevations of the building. • Branches at maturity should not touch or overhang a building or powerline. • Lower branches and loose bark should be removed to a height of two metres above the ground and/or surface vegetation. • Canopy cover within the APZ should be <15 per cent of the total APZ area. • Tree canopies at maturity should be at least five metres apart to avoid forming a continuous canopy. Stands of existing mature trees with interlocking canopies may be treated as an individual canopy provided that the total canopy cover within the APZ will not exceed 15 per cent and are not connected to the tree canopy outside the APZ.

Figure 19: Tree canopy cover – ranging from 15 to 70 per cent at maturity



Shrub* and scrub* (0.5 metres to six metres in height). Shrub and scrub >6 metres in height are to be treated as trees	• Should not be located under trees or within three metres of buildings. • Should not be planted in clumps >5 square metres in area. • Clumps should be separated from each other and any exposed window or door by at least 10 metres.
Ground covers* (<0.5 metres in height. Ground covers >0.5 metres in height are to be treated as shrubs)	• Can be planted under trees but must be maintained to remove dead plant material, as prescribed in 'Fine fuel load' above. • Can be located within two metres of a structure, but three metres from windows or doors if >100 millimetres in height.
Grass	• Grass should be maintained at a height of 100 millimetres or less, at all times. • Wherever possible, perennial grasses should be used and well-hydrated with regular application of wetting agents and efficient irrigation.
Defendable space	• Within three metres of each wall or supporting post of a habitable building, the area is kept free from vegetation, but can include ground covers, grass and non-combustible mulches as prescribed above.
LP Gas Cylinders	• Should be located on the side of a building furthest from the likely direction of a bushfire or on the side of a building where surrounding classified vegetation is upslope, at least one metre from vulnerable parts of a building. • The pressure relief valve should point away from the house. • No flammable material within six metres from the front of the valve. • Must sit on a firm, level and non-combustible base and be secured to a solid structure.

** Plant flammability, landscaping design and maintenance should be considered – refer to explanatory notes*

B3: The Standards for the APZ as Established by the Local Government

Refer to the firebreak / hazard reduction notice issued annually (under s33 of the Bushfires Act 1954) by the relevant local government. It may state Standards that vary from those established by the Guidelines and that have been endorsed by the WAPC and DFES as per Section 4.5.3 of the Guidelines.

A copy of the applicable notice is not included here as they are subject to being reviewed and modified prior to issuing each year. Refer to ratepayers notices and/or the local government's website for the current version.

B4: Vegetation and Areas Excluded from Classification - Ensure Continued Exclusion

AS 3959:2018 establishes the methodology for determining a bushfire attack level (BAL). The methodology includes the classification of the subject site's surrounding vegetation according to their 'type' and the application of the corresponding relevant bushfire behaviour models to determine the BAL.

Certain vegetation can be considered as low threat or managed in a minimal fuel condition and can be excluded from classification. Where this has occurred in assessing the site, the extract from AS3959:2018 below states the requirements that must continue to exist for the vegetation on those areas of land to be excluded from classification (including the size of the vegetation area if relevant to the assessment).

2.2.3.2 *Exclusions—Low threat vegetation and non-vegetated areas*

The following vegetation shall be excluded from a BAL assessment:

(a) Vegetation of any type that is more than 100 m from the site.

(b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified vegetation.

(c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified vegetation.

(d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified vegetation.

(e) Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.

(f) Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTES:

1 Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).

2 A windbreak is considered a single row of trees used as a screen or to reduce the effect of wind on the leeward side of the trees.

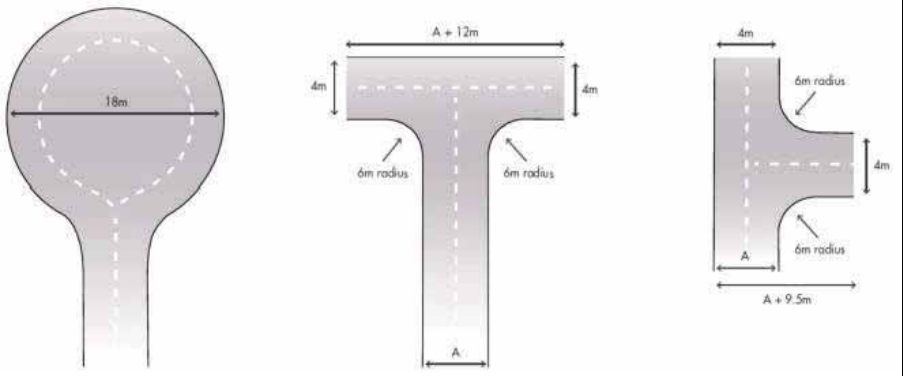
APPENDIX C: TECHNICAL REQUIREMENTS FOR VEHICULAR ACCESS

The design/layout requirements for access are established by the acceptable solutions of the Guidelines (DPLH, 2021 v1.4) Element 3 and vary dependent on the access component, the land use and the presence of 'vulnerable' persons. Consequently, the best reference source are the Guidelines. The technical requirements that are fixed for all components and uses are presented in this appendix.

GUIDELINES TABLE 6, EXPLANATORY NOTES E3.3 & E3.6 AND RELEVANT ACCEPTABLE SOLUTIONS

Technical Component	Vehicular Access Types / Components			
	Public Roads	Emergency Access Way [1]	Fire Service Access Route [1]	Battle-axe and Private Driveways [2]
Minimum trafficable surface (m)	In accordance with A3.1	6	6	4
Minimum Horizontal clearance (m)	N/A	6	6	6
Minimum Vertical clearance (m)	4.5			
Minimum weight capacity (t)	15			
Maximum Grade Unsealed Road [3]	As outlined in the IPWEA Subdivision Guidelines	1:10 (10%)		
Maximum Grade Sealed Road [3]		1:7 (14.3%)		
Maximum Average Grade Sealed Road		1:10 (10%)		
Minimum Inner Radius of Road Curves (m)		8.5		

Turnaround Area Dimensions for No-through Road, Battle-axe Legs and Private Driveways [4]



Passing Bay Requirements for Battle-axe leg and Private Driveway

When the access component length is greater than the stated maximum, passing bays are required every 200m with a minimum length of 20m and a minimum additional trafficable width of 2m (i.e. the combined trafficable width of the passing bay and constructed private driveway to be a minimum 6m).

Emergency Access Way – Additional Requirements

Provide a through connection to a public road, be no more than 500m in length, must be signposted and if gated, gates must be open the whole trafficable width and remain unlocked.

[1] To have crossfalls between 3 and 6%.

[2] Where driveways and battle-axe legs are not required to comply with the widths in A3.5 or A3.6, they are to comply with the Residential Design Codes and Development Control Policy 2.2 Residential Subdivision.

[3] Dips must have no more than a 1 in 8 (12.5% or 7.1 degree) entry and exit angle.

[4] The turnaround area should be within 30m of the main habitable building.

APPENDIX D: TECHNICAL REQUIREMENTS FOR FIREFIGHTING WATER SUPPLY

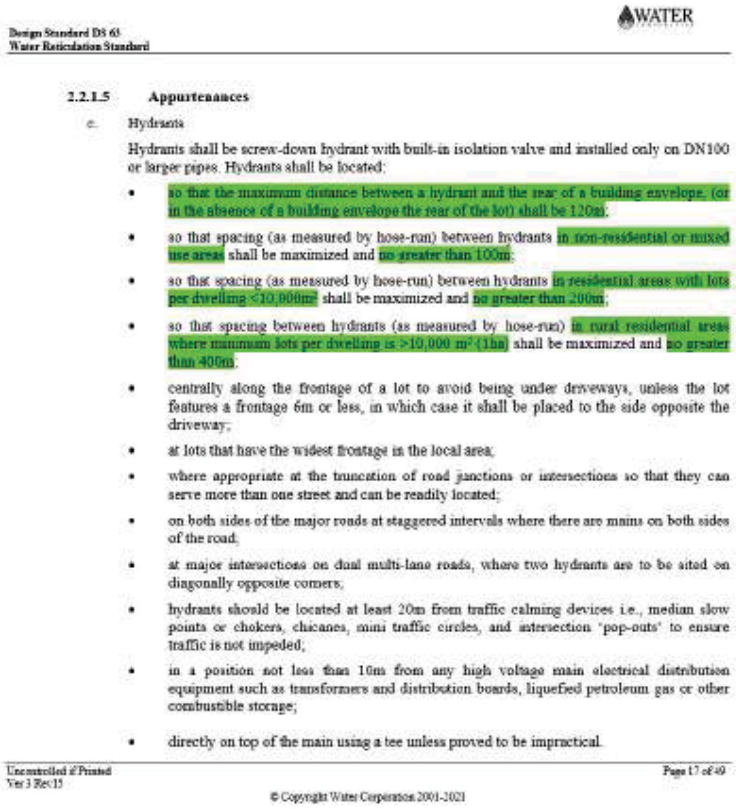
D1: Reticulated Areas – Hydrant Supply

The Guidelines state "where a reticulated water supply is existing or proposed, hydrant connection(s) should be provided in accordance with the specifications of the relevant water supply authority."

The main scheme water suppliers / authorities in WA are The Water Corporation, AqWest – Bunbury Water Corporation and Busselton Water Corporation. Various local authority exists in other non-scheme and regional areas. However, most existing fire hydrants are connected to Water Corporation water mains.

Consequently, the hydrant location specifications from The Water Corporation's 'No 63 Water Reticulation Standard' (Ver 3 Rev 15) are provided in the extract below with the key distances relevant to bushfire planning assessments being highlighted. This Standard is deemed to be the baseline criteria for developments and should be applied unless different local water supply authority conditions apply. Other applicable specification will be found in the Standard.

Note: The maximum distance from a hydrant to the rear of a lot/building is generally interpreted as not applicable to large lot sizes where the maximum distance becomes an impractical limitation i.e., typically rural residential areas.



Design Standard DS 63
Water Reticulation Standard

WATER

2.2.1.5 Appurtenances

e. Hydrants

Hydrants shall be screw-down hydrant with built-in isolation valve and installed only on DN100 or larger pipes. Hydrants shall be located:

- so that the maximum distance between a hydrant and the rear of a building envelope, (or in the absence of a building envelope the rear of the lot) shall be 120m;
- so that spacing (as measured by hose-run) between hydrants in non-residential or mixed use areas shall be maximized and no greater than 100m;
- so that spacing (as measured by hose-run) between hydrants in residential areas with lots per dwelling <10,000m² shall be maximized and no greater than 200m;
- so that spacing between hydrants (as measured by hose-run) in rural residential areas where minimum lots per dwelling is >10,000 m² (1ha) shall be maximized and no greater than 400m;
- centrally along the frontage of a lot to avoid being under driveways, unless the lot features a frontage 6m or less, in which case it shall be placed to the side opposite the driveway;
- at lots that have the widest frontage in the local area;
- where appropriate at the truncation of road junctions or intersections so that they can serve more than one street and can be readily located;
- on both sides of the major roads at staggered intervals where there are mains on both sides of the road;
- at major intersections on dual multi-lane roads, where two hydrants are to be sited on diagonally opposite corners;
- hydrants should be located at least 20m from traffic calming devices i.e., median slow points or chokers, chicanes, mini traffic circles, and intersection 'pop-outs' to ensure traffic is not impeded;
- in a position not less than 10m from any high voltage main electrical distribution equipment such as transformers and distribution boards, liquefied petroleum gas or other combustible storage;
- directly on top of the main using a tee unless proved to be impractical.

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D2: Non-Reticulated Areas – Static Supply

For specified requirements, refer to the Guidelines Element 4: Water – Acceptable Solution A4.2 , Explanatory Notes E4 (that provide water supply establishment detail under the headings of water supply; independent water and power supply; strategic water supplies, alternative water sources and location of water tanks) and the technical requirements established by Schedule 2 (reproduced below).

SCHEDULE 2: WATER SUPPLY DEDICATED FOR BUSHFIRE FIREFIGHTING PURPOSES

2.1 Water supply requirements

Water dedicated for firefighting should be provided in accordance with Table 7 below, and be in addition to water required for drinking purposes.

Table 7: Water supply dedicated for bushfire firefighting purposes

PLANNING APPLICATION	NON-RETICULATED AREAS
Development application	10,000L per habitable building
Structure Plan / Subdivision: Creation of 1 additional lot	10,000L per lot
Structure Plan / Subdivision: Creation of 3 to 24 lots	10,000L tank per lot **or** 50,000L strategic water tank
Structure Plan / Subdivision: Creation of 25 lots or more	50,000L per 25 lots or part thereof Provided as a strategic water tank(s) or 10,000L tank per lot

2.2 Technical requirements

2.2.1 Construction and design

An aboveground tank and associated stand should be constructed of non-combustible material. The tank may need to comply with AS/NZS 3500.1:2018.

Below ground tanks should have a 200mm diameter access hole to allow tankers or emergency service vehicles to refill direct from the tank, with the outlet location clearly marked at the surface. The tank may need to comply with AS/NZS 3500.1:2018. An inspection opening may double as the access hole provided that the inspection opening meets the requirements of AS/NZS 3500.1:2018. If the tank is required under the BCA as part of fire hydrant installation, then the tank will also need to comply with AS 2419.

Where an outlet for an emergency service vehicle is provided, then an unobstructed, hardened ground surface is to be supplied within four metres of any water supply.

2.2.2 Pipes and fittings

All aboveground, exposed water supply pipes and fittings should be metal. Fittings should be located away from the source of bushfire attack and be in accordance with the applicable section below, unless otherwise specified by the local government.

2.2.2.1 Fittings for above-ground water tanks:

- Commercial land uses: 125mm Storz fitting; or
- Strategic water tanks: 50mm or 100mm (where applicable and adapters are available) male camlock coupling with full flow valve; or
- Standalone water tanks: 50mm male camlock coupling with full flow valve; or
- Combined water tanks: 50mm male camlock coupling with full flow valve or a domestic fitting, being a standard household tap that enables an occupant to access the water supply with domestic hoses or buckets for extinguishing minor fires.

2.2.2.2 Remote outlets

In certain circumstances, it may be beneficial to have the outlet located away from the water supply. In such instances in which a remote outlet is to be used, the applicant should consult the local government and DFES on their proposal.

EXAMPLE CONSTRUCTION AND FITTINGS





Strategic 47,000 Litre Concrete Tank & Protected Fittings



10,000 Litre Concrete Tank



Storz and Camlock Couplings



Full Flow 50mm Ball Valve



Full Flow 50mm Gate Valve and Male Camlock

APPENDIX E: ADVICE - BAL RATINGS – CORRESPONDING THREATS AND CONSTRUCTION REFERENCES

BAL [1]	DESCRIPTION OF PREDICTED BUSHFIRE DIRECT ATTACK MECHANISMS (THREATS) AND LEVELS OF EXPOSURE	REFERENCES FOR CONSTRUCTION REQUIREMENTS	
		AS 3959:2018 Construction of Buildings in Bushfire Prone Areas	**The NASH Standard (2021) – Steel Framed Construction in Bushfire Areas**
		Referenced by the Building Code of Australia for Building Classes 1, 2, 3 & 10a	Referenced by the Building Code of Australia for Building Classes 1 & 10a
BAL – LOW	There is insufficient risk to warrant specific construction requirements but there is still some risk. *(Note: DFES recommend that ember attack protection features be incorporated into the design where practicable).*	Section 4. No Requirements	No Requirements
BAL – 12.5	There is a risk of ember attack. Construction elements are expected to be exposed to heat flux not greater than 12.5 kW/m^2	Sections 3 & 5.	All construction requirements for BAL-12.5 to BAL-40 are the same except for windows and external doors, which must comply with AS 3959. The construction requirements are set out as essentially non-combustible construction systems for each of the following building elements: Section 1.4: General Requirements Section 2: Roof and Ceiling System Section 3: External Wall System Section 4: Floor System Section 5: Carports Verandahs and Decks.
BAL – 19	There is a risk of ember attack and burning debris ignited by windborne 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.	Sections 3 & 6	
BAL – 29	There is an increased risk of ember attack and burning debris ignited by windborne embers and a likelihood of exposure to an increased level radiant heat. The construction elements are expected to be exposed to a heat flux not greater than 29 kW/m^2.	Sections 3 & 7.	
BAL – 40	There is a much increased risk of ember attack and burning debris ignited by windborne 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 40kW/m^2.	Sections 3 & 8.	
BAL – FZ (Flame Zone)	There is an extremely high risk of ember attack and burning debris ignited by windborne embers, and 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.	Sections 3 & 9.	The construction requirements are set out in Sections 1-5 and differ from the requirements for all other BAL ratings.

[1] AS 3959:2018 *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 flux expressed in kW/m^2, and is the basis for establishing the requirements for construction to improve protection of building elements from attack by bushfire."*

ADDENDUM:

- **Broader Landscape Assessment – Addendum accompanying the Bullsbrook South Bushfire Management Plan (LSP)**

Bullsbrook South

Broader Landscape Assessment Report

(PREPARED FOR PLANNING APPLICATION ASSESSMENT PURPOSES)



Compiled in accordance with State Planning Policy 3.7 Bushfire and the Planning for Bushfire Guidelines

Address / Locations:
Lot 900 (61) Lage Road
Lot 400 (2428) Great Northern Highway
Lot 2 (2424) Great Northern Highway
Lot 5 (2422) Great Northern Highway
Lot 6 (2416) Great Northern Highway
Lot 4 Lage Road
Lot 61 (2342) Great Northern Highway
Lot 201 (2306) Great Northern Highway
Part Lot 1011 (2274) Great Northern Highway
Part Lot 803 (2242) Great Northern Highway
Part Lot 20 (2234) Great Northern Highway
Lot 802 (2258) Great Northern Highway
Lot 100 (2286) Great Northern Highway

City of Swan

Structure Plan (lot layout and/or internal road network is known)

23 January 2025

BPP GROUP PTY LTD T/A BUSHFIRE PRONE PLANNING

ACN: 39 166 551 784 | ABN: 39 166 551 784

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Rebecca Thompon – Rowe Group	Rebecca.Thompson@rowegroup.com.au	1.0	1	☐	☒
		-		☐	☐

Limitations: *The protection measures that will be implemented based on information presented in this Bushfire Management Plan are minimum requirements and they do not guarantee that buildings or infrastructure will not be damaged in a bushfire, persons injured, or fatalities occur either on the subject site or off the site while evacuating.*

This is substantially due to the unpredictable nature and behaviour of fire and fire weather conditions. Additionally, the correct implementation of the required protection measures (including bushfire resistant construction) and any other required or recommended measures, will depend upon, among other things, the ongoing actions of the landowners and/or operators over which Bushfire Prone Planning has no control.

All surveys, forecasts, projections and recommendations made in this report associated with the proposed development are made in good faith based on information available to Bushfire Prone Planning at the time. All maps included herein are indicative in nature and are not to be used for accurate calculations.

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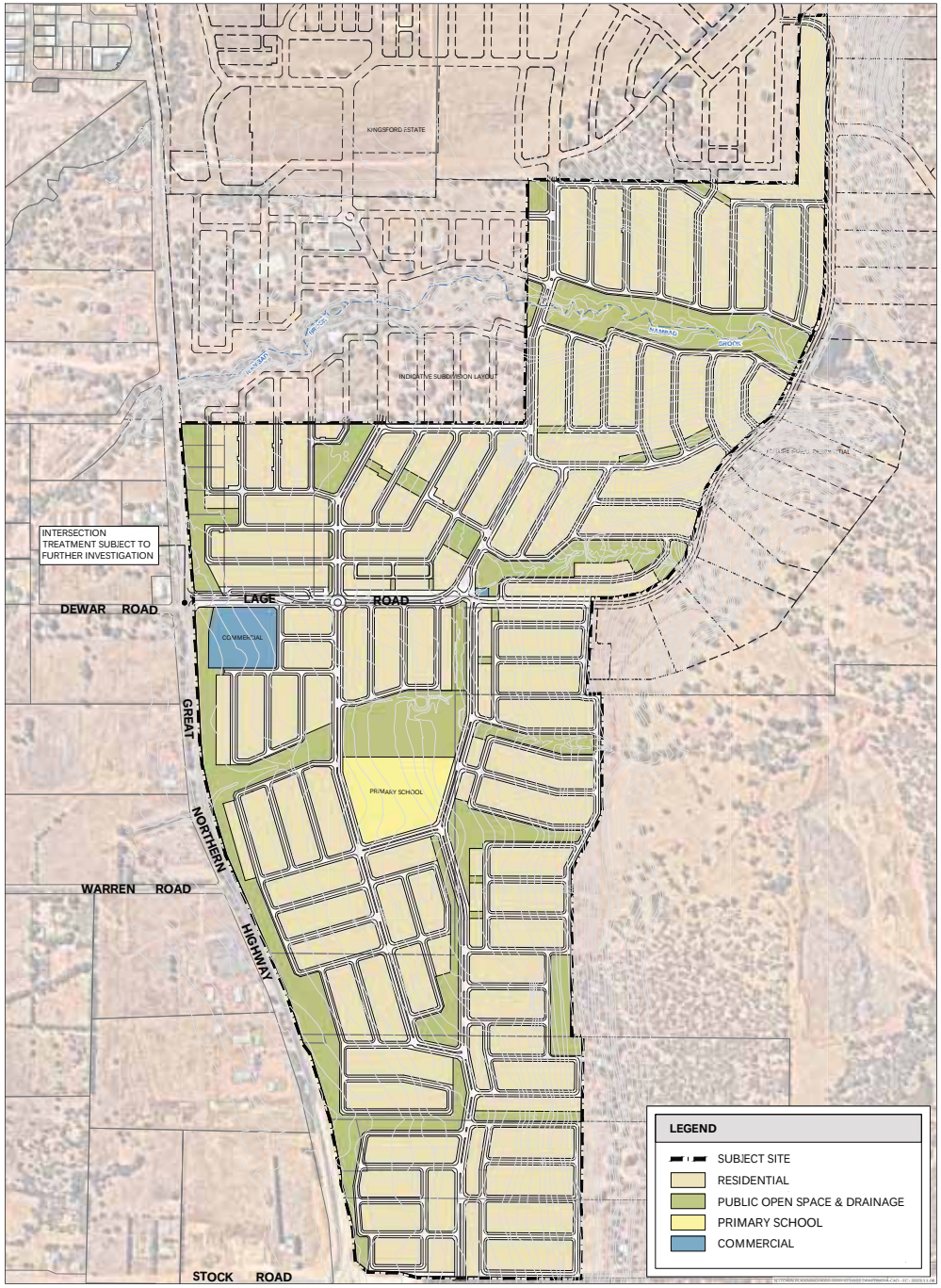
1 THE PLANNING PROPOSAL

1.1 Details, Plans and Maps

SUBJECT LAND AND PROPONENT (LANDOWNER)		
The Subject Land / Site	Bullsbrook South – City of Swan Various Land Parcels (per below): Lot 900 (61) Lage Road Lot 400 (2428) Great Northern Highway Lot 2 (2424) Great Northern Highway Lot 5 (2422) Great Northern Highway Lot 6 (2416) Great Northern Highway Lot 4 Lage Road Lot 61 (2342) Great Northern Highway Lot 201 (2306) Great Northern Highway Part Lot 1011 (2274) Great Northern Highway Part Lot 803 (2242) Great Northern Highway Part Lot 20 (2234) Great Northern Highway Lot 802 (2258) Great Northern Highway Lot 100 (2286) Great Northern Highway	
Total Area of Subject Land / Site	150.1 hectares	
Proponent	Mirvac	
Entity Commissioning Production of the BMP	Rowe Group	
THE PLANNING PROPOSAL STAGE AND TYPE		
Strategic Planning Document	☐	N/A
Structure Plan	☑	A structure plan, subject to bushfire planning requirements, where the lot layout and/or internal road network is known.
Subdivision Application	☐	N/A
Development Application	☐	N/A
ADDITIONAL DETAILS		
This Broader Landscape Assessment Report is an Addendum to accompany the Bullsbrook South Bushfire Management Plan (BMP) v1.3 – Prepared under the Guidelines for Planning in Bushfire Prone Areas (version 1.4). BPP are of the view that limited value would be added in requiring the BMP be rewritten to address the new Guidelines. It is acknowledged however that the new requirement for a 'Broader Landscape Assessment for strategic proposals' is directly relevant to the decision before the WAPC regarding Bullsbrook South.		

For this reason, this Addendum is limited to a Broader Landscape Assessment as this remains the key policy change between the previous and new Bushfire Policy Framework (SPP 3.7 and associated Planning for Bushfire Guidelines) relative to strategic proposals.



BULLSBROOK SOUTH URBAN EXPANSION AREA - CONCEPT PLAN
VARIOUS LOTS - GREAT NORTHERN HIGHWAY
BULLSBROOK

N

0 200 m
SCALE @ A3: 1:7500
9714-CON-18-A

DRAWN: WC
DATE CREATED: 2023.11.06
PROJECTION: PCG94
CADASTRE: MNG 105670ds-006a
CONTOURS: LANDGATE
AERIAL: NEARMAP 2023

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ROWE GROUP DESIGN

2 THE BUSHFIRE HAZARD – POTENTIAL IMPACT - LANDSCAPE AND VEGETATION DATA

2.1 Broader Landscape Assessment (BLA)

EXPLANATORY INFORMATION

SPP 3.7 cl. 6.1 establishes that strategic planning, subdivision and development should avoid broader landscapes that present an unacceptable bushfire risk to people, property and infrastructure.

An assessment is to be conducted in accordance with the methodologies established within the Guidelines Appendix A1 examining the area external to the planning proposal and extending for a distance of approximately two kilometres.

When considering the suitability of a location for the intensification of land use or development, the BLA provides a means of quantifying the characteristics and the potential impacts of bushfire in the broader landscape.

The BLA will identify one of the following:

1. That a 'Simplified BLA' assessment can be conducted to demonstrate compliance with BPC Element 1: Location.
2. That the broader landscape is 'Type A' and the proposal therefore achieves the required outcome of BPC Element 1: Location; or
3. That the broader landscape is 'Type B' and the proposal will not be supported unless it has demonstrated that the level of risks, to people, property and infrastructure, associated with a bushfire event in the broader landscape, is acceptable.

2.1.1 Application of the Simplified Assessment

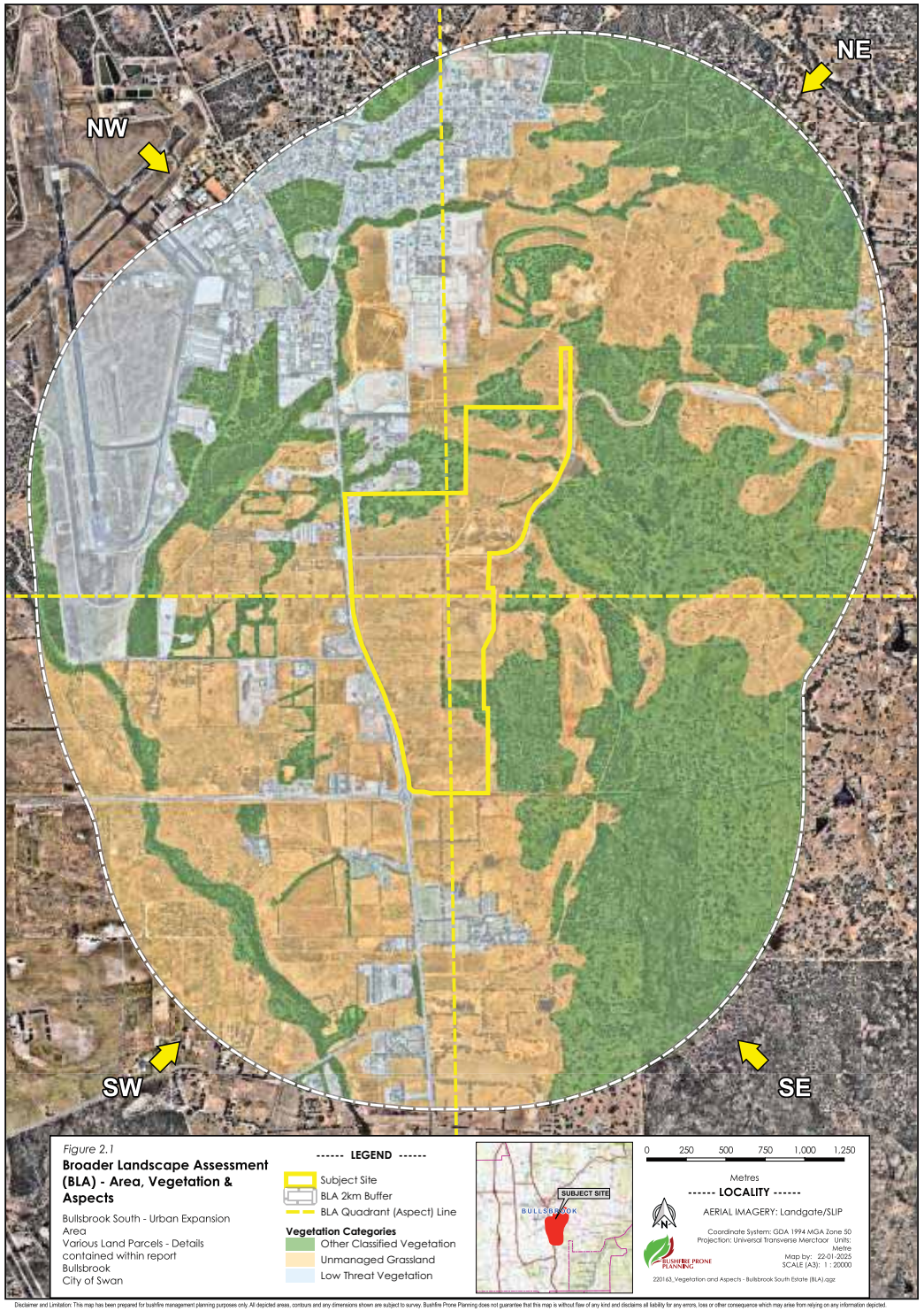
DETERMINATION OF THE ABILITY TO UNDERTAKE A SIMPLIFIED ASSESSMENT	
APPLIED METHODOLOGY (GUIDELINES APPENDIX A1, NOV 2024)	
Criteria Questions	Assessed Answer [1]
Is the subject site within a kilometre of a townsite, urban area or suitable destination?	Yes
Is the road pattern from the planning proposal to the closest townsite, urban area or suitable destination, simple and/or direct (limited intersections)?	Yes
Is the majority of vegetation within the broader landscape assessment area cleared, managed in a low threat state or Class G Grassland, (e.g. clearing for residential zoned urban lots)?	Yes
Is the planning proposal exposed to two or less aspects with external bushfire hazards (excluding Class G Grassland)?	No
ASSESSMENT OUTCOME	
The assessed answers include a 'NO'. A full BLA must be undertaken.	
Note 1: Refer to the assessment map and supporting details on the following pages when the 'Simplified BLA' can be undertaken. Otherwise, refer to the information presented in Section 2.1.2 'Application of the Full BLA'.	

2.1.2 Application of the Full Assessment

DETERMINATION OF THE BROADER LANDSCAPE TYPE – ASSESSED APPLYING A POINTS BASED SYSTEM				
APPLIED METHODOLOGY (GUIDELINES APPENDIX A1, NOV 2024)				
Criteria	5 Points	2 Points	1 Point	Assessed Points [1]
Proximity of the planning proposal to a 'suitable destination' (refer to SPP 3.7 Definitions).	>10 km	1-10 km	<1 km	**1**
The road pattern from the planning proposal to a suitable destination.	Complex and indirect (cul-de-sacs and/or multiple intersections)	Mixed road patterns	Simple and/or direct (limited intersections)	**1**
The predominant vegetation pattern.	Large tracts of contiguous vegetation	A mosaic pattern of vegetation (e.g. vegetation within rural living precincts)	Cleared vegetation (e.g. clearing for residential zoned urban lots)	**2**
Aspect exposure of the planning proposal to an identified external bushfire hazard (excluding Class G Grassland).	Three or four aspects	Two aspects	One aspect or none	**5**
DETERMINED BROADER LANDSCAPE TYPE (BLT)				
4 - 11 Points = Type A				
IMPLICATIONS FOR THE SUBJECT PLANNING PROPOSAL AND CONTENT OF THIS BMP				
The determination as Landscape Type A demonstrates compliance with BPC Element 1: Location. No further assessments are required.				
Note 1: Refer to assessment supporting details and maps and on the following pages.				

FULL BLA - CRITERIA ASSESSMENT - SUPPORTING DETAILS
Proximity of the planning proposal to a 'suitable destination' (refer to SPP 3.7 Definitions).
Refer to Figure 2.3 contained within this report – A 'suitable destination' as defined under the State Planning Policy (SPP) 3.7 is located less than 1 kilometre from the Subject Site. Note - Figure 2.4 has been included to further substantiate the above-mentioned commentary – i.e A suitable destination that is not designated bushfire prone on the Map of Bush Fire Prone Areas.
The road pattern from the planning proposal to a suitable destination.
Refer to Figure 2.3 contained within this report - The Subject Site is located immediately adjacent to the Great Northern Highway, a major arterial route of the public road network that provides travel from the planning proposal to a suitable destination – i.e travel in two different directions (north and south) to two different destinations with limited intersections. It is a straight road with minimal curved or cul-de-sac patterns. In addition (and as also depicted in Figure 2.3) – development of the land surrounding the Subject Site appears to be underway as not only does the newly constructed Yarrimbah Drive (formerly Lage Road – refer to Landgate image below for substantiation) connects to Clarkson Road to the east, development of the Kingsford Estate to the North can provide alternative access and egress options as development progresses.  Furthermore, as development progresses at a local level, access options won't be limited to a single road in two directions to at least two suitable destinations once construction of the internal road network and surrounding road network connections to arterial roads (i.e Great Northern Highway) have been completed.
The predominant vegetation pattern.
As depicted in Figure 2.2 – The predominant vegetation pattern is mosaic as the vegetation consists of either cleared vegetation (i.e existing residential or urban zoned and developed or developing land) or Class G Grassland (and other vegetation) contained within the rural living precincts. The large tracts of vegetation identified are mostly contained to designated Bush Forever sites or reserves. Most of the vegetation identified however, appears to be on private land and subject to various levels of fuel load management. General Comments: - The topography in the area in relation to the Subject Site has an overall flat land or upslope appearance. - Fire behaviour within the large tracts of vegetation will be predominantly fuel driven. - Fire behaviour within grassland and/or open areas will be predominantly wind driven. - Significant fire behaviour such as a pyroconvective event, while possible, is limited due to the fragmentation of areas of bushfire prone vegetation – i.e cleared and/or pastured areas, fuel load management by landowners and the availability of emergency services (including being part of the greater Perth Metropolitan Area).

Aspect exposure of the planning proposal to an identified external bushfire hazard (excluding Class G Grassland).
Refer to Figure 2.1 contained within this report – It is acknowledged in Section 2.1.2 that identified external bushfire hazards (excluding Class G Grassland) are present within three or four aspects. The likely bushfire behaviour has been discussed in the predominant vegetation above.



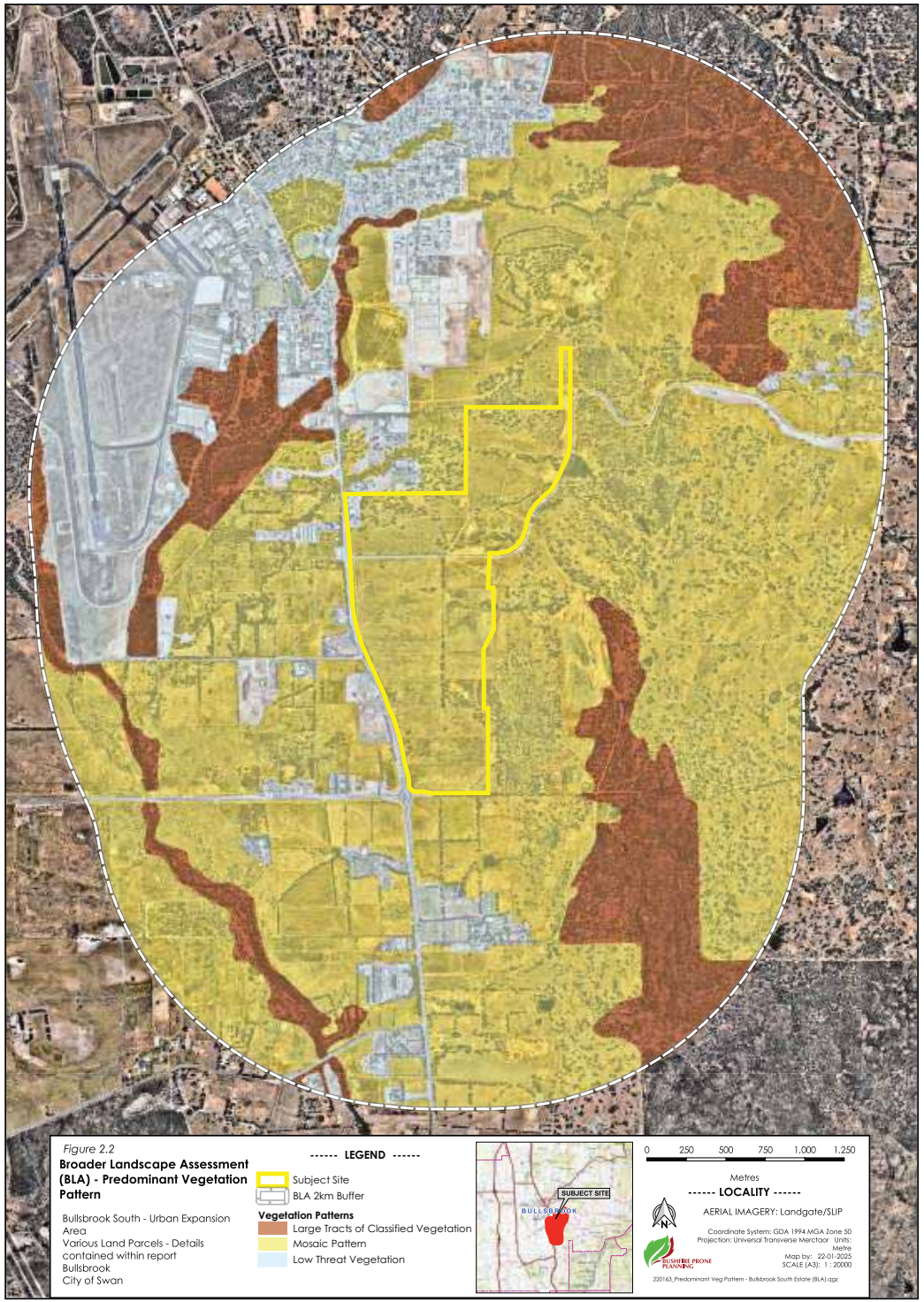


Figure 2.2

Broader Landscape Assessment (BLA) - Predominant Vegetation Pattern

Bullsbrook South - Urban Expansion Area
Various Land Parcels - Details contained within report
Bullsbrook
City of Swan

------ LEGEND ------

Subject Site
BLA 2km Buffer

Vegetation Patterns

Large Tracts of Classified Vegetation
Mosaic Pattern
Low Threat Vegetation

SUBJECT SITE
BULLSBROOK

0 250 500 750 1,000 1,250
Metres

------ LOCALITY ------

AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map by: 22-01-2025
SCALE (A3): 1 : 20000

220163_Predominant Veg Pattern - Bullsbrook South Estate (BLA).qgz

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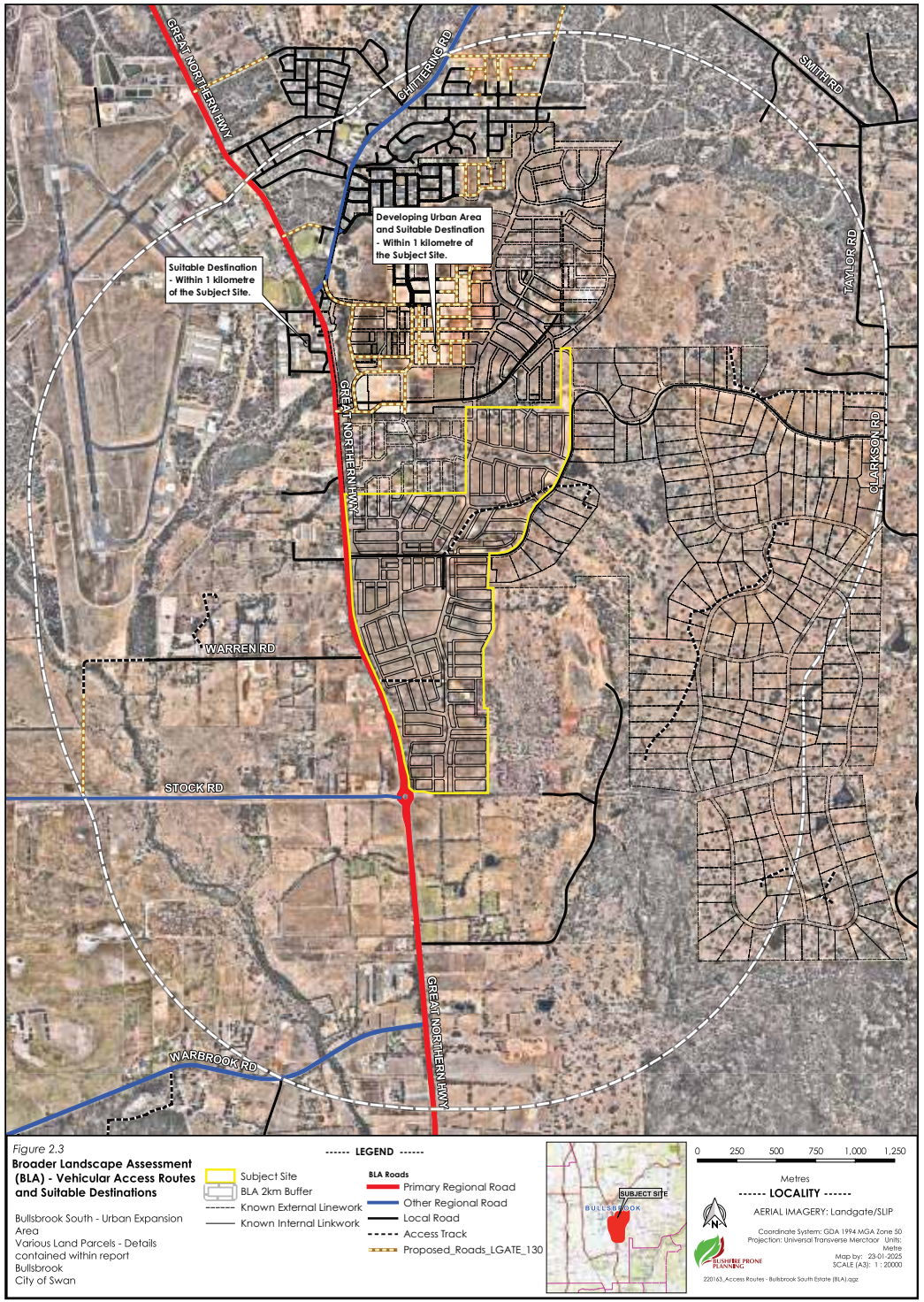

Figure 2.3

Broader Landscape Assessment (BLA) - Vehicular Access Routes and Suitable Destinations

Bullsbrook South - Urban Expansion Area
Various Land Parcels - Details contained within report
Bullsbrook
City of Swan

------ LEGEND ------

Subject Site
BLA 2km Buffer
Known External Linework
Known Internal Linkwork

BLA Roads

Primary Regional Road
Other Regional Road
Local Road
Access Track
Proposed_Roads_LGATE_130

SUBJECT SITE
BULLSBROOK

0 250 500 750 1,000 1,250
Metres

------ LOCALITY ------

AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map by: 23-01-2025
SCALE (A3): 1 : 20000

220163_Access Routes - Bullsbrook South Estate (BLA).qgz

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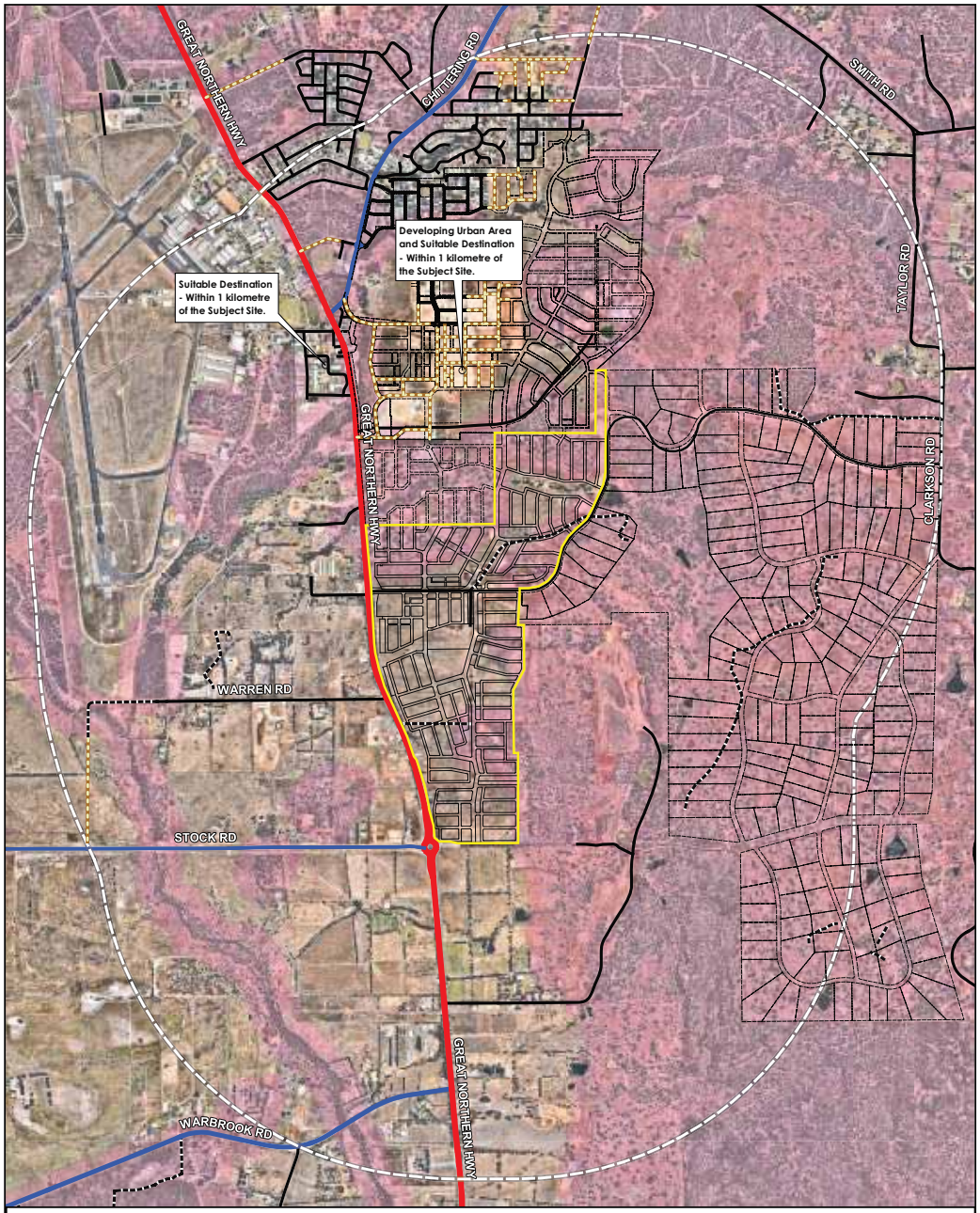


Figure 2.4

Broader Landscape Assessment (BLA) - Vehicular Access Routes and Suitable Destinations - Considers Designated Bushfire Prone Areas

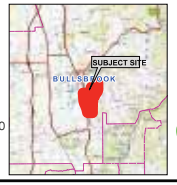
Bullsbrook South - Urban Expansion Area
Various Land Parcels - Details contained within report
Bullsbrook
City of Swan

------ LEGEND ------

- Subject Site
- BLA 2km Buffer
- Known External Linework
- Known Internal Linkwork

BLA Roads

- Primary Regional Road
- Other Regional Road
- Local Road
- Access Track
- Proposed_Roads_LGATE_130



0 250 500 750 1,000 1,250

Metres

------ LOCALITY ------

AERIAL IMAGERY: Landgate/SLIP

Coordinate System: GDA 1994 MGA Zone 50
Projection: Universal Transverse Mercator Units: Metre
Map by: 23-01-2025
SCALE (A3): 1 : 20000

220163_Access Routes_BPA - Bullsbrook South Estate (BLA).qgz

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Attachment 6

Retail Needs Assessment

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Taktics4

Bullsbrook South Neighbourhood Centre City of Swan

Retail Needs Assessment

In accordance with SPP4.2

Project

Project name	**Bullsbrook South**
Project number	**2221**
Prepared for	**Mirvac**

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Version

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Acknowledgement of Country

Taktics4 acknowledges the First Nations people as the custodians of the land which is the subject of this assessment. We pay our respect to their continuing culture, and to Elders past, present, and emerging.

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1 EXECUTIVE SUMMARY

The assessment has been prepared in accordance with the objectives and criteria established in State Planning Policy 4.2 Activity Centres (2023). It represents a Retail Needs Assessment for a Neighbourhood Centre, in Bullsbrook South, City of Swan.

Centre Hierarchy	**Neighbourhood**
Centre Status/ Development Type	**Currently Planned Centre**
Policy Criteria	**Local Structure Plan which includes a planned activity centre where the Retail Needs Assessment / LCACS has not been updated within 5 years.**
Required Assessment	**Retail Needs Assessment**

Based on the analysis outlined in this report:

- The resident population for Bullsbrook is forecast to grow from 6,300 residents in 2026, to 31,000 residents by 2046, an increase of 24,700 additional residents over 20 years at an average of 1,235 additional residents p.a.
- Population growth will be responsible for generating an additional $130.2 M p.a. in supermarket spending in the trade area between 2026 and 2046.

Economic modelling of the planned Bullsbrook activity centres network reveals that the Bullsbrook trade area can comfortably sustain three supermarket-based centres, including:

- A single full line supermarket-based District Centre at Bullsbrook Central planned to be developed by 2026.
- A single full line supermarket-based Neighbourhood Centre at Bullsbrook South sustainable from 2031.
- A single full line supermarket-based Neighbourhood Centre at Bullsbrook North sustainable from 2036.
- An opportunity for a fourth limited line supermarket to be included in the network in the future.

The proposed Neighbourhood Centre at Bullsbrook South could sustain a 3,5000 sqm NLA supermarket and up to 10-15 shops (1,500 sqm NLA), creating a total retail floor space of 5,000 sqm NLA. A single supermarket-based neighbourhood centre will also support a range of non-retail activities including:

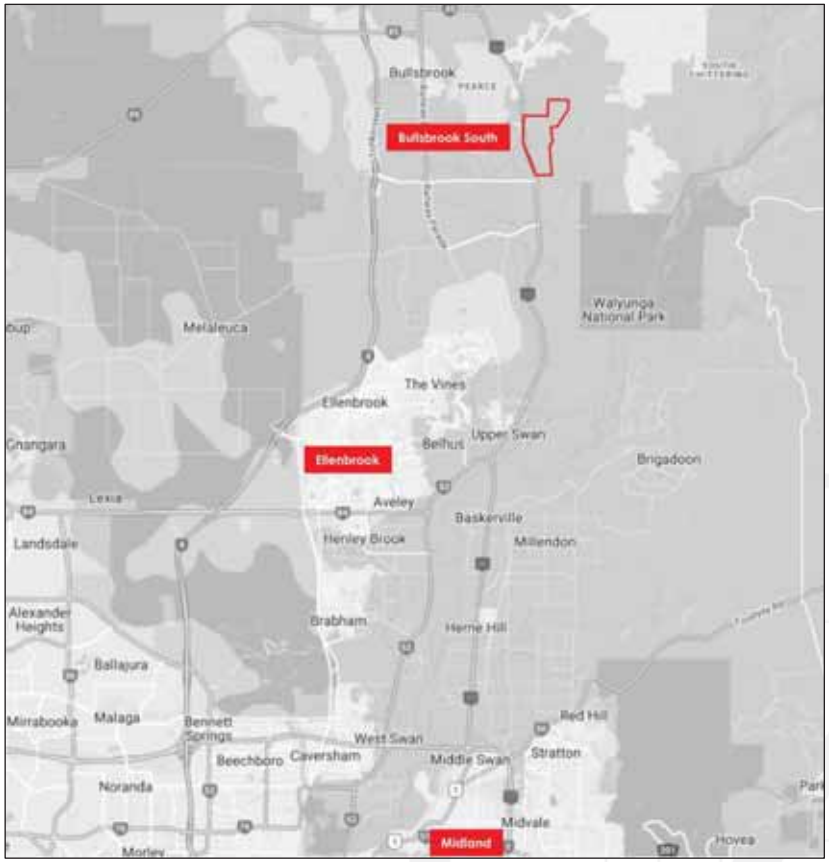
- Medical facilities
- Service station / petrol filling station
- Childcare centre
- Fast food outlets

These activities can be physically accommodated on a regular shaped 2.0 Ha (20,000 sqm) site.

2 INTRODUCTION

This report represents a Retail Needs Assessment for a planned Neighbourhood Centre, in Bullsbrook South, City of Swan.

FIGURE 1 - LOCALITY MAP



Remplan Mapbuilder

2.1 State Planning Policy 4.2 Activity Centres

This assessment has been prepared in accordance with the objectives and outcomes adopted in State Planning Policy 4.2 Activity Centres, gazetted July 2023. SPP4.2 (2023) replaces SPP 4.2 (2010). SPP 4.2 prescribes three distinct assessment types, **Needs** Assessment, **Impact** Test, and **Community Benefit** Test. These assessments are used to test a proposed or planned activity centre's ability to satisfy the objectives of SPP 4.2.

2.2 Needs Assessment

The Needs Assessment:

- Guides future development as part of a Local Planning Strategy for an LGA.
- Assesses the projected demand for all activity centre uses of communities in a Local Government Area.

The Needs Assessment is **also required** to be prepared in support of a district or local structure plan that includes an activity centre:

- where a Local Planning Strategy is not supported by a Needs Assessment, or
- the Needs Assessment for a Local Planning Strategy has not been updated for more than five years.

2.3 Development/Proposal Types

SPP4.2 adopts a position that major development proposals within activity centres and out-of-centre developments have the potential to have an adverse effect on the extent and adequacy of facilities and services available to a local community, and the ability to access them in an efficient and equitable manner.

An **Out-of-Centre Development** is defined as:

1. Any development that proposes retail floorspace greater than 500 sqm NLA of floor space located outside the boundary of an existing or planned activity centre,
2. Any allocation of new land introduced by a planning instrument capable of accommodating activity centre retail and non-retail uses outside of existing or planned activity centres.

A **Major Development** is defined as:

1. Any development in an existing activity centre which proposes an increase in the allocated floor space beyond a floor space threshold prescribed according to centre hierarchy types.

District Centre	5,000 sqm NLA
Neighbourhood Centre	3,000 sqm NLA
Local Centre	1,500 sqm NLA

2. Any development in a planned activity centre which proposes an increase in the allocated floor space beyond a floor space threshold prescribed by the adopted planning instruments.

Activity centre proposals which fall into these development categories require an Impact Test and/or Net Community Benefit test.

2.4 Impact Test

The Impact Test replaces the Retail Sustainability Assessment established in the 2010 gazetted version of SPP 4.2. The Impact Test demonstrates whether a proposal will:

- Satisfy market demand for additional floorspace in the area.
- Have an unreasonable or detrimental impact on the role and function of the activity centre hierarchy and framework in an area.
- Have an unreasonable or detrimental impact on the overall sustainability, viability, and vibrancy of other existing or planned functions of activity centres in an area.
- Have an unreasonable or detrimental impact on existing, committed, and planned public and private infrastructure investment.

SPP 4.2 guidelines establish three levels of potential sales impact of a proposal on other activity centres.

Turnover Impact (%)	Level of Impact
Less than 5%	Minor / Insignificant
5.1% to 9.9%	Moderate
10% and above	Significant

Where there is a moderate or significant impact on one or more activity centres identified in the Impact Test, the proposal must demonstrate how the development will deliver a Net Benefit to the local community.

2.5 Net Benefit Test

A net benefit occurs when the benefits (pros) to the community arising from a proposal outweigh any identified impacts (cons) to the community arising from a proposal. A Net Benefit Test must demonstrate whether a proposal will:

- Reduce the level of access to services by the community.
- Contribute to employment generation (or loss) during operation.
- Contribute to the level of choice and availability of goods and services.
- Adhere to this policy and the planning framework.

Where an endorsed local planning strategy or structure plan includes an indicative amount of activity centre use floorspace for the activity centre derived from a Needs Assessment, a Net Benefit Test is only required where this indicative activity centre use floorspace is proposed to be exceeded.

2.6 This Assessment

The Bullsbrook South Neighbourhood Centre has been provided for in all current relevant planning instruments.

- It has been assessed as a Neighbourhood Centre in the City of Swan Retail Needs Assessment (2010).
- It has been planned as a Neighbourhood Centre in City of Swan LCACS (2017).
- It has been planned as a Neighbourhood Centre in the Bullsbrook District Structure Plan.

The centre is therefore considered a future development scenario that could be reasonably expected to occur.

The most recent City of Swan Retail Needs Assessment was completed in 2010. It was used to inform the most recent LCACS (adopted in 2017). The City of Swan Local Commercial Activity Centres Strategy (2017) therefore reflects the findings in the current Retail Needs Assessment (2010) for the City of Swan. The City of Swan LCACS (2017) has therefore not been updated for over 5 years, triggering the provision for an updated RNA for this Local Structure Plan which includes an activity centre as prescribed in Section 7.2 of SPP 4.2.

This assessment has subsequently been prepared under the following SPP4.2 implementation guideline criteria for:

Centre Hierarchy	**Neighbourhood**
Centre Status/ Development Type	**Planned Centre**
Planning Instrument	**Local Structure Plan which includes a planned activity centre where the Retail Needs Assessment / LCACS has not been updated within five years.**
Assessment Types	**Needs Assessment**

The Planned Neighbourhood Centre is not defined as a ‘major development’ nor an ‘out of centre development’. Neither an ‘Impact Test’ nor ‘Community Benefit Test’ is required.

2.7 Methodology

This assessment uses a range of tools to identify the need and sustainability of the activity centres network in consideration of the proposed local centre. Retail gravity modelling is a statistical method used to analyse the spatial interactions between different retail centres in a prescribed area. It has been adopted by the development, retail, and planning sectors as a reliable method for understanding the impact of location and competition on retail performance. The modelling involves a three-stage process,

1. Collate the significant market factors influencing retail locations and their respective trade areas.
2. Measure the strength of attraction between different activity centres by estimating distance decay functions from trade areas.
3. Assess the differences in attraction at activity centres under differing network considerations.

Retail gravity models can be used to assess:

- future retail demand in a trade area.
- interactions between activity centres and customers from a trade area.
- where to build new activity centres, or how to manage existing activity centres.
- the optimal size of an activity centre according to its location – how far it is from the customer base and what type of customers they are likely to attract.
- Potential changes to the activity centre network under different development scenarios.

The key factors/datasets required to develop a robust retail gravity model include:

- Activity Centres - location, size, role, and distance of centres from residential and other markets.
- Population - location, size, forecast growth, and distance of the resident population base to a range of activity centres.
- Retail Spending - average retail spending profile, available retail spending capacity, by retail category of spending per population in each catchment/area.
- Potential development opportunities in the centres network.

The following data sets have been collected and collated to populate the retail gravity model.

- Forecast population by trade area by year.
- Forecast retail floorspace by centre by year.
- Forecast retail spending capacity available to be captured by the network by trade area by year.
- Travel distance between trade area and each centre.

3 CENTRES FRAMEWORK

Consumer dynamics vary significantly between different retail categories and is influenced by the frequency in which consumers require access to certain retail goods and services. Retailers, shopping centre developers, and urban planners acknowledge this variation in dynamics through the establishment of a clearly defined hierarchy of activity centres which reflect different shopping trips and expectations for consumers/residents.

Convenience

Convenience retail trips include visits to supermarkets, other food and grocery stores, newsagencies, and cafes/takeaway stores. These trips are typically daily or weekly trips and are generally made to activity centres closest to the resident/consumer. Activity centres serving this category are typically anchored by a supermarket, or small grocery store and classified as Neighbourhood and/or Local Centres.

Comparative

Comparative retail trips include visits to department stores, discount department stores, fashion, and household goods stores. These are typically less frequent trips than convenience-based trips and consumers are more likely to target specific items, brands, products, and prices on these trips. They are therefore more likely to travel further to access these goods and services. Centres serving this category are typically anchored by a Department Store or DDS and classified as Strategic, Secondary, or District Centres. These centres invariably also serve a convenience-based role.

Large Format/Bulky Goods

Homewares, furnishing, and recreation goods are more likely to reflect infrequent trips for targeted goods/purchases. Consumers are prepared to travel further for these goods and services. These centres are less likely to include a convenience-based role beyond access to cafes/takeaway facilities as part of the shopping experience.

Consumer Behaviour Philosophy

The fundamental retail consumer principles adopted by modelling techniques in this assessment is that:

- Residents are generally less likely to travel beyond the nearest Strategic Centre and or Secondary Centre to visit another centre with the same role/function/offer.
- Residents are generally less likely to travel beyond the nearest District Centre to visit another District Centre with the same role/function/offer.
- Residents are just as likely to travel beyond one supermarket-based neighbourhood centre to visit another supermarket-based centre with another operator (i.e., to shop at a Coles instead of a Woolworths or vice versa).
- Residents are less likely to travel beyond the nearest local centre to visit another local centre with the same role/function/offer (i.e., to drive past one IGA to shop at another IGA).

That is not to say that residents will not visit other centres, but that they will not visit these centres frequently enough to establish a pattern of behaviour.

3.1 Centres Network

The proposed centre is expected to operate within an activity centres framework which contains other retail-based activity centres. In this location, that framework includes a retail network which comprises existing, planned, and potential centres. The activity centres framework includes all centres in the adopted retail hierarchy, including:

FIGURE 2 – ACTIVITY CENTRE FRAMEWORK

Activity Centre Type	Number of Centres in Framework	Name of Centres in Framework	Relevant Planning Instrument
Strategic Centre	1	Midland Town Centre	SPP4.2 (2023) LCACS (City of Swan 2017)
Secondary Centre	1	Ellenbrook Regional Centre	SPP4.2 (2023) LCACS (City of Swan 2017)
District Centres	1	Kingsford Town Centre / Bullsbrook Central (Proposed)	SPP4.2 (2023) LCACS (City of Swan 2017)
Neighbourhood Centres	2	Bullsbrook South (proposed) Bullsbrook North (proposed)	LCACS (City of Swan 2017) Bullsbrook District Structure Plan
Local Centre *	0	None proposed	

SPP4.2 (2023) / City of Swan LCACS (2017)
** (More local centres may be added to the framework as Local Structure Planning for areas evolve).*

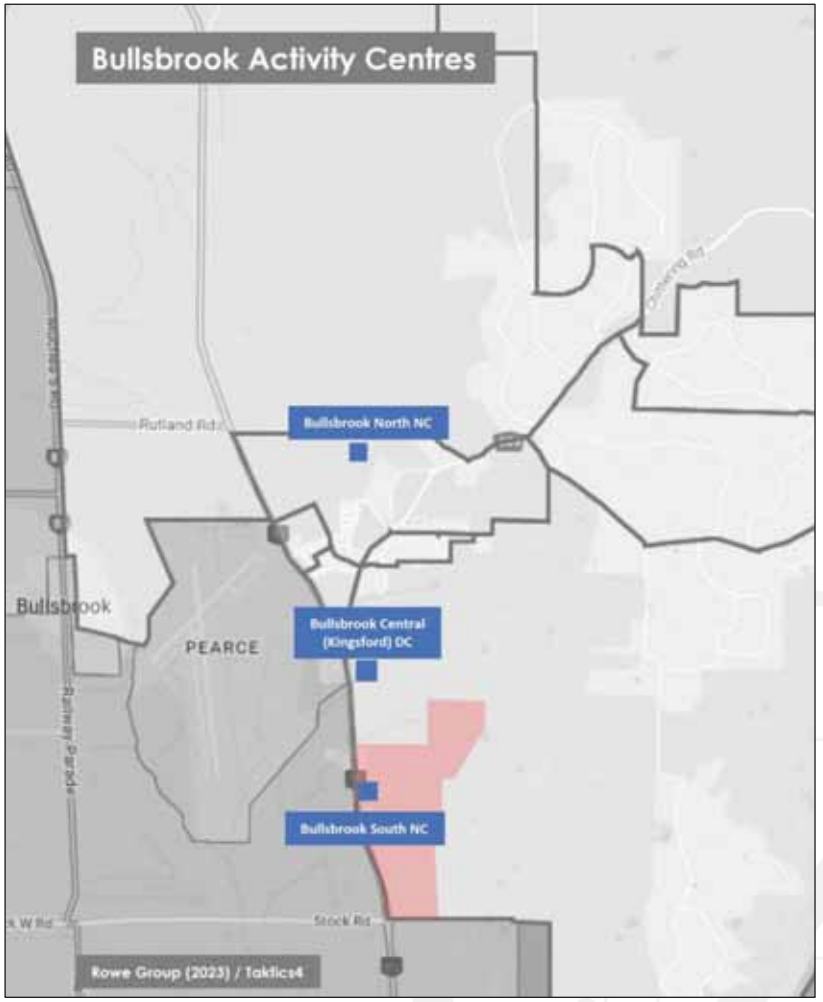
3.2 Strategic Metropolitan Centres

The nearest major centres outside the trade area are expected to influence the trading potential of centres within the trade area. These centres have been included in the modelling framework primarily because of their likely influence on current and forecast retail spending behaviour. They are likely to have less influence on consumers behaviour as similar centre types are developed within the trade area.

Midland Strategic Metropolitan Centre

- A designated Strategic Centre in SPP4.2 (2023) and the LCACS (2017).
- Located approximately 24 km south of the proposed centre.
- Currently contains:
  - three full line supermarkets (2 x Woolworths, 1 x Coles).
  - three limited line supermarkets (Supa IGA, Aldi, Spudshed).
- Estimated to contain up to 15,000 sqm NLA of supermarket floor space.
- Not expected to significantly increase its supermarket offer over the next 10 years.

FIGURE 3 - ACTIVITY CENTRE MAP



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3.3 Secondary/Regional Centres

Ellenbrook Regional Centre

- A designated Regional Centre in SPP4.2 (2023) and the LCACS (2017).
- Located approximately 19 km southwest of the proposed centre.
- Currently contains:
  - Two full line supermarkets (Woolworths, Coles)
  - One limited line supermarket (Aldi)
- Estimated to contain up to 8,500 sqm NLA of supermarket floor space.
- Not expected to significantly increase its food/grocery offer over the next 10 years.

3.4 District Centres

According to the LCACS (2017), District Centres have a greater focus on servicing the daily and weekly needs of residents. Their relatively smaller scale catchment enables them to have a greater local community focus and provide services, facilities and job opportunities that reflect the needs of their catchments. Examples of services and facilities provided in District Centres:

- Retail: Range of convenience-based retailing, with at least one large supermarket and a variety of convenience-based speciality retailing. Opportunities for Discount Department Stores and tourism focus retail also exists in some instances.
- Cultural, recreation and entertainment facilities: Including restaurants/cafes, small scale arts centres/galleries, local sporting facilities, gymnasiums, etc
- Health: Including medical centres and allied health services (i.e., dental, physiotherapy, podiatry, etc).
- Education: Including pre-school, primary and secondary schools and potentially adult training and education.
- Community facilities: Including libraries, child-care, community and youth centres, public halls, religious buildings, etc.
- Visitor facilities: Potential for tourism infrastructure may exist for those centres with a tourism focus.
- Residential: Including intensification of residential development. Recommended share of floorspace allocated to mixed uses in District Centres of 20,000-50,000 sqm, as identified in SPP 4.2, is 30%, and for centres of 10,000-20,000 sqm is 20%

Relevant LCACS (2017) Directions and Actions

4	*In the first instance, support the future development of district centres that serve a neighbourhood role at The Broadway (Ellenbrook), **Bullsbrook** and Brabham.*
5	*Retain the opportunity for the expansion of The Broadway (Ellenbrook), **Bullsbrook** and Brabham to district centres at a time when market demand warrants.*
6	*Seek to maximise exposure for the future **Bullsbrook district centre** to the Great Northern Highway and the 'activity corridor' identified in the Bullsbrook Masterplan that connects Chittering Road and the Great Northern Highway.*

Bullsbrook Central (Kingsford) District Centre

- A designated District Centre in SPP4.2 (2023) and the LCACS (2017).
- Located approximately 1.5 km north of the proposed centre.
- The Town Centre currently contains a small, limited line supermarket (IGA).
- Is proposed to contain a single full-line supermarket (Woolworths).

- Estimated to contain up to 3,500 sqm NLA of supermarket floor space.
- Is proposed to be developed by 2024.

3.5 Neighbourhood Centres

According to the LCACS (2017), Neighbourhood Centres have a more limited role in providing convenience retailing and community facilities for an immediate surrounding catchment. Usually, these centres are anchored by a supermarket. In some cases, these centres also serve a tourist market. Examples of services and facilities provided in Neighbourhood Centres:

- Retail: Limited range of convenience-based retailing, including a supermarket and a variety of convenience-based speciality retailing. Opportunities for tourism focus retail also exists in some instances.
- Health: May include medical centres and allied health services (i.e., dental, physiotherapy, podiatry, etc).
- Education: May include pre-school, primary and secondary schools.
- Community facilities: May include a library, child-care, community and youth centres, public halls, religious buildings, etc.
- Visitor facilities: May include tourism infrastructure in for those centres with a tourism focus. This may involve small scale visitor accommodation.

Relevant LCACS (2017) Directions and Actions

10	*Support the future development of neighbourhood centres at the following locations:* • *Millhouse Road,* • *Averley* • *Bennett Springs* • *Dayton,* • ***Bullsbrook North**,* • ***Bullsbrook South***

Bullsbrook North Centre

- A designated Neighbourhood Centre in the LCACS (2017).
- Located approximately 4 km north of the proposed centre.
- Not developed.
- No current timeline for development.
- Expected to contain at least one full line supermarket and possibly one limited line supermarket.
- Expected to increase its food/grocery offer in response to market demand.

Bullsbrook South Centre

- The subject centre.
- A designated Neighbourhood Centre in the LCACS (2017).
- Not currently developed / no current timeline for development.
- Expected to contain at least one full line supermarket and possibly one limited line supermarket.
- Expected to increase its food/grocery offer in response to market demand.

3.6 Local Centres

Bullsbrook IGA (Town Centre)

- An existing limited-line supermarket (IGA) is located across the Highway from the planned Kingsford Town Centre.
- Not currently expected to significantly increase its food/grocery offer over the next 10 years.
- The trading potential of the existing supermarket is likely to be significantly influenced by the imminent introduction of a full line supermarket nearby.

No other local centres are currently planned or proposed in the area. However, local centres may be proposed as further detailed structure planning of the area continues.

3.7 Implications

Based on analysis of existing, planned, and potential centres in the network, existing and future residents:

- Currently have access to 1,000 sqm NLA of limited line supermarket floor space.
- Must currently travel between 20-25 km to access 23,500 sqm NLA (96%) of full line supermarket floor space.
- Are expected to have access to 3,500 sqm NLA of supermarket (Woolworths) floor space by 2024.
- Will not have access to a second full line supermarket (Coles) or limited line supermarket (Aldi, Spudshed) until at least one neighbourhood centre is developed in Bullsbrook.
- Will continue to rely on Midland (25 km) and Ellenbrook (20 km) to satisfy their supermarket choices until at least one neighbourhood centre is developed in Bullsbrook.

4 CATCHMENT PROFILE

By its very nature and role, the proposed centre as a designated neighbourhood centre is designed to predominantly serve its immediate neighbourhood. The trade area for the proposed centre is therefore delineated by a smaller area than that defined by the relevant activity centres network listed in the previous section.

4.1 Trade Area Delineation

The location of planned urban growth areas together with the location of planned centres The and road networks, create a clearly delineated trade areas based on travel patterns and accessibility to centres. The trade areas for Bullsbrook may be delineated by:

- North - north of Chittering Road
- Central – between Chittering Road and the Kingsford Town Centre
- South – from the Town centre to the Stock Road
- East – rural residential estates on the Eastern Hills

East may be further divided by:

- East – North – of Chittering Road
- East – Central - immediately south of Chittering Road
- East – South – directly east of the southern trade area.

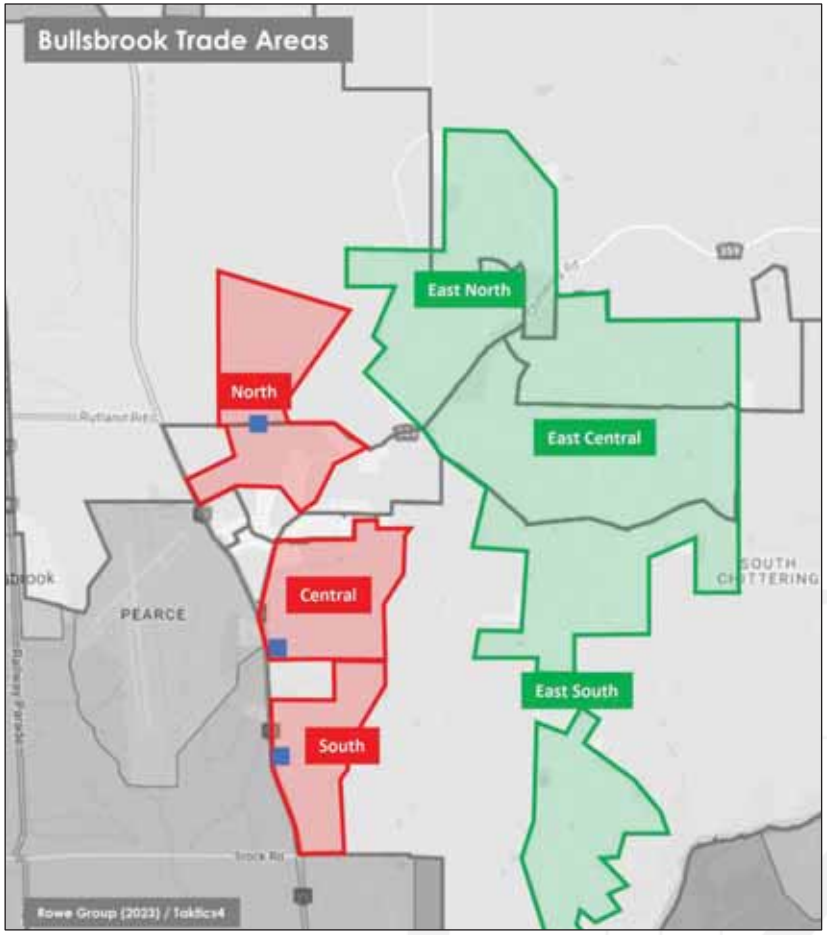
The map shows the anticipated trade areas in proximity to the centres they are intended to serve.

- The three proposed neighbourhood centres are evenly distributed and located to best serve the trade areas they correlate to.
- The northern Neighbourhood centre is ideally located 2 km north of the central district centre in the middle of the northern trade area.
- The southern neighbourhood centre is planned to be located on the intersection of Lage Road and Great northern Highway – 1.5 km south of the Central District centre.
- Each of the Neighbourhood Centres has an overlap with the trade area of the central trade area.

Residents in each of these trade areas/catchments are generally likely to exhibit different shopping patterns from residents in the other trade areas. However, the relatively self-contained satellite nature of Bullsbrook reduces the need for significant spatial separation between centres. All centres are likely to draw customers from the entire Bullsbrook urban area. Each will be expected to draw most of their sales from their immediate catchment. However, it will also be common for northern residents to travel to the southern centre and southern resident to travel to northern centre due to subjective or qualitative preferences.

This dynamic will likely be highlighted during the needs analysis modelling.

FIGURE 4 – TRADE AREAS



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4.2 Dwellings/Population

According to the 2021 Population and Household Census, the urban area in the vicinity of Bullsbrook comprised 4,600 residents in 2021, including 2,150 residents in the immediate township and 2,450 residents in the Eastern Hills area, approximately 3-5 km out of the township.

A significant amount of urban planning is still required to confirm the exact extent, nature, and distribution of residential development in Bullsbrook. However, planning investigations completed to date indicate:

- The potential for residential development north of Chittering Road capable of accommodating up to an additional 11,200 residents (4,000 dwellings).
- The potential for residential development in Central Bullsbrook capable of accommodating up to an additional 7,700 residents (2,750 dwellings)
- The potential for residential development south of the central Bullsbrook capable of accommodating up to an additional 2,500 residents (2,500 dwellings).
- The potential for existing residential areas to grow at an average conservative rate of 2% p.a.

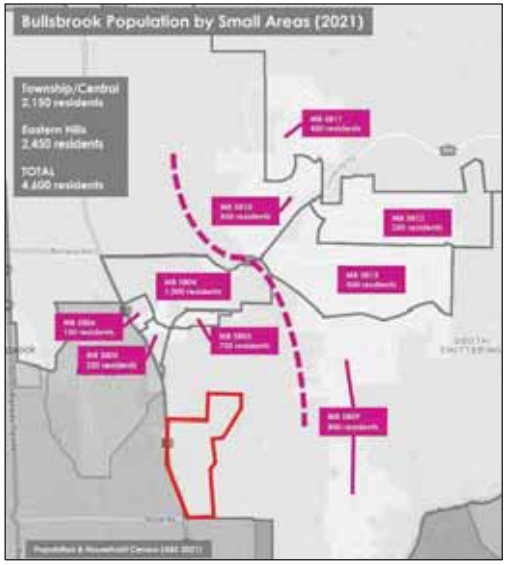
The resident population for Bullsbrook is forecast to grow from 6,300 residents in 2026, to 31,000 residents by 2046, an increase of 24,700 additional residents over 20 years at an average of 1,235 additional residents p.a. Population growth will be responsible for generating an additional $130.2 M p.a. in supermarket spending in the trade area between 2026 and 2046.

FIGURE - CURRENT & FORECAST POPULATION by TRADE AREA by YEAR

Catchment	2026	2031	2036	2041	2046	2026-2046
North	950	1,950	3,970	5,970	12,200	11,250
East North	940	960	980	990	1,000	60
Central	2,800	4,850	6,840	8,850	9,100	6,300
East Central	780	790	800	810	820	40
South	-	2,100	4,750	7,000	7,000	7,000
East South	830	850	860	880	880	50
Total Trade Area	**6,300**	**11,500**	**18,200**	**24,500**	**31,000**	**24,700**
Average growth per census		5,200	6,700	6,300	6,500	**6,175**
Average growth p.a.	-	1,040	1,340	1,260	1,300	**1,372**

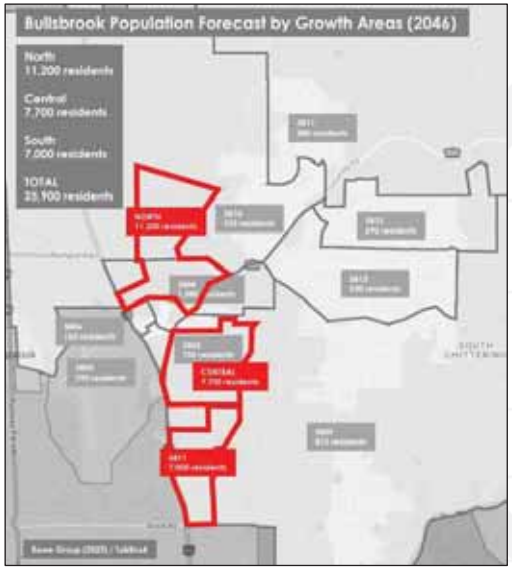
Population and Household Census (ABS 2021) / Rowe Group 2023

FIGURE 5 – RESIDENT POPULATION DISTRIBUTION (2021)



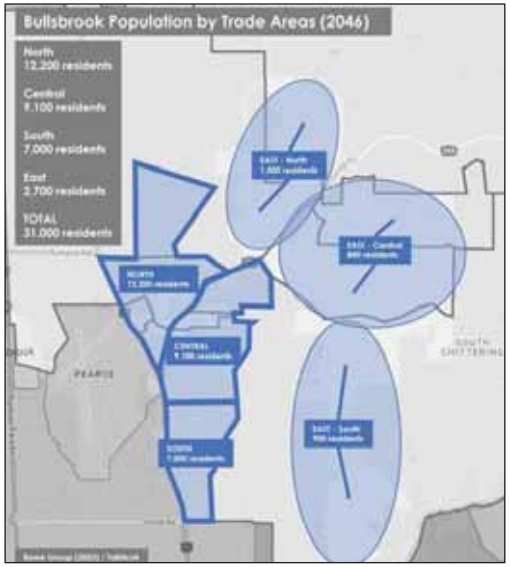
Population & Household Census (2021)

FIGURE 6 – FORECAST GROWTH AREAS / INDICATIVE ADDITIONAL POPULATION (2046)



Rowe Group (2023)

FIGURE 7 – FORECAST POPULATION by TRADE AREA (2046)



Rowe Group (2023)

4.3 Demographic Profile

The demographic characteristics of the resident population in the trade area will determine the retail spending profile and retail spending capacity available to retailers/centres in the trade areas. Key demographic characteristics include household composition, dwelling tenure, and income potential. Some areas in the catchment may not currently have sufficient population bases to extract valid current demographic profiles. The demographic profiles for these areas have been adopted from demographic profiles from similarly located areas with sufficient demographic profiles. Relevant socio-economic characteristics for residents in the trade area are highlighted below.

Person and Household Profile

The Bullsbrook Trade Area population is characterised by:

- An average age of 37.8 years which is 2% younger than Perth average age of 38.6 years.
- A slightly higher representation of residents aged 15-24 years (14%) than Perth (12%).
- A slightly lower representation of persons aged 35-44 years (12%) than Perth (14.5%).
- A higher representation of residents aged 50-64 years (21%) than Perth (18%).
- A higher representation of one family households (78% of households) than Perth (70%).
- An average household size of 2.8 persons per dwelling which 9% larger than Perth (2.6 persons).
- A higher representation of Australian born persons (81%) than Perth (66%).
- An established community with 64% of residents in 2021 at the same address as 2016 compared to Perth (58%).

Employment, Income, Economic Profile

The resident labour force in the Bullsbrook Trade Area is characterised by:

- An employment status generally consistent with Perth averages.
- A slightly higher representation of full-time workforce (43% of labour force) than Perth (39%).
- A higher representation of the labour force in Agriculture, Mining, Manufacturing and Construction sectors (35%) than Perth (24%).
- An average personal income 3% below the Perth average.
- An average of 2.3 incomes per dwelling which is 13% higher than Perth average.
- An average household income which is 2% below the Perth average.
- A higher representation of dwellings with mortgages (56% of dwellings) than Perth (42%).
- An average mortgage commitment which is 2% below Perth averages.
- An average rental commitment which is 5% below Perth averages.

Dwelling Profile

The Dwelling stock in the Bullsbrook Trade Area is characterised by:

- A higher representation of separate dwellings (99% of dwellings) than Perth (76%).
- A higher representation of four-bedroom dwellings (52%) than Perth (40%).
- An average of 3.6 bedrooms per dwelling which is 10% larger than Perth averages (3.3 bedrooms).

These profiles are used to calculate the average resident retail spending profile for residents in the designated trade areas.

4.4 Resident Retail Spending Profiles

Resident retail spending profiles for the trade area are derived by extrapolating data from a range of sources including:

- Household Expenditure Survey (ABS 2015) by socio economic characteristics
- Population and Household Census (ABS 2021) by socio economic characteristics
- Retail Sales (ABS 2023) by store categories

Correlation of data from these sources relative to the demographic profiles of an area produces an estimate of the average retail spending potential of residents within that area. Some of the trade areas may not currently have sufficient population bases to extract valid demographic profiles. Where trade areas do not have sufficient population base the retail spending profiles have been adopted from neighbouring/adjoining trade areas. Correlation of demographic profiles to retail spending profiles for residents in the trade area reveal that:

- Residents in the North and South Trade Areas are estimated to share similar demographics and therefore share an average potential supermarket retail spending profile of $5,194 per person p.a.
- Residents in Central Trade Area are estimated to have an average potential supermarket retail spending profile of $5,477 per person p.a.
- Residents in Eastern North and Eastern Central Trade Areas are estimated to have an average potential supermarket retail spending profile of $6,008 per person p.a.

- Residents in Eastern South Trade Area are estimated to have an average potential supermarket retail spending profile of $6,153 per person p.a.

FIGURE 8 - ESTIMATED AVERAGE RETAIL SPENDING PER CAPITA by RETAIL CATEGORY by TRADE AREA

Retail Store Category	Supermarket	Balance of Retail	Total Retail
North	$5,194	$11,689	$16,883
East North	$6,008	$13,924	$19,932
Central	$5,477	$12,466	$17,944
East Central	$6,008	$13,924	$19,932
South	$5,194	$11,689	$16,883
East South	$6,153	$14,964	$21,117
Perth Average	$5,560	$12,694	$18,255

Household Expenditure Survey (ABS 2015)
Population and Household Census (ABS 2021)
Retail Sales (ABS 2023)

4.5 Resident Retail Spending Capacity

The average potential resident retail spending profile for each area is multiplied by the forecast resident population in each area to determine the forecast resident retail spending capacity of each trade area over time.

Based on the average potential resident retail spending profiles for supermarkets, residents in the trade area are estimated to generate:

- $35.7 M p.a. in supermarkets in 2026.
- $63.3 M p.a. in supermarket-based centres by 2031.
- $98.7 M p.a. in supermarket-based centres by 2036.
- $132.1 M p.a. in supermarket-based centres by 2041.
- $165.9 M p.a. in supermarket-based centres by 2046.

That growth represents an additional $130.2 M p.a. in supermarket spending generated purely from planned population growth in the trade area between 2026 and 2046. Not all this retail spending can expect to be captured by centres in Bullsbrook.

FIGURE 9 - ESTIMATED ANNUAL RESIDENT RETAIL SPENDING CAPACITY ($M p.a.) by TRADE AREA by YEAR by RETAIL CATEGORY (Supermarket)

Year	2026	2031	2036	2041	2046
North	$4.9	$10.1	$20.6	$31.0	$63.4
East North	$5.6	$5.8	$5.9	$5.9	$6.0
Central	$15.3	$26.6	$37.5	$48.5	$49.8
East Central	$4.7	$4.7	$4.8	$4.9	$4.9
South	$0.0	$10.9	$24.7	$36.4	$36.4
East South	$5.1	$5.2	$5.3	$5.4	$5.4
Total Trade Area	**$35.7**	**$63.3**	**$98.7**	**$132.1**	**$165.9**

Taktics4 Retail Model (2023)

5 RETAIL NEEDS ASSESSMENT

The Retail Needs Assessment:

1. Guides future development as part of a Local Planning Strategy for an LGA.
2. Assesses the projected demand for all activity centre uses of communities in a Local Government Area.

5.1 Importance of Supermarkets

It is important to consider the role of Supermarkets when assessing demand for activity centres in an area. Supermarkets play a fundamental role in centre sustainability and therefore retail planning in the Australian urban retail environment. Food and grocery spending represents nearly 40% of all retail spending by Australian residents. Supermarkets capture an average of 83% of all food & grocery spending from residents. Non-supermarket-based convenience retailers, such as butchers, bakers etc., can only expect to capture up to 17% of this spending category. Most of this 17% of convenience-based retail spending available to specialty food & grocery retailers is captured by retailers adjacent to supermarkets. Non supermarket based local centres will not have access to the same amount of retail spending that centres with supermarkets will have access to. This commercial dynamic highlights the importance of supermarkets to the retail network, and subsequently to the retail planning sector, especially at the Neighbourhood and Local centre level of the hierarchy.

A specialty convenience-based retailer relies almost solely on the foot traffic generated by a supermarket in its centre to generate sufficient sales to be sustainable. Logic therefore suggests that any assessment of neighbourhood retail network should focus on the extent to which supermarket demand may be met, and the impacts of a supermarket in the network influencing sales at another supermarket, to determine the sustainability of the network. This assessment focuses on the future supermarket-based demand in the trade area to determine the sustainability of the centres network in the trade area.

5.1 Covid Impacts

Consumer Retail spending as percentage of total retail spending has remained relatively consistent over the past 40 years. The graph shows that there have been only two major event-based disruptions to the relative constant distribution of retail spending since 1982. The first was the introduction of GST in 2000. And the second and most disruptive was the Covid pandemic between 2020-2021. The prolonged disruption to customers and retailers and created significant change in shopping/spending behaviour. However, as was the case with GST, retail spending behaviour has predominantly returned to pre covid patterns.

However, the return to pre covid patterns has been slow and there is still not sufficient post covid data to utilise in the model. This use of skewed retail spending/sales data, which influences the spending profiles in the modelling will render the findings unreliable. Until such time that the data has a full year of 'normalised' spending/sales patterns post covid the model uses pre-pandemic spending patterns – inflated to current figures.

FIGURE 10 – RETAIL SALES DISTRIBUTION BY RETAIL CATEGORY



Retail Sales (ABS 1982-2022)

5.2 Supermarket Demand

Overall, the commercial demand drivers for the supermarket sector are represented by the following characteristics.

- An average urban residential environment with typical urban densities generally produces a resident population of around 8,000 residents, depending on the extent of non-residential land uses and infrastructure.
- On average a resident in urban Australia has access to a full line supermarket within 1.5 km of their residence.
- An Australian average spend of $5,000 per person p.a. on supermarkets creates an average supermarket spending capacity of $40 M p.a. for an average urban population of 8,000 residents within a 1.5 km radius.
- An average full line supermarket has a Net Lettable Area of 3,500 sqm.
- An average full line supermarket achieves sales of $35M p.a. at an average sales productivity of $10,000 / sqm p.a.
- A sales productivity of $10,000/sqm p.a. is a sustainable level of performance for a supermarket operator.
- It is not uncommon for a supermarket to be developed before a population base of 8,000 residents is reached.

Based on these industry variables, the forecast Bullsbrook population is expected to generate demand for a single supermarket in 2026 and up to the equivalent of four full line supermarkets by 2046.

The areas with the highest demand for supermarkets include:

- Northern trade area, sustainable from about 2041, based on the forecast population growth.
- Central trade area, which is planned to introduce a full line supermarket by 2024 based on the forecast population growth.
- Southern trade area, which will be sustainable from between 2036-2041 based on the forecast population growth.

FIGURE 11 – INDICATIVE SUPERMARKET DEMAND BY TRADE AREA BY YEAR

Catchment	2026	2031	2036	2041	2046
North	0.1	0.2	0.5	0.7	1.5
East North	0.1	0.1	0.1	0.1	0.1
Central	0.4	0.6	0.9	1.1	1.1
East Central	0.1	0.1	0.1	0.1	0.1
South	-	0.3	0.6	0.9	0.9
East South	0.1	0.1	0.1	0.1	0.1
Total Trade Area	**0.8**	**1.4**	**2.3**	**3.1**	**3.9**

Taktics4

5.3 Supermarket Development Models

Supermarkets are not typically able to develop to a random range of floor space demand or criteria or threshold. Each operator has their own specific floor layout/design concept. Whilst these may vary over time, or to specific/unique circumstances, the floor space size and configuration remains relatively consistent. There are two main supermarket types in Australia.

Full line supermarkets

- Coles and Woolworths are both full line supermarkets.
- These supermarkets comprise a full range of food/grocery products for consumers
- Typically have a development foot print of 3,500 sqm NLA.
- These supermarkets typically anchor between 10-15 shops (1,500 sqm NLA)
- Creating a total retail floor space of around 5,000 sqm NLA.

Limited line supermarkets

- IGA, Aldi, Spudshed, and Farmer Jacks are all considered limited line supermarkets
- These supermarkets comprise less products and less range of food/grocery products
- These stores typically have a development foot print of between 1,000 sqm and 2,000 sqm NLA
- These supermarket types typically anchor between 5-10 shops (1,000 sqm NLA)
- Creating a total retail floor space of 2,000 – 3,000 sqm NLA

Supermarkets and Neighbourhood Centres are typically developed in a single stage.

5.4 Retail Modelling

The retail model is designed to assess the likely propensity for a resident in a particular area to visit/spend at each centre in the network. Based on the proximity of the resident to each centre, the role and function of each centre, the size of the retail offer at each centre, relative to other centres. The sales potential for the proposed centre will be based on the extent to which it may capture retail sales from each trade area.

Based on the analysis of the centres network, population, and supermarket demand in previous sections, the following supermarket floor space has been modelled.

FIGURE 12 – MODELLED ACTIVITY CENTRE (SUPERMARKET) FLOOR SPACE (SQM NLA) BY YEAR

	Estimated NLA Floorspace (sqm)				
Centre Name	**2026**	**2031**	**2036**	**2041**	**2046**
Bullsbrook IGA	1,000	1,000	1,000	1,000	1,000
Kingsford Town Centre	3,500	3,500	3,500	3,500	3,500
Bullsbrook North NC	-	-	3,500	5,000	5,000
Bullsbrook South NC	-	3,500	3,500	3,500	3,500
Total Bullsbrook	**4,500**	**8,000**	**11,500**	**13,000**	**13,000**
Midland Town Centre	15,000	15,000	15,000	15,000	15,000
Ellenbrook	8,500	8,500	8,500	8,500	8,500
Total Other Major Centres	**23,500**	**23,500**	**23,500**	**23,500**	**23,500**
Total Existing and Planned Centres	**28,000**	**31,500**	**35,000**	**36,500**	**36,500**

Taktics4

The model findings reveal:

5.5 Bullsbrook South Neighbourhood Centre

If developed by 2031, a Neighbourhood Centre in Bullsbrook South could expect to:

- capture 36% of total trade area supermarket spending, including 79% of southern trade area spending.
- generate $24.1 M p.a. at an average sales productivity of $6,900/sqm p.a.
- derive 37% of its total sales from the southern trade area.

By 2036, a Neighbourhood Centre in Bullsbrook South could expect to:

- capture 31% of total trade area supermarket spending, including 77% of southern trade area spending.
- generate $31.9 M p.a. at an average sales productivity of $9,100/sqm p.a.
- derive 62% of its total sales from the southern trade area.

By 2041, a Neighbourhood Centre in Bullsbrook South could expect to:

- capture 31% of total trade area supermarket spending, including 77% of southern trade area spending.
- generate $43.3 M p.a. at an average sales productivity of $12,400/sqm p.a.
- derive 68% of its total sales from the southern trade area.

5.6 Bullsbrook Central District Centre

When developed by 2026, a supermarket-based District Centre in Bullsbrook Central could expect to:

- capture 68% of total trade area supermarket spending, including 86% of central trade area spending.
- generate $24.4 M p.a. at an average sales productivity of $7,000/sqm p.a.
- derive 54% of its total sales from the central trade area.

By 2031, a supermarket-based District Centre in Bullsbrook Central could expect to:

- capture 50% of total trade area supermarket spending, including 76% of central trade area spending.
- generate $31.5 M p.a. at an average sales productivity of $9,000/sqm p.a.
- derive 64% of its total sales from the central trade area.

By 2036, a supermarket-based District Centre in Bullsbrook Central could expect to:

- capture 36% of total trade area supermarket spending, including 71% of central trade area spending.
- generate $35 M p.a. at an average sales productivity of $10,000/sqm p.a.
- derive 75% of its total sales from the central trade area.

By 2041, a supermarket-based District Centre in Bullsbrook Central could expect to:

- capture 35% of total trade area supermarket spending, including 71% of central trade area spending.
- generate $45.7 M p.a. at an average sales productivity of $13,100/sqm p.a.
- derive 75% of its total sales from the central trade area.

5.7 Bullsbrook North Neighbourhood Centre

If developed by 2036, a single supermarket-based Neighbourhood Centre in Bullsbrook North could expect to:

- capture 26% of total trade area supermarket spending, including 84% of northern trade area spending.
- generate $25.2 M p.a. at an average sales productivity of $7,200/sqm p.a.
- derive 68% of its total sales from the northern trade area.

By 2041, a single supermarket-based Neighbourhood Centre in Bullsbrook North could expect to:

- capture 27% of total trade area supermarket spending, including 84% of northern trade area spending.
- generate $35 M p.a. at an average sales productivity of $10,000/sqm p.a.
- derive 74% of its total sales from the northern trade area.

5.8 Escape Expenditure

Some of the resident retail spending generated by residents in the trade areas will inevitably escape or be captured by supermarkets at centres outside the catchment, either as a designated supermarket shopping trip or as part of an unrelated trip. The amount of escape expenditure varies according to the retail category. The relatively self-contained nature of supermarket shopping means there is likely to be less escape expenditure in this convenience-based supermarket retail category than the more comparative retail spending which is less frequent and typically involves more targeted access based on product type, quality, and price.

- The model estimates that supermarkets outside the Bullsbrook Town Centre currently capture 47% of total supermarket spending generated by Bullsbrook residents.
- By 2026, when Bullsbrook Central District Centre has been developed, the amount of supermarket-based spending escaping to centres outside the trade area is estimated to decrease to 22%.
- By 2031, when a further supermarket is developed in Bullsbrook South the amount of supermarket-based spending escaping to centres outside the trade area is estimated to decrease to 7%.
- By 2036, when a further supermarket is developed in Bullsbrook North the amount of supermarket-based spending escaping to centres outside the trade area is estimated to decrease to 3%.

5.9 Implications

Modelling of the planned Bullsbrook activity centres network reveals:

- That the Bullsbrook trade area can comfortably sustain three supermarket-based centres.
- That each of the three centres can be sustained by predominantly capturing spending from their immediate catchments, whilst also capturing additional sales from other trade areas.
- A single full line supermarket-based District Centre at Bullsbrook Central is planned to be developed by 2026.
- A single full line supermarket-based Neighbourhood Centre at Bullsbrook South may be sustained by 2031.
- A single full line supermarket-based Neighbourhood Centre at Bullsbrook North may be sustained by 2036.
- An opportunity may exist for a fourth limited line supermarket to be included in the network in the future.

Based on the findings in this Retail Needs Assessment, the development of the planned neighbourhood centre in Bullsbrook South adheres to the policy objectives, principles, and centres framework/hierarchy for SPP 4.2 (2023) and the City of Swan LCACS (2017).

5.10 Bullsbrook South - Configuration

A proposed neighbourhood centre at Bullsbrook South could sustain a 3,5000 sqm NLA supermarket and up to 10-15 shops (1,500 sqm NLA), creating a total retail floor space of 5,000 sqm NLA. A single supermarket-based neighbourhood centre is typically capable of also supporting a range of non-retail activities including:

- Medical facilities
- Service station / petrol filling station
- Childcare centre
- Fast food outlets

These activities can usually be physically accommodated within a 2 Ha (20,000 sqm) land area.



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Attachment 7

Acoustic Assessment

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HERRING STORER ACOUSTICS

ROWE GROUP

RESIDENTIAL DEVELOPMENT
BULLSBROOK SOUTH LOCAL STRUCTURE PLAN
GREAT NORTHERN HIGHWAY

SPP 5.4 NOISE MANAGEMENT PLAN

SEPTEMBER 2025

OUR REFERENCE: 35231-2-25307

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SPP 5.4 NOISE MANAGEMENT PLAN
BULLSBROOK SOUTH LOCAL STRUCTURE PLAN
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FOR

ROWE GROUP

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APPENDICES

A	Site Layout
B	Calculated Noise Levels and Required R_w and C_{tr} Ratings
C	Quiet House Design Requirements
D	MRWA Traffic Flows

1. INTRODUCTION

Herring Storer Acoustics were commissioned by Rowe Group to carry out an acoustic study with regards to traffic related noise for the proposed "Bullsbrook South" local structure plan located to the east of Great Northern Highway and north of Stock Road.

The purpose of the study was to:

- Assess the noise that would be received within the development area from vehicles travelling on Great Northern Highway for future traffic volumes.
- Compare the results with accepted criteria and if exceedances exist, develop the framework for the management of noise.

A plan is attached in Appendix A.

Note; whilst RAAF Airbase Pearce is within the proximity of the development. The Year 2012 ANEF contours (*RI 24 06 2003 ISS 3*) indicate that the lots fall outside of the 20 ANEF contour, hence noise from aircraft has not been taken into consideration for the development.

2. ACOUSTIC CRITERIA

2.1 NOISE

The Western Australian Planning Commission (WAPC) released on 6th September 2019 State Planning Policy 5.4 *"Road and Rail Noise".* The requirements of State Planning Policy 5.4 are outlined below.

POLICY APPLICATION (Section 4)

When and where it applies (Section 4.1)

SPP 5.4 applies to the preparation and assessment of planning instruments, including region and local planning schemes; planning strategies, structure plans; subdivision and development proposals in Western Australia, where there is proposed:

*a) noise-sensitive land-use within the policy's trigger distance of a transport corridor as specified in **Table 1**;*

*b) New or major upgrades of roads as specified in **Table 1** and maps **(Schedule 1,2 and 3);** or*

*c) New railways or major upgrades of railways as specified in maps (**Schedule 1, 2 and 3);** or any other works that increase capacity for rail vehicle storage or movement and will result in an increased level of noise.*

Policy trigger distances (Section 4.1.2)

***Table 1** identifies the State's transport corridors and the trigger distances to which the policy applies.*

*The designation of land within the trigger distances outlined in **Table 1** should not be interpreted to imply that land is affected by noise and/or that areas outside the trigger distances are un-affected by noise.*

*Where any part of the lot is within the specified trigger distance, an assessment against the policy is required to determine the likely level of transport noise and management/ mitigation required. An initial screening assessment (**guidelines: Table 2: noise exposure forecast**) will determine if the lot is affected and to what extent."*

TABLE 1: TRANSPORT CORRIDOR CLASSIFICATION AND TRIGGER DISTANCES

Transport corridor classification	*Trigger distance*	*Distance measured from*
Roads		
Strategic freight and major traffic routes *Roads as defined by Perth and Peel Planning Frameworks and/or roads with either 500 or more Class 7 to 12 Austroads vehicles per day, and/or 50,000 per day traffic volume*	*300 metres*	*Road carriageway edge*
Other significant freight/traffic routes *These are generally any State administered road and/or local government road identified as being a future State administered road (red road) and other roads that meet the criteria of either >=23,000 daily traffic count (averaged equivalent to 25,000 vehicles passenger car units under region schemes)*	*200 metres*	*Road carriageway edge*
Passenger railways		
	100 metres	*Centreline of the closest track*
Freight railways		
	200 metres	*Centreline of the closest track*

Proponents are advised to consult with the decision making authority as site specific conditions (significant differences in ground levels, extreme noise levels) may influence the noise mitigation measures required, that may extend beyond the trigger distance.

POLICY MEASURES (Section 6)

The policy applies a performance-based approach to the management and mitigation of transport noise. The policy measures and resultant noise mitigation will be influenced by the function of the transport corridor and the type and intensity of the land-use proposed. Where there is risk of future land-use conflict in close proximity to strategic freight routes, a precautionary approach should be applied. Planning should also consider other broader planning policies. This is to ensure a balanced approach takes into consideration reasonable and practical considerations.

Noise Targets (Section 6.1)

***Table 2** sets out noise targets that are to be achieved by proposals under which the policy applies. Where exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.*

In the application of the noise targets the objective is to achieve:

- *indoor noise levels as specified in **Table 2** in noise sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*
- *a reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and child care centres the design of outdoor areas should take into consideration the noise target.*

It is recognised that in some instances, it may not be reasonable and/or practicable to meet the outdoor noise targets. Where transport noise is above the noise targets, measures are expected to be implemented that balance reasonable and practicable considerations with the need to achieve acceptable noise protection outcomes.

TABLE 2: NOISE TARGETS

Proposals	*New/Upgrade*	*Noise Targets*		
		Outdoor		*Indoor*
		Day (L_{Aeq}(Day) dB) (6 am-10 pm)	*Night (L_{Aeq}(Night)dB) (10 pm-6 am)*	*(L_{Aeq} dB)*
Noise-sensitive land-use and/or development	*New noise sensitive land use and/or development within the trigger distance of an existing/proposed transport corridor*	*55*	*50*	*L_{Aeq} (Day) 40(Living and work areas) L_{Aeq} (Night) 35 (bedrooms)*
Roads	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*
Railways	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*

Notes:

- *The noise target is to be measured at one metre from the most exposed, habitable façade of the proposed building, which has the greatest exposure to the noise-source. A habitable room has the same meaning as defined in State Planning Policy 3.1 Residential Design Codes.*
- *For all noise-sensitive land-use and/or development, indoor noise targets for other room usages may be reasonably drawn from Table 1 of Australian Standard/New Zealand Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors (as amended) for each relevant time period.*
- *The 5dB difference in the criteria between new and upgrade infrastructure proposals acknowledges the challenges in achieving noise level reduction where existing infrastructure is surrounded by existing noise-sensitive development.*
- *Outdoor targets are to be met at all outdoor areas as far as is reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines. For example, it is likely unreasonable for a transport infrastructure provider to achieve the outdoor targets at more than 1 or 2 floors of an adjacent development with direct line of sight to the traffic.*

Noise Exposure Forecast (Section 6.2)

*When it is determined that SPP 5.4 applies to a planning proposal as outlined in Section 4, proponents and/or decision makers are required to undertake a preliminary assessment using **Table 2**: noise exposure forecast in the guidelines. This will provide an estimate of the potential noise impacts on noise-sensitive land-use and/ or development within the trigger distance of a specified transport corridor. The outcomes of the initial assessment will determine whether:*

- *no further measures is required;*
- *noise-sensitive land-use and/or development is acceptable subject to deemed-to-comply mitigation measures; or*
- *noise-sensitive land-use and/or development is not recommended. Any noise-sensitive land-use and/ or development is subject to mitigation measures outlined in a noise management plan."*

3. MEASUREMENTS

This noise logging was conducted from 9 October 2024 to 16 October 2024 with an NSRT noise logger located as shown in Figure 3.1 below.



FIGURE 3.1 – NOISE LOGGER LOCATION

The automatic noise data logger records sound pressure levels in accordance with Australian Standard 2702-1984: *Acoustics - Method for Measurement of Road Traffic Noise.* The logger used records statistical noise level data, of which the L_{A10}, L_{Aeq} and L_{A90} levels are reported. These are defined below:

L_{A10} The noise level exceeded for 10% of the time (in this instance, the noise level exceeded for 6 minutes in each 1-hour period).

L_{Aeq} The energy equivalent noise level for the 1-hour period. A single number value that expresses the time-varying sound level for the 1-hour period as though it were a constant sound level with the same total sound energy as the time-varying level.

L_{A90} The noise level exceeded for 90% of the time (in this instance, the noise level exceeded for 54 minutes in each 1-hour period).

The results of the noise logging are summarised in Table 3.1.

TABLE 3.1 - SUMMARY OF MEASURED NOISE LEVELS

Measurement Location	Measured/Calculated Noise Level, dB(A)		
	L_{A10}	$L_{Aeq,\ day\ (6am\ to\ 10pm)}$	$L_{Aeq,\ night\ (10pm\ to\ 6am)}$
Great Northern Highway	70.8	69.5	64.1

4. MODELLING

To determine the noise levels from traffic on Great Northern Highway, acoustic modelling was carried out using SoundPlan, using the Calculation of Road Traffic Noise (CoRTN)[1] algorithms.

The input data for the model included:

- Plans supplied by client (Shown in Appendix A).
- Traffic data as per Table 4.1 (And Sourced in Appendix C from MRWA – provided by Suk Ling Chang, Ref: #43468).
- Adjustments as listed in Table 4.2.

TABLE 4.1 - NOISE MODELLING INPUT DATA

Parameter	Great Northern Highway 2021 MRWA	Great Northern Highway 2041 MRWA	Great Northern Highway 2046 MRWA
Traffic Volumes	8,400 vpd	26,000 vpd	29,900 vpd
Percentage traffic 0600 – 2400 hours (Assumed)	94%	94%	94%
Heavy Vehicles (%) (Assumed)	26%	13%	13%
Speed (km/hr)	80/100 km/hr	80 km/hr	80 km/hr
Road Surface	14mm Chip Seal	14mm Chip Seal // Dense Graded Asphalt	14mm Chip Seal // Dense Graded Asphalt

TABLE 4.2 – ADJUSTMENTS FOR NOISE MODELLING

Description	Value
Façade Reflection Adjustment	+2.5 dB
Conversion from $L_{A10\ (18\ hour)}$ to $L_{Aeq\ (16\ hour)}$ (Day)	-1.3 dB*

* Based on measured results listed in Table 3.1.

Four scenarios have been modelled;

- 1- 2046 Future noise, No noise barrier, no road surface upgrade.
- 2- 2046 Future noise, 1800mm barrier, no road surface upgrade.
- 3 - 2046 Future noise, No noise barrier, surface upgraded to dense graded asphalt.
- 4 - 2046 Future noise, 1800mm barrier, surface upgraded to dense graded asphalt.

1 *Calculation of Road Traffic Noise* UK Department of Transport 1987

5. TRAFFIC NOISE ASSESSMENT

Using the data contained in Tables 4.1 and 4.2, noise modelling was conducted for the future planning window with areas requiring "Quiet House Design", have been indicated in Appendix C.

Additionally, Appendix A contains a site plan and Appendix B shows future day time noise contour for reference, noting that once built form is complete, exposure levels may change.

It is noted that all requirements pertain to only acoustic advice in regard to *State Planning Policy 5.4* and may be superseded by other requirements (BAL, Thermal, etc).

6. CONCLUSION

In accordance with the WAPC Planning Policy 5.4, an assessment of the noise that would be received within the development of Bullsbrook South, Great Northern Highway from vehicles travelling on Great Northern Highway has been undertaken.

In accordance with the Policy, the following would be the acoustic criteria applicable to this project:

External

Day	55 dB(A) L_{Aeq}
Night	50 dB(A) L_{Aeq}

Internal

Sleeping Areas	35 dB(A) $L_{Aeq(night)}$
Living Areas	40 dB(A) $L_{Aeq(day)}$

The results of the acoustic assessment indicate that noise received at the development from future traffic does exceed external noise level criteria. Therefore, "Quiet House Design" Packages as indicated in Appendix C (or equivalent provided by an Acoustic Consultant), would be required for any new dwelling.

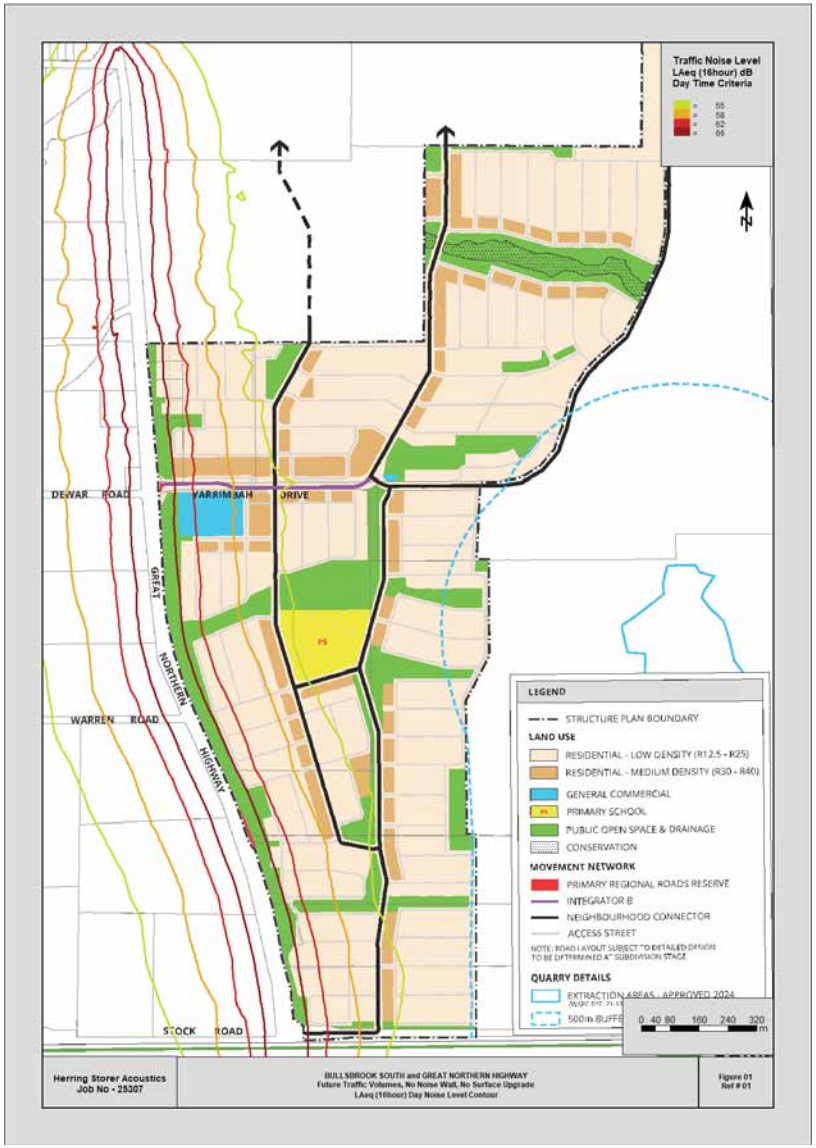
APPENDIX A

Site Layout

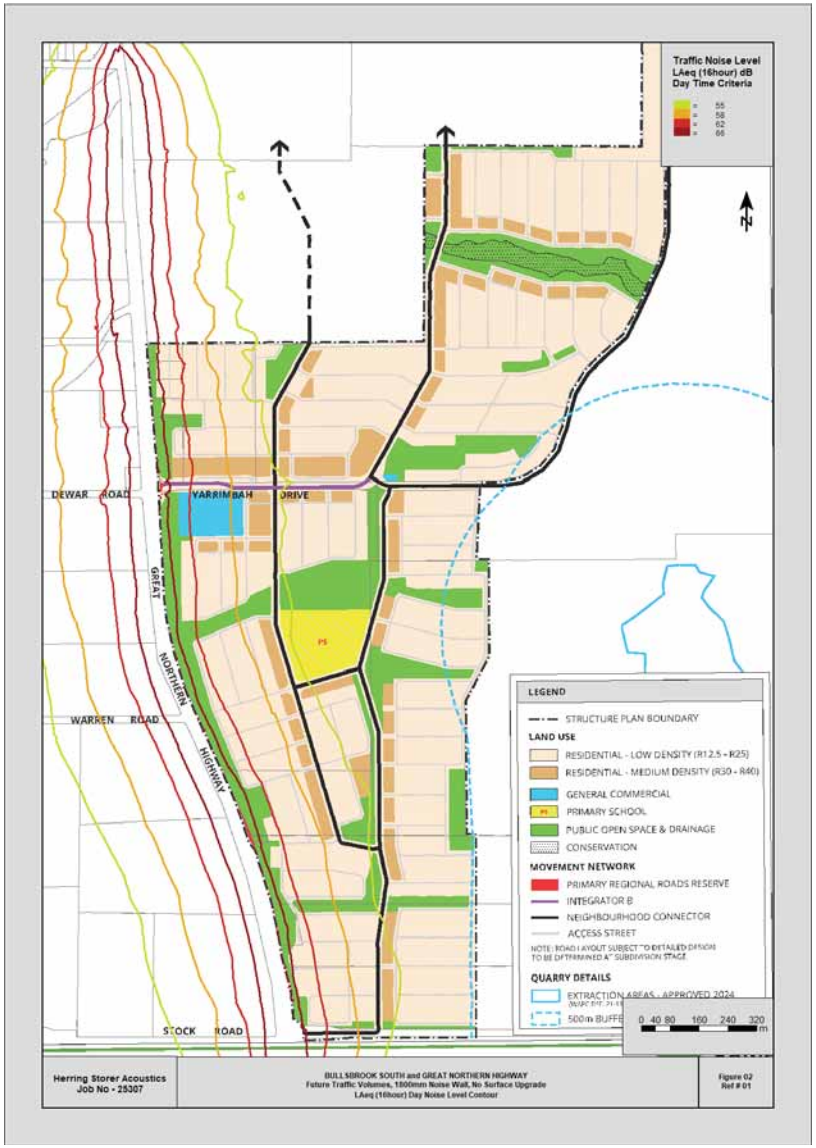


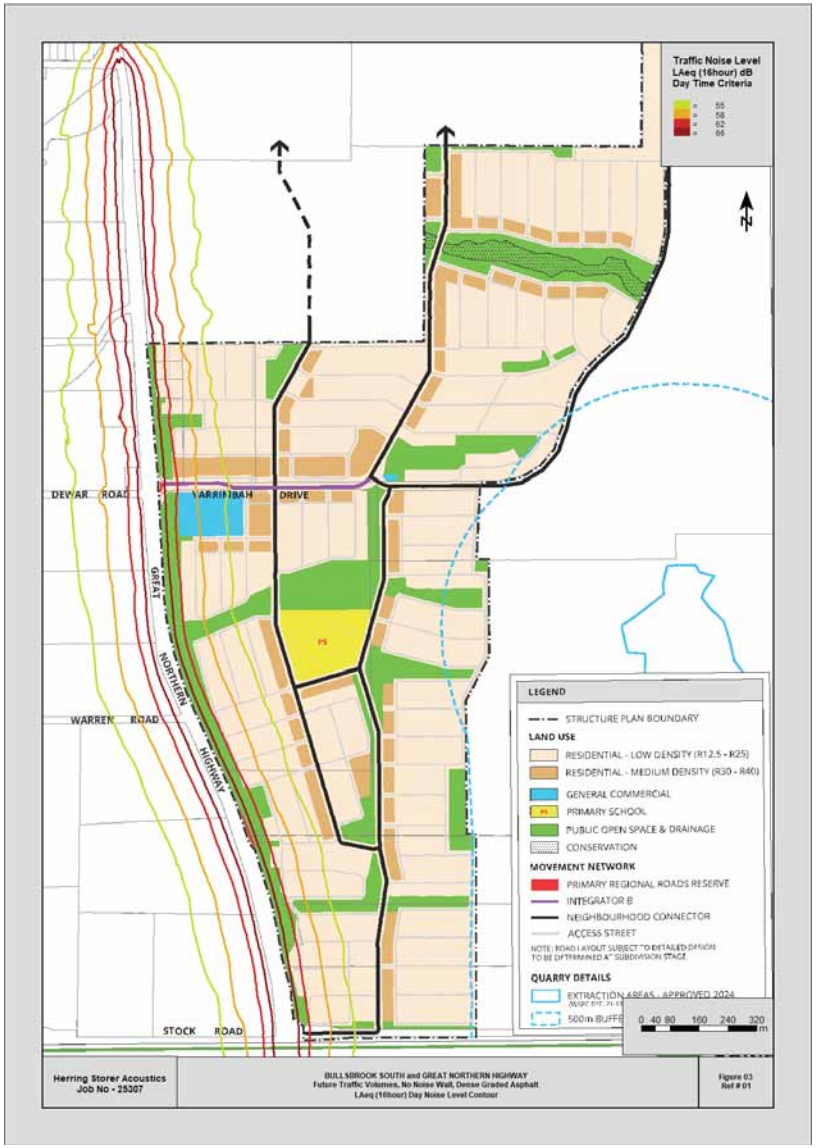
APPENDIX B

Future Day Time Noise Contours



Herring Storer Acoustics
Our ref: 35231-2-25307
APPENDIX B





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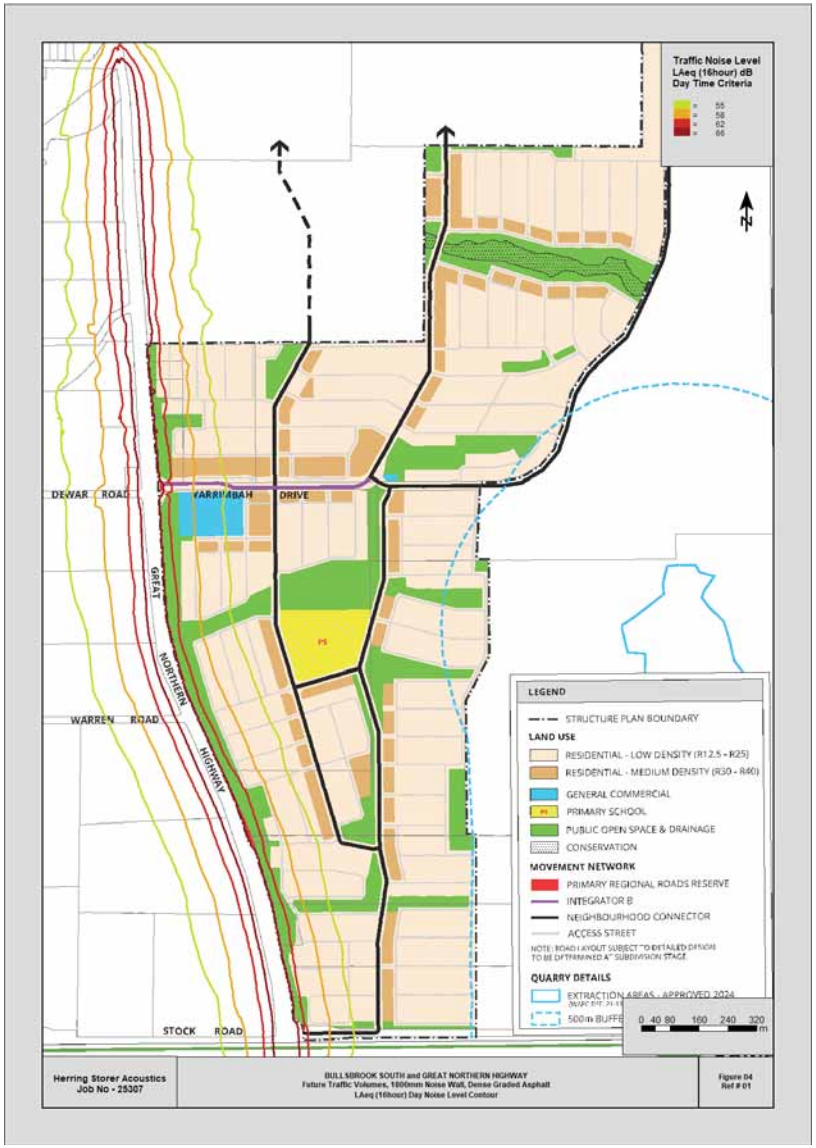
Our ref: 35231-2-25307
APPENDIX B



APPENDIX C

QHD Requirements

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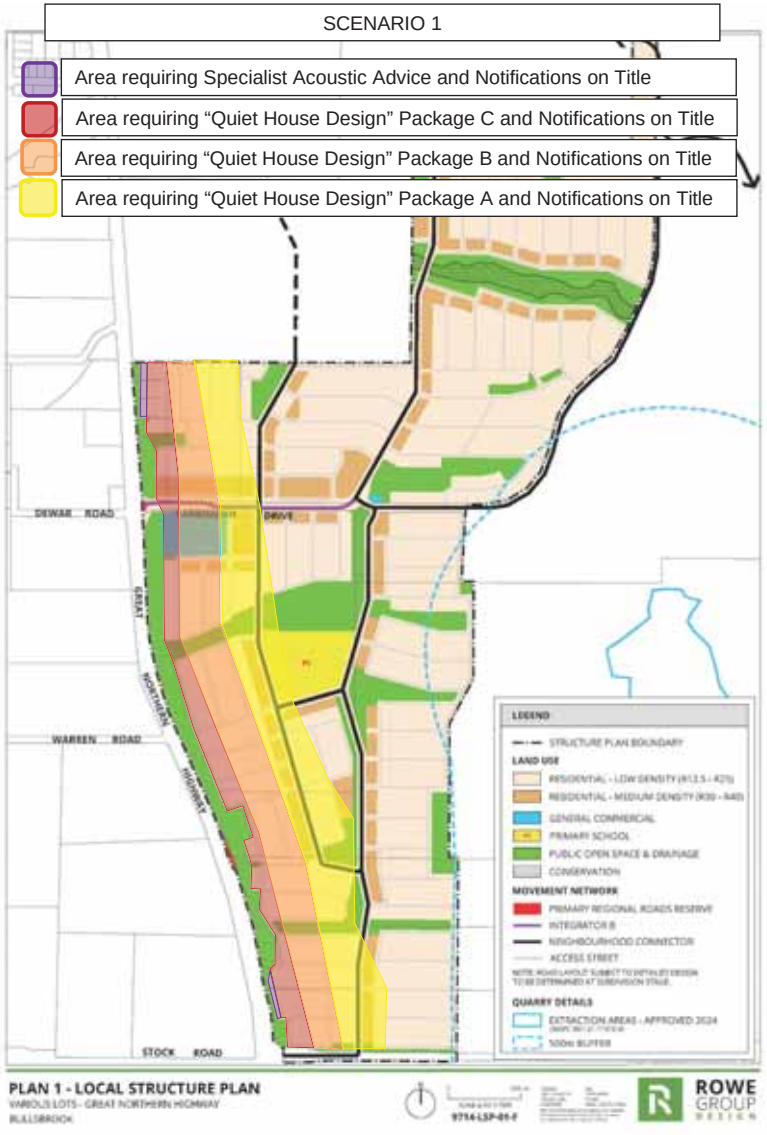
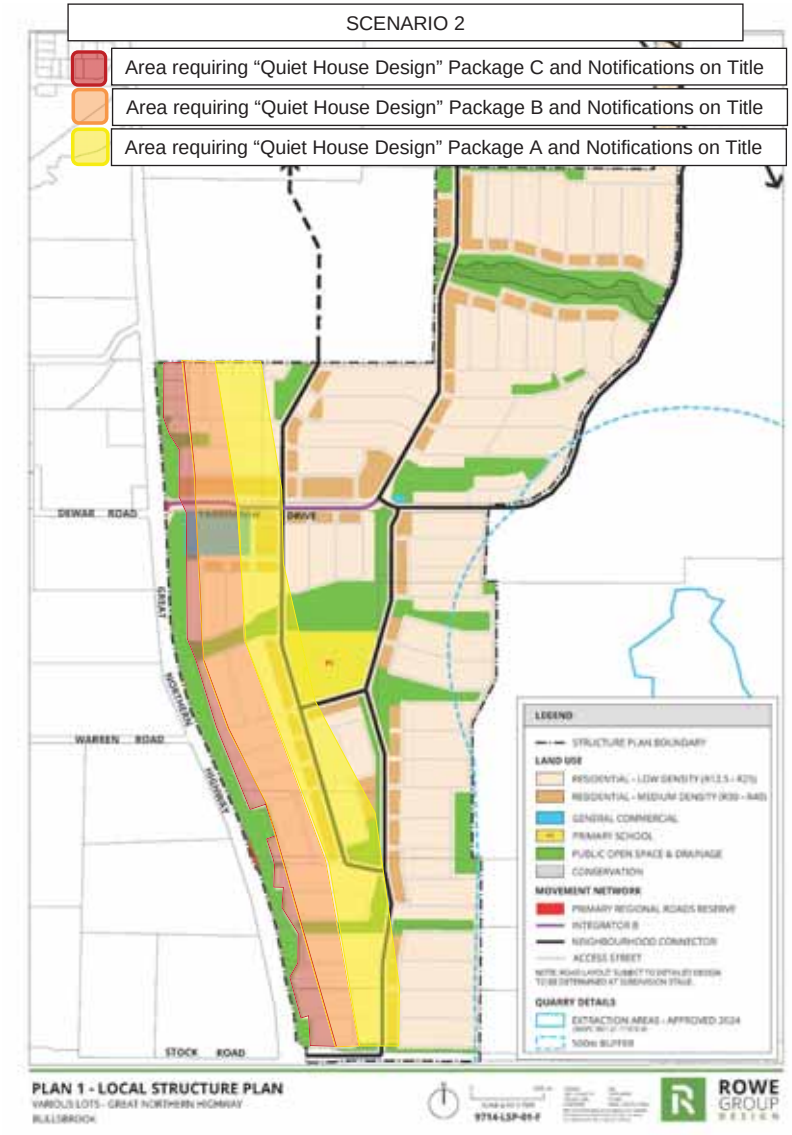
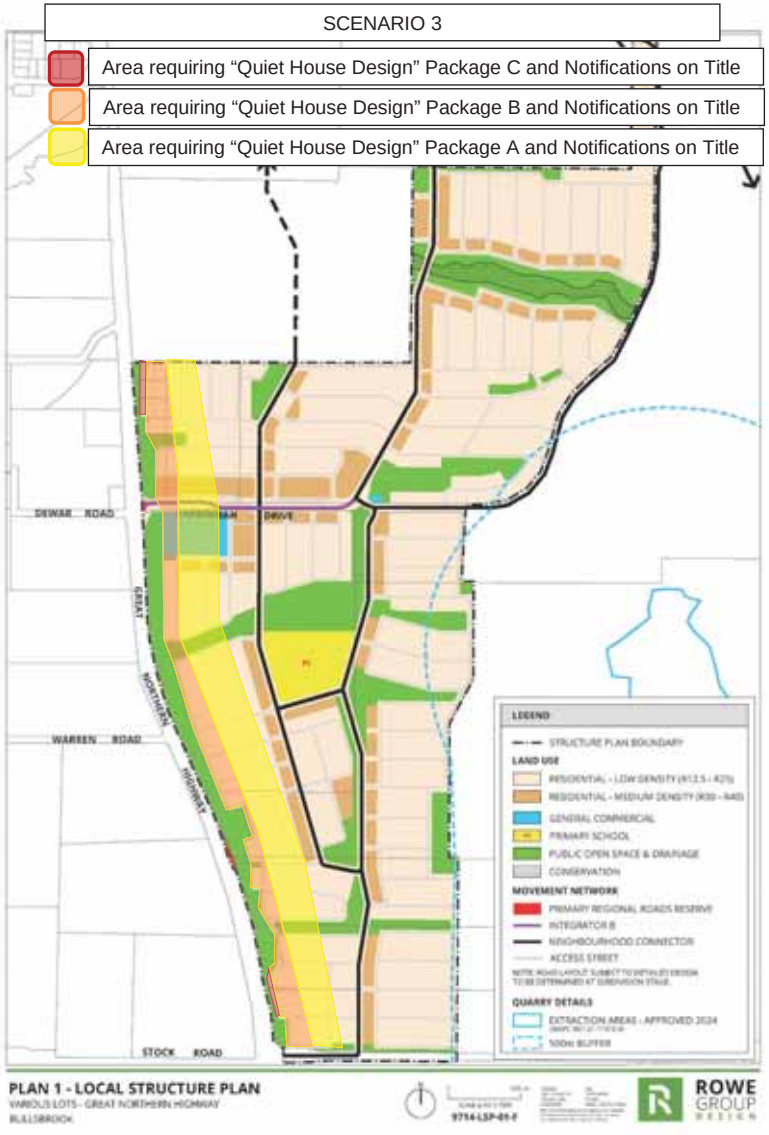
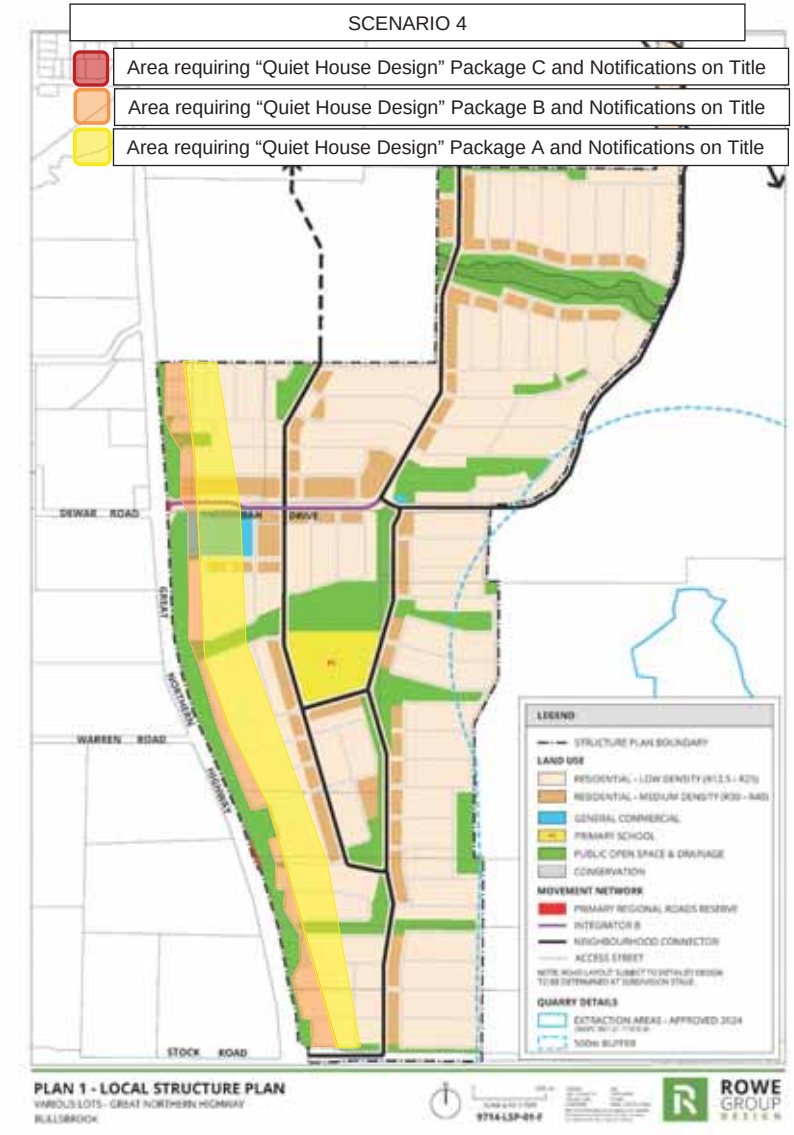
APPENDIX C





Herring Storer Acoustics
Our ref: 35231-2-25307
APPENDIX C





APPENDIX D

MRWA Traffic Flows

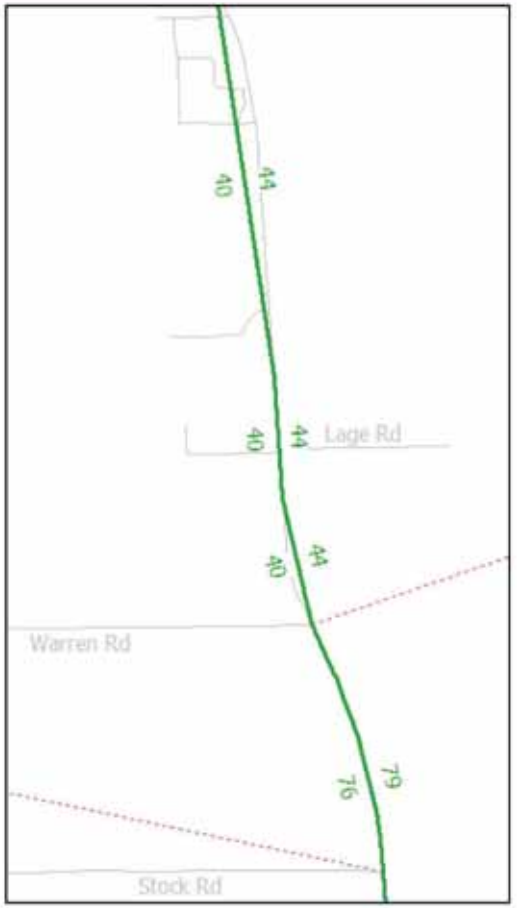
4

MAIN ROADS WESTERN AUSTRALIA

2021 ROM24 Scenario

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- 4 Lanes Each Direction
- 5 Lanes Each Direction
- >=6 Lanes Each Direction
- Zone Connector



MRWA Traffic Modelling Data, as supplied to approved clients, is confidential and is not to be made available to unauthorised persons or organisations.

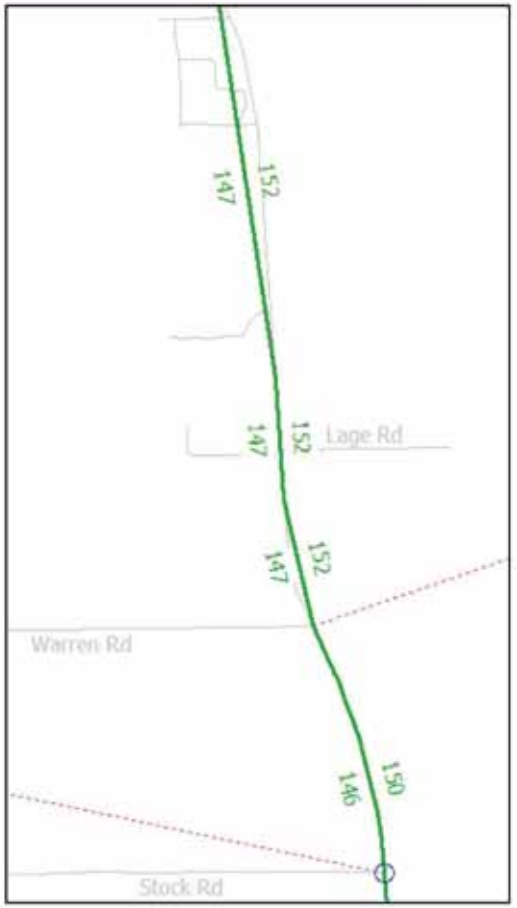
6

MAIN ROADS WESTERN AUSTRALIA

2046 ROM24 Scenario

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- 4 Lanes Each Direction
- 5 Lanes Each Direction
- >=6 Lanes Each Direction
- Zone Connector



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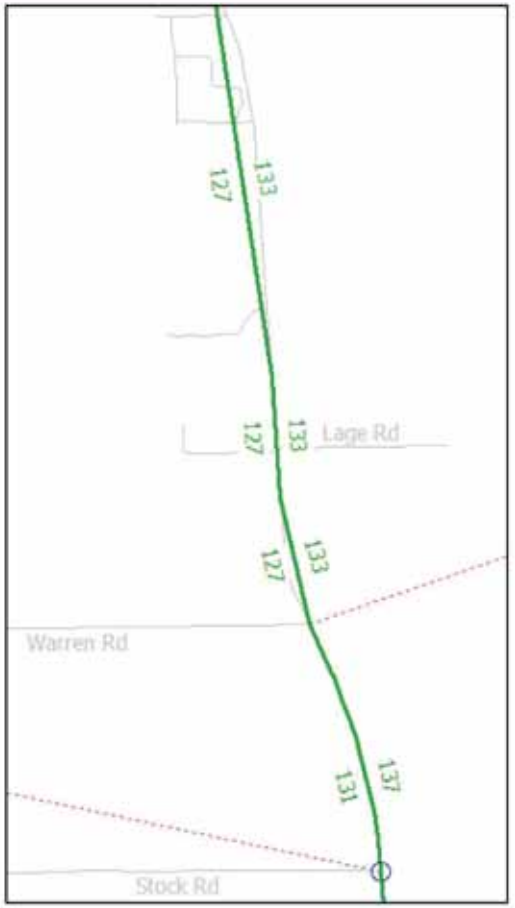
5

MAIN ROADS WESTERN AUSTRALIA

2041 ROM24 Scenario

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- 4 Lanes Each Direction
- 5 Lanes Each Direction
- >=6 Lanes Each Direction
- Zone Connector



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Attachment 8

Landscape Master Plan and Public Open Space Strategy

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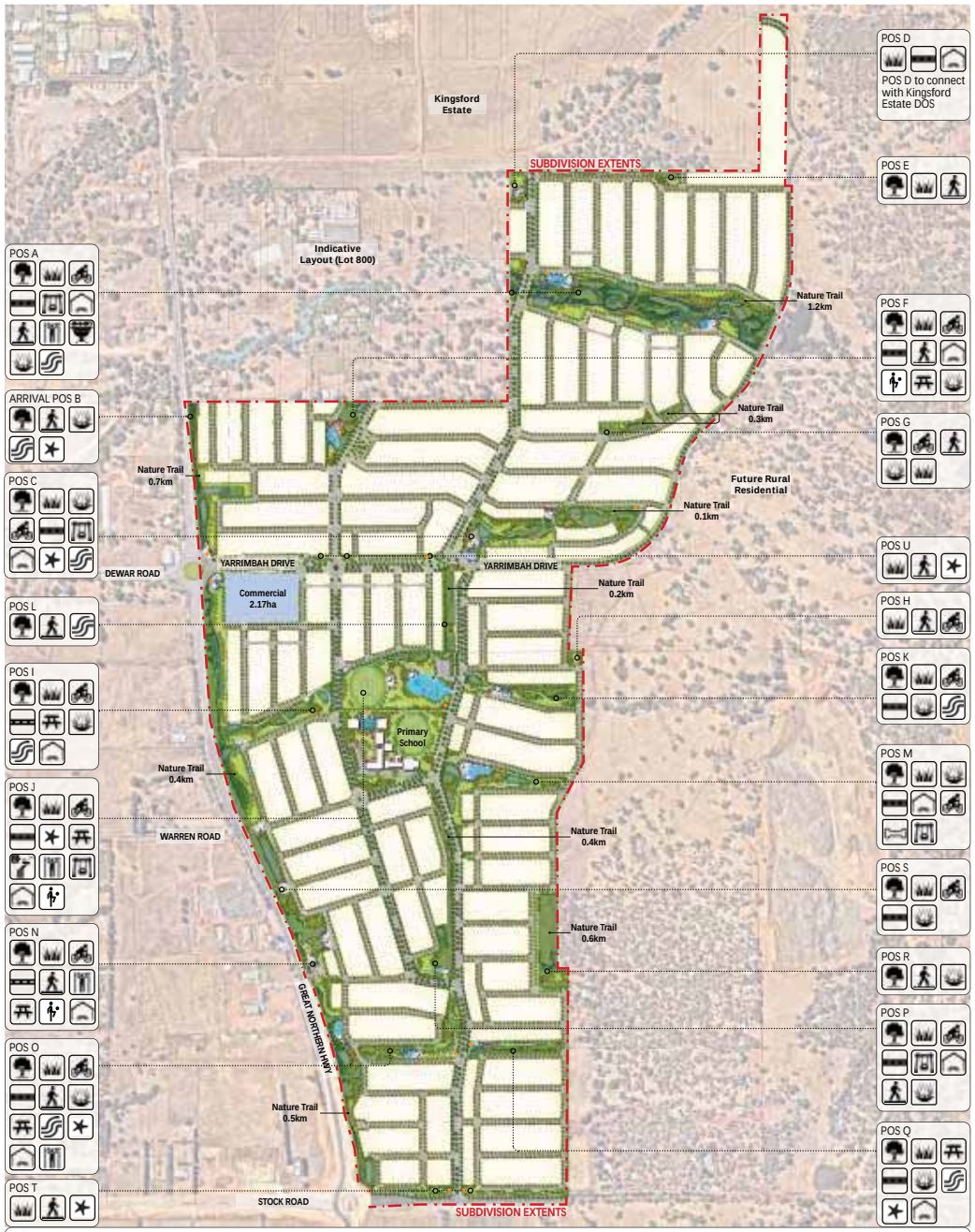

BULLSBROOK SOUTH URBAN EXPANSION AREA

PRELIMINARY LANDSCAPE MASTERPLAN

DWG MSBA01-1
REV H
DATE 27-08-25
SCALE 1 : 8000 @ A3

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POS A TYPOLOGY

- Linear POS following Nambad Brook

POS A CONCEPT

- Linear parkland connects to adjacent POS, creating continuous parkland network throughout residential area, responding to the brook
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through linear parkland providing approx. 2km walking/cycling trail
- Bridge crossings over brook creates connections across foreshore areas. Minimal intrusion to the brook
- Shelter and picnic nodes for gathering opportunities
- Grass area adjacent playspace provides for active recreation
- All age fitness node provides for active and healthy lifestyle

FUNCTIONS / MATERIALS

- Footpath connection to broader path network
- Park furniture provides rest points
- Play space for kids and fitness node for all ages
- Grass area for active or passive recreation
- Revegetated planting areas
- Storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS

- Significant existing trees to be retained
- Provide buffer and ecological access to brook
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat

DRAINAGE LEGEND - CATCHMENT	A	B	C	D	E
FIRST 15MM DETAILS					
Depth(m):	0.30	0.30	0.30	0.30	0.30
Top Area(m²):	185	638	324	389	840
Volume(m³):	55	191	97	116	252
Slope:	1:4	1:4	1:4	1:4	1:4
1 IN 5 YR STORAGE					
Depth(m):	0.38	0.45	0.42	0.44	0.44
Top Area(m²):	190	644	329	395	846
Volume(m³):	71	288	137	172	371
Slope:	1:6	1:6	1:6	1:6	1:6
1 IN 100 YR STORAGE					
Depth(m):	0.46	0.62	0.54	0.59	0.59
Top Area(m²):	195	651	336	402	853
Volume(m³):	89	401	180	235	501
Slope:	1:6	1:6	1:6	1:6	1:6



POS A CONCEPT







POS A CONCEPT

LOCATION PLAN







LEGEND

POS EXTENT
LOTS
COMMERCIAL
ART OPPORTUNITY
PLAYGROUND
NODES / SHELTERS
FOOTPATH
LIMESTONE TRACK
FEATURE PLANTING
TURF
REVEGETATION AREA
RETAINED VEGETATION
TIMBER BRIDGE
BROOK
BASIN
PARKING
OPEN CHANNEL
PROPOSED TREE
STREET TREE
FORESHORE ZONE

BULLSBROOK SOUTH URBAN EXPANSION AREA

LANDSCAPE DETAILED PLAN POS A

DWG MSBA01-2
REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3

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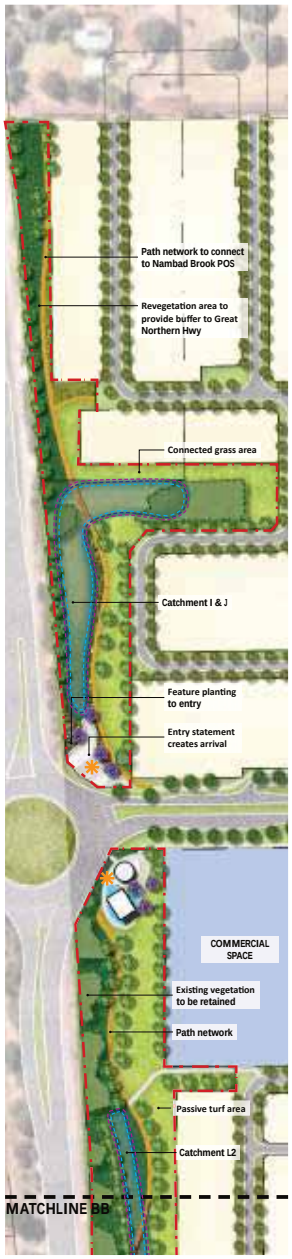
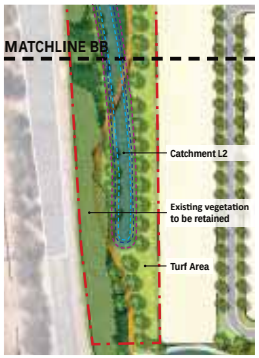
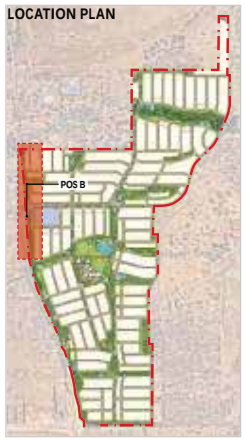


POS B CONCEPT











POS B TYPOLOGY
- Linear POS

POS B CONCEPT
- Entry statement provides wayfinding, and sense of arrival through featured landscape planting and finishes
- Statement trees at arrival point with complimenting vegetation to reflect species and aesthetic of the local flora
- Linear parkland creating buffer from Great Northern Hwy and connecting to broader POS network throughout residential area
- Existing vegetation to be retained where possible to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Cycle/path network meandering through linear parkland providing approx. 0.7km walking/cycling trail
- Grass area provided for relief and linked to improve connectivity
- Entry statement to create sense of arrival adjacent commercial lot

FUNCTIONS / MATERIALS
- Compliment commercial area
- Entry statement and feature walls
- Footpath connection to broader path network
- Grass area for active or passive recreation
- Revegetated planting areas to create buffer from Great Northern Hwy
- Storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer to adjacent Great Northern Hwy
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat

DRAINAGE LEGEND - CATCHMENT	I+J	L2
FIRST 15MM DETAILS		
Depth(m):	0.30	0.3
Top Area(m²):	2510	755
Volume(m³):	753	226
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.72	0.46
Top Area(m²):	2519	761
Volume(m³):	1811	349
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	1.04	0.83
Top Area(m²):	2532	771
Volume(m³):	2626	636
Slope:	1:6	1:6



LEGEND

POS EXTENT · LOTS · COMMERCIAL · ART OPPORTUNITY · PLAYGROUND · NODES / SHELTERS · FOOTPATH · LIMESTONE TRACK · FEATURE PLANTING · TURF · REVEGETATION AREA · RETAINED VEGETATION · TIMBER BRIDGE · BROOK · BASIN · PARKING · OPEN CHANNEL · PROPOSED TREE · STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS B

DWG MSBA01-3 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3
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POS C TYPOLOGY
- Linear POS with Local Park focus at eastern end

POS C CONCEPT
- Linear parkland connects to adjacent POS, creating continuous parkland network throughout residential area
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through linear parkland providing approx. 1km walking/cycling trail
- Bridge crossings over overland drainage corridor creates connections across foreshore areas
- Shelter and picnic nodes for gathering opportunities
- Grass area adjacent playspace provides for active recreation
- Opportunity for commercial area addressing the play provision and providing community space

FUNCTIONS / MATERIALS
- Commercial area
- Footpath connection to broader path network
- Park furniture provides rest points
- Play space for kids
- Grass area for active or passive recreation
- Revegetated planting areas
- Overland drainage corridor and storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer and ecological access to brook
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat

DRAINAGE LEGEND - CATCHMENT H+K	
FIRST 15MM DETAILS	
Depth(m):	0.30
Top Area(m²):	742
Volume(m³):	222
Slope:	1:4
1 IN 5 YR STORAGE	
Depth(m):	0.46
Top Area(m²):	748
Volume(m³):	343
Slope:	1:6
1 IN 100 YR STORAGE	
Depth(m):	0.62
Top Area(m²):	755
Volume(m³):	466
Slope:	1:6













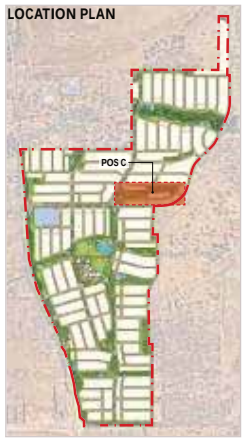







POS C CONCEPT

LEGEND

POS EXTENT · LOTS · COMMERCIAL · ART OPPORTUNITY · PLAYGROUND · NODES / SHELTERS · FOOTPATH · LIMESTONE TRACK · FEATURE PLANTING · TURF · REVEGETATION AREA · RETAINED VEGETATION · TIMBER BRIDGE · BROOK · BASIN · PARKING · OPEN CHANNEL · PROPOSED TREE · STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS C

DWG MSBA01-4 REV H
DATE 27-08-25
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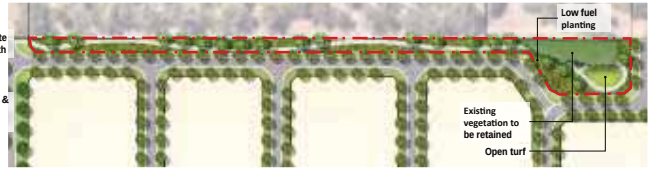
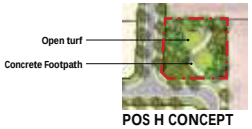
POS D CONCEPT



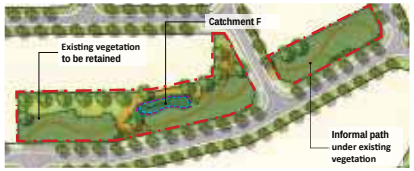
POS E CONCEPT



POS F CONCEPT



POS H CONCEPT



POS G CONCEPT

LOCATION PLAN







POS E, G & H TYPOLOGIES
- Pocket Park

POS E, G & H CONCEPTS
- Pocket park designed to retain trees, providing canopy for shade and immediate amenity
- Park furniture providing quieter rest nodes
- Supplement planting to enhance local flora and fauna

FUNCTIONS / MATERIALS
- Footpath connection to broader path network
- Park furniture provides rest points
- Retained trees
- POS G contains storage basin as per the LWMS design

POS D & F TYPOLOGIES
- Local Park

POS D & F CONCEPTS
- Local park located to retain trees, providing canopy for shade and immediate amenity
- Park furniture providing quieter rest nodes
- Path provided to connect to broader walkability of the residential area linking local park to the linear parks
- Shelter and picnic nodes for gathering opportunities
- Grass area adjacent playspace provides for active recreation
- POS D to connect with Kingsford Estate DOS
- POS F low key youth space



ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Low fuel plantings to minimise bushfire threat

FUNCTIONS / MATERIALS
- Footpath connection to broader path network
- Park furniture provides rest points
- Play space for kids and youth facilities
- Grass area for active or passive recreation
- Retained trees with planted understory
- POS F & G Storage basins as per the LWMS design





DRAINAGE LEGEND - CATCHMENT	F	G
FIRST 15MM DETAILS		
Depth(m):	0.30	0.30
Top Area(m²):	112	407
Volume(m³):	33	122
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.36	0.40
Top Area(m²):	117	412
Volume(m³):	41	164
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	0.43	0.49
Top Area(m²):	122	418
Volume(m³):	51	203
Slope:	1:6	1:6





LEGEND

POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS D, E, F, G & H

DWG MSBA01-5 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3
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POS J TYPOLOGY
- Central POS

POS J CONCEPT
- Existing vegetation to be retained to provide immediate amenity shade
- Provision of high quality shared path network including connections to broader precinct
- Shelter and picnic setting with BBQ node
- Youth activity area including custom playspace catering to all ages, parkour circuit and fitness equipment
- Passive turf to provide open space for activities
- Buffer planting to provide physical separation with primary school grounds
- Fully accessible amenities to support playing fiels activities, school outings and locals/visitors gatherings
- Carpark to accomodate influx of visitors
- Dedicated spaces for public art displays
- Feature turf mounding to topographically shape the landscape space as well as to provide opportunities for sitting, laying, and gathering
- Feature trees to create a unique sense of arrival and as distinct markers within the estate landscape

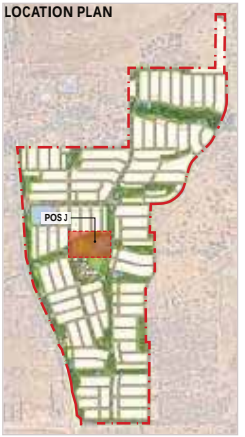
FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Shelter and picnic settings to provide gathering opportunity
- Fitness for all ages
- Open turf area to provide passive recreation
- Public art opportunity
- Overland drainage corridor

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Amenities using renewable energies
- Low fuel planting to minimise bushfire threat
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment





LOCATION PLAN







POS J CONCEPT











LEGEND

POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS J

DWG MSBA01-6 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3
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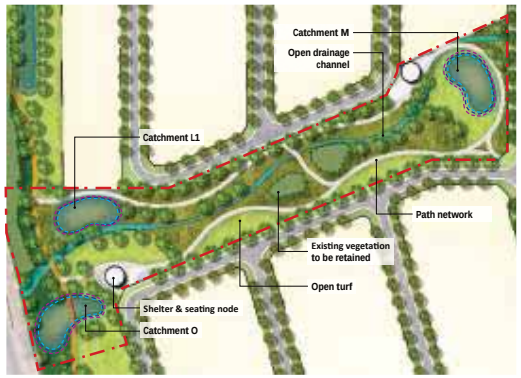
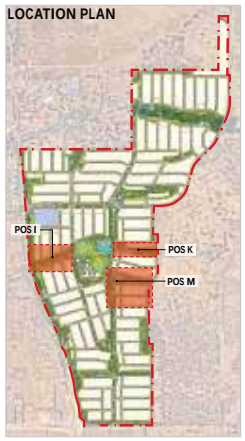


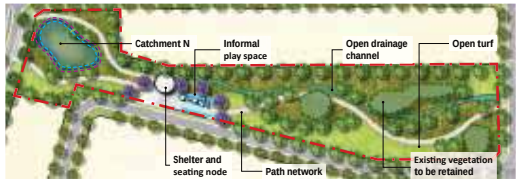
POS I CONCEPT



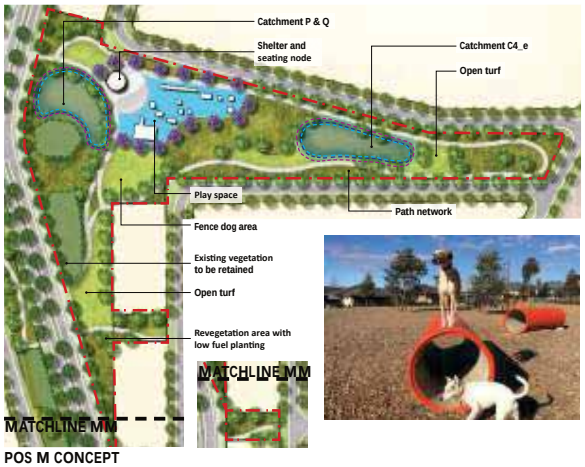








POS K CONCEPT









POS M CONCEPT

POS I, K & M TYPOLOGIES
• Linear/Local POS

POS I, K & M CONCEPTS
• Existing vegetation to be retained to provide immediate amenity shade
• Linear POS that provides connections between the residential lots and the central POS, playing fields and primary school site
• Footpath connections to improve the connectivity & walkability/cyclability of east-west ecological corridor
• Shelter and picnic nodes
• Fenced dog park space with reserved quiet corners
• Linked turf spaces to improve connectivity and provide resting points throughout the estate
• Play space for kids

FUNCTIONS / MATERIALS
• Footpath connection to broader path network
• Park furniture provides rest points
• Play space for kids
• Grass area for active or passive recreation
• Revegetated planting areas
• Storage basins as per the LWMS design
• Overland drainage channel to POS I and K

ENVIRONMENTAL CONSIDERATIONS
• Significant existing trees to be retained
• Low fuel plantings to minimise bushfire threat
• Water-wise basin native planting to basins
• Consider long-term maintenance requirements
• Source local materials where possible to minimise transport requirements and provide local employment

DRAINAGE LEGEND - CATCHMENT	L1	M	O	N	C4_e	P&Q
FIRST 15MM DETAILS						
Depth(m):	0.30	0.30	0.30	0.30	0.30	0.30
Top Area(m²):	468	463	480	458	814	882
Volume(m³):	140	139	144	137	244	264
Slope:	1:4	1:4	1:4	1:4	1:4	1:4
1 IN 5 YR STORAGE						
Depth(m):	0.42	0.46	0.44	0.47	0.58	0.43
Top Area(m²):	473	469	486	464	821	888
Volume(m³):	198	214	213	217	474	381
Slope:	1:6	1:6	1:6	1:6	1:6	1:6
1 IN 100 YR STORAGE						
Depth(m):	0.53	0.81	0.93	0.65	1.15	0.93
Top Area(m²):	480	479	497	472	835	899
Volume(m³):	253	384	457	304	952	831
Slope:	1:6	1:6	1:6	1:6	1:6	1:6

LEGEND

POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA

LANDSCAPE DETAILED PLAN POS I,K & M

DWG MSBA01-7 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3
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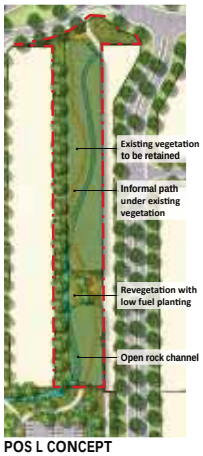
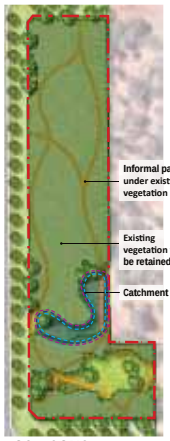


POS L CONCEPT



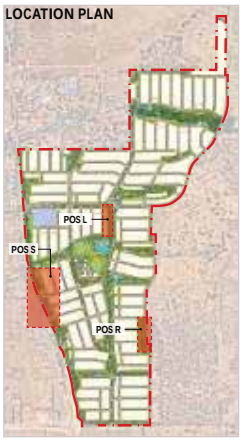
POS R CONCEPT







POS S CONCEPT











POS L, R & S TYPOLOGIES
• Linear/Informal POS

POS L, R & S CONCEPTS
• Existing vegetation to be retained to provide immediate amenity shade
• Informal track meandering through existing vegetation providing approx 0.6km walking trail
• Footpath connections to improve the connectivity & walkability/ cyclability of north-south ecological corridor
• Shelter and picnic nodes

FUNCTIONS / MATERIALS
• Footpath connection to the broader path and cycle network
• Bench seats to provide rest point
• Shelter and picnic settings to provide gathering opportunity
• POS L overland drainage
• Storage basins as per the LWMS design

ENVIRONMENTAL CONSIDERATIONS
• Significant existing trees to be retained
• Low fuel planting to minimise the bushfire treat
• Water-wise basin native planting to basins
• Consider long-term maintenance requirements
• Source local materials where possible to minimise transport requirements and provide local employment

DRAINAGE LEGEND - CATCHMENT	S	C6_a
FIRST 15MM DETAILS		
Depth(m):	0.30	0.30
Top Area(m²):	664	493
Volume(m³):	199	148
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.44	0.77
Top Area(m²):	670	503
Volume(m³):	293	383
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	0.70	1.12
Top Area(m²):	678	516
Volume(m³):	472	570
Slope:	1:6	1:6

LEGEND

POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA

LANDSCAPE DETAILED PLAN POS L, R & S

DWG MSBA01-8 REV H
DATE 27-08-25
SCALE 1 : 2000 @ A3
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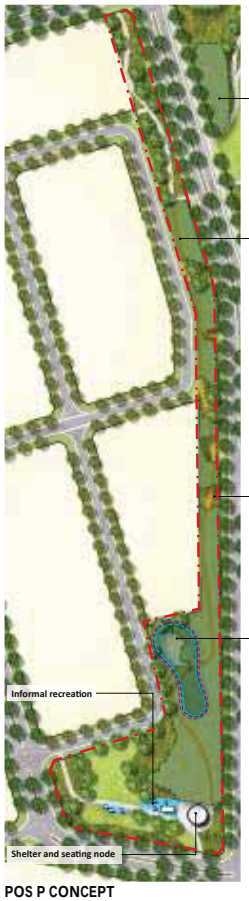
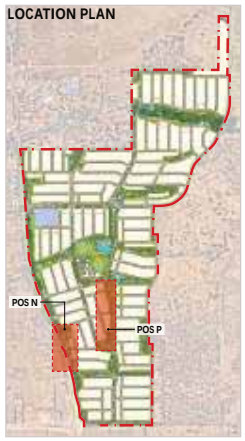
POS N CONCEPT





POS P CONCEPT

LOCATION PLAN









POS N & P TYPOLOGIES
- Linear/Local POS

POS N & P CONCEPTS
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through existing vegetation providing approx 1.2km walking trail
- Footpath connections to improve the connectivity & walkability/cyclability of east-west ecological corridor
- Shelter and picnic nodes
- Linked turf spaces to improve connectivity and provide resting points throughout the estate, providing open space for activities
- All aged fitness area to provide exercise space
- Informal play space for kids

FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Shelter and picnic settings to provide gathering opportunity
- Play space for kids, fitness for all ages
- Open turf area to provide passive recreation
- Storage basins as per with LWMS design

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Low fuel plantings to minimise the threat of bushfire
- Water-wise basin native planting to basins
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment

DRAINAGE LEGEND - CATCHMENT R

FIRST 15MM DETAILS	
Depth(m):	0.30
Top Area(m²):	625
Volume(m³):	187
Slope:	1:4
1 IN 5 YR STORAGE	
Depth(m):	0.49
Top Area(m²):	631
Volume(m³):	308
Slope:	1:6
1 IN 100 YR STORAGE	
Depth(m):	0.95
Top Area(m²):	643
Volume(m³):	605
Slope:	1:6



LEGEND

POS EXTENT · LOTS · COMMERCIAL · ART OPPORTUNITY · PLAYGROUND · NODES / SHELTERS · FOOTPATH · LIMESTONE TRACK · FEATURE PLANTING · TURF · REVEGETATION AREA · RETAINED VEGETATION · TIMBER BRIDGE · BROOK · BASIN · PARKING · OPEN CHANNEL · PROPOSED TREE · STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS N & P

DWG MSBA01-9 · REV H · DATE 27-08-25 · SCALE 1 : 2000 @ A3

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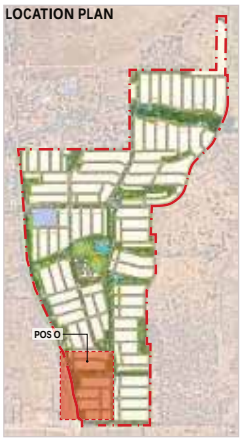
POS O CONCEPT

LOCATION PLAN



POS O TYPOLOGY
- Local POS

POS O & Q CONCEPTS
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through existing vegetation providing approx 0.5km walking trail
- Footpath connections to improve the connectivity & walkability/cyclability of north-south and east-west ecological corridor
- Shelter and picnic nodes
- Linked turf spaces to improve connectivity and provide resting points throughout the estate

FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Picnic settings to provide gathering opportunity

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer to adjacent Great Northern Hwy
- Low fuel plantings to minimise bushfire threat
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Open turf area to provide passive recreation
- Overland drainage corridor
- Storage basins as per with LWMS design

DRAINAGE LEGEND - CATCHMENT

	T	V
FIRST 15MM DETAILS		
Depth(m):	0.30	0.30
Top Area(m²):	727	1128
Volume(m³):	218	338
Slope:	1:4	1:4
1 IN 5 YR STORAGE		
Depth(m):	0.50	0.50
Top Area(m²):	733	1134
Volume(m³):	365	566
Slope:	1:6	1:6
1 IN 100 YR STORAGE		
Depth(m):	1.12	0.71
Top Area(m²):	747	1143
Volume(m³):	829	808
Slope:	1:6	1:6

LEGEND

POS EXTENT · LOTS · COMMERCIAL · ART OPPORTUNITY · PLAYGROUND · NODES / SHELTERS · FOOTPATH · LIMESTONE TRACK · FEATURE PLANTING · TURF · REVEGETATION AREA · RETAINED VEGETATION · TIMBER BRIDGE · BROOK · BASIN · PARKING · OPEN CHANNEL · PROPOSED TREE · STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS O

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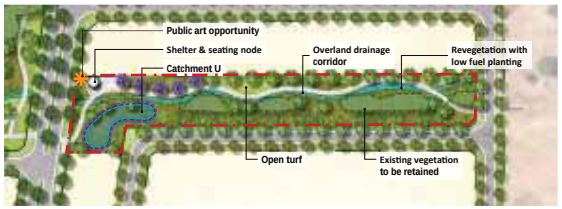
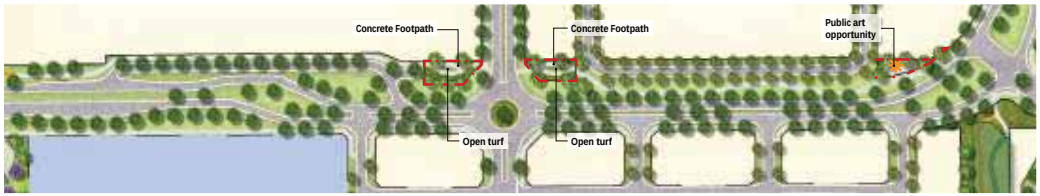


POS Q CONCEPT



POS T CONCEPT



POS U CONCEPT

LOCATION PLAN



POS Q TYPOLOGY
- Local POS

POS T & U TYPOLOGY
- Linear / Pocket POS

POS Q CONCEPTS
- Existing vegetation to be retained to provide immediate amenity and shade with supplement planting to enhance local flora and fauna
- Informal track meandering through existing vegetation providing approx 0.6km walking trail
- Footpath connections to improve the connectivity & walkability/ cyclability of north-south and east-west ecological corridor
- Shelter and picnic nodes
- Linked turf spaces to improve connectivity and provide resting points throughout the estate

POS T & U CONCEPTS
- Pocket park designed to retain trees, providing canopy for shade and immediate amenity
- Footpath connections to improve the connectivity & walkability/ cyclability of north-south ecological corridor
- Supplement planting to enhance local flora and fauna

FUNCTIONS / MATERIALS
- Footpath connection to the broader path network
- Bench seats to provide rest point
- Picnic settings to provide gathering opportunity
- POS Q contains storage basin as per the LWMS design
- Open turf area to provide passive recreation
- Public art opportunity

ENVIRONMENTAL CONSIDERATIONS
- Significant existing trees to be retained
- Provide buffer to adjacent Great Northern Hwy
- Low fuel plantings to minimise bushfire threat
- Water-wise basin native planting to drainage basin
- Consider long-term maintenance requirements
- Source local materials where possible to minimise transport requirements and provide local employment
- Open turf area to provide passive recreation
- Overland drainage corridor
- Storage basins as per with LWMS design







DRAINAGE LEGEND - CATCHMENT U	
FIRST 15MM DETAILS	
Depth(m):	0.30
Top Area(m²):	398
Volume(m³):	119
Slope:	1:4
1 IN 5 YR STORAGE	
Depth(m):	0.43
Top Area(m²):	404
Volume(m³):	172
Slope:	1:6
1 IN 100 YR STORAGE	
Depth(m):	0.56
Top Area(m²):	410
Volume(m³):	228
Slope:	1:6

LEGEND

POS EXTENT, LOTS, COMMERCIAL, ART OPPORTUNITY, PLAYGROUND, NODES / SHELTERS, FOOTPATH, LIMESTONE TRACK, FEATURE PLANTING, TURF, REVEGETATION AREA, RETAINED VEGETATION, TIMBER BRIDGE, BROOK, BASIN, PARKING, OPEN CHANNEL, PROPOSED TREE, STREET TREE

BULLSBROOK SOUTH URBAN EXPANSION AREA
LANDSCAPE DETAILED PLAN POS Q & T

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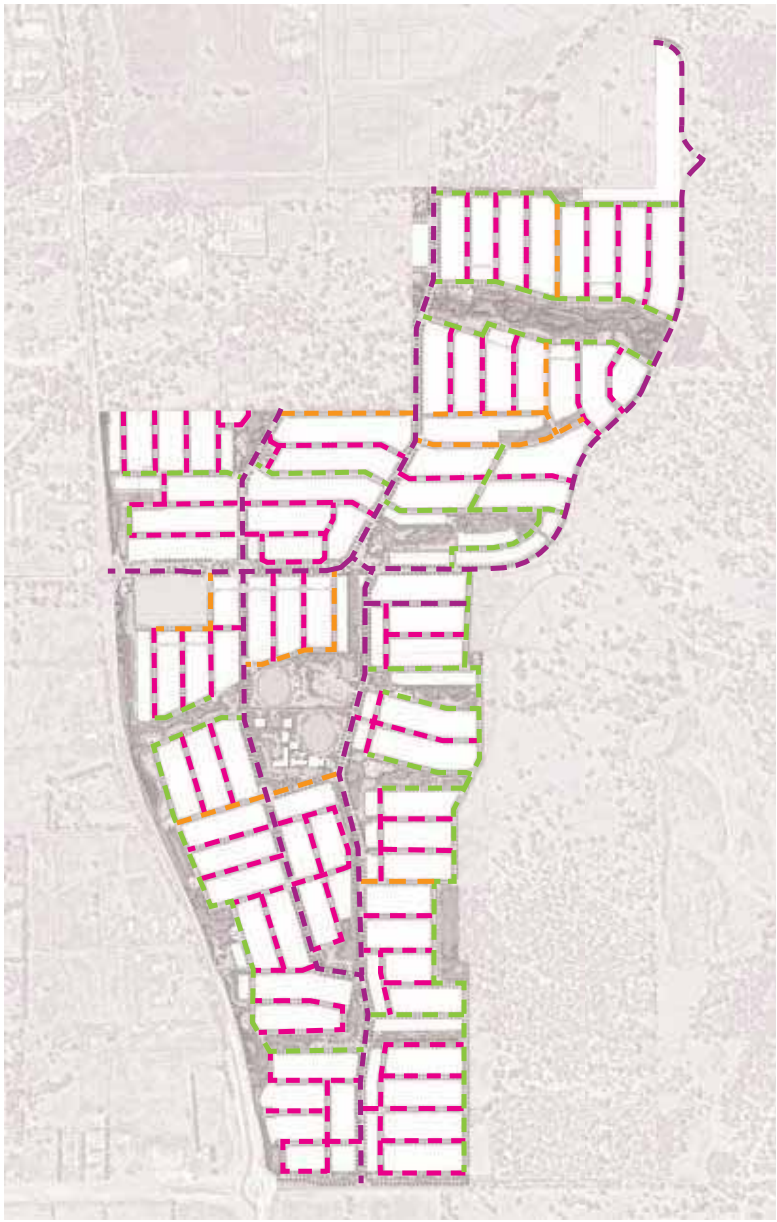


Corymbia maculata* - Spotted Gum (MEDIAN STRIPS)


Eucalyptus torquata - Coral Gum


Jacaranda mimosifolia* - Jacaranda


Eucalyptus marginata* - Jarrah


Melaleuca quinquenervia - Broad-leaved Paperbark


Melaleuca leucadendron - Weeping Paperbark


Corymbia ficifolia - Flowering Gum

LEGEND

PRIMARY STREET TREE
SECONDARY STREET TREE
SECONDARY STREET TREE
TERTIARY STREET TREE- RESIDENTIAL


Fraxinus oxycarpa "Raywoodii" - Claret Ash


Callistemon "Kings Park Special" - KPS Bottlebrush


Cupaniopsis anacardioides - Tuckeroo

BULLSBROOK SOUTH URBAN EXPANSION AREA
STREET TREE MASTERPLAN

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