# DEVELOPMENT SERVICES ATTACHMENTS
# ORDINARY MEETING OF COUNCIL
# WEDNESDAY 18 MARCH 2020

| REPORT NUMBER | REPORT TITLE AND ATTACHMENT DESCRIPTION | PAGE NUMBER(S) |
|---|---|---|
| **9.1.1** | **Proposed Scheme Amendment No 67: Initiation of Proposal to Rezone from "Agriculture Resource" to "Industrial Development" - Lots M1601, 800-804, 192, 194 and 35 Great Northern Highway, Muchea**<br><br>**Attachments**<br>1. Scheme Amendment Revision Documentation<br>2. Additional rationale for 'loop road' location | 1 – 691 |
| **9.1.3** | **Application for Exemptions of Limitation of Number of Dogs: Lot 302 (RN 102) Ayrshire Loop, Lower Chittering**<br><br>**Attachment**<br>2. Site Plan – Fencing & Containment Area | 692 |
| **9.1.4** | **Proposal to Revoke Multiple Local Planning Policies**<br><br>**Attachments**<br>1. Local Planning Policy No. 10 – Basic Raw Materials and Extractive Industries<br>2. Local Planning Policy No. 21 – Fire Management Plans<br>3. Local Planning Policy No. 26 - Waste Management<br>4. Local Planning Policy No. 28 – Public Open Space dedication on zoning<br>5. Local Planning Policy No. 30 – Registered Road Verges | 693 – 750 |
| **9.1.5** | **Amendment to Local Planning Policy No. 7 – Outbuildings**<br><br>**Attachments**<br>1. Amended Local Planning Policy No. 7 – Outbuildings<br>2. Schedule of Submission | 751 – 763 |
| **9.1.6** | **Application for Development Approval – "Proposed dwelling with reduced setbacks": Lot 107 Chittering Road, Chittering**<br><br>**Attachments**<br>1. Schedule of submissions | 764 – 765 |

# Shire of Chittering

# Local Planning Scheme No. 6

# Amendment No. 67

***Summary of Amendment Details***

***Rezoning land contained within Precinct 3 of the Muchea Employment Node Structure Plan, being Lots 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Light Industrial' zone and introducing provisions relating to land use and development requirements***

FORM 2A

# Planning and Development Act 2005

## RESOLUTION TO PREPARE AMENDMENT TO LOCAL PLANNING SCHEME

## *Shire of Chittering Local Planning Scheme No.6*
## *Amendment No.67*

**Resolved that the Local Government pursuant to section 75 of the *Planning and Development Act* 2005, amend the above Local Planning Scheme by:**

1. ***Rezoning Lots 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to the 'Light Industrial' zone.***

   ***And amending the Scheme Maps accordingly.***

2. ***Amending clause 5.1.1 Operation of Special Control Areas to include 'Muchea Employment Node' as new dot point 6; and reflecting Precinct 3 of the Muchea Employment Node on the Scheme Maps accordingly.***

3. ***Introducing the following uses into Schedule 1 – Dictionary of Defined Words and Expressions of Local Planning Scheme 1 as follows:***

   ***'Concrete Batching Plant means premises used for concrete batching, as defined in the Environmental Protection Regulations 1987'***

   ***'Workforce Accommodation means premises, which may include modular or relocatable buildings, used –***
   ***(a) Primarily for the accommodation of workers engaged in construction, resource, agricultural or other industries on a temporary basis; and***
   ***(b) For any associated catering, sporting and recreation facilities for the occupants and authorised visitors'***

4. ***Amending Schedule 2 – Zoning Table to identify the uses:***
   ***i. 'Concrete Batching Plant' as a 'D' use in the Light Industrial and General Industrial zones, and an 'X' use otherwise***
   ***ii. 'Workforce Accommodation' as a 'D' use in the Light Industrial zone, and an 'X' use otherwise***
   ***iii. 'Fast Food Outlet' in the Light Industrial Zone as a 'D' use***

5. ***Amending clause 4.9: Requirements for Industrial Zones and Land Uses, of Local Planning Scheme 1 to introduce the following provisions:***

***(g) where Workforce Accommodation is a discretionary use-***

***i. the accommodation is to have a maximum floor area of 250m2***

***ii. the accommodation is to be incidental to the industrial land use***

***iii. subdivision of the accommodation from the parent lot will not be permitted***

***iv. the local government will not consider applications for Workforce Accommodation prior to the primary site activity being either approved or constructed***

***v. where simultaneous approval has been granted by local government for both Workforce Accommodation and the main activity on the same lot, the main activity must be developed and be operational prior to the occupation of the Workforce Accommodation***

***vi. Workforce Accommodation must be carefully sited and constructed so the potential site (or estate) impacts from noise, dust, odour, amenity and heavy vehicle access/egress from the site are minimised***

***And renumber the subsequent clauses accordingly.***

***6. Amending Schedule 11 – Muchea Employment Node Special Control Area of Local Planning Scheme No.1 to add Precinct 3, by including provisions for Precinct 3 of the Muchea Industrial Precinct No.1 as follows:***

| NO. | DESCRIPTION OF LAND | CONDITIONS |
|---|---|---|
| 2. | Precinct 3 (P3) of the Muchea Industrial Park | **1. Hierarchy of Plans**<br>Structure planning, subdivision and development shall be undertaken in accordance with the Scheme.<br>**2. Structure Plan**<br>a. Structure Plan Preparation<br>A Structure Plan shall be prepared in accordance with the provisions of the deemed provisions over the entire area of Precinct 3 of the Muchea Industrial Park.<br>b. Environmental Management Plans<br>The following Environmental Management Plans shall be prepared as part of the Structure Plan process and approved as required by the relevant agency:<br>i. Local Water Management Strategy<br>ii. Environmental Assessment and Management Strategy<br>iii. Transport Impact Assessment<br>Environmental Management Plans shall be implemented to the satisfaction of the local authority.<br>**3. Subdivision**<br>i. An Urban Water Management Plan shall be prepared by the developer, consistent with the Local Water Management Strategy, for approval by the relevant |

| NO. | DESCRIPTION OF LAND | CONDITIONS |
|---|---|---|
| | | agency, to satisfy a condition of subdivision approval.<br>ii. A reticulated water supply provided by a licensed operator shall be provided at the first stage of subdivision.<br>iii. Road Reservation and Construction<br>a. An internal Loop Road, constructed to accommodate RAV10 vehicles, shall be constructed in accordance with Austroads and MRWA standards<br>b. When a lot is subdivided, the totality of land required for all road reserves within that lot shall be ceded to the Crown<br>c. The full length of roads within the subdivision area is to be constructed on the creation of all lots. A staging plan and triggers for road construction, to ensure construction of all roads within the subdivided area is to be outlined in an approved Structure Plan.<br>iv. Subdivision applications shall demonstrate that a suitable temporary turning circle for the Loop Road can be provided within the boundaries of the subdivision area until the entire Loop Road is constructed to allow RAV10 vehicles access and egress onto Great Northern Highway. At that time, the temporary turning circle shall be removed and the land suitably remediated.<br>v. Drainage<br>a. The drainage approach for Precinct 3 is set out in the Structure Plan.<br>b. When the first lot in a subdivision is created, any works or ceding of land associated with the drainage network is to be implemented.<br>c. Where staging of drainage infrastructure is determined to be acceptable by the WAPC and relevant agencies including DWER and the local authority, proposals are to make provision for connection to the overall drainage network, and the approach is to be outlined in an UWMP that accompanies the subdivision application.<br>**4. Development**<br>**i.** Development of land shall be generally in accordance with the Scheme and approved Structure Plan. |

| NO. | DESCRIPTION OF LAND | CONDITIONS | |
|---|---|---|---|
| | | ii. | Land use permissibility within Precinct 3 shall be in accordance with the Light Industrial Zone of LPS6 (as amended). |

**The amendment is standard under the provisions of the *Planning and Development (Local Planning Schemes) Regulations* 2015 for the following reason(s):**

1. **The Amendment is consistent with the approved Muchea Employment Node Structure Plan 2011**
2. **The Amendment is consistent with the Draft Shire of Chittering Local Planning Strategy**

**Dated this _____ day of _____ 20___**

_____
**(Chief Executive Officer)**

URBIS

# MUCHEA INDUSTRIAL PARK SCHEME AMENDMENT

## PRECINCT 3

PREPARED FOR

**TOMAHAWK PROPERTY ON BEHALF OF THE MUCHEA EMPLOYMENT NODE PRECINCT 3 LANDOWNER GROUP**

FEB 2019

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# 1. INTRODUCTION

This report has been prepared by Urbis for Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group, in support of an application to rezone land (and introduce relevant provisions) within Precinct 3 (P3) of the Muchea Employment Node Structure Plan area (MENSP). This Amendment proposes the land be rezoned from 'Agricultural Resource' to 'Industrial Development', to facilitate its development for a range of industrial purposes.

The MENSP was adopted by the WAPC in August 2011, and provides a 20 year planning framework for industrial development within the Shire of Chittering. P3 forms the eastern portion of the MENSP, to the west of Great Northern Highway (GNH). The MENSP is also more recently referred to the as the Muchea Industrial Park (or MIP).

The land is ideally suited to industrial development given its locational context within the MENSP, being on the boundary of the Metropolitan Region, separated from residential areas, and being located along GNH and the Perth Darwin National Highway (PDNH), which provide commercial exposure and excellent accessibility.

A Structure Plan has also been prepared and lodged with the Shire of Chittering, to provide the detailed framework to deliver industrial development in a timely and coordinated manner, in a form which will facilitate flexibility in lot size and layout, and enable access and manoeuvrability within the Estate for Restricted Access Vehicles, or RAV10 and RAV7 industrial vehicles.

The Amendment (and associated Structure Plan) have been prepared in consultation, and with the agreement, of all landowners within the Structure Plan area.

This report has been informed by a variety of technical investigations which are appended to this report.

This Amendment report addresses the relevant considerations of the *Planning and Development (Local Planning Scheme) Regulations 2015*, and the requirements of the Shire of Chittering Local Planning Scheme No.6 (LPS6).

## 1.1. RELATIONSHIP TO PLANNING REGULATIONS

This report has been prepared in accordance with the principles of the Western Australian Planning Commission's (WAPC) key State Planning Policies which guide industrial subdivision and development.

Under Clause 35 of the *Planning and Development (Local Planning Schemes) Regulations 2015 ('the Regulations')* when undertaking a scheme amendment, a local government must specify and justify whether the proposed amendment is basic, standard or complex.

The proposed amendment is considered to be a 'standard amendment', which is described under Clause 34 of the Regulations as follows:

*Standard amendment means any of the following amendments to a local planning scheme:*

(a) an amendment relating to a zone or reserve that is consistent with the objectives identified in the scheme for that zone or reserve;
(b) (b an amendment that is consistent with a local planning strategy for the scheme that has been endorsed by the Commission;
(c) an amendment to the scheme so that it is consistent with a region planning scheme that applies to the scheme area, other than an amendment that is a basic amendment;
(d) an amendment to the scheme map that is consistent with a structure plan, activity centre plan or local development plan that has been approved under the scheme for the land to which the amendment relates if the scheme does not currently include zones of all the types that are outlined in the plan; (emphasis added)
(e) an amendment that would have minimal impact on land in the scheme area that is not the subject of the amendment;
(f) an amendment that does not result in any significant environmental, social, economic or governance impacts on land in the scheme area;
(g) any other amendment that is not a complex or basic amendment.

The amendment is standard under the provisions of the Planning and Development (Local Planning Schemes) Regulations 2015 for the following reason(s):

1. The Amendment is consistent with the approved Muchea Employment Node Structure Plan 2011
2. The Amendment is consistent with the Draft Shire of Chittering Local Planning Strategy

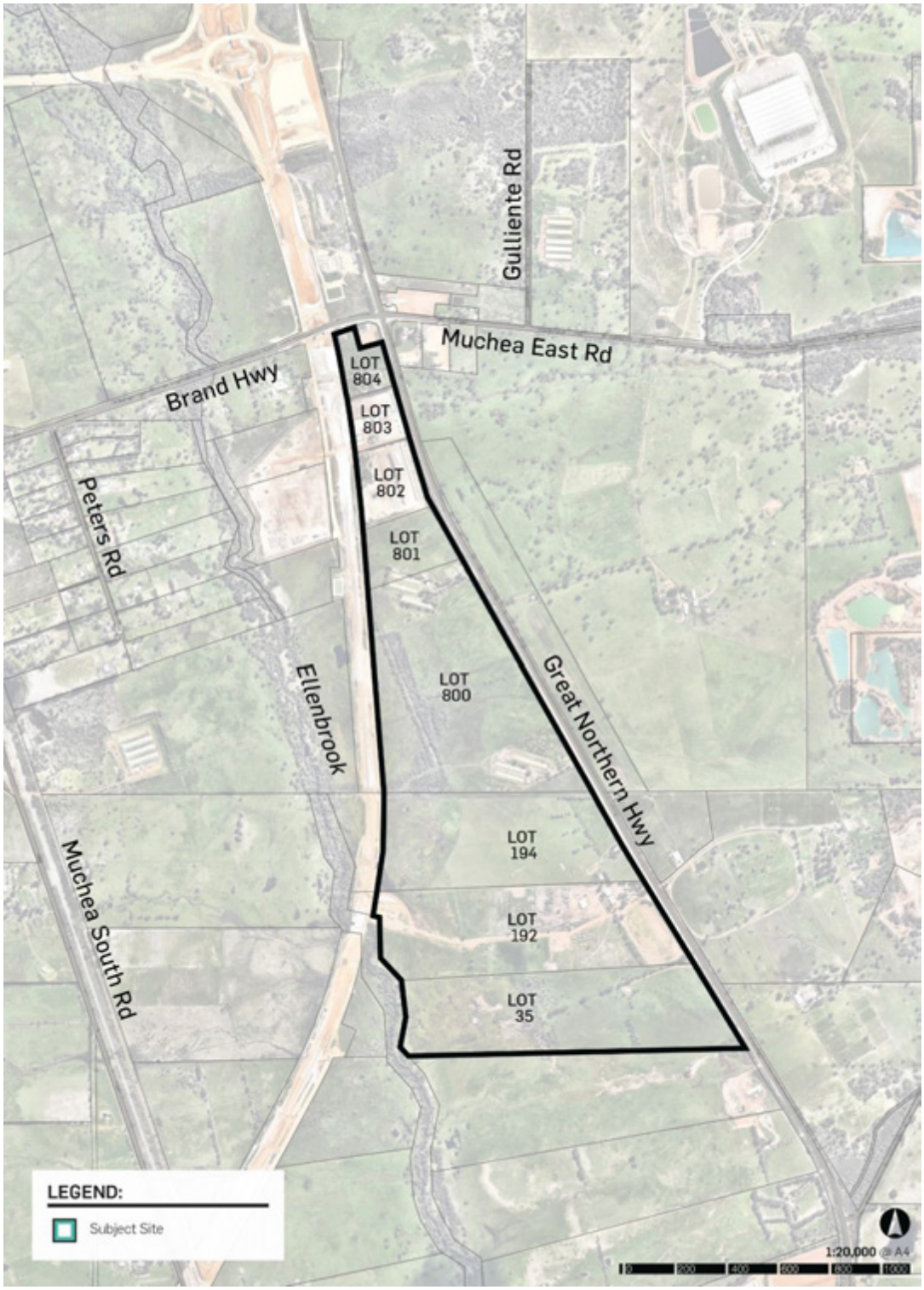
# 2. SITE DESCRIPTION

## 2.1. LAND DESCRIPTION

### 2.1.1. Location

The Amendment area, comprising P3, is approximately 185ha in area, and bound by GNH to the east, the PDNH to the west, Brand Highway to the north, and the southern boundary of the Shire of Chittering to the south (refer to **Figure 1 – Location Plan**).

Figure 1 – Location Plan



### 2.1.2. Area and Land Use

The Scheme Amendment area is 185ha, and comprised of farmland, logistics businesses, manufacturing and three poultry farms (under lease agreements – to end 2019). The following businesses are notable as operating within the Scheme Amendment area:

| | |
|---|---|
| Lots 802 and 803: | Aussie Modular Solutions (AMS) |
| Lots 800 and 801: | Ingham Enterprises (poultry farms) |
| Lot 192: | Road Trains of Australia (RTA) |

The land has largely been historically cleared for agricultural purposes and contains stands of large, mature trees with degraded understorey, and a number of rural drainage lines. At its south-west, P3 abuts the Ellen Brook foreshore.

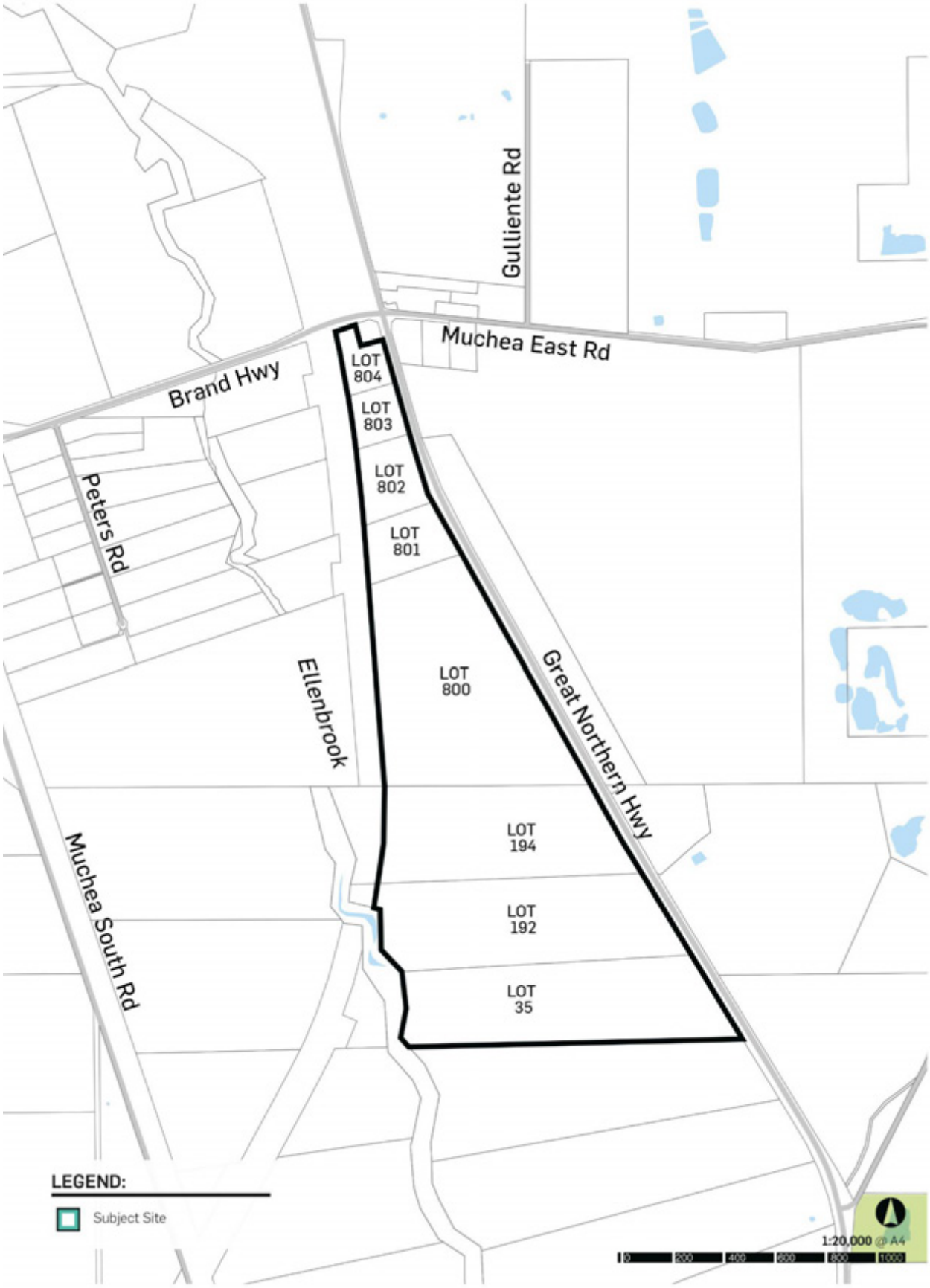
## 2.1.3. Site Particulars

Details of the subject land's legal particulars are provided in **Table 3 and Figure 2 – Cadastral Plan**. Copies of the Certificates of Title are included at **Appendix A – Certificates of Title**.

**Table 1 – Certificates of Title: P3 Properties**

| Lot | Street | Volume/ Folio | Plan/ Diagram | Owner | Land Area | Encumbrances (easement, caveats etc.) |
|---|---|---|---|---|---|---|
| **804** | 43 Brand Hwy, Muchea | 2895/897 | Deposited Plan 404617 | Andrew Quince | 3.9ha | Except and reserving metals, minerals, gems and mineral oil specified in transfer 1132/1935.<br>Caveat by Pure Steel Shed Constructions Pty Ltd as to portion only lodged 3/9/2015. |
| **803** | 3571 Great Northern Hwy, Muchea | 2903/24 | Deposited Plan 404616 | Karratha Enterprises Pty Ltd | 4.3ha | Except and reserving metals, minerals, gems and mineral oil specified in transfer 3000/1933 |
| **802** | N/A | 2903/23 | Deposited Plan 404616 | Karratha Enterprises Pty Ltd | 7.1ha | Except and reserving metals, minerals, gems and mineral oil specified in transfer 3000/1933 |
| **801** | N/A | 2903/33 | Deposited Plan 404613 | Ingham Rural Property Group Pty Ltd | 7.6ha | As per Lot 800 |
| **800** | N/A | 2903/33 | Deposited Plan 404613 | Ingham Rural Property Group Pty Ltd | 51.3ha | Except and reserving metals, minerals, gems and mineral oil specified in transfer 188/1945<br>Easement benefit (D72548). |
| **194** | 3383 Great Northern Hwy, Muchea | 2862/298 | Deposited Plan 405699 | Amuse Pty Ltd | 33.5ha | Except and reserving metals, minerals, gems and mineral oil specified in transfer 9703/1919 and 9704/1919<br>Restrictive Covenant Burden. Registered 1/7/1980<br>Easement Burden for right of carriageway purposes. See DP 405699 and sketch on Vol 1868 Fol 805. Refer Lot 800. |
| **192** | 3363 Great Northern Hwy, Muchea | 2862/297 | Deposited Plan 405698 | Barton Cecil Jones<br>David John Cecil Jones | 37.9ha | Except and reserving metals, minerals, gems and mineral oil specified in transfer 9703/1919 and 9704/1919<br>Restrictive Covenant Burden. Registered 1/7/1980.<br>Caveat by Shire of Chittering as to portion only lodged 2/12/2015 |
| **35** | 3329 Great Northern Hwy, Muchea | 1868/807 | Diagram 72548 | Neil John Bovenizer | 38.9ha | Except and reserving metals, minerals, gems and mineral oil specified in transfer 9703/1919 and 9704/1919 |
| | **TOTAL** | | | | **184.5ha** | |

**Figure 2 – Cadastral Plan**



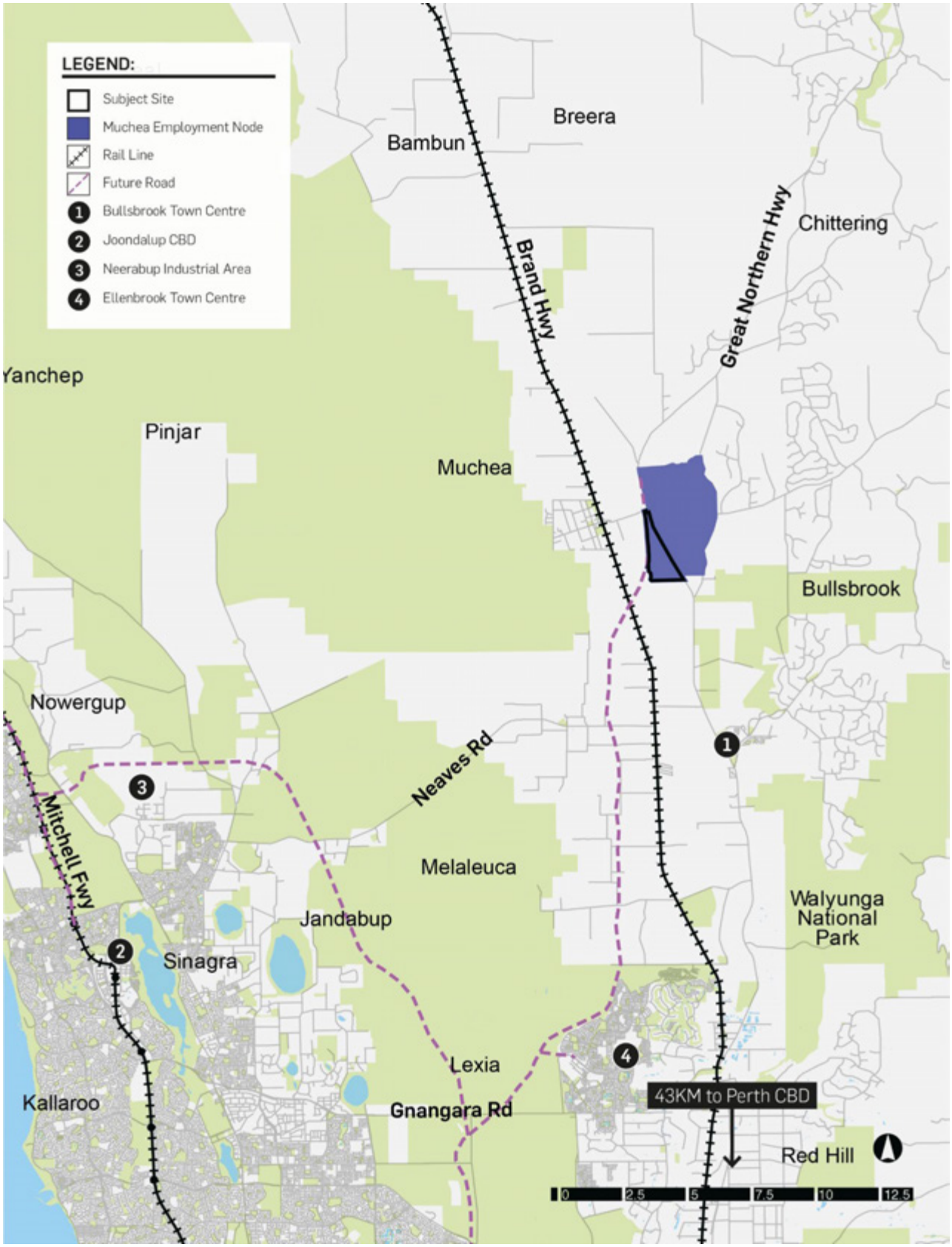
## 2.1.4. Site Context

### 2.1.4.1. Regional Context

**Figure 3 – Regional Context Plan** identifies the Amendment area's location in a broader context, being:

- 43km to Perth CBD – Muchea is located within the Wheatbelt region of Western Australia
- High level of commercial exposure and convenient access to GNH within the eastern portion of P3; and commercial exposure to the PDNH (under construction)
- Immediately to the west of the Scheme Amendment area is the Midland-Geraldton railway, providing direct freight access to Fremantle Port and Geraldton
- Joondalup CBD is located 28km south west of the subject site – this is a strategic metropolitan centre and the highest order retail offered in Perth's north
- Neerabup Industrial Area is located 23km south west of the subject site, the current nearest industrial area to the subject site
- P3 forms part of the Muchea Employment Node (also referred to as the MIP) which in time, will provide significant land for a range of industrial purposes
- Other key activities within the region include:
- Ellenbrook Town Centre
- Royal Australian Air Force Australia Base (RAAF)
- Numerous national parks and nature reserves

**Figure 3 – Regional Context Plan**

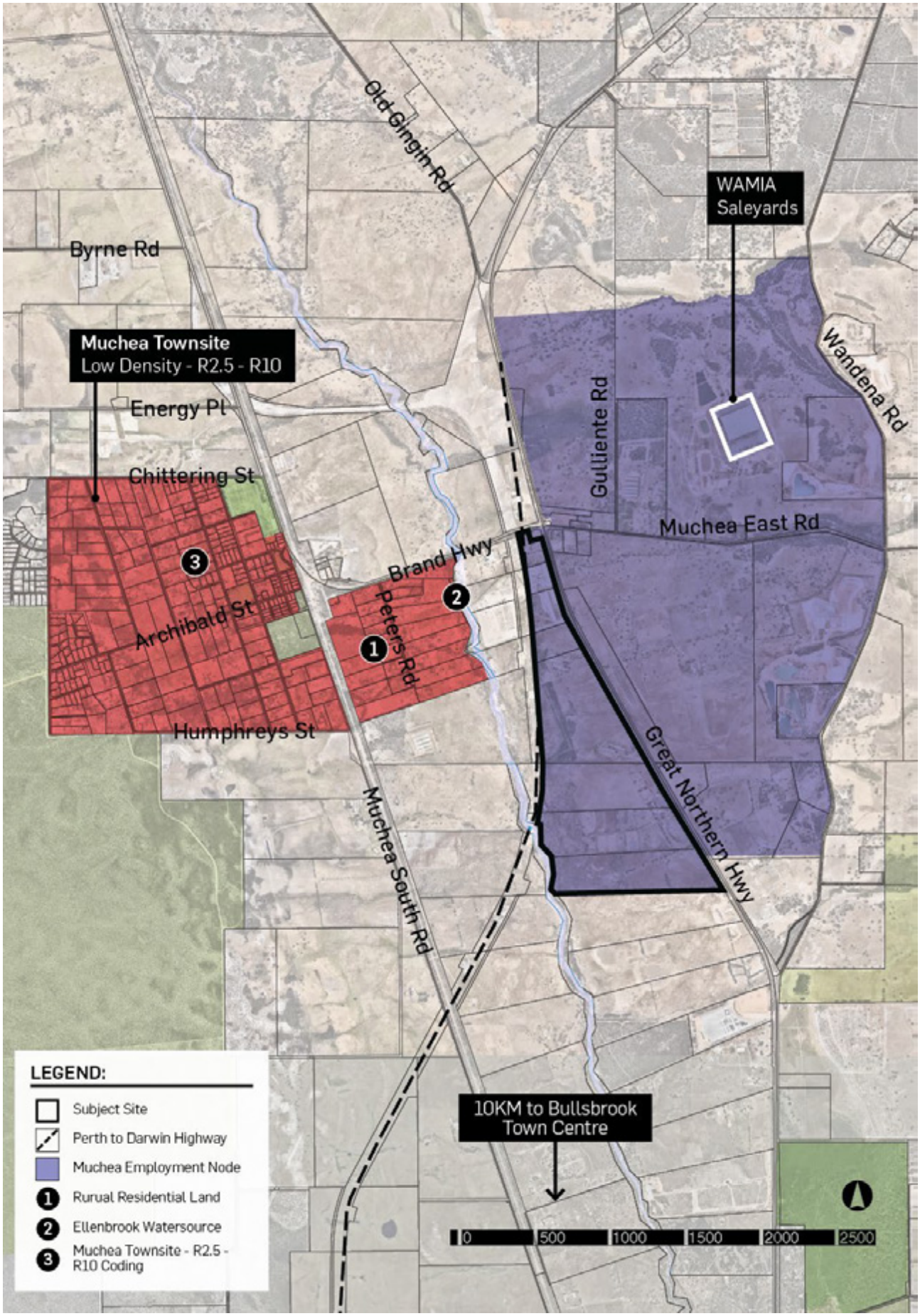


#### 2.1.4.2. Local Context

**Figure 4 – Local Context** illustrates the Amendment area's local context:

- Muchea is generally characterised by agricultural development with low density and rural residential living opportunities
- Bullsbrook is located 10km south of the subject site – this is the closest service centre
- Immediately to the north-west of the Scheme Amendment area are rural residential lots ranging from 2ha – 6.6 hectares.
- The poultry farms located on Lots 800 and 801 are subject to lease arrangements ending December 2019, leased to Ingham Enterprises
- Lot 802 is an Additional Use 17 (AU17) in the Shire of Chittering's LPS6, allowing P3 to be used for general warehouse/storage purposes, limited to the manufacture, assembly, storage and transportation of transportable buildings
- Lot 192 accommodates Road Trains of Australia (RTA), a well established transport logistics business
- To the east of the subject land including land within P3 is the MENSP area – an area envisioned for a range of industrial uses
- To the north-west of the subject land is Muchea Townsite - a low density (R2.5 – R10) residential area, home to a population of approximately 1000 people (ABS 2016)
- To the north-east of the subject land is the WAMIA Sale Yards which is a substantial employer and contributor to the Chittering and Wheatbelt economies.

**Figure 4 – Local Context Plan**



# 3. PLANNING FRAMEWORK

This section details the local planning framework applicable to the Amendment area.

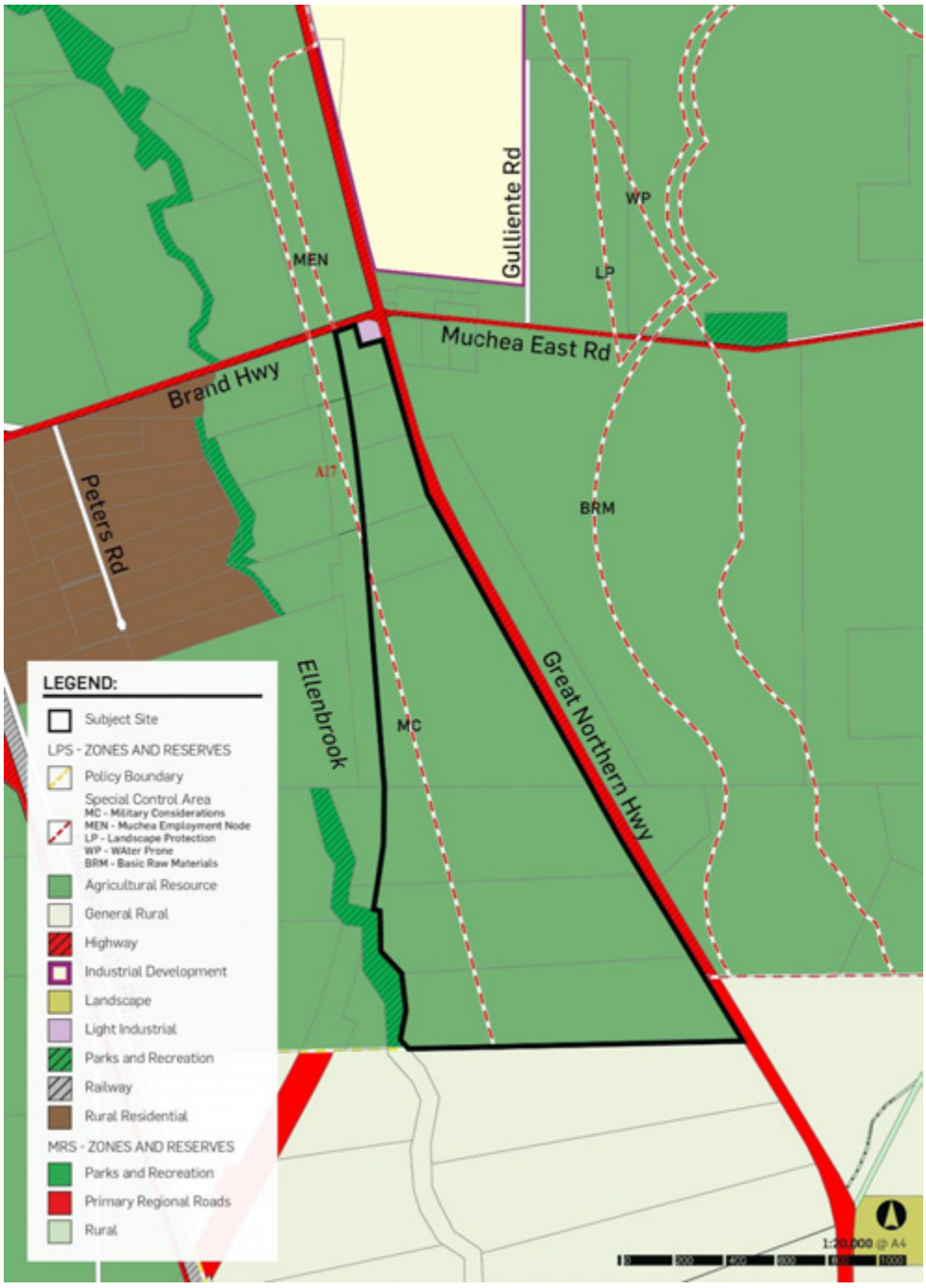
## 3.1. ZONING, RESERVATIONS AND LAND USE PERMISSIBILITY

### 3.1.1. Shire of Chittering Local Planning Scheme No.6

The subject land is currently zoned 'Agricultural Resource' under the Shire of Chittering LPS6 and has frontage to GNH which has a 'Highway' reservation, and exposure to the PDNH (under construction). Refer **Figure 5 – Shire of Chittering Local Planning Scheme No.6**.

The subject land is located just outside the boundary of the Perth Metropolitan Area and is therefore not affected by the Metropolitan Region Scheme (MRS).

**Figure 5 – Shire of Chittering Local Planning Scheme No.6**



### 3.1.1.1. Industrial Development Zone

To facilitate industrial development over the Scheme Amendment area, it is proposed that the land will be included in the 'Industrial Development' zone. The objectives of the 'Industrial Development' zone within LPS6 are as follows:

- *'Designate strategic land areas for future industrial development and employment creation purposes, and prevent such land from being used or developed in a manner which could prejudice its use for this purpose*
- *Ensure orderly and comprehensive planning and co-ordinated subdivision and development through the requirement for the preparation and endorsement of a Scheme Amendment in accordance with Part 4 of the deemed provisions and any associated provisions contained in Schedule 10 of the Scheme*
- *Ensure the coordinated provision of infrastructure, and the equitable sharing of service costs associated with subdivision and development of industrial land*
- *Protect the amenity of adjacent properties*
- *Protect the environmental assets of the site'*

The purpose of this Scheme Amendment is to facilitate the development of the subject land for industrial development in accordance with the planning framework, in a manner which protects residential amenity and environmental values.

### 3.1.1.2. Land Use Permissibility

Currently land use permissibility set out in the Zoning Table of LPS6 states that landuse for the 'Industrial Development' zone is to be '*in accordance with Clause 3.4.3*'. This clause requires that the local government is to have due regard to a Structure Plan (or similar) when determining applications within this zone. Other appropriate land uses may be introduced via a scheme amendment to LPS6.

Land use permissibility for P3 will be in accordance with the General Industrial Zone of LPS6 (as amended). The following uses will also be considered within P3, in accordance with their applicable permissibility as outlined below:

**Table 2 – MENSP Land Use Permissibility**

| Land Use | Permissibility |
|---|---|
| **Animal Establishment** | D |
| **Concrete Batching Plant** | D *1 |
| **Fast Food Outlet** | D *2 |
| **Garden Centre** | P |
| **Shop** | I |
| **Transport Depot** | P *3 |

*1 Concrete Batching Plant means 'premises on which concrete is batched for concrete products manufactured on site for use at places other than the subject site, and includes storage of associated products and ancillary office use'

*2 Only where the use is located abutting Great Northern Highway, and associated with a Convenience Store and/or Service Station

*3 In the case of 'Transport Depot', accommodation for a site manager and drivers' accommodation will be allowed, in order to accommodate critical operational requirements of these businesses, ancillary to the Transport Depot use.

All other uses are 'X' (not permitted)

It is noted that the MENSP sets out a range of land uses and their related permissibility, along with the uses considered most suitable for the highway location. There are a number of inconsistencies, however, in terminology and permissibility between the land uses listed in the MENSP. In addition, the MENSP is currently under review and the Shire of Chittering is approaching gazettal of Amendment No.65 which proposes modifications to the Zoning Table.

Determination of land use and lot size will be subject to servicing provision, the requirements of business, vehicle access and egress and other factors, and further discussion with the Shire at the subdivision and development stage will be required.

Development standards will be otherwise consistent with the 'Industrial Development' zone and Schedule 11 of the Scheme.

Clause 4.9 of LPS6 sets out development requirements for industrial zones includes the following relevant requirements:

- *Emissions are to be avoided or suitably managed*
- ***Where an on-site wastewater disposal system is proposed, land capability assessment, use of fill or drains and land area to distribute treated sewerage is required (with secondary treatment systems where required)***
- ***Industrial development not connected to reticulated sewerage is to be restricted to 'dry industry'*** *being land use that intends to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building*
- *Trade waste is to be managed and appropriately disposed of*
- *Caretakers accommodation requirements apply* (Note: caretaker accommodation is not permitted as per MENSP and LPS6)
- *A structure plan may be required* (in the case of land within the MENSP, a structure plan is required)

Points 2 and 3 relating to on site wastewater disposal above are particularly relevant to the Structure Plan and are addressed below in the servicing section.

#### 3.1.1.3. Military Considerations Special Control Area

The Military Considerations Special Control Area (SCA) affects the eastern portion of the Scheme Amendment area. Development approval is required for any development within the SCA, with any dwelling constructed to comply with AS2021-2000 Aircraft Noise Intrusion – Building Siting and Construction. One dwelling per lot only is allowed. Given the proposed development is for industrial purposes, there are no implications for the Scheme Amendment, unless any structures are proposed above 90m.

#### 3.1.1.4. Muchea Employment Node SCA and Schedule 11

As noted above, the subject land is located within the Muchea Employment Node SCA and Schedule 11. The purpose of the MENSP SCA is to implement the MENSP, and to require development approval for any development within the SCA.

No residential development or caretaker accommodation is permitted within the SCA.

A Scheme Amendment is required for land proposed for industrial development, with subdivision or development in accordance with the provisions and requirements of Schedule 11 of LPS6. Reticulated water and suitable servicing including reserving/construction of roads is required. Other provisions relating to separation distances, visual impact and protection of environmental assets are required to be addressed.

Where basic raw materials are located on the lot, proposals need to consider whether the proposed development will impact upon extraction of the resource.

Schedule 11 lists a range of strategies required to support a Structure Plan comprising:

- Requirement for preparation of a Structure Plan
- Preparation of Environmental Management Plans to inform the design and proposed subdivision and development of the Scheme Amendment area, being (where appropriate):
    - Local Water Management Strategy
    - Environmental Assessment and Management Strategy
    - Strategic Noise Assessment and Management Strategy
    - Strategic Odour Assessment and Management Strategy

- Transport Assessment and Management Strategy
- Flora, Vegetation, Wetland and Waterway Management Plans
- Acid Sulphate Soils (ASS) Site Assessment Management Plan
- Urban Water Management Plan
- Geotechnical Report
- Water Supply and Wastewater Disposal Strategy
- Noise Management Plan
- Construction Management Plan
- Odour Management Plan
- Waste Management Plan

In addition, the provisions require the following:

- Reticulated water supply and wastewater disposal systems at the first stage of subdivision
- Reticulated water and wastewater systems to be provided by licensed service providers
- Provision of water and wastewater systems subject to a Development Contribution Plan (*note that the Shire has since advised that it does not intend to prepare a Development Contribution Plan for the MENSP area*)
- Separation distances as set out by State Planning Policy (SPP) or the Environmental Protection Authority (EPA)
- Where a licensed reticulated water scheme is not available and connected to the estate's reticulated system at the time of development, land uses shall be generally limited to Transport Depot, Storage, Warehouse and Landscape Supplies. In the case of P3, reticulated water will be provided.

  Development applications are required to demonstrate that the proposed use/development has an adequate and sustainable water supply to service the day to day operational needs of the land use on an ongoing basis and the proposed use shall be consistent with the objectives of the zone, and any applicable Structure Plan.

# 4. REGIONAL AND SUBREGIONAL PLANNING CONTEXT

This section details the State and sub-regional planning framework applicable to the subject land.

## 4.1. PLANNING STRATEGIES

### 4.1.1. State Planning Strategy (2014)

The State Planning Strategy (SPS) details strategic goals and objectives for regional planning issues. The SPS aims to achieve 'strong and resilient regions' through embracing diverse (employment) opportunities and building strong networks, while also 'planning for economic development' through the development of industrial and economic clusters. The identification of the MENSP for industrial development is consistent with the State's objectives.

### 4.1.2. Perth & Peel @ 3.5 Million (2018)

While P3 sits outside of the Perth & Peel @ 3.5 million study area, the document identifies the nearby Bullsbrook townsite as a centre for expansion for the north-east metro area. Muchea is expected to reap the benefits of this growth through the expansion of the Bullsbrook Intermodal Terminal and completion of the PDNH. This will enable greater accessibility to P3, and promote Muchea as an emerging employment node for the expanded Bullsbrook townsite and surrounding areas.

### 4.1.3. Wheatbelt Regional Planning and Infrastructure Framework (2015)

The Wheatbelt Regional Planning and Infrastructure Framework provides an overview of regional planning issues and a basis for ongoing planning and development. The MENSP area is recognised as being important in providing serviced industrial land to provide opportunities in the short and long term for the establishment of new industries in, and relocation of existing industries, to the Wheatbelt. It is a high level document and there are no implications of direct relevance to the Scheme Amendment area.

### 4.1.4. Muchea Employment Node Scheme Amendment (MENSP) (2011)

As noted, the Scheme Amendment area forms part of P3 of the MENSP (refer **Figure 6 - MENSP**). The MENSP provides the 20 year land use planning framework for industrial development in order to concentrate local employment opportunities within the Shire of Chittering and its surrounds. Intended land uses are industrial service based, such as transport, livestock, fabrication, warehousing, wholesaling and general commercial use.

The subject land is identified for 'Proposed Industrial Development', and is affected by the following:

- 500m poultry farm buffer (Note: the Poultry Farms are under lease to Ingham Poultry until end 2019)
- 500m rural residence buffer
- Proposed access road (service road) running parallel with GNH
- Reserves for conservation, recreation, foreshore management or regional open space over minor waterway (non-perennial)
- The western portion of the land is also affected by a 1000m townsite buffer and the 500m rural residence buffer

#### 4.1.4.1. Separation Distances

The separation distances (or buffers) noted above limit sensitive uses, such as residential development, being allowed within proximity to uses such as industry and poultry farms. Reference to the Rural Residence and Townsite Buffers is limited within the MENSP plan to the following text:

*'Residences in and surrounding the Scheme Amendment area are deemed to be sensitive receivers. They pose a constraint to the future development of the Scheme Amendment area, with regard to noise emissions subject to assessment under the Environmental Protection (Noise) Regulations 1997 and State Planning Policy 5.4. This must be taken into further consideration in the determination of land use applications for future industrial development'*

As noted, the Poultry Farms will be removed to facilitate development of the land for industrial purposes.

#### 4.1.4.2. Development Contribution Plan

The MENSP notes that a Development Contribution Plan (DCP) is intended to be prepared to require developers to provide contributions for improvements and intersection treatments for existing and future primary regional roads.

It is understood that the Shire has, however, since decided not to prepare a DCP, and therefore any infrastructure requiring cost sharing (if required) will need to be addressed by private landowner agreements in accordance with State Planning Policy 3.6: Development Contributions.

#### 4.1.4.3. Development Provisions

Provisions for P3 include:

- Low water type industries with a minimum lot size of 10,000m2 unless wastewater can be otherwise managed
- ATU's are required with secondary pond treatment
- Development to not conflict with the PDNH
- The access road (loop road) shall have a road reserve of 30m
- Structures higher than 90m require referral to RAAF

Land use permissibility is discussed above.

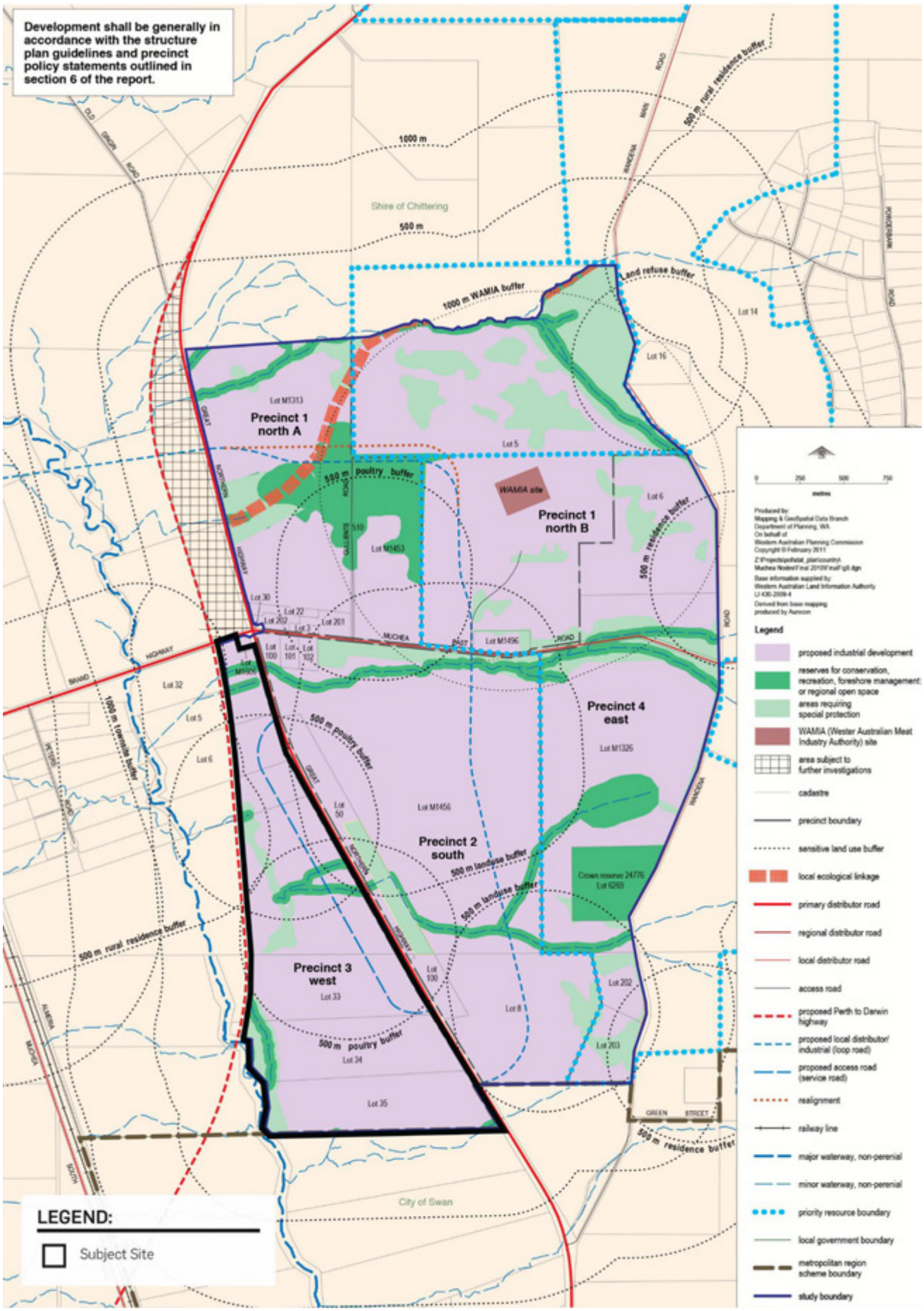
Servicing and vehicle movement are addressed in sections 7 and 10 below and comply with the above development provisions. The other requirements will largely be addressed at the development application stage.

#### 4.1.4.4. Zoning

The MENSP proposes a 'Future Industry Zone' for the area which would be a new zone in LPS6, requiring Scheme Amendments to be prepared over individual precincts.

LPS6, however, already contains an 'Industrial Development' Zone which is consistent with the Model Scheme Text provisions contained within the *Town Planning (Local Planning Schemes) Regulations 2015 (*'the Regulations'*)*, and also requires a Scheme Amendment to be prepared. The terminology of this zone effectively supersedes the MENSP proposed 'Future Industry Zone' and therefore Amendment No.67 to LPS6 subsequently proposes the 'Industrial Development' Zone for the subject land, consistent with the Model Provisions of the Regulations.

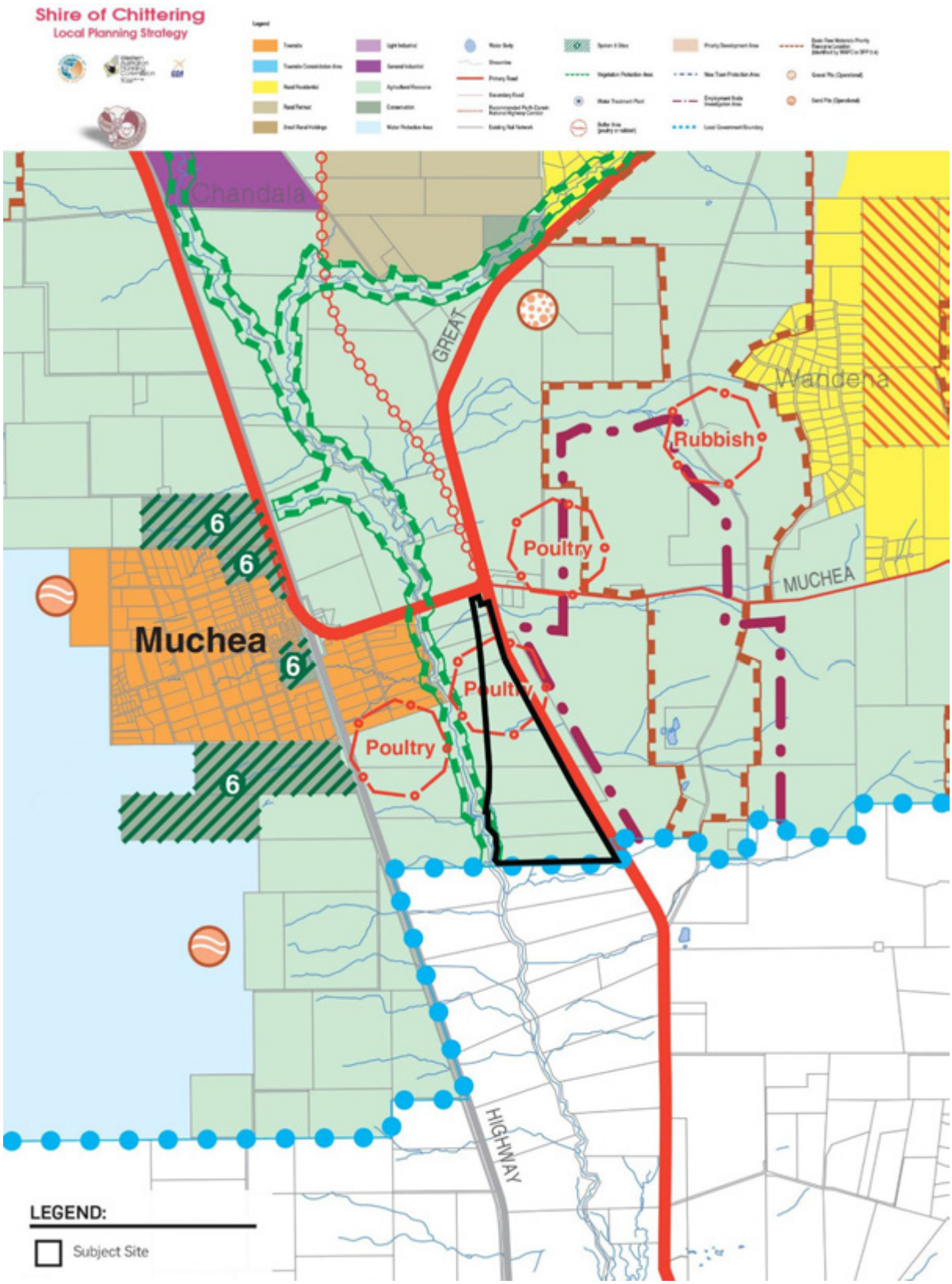
**Figure 6 – Muchea Employment Node Structure Plan**



### 4.1.5. Local Planning Strategy 2001-2015 (2004)

The Shire of Chittering LPS identifies the current Ellen Brook water course on the property, GNH and current poultry operation buffers, and the current extent of the Agricultural Resource Zone. The LPS precedes the MENSP (refer **Figure 7 – LPS Extract**).

**Figure 7 – LPS Extract**



### 4.1.6. Draft Local Planning Strategy

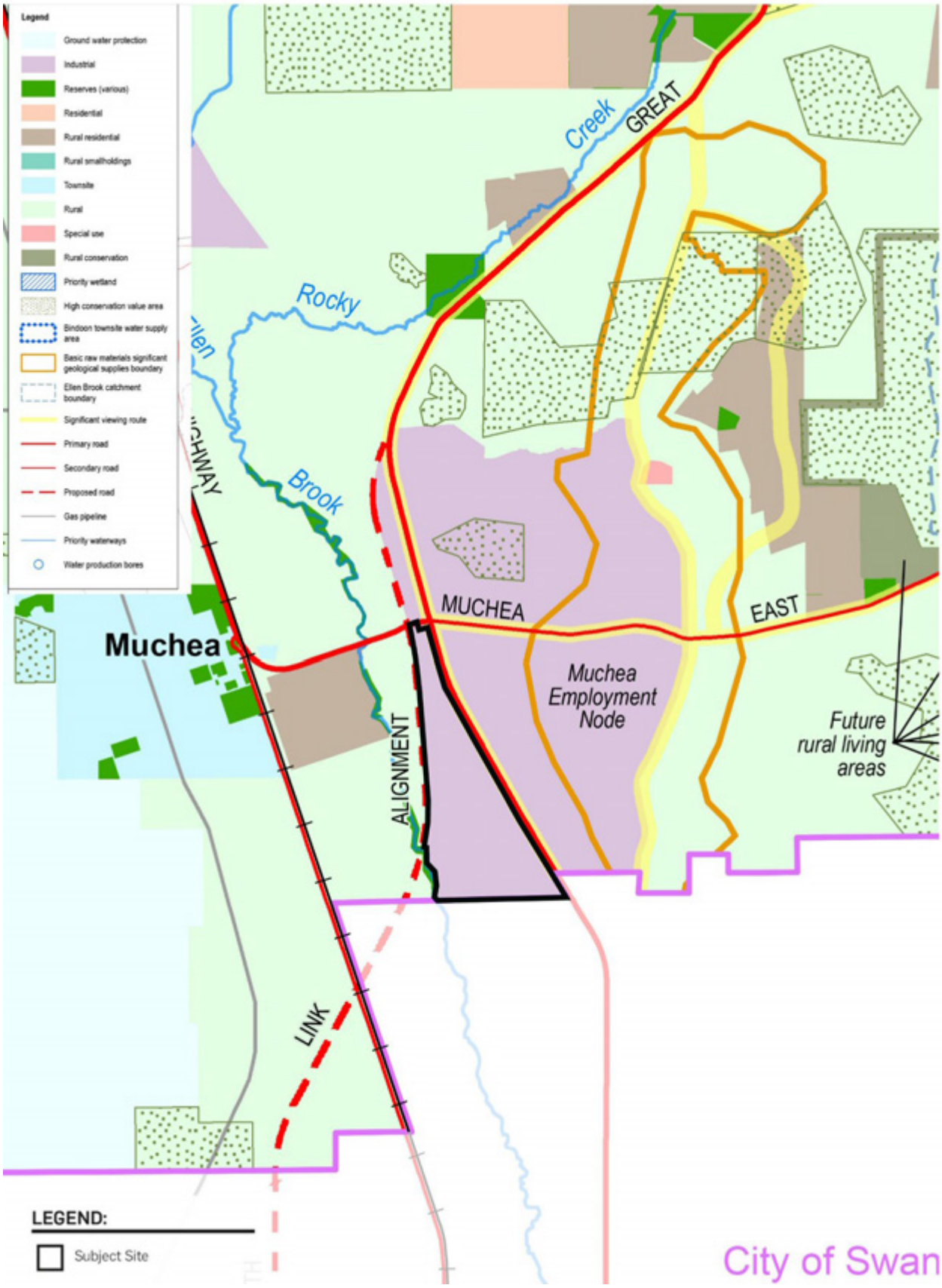
The Shire of Chittering's Draft LPS was advertised for public comment in 2018. The strategy identifies the MENSP as a planning precinct, referred to as Muchea Industrial Park (MIP) (refer **Figure 8 – Draft LPS Extract**). MIP is expected to both facilitate and contain all of the Shire's future industrial activity. Upon its completion in 2019, the PDNH and an intended GNH upgrade is expected to stimulate the MIP's industrial development to become a 'major employment hub of (Perth's) north-east corridor'.

The Draft LPS also provides strategic provisions and actions for the MIP's development. This includes protecting and preserving areas of high environmental value within P3. Future development of precincts within the MENSP will require consideration of the following:

- Ensure 324ha of vegetation within the MENSP (MIP) is reserved for conservation
- Have primary regard for the Ellen Brook catchment, including water quality in planning industrial land uses
- Be separated from all residential and rural residential areas by a 1km buffer to ensure sufficient separation of incompatible uses
- Reflect the potential for mineral sands to exist on the coastal plain
- Provision of an acceptable means of wastewater disposal, stormwater management and drainage, effluent disposal and water supply
- Removal of uses that are permissible within the 'Agricultural Resource Zone', but are not compatible with primary production
- Subdivision design of P3 to accommodate servicing by RAV vehicles
- Establishment of compatible design features over screening design elements such as fencing, vegetation, buffers and open space

The Scheme Amendment has been prepared in the context of the Draft LPS and addresses the above considerations.

**Figure 8 – Draft LPS Extract**



## 4.2. PLANNING POLICIES

### 4.2.1. State Planning Policy No.3.7 – Bush Fire Risk Management

As P3 is identified to be within a designated bushfire prone area, the Scheme Amendment will be accompanied by a Bushfire Management Plan. Compliance with bushfire protection criteria will is required in accordance to the policies set out within SPP 3.7. This will include a Bushfire Hazard Level assessment and BAL Contour Map. Bush Fire Management is addressed below.

### 4.2.2. State Planning Policy No.2.4 – Basic Raw Materials

SPP2.4 sets out matters which are to be taken into account when considering zoning, subdivision and development applications in the vicinity of identified basic raw material resource areas. P3 is currently zoned Agricultural Resource; a zone which permits the extraction of basic raw material resources, although no extraction areas are identified within P3. The Tiwest processing plant is the nearest raw material extraction land use to the Scheme Amendment area, located 3km to the north.

### 4.2.3. Draft State Planning Policy No.2.4 – Basic Raw Materials (October 2018)

SPP2.4 was recently reviewed by the WAPC, with a draft revised version of the policy advertised until late January 2019. The Policy requires the conservation of key resources areas, and the protection of existing resource and extraction areas from development or incompatible land uses. To achieve this, key considerations include:

- Avoiding development on low lying areas that require large volumes of fill, or by using different design and construction methods, and alternative earthworks strategies such as subsoil drainage
- Use of existing extraction sites and significant geological supply areas, favouring those sites located within the local vicinity to minimise transportation requirements and potential related impacts on communities, amenity, safety and the environment
- Existing significant geological supply areas and extraction site (and relevant buffers) should not be developed for any other purpose unless the proposed use is compatible, or until the resource is extracted

Advice received from the Department of Mining, Industry Regulation and Safety (DMIRS) confirms that there are no resources present within the Scheme Amendment area, following extensive mineral exploration along the foot of the scarp over some years. If, through development or further site excavations, an individual landowner finds a quality deposit, then DMIRS advised it would be a private matter between the landowner and the exploration license holder if it were decided to proceed with any removal of the resource. In addition, advice received from the DMIRS confirms that there is no land within P3 affected by separation buffers or key resource areas.

### 4.2.4. State Planning Policy No.3.6 – Development Contributions

This policy sets out the principles and considerations that apply to development contributions for the provision of infrastructure in new and established urban areas, and the form, content and process to be followed. The funding mechanisms for future infrastructure requirements will be a consideration for the Shire and landowners.

### 4.2.5. Other State Policies

**Table 3 – Other State Planning Policy Considerations**

| State Planning Policy | Details |
|---|---|
| **SPP 2 Environment and Natural Resource Policy** | SPP2 sets out to create sustainable development outcomes by resolving conflicts between land use and protection of natural resources. Ecological, social and economic factors must be considered to allow for integrated decision making. Future land uses within P3 will be assessed based on their adherence to requirements for air quality, water resources, soil & land quality, landscape, basic raw material resources, greenhouse gas emissions and energy efficiency. Given P3's proximity to the Ellen Brook, potential impact from changes in climate and weather from human activities, natural resources, and water resources may also be considered in relation to the area. |
| **SPP 2.5 Agricultural and Rural Land Use Planning** | The Scheme Amendment area is currently zoned Agricultural Resource. SPP 2.5 aims to protect and sustainably manage environmental, landscape, and water resource assets within the state's rural areas. SPP2.5 aims to avoid land use conflict in rural areas. As P3 is to be developed for industrial purposes, future development applications will need to address separation requirements. Given the proximity of P3 to the Muchea Town Centre (1km to the north east), separation distances will need to comply with EPA requirements. |
| **SPP 2.9 Water Resources** | SPP2.9 outlines policy concerning environmental and natural resources to be considered during Scheme Amendment. This includes identifying and prioritising water resources for potential state, regional, and local significance, as well as ameliorating environmental impacts on site. The Scheme Amendment identifies water resources situated within P3 (incl. Ellen Brook) and an assessment of their value. Integration and protection of water resources within the MENSP is vital to ensure state environmental goals are achieved. |
| **SPP3.7 Planning in Bush Fire Prone Areas** | This policy provides the foundation for land use planning to address bushfire risk management in Western Australia. It is used to inform and guide decision-makers, referral agencies and landowners/ proponents to help achieve acceptable bushfire protection outcomes. The subject site is identified as being within a Fire Prone Area. A Bush Fire Management Plan is required to be prepared at the Scheme Amendment and Structure Plan stage. |
| **SPP 4.1 State Industrial Buffer Policy** | Buffer areas are inevitably determined by the size, scale, and form of industrial land uses. Separation between the industrial land use and residential or other sensitive land uses will be determined at the development stage. |
| **SPP 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning**<br><br>**And DRAFT revised SPP5.4 (September 2017)** | Road and rail transport corridors play a vital role in moving people and goods safely, efficiently and effectively, while providing wide-ranging economic and social benefits to the community. However excessive noise from road and rail traffic can also have the potential to affect the health and amenity. As P3 is to be developed for industrial purposes, no noise assessments at the Scheme Amendment stage are required, as advised by DPLH. |

### 4.2.6. EPA Guidance for the Assessment of Environmental Factors No.3

This document provides guidelines for separation distances between industrial and sensitive land uses. P3 is located approximately 1km from Muchea and largely in excess of 500m from any sensitive uses, also separated by the PDNH alignment. It is therefore unlikely that any issues relating to separation or buffers will arise.

At the development application stage, proponents will need to give consideration to separation distances between the proposed land use and any affected residential or other sensitive uses in accordance with the Guidance Statement.

## 4.3. LOCAL PLANNING POLICIES

Table 4 – Local Planning Policy Considerations

| Local Planning Policy | Details |
|---|---|
| **LPP 10. Basic Raw Materials and Extractive Industries** | LPP10 provides development guidelines for all material extraction industry within the Shire of Chittering. Supported by the previous Local Planning Strategy 2001-2015 (2004), Extractive Industries are an "A" use in Agricultural Resources zoned land, with preferred development to have access to either Brand or GNH. LPP 10 highlights the TiWest (Tronox) Processing Plant in Muchea as the only extractive industry location within the Shire. The plant is located on Brand Highway, approximately 3km North of the MENSP. The policy has no direct implications for the subject land. |
| **LPP 16. Roads and Drainage** | LPP16 provides guidelines for the construction and development of roads and new drainage systems within the Shire. Drainage is to be constructed in accordance with Water Sensitive Urban Design (WSUD) principles. |
| **LPP 18. Setbacks** | Introduced to protect the Shire's environmental and aesthetic assets, LPP18 establishes setback requirements in addition to those set out in TPS 6. Aside from maintaining the rural character of the Shire, LPP18 also seeks to protect water courses and wetlands, while also preserving natural vegetation from increased development. Whilst the setbacks do not refer to industrial zones, the setback to a drainage easement is 10m. Setbacks also apply to bores and wells in all zones. |
| **DRAFT LPP 33. Muchea Industrial Park Design Guidelines and Road and Drainage Guidance Note** | Draft LPP33 and its associated Road and Drainage Guidance Notes were advertised during December 2018. The intention of the Design Guidelines is to achieve a reasonable level of design and visual consistency, and requirement for structures to be constructed of new materials. Submissions on the Policy are currently being considered and the Policy finalised. |

## 4.4. KEY OUTCOMES FROM REVIEW OF STRATEGIC AND STATUTORY PLANNING CONTEXT

Overall, the proposed development of P3 for industrial purposes is consistent with P3's strategic and statutory context. The development of P3 will address the current and expected future shortage of industrial land within this area, and provide for business growth, increased employment and industrial support for logistics operations, consistent with the objectives of the various strategic documents reviewed, and with the substantial improvements in the regional transport network provided by the construction of the PDNH and the proposed upgrade of GNH.

The key considerations arising from the above review are relevant:

- The MENSP proposed P3 to be developed for industrial land use of the nature proposed in this Scheme Amendment
- A number of development provisions are applicable to the land, including the low water type industries with a minimum lot size of 1ha (unless wastewater can be managed), ATU's required with secondary pond treatment, access road reserves to be 30m, structures higher than 90m to be referred to RAAF and development to ultimately not conflict with the PDNH. These requirements will largely be addressed at the development stage
- The land is impacted by two 500m buffers associated with a poultry farm and rural residence, and a 1000m townsite buffer, which establish separation distances between residential and sensitive uses, and industrial development proposed on individual lots within P3. The poultry farms within P3 will be discontinued in due course to enable the land to be developed for industrial purposes. Other separation distances will be addressed via the EPA's Guidance Statement via the development approval process
- There is a focus on protecting and preserving areas of high environmental value within P3, including land adjacent to Ellen Brook within the southern portion of P3
- In relation to basic raw materials, advice received from the DMIRS confirms that there are no resources present within the area, nor is there land within P3 affected by separation buffers or key resource areas
- Integration and protection of water resources within the MENSP is essential

Each of these items is addressed, and demonstrated to be complied with, in this Scheme Amendment.

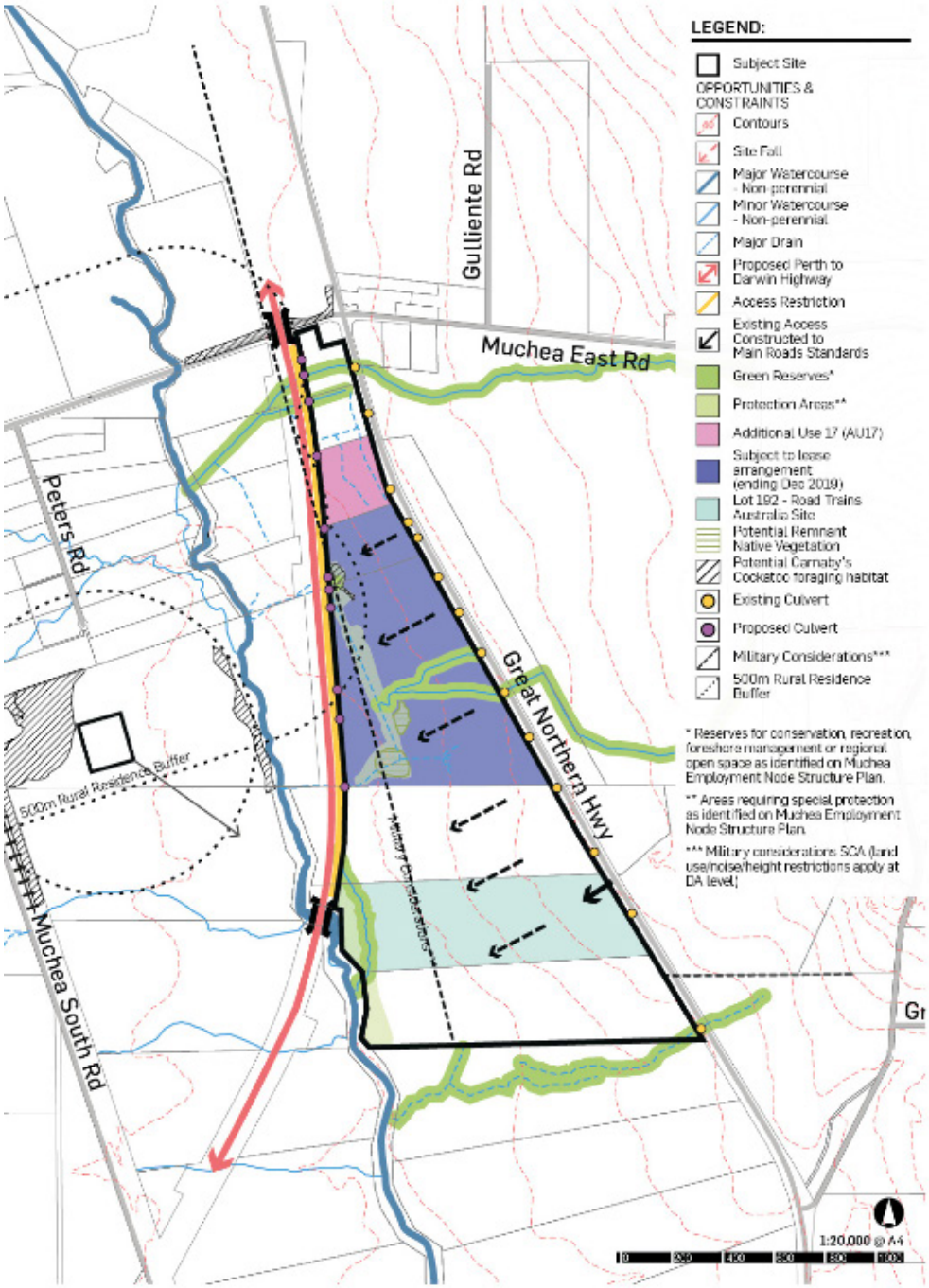
# 5. SITE CONDITIONS AND CONSTRAINTS

Key opportunities and constraints of the Scheme Amendment area are detailed on **Figure 9 – Opportunities and Constraints Plan**.

The following section outlines these opportunities and constraints in further detail, informed by the technical reports appended to the Scheme Amendment including:

- Environmental Assessment and Management Strategy (EAMS) prepared by Bayley Environmental (**Appendix B – EAMS**)
- Transport Impact Assessment (TIA) prepared by GTA (**Appendix C – TIA**); and
- Engineering Servicing Report prepared by Cossill & Webley (**Appendix D – Engineering Servicing Report**)

**Figure 9 – Opportunities and Constraints**



# 5.1. LANDFORM AND SOILS

## 5.1.1. Topography

The Scheme Amendment area ranges in elevation from RL59m AHD at the eastern boundary with GNH to RL 42m AHD abutting PDNH. P3 slopes gently to the west-southwest at gradients of up to 2.5%, decreasing to less than 0.4% near Ellen Brook. The subject land provides suitable grade for drainage purposes, though some re-grading of the natural topography may be required for industrial land uses.

## 5.1.2. Landscape

P3 is visible from GNH and Brand Highway. The view is screened in part by roadside trees and vegetation within P3. The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations including Road Trains of Australia (RTA), Aussie Modular Solutions (AMS) and Inghams' Enterprises (poultry farms). The PDNH works have caused a major change to the landscape, particularly near the northern end of the Scheme Amendment area.

## 5.1.3. Geology, Landform and Soils

P3 is located on the Pinjarra Plain, with soils of pebbly silt and sand over pebbly silt, and a spine of sand in the vicinity of the Ellen Brook, within the Guildford Formation. These soils are described by the Geological Survey of Western Australia as "*strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin".*

Testing found silty soils containing varying proportions of clay, with the clay content increasing with depth. The low-lying western parts of P3 are underlain in places by an ironstone (laterite) hardpan at depths of around one metre. At the western edge of P3 the alluvial deposits are overlain by a thin veneer of grey sand transported by floods in Ellen Brook.

**Appendix E** contains the Geotechnical Assessment undertaken by Structerre over the Scheme Amendment area.

## 5.1.4. Soil Permeability

The permeability of P3 soils is variable, depending on the clay content. Pebbly Silt contains lower permeability material, and may increase the area required for stormwater infiltration. The ironstone hardpan in low-lying areas would impede vertical groundwater movement but its restricted extent means that its effect would be localised. In the south-east of P3, clay subsoils impede groundwater flow and cause a perched water table to develop in that area.

The presence of a water table at the ground surface in winter across much of P3 means that all infiltration of drainage and effluent will be within fill, so the permeability of the natural soils is of reduced importance. The soil conditions across the Scheme Amendment area are consistent with the general Muchea area, and do not pose an impediment to industrial development.

## 5.1.5. Contaminated Sites

Historic Landgate aerial photography shows that the project area has been cleared and used for farming since at least 1965. The DWER Contaminated Sites Database shows no record of any contaminated sites in the project area.

### 5.1.5.1. Acid Sulfate Soils

Most of P3 is mapped as Low to Nil risk of Acid Sulfate Soils (ASS). Areas within 50-250m of Ellen Brook are mapped as Low to Moderate risk. Bore sampling in August 2018 found no indicators of potential or actual ASS in the groundwater and no further investigation of ASS is considered necessary.

# 5.2. EXISTING MOVEMENT NETWORK

## 5.2.1. PDNH

PDNH is a 37km link currently under construction by Main Roads WA (MRWA) from the intersection of Reid and Tonkin Highways to GNH and Brand Highway at Muchea, to the immediate north of the Scheme Amendment area. This new route will increase efficiency, and support the development of the MENSP when completed by the end of 2019. Once completed, this road is expected to carry in the order of 11,500vpd by 2031 south of Brand Highway.

The proposed Highway will consist of a four-lane divided rural road, with an off-road Principle Shared Path (PSP) within the reserve to the east of the main road. Batters for the road and PSP are contained within the proposed reserve.

Construction of the PDNH will sever access to a number of the parent lots within the Scheme Amendment area, which MRWA proposes to service with a slip road off Brand Highway to the west of the PDNH alignment. There will be no access onto PDNH at Brand Highway, with the nearest interchange proposed an additional 1 kilometre north.

### 5.2.2. Great Northern Highway

GNH is a Primary Distributor road controlled by MRWA with a posted speed limit of 110km/h except on the southern approach to the intersection of Brand Highway/Muchea East Road where it drops to 80km/h. It is also currently the key route to the Perth Metropolitan Region. GNH experiences 8,605vpd with 25.6% heavy vehicles (including RAVs).

GNH transitions from a four lane road at the south-eastern corner of P3 to a two lane road at the north-eastern corner. There are overtaking lanes for both northbound and southbound traffic flows near the Scheme Amendment area. The pavement is in good condition and includes sealed shoulders and table drains both sides of the road. There is an existing uncontrolled T-intersection with passing lanes into Lot 192 (the RTA site), with all other lots being accessed via standard driveway cross-overs.

### 5.2.3. Brand Highway

The Brand Highway forms the northern boundary of P3, and consists of a single carriageway two lane rural style unkerbed road. The existing intersection of Brand Highway and GNH is controlled by traffic signals. A fly-over of PDNH across Brand Highway is proposed as part of the PDNH construction, which requires reconstruction, by MRWA, of a portion of the Brand Highway abutting the Scheme Amendment area.

### 5.2.4. Muchea East Road

Muchea East Road is a Regional Distributor and has a posted speed limit of 80km/h for approximately 1.5km east from the GNH intersection then 100km/h and 90km/h when it reaches Lower Chittering.

### 5.2.5. RAV Network

Most major roads in the vicinity of the Scheme Amendment area allow the movement of RAVs up to RAV7. GNH is presently a high/wide load route for the transit of over-dimensional loads. This section of GNH is proposed by MRWA to be incorporated in the RAV10 network.

## 5.3. BIODIVERSITY AND NATURAL ASSETS

### 5.3.1. Vegetation

The Scheme Amendment area is mostly cleared of native vegetation, consisting of current and former farm paddocks and industrial sites.

Remnant native vegetation consists of a few mature paddock trees (Marri, Flooded Gum and Wandoo), including several very large Marri trees that have been retained within Lots 802 & 803 and a few large Wandoo trees in Lot 804. Native regrowth is present near the large drain on Lot 800 with a small (0.5ha) thicket of species over grasses. Nearby is a smaller thicket on a drainage line with regrowth.

The area around the large drain on Lot 800 has been densely planted with native tree species. The drain itself contains a heavy growth of sedges and grasses. Other areas near the large drain and in other low-lying parts of P3 contain dense growths of declared pests, along with *Juncus kraussii* in some areas.

Lot 35 contains a few large isolated Flooded Gums and a 2.5ha patch of open woodland of young *E. rudis* regrowth over grass. Elsewhere on P3 there are lines and clumps of planted trees, mostly Flooded Gums, Bluegums, River Red Gums and other non-local eucalypts. There are also scattered regrowth of sedges and isolated shrubs.

Overall the condition of the vegetation is classed as Cleared to Completely Degraded. There is no vegetation in Good or better condition. Adjacent to Ellen Brook there is a sparse to dense woodland species which thins rapidly with distance from the Brook and is mostly outside the Scheme Amendment area. The ground cover over most of this area consists of a heavy growth of pasture grasses and weeds, which extend into the waterway itself.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas in Good condition. Lots 800 & 801 are accessible to cattle and are in poorer condition than the rest due to grazing. On Lots 801-804 there is a dense growth of *Watsonia meriana ssp bulbillifera* in areas not accessed by cattle.

The vegetation of the project area is mapped as Yanga Complex, described by Heddle et al. (1980) as a low open-forest.

### 5.3.2. Rare and Significant Flora

The DBCA's Naturemap database lists no Declared Rare Flora, Priority Flora or other significant flora species as occurring within the Scheme Amendment area. Given the farmland cleared nature of the area, no rare or significant species are likely to be present. The Naturemap database lists six Declared Rare Flora (DRF) taxa and twelve Priority Flora taxa as occurring within a 5km radius of the Scheme Amendment area.

### 5.3.3. Fauna

The Scheme Amendment area contains little habitat for native fauna apart from scattered mature paddock trees and small areas of regrowth and planted vegetation around the drains near the PDNH reserve. The largest area of fauna habitat is the fringing vegetation along Ellen Brook, which borders the south western part. Fauna including kangaroos are likely to use this habitat as refuge and venture out to feed on paddocks.

Bandicoot (Quenda) diggings were observed around Sharp Rush thickets along a drain in Lot 800.

The DBCA's Naturemap database lists three Threatened Fauna and one Priority Fauna species as occurring within a 5km radius of the Scheme Amendment including Carnaby's Black Cockatoo, the Forest Red-tailed Black Cockatoo, Australasian Bittern and the Blackstriped Burrowing Snake. The two species of black cockatoo both nest in large hollows in mature eucalypts. The few large remaining eucalypts present in the project area might contain suitable hollows but their isolation and the lack of nearby food resources mean that they are unlikely to be used for nesting. Other species are not expected to be present within the area as the habitat is not suitable.

## 5.4. GROUNDWATER AND SURFACE WATER

### 5.4.1. Groundwater

Groundwater occurs at a shallow depth across the Scheme Amendment area. The DWER maps minimum groundwater levels at 39-48m AHD (2-7m below ground), flowing south-west towards Ellen Brook. In winter, the groundwater rises to the ground surface across the lower western parts of P3 and creates surface discharge to creeks, drainage lines and Ellen Brook. In the higher eastern parts of P3, rainfall infiltration is impeded by the low-permeability subsoils, creating a perched water table which flows downslope and discharges as surface flow on the lower parts of P3. The net result of these two processes is that groundwater is at or near the ground surface over much of P3 in winter.

Groundwater levels measured in August 2018 were slightly above the AAMGL, and the MGL is above the ground surface over much of P3. This does not take into account the effects of existing drains and surface runoff, which would generally limit the groundwater levels to at or just below the ground surface.

### 5.4.2. Surface Water

The high water tables and low permeability soils result in surface flow in channels, and sheet flow across the ground surface during wet winters. Several natural and artificial drainage lines cross P3 from 15 culverts beneath GNH. All drainage from P3 flows into Ellen Brook which is normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land.

MRWA modelled the 100-year ARI floodplain of Ellen Brook for the PDNH project. Further flood modelling was carried out by BG&E for the Scheme Amendment area (refer **Appendix F – Ellen Brook Flood Modelling**), in order to define the foreshore reserve.

### 5.4.3. Water Resources

The Amendment area is within the Lake Mungala sub-area of the Gingin Groundwater Area for the superficial and semi-confined (Mirrabooka) aquifers, and the SA3 South sub-area for the confined Leederville and Yarragadee aquifers. Groundwater allocations are fully or over allocated, and no new allocations are available. The DWER intends to release a new Gnangara Groundwater Allocation Plan in late 2018, which may further reduce allocation limits.

The DWER Water Register shows a number of licensed bores within the project area, abstracting water from the superficial and Leederville aquifers. For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the Precinct is possible. The landowners group will negotiate with existing licence holders within and outside of P3 with a view to purchasing an existing groundwater allocation, and will submit a groundwater licence application to the DWER in due course. Potable water will be provided by a licensed water provider, addressed in section 10.3 of this report.

## 5.4.4. Water Quality

### 5.4.4.1. Groundwater

Groundwater quality within the project area is Moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally Moderate with the exception of a notably high reading for total phosphorus in the north-west of the project area.

### 5.4.4.2. Surface Water

Surface water quality upstream of the project area is variable with Ellen Brook having high phosphorus levels. Suspended sediment levels in surface water upstream and downstream are generally low.

## 5.5. BUSHFIRE HAZARD

A Bushfire Management Plan has been prepared by EcoLogical Australia for the Scheme Amendment area and is included in **Appendix G – Bush Fire Management Plan.**

The Scheme Amendment area is within a designated Bushfire Prone Area (refer **Figure 10 – Bushfire Prone Area**) which triggers bushfire planning requirements under State Planning Policy 3.7: Planning in Bushfire Prone Areas (SPP3.7) and reporting to accompany the Scheme Amendment in accordance with the associated Guidelines for Planning in Bushfire Prone Areas.

**Figure 10 – Bushfire Prone Area**

## 5.5.1. Bushfire Assessment Results

**Table 9** and **Figure 11 – Bushfire Hazard Level** contain a summary of the Bushfire Hazard Level (BHL) assessment for each vegetation class or exclusion with ratings of Low to Extreme. Clearing and revegetation will be undertaken within the subject site for development purposes, and consequently the pre-development BHLs are subject to change (refer **Figure 12 – Likely BHL – Post Development**). A post-development BHL, following clearing for subdivision works, will be required.

**Table 5 – Bushfire Hazard Level (BHL) Assessment**

**Table 1: Bushfire Hazard Level (BHL) Assessment**

| Plot | Vegetation Classification | Effective Slope | Bushfire Hazard Level |
|---|---|---|---|
| 1 | Class B Woodland | Upslope/flat | Extreme |
| 2 | Class G Grassland | Upslope/flat | Moderate |
| 3 | Excluded as per clause 2.2.3.2 (e) & (f) | N/A | Low |

**Figure 11 – Bushfire Hazard Level**

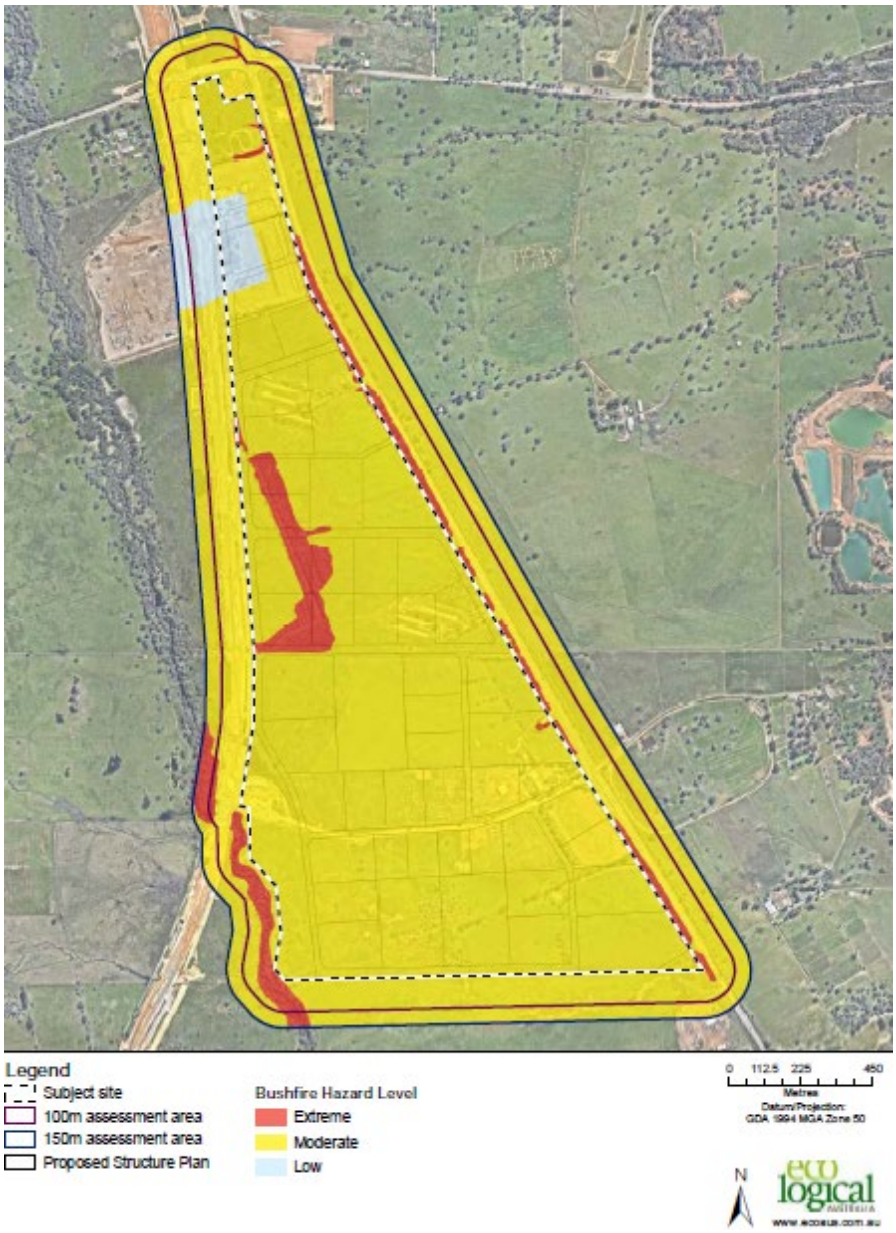
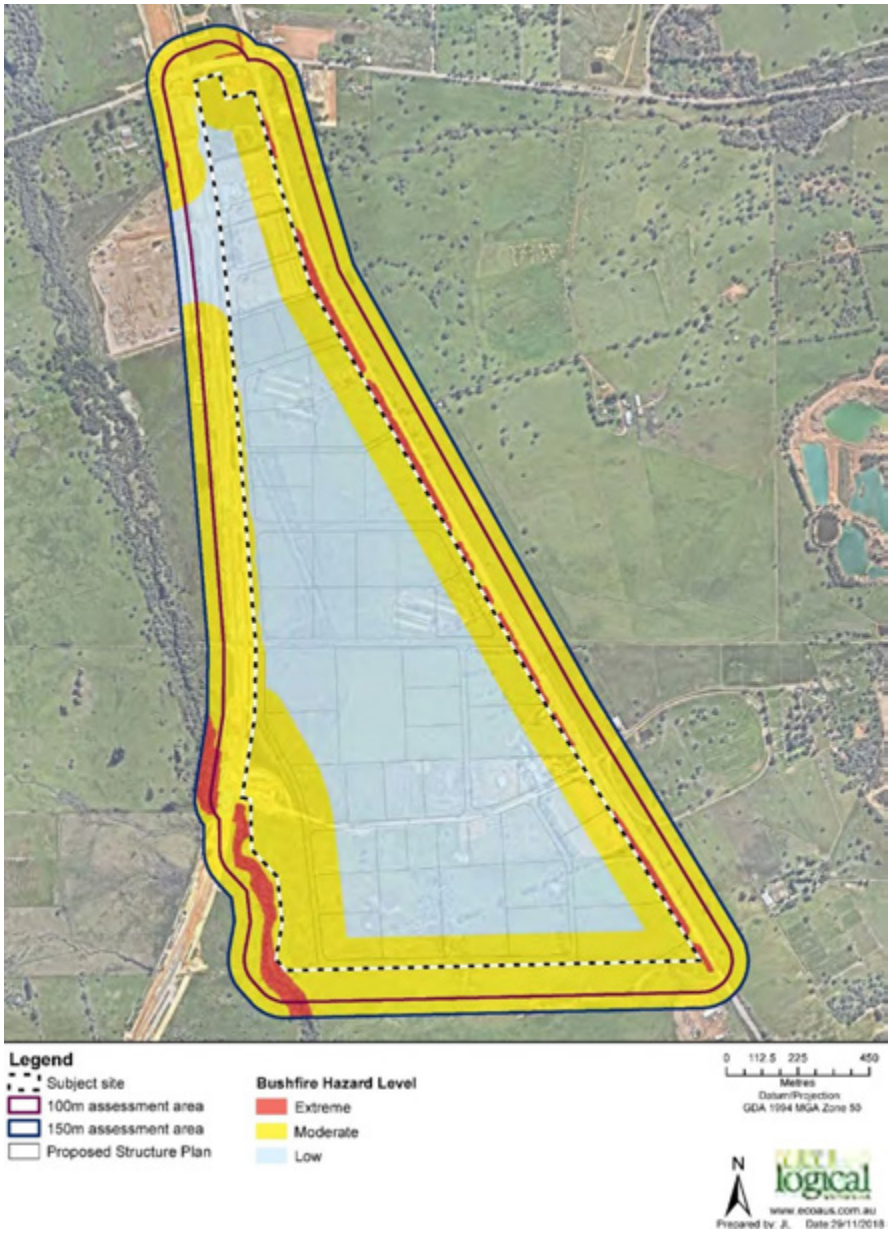


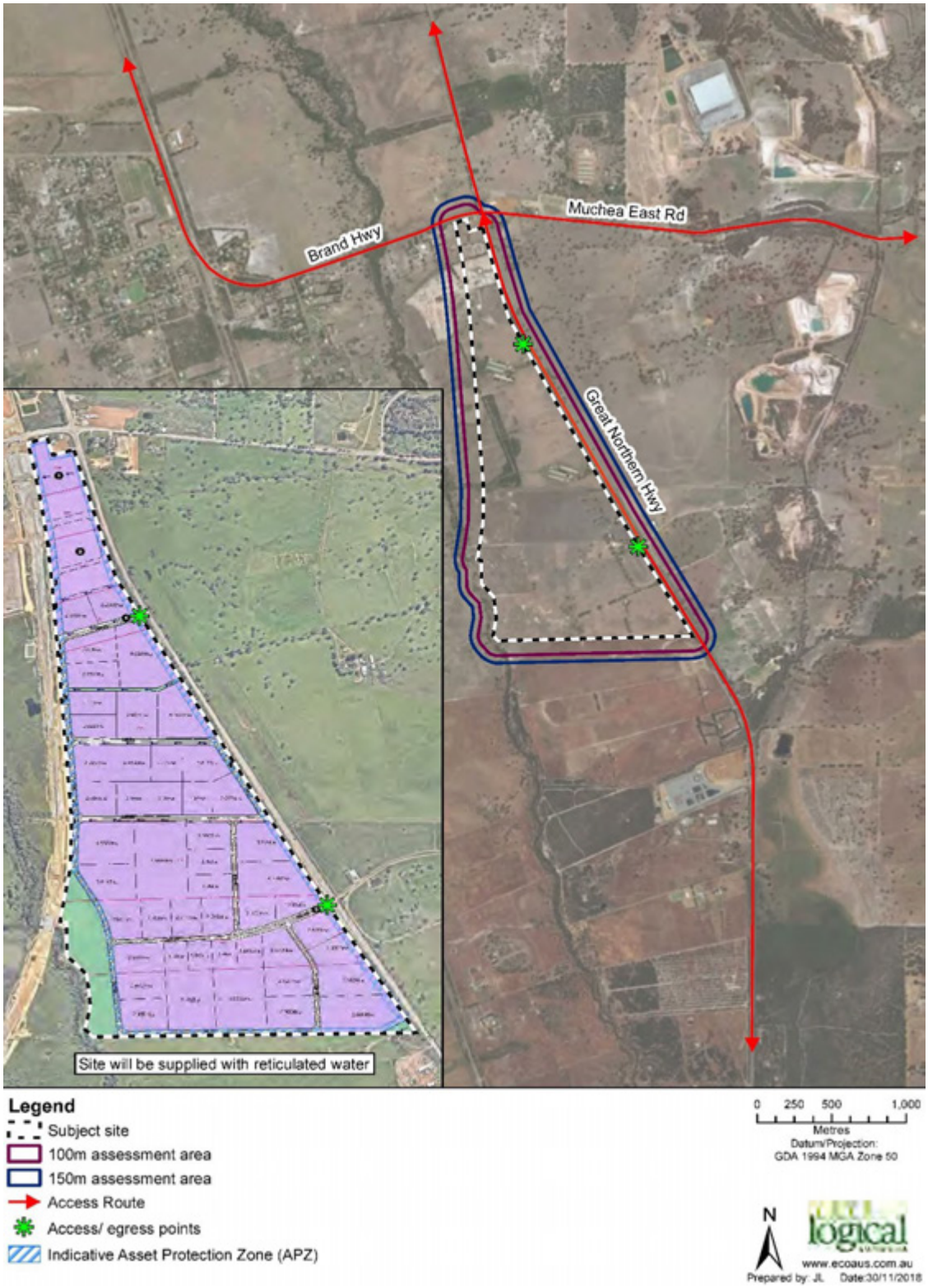
**Figure 12 – Likely BHL Post Development**



Bushfire management can be addressed through a staged clearing process, adequate separation of future built assets from classified vegetation, and ongoing fuel management that can be undertaken in and around individual development stages.

Bushfire hazards within and adjacent to the Scheme Amendment area are considered to be readily manageable through standard management responses and compliance with acceptable solutions outlined in the Guidelines and AS 3959-2009. Bushfire management measures contained within the BMP demonstrate that the proposed measures meet the intent of each element of the bushfire protection criteria (refer **Figure 13 – Bushfire Management Measures**).

**Figure 13 – Bushfire Management Measures**



## 5.6. INDIGENOUS HERITAGE

The DPLH's online database shows one registered site (ID 3525 Ellen Brook: Upper Swan) and seven "other" sites within P3. The DAA has advised that registered sites do occur within the subject land, in connection with Ellen Brook and tributary creeks. Any disturbance of the registered sites will require approval under Section 18 of the Aboriginal Heritage Act 1972.

## 5.7. ACOUSTICS

Certain industrial uses generate noise via traffic, machinery, power tools, ventilators and impacts. The eastern part of P3 currently experiences high levels of noise from GNH, which carries a high volume of heavy traffic including road trains. With the opening of the PDNH, the noise from GNH will diminish significantly, with the noise impact shifting to the western side of the project area near the PDNH.

Noise sensitive premises (residences) are located in Muchea, to the north-west of P3. Isolated residences are also located east of GNH, 70m east and 150m south-east of the project area. Other noise sources include a clay quarry located 1km east and air traffic (including jets) from Pearce RAAF Base located 6.5km south. The project area is in line with the main runway at Pearce. In the case of P3, noise emissions are expected to be relatively low, given that the area is primarily expected to accommodate logistics operations.

Reference to the Rural Residence and Townsite Buffers within the MENSP provide the following in relation to separation distances for noise considerations:

*'Residences in and surrounding the Structure Plan area are deemed to be sensitive receivers. They pose a constraint to the future development of the Scheme Amendment area, with regard to noise emissions subject to assessment under the Environmental Protection (Noise) Regulations 1997 and State Planning Policy 5.4. This must be taken into further consideration in the determination of land use applications for future industrial development'*

## 5.8. DUST

Industrial land uses may generate dust, depending on the activities carried out and the condition of the ground surface. Potentially dusty activities include processing (materials handling), unsealed roads and exposed soil surfaces. The silty soils of the project area are susceptible to dust generation when disturbed. The main dust risk will be during construction work. Sensitive dust receptors are the town of Muchea and residences located east of PDNH. A Construction Management Plan will be required at the development stage in this regard.

# 6. PROPOSED SCHEME AMENDMENT

## 6.1. ZONING AND LAND USE

### 6.1.1. Zoning

#### 6.1.1.1. Proposed Industrial Development Zoning

The land the subject of this Scheme Amendment is proposed to be zoned 'Industrial Development' under LPS6. LPS6 requires that development within the 'Industrial Development' zone be undertaken in accordance with an approved Structure Plan.

Under LPS6, the objectives of the Industrial Development Zone are to:

- 'Designate strategic land areas for future industrial development and employment creation purposes, and prevent such land from being used or developed in a manner which could prejudice its use for this purpose;
- Ensure orderly and comprehensive planning and co-ordinated subdivision and development through the requirement for the preparation and endorsement of a structure plan in accordance with Part 4 of the deemed provisions and any associated provisions contained in Schedule 10 of the Scheme;
- Ensure the coordinated provision of infrastructure, and the equitable sharing of service costs associated with subdivision and development of industrial land;
- Protect the amenity of adjacent properties; and
- Protect the environmental assets of the site.'

The objectives of the Industrial Development zone, set out under the *Planning and Development (Local Planning Schemes) Regulations 2015* are:

- 'To designate land for future industrial development
- To provide a basis for future detailed planning in accordance with the structure planning provisions of this Scheme.'

The intention of the Industrial Development Zone is to facilitate the development of new industrial areas in accordance with an approved Structure Plan. In time, as the area becomes fully or near fully developed, the zoning of the land is 'normalised' to an appropriate zone reflecting the land use and development of the subject land, developed in accordance with an approved Structure Plan.

An Industrial Development Zone is therefore considered to be the appropriate zone for the P3 area.

#### 6.1.1.2. MENSP

It is noted that the MENSP proposes a 'Future Industry Zone' for the area which would be a new zone in LPS6, requiring Scheme Amendments to be prepared over individual precincts.

LPS6, however, already contains an 'Industrial Development' Zone which is consistent with the Model Scheme Text provisions contained within the *Town Planning (Local Planning Schemes) Regulations 2015* ('the Regulations'), and also requires a Scheme Amendment to be prepared.

The terminology of this zone effectively supersedes the MENSP proposed 'Future Industry Zone' and therefore this Amendment proposes the 'Industrial Development' Zone for the subject land, consistent with the Model Provisions of the Regulations.

### 6.1.3. Land Use and Development

The land will be developed for industrial purposes, consistent with the General Industrial zone, as amended by Amendment 65, which at the time of writing this report, was expected to be imminently finalised and gazetted.

The land uses set out in LPS6 for the General Industrial zone, as amended, are considered to be the most appropriate uses to the proposed P3 area. There are, however, a number of other uses considered to be appropriate to the P3 area which currently are not considered under the Industrial Development zone. Amendment No.67 therefore proposes to allow the following uses to be considered as follows:

- Animal Establishment: (D)
- Concrete Batching Plant (D)*1
- Fast Food Outlet (D)*2
- Garden Centre (P)
- Shop (I)
- Transport Depot (P)*3.

The above uses are considered to be appropriate within P3 and consistent with the purposes set out in the Structure Plan and MENSP for this area. A number of notes relate to several of these uses as follows:

1. Concrete Batching Plant means 'premises on which concrete is batched for concrete products manufactured on site for use at places other than the subject site, and includes storage of associated products and ancillary office use'
2. Only where the use is located abutting Great Northern Highway, and associated with a Convenience Store or Service Station
3. In the case of 'Transport Depot', accommodation for a site manager and drivers' accommodation will be allowed, in order to accommodate critical operational requirements of these businesses, ancillary to the Transport Depot use.

   All other uses are 'X' (not permitted)

Whilst the MENSP sets out land use permissibility within the MENSP area, land uses and permissibilities are currently inconsistent with LPS6, and therefore Amendment No.67 seeks to rationalise and clarify these provisions as set out above.

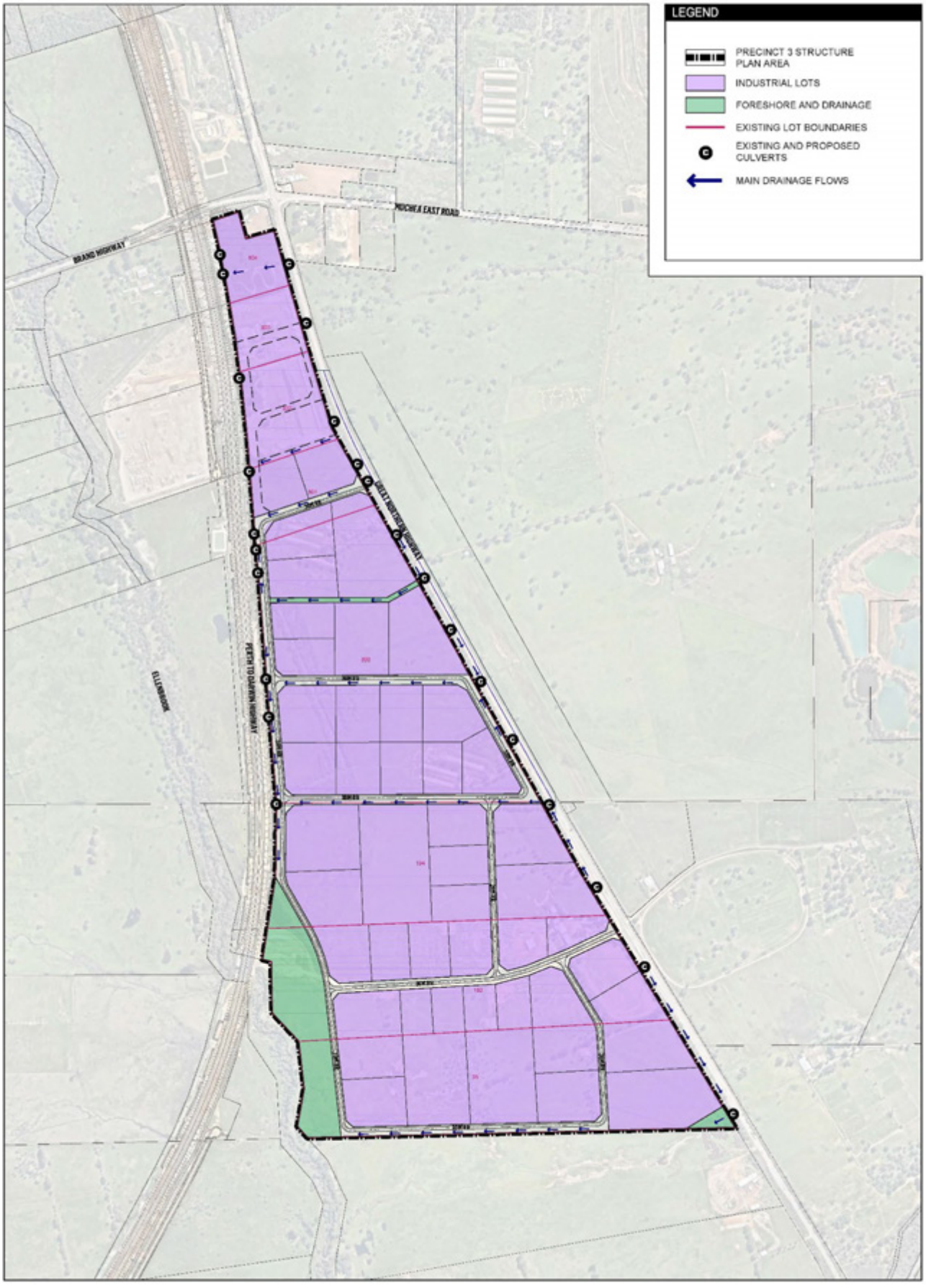
Land use and development standards within the 'Industrial Development' zone are required to be in accordance with LPS6.

## 6.2. DESIGN CONCEPT

The Scheme Amendment provides the framework for the development of the P3 area for industrial land uses.

A preferred Design Concept was identified through the design exploration phase. The design Concept Option is considered to be one potential spatial outcome for the subject land at maturity (refer **Figure 14 – Design Concept**). The plan should be used only as a guide for interpretation and decision making, but in no should be viewed as a requirement or standard.

**Figure 14 – P3 Concept Plan**



# 7. MOVEMENT NETWORK

## 7.1. PROPOSED ROAD NETWORK

Access to the Scheme Amendment area will be via GNH. This access is proposed to be via two intersections, a northern intersection closer to Brand Highway and a southern intersection near the southern boundary of the Scheme Amendment Area. The loop road through the proposed Scheme Amendment area will cater for vehicles up to RAV10 size with other roads accommodating RAV7 vehicles.

When the PDNH is opened, vehicles up to RAV7 will be allowed placing less reliance on GNH for RAV use. RAV10 vehicles are expected to travel to and from the wider MENSP plan area via the northern approaches whilst RAV7 vehicles would be able to approach P3 from both north and south approaches of GNH.

Road cross-sections will be designed to cater for utility services, on standard verge alignments, accommodating drainage requirements. Due to the proximity of the groundwater table, and the clay foundations of the Scheme Amendment area, the inclusion of subsoil drainage adjacent to the road pavement may be required to protect the road base.

## 7.2. CHANGES TO EXTERNAL TRANSPORT NETWORKS

Other than the proposed full movement T-junction at the northern and southern intersections leading into the Scheme Amendment area, no other changes to the external transport network are proposed.

The PDNH construction work will not impact the access nor the current form of GNH, but there will be a decrease in traffic volumes on GNH. Currently there is approximately 8,600vpd utilising this section of GNH travelling at speeds up to the 110km/h posted speed limit. Once completed at the end of 2019, traffic volumes on GNH are expected to decrease.

Estimates for 2031 have indicated that there would be approximately 2,250vpd on this section of GNH (this prior to any consideration of MENSP traffic effects). Even with this substantial drop from 8,600 to 2,250vpd in traffic, the function of GNH is expected be retained as a Primary Distributor under the control of MRWA. It is expected the speed limit may also decrease in due course.

# 8. LOCAL WATER MANAGEMENT

A Local Water Management Strategy (LWMS) has been prepared by Bayley Environmental and is included in this Scheme Amendment as **Appendix H.**

## 8.1. WATER EFFICIENCY MEASURES

P3 will be designed as a low water-use precinct, with industries preferred being those with low water consumption. This is driven largely by the hydrology of P3 and its proximity to Ellen Brook, which demands that wastewater disposal be minimised. Potable water use within P3 will be limited to consumption for domestic use in toilets, bathrooms and kitchens. Groundwater will be used mainly for irrigation of landscape plantings and swales.

## 8.2. STORMWATER MANAGEMENT STRATEGY

### 8.2.1. Principles and Objectives

The stormwater management strategy aims to comply with the principles and objectives for stormwater management identified in the Stormwater Management Manual for WA and Better Urban Water Management. Nutrient concentrations and loads in water leaving P3 will be managed to comply with the targets of the draft Swan Canning Water Quality Improvement Plan for the Ellen Brook catchment.

### 8.2.2. Drainage Management System

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at their pre-development levels. The priorities for managing the various sizes of storm event will be:

- 1 year ARI Infiltrate all flows as close to the source as possible. Maintain pre-development flow rates and volumes. Minimise export of nutrients and sediments.
- 5 year ARI Detain water prior to discharge. Maintain pre-development flow rates and volumes. Maintain amenity and serviceability. Prevent scouring and damage.
- 100 year ARI Maintain pre-development flow rates and volumes. Prevent flooding and damage.

### 8.2.3. Through Drainage

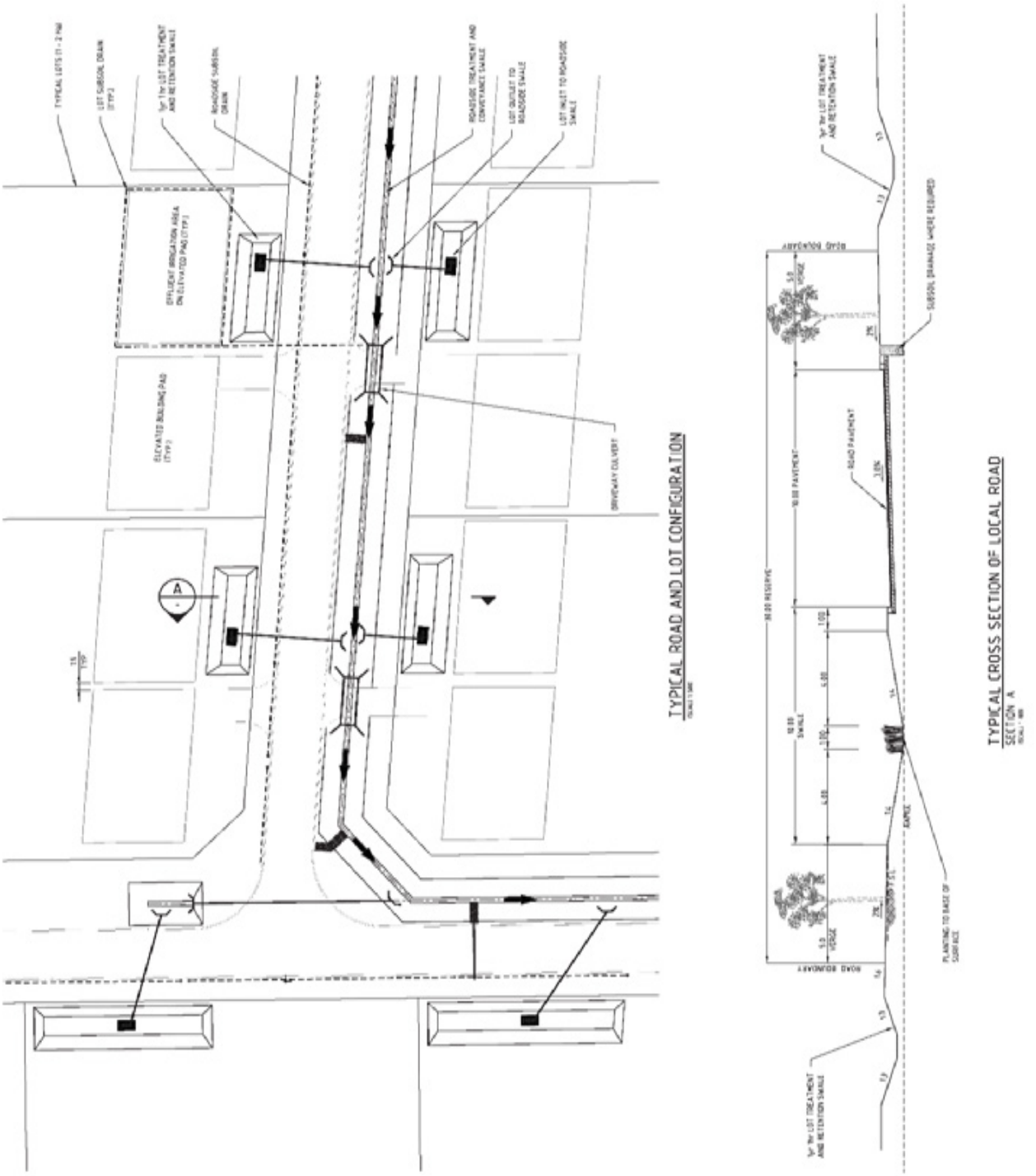
The existing drainage lines will be either preserved within easements or realigned and consolidated in vegetated swales within road reserves, which will be wider than normal to accommodate the swales. The swales will be sized to accommodate the flow from a 100-year ARI critical storm from the upstream and internal catchments. A series of low weirs within the swales will capture and detain or infiltrate road runoff from storms up to 1-year ARI 1-hour. The invert of the swales will be at or above the AAMGL. The swales will be configured as living streams and densely planted with sedges and shrubs to slow the water flow and help to remove sediments and nutrients from the water.

### 8.2.4. Internal Drainage

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, swales and/or landscaping areas. These will be subject to detailed design on individual lots. Lot runoff from larger storms will overflow via pipes into the roadside swales. The overflow pipes will be sized to regulate the flow to predevelopment rates.

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The invert of the swales will be at or above the AAMGL. The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm. In road reserves that also include a through-drainage swale, the weirs may incorporate underdrains to promote infiltration of the 1-year flows. Alternatively, the 1-year ARI swale may be formed in the bank of the through-swale to create a double swale. The configuration of the swales and internal weirs will be subject to detailed design (refer **Figure 15 – Typical Drainage Design Concept**).

**Figure 15 – Typical Drainage Design Concept**



### 8.2.5. Major Storm Drainage

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where eleven culverts beneath the PDNH embankment will carry it across to Ellen Brook. Because the PDNH was designed in the context of a rural setting, the culverts are not large enough to carry the full flow from upstream in a 100-year storm event. The drainage design therefore incorporates a swale running adjacent to the southern part of the PDNH embankment. During a 100-year storm, flows that exceed the capacity of the PDNH culverts will be carried south within this swale to the next culvert or into the drainage/landscape reserve, where it will slowly make its way overland through dense vegetation to Ellen Brook.

### 8.2.6. Ellen Brook Floodplain

The 100-year ARI floodplain of Ellen Brook was modelled by BGE in 2017 on behalf of MRWA for the PDNH project. The modelling mapped only the floodplain extent, and not the floodway. BGE revisited the modelling in 2018 for this project to define the 100-year floodway of Ellen Brook (refer **Appendix F – Ellen Brook Flood Modelling**). The modelling focussed only on the part of Ellen Brook south of the PDNH crossing and adjacent to the project area, and was carried out in consultation with DWER.

The floodplain is the area expected to be inundated by a 100-year ARI flood. Development within the floodplain but outside the floodway is permitted provided that roads and other infrastructure are not damaged by floodwaters and all habitable buildings have a floor level at least 0.5m above the 100-year flood level.

### 8.2.7. Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15
- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out (refer **Figure 16**).

**Figure 16 – Drainage Concept**

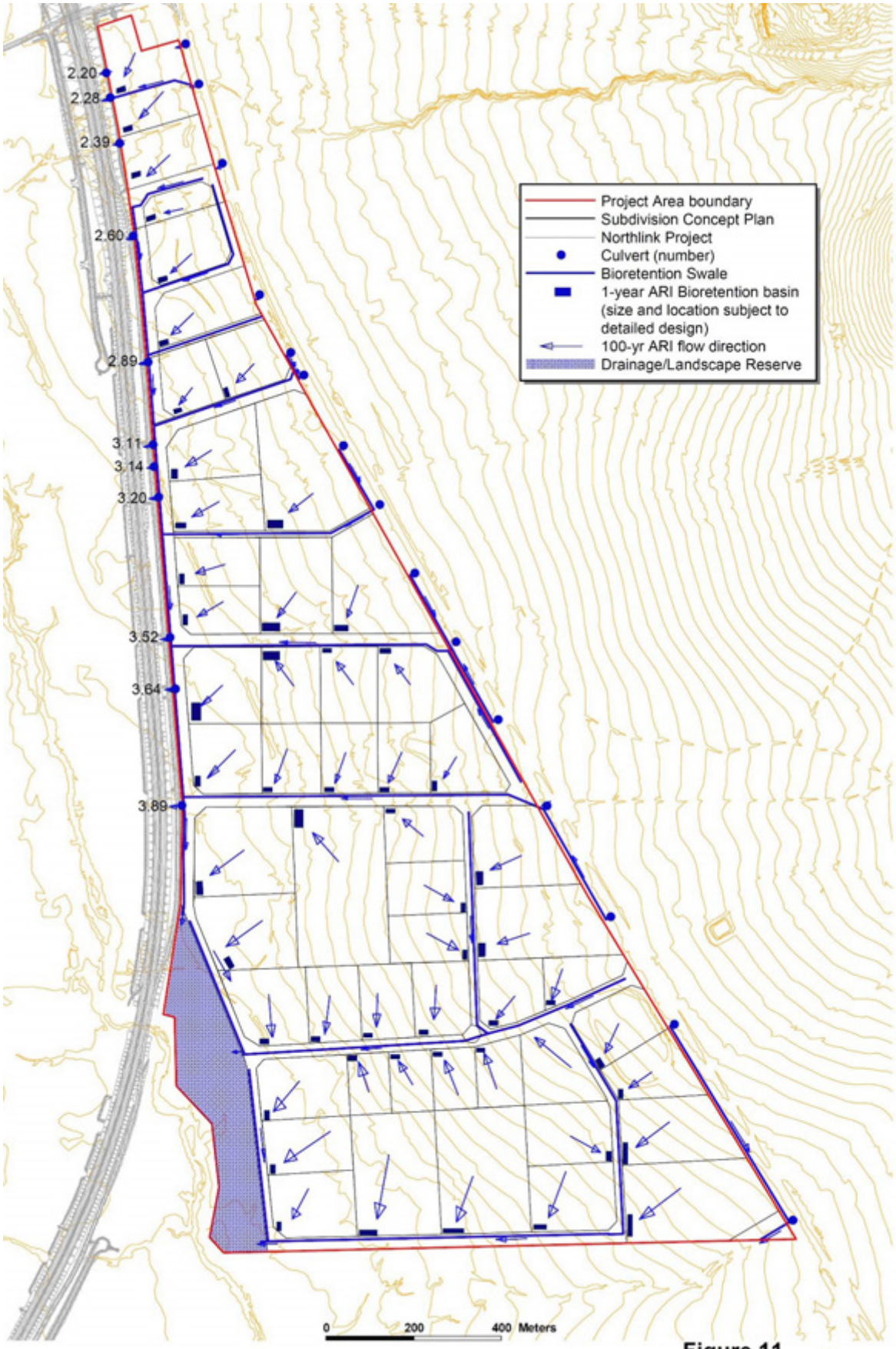



Figure 11

DRAINAGE CONCEPT

bayley environmental services

## 8.2.8. Groundwater Management Strategy

### 8.2.8.1. Groundwater Levels

The AAMGL is at or near the ground surface over much of P3. In the west of P3, groundwater rise in winter is limited by intersecting the ground surface, giving rise to surface runoff. The drainage system for the Scheme Amendment area is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their invert at or above the AAMGL.

Subsoil drainage within lots will be generally limited to the location and immediate surrounds of buildings and structures, associated site area as required for business operations, and the irrigation areas of effluent disposal systems.

### 8.2.8.2. Subsoil Drainage

Subsoil drainage will be employed within lots to maintain groundwater clearance for building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales. Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement. All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of P3 will be minimal.

### 8.2.8.3. Groundwater Quality

Groundwater beneath P3 contains low to moderate concentrations of nitrogen and phosphorus. This is to be expected given the nature of the soils and the land use history of P3.

The aim of nutrient management will be to limit nutrient inputs to P3 so that nutrient outputs are minimised. As an industrial precinct, the area of fertilised gardens and lawns will be minimal. Landscaping areas including street trees, swales and vegetation buffers will be established with minimal fertilisers and irrigation.

Measures available to minimise nutrient inputs and exports in the development will include:

- Regular street sweeping to remove accumulated contaminants; and
- Selection of native species with low water and fertiliser requirements for public open space and landscape areas.

# 9. SERVICING AND INFRASTRUCTURE

Cossill & Webley has prepared an Engineering Servicing Report which is included in this Scheme Amendment as **Appendix D.**

## 9.1. STORMWATER MANAGEMENT

Ellen Brook is an ephemeral river which typically flows from May to December. P3 naturally grades towards Ellen Brook, hence it is anticipated discharge will be permitted from the Scheme Amendment area at the pre-development flow rates.

It is anticipated that stormwater runoff generated from the lots will be treated in swales at the front of the lots sized to retain the 1 hour 63.2% Average Exceedance Probability (AEP) storm event. Larger events will overtop to roadside drainage channels.

All roads will include roadside treatment swales sized to treat the 1 hour 63.2% AEP storm event, with larger storm events from the roads and lots contained in the wider drainage swales within the road reserves, conveyed westward with the natural topography, towards the Ellenbrook. Road-side drainage swales will be sized to convey the critical 1% AEP event. Some areas of piped drainage may be included where driveway cross-overs, or planning considerations do not support swale designs.

Flows to the Ellen Brook will be either via existing culverts constructed under PDNH, with any flow exceeding the culvert capacity diverted south to a detention basin at the southern area of the Scheme Amendment area abutting Ellen Brook.

## 9.2. EFFLUENT DISPOSAL

The Water Corporation has advised that P3 is not within a current wastewater catchment, and there is no proposal to extend the catchment boundary at this stage.

An alternative option proposed by the MENSP is to manage general wastewater (wastewater from buildings/site offices) on an individual inter-allotment scale utilising Aerobic Treatment Units (ATUs). For ATU's, the individual lot must provide sufficient landscaped area to avoid inundation and surface runoff. A typical lot configuration showing the extent of landscaped area for the effective disposal of effluent is included in **Figure 17 - Typical Drainage Design Concept.**

Sewer reticulation and a centralised treatment system may be considered for parts of the Scheme Amendment area where there are smaller industrial lots which have reduced capacity for irrigation volumes, or lots with a requirement for a large volume of sewer treatment. These options have not been assessed, and will require the relevant approvals prior to any agreements with potential industrial developments.

Wastewater produced on lots from industrial processes will be required to be treated appropriately on each lot. Where appropriate treatment is not achievable (due to the volumes or contaminants) industrial process wastewater will be captured and removed from site to an appropriate treatment facility.

### 9.2.1. Land Capability for On-Site Effluent Disposal

The proposed lots are located on land mapped mostly as Guildford Formation where the more elevated parts are rated Fair to High for effluent disposal, while the lower-lying parts are rated as Low to Very Low for effluent disposal. The main constraints to effluent disposal in the lower areas are high water tables and poor drainage.

The revised draft Government Sewerage Policy currently being considered by the WAPC identifies the project area as being within a Sewage Sensitive Area (SSA) due to its location within the catchment of the Swan-Canning Estuary. The draft Policy places additional site requirements in terms of groundwater clearance and lot density on effluent disposal within SSAs.

#### 9.2.1.1. Phosphorus Retention Index

The Health Department's draft Code of Practice for Onsite Sewage Management (2012) recommends a PRI of at least 20 for soils beneath effluent irrigation areas. Testing demonstrates the soils of the Scheme Amendment area have a very high capacity to bind phosphorus.

#### 9.2.1.2. Depth to Groundwater

The current Country Sewerage Policy requires that land used for effluent disposal have a minimum clearance of 0.5m from the natural ground surface to the highest seasonal or permanent water table. Under the Policy, the required clearance cannot be achieved solely by filling but can be achieved by subsoil drainage, provided that the land has sufficient fall and area to dispose of the drained water and the drainage does not affect water flows or quality downstream.

A revised Draft Government Sewerage Policy currently being considered by the WAPC applies the 0.5m natural ground surface clearance requirement only to lots smaller than 1ha. For larger lots in SSA (including the Scheme Amendment area area), the revised draft Policy requires a separation of 1.5m from the effluent discharge point to the groundwater, which may be achieved by drainage, filling or a combination of both.

As the AAMGL is within 0.5m of the ground surface over much of the P3 area, a combination of subsoil drainage and fill will be required over most of P3 where effluent disposal is proposed. In lower parts of the project area where the AAMGL is at the ground surface, subsoil drains will be set at the existing ground level and fill will be used to achieve the required groundwater clearance.

#### 9.2.1.3. Slope

The Country Sewerage Policy prohibits on-site effluent disposal on land with a slope of more than 1 in 5 (20%), in order to prevent runoff of effluent. The slope of the subject land does not exceed 2.5%. Therefore, effluent disposal in P3 is not constrained by slope.

### 9.2.2. System Selection and Location

All effluent generated within the Scheme Amendment area will be treated and disposed by means of individual on-site effluent disposal systems. Given the hydrology of P3 and its proximity to Ellen Brook, all lots will be required to employ nutrient-attenuating alternative systems such as aerobic treatment units (ATUs) with high-PRI irrigation areas or modified leach drain systems. Effluent disposal systems will be located at least 30m from watercourses.

ATU irrigation areas will be filled to approximately 2m above the AAMGL in order to provide 1.5m clearance from the AAMGL to the effluent drip lines allowing for 0.3m groundwater mounding and 0.2m soil cover over the drip lines. The effluent irrigation areas will be filled with soil either sourced from on site or imported. The soil will be tested to confirm a PRI of at least 20. The ATU irrigation area on each lot will be sized to suit the expected population of the lot.

### 9.2.3. Subsoil Drainage

Where fill is used to raise pads for effluent disposal, surface cutoff drains and/or subsoil drains will be placed upslope of the pad to prevent groundwater rise into the fill. The drains will be set with their inverts at or above the AAMGL and will discharge into the roadside swales, where the water will be further treated by infiltration and/or vegetation uptake within the swales. Because the water will be draining from high-PRI soil, it will be of high quality.

## 9.3. WATER RETICULATION

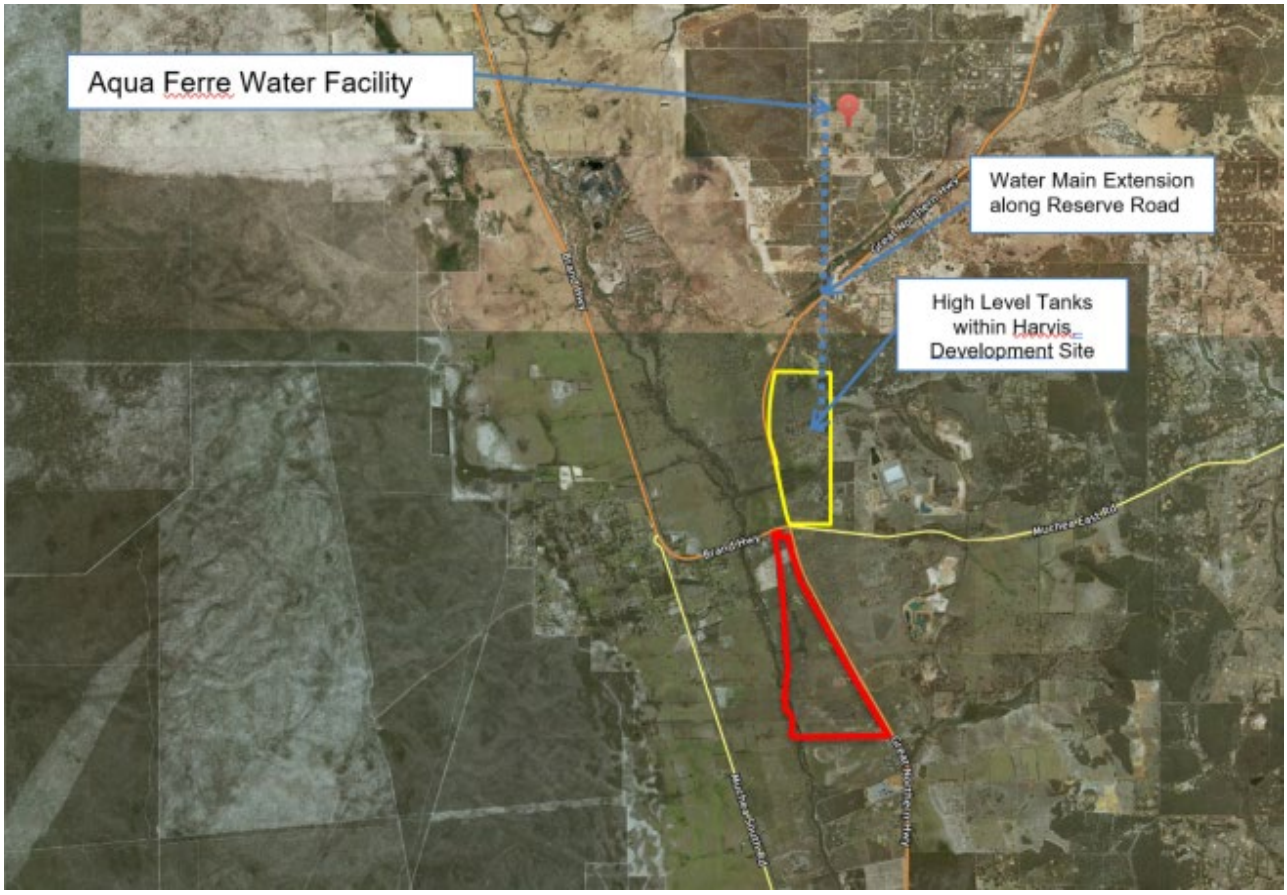
The Water Corporation has advised that the Scheme Amendment area is not within a current water catchment, and there are no plans to extend the water catchment boundary at this stage.

A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre, which includes construction of a water treatment facility on Lot 2 Reserve Road, Chittering capable of supplying potable water to residential and commercial properties in the Lower Chittering-Muchea area. Aqua Ferre is in the process of applying for a Water Service Provider Licence from the Economic Regulation Authority.

The project proposes to draw water from the Leederville Aquifer, with treatment to meet drinking water quality guidelines. Aqua Ferre has confirmed they have capacity within their proposed licence to service the proposed industrial development of the Scheme Amendment area with potable water, and have advised the most likely strategy would include an extension of the proposed Harvis network (to the north) to service the proposed development (refer **Figure 17 – Aqua Ferre Water Strategy**).

Provision to P3 is still subject to mutually agreeable commercial terms with Aqua Ferre, though from the Scheme Amendment perspective, P3 can be serviced with water reticulation by a licensed provider, as required by the MENSP, and that there are no engineering impediments to the provision of water to the proposed development.

**Figure 17 – Aqua Ferre Water Strategy**




## 9.4. POWER

There are existing overhead 22kV high voltage overhead power cables in the eastern verge of GNH and southern verge of Brand Highway which are fed from the existing Muchea Zoned Sub-Station.

The Western Power Network Capacity Mapping Tool was used to determine future forecast remaining capacity in the electricity network, which confirmed the network will have more than 30MVA remaining capacity in 2020. This capacity will be sufficient to service the future power requirements of the development, though Western Power will need to confirm the connection locations and capacity of the existing system as part of a feasibility assessment at the next stage of the planning process.

A series of HV feeds, switch stations and transformers will be required throughout the development to meet individual site requirements. Additional distribution mains from the Muchea Sub-Station may be required in the future to augment the existing supply network, depending on industrial uses proposed and likely power requirements.

## 9.5. GAS

There is no proposed gas distribution within the vicinity of the Scheme Amendment area. The supply of a gas distribution network in the future is not ruled out, however it will depend on economics and likely demand of the broader Muchea area.

## 9.6. EARTHWORKS

Siteworks for the proposed development will generally comprise clearing of existing vegetation and, where necessary, earthworking the existing ground to facilitate a required form of development. Following clearing, topsoil is likely to be stripped. The grades from east to west are generally about 2%, and typical industrial grades are preferred to be flatter, at approximately 1%.

The extent of siteworks and earthworks will be dictated by the proposed industrial usage, which may involve some filling of parts (or all) of the lot to provide flood protection from prevailing groundwater, level out grade across the lots and provide sufficient area for the effective disposal of treated effluent. As a guide, the following earthworks are anticipated, which will be confirmed as part of the subdivision and subsequent development process, once further certainty on proposed land use, flood protection and effluent disposal requirements are known:

- Roads – approximately 800mm separation between the finished road pavement and prevailing groundwater may be required to ensure the road pavement remains flood protected. This will be confirmed as part of the future detailed design, which will include the road pavement requirements and more accurately determine the depth to groundwater from the existing natural surface
- Lots – the extent of fill is likely to vary across the lots depending on the needs and sensitivity of the proposed land-use. Some fill may be provided to buildings areas (say 1 metre over the building pad), though this will be confirmed at the detailed design stage. Utilising the existing east/west grade across P3, there may be opportunity to minimise fill (to ensure adequate flood protection) by constructing cut-off diversion drains and grading P3 to ensure any surface flows are directed away from proposed building pads
- Effluent irrigation areas will be filled and sized to suit anticipated effluent disposal requirements
- Subsoil drainage may be installed locally around existing building pads and effluent disposal areas to provide protection from prevailing groundwater
- The filling of land willl be minimised and generally be limited to the location and immediate surrounds of buildings and structures, associated site area as required for business operations, and the irrigation areas of effluent disposal systems.

## 9.7. TELECOMMUNICATIONS

The Scheme Amendment area has not yet been served with NBN, but there is existing Telstra communications in GNH servicing the area.

Using the NBN Co ‘Check your address’, the Scheme Amendment area is planned to be connected to the NBN network in January-June 2020 with a fixed wireless connection. It is likely the area will be connected to the NBN network by the time development commences and no offsite upgrade by the developer would be applicable.

# 10. LANDSCAPE MASTERPLAN

A Landscape Masterplan has been prepared by Bayley Environmental and is included in this Scheme Amendment report in **Appendix I.**

The Landscape Masterplan has been prepared in the context of the Draft Shire of Chittering Local Planning Strategy and Draft Design Guidelines for the Muchea Industrial Park. Precinct 3 will constitute the southern gateway to the Shire of Chittering. A priority of the Shire is that the precinct should present an attractive visual landscape for observers travelling on the main approaches into Chittering. This includes preserving native vegetation where it occurs (mostly roadside trees), landscape plantings within the precinct, building design and layout of development within lots.

The Shire of Chittering has set out its priorities in its Muchea Industrial Park Design Guidelines (2018). The Guidelines deal with development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. LPS6 also contains provisions relating to landscape within industrial zones. The Landscape Master Plan recognises and reflects the recommendations of the Design Guidelines and the Scheme provisions.

The project area is visible from GNH and Brand Highway. The view is screened in part by roadside trees and vegetation within P3. The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations. The PDNH works have caused a major change to the landscape, particularly near the northern end of the project area.

**Figures 18-21** shows an overview of the conceptual landscaping strategy and the Landscape Masterplan sets out landscaping anticipated for the various landscaping zones. Lot layout to accommodate landscaping, swale treatment and landscaping anticipated around Ellen Brook within the Scheme Amendment area are also depicted.

**Figure 18 – Landscape Masterplan**

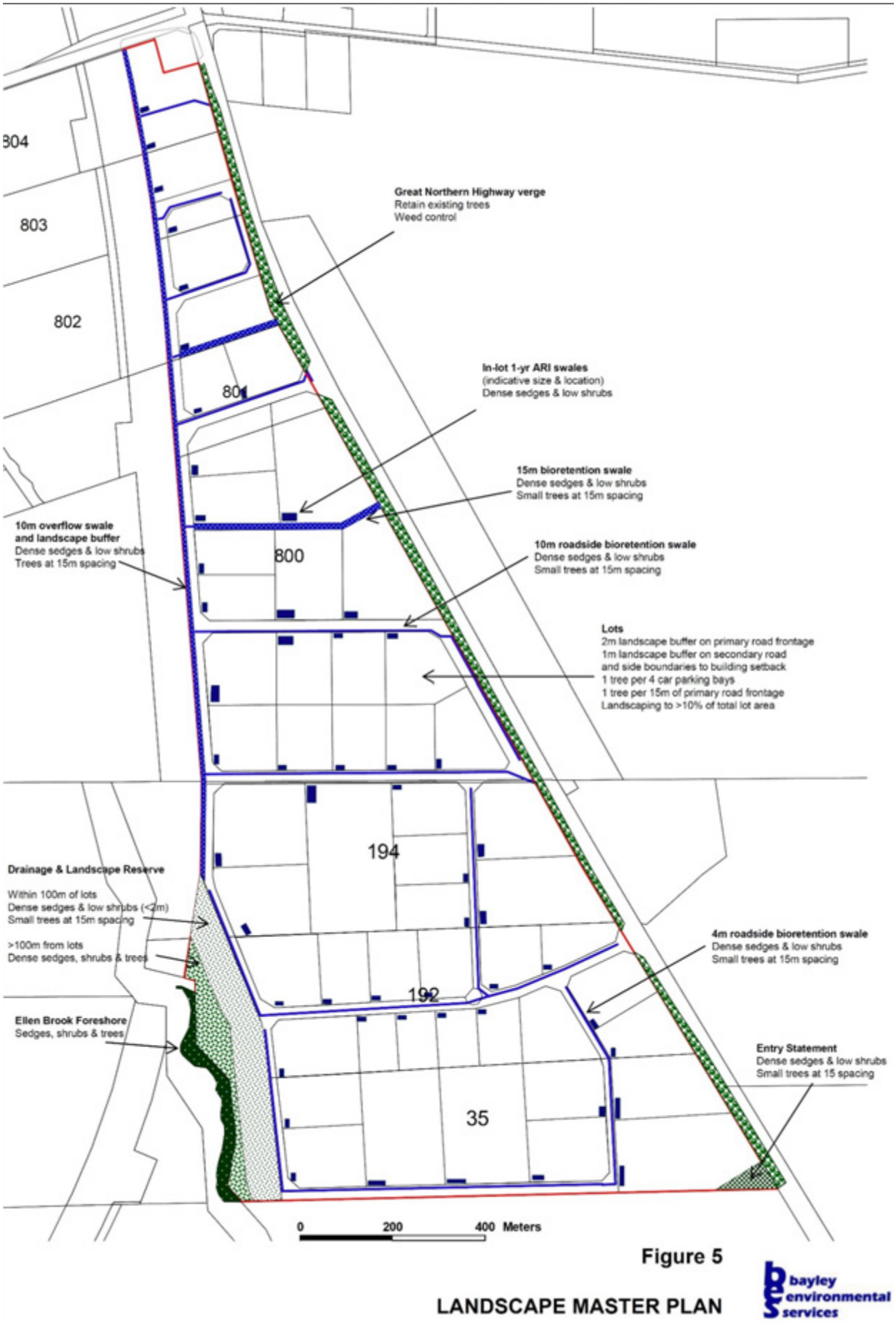


**Figure 19 – Landscaping of Bio-Retention Swales**

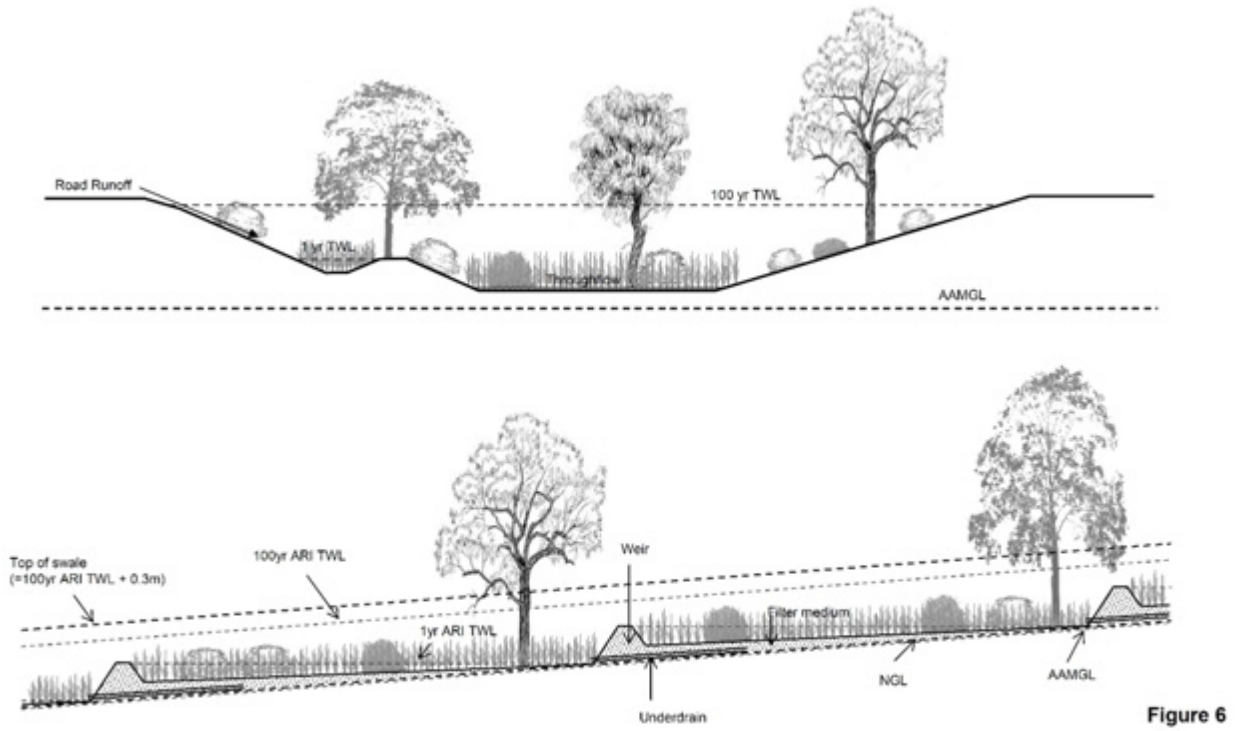



Figure 6

BIORETENTION SWALES

bayley environmental services

**Figure 20 – Individual Lot Landscaping Concept**

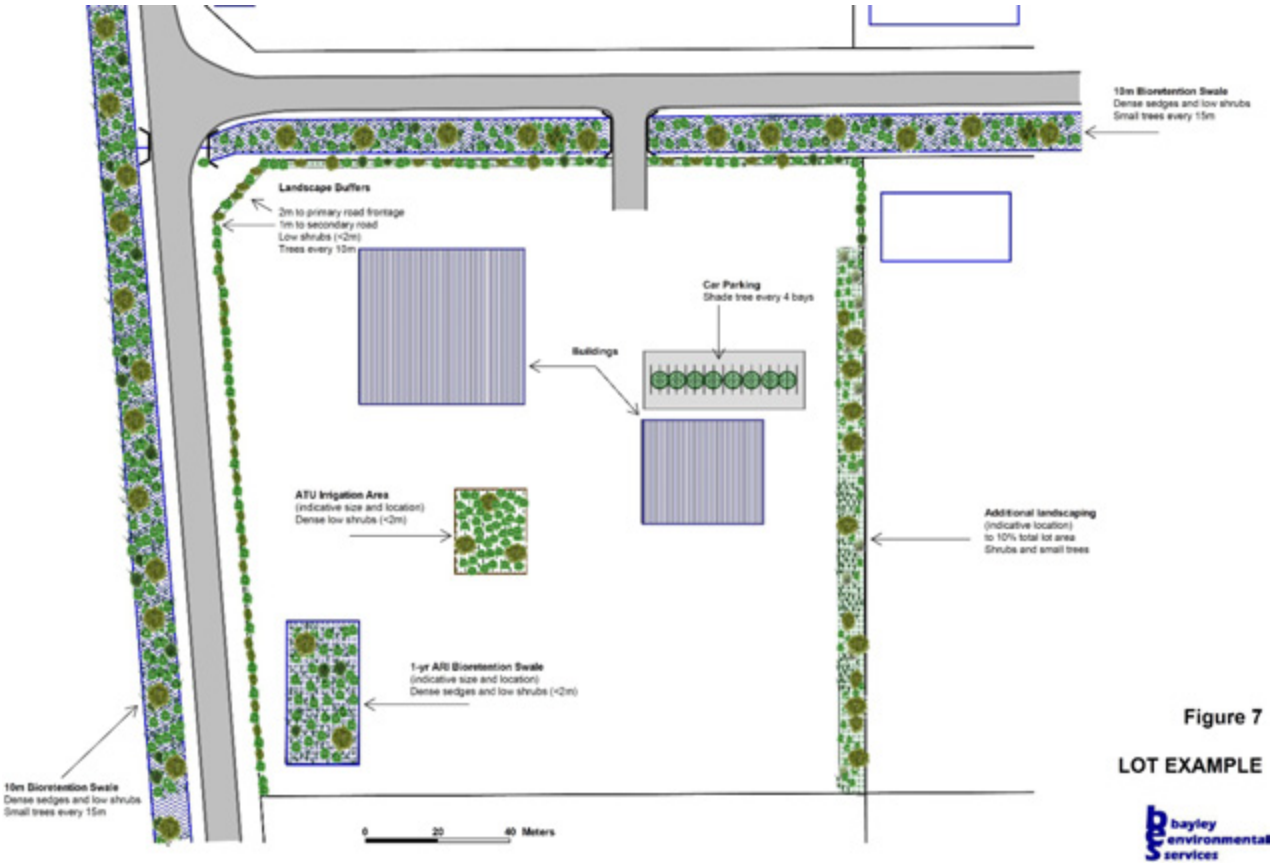
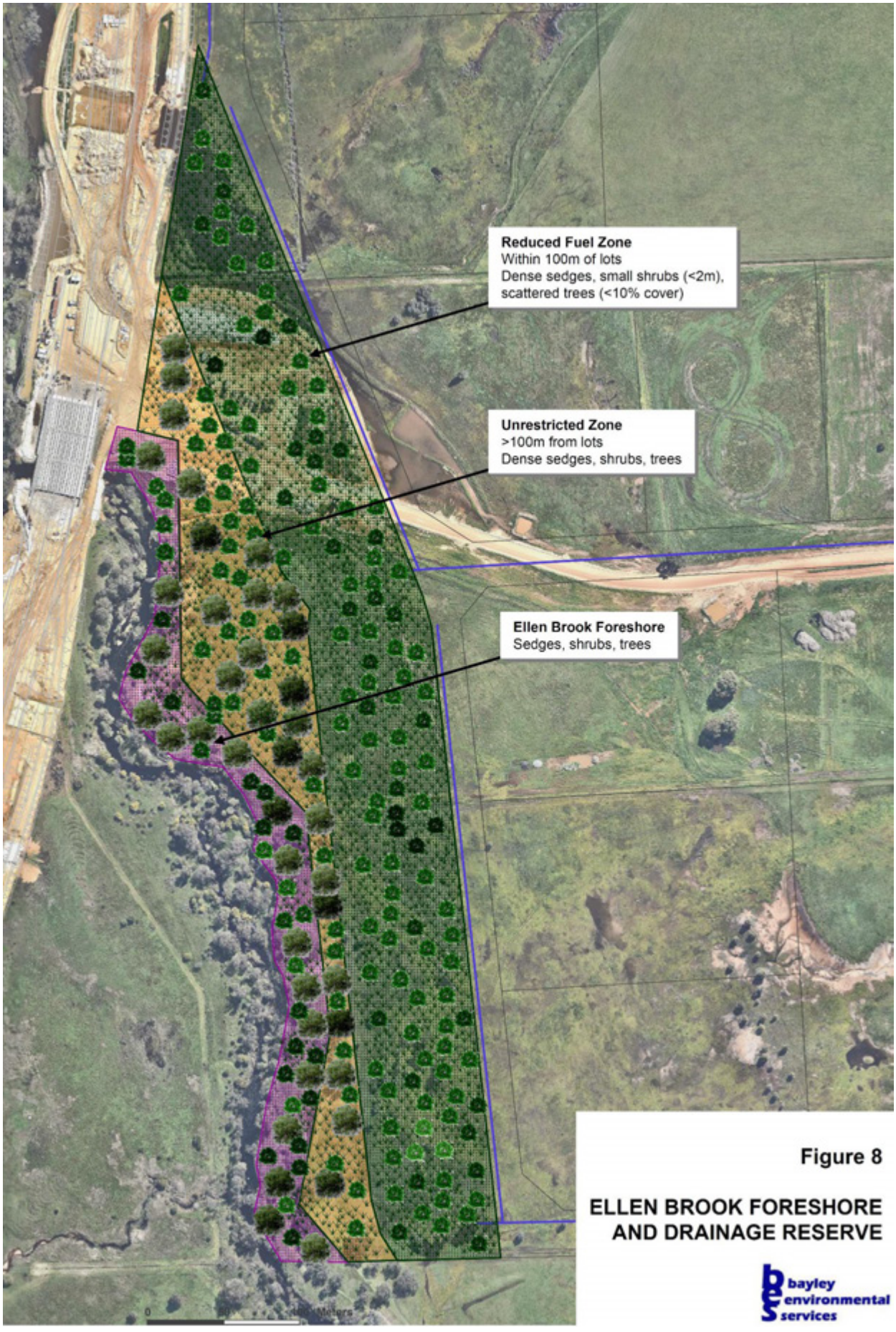



Figure 7

LOT EXAMPLE

bayley environmental services

**Figure 21 – Ellen Brook Landscaping**



# 11. ENVIRONMENTAL MANAGEMENT

Environmental management is set out in the EAMS and LWMS; and referred to in Schedule 11 of LPS6 (refer **Appendices B and H**).

## 11.1. ACOUSTICS

Given the presence of GNH and particularly PDNH, noise generated by the industrial activities anticipated within P3, does not warrant preparation of a Strategic Noise Assessment and Management Strategy at the Scheme Amendment or Structure Plan stage. At the development application stage, should a proposed industrial land use be expected to generate substantial noise that may impact residential (or other sensitive) uses in areas outside P3, such applications will need to demonstrate that they comply with EPA requirements by way of preparation of a suitable assessment and management plan.

## 11.2. ODOUR

Where odour causing industries are proposed, a Strategic Odour Assessment and Management Strategy would need to be prepared. In the case of P3, industries proposed are not expected to generate unreasonable levels of odour. As is the case with noise, at the development application stage, should a proposed industrial land use be expected to generate substantial odour that may impact residential (or other sensitive) uses in areas outside P3, such applications will need to demonstrate that they comply with EPA requirements by way or preparation of a suitable management plan.

## 11.3. DUST

Individual lot owners within the Scheme Amendment area will be required to manage dust to prevent dust escape beyond their boundaries. Industries that generate appreciable dust will be required to hold a DWER licence, which will include dust limits and specify monitoring requirements. Management of construction impacts will be the subject of conditions attached to subdivision approvals, works approvals and development approvals. In general, control of construction impacts will be the responsibility of the construction contractor by way of a Construction Management Plan prepared to satisfy a condition of development approval.

## 11.4. VEGETATION AND FLORA

The largest area of native vegetation near the project area is the fringing vegetation of Ellen Brook. This will be preserved in the foreshore reserve. Remnant trees within the development area will be preserved where possible. No remnant trees may be cleared without a Development Approval from the Shire of Chittering and/or a clearing permit from the DWER. Approximately 48 hectares of native sedges, shrubs and trees will be planted in the Ellen Brook foreshore, in drainage swales and within lots, within the Scheme Amendment area.

## 11.5. FAUNA

There is little native fauna habitat in the project area, although the adjacent Ellen Brook provides substantial habitat for faun which may venture into the project area to forage and graze. The existing fauna habitat within the project area will be retained and enhanced by new plantings of native vegetation in the Ellen Brook foreshore and minor drainage lines. Additional fauna habitat will be created in the revegetation of drainage swales and basins. Street trees planted within the project area will focus on native tree species that provide habitat for nectar-eating and seed-eating birds.

## 11.6. GROUNDWATER MONITORING

Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in the creeklines and Ellen Brook will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses. Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the UWMPs to be prepared for each stage of subdivision.

# 12. CONCLUSION

It is requested that the Shire of Chittering initiate an Amendment to rezone P3 from 'Agricultural Resource' to 'Industrial Development', and introduce relevant provisions into Schedule 11 as set out in this Amendment.

The Amendment will facilitate the future development of the subject site for industrial purposes providing for a range of industrial activities including transport logistics and general industry purposes in accordance with the State and local planning framework.

The proposed development of P3 will ensure the timely supply and release of industrial land within Muchea. This Scheme Amendment is supported by a range of technical inputs, and demonstrates that the land can be developed for industrial purposes, consistent with the strategic and statutory planning framework.

This Amendment will facilitate the development of the subject land for industrial purposes as intended by the MENSP and ensure the timely supply and release of industrial land within the Shire of Chittering.

We therefore request the Shire of Chittering initiate an Amendment to rezone P3 as proposed in this Amendment from 'Agricultural Resource' to 'Industrial Development' supported by the preparation of a Structure Plan prepared in accordance with the Regulations and the WAPC Scheme Amendment Framework.

# APPENDIX A
# CERTIFICATES OF TITLE

WESTERN AUSTRALIA

| REGISTER NUMBER | |
|---|---|
| 804/DP404617 | |
| DUPLICATE EDITION | DATE DUPLICATE ISSUED |
| 1 | 28/2/2017 |

VOLUME 2895 FOLIO 897

# RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 804 ON DEPOSITED PLAN 404617

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

ANDREW QUINCE OF LOT 4 BRAND HIGHWAY,MUCHEA

(AF N339402 ) REGISTERED 27/5/2016

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 1132/1935.
2. *N112518 CAVEAT BY PURE STEEL SHED CONSTRUCTIONS PTY LTD AS TO PORTION ONLY LODGED 3/9/2015.

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

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

**STATEMENTS:**

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

| | |
|---|---|
| SKETCH OF LAND: | DP404617 |
| PREVIOUS TITLE: | 2577-167 |
| PROPERTY STREET ADDRESS: | 43 BRAND HWY, MUCHEA. |
| LOCAL GOVERNMENT AUTHORITY: | SHIRE OF CHITTERING |

WESTERN AUSTRALIA

| REGISTER NUMBER | |
|---|---|
| 803/DP404616 | |
| DUPLICATE EDITION | DATE DUPLICATE ISSUED |
| N/A | N/A |

VOLUME 2903 FOLIO 24

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REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 803 ON DEPOSITED PLAN 404616

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

KARRATHA ENTERPRISES PTY LTD OF POST OFFICE BOX 419, MORLEY BC
(AF N339403 ) REGISTERED 27/5/2016

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 3000/1933.
2. *N470501 CAVEAT BY AUSSIE MODULAR SOLUTIONS PTY LTD LODGED 28/10/2016.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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SKETCH OF LAND: DP404616
PREVIOUS TITLE: 1689-590
PROPERTY STREET ADDRESS: 3571 GREAT NORTHERN HWY, MUCHEA.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF CHITTERING

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING L740226

WESTERN AUSTRALIA

| REGISTER NUMBER | |
|---|---|
| 192/DP405698 | |
| DUPLICATE EDITION | DATE DUPLICATE ISSUED |
| N/A | N/A |

VOLUME 2862 FOLIO 297

# RECORD OF CERTIFICATE OF TITLE

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REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 192 ON DEPOSITED PLAN 405698

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

BARTON CECIL JONES OF PO BOX 4188, KALGOORLIE
DAVID JOHN CECIL JONES OF 43 JUTLAND PARADE, DALKEITH
AS JOINT TENANTS

(AF N023683 ) REGISTERED 10/6/2015

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9703/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 806.
2. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9704/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 806.
3. *B946572 RESTRICTIVE COVENANT BURDEN. REGISTERED 1/7/1980.
4. *M965766 MORTGAGE TO WESTPAC BANKING CORPORATION REGISTERED 13/4/2015.
5. *N191401 CAVEAT BY SHIRE OF CHITTERING AS TO PORTION ONLY LODGED 2/12/2015.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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----------END OF CERTIFICATE OF TITLE----------

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| | |
|---|---|
| SKETCH OF LAND: | DP405698 |
| PREVIOUS TITLE: | 1868-806 |
| PROPERTY STREET ADDRESS: | 3363 GREAT NORTHERN HWY, MUCHEA. |
| LOCAL GOVERNMENT AUTHORITY: | SHIRE OF CHITTERING |

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING M965766

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REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 194 ON DEPOSITED PLAN 405699

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

AMUSE PTY LTD OF 28 ROWLEY PLACE, MARIGINIUP

(AF N023684 ) REGISTERED 3/9/2015

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9703/1919. AS TO PORTION ONLY SEE DEPOSITED PLAN 405699 AND SKETCH ON VOL 1868 FOL 805.
2. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9704/1919. AS TO PORTION ONLY SEE DEPOSITED PLAN 405699 AND SKETCH ON VOL 1868 FOL 805.
3. *B946572 RESTRICTIVE COVENANT BURDEN. REGISTERED 1/7/1980.
4. *B946572 EASEMENT BURDEN FOR RIGHT OF CARRIAGEWAY PURPOSES. SEE DEPOSITED PLAN 405699 AND SKETCH ON VOL 1868 FOL 805. REGISTERED 1/7/1980.
5. *G921742 MORTGAGE TO ST. GEORGE BANK LTD REGISTERED 8/10/1998.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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| | |
|---|---|
| SKETCH OF LAND: | DP405699 |
| PREVIOUS TITLE: | 1868-805 |
| PROPERTY STREET ADDRESS: | 3383 GREAT NORTHERN HWY, MUCHEA. |
| LOCAL GOVERNMENT AUTHORITY: | SHIRE OF CHITTERING |

NOTE 1: N023684 THIS LOT/TITLE CREATED AFTER PORTION OF THE LAND TAKEN FROM THE FORMER LOT WITHOUT PRODUCTION OF THE DUPLICATE TITLE BY TAKING ORDER N023684. CURRENT DUPLICATE FOR THE WITHIN LAND IS STILL VOL.1868 FOL.805

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| 1 | 19/12/2016 |

VOLUME 2903 FOLIO 33

# RECORD OF CERTIFICATE OF TITLE

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REGISTRAR OF TITLES

**THIS IS A MULTI-LOT TITLE**

**LAND DESCRIPTION:**

LOTS 800 & 801 ON DEPOSITED PLAN 404613

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

INGHAM RURAL PROPERTY GROUP PTY LTD OF DARLING PARK TOWER 2, 201 SUSSEX STREET, SYDNEY, NEW SOUTH WALES

(XA N357645 ) REGISTERED 17/6/2016

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 188/1945.
2. B946572 EASEMENT BENEFIT SEE DIAGRAM 72548. AS TO LOT 800 ON DP 404613 ONLY REGISTERED 1/7/1980.
3. M195093 LEASE TO INGHAMS ENTERPRISES PTY LTD OF 203-209 NORTHUMBERLAND STREET, LIVERPOOL, NEW SOUTH WALES EXPIRES: SEE LEASE. REGISTERED 25/2/2013.
   M276626 EXTENSION OF LEASE M195093. REGISTERED 17/5/2013.

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| | |
|---|---|
| SKETCH OF LAND: | DP404613 |
| PREVIOUS TITLE: | 2903-30, 2903-31 |
| PROPERTY STREET ADDRESS: | NO STREET ADDRESS INFORMATION AVAILABLE. |
| LOCAL GOVERNMENT AUTHORITY: | SHIRE OF CHITTERING |

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VOLUME 2903 FOLIO 33

# RECORD OF CERTIFICATE OF TITLE

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**LAND DESCRIPTION:**

LOTS 800 & 801 ON DEPOSITED PLAN 404613

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

INGHAM RURAL PROPERTY GROUP PTY LTD OF DARLING PARK TOWER 2, 201 SUSSEX STREET, SYDNEY, NEW SOUTH WALES

(XA N357645 ) REGISTERED 17/6/2016

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 188/1945.
2. B946572 EASEMENT BENEFIT SEE DIAGRAM 72548. AS TO LOT 800 ON DP 404613 ONLY REGISTERED 1/7/1980.
3. M195093 LEASE TO INGHAMS ENTERPRISES PTY LTD OF 203-209 NORTHUMBERLAND STREET, LIVERPOOL, NEW SOUTH WALES EXPIRES: SEE LEASE. REGISTERED 25/2/2013.
   M276626 EXTENSION OF LEASE M195093. REGISTERED 17/5/2013.

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| | |
|---|---|
| SKETCH OF LAND: | DP404613 |
| PREVIOUS TITLE: | 2903-30, 2903-31 |
| PROPERTY STREET ADDRESS: | NO STREET ADDRESS INFORMATION AVAILABLE. |
| LOCAL GOVERNMENT AUTHORITY: | SHIRE OF CHITTERING |

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| N/A | N/A |

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# RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

**LAND DESCRIPTION:**

LOT 802 ON DEPOSITED PLAN 404616

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

KARRATHA ENTERPRISES PTY LTD OF 50 CLUNE STREET, BAYSWATER

(AF N339403 ) REGISTERED 27/5/2016

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 3000/1933.
2. *N477988 MORTGAGE TO AUSTRALIA & NEW ZEALAND BANKING GROUP LTD REGISTERED 8/11/2016.
3. *N477989 CAVEAT BY AUSSIE MODULAR SOLUTIONS PTY LTD AS TO PORTION ONLY LODGED 8/11/2016.
4. *N477990 CAVEAT BY KELAIR HOLDINGS PTY LTD AS TO PORTION ONLY LODGED 8/11/2016.

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

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

**STATEMENTS:**

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

| | |
|---|---|
| SKETCH OF LAND: | DP404616 |
| PREVIOUS TITLE: | 1689-591 |
| PROPERTY STREET ADDRESS: | NO STREET ADDRESS INFORMATION AVAILABLE. |
| LOCAL GOVERNMENT AUTHORITY: | SHIRE OF CHITTERING |

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING L324122

WESTERN AUSTRALIA

| REGISTER NUMBER | |
|---|---|
| 35/D72548 | |
| DUPLICATE EDITION | DATE DUPLICATE ISSUED |
| 2 | 9/9/2016 |

VOLUME 1868 FOLIO 807

# RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 35 ON DIAGRAM 72548

**REGISTERED PROPRIETOR:**
(FIRST SCHEDULE)

NEIL JOHN BOVENIZER OF 12A CADDY AVENUE WEST LEEDERVILLE

(T E989850 ) REGISTERED 17/9/1992

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9703/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 807.
2. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 9704/1919. AS TO PORTION ONLY SEE SKETCH ON VOL 1868 FOL 807.

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Lot as described in the land description may be a lot or location.

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

**STATEMENTS:**

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

| | |
|---|---|
| SKETCH OF LAND: | 1868-807 (35/D72548) |
| PREVIOUS TITLE: | 1869-417 |
| PROPERTY STREET ADDRESS: | 3329 GREAT NORTHERN HWY, MUCHEA. |
| LOCAL GOVERNMENT AUTHORITY: | SHIRE OF CHITTERING |

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# APPENDIX B ENVIRONMENTAL ASSESSMENT MANAGEMENT PLAN

# MUCHEA EMPLOYMENT NODE
# PRECINCT 3

# ENVIRONMENTAL ASSESSMENT AND MANAGEMENT STRATEGY

**Prepared for**

**Muchea Employment Node**
**Precinct 3 Landowner Group**
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Report No. J18015a
4 February 2019

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

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# 1.0 INTRODUCTION

## 1.1 Background

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the site) have applied to the WAPC for the lots to be rezoned from Rural to Industrial Development. The Muchea Employment Node Structure Plan 2011 (MENSP) showed the eastern parts of the subject lots as future industrial Precinct 3, bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH) and Ellen Brook. Figure 1 shows the location of the site within the Muchea Employment Node Structure Plan.

The total area of the rezoning is approximately 185 hectares. Figure 2 shows the boundaries of the site.

The MENSP concept for Precinct 3 is for low water-use industries with a minimum lot size of one hectare, with effluent disposed on-site using aerobic treatment units and evaporation ponds. This recognises the site constraints posed by the land's low elevation and high winter water table. Figure 3 shows a preliminary conceptual plan of subdivision for the site.

## 1.2 Scope of the EAMS

The scope of this Environmental Assessment & Management Strategy (EAMS) is to:

- document the existing environment on the site;
- briefly describe the proposed development;
- examine the potential impacts of development;
- propose management strategies to avoid or mitigate impacts; and
- outline a proposed monitoring program.

This EAMS is accompanied by a Local Water Management Strategy (LWMS), which deals specifically with water-related matters including drainage, groundwater management and wastewater disposal.

## 1.3 Relevant Guidelines and Policies

### 1.3.1 Better Urban Water Management

*Better Urban Water Management* (WAPC, 2008) sets out the following objectives for water sensitive urban design:

*Water Conservation*

- Consumption of 100kL/p/yr including less than 40-60 kL/p/yr scheme water.

*Water Quantity*

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.

- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

*Water Quality*

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).

- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.

- As compared to a development that does not actively manage stormwater quality, achieve:

  - at least 80% reduction of Total Suspended Solids;
  - at least 60% reduction of Total Phosphorus;
  - at least 45% reduction of Total Nitrogen; and
  - at least 70% reduction of gross pollutants.

*Mosquitoes and Midges*

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DWER) to maximise predation of mosquito larvae by native fauna.

### 1.3.2 Shire of Chittering Town Planning Scheme No. 6

"The following development requirements shall apply to the development and subdivision of land within industrial zones and to industrial land uses –

(a) the effect on the environment by means of discharge of pollutants or contaminants into the air, ground and water be avoided, or managed within acceptable limits;

(b) where an on-site wastewater disposal system is proposed –

i. land capability assessment may be required to demonstrate the capability of the site to manage wastewater and the suitability of the proposed system;
ii. the use of fill and drains to achieve the required separation from groundwater is to be limited; and
iii. a suitable and unencumbered land application area is to be set aside to distribute treated sewage, where required;

(c) within sewerage sensitive areas secondary treatment systems with nutrient removal are to be utilised;

(d) notwithstanding any other provisions of this scheme, industrial development not connected to reticulated sewerage (for treatment on-site or off-site) is to be restricted to 'dry industry' being land uses that intend to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building at a daily volume of less than 540 litres per 1,000m$^2$ of the site area [R10 equivalent];

(e) where trade waste is to be managed and/or disposed of on-site or off-site the associated risks must be identified and addressed, including the vulnerability of the receiving environment where relevant;

(f) where a caretaker's dwelling is a discretionary use –

i. only one dwelling be permitted on each lot;
ii. the dwelling is to have a maximum floor area of 100m²;
iii. the dwelling is to be incidental to the industrial land use;
iv. subdivision of the dwelling from the parent lot will not be permitted;
v. the use of notifications on title may be considered to advise prospective purchasers of potential impacts from noise, dust, odour or amenity that may arise from the location of a residential land use within the zone;
vi. the local government will not consider applications for caretakers' dwellings prior to the primary site activity being either approved or constructed;
vii. where simultaneous approval has been granted by local government for both a caretaker's dwelling and the main activity on the same lot, the main activity must be developed and operational prior to occupation of the dwelling; and
viii. caretaker's dwellings are to be carefully sited and constructed so the potential site (or estate) impacts from noise, dust, odour or amenity are minimised;

(g) in considering rezoning proposals for industrial zones, the local government may require the preparation of a structure plan, and any information relevant to the site conditions, in keeping with the matters listed in clause 67 of the deemed provisions and clause 5.7 of the scheme; and

(h) any other requirement as included in a Local Planning Policy adopted by the local government."

The Scheme shows Precinct 3 and its surroundings as part of a Water Prone Area (Ellen Brook Palusplain), within which the following special provisions apply:

"5.3.3 Planning Requirements

The local government will impose conditions on any Development approval relating to -

a) the construction and occupation of any dwelling or outbuilding;

b) the type of effluent disposal system used in this area shall be high performance with bacterial and nutrient stripping capabilities to the specifications of local government and the Health Department and shall be located in a position determined by local government.;

c) minimum floor levels for any building above the highest known water levels;

d) any land use that may contribute to the degradation of the surface or sub-surface water quality.

e) no development other than for conservation purposes will be permitted within 30 metres of any natural water body; AMD 21 GG 3/4/09

f) damming, draining or other developments which may alter the natural flow of surface water will not be permitted unless such works are part of an approved Catchment Management Plan."

Schedule 11 of the Scheme contains the following provisions that apply to the Muchea Employment Node:

"2.2 Environmental Management Plans

The following Environmental Management Plans shall be prepared and used to inform the design and proposed subdivision and development within the Structure Plan area. They shall be submitted as an additional detail of a Structure Plan unless otherwise determined by the Western Australian Planning Commission.

2.2.1 Local Water Management Strategy

The developer shall submit to the Local Authority a Local Water Management Strategy (LWMS) for approval as an additional detail of a Structure Plan pursuant to clause 5.19 in order to ensure that surface and ground waters are managed with the aim of maintaining the natural water balance. The Local Authority must notify and consult with the authority responsible for water and the environment on the proposed strategy in advertising the Local Structure Plan(s) pursuant to Part 4 of the deemed provisions.

The LWMS shall be prepared in accordance with Better Urban Water Management or its successor document.

The Structure Plan design shall respond to the LWMS required by 2.2.1 and shall be implemented to the satisfaction of the Local Authority, having regard to any advice from the Department of Water.

2.2.2 Environmental Assessment and Management Strategy

The developer shall submit to the Local Authority an Environmental Assessment and Management Strategy for approval as an additional detail of a Local Structure Plan pursuant to Part 4 of the deemed provisions in order to ensure the local structure plan provides a comprehensive and coordinated response to all environmental features within the Structure Plan area and in accordance with the Muchea Employment Node Structure Plan.

The Environmental Assessment and Management Strategy is to include the following:

- Identification of significant environmental features within the local structure plan area including flora, vegetation, fauna, wetlands and waterways;
- Identification of appropriate management strategies, consistent with industry best practice, to ensure that the local structure plan responds appropriately to these environmental features. Appropriate management strategies might include identification of buffers / setbacks, potential areas of revegetation / rehabilitation, public open space and fauna relocation; and
- Consideration of Acid Sulphate Soils (if present) and identification of the likely requirement for ASS management during future planning stages.
- Identification of, and the means for retention and protection of, key cockatoo habitat trees / locations
- Identification of measures to retain the rural character of views of the Structure Plan area from roads within, adjoining, or in the vicinity of the Structure Plan area, by providing details of vegetation screen planting, as well as the details for the siting and design of structure and major earthworks within the Structure Plan area.

The Local Authority must consult with the relevant environmental agencies regarding the proposed strategy in advertising the Local Structure Plan pursuant to clause 5.19.

The Environmental Assessment and Management Strategy shall be consistent with the EPA's current Guidance Statement No. 33 Environmental Guidance for Planning and Development, or any successor Guidance Statement.

The Environmental Assessment and Management Strategy required by 2.2.2 shall be implemented to the satisfaction of the Local Authority on the advice of the applicable environmental agencies."

This Environmental Assessment and Management Strategy (EAMS) has been prepared to satisfy the requirements of Clause 2.2.2 of Schedule 11.

### 1.3.3 Country Sewerage Policy

The draft Country Sewerage Policy requires that all new subdivision and development should be deep-sewered unless it is exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and, where appropriate, density limits.

Commercial and industrial development in towns where no sewer is available may be permitted subject to:

- the overall objectives of the Policy not being compromised; and
- the statutory authority being satisfied after considering the advice of consultative authorities that the intended wastewater disposal arrangements are acceptable.

In this situation, the Health Department does not put a fixed limit on development density but assesses each proposal on its merits including the nature of the proposal and the physical capability of the site to accept the effluent.

Land used for on-site effluent disposal must meet the following requirements:

- The slope must be less than 20% (1 in 5) and the land shall be engineered to prevent runoff.
- The site should not be subject to inundation or flooding at a probability greater than once in 10 years.
- The land should have a minimum depth to the seasonal or permanent water table from the natural ground surface of at least 0.5 metre.
- The site should have free-draining soil (i.e. free from bedrock, impervious clay or groundwater table ) to a depth of at least 1.2m below the base of a leach drain or 0.5m below the discharge point of an ATU subsoil dripper system.
- Where site modification involves blasting or fissuring of rock, an imported soil type is required to surround the disposal area unless the local authority grants an exemption.

### 1.3.4 DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas

DoW Operational Policy 4.3 was published in 2012 and sets out the Department of Water's policy on defining and protecting foreshore reserves. It is intended to apply to all waterways within development areas. The policy sets out procedures for identifying, delineating and protecting foreshore areas.

The procedure may vary depending on the size and nature of the waterway and the nature of the proposed adjacent development. The policy provides for standard or nominal foreshore widths to be employed in some cases, such as small subdivisions and/or minor tributary creeks where the waterway is adequately protected and the proposed development poses an insignificant additional risk to the waterway.

## 2.0 EXISTING ENVIRONMENT

### 2.1 Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 13.6km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Figure 4 shows a rainfall occurrence chart for Pearce RAAF.

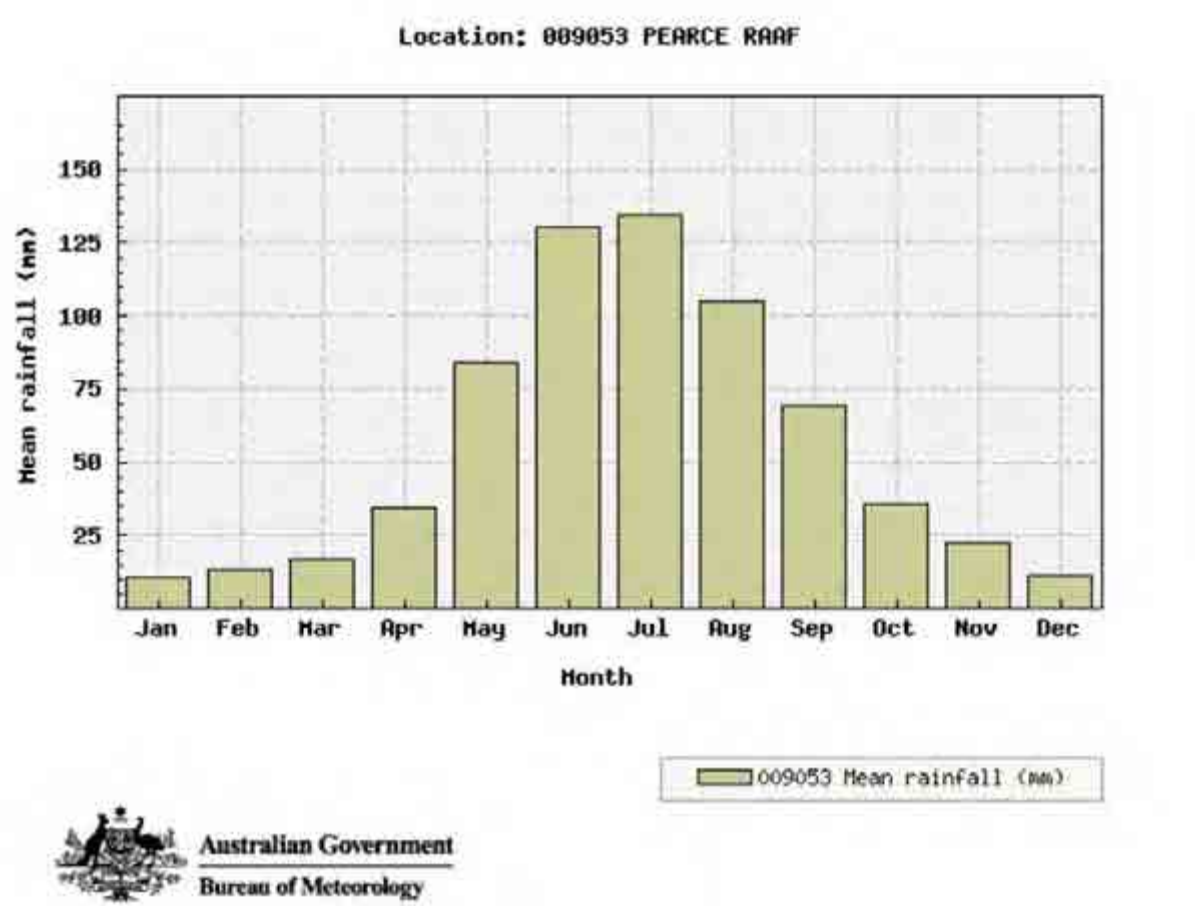


**Figure 4 Pearce RAAF Mean Rainfall**

### 2.2 Physiography

#### 2.2.1 Topography

The site lies on a very gently sloping plain on the eastern side of Ellen Brook. The site slopes gently to the west-southwest at gradients of up to 2.5%, decreasing to less than 0.4% near Ellen Brook. Figure 5 shows the topography of the site.

### 2.2.2 Geology, Landforms and Soils

Precinct 3 is located on the Pinjarra Plain, with soils of pebbly silt belonging to the Guildford Formation. These soils originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams.

The Guildford Formation soils are described by the Geological Survey of Western Australia (Gozzard, 1982) as "Strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin".

Drilling at six sites across the project area for this EAMS found silty soils containing varying proportions of clay, with the clay content increasing with depth. The low-lying western parts of the site are underlain in places by an ironstone (laterite) hardpan at depths of around one metre. Bore logs from the drilling are attached in Appendix A.

At the western edge of the site the alluvial deposits are overlain by a thin veneer of grey sand transported by floods in Ellen Brook. Figure 5 shows the site geology.

### 2.2.3 Soil Permeability

The permeability of the site soils is variable, depending on the clay content. Test pumping during sampling of the on-site bores indicated hydraulic conductivities in the top few metres ranging from about 1 m/day to over 5 m/day.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken at six sites at depths of 0.5m to 1m in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.25m/day to 4.2m/day with a mean of 1.8m/day.

Structerre Consulting Engineers carried out falling-head permeability tests at 1m depth at seven sites in November 2018. The falling-head tests returned hydraulic conductivity values ranging from 0.3m/day to 1.2m/day with a mean of 0.7m/day.

Figure 5 shows the locations of the permeability tests. Details of the tests are attached in Appendix B.

The ironstone hardpan in low-lying areas would impede vertical groundwater movement but its restricted extent means that its effect would be localised. In the south-east of the site, clay subsoils impede groundwater flow and cause a perched water table to develope in that area.

The presence of a water table at the ground surface in winter across much of the site (see Section 2.3.2) means that all infiltration of drainage and effluent will be in fill, so the permeability of the natural soils is of reduced importance.

### 2.2.4 Acid Sulphate Soils

The DBCA maps most of the site as Low to Nil risk of Acid Sulphate Soils (ASS). Areas within 50-250m of Ellen Brook (corresponding to the alluvial sand S11 and ironstone) are mapped as Low to Moderate risk. The nearest mapped High ASS risks are an area of palusplain about 850m to the south-east and a sumpland about 900m to the west of the site. Bore sampling in August 2018 found no indicators of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary, although monitoring should be undertaken during any dewatering activities, with lime dosing of water and/or soil if required.

### 2.2.5 Phosphorus Retention Index

Previous experience has shown that the gravelly and silty soils of the Guildford Formation generally have moderate to high PRI.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

| *PRI Range* | *Rating* | *Typical soils* |
|---|---|---|
| 0 – 0.5 | Very Low | Bassendean Sand |
| 2 – 4 | Low – Moderate | Karrakatta Sands |
| 5 – 12 | Moderate – High | Cottesloe Sands |
| 12 – 20 | High | Crushed Limestone, Limesand |
| 20 – 1000+ | Very High | Clay |

The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins and swales.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

## 2.3 Hydrology

The hydrology of the project area is complex, with soils of varying permeability, shallow and deep groundwater, runoff and surface discharge. Figure 6 depicts the overall hydrology of the site.

### 2.3.1 Groundwater

Groundwater occurs at shallow depth across the site. The DWER maps minimum groundwater levels at 39-48m AHD (2-7m below ground), flowing south-west towards Ellen Brook.

In winter, the groundwater rises to the ground surface across the lower western parts of the site and creates surface discharge to creeks, drainage lines and Ellen Brook. In the higher eastern parts of the site, rainfall infiltration is impeded by the low-permeability subsoils, creating a perched water table which flows downslope and discharges as surface flow on the lower parts of the site. The net result of these two processes is that groundwater is at or near the ground surface over much of the site in winter.

Bores installed and measured in August 2018 (Figure 7), during a wetter than average winter, gave water depths and levels shown in Table 2.1. Simultaneous measurements of DWER bores located 480m south-east (Swan GWA 2-98) and 580m north-east (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated. Figure 7 shows the calculated AAMGL contours across the site.

Table 2.1 shows that the groundwater levels measured on 22 August 2018 were slightly above the AAMGL. The table also shows that the estimated MGL is above the ground surface over much of the site. This does not take into account the effects of existing drains and surface runoff, which would generally limit the groundwater levels to at or just below the ground surface.

**Table 2.1 Groundwater Depths and Levels 22 August 2018**

| *Bore* | *Depth (mbgl)* | *Level (m AHD)* | *AAMGL (m AHD)* | *MGL (m AHD)* | *Depth to AAMGL (m)* | *Depth to MGL (m)* |
|---|---|---|---|---|---|---|
| MB1 | 0.2 | 51.39 | 51.14 | 51.72 | 0.45 | -0.13 |
| MB2 | 0.34 | 45.29 | 45.04 | 45.62 | 0.59 | 0.01 |
| MB3 | 0.21 | 52.37 | 52.12 | 52.70 | 0.46 | -0.12 |
| MB4 | 0.02 | 42.58 | 42.33 | 42.91 | 0.27 | -0.31 |
| MB5 | 0.69 | 56.1 | 55.85 | 56.43 | 0.94 | 0.36 |
| MB6 | -0.08 | 42.98 | 42.73 | 43.31 | 0.17 | -0.41 |
| MB7 | 0.32 | 55.19 | 54.94 | 55.52 | 0.57 | -0.01 |
| MB8 | 0.23 | 42.64 | 42.39 | 42.97 | 0.48 | -0.10 |
| 399 | 0.02 | 48.42 | 48.17 | 48.75 | 0.27 | -0.31 |
| GD20 | 0.12 | 61.36 | 59.85 | 61.35 | 1.63 | 0.13 |
| 2-98 | 1.44 | 56.85 | 56.6 | 57.18 | 1.69 | 1.11 |

### 2.3.2 Surface Drainage

The high water tables and low permeability soils of the site result in surface flow in channels and sheet flow across the ground surface during wet winters.

Several natural and artificial drainage lines cross the site from fifteen culverts beneath Great Northern Highway. The largest of these is a creek at the northern end, which has a catchment east of Great Northern Highway of 384ha. Two other drainage lines enter on the mid eastern boundary, draining catchments of 67ha and 121ha east of Great Northern Highway. Several other culverts beneath the highway drain into minor drainage lines within

the site. Other small drainage lines rise within the site and flow west. Figure 8 shows the existing drainage within the site.

All drainage from the site flows into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow in the system, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715km$^2$ (WRC, 2012). The Brook rises as Chandala Brook about 20km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. Main Roads Western Australia (MRWA) modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project. Figure 8 shows the 100-year ARI floodplain as modelled by MRWA.

Further flood modelling was carried out by BG&E for this project, in order to define the floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area interacts with the Brook. The BG&E floodway modelling report is attached in Appendix C. Figure 8 shows the floodway as mapped by BG&E, which falls within the foreshore and drainage/landscape reserve.

### 2.3.3 Water Resources

The project area is within the Lake Mungala sub-area of the Gingin Groundwater Area for the superficial and semi-confined (Mirrabooka) aquifers, and the SA 3 South sub-area for the confined Leederville and Yarragadee aquifers. Groundwater allocations within the Lake Mungala and SA 3 South sub-areas are managed under the Gnangara Groundwater Areas Allocation Plan. Under the plan, all of the aquifers within the Lake Mungala and SA 3 South sub-areas are fully or over allocated, and no new allocations are available. The DWER intends to release a new Gnangara Groundwater Allocation Plan in late 2018, which may further reduce allocation limits within the plan area (G. Chandler, 2018 pers. comm.).

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows a number of licensed bores within the project area, abstracting water from the superficial and Leederville aquifers. The total licensed allocations within the project area are 82,150 KL/yr from the Leederville and 35,000 KL/yr from the superficial aquifer.

The water requirement for the fully developed project area is unknown, although the Muchea Employment Node Structure Plan (WAPC, 2011) implies that the total combined requirement for the Employment Node and the Muchea townsite is less than 288 ML/a. From this it may be deduced, on a area basis, that the ultimate water requirement for the

project area would be somewhat less than 60 ML/yr. This is roughly half of the currently licensed allocations within the project area.

Water supply will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand is likely to be limited to landscape irrigation, as industries within the Precinct will be limited to those with low water usage.

Potable water will be supplied to the Precinct by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Precinct 3 with potable water. Discussions with Aqua Ferre are ongoing.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the Precinct is likely to be necessary. The landowners group will negotiate with existing licence holders within and outside of the Precinct with a view to purchasing an existing groundwater allocation., and will submit a groundwater licence application to the DWER in due course.

## 2.4 Water Quality

### 2.4.1 Groundwater

Groundwater samples were collected from eight bores within the project area (Figure 7) on 22 August 2018, when groundwater levels were at or near their peak for the year. The results of the analysis are shown in Table 2.2 and summarised below.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally moderate with the exception of a notably high reading for total phosphorus in Bore MB2, in the north-west of the project area. This bore is downstream of a heavily-stocked special rural lot and also has sandy surface soils. The high Total Phosphorus concentration is not reflected in the dissolved (reactive) phosphorus concentration.

The groundwater shows low acidity and sulphate contents, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are low except for aluminium and zinc, which are slightly elevated across much of the site.

### 2.4.2 Surface Water

Surface water samples were collected on 22 August 2018 from ten drains and creeklines flowing into the project area from culverts beneath Great Northern Highway (Figure 8). A further six samples were collected from drains flowing out of the project area into Ellen Brook. Samples were also collected from Ellen Brook immediately upstream and downstream of the project area, and from two small dams in the south of the project area (Figure 8). The results of the analysis are shown in Tables 2.3 and 2.4 and summarised below.

Surface water quality upstream of the project area is variable, with total phosphorus in ten drains and creeklines flowing into the site (Figure 8) ranging from 0.04mg/L to 0.31mg/L (the ANZECC target for freshwater ecosystems is 0.065mg/L). Total nitrogen in these watercourses ranged from 0.6mg/L to 2.1mg/L, against an ANZECC target of 1.2mg/L.

Water quality downstream of the project area was generally poorer, with six outflowing drains (Figure 8) having total phosphorus of 0.07 - 1.8 mg/L and total nitrogen of 1.3 - 3.0 mg/L.

The most notable feature of surface water quality is Ellen Brook itself, which showed total phosphorus of 0.59mg/L upstream of the project area and 0.54mg/L downstream. Coupled with the high flow at the time, this emphasises the primary role of Ellen Brook in the water quality issues facing the Swan-Canning River system.

Suspended sediment levels in surface water upstream and downstream were generally low except at Site 369 (Figure 8) in Ellen Brook immediately downstream of the confluence of a small drain carrying sediment-laden water from the PDNH roadworks. The effect of this drain was not apparent in samples further down Ellen Brook.

The two dams sampled in the south of the project area, which held a blend of surface and ground water, gave mixed water quality results, with low phosphorus but elevated nitrogen levels.

**Table 2.2 Groundwater Quality 22/8/2018**

(see Figure 7 for bore locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *MB1* | *MB2* | *MB3* | *MB4* | *MB5* | *MB7* | *MB8* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **1.7** | **4.3** | **3** | <0.2 | **2** | 1.2 | 0.5 |
| | NOx | mg/L | 0.15 | ng | **1.5** | **2.5** | **3** | <0.01 | **2** | **0.21** | 0.07 |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 0.2 | 1.8 | <0.2 | <0.2 | <0.2 | 1 | 0.4 |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | 0.04 | **0.99** | 0.03 | **0.15** | **0.2** | **0.2** | **0.25** |
| | Reactive Phosphorus | mg/L | 0.04 | ng | <0.01 | 0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.03 |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 6.5 | 6.9 | 6.7 | **4.7** | 6.6 | **6.3** | **5.5** |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **4.8** | **1.6** | **0.82** | **2.8** | 0.25 | **3.5** | **4.4** |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **2880** | **960** | **492** | **1680** | 150 | **2100** | **2640** |
| | Acidity | mg/L | 40[c] | ng | 15 | 20 | 9 | **63** | 15 | **77** | **67** |
| | Alkalinity | mg/L | ng | ng | 29 | 70 | 22 | <5 | 27 | 65 | <5 |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.52 | 0.11 | 0.18 | 0.57 | 0.29 | 0.45 | 0.37 |
| | Hardness | mg/L | ng | 60-350 | 140 | 190 | 51 | 110 | 52 | 170 | 180 |
| | Sulphate | mg/L | ng | ng | 240 | 130 | 13 | 120 | 12 | 130 | 120 |
| | Chloride | mg/L | ng | 350 | 1400 | 400 | 230 | 850 | 44 | 1100 | 1400 |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.17 | 0.33 | 0.06 | 0.14 | 0.27 | 0.12 | 0.09 |
| Major Ions | Calcium | mg/L | ng | ng | 54 | 44 | 20 | 23 | 17 | 54 | 32 |
| | Sodium | mg/L | ng | 230 | 820 | 300 | 110 | 420 | 29 | 630 | 710 |
| | Potassium | mg/L | ng | ng | 1.7 | 19 | 0.3 | 13 | 2.3 | 8 | 24 |
| | Magnesium | mg/L | ng | ng | 160 | 28 | 23 | 83 | 8.8 | 67 | 140 |
| | Iron | mg/L | ng | 10 | 0.16 | 0.19 | 0.08 | 0.39 | 0.08 | 4.3 | 18 |

**Notes**

ng denotes "no guideline". na denotes "not analysed"

a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)

b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)

c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.

d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | <0.1 | **0.2** | **0.2** | **0.1** | **0.2** | **0.2** | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | 0.006 | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | 0.003 | <0.002 | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | |
| | Zinc | mg/L | 0.015 | 2 | <0.01 | 0.01 | 0.01 | **0.06** | <0.01 | **0.07** | **0.02** | |

**Table 2.3 Upstream Surface Water Quality 22/8/2018**

(see Figure 8 for sample locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *Ellen Brook Upstream* | *407* | *405* | *395* | *393* | *392* | *391* | *410* | *409* | *415* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **3** | 0.7 | **2.1** | 1.2 | **1.7** | 0.6 | 0.6 | **1.7** | **1.7** | **1.7** |
| | NOx | mg/L | 0.15 | ng | 0.01 | 0.06 | <0.01 | 0.02 | 0.12 | <0.01 | 0.01 | **0.45** | **0.32** | <0.01 |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 3 | 0.6 | 2.1 | 1.2 | 1.6 | 0.6 | 0.6 | 1.2 | 1.4 | 1.7 |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | **0.59** | **0.11** | **0.27** | **0.08** | **0.09** | 0.04 | 0.04 | 0.05 | **0.24** | **0.31** |
| | Reactive Phosphorus | mg/L | 0.04 | ng | **0.47** | <0.01 | **0.13** | 0.01 | 0.01 | <0.01 | <0.01 | <0.01 | **0.18** | **0.22** |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 7.2 | | | | | | | | | |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **1.7** | | | | | | | | | |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **1020** | | | | | | | | | |
| | Acidity | mg/L | 40[c] | ng | 8 | | | | | | | | | |
| | Alkalinity | mg/L | ng | ng | 62 | | | | | | | | | |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.04 | | | | | | | | | |
| | Hardness | mg/L | ng | 60-350 | 180 | | | | | | | | | |
| | TSS | mg/L | ng | ng | 7 | 6 | 14 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| | Sulphate | mg/L | ng | ng | 49 | | | | | | | | | |
| | Chloride | mg/L | ng | 350 | 470 | | | | | | | | | |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.10 | | | | | | | | | |
| Major Ions | Calcium | mg/L | ng | ng | 56 | | | | | | | | | |
| | Sodium | mg/L | ng | 230 | 220 | | | | | | | | | |
| | Potassium | mg/L | ng | ng | 10 | | | | | | | | | |
| | Magnesium | mg/L | ng | ng | 53 | | | | | | | | | |
| | Iron | mg/L | ng | 10 | 2.8 | | | | | | | | | |

**Notes**

ng denotes "no guideline", na denotes "not analysed"
a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)
b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)
c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.
d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Aluminium | mg/L | 0.08 | 5 | **0.2** | | | | | | | | | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | | | | | | | | | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | | | | | | | | | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | | | | | | | | | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | | | | | | | | | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | | | | | | | | | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | | | | | | | | | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | | | | | | | | | |
| | Zinc | mg/L | 0.015 | 2 | **0.03** | | | | | | | | | |

**Table 2.4 Downstream Surface Water Quality 22/8/2018**

(see Figure 8 for sample locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *Ellen Brook Down -stream* | *AMS1* | *Ingham1* | *Ingham2* | *MD* | *369* | *362* | *Dam1* | *Dam2* | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **2.6** | **1.5** | **2.3** | **1.7** | **1.6** | **3** | **1.3** | **3.2** | **2.9** | ng denotes "no guideline", na denotes "not analysed" |
| | NOx | mg/L | 0.15 | ng | 0.02 | **0.23** | <0.01 | <0.01 | <0.01 | **0.34** | <0.01 | **2.4** | **2.9** | a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 2.6 | 1.3 | 2.3 | 1.7 | 1.6 | 2.7 | 1.3 | 0.8 | <0.2 | b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years) |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | **0.54** | **0.12** | **0.14** | **0.07** | **0.16** | **0.18** | **0.12** | 0.05 | 0.04 | c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater. |
| | Reactive Phosphorus | mg/L | 0.04 | ng | **0.45** | <0.01 | 0.04 | <0.01 | 0.02 | 0.04 | 0.02 | <0.01 | <0.01 | d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals. |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 7.3 | | | | | | | | | |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **1.7** | | | | | | | | | |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **1020** | | | | | | | | | |
| | Acidity | mg/L | 40[c] | ng | 7 | | | | | | | | | |
| | Alkalinity | mg/L | ng | ng | 65 | | | | | | | | | |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.04 | | | | | | | | | |
| | Hardness | mg/L | ng | 60-350 | 200 | | | | | | | | | |
| | TSS | mg/L | ng | ng | <5 | 7 | 10 | <5 | 7 | 51 | <5 | <5 | <5 | |
| | Sulphate | mg/L | ng | ng | 51 | | | | | | | | | |
| | Chloride | mg/L | ng | 350 | 480 | | | | | | | | | |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.11 | | | | | | | | | |
| Major Ions | Calcium | mg/L | ng | ng | 64 | | | | | | | | | |
| | Sodium | mg/L | ng | 230 | 220 | | | | | | | | | |
| | Potassium | mg/L | ng | ng | 10 | | | | | | | | | |
| | Magnesium | mg/L | ng | ng | 53 | | | | | | | | | |
| | Iron | mg/L | ng | 10 | 2.9 | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | | | | | | | | | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | | | | | | | | | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | | | | | | | | | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | | | | | | | | | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | | | | | | | | | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | | | | | | | | | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | | | | | | | | | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | | | | | | | | | |
| | Zinc | mg/L | 0.015 | 2 | <0.01 | | | | | | | | | |

## 2.5 Vegetation

### 2.5.1 Vegetation Type and Condition

The project area is mostly cleared of native vegetation, consisting of current and former farm paddocks and industrial sites. Figure 9 shows the vegetation of the project area.

Remnant native vegetation consists of a few mature paddock trees (Marri, Flooded Gum and Wandoo), including several very large Marri trees that have been retained within the AMS site (Lots 802 & 803) and a few large Wandoo trees in Lot 804.

Native regrowth is present near the large drain on Lot 800 in the form of a small (0.5ha) thicket of species including *Allocasuarina fraseriana, Melaleuca preissiana, Eucalyptus rudis, Astartea fascicularis* and *Acacia ?rostellifera* over grasses. Nearby is a smaller thicket on a drainage line with regrowth of *Juncus ?kraussii*, *M. preissiana, A. fascicularis* and *E. rudis*.

The area around the large drain on Lot 800 has been densely planted with native tree species including *E. rudis, A. fraseriana, M. preissiana, M. cuticularis* and *Corymbia calophylla.* The drain itself contains a heavy growth of sedges, Bulrush (*Typha orientalis*) and Kikuyu and Couch grasses.

Other areas near the large drain and in other low-lying parts of the site contain dense growths of Cape Tulip (*Moraea flaccida*), Spiny Rush (*Juncus acutus*) and Narrow-leaf Cotton Bush (*Gomphocarpus fruticosus*), all of which are declared pests in Western Australia (www.agric.wa.gov.au/pests-weeds-diseases/weeds/declared-plants). The native rush *Juncus kraussii* occurs along with the introduced *J. acutus* in some areas.

In the west of Lot 35 in the south of the project area are a few large isolated Flooded Gums. In the central south of the site (Lot 35) is a 2.5ha patch of open woodland of young *E. rudis* regrowth over grass.

Elsewhere on the site there are lines and clumps of planted trees, mostly Flooded Gums, Bluegums (*Eucalyptus globulus*), River Red Gums (*E. camaldulensis*) and other non-local eucalypts. There is also scattered regrowth of sedges (*Juncus* ?kraussii) and isolated shrubs.

Overall the condition of the vegetation is classed as Cleared to Completely Degraded. There is no vegetation in Good or better condition.

Adjacent to Ellen Brook there is a sparse to dense woodland of *Eucalyptus rudis, Allocasuarina fraseriana, Melaleuca preissiana, M. rhaphiophylla, Astartea affinis, Jacksonia furcellata and Acacia saligna.* This woodland thins rapidly with distance from the Brook and is mostly outside of the project area. The ground cover over most of this area consists of a heavy growth of pasture grasses and weeds, which extend into the waterway itself.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas of Good condition. The central part (Lots 800 & 801) is accessible to cattle and is in poorer condition than the rest due to grazing. In the northern part (Lots 801-804) there is a dense growth of *Watsonia meriana* ssp *bulbillifera* in areas not accessed by cattle.

### 2.5.2 Vegetation Complexes

The vegetation of the project area is mapped as Yanga Complex, described by Heddle *et al.* (1980) as a low open-forest of *Casuarina obesa*, *Actinostrobus* (now *Callitris*) *pyramidalis, Melaleuca* spp. (including *M. lateritia, M. hamulosa*, *M. preissiana and M. rhaphiophylla*) and *Eucalyptus rudis* in the lower-lying areas, with *Banksia* spp., *Eucalyptus todtiana* and *Corymbia calophylla* open-woodland in the higher areas.

### 2.5.3 Rare and Significant Flora

The DBCA's Naturemap database lists no Declared Rare Flora, Priority Flora or other significant flora species as occurring within the project area. Given the almost completely cleared nature of the project area, no rare or significant species are likely to be present.

The Naturemap database lists six Declared Rare Flora (DRF) taxa and twelve Priority Flora taxa as occurring within a 5km radius of the project area. These are listed in Table 2.5.

**Table 2.5 Significant Flora Within 5km Radius**

| *Taxon* | *Cons Code* |
|---|---|
| Acacia anomala | R |
| Darwinia foetida | R |
| Grevillea althoferorum subsp. fragilis | R |
| Grevillea curviloba subsp. curviloba | R |
| Grevillea curviloba subsp. incurva | R |
| Verticordia plumosa subsp. pleiobotrya | R |
| Isotropis cuneifolia subsp. glabra | P2 |
| Acacia drummondii subsp. affinis | P3 |
| Adenanthos cygnorum subsp. chamaephyton | P3 |
| Chamaescilla gibsonii | P3 |
| Cyathochaeta teretifolia | P3 |
| Eryngium pinnatifidum subsp. Palustre | P3 |
| Platysace ramosissima | P3 |
| Stylidium aceratum | P3 |
| Verticordia serrata var. linearis | P3 |
| Drosera occidentalis subsp. occidentalis | P4 |
| Ornduffia submersa | P4 |
| Synaphea grandis | P4 |

The habitats of the listed DRF species, as recorded in the search area and described in the DBCA's *Florabase*, are as follows:

- *Acacia anomala*
  Florabase: Lateritic soils. Slopes.
  Search area: Marri/*E. todtiana*/Banksia woodland on yellow sand.

- *Grevillea althoferorum* subsp. *fragilis*
  Florabase: Grey sand with gravel.
  Search area: Marri/*E. todtiana*/Banksia woodland on yellow sand.

- *Grevillea curviloba* subsp. *curviloba*
  Florabase: Grey sand. Winter-wet heath.
  Search area: Muchea townsite and the railway reserve south of Muchea.

- *Grevillea curviloba* subsp. *incurva*
  Florabase: Sand, sandy loam. Winter-wet heath.
  Search area: Several locations in the Brand Hwy and railway reserve north of Muchea and the Muchea townsite.

- *Verticordia plumosa* subsp. *pleiobotrya*.
  Florabase: Sandy or clayey soils, gravel, granite. Seasonally wet situations, rock outcrops, undulating plains, hills, road verges.
  Search area: Marri/*E. todtiana* woodland on yellow sandy rise.

## 2.6 Fauna

The project area contains little habitat for native fauna apart from scattered mature paddock trees and small areas of regrowth and planted vegetation around the drains near the PDNH reserve.

The largest area of fauna habitat in the vicinity is the fringing vegetation along Ellen Brook, which borders the southern part of the project area. Fauna including kangaroos are likely to use this habitat as refuge and venture out into the project area to feed on the paddocks.

Bandicoot (Quenda) diggings were observed around Sharp Rush thickets along a drain in Lot 800 (Figure 9).

The DBCA's Naturemap database lists three Threatened Fauna and one Priority Fauna species as occurring within a 5km radius of the project area. These are:

- Carnaby's Black Cockatoo *Calyptorhynchus latirostris* (T)
- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii* subsp. *naso* (T)
- Australasian Bittern *Botaurus poiciloptilus* (T)

- Black-striped Burrowing Snake *Neelaps calanotos* (P3).

The two species of black cockatoo both nest in large hollows in mature eucalypts. The few large remaining eucalypts present in the project area might contain suitable hollows (most were unavailable for inspection) but their isolation and the lack of nearby food resources mean that they are unlikely to be used for nesting.

The Australasian Bittern is a water bird that feeds on aquatic animals such as frogs, eels and freshwater crustaceans, and nests in dense wetland vegetation. There is no feeding or nesting habitat for the species in the project area.

The Black-striped Burrowing Snake inhabits sandy areas and Banksia woodlands. The cleared vegetation and silty clay soils of the project area do not provide the preferred habitat for this species.

## 2.7 Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been cleared and used for farming since at least 1965.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area. The nearest mapped contaminated site is a service station in Muchea, 700m west of the northern end of the project area and on the other side of Ellen Brook. There is no potential for this contamination to directly affect the project area.

The DWER (DoE, 2004) considers intensive agriculture such as the poultry farming operation on Lots 800 and 801 to be a potentially contaminating land use, with potential contaminants including organochlorine, organophosphate and carbamate pesticides, herbicides, metals, salinity and nutrients. Residual soil contamination is most likely to be present around the poultry sheds. Groundwater contamination by nutrients and salinity may be present downgradient of the sheds but would diminish and eventually clear once the sheds were removed. There is no visual or olfactory evidence of soil or groundwater contamination at the poultry farm.

The DWER has advised that, given the proposed use of the land for industry, and assuming the poultry farm has been operating in according with its licence, there should be no need for a site contamination assessment before the land is redeveloped.

There is no visual evidence of other potentially contaminating activities such as piggeries, hydrocarbon storage or landfill.

## 2.8 Aboriginal and European Heritage

The Department of Planning Lands & Heritage's online database shows one registered site, (ID 3525 Ellen Brook: Upper Swan) and seven "other" sites impinging on the project area. Appendix D shows the search reports.

The DPLH mapping usually extends well beyond the actual registered site boundary in order to protect sensitive sites.

The DAA has advised that registered sites do occur within the subject land, in connection with Ellen Brook and tributary creeks. Any disturbance of the registered sites will require approval under Section 18 of the Aboriginal Heritage Act 1972.

## 2.9 Landscape

The project area is visible from Great Northern Highway and Brand Highway. The view is screened in part by roadside trees and vegetation within the site. Figure 10 shows views from Great Northern Highway and Brand Highway.

The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations including Road Trains of Australia (RTA), Aussie Modular Solutions (AMS) and Inghams' poultry farms. The Perth-Darwin National Highway (PDNH) works have caused a major change to the landscape, particularly near the northern end of the project area.

# 3.0 ENVIRONMENTAL IMPACTS AND MANAGEMENT

## 3.1 Surface Water Protection

Ellen Brook is a major tributary of the Swan-Canning River system and the largest contributor of nutrients, mostly from agriculture on the grey sandy soils west of the Brook. Small creeks and drainage lines are important contributors to the flow and water quality of Ellen Brook.

Industrial development has the potential to affect the volume, rate and quality of water flows in the small watercourses and Ellen Brook. The Structure Plan recognises the project area's sensitivity with respect to its proximity to Ellen Brook by restricting future land uses within the project area to industries with low water requirements that do not produce large amounts of industrial waste water. Water outputs from the project area will therefore be limited to stormwater, groundwater and minor process water (such as washdown water).

The Structure Plan has been laid out in order to provide physical protection to Ellen Brook and the significant drainage lines that cross the project area.

*Management*
The aim of surface water protection is to improve the quality of surface water leaving the project area. Given the site's current use for broadacre and intensive agriculture, this is considered achievable.

The contaminant of major concern in Ellen Brook and the Swan-Canning River system is phosphorus. Monitoring in September 2018 (Tables 2.3 and 2.4) showed that Ellen Brook carries very heavy phosphorus loads. Phosphorus is a major contaminant in agricultural runoff but a minor component in runoff from industrial areas.

Management strategies to be implemented include:

- In accordance with the Shire of Chittering Town Planning Scheme No. 4, industries permitted in the precinct will be those that dispose of domestic-quality wastewater at a rate less than 5,400 litres per hectare per day (R10 equivalent).

- Wastewater from toilets and bathrooms will be treated by nutrient-removing systems (e.g. ATU or modified leach drains) in accordance with Health Department requirements. An analysis of the capability of the site to support on-site effluent disposal is presented in the Local Water Management Strategy (Appendix E).

- Existing major drainage lines crossing the project area will be retained and protected within vegetated streamlines (see LWMS and Landscape Master Plan).

- All road runoff will be captured and infiltrated (up to 1-year ARI 1-hour storm) or detained (up to critical 100-yr storm) in bioretention swales in accordance with DWER guidelines. Stormwater management is detailed in the LWMS. Figure 11 shows an overview of the stormwater management system.

- Any process wastewater generated by industries will be treated on-site to a standard suitable for discharge or disposed offsite.

- All lot drainage from storms up to 1-year ARI will be retained and infiltrated on site.

- A monitoring program for stormwater, internal drainage and Ellen Brook will be implemented as detailed in the LWMS.

- Temporary drainage controls will be implemented during the construction period (see Section 3.5).

### 3.2 Groundwater Protection

Groundwater is an important contributor to water flow and quality in Ellen Brook. Given the silty clay soils of the project area, groundwater throughflow and discharge is relatively low.

Groundwater reaches the ground surface over much of the project area in wet winters, leading to high rates of surface runoff and groundwater discharge to surface drains.

Bore samples collected in September 2018 show that the quality of groundwater is generally moderate, with moderate concentrations of phosphorus and nitrogen.

The Structure Plan aims to maintain groundwater levels, discharge volumes and quality at their pre-development levels. With the progressive removal of cattle grazing and poultry farms, the quality of groundwater is expected to gradually improve.

*Management*
Groundwater protection measures are detailed in the LWMS and will include:

- Industries will be restricted to those with low water use and minimal or no waste water (see Structure Plan report).

- Subsoil drains will be set at or above the pre-existing Average Annual Maximum Groundwater Level (AAMGL).

- Subsoil and stormwater drains will discharge to vegetated swales with PRI of at least 15 (see LWMS).

### 3.3 Noise

Industrial land use is inherently noisy. Noise sources include traffic, machinery, power tools, ventilators and impacts.

The eastern part of the project area currently experiences high levels of noise from Great Northern Highway, which carries a high volume of heavy traffic including road trains. With the opening of the Perth-Darwin National Highway, the noise from Great Northern Highway will diminish significantly, with the noise impact shifting to the western side of the project area near the PDNH.

Noise sensitive premises (residences) are located in Muchea, 400 metres west of the project area. Isolated residences are also located east of Great Northern Highway, 70m east and 150m south-east of the project area.

Other noise sources include a clay quarry located 1km east and air traffic (including jets) from Pearce RAAF Base located 6.5km south. The project area is in line with the main runway at Pearce.

Future noise sources will include the PDNH and industry east of Great Northern Highway (Muchea Employment Node Precinct 2).

*Management*
Active management of noise within and from the Structure Plan area will not generally be required. Industries with high noise emissions may be required to undertake technical analyses to determine separation requirements. These industries may be restricted to certain parts of the Structure Plan area where suitable separations are available.

### 3.4 Dust

Industrial land uses may generate significant amounts of dust, depending on the activities carried out and the condition of the ground surface. Potentially dusty activities include processing (materials handling), unsealed roads and exposed soil surfaces.

The silty soils of the project area are susceptible to dust generation when disturbed. The main dust risk will be during construction work. Management of construction impacts is detailed in Section 3.5.

Sensitive dust receptors are the same as those for noise: the town of Muchea and residences located east of Great Northern Highway.

*Management*
Individual lot holders within the project area will be required to manage dust to prevent dust escape beyond their boundaries. Industries that generate appreciable dust will be

required to hold a DWER licence, which will include dust limits and specify monitoring requirements.

### 3.5 Construction Impacts

Construction of the Precinct 3 industrial estate will be carried out by various parties at various times, in accordance with individual land owners' preferences. Construction of roads, drainage and other services will be undertaken by the owner(s) of each stage of subdivision.

Construction stage impacts relate mainly to the movement of machinery and the presence of areas of exposed soil, and include noise, vibration, dust, erosion and sedimentation.

*Management*
Management of construction impacts will be the subject of conditions attached to subdivision approvals, works approvals and development approvals.

In general, control of construction impacts will be the responsibility of the construction contractor. The general principles of construction management will be as follows:

The developer will implement a Construction Management Plan for the development dealing with dust management, erosion and sediment control, containment of environmentally hazardous materials (chiefly fuel and oils) and spill response. The key elements of the Construction Management Plan will include the following:

*Dust Minimisation*
- No topsoil stripping will be undertaken in dry conditions when the wind speed is greater than 25km/h unless appropriate dust control watering is undertaken prior to and during disturbance..
- No earthworks will be undertaken in dry conditions when the wind speed is greater than 40km/h unless appropriate dust control watering is undertaken prior to and during disturbance.
- Dust will be suppressed on open ground and stockpiles by regular watering, hydromulching, wind fencing and/or covering.
- An adequate supply of water for dust suppression will be kept on site at all times.
- Soil stockpiles will be limited to a height of 2.5m to minimise dust generation and to facilitate watering.
- Other dust minimisation measures will include minimising areas of disturbance, limiting volume and speed of construction traffic and instructing site workers in dust minimisation.

*Erosion and Sedimentation*
- Drains and bunds will be constructed at the beginning of site disturbance as necessary to capture and direct all runoff from disturbed areas into settling ponds.

Drains, bunds and ponds will be appropriately designed and sized to provide adequate settling of sediments from drained water before release.
- Vehicles and machinery will be kept to designated roads, tracks and work areas.

*Water Conservation*
- Water consumption during construction will be minimised by:
  - limiting dust suppression watering to prevent ponding and runoff; and
  - use of non-water dust control methods such as wind fencing and hydromulching where appropriate.

*Hazardous Materials*
- All environmentally hazardous materials will be stored in their original labelled containers (or labelled jerrycans or drums in the case of petroleum fuels) in a ventilated enclosure equipped with appropriate signage, fire extinguishers and a spill response kit.
- Petroleum products will be held in a bunded enclosure.
- Material Safety Data Sheets (MSDS) and a chemical register for all hazardous materials on the site will be maintained by the site supervisor in the site office.

*Complaints Register*
- The site supervisor will maintain a record of any public complaints and the actions taken in response.

### 3.6 Vegetation and Flora

The native vegetation of the project area consists of a few paddock trees, rows and thickets of planted trees, sedges and shrubs in drainage lines and a small thicket of regrowth consisting of flooded gums, casuarinas and acacias near the large drain on Lot 800 (Inghams).

The largest area of native vegetation near the project area is the fringing vegetation of Ellen Brook. This will be preserved in the foreshore reserve.

Remnant trees within the development area will be preserved where possible. No remnant trees may be cleared without a Development Approval from the Shire of Chittering and/or a clearing permit from the DWER.

Approximately 31.5 hectares of native sedges, shrubs and trees will be planted in the Ellen Brook foreshore, in drainage swales and within lots. This is described in more detail in the Landscape Master Plan.

## 3.7 Fauna

There is little native fauna habitat in the project area, although the adjacent Ellen Brook provides substantial habitat for fauna which may venture into the project area to forage and graze.

The existing fauna habitat within the project area will be retained and enhanced by new plantings of native vegetation in the Ellen Brook foreshore and minor drainage lines.

Additional fauna habitat will be created in the revegetation of drainage swales and basins.

Street trees planted within the project area will focus on native tree species that provide habitat for nectar-eating and seed-eating birds.

## 3.8 Aboriginal Heritage

The development of Precinct 3 may affect three registered Aboriginal heritage sites associated with minor tributaries of Ellen Brook. Any disturbance of these sites will require permission under Section 18 of the *Aboriginal Heritage Act 1972*. Liaison with the Department of Planning, Lands & Heritage will be required before any physical site development works. The major Aboriginal site associated with Ellen Brook itself will be protected by inclusion in the foreshore reserve.

## 3.9 Landscape

### 3.9.1 Overview

Development in accordance with the Structure Plan will change the landscape of the project area from a mix of rural and industrial to wholly industrial, in keeping with the industrial landscape of the overall Muchea Employment Node.

With the opening of the Perth-Darwin National Highway, the principal view of the site seen by passers-by will shift from the east (Great Northern Highway) to the west (PDNH).

The objective of landscaping within Precinct 3 will be not to hide the industry from view but to provide vegetation features that “soften” and break up the industrial landscape. This will include plantings within the Ellen Brook foreshore, drainage swales and basins, vegetated creek lines, verge trees within the developed areas and landscape buffers within lots.

### 3.9.2 Landscape Plantings

The Shire of Chittering Town Planning Scheme imposes a general requirement that all non-residential lots should provide landscaping with approved species to a minimum of 10% of the total site area, including a minimum of one shade tree per four car parking bays.

The Shire of Chittering's *Muchea Industrial Park Design Guidelines* (2018) set out the Council's requirements and recommendations for development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. The Guidelines require:

- a minimum 2m wide landscape buffer on the primary road frontage;
- a minimum 1m wide landscape buffer on secondary road interface and side boundaries extending to the building setback line;
- one shade tree per four car parking bays; and
- one tree per 10m of road frontage.

The landscape plantings within lots will be of a mix of native trees, shrubs and ground covers. The 1-year ARI 1-hour bioretention swales within each lot will be densely planted with native sedges and low shrubs. This will form part of the 10% landscaping requirement for each lot.

### 3.9.3 Streamline Revegetation

Roadside bioretention swales and through-drainage swales will be densely planted with native sedges and low shrubs to stabilise the beds and banks of the swales, slow water flows and promote the uptake of sediments and nutrients from the water. The areas to be planted, species and planting densities are described in more detail in the Landscape Master Plan (BES, 2018).

Plantings within the swales will be kept to a height that meets the definition of Shrubland in the Bushfire Management Plan (Eco Logical Australia, 2018) so as not to create an unacceptable fire hazard.

### 3.9.4 Ellen Brook Foreshore

Ellen Brook is an important waterway in the Swan-Canning River system and is the largest contributor of nutrients (phosphorus and nitrogen) to the system. The major source of nutrients is farmland on grey sandy soils to the west of the Brook, although farmland and intensive agricultural activities (e.g. poultry farms, piggeries, feedlots) to the east of the Brook may contribute significant quantities of nutrients to the Brook.

Lots 35 and 192 within Precinct 3 adjoin Ellen Brook. The other lots within the Precinct are separated from the Brook by the PDNH. Where the Structure Plan area adjoins Ellen Brook, a foreshore reserve has been defined according to the Water & Rivers

Commission's *Water Note 23: Determining Foreshore Reserves* (2001) and *Foreshore Policy 1: Identifying the Foreshore Area* (2002).

The foreshore definition process takes account of physical, biological and cultural factors including soils, landforms, stream morphology, erosion, floodways, vegetation, Aboriginal sites and existing land uses. Figure 3 shows the foreshore reserve defined through this process.

The Ellen Brook foreshore reserve adjoining Lots 35 and 192 will be planted with native vegetation to enhance its landscape amenity and habitat value for native fauna. The species list, planting density and planting areas will be set out in a Foreshore Management Plan to the satisfaction of the Shire of Chittering. Planting of the foreshore reserve will be undertaken by the developer of each stage of subdivision adjoining the Brook and will occur during the subdivision works.

The rezoning process for Precinct 3 does not include any change to the zoning of Ellen Brook, so the foreshore reserve defined here is indicative only and intended only for the purpose of planning land uses outside of the foreshore setback. Future planning undertaken by the WAPC or other parties may change the boundaries or management of the reserve outside of the amendment area.

## 4.0 MONITORING

Baseline water quality results for the project area and Ellen Brook are shown in Tables 2.2, 2.3 and 2.4. Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in Ellen Brook will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourse.

The proponent of each stage of subdivision will be responsible for monitoring water quality in bores and drainage swales within that stage as well as Ellen Brook upstream and downstream.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

## 5.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Subdivision and development in the project area will be undertaken in accordance with the Structure Plan, this EAMS and the attached LWMS.

Development may occur in accordance with a subdivision approval or, in the absence of subdivision, a Development Approval. Subdivision approvals will include a requirement for an Urban Water Management Plan (UWMP). If development occurs without a subdivision, a Local Water Management Plan (LWMP) may be required to set out drainage design for the development.

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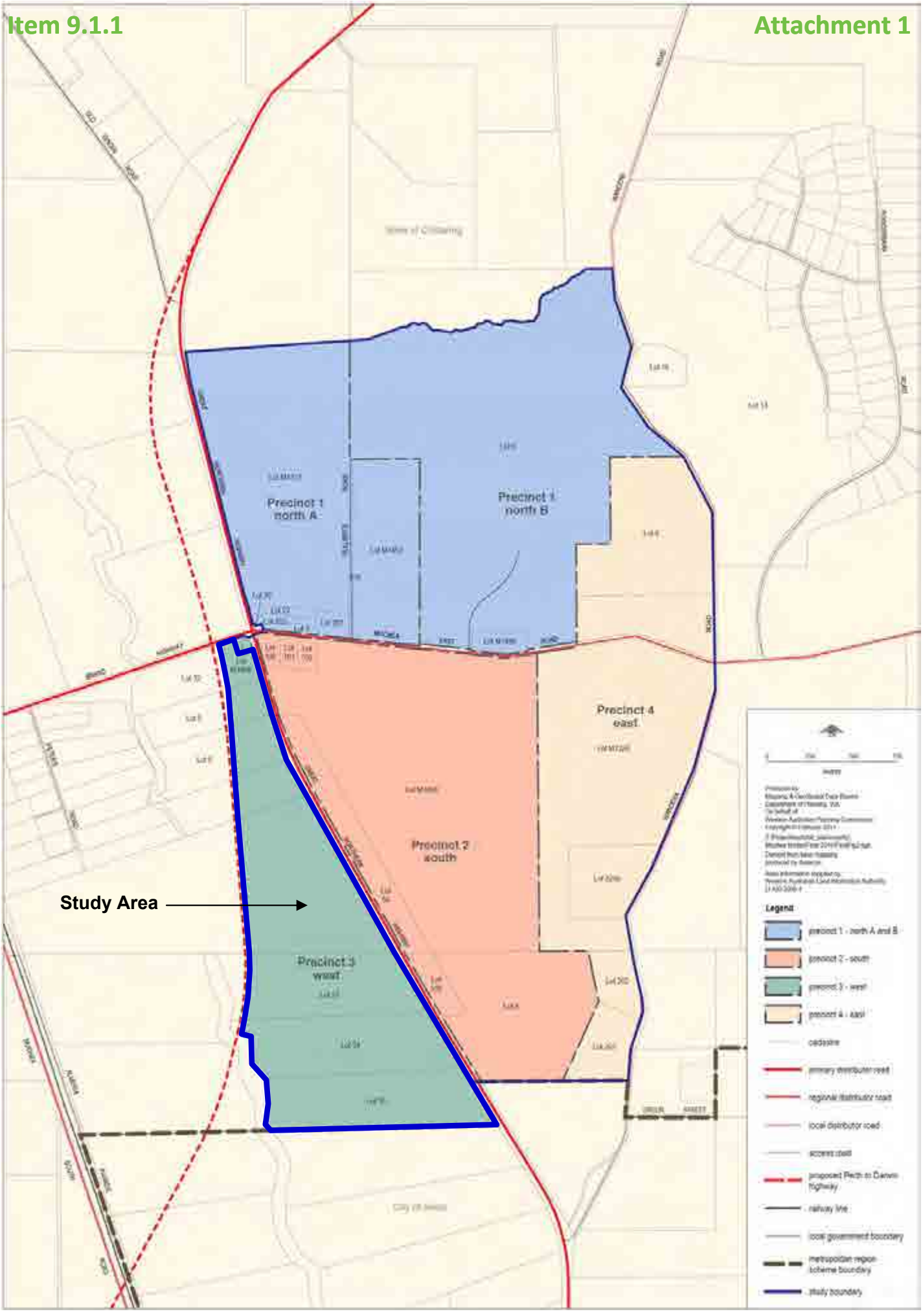
# Figures




Source: WAPC, 2011

**Figure 1**

**MUCHEA EMPLOYMENT NODE STRUCTURE PLAN**

bayley environmental services

**Figure 2**

**THE SITE AND SURROUNDINGS**

Image: Google Earth

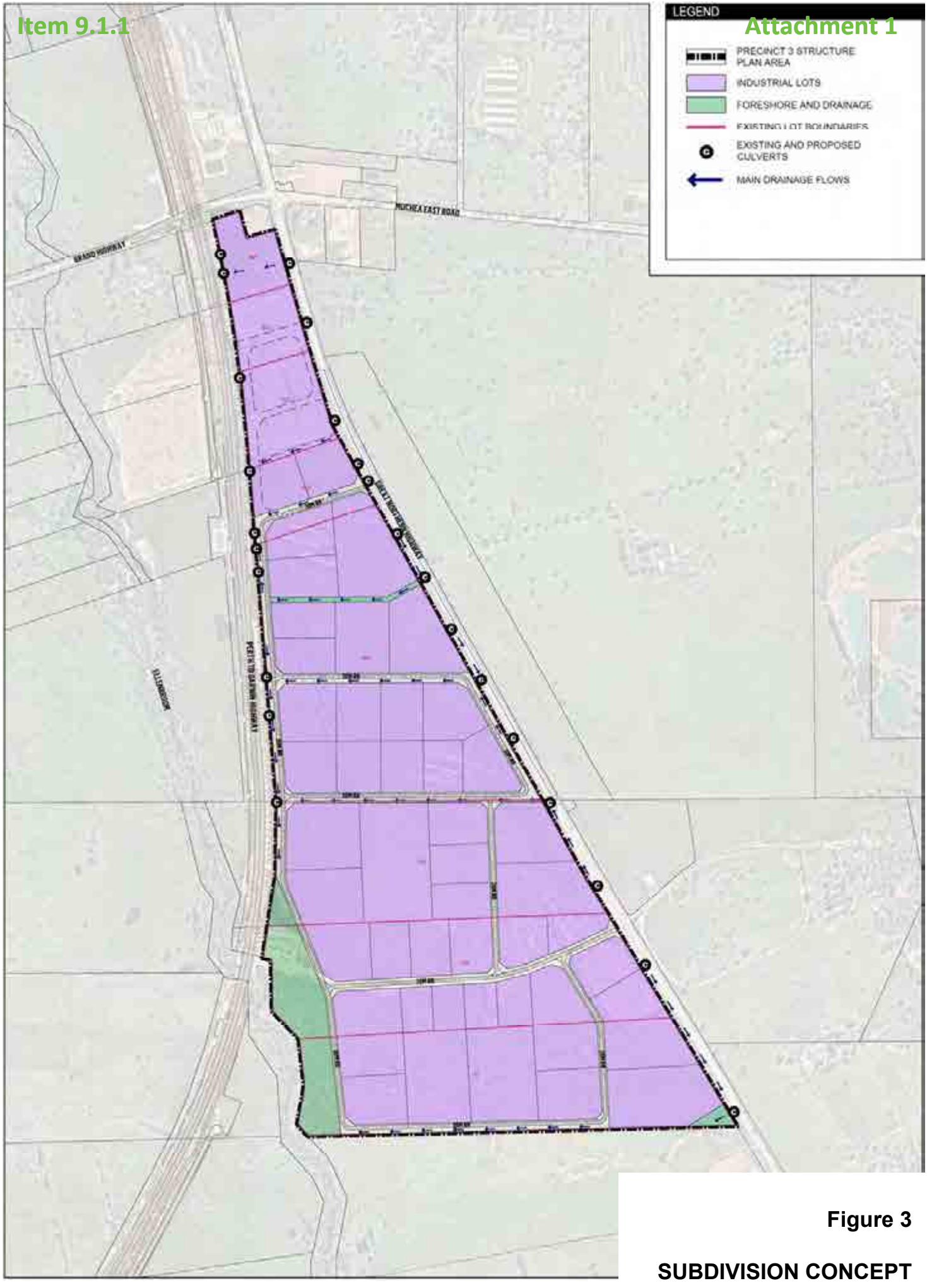



**Figure 3**

**SUBDIVISION CONCEPT**

URBIS

bayley environmental services

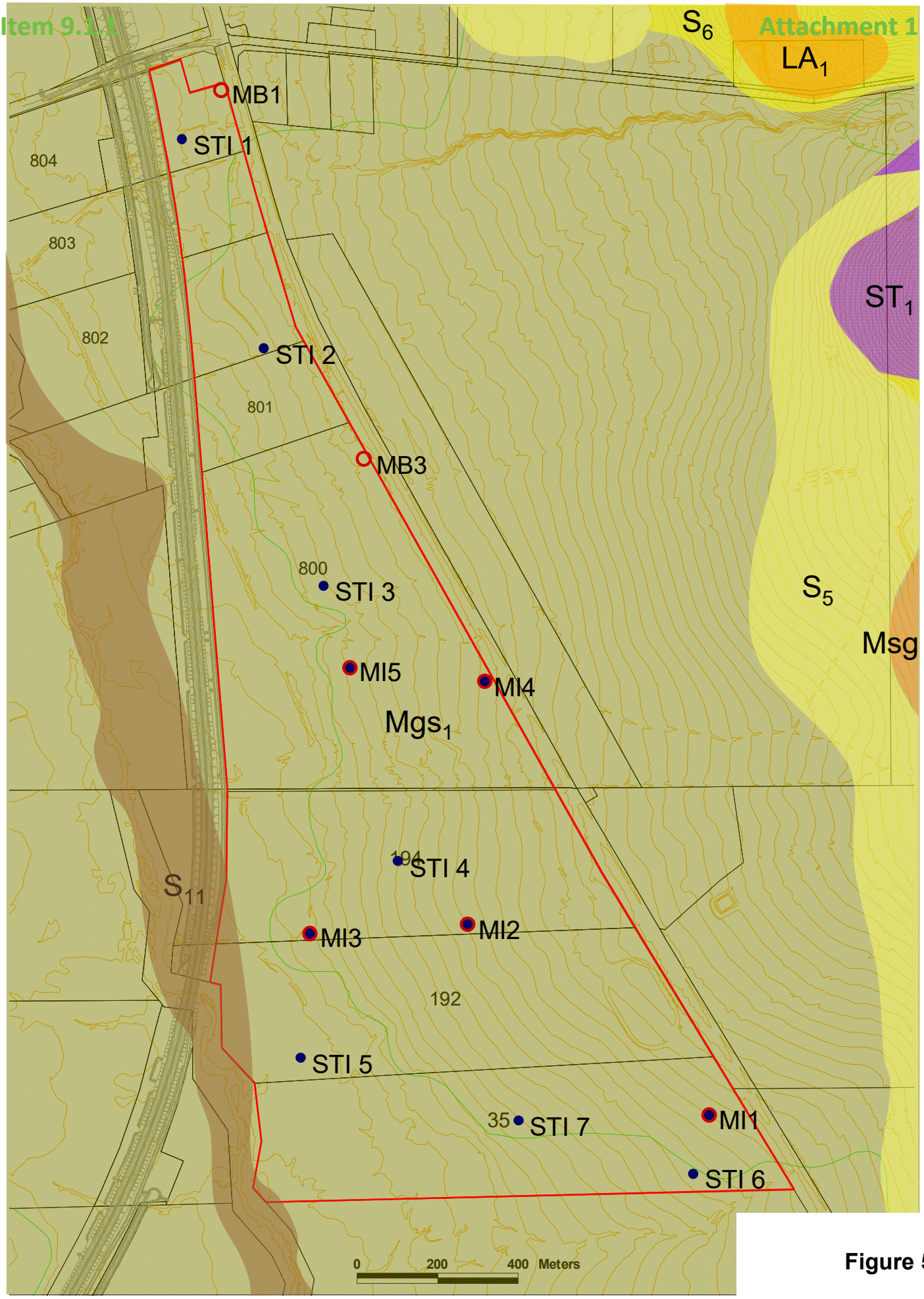



**Figure 5**

**PHYSIOGRAPHY**

Permeability Test
PRI Analysis

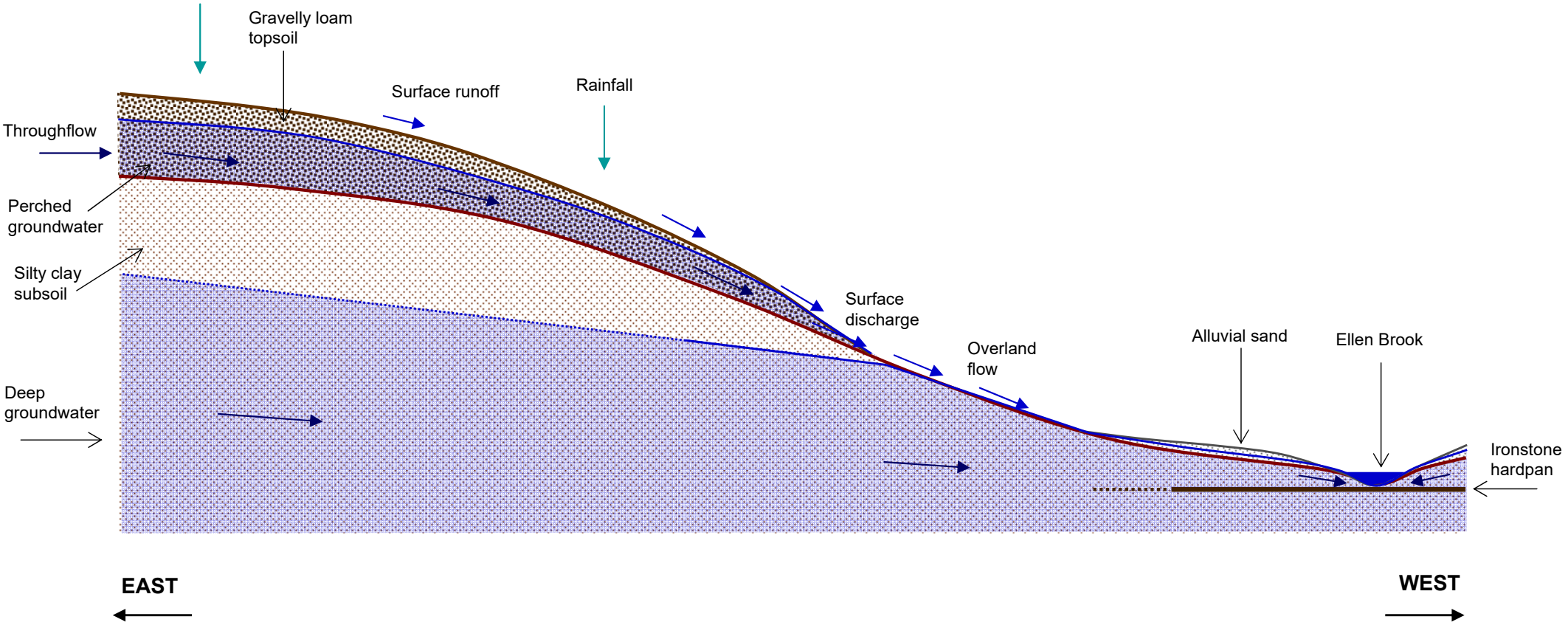
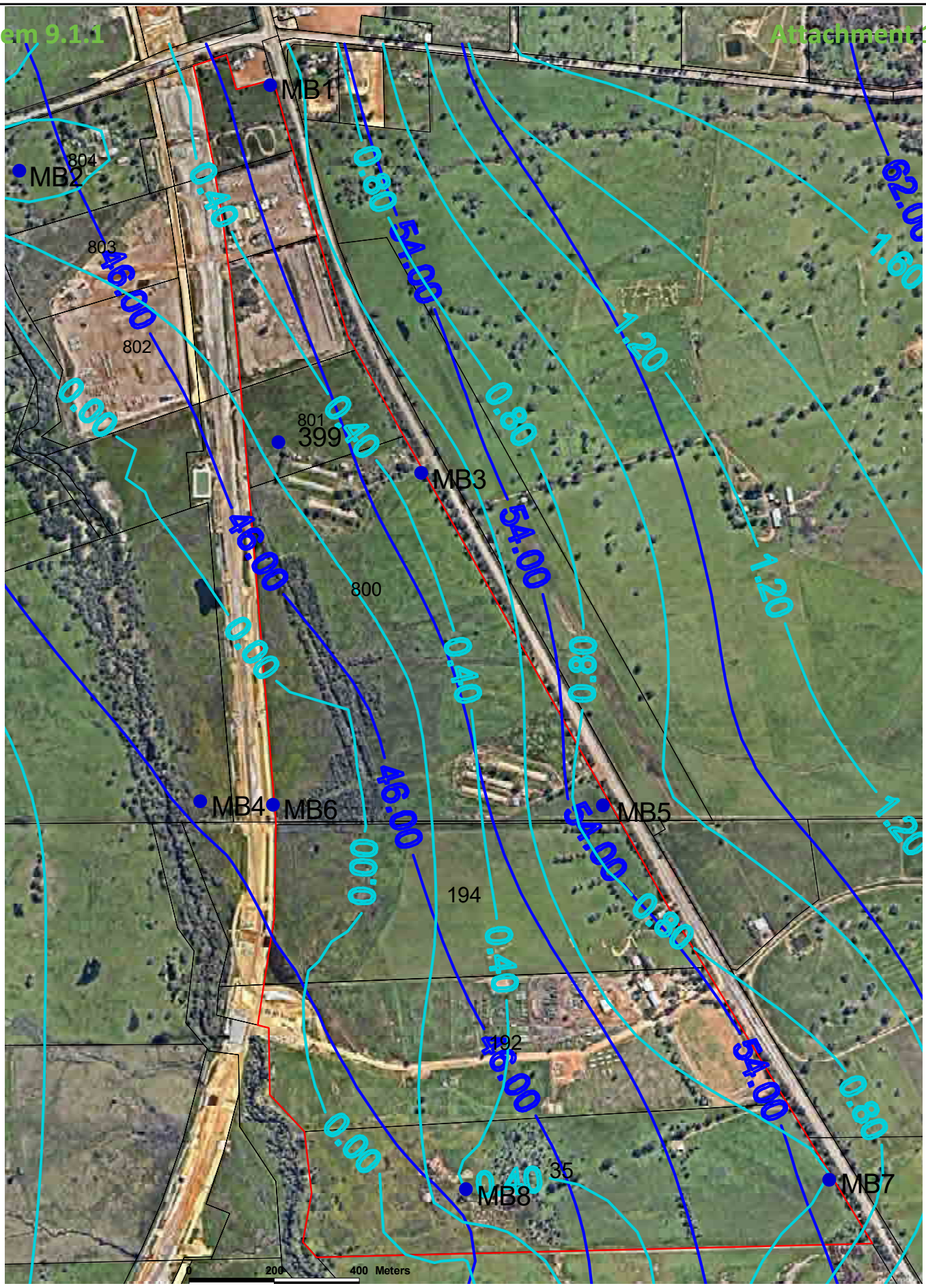



**Figure 6**

**HYDROLOGY OVERVIEW**

Not to scale




AAMGL Contour
Depth to AAMGL Contour
Bore

**Figure 7**

**GROUNDWATER**

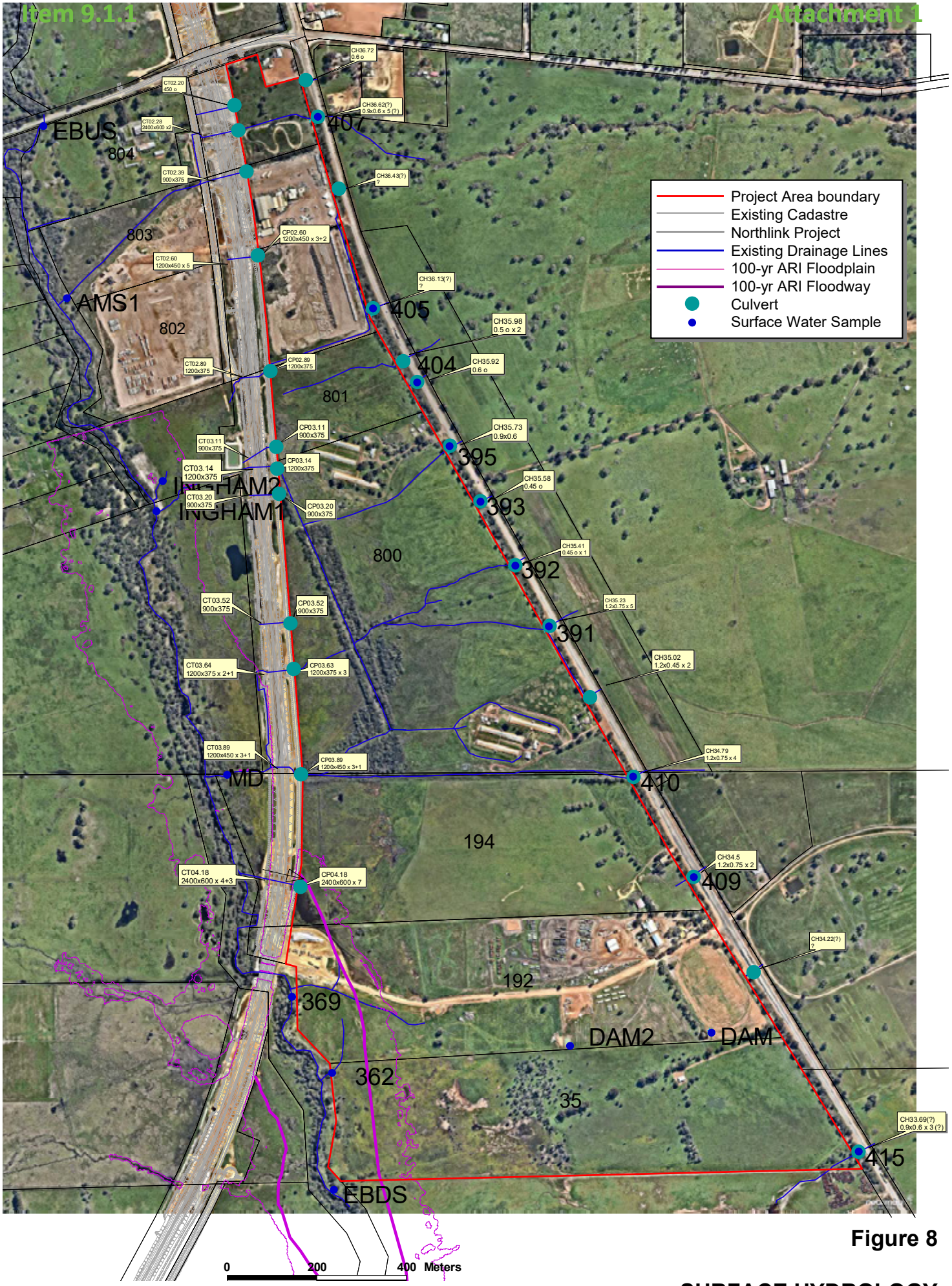



**Figure 8**

**SURFACE HYDROLOGY**

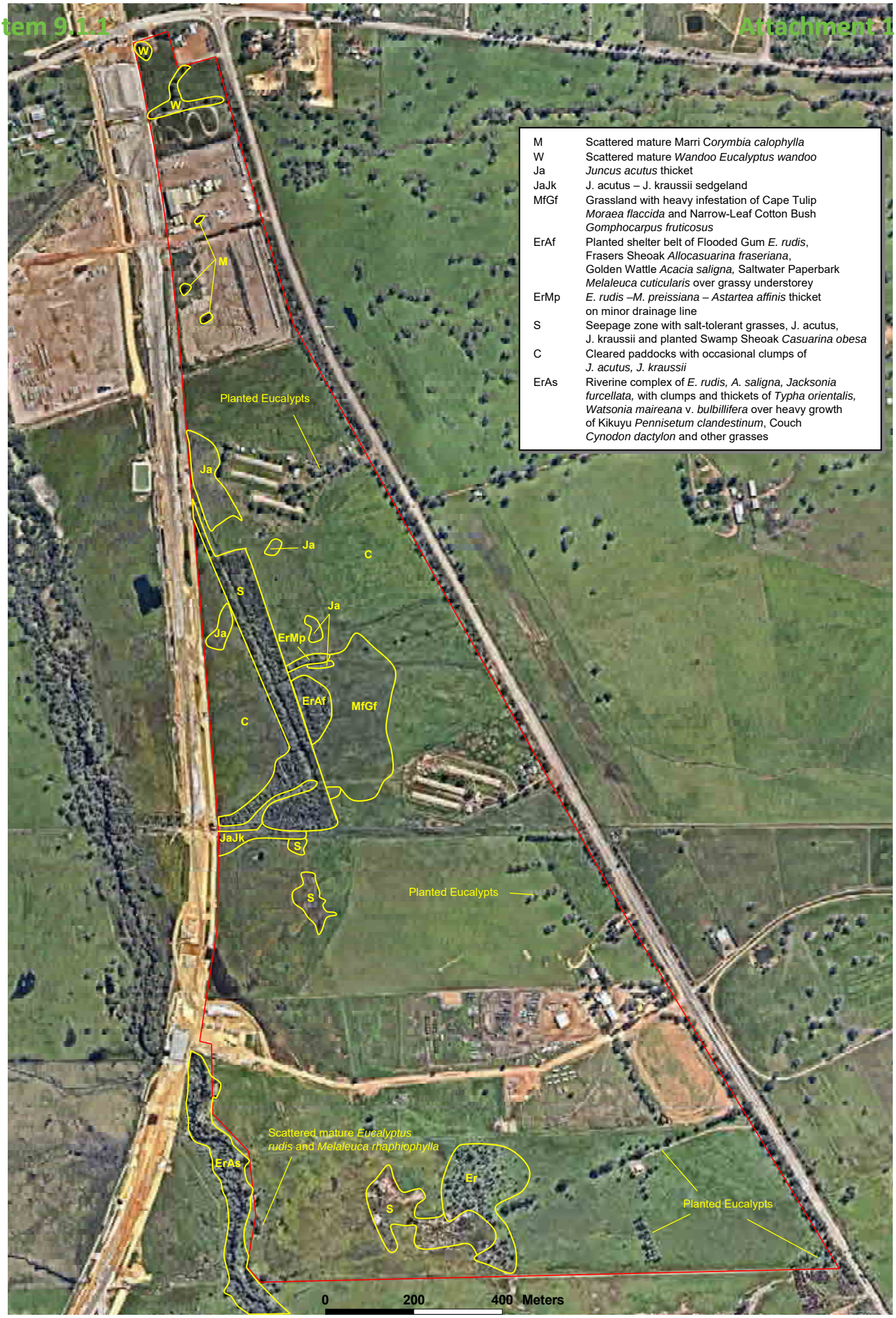



**Figure 9**

**VEGETATION**

Lot 35 from Great Northern Highway

Lot 192 (RTA) from Great Northern Highway

Lot 800 (Inghams) from Great Northern Highway

803 (AMS) from Great Northern Highway

Lot 804 from Great Northern Highway

**Figure 10**

**VIEWS OF THE SITE**

All images: Google

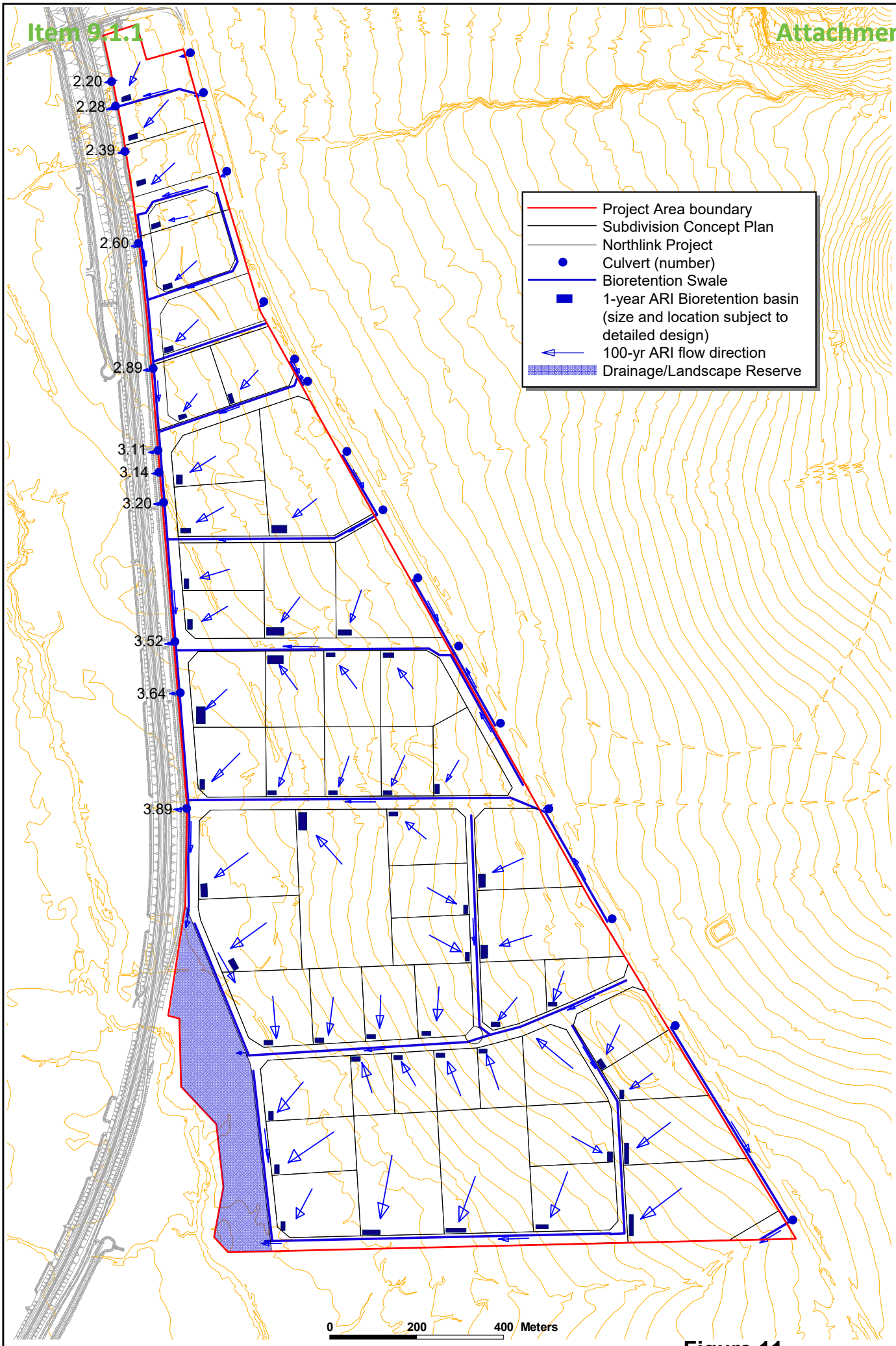



Figure 11

DRAINAGE CONCEPT

# Appendix A

## Soil Logs

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB1 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.5 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 0.5 | Grey-brown gravelly silty loam | | |
| 1 - 1.5 | Yellow-brown clayey silt, wet | | |
| 2 - 3.5 | Yellow clayey silt, wet | | |
| 4 - 4.5 | Pink-grey silty clay, very wet | | |
| | | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB2 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 3.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 0.5 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Dk grey sandy topsoil | | |
| 0.5 - 1 | Grey silty sand, wet | | |
| 1.5 - 2 | Grey brown sandy silt, very wet | | |
| 2.5 | Yellow-brown clayey silt, very wet | | |
| 3 | Green-brown clayey silt, very wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB3 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 3.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Grey-brown gravelly loam | | |
| 0.5 | Brown pebbly silt | | |
| 1 - 2.5 | Orange-brown gravelly clayey silt | | |
| 3 - 3.5 | Pink-brown clayey silt, very wet | | |
| 4 | Pink-grey silty clay, very wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB5 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 0.5 | Yellow-brown silty loam, moist | | |
| 1 - 1.5 | Yellow-brown gravelly silt, very wet | | |
| 2 | Yellow-brown silt, very wet | | |
| 2.5 - 4 | Yellow-brown clayey silt, moist | | |
| | | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB7 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 6.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 0.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Brown gravelly loam, wet | | |
| 0.5 | Orange-brown pebbly silt, moist | | |
| 1 | Red-brown pebbly clay, moist | | |
| 1.5 - 2 | Orange-brown silty clay, wet grading to moist | | |
| 2.5 - 3 | Orange-brown clay, moist | | |
| 3.5 - 6 | Brown clay, wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB8 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 5.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 1.5 | Brown silty clayey gravel, moist | | |
| 2 - 2.5 | Pale yellow-brown silt, wet | | |
| 3 - 5 | Grey silty clay, very wet | | |

# Appendix B

## Infiltration Test Results

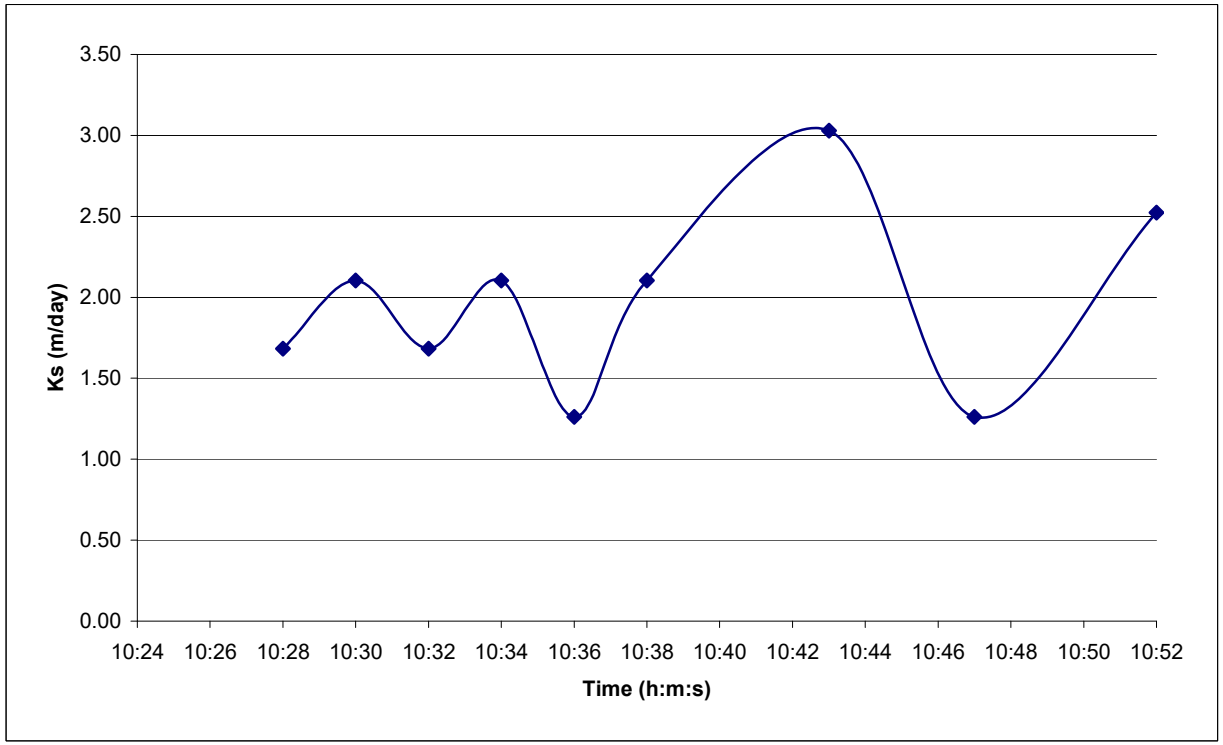
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI1-S |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 10:26:00 | 39.8 | | |
| 10:28:00 | 39.4 | 0.4 | **1.68** |
| 10:30:00 | 38.9 | 0.5 | **2.10** |
| 10:32:00 | 38.5 | 0.4 | **1.68** |
| 10:34:00 | 38 | 0.5 | **2.10** |
| 10:36:00 | 37.7 | 0.3 | **1.26** |
| 10:38:00 | 37.2 | 0.5 | **2.10** |
| 10:43:00 | 35.4 | 1.8 | **3.03** |
| 10:47:00 | 34.8 | 0.6 | **1.26** |
| 10:52:00 | 33.3 | 1.5 | **2.52** |
| | | 33.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 1.9 m/d**



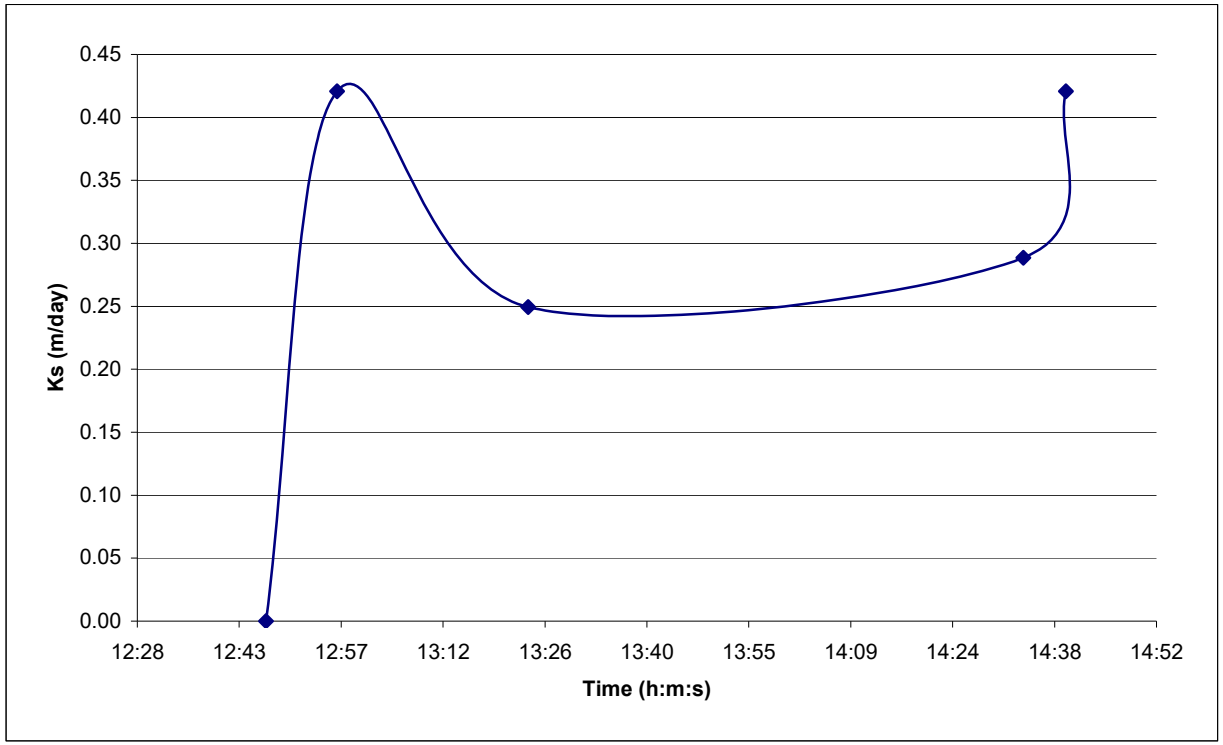
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI1-D |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 1m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 12:42:00 | 40.4 | | |
| 12:47:00 | 40.4 | | |
| 12:57:00 | 39.9 | 0.5 | **0.42** |
| 13:24:00 | 39.1 | 0.8 | **0.25** |
| 14:34:00 | 36.7 | 2.4 | **0.29** |
| 14:40:00 | 36.4 | 0.3 | **0.42** |
| | | 36.4 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 0.25 m/d**



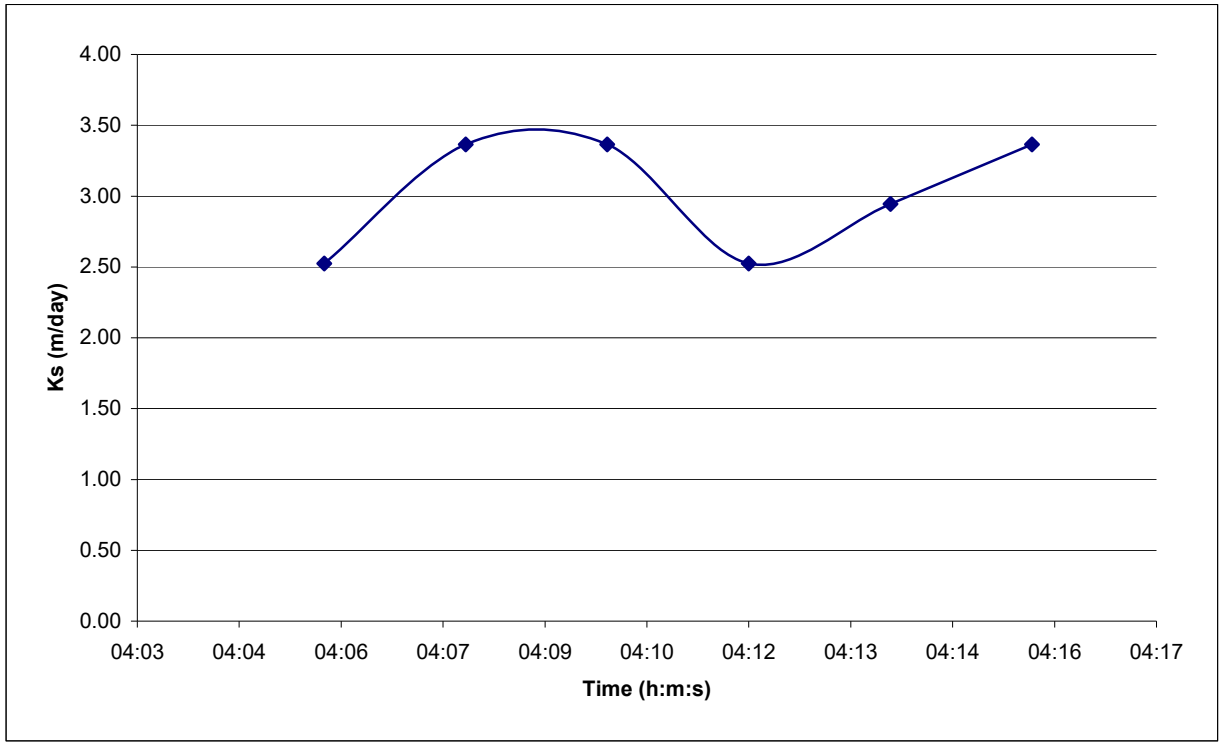
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI2 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 04:05:00 | 36.3 | | |
| 04:06:00 | 36 | 0.3 | **2.52** |
| 04:08:00 | 35.2 | 0.8 | **3.37** |
| 04:10:00 | 34.4 | 0.8 | **3.37** |
| 04:12:00 | 33.8 | 0.6 | **2.52** |
| 04:14:00 | 33.1 | 0.7 | **2.94** |
| 04:16:00 | 32.3 | 0.8 | **3.37** |
| | | 32.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 3.0 m/d**



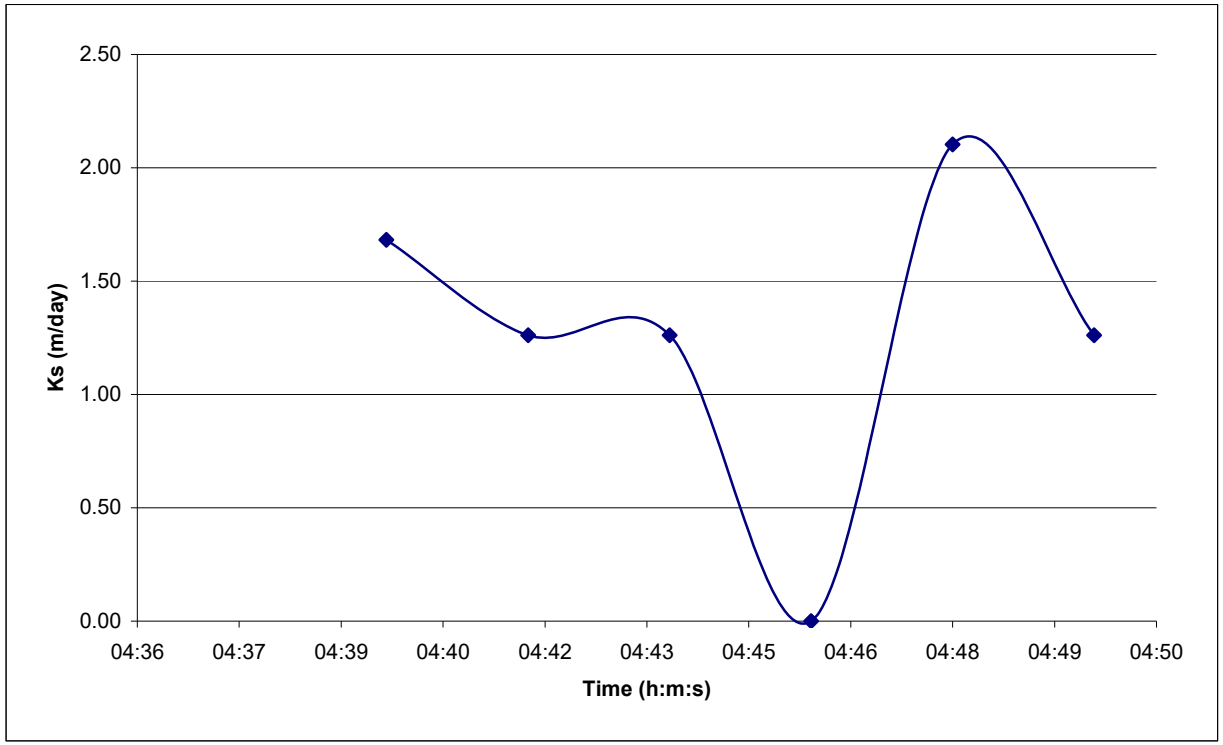
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI3 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 04:38:00 | 27.1 | | |
| 04:40:00 | 26.7 | 0.4 | **1.68** |
| 04:42:00 | 26.4 | 0.3 | **1.26** |
| 04:44:00 | 26.1 | 0.3 | **1.26** |
| 04:46:00 | 26.1 | | |
| 04:48:00 | 25.6 | 0.5 | **2.10** |
| 04:50:00 | 25.3 | 0.3 | **1.26** |
| | | 25.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 1.25 m/d**



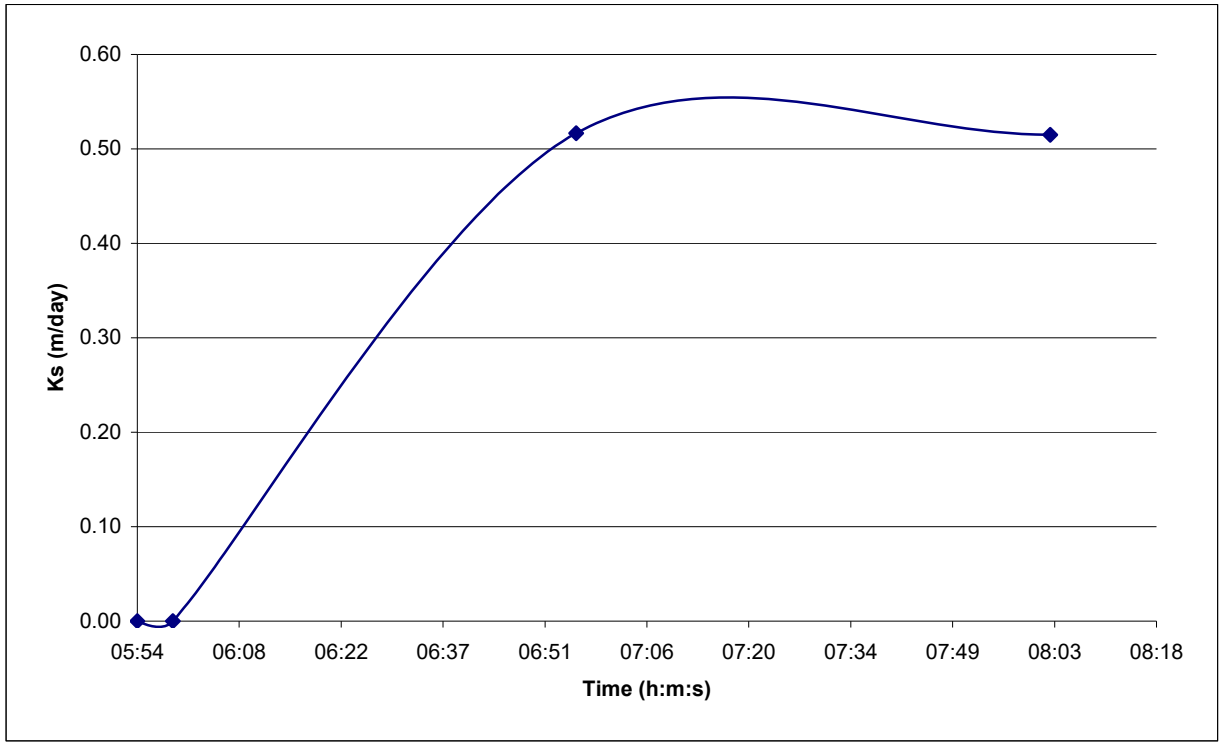
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI4 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 05:49:00 | 34 | | |
| 05:54:00 | 34 | | |
| 05:59:00 | 34 | | |
| 06:56:00 | 30.5 | 3.5 | **0.52** |
| 08:03:00 | 26.4 | 4.1 | **0.51** |
| | | 26.4 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 0.5 m/d**



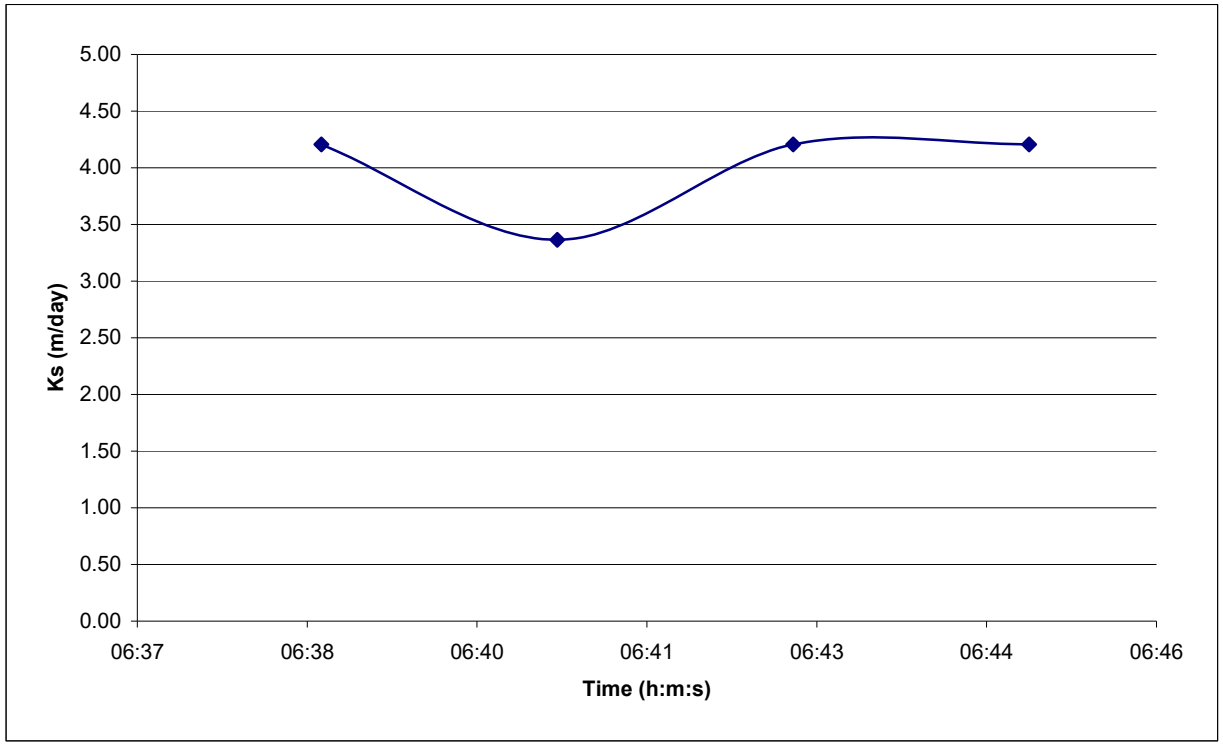
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI5 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5 |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 06:36:00 | 22.9 | | |
| 06:39:00 | 21.4 | 1.5 | **4.21** |
| 06:41:00 | 20.6 | 0.8 | **3.37** |
| 06:43:00 | 19.6 | 1 | **4.21** |
| 06:45:00 | 18.6 | 1 | **4.21** |
| | | 18.6 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 4.2 m/d**



### 3.2. Groundwater

Groundwater was encountered in boreholes BH01, BH02, BH05 and BH12 at an approximate depth of 1.0m below the existing ground level. Groundwater is expected to perch above the impermeable materials.

### 3.3. Percolation Testing

Percolation testing of the in situ soils was undertaken in two locations. Results of the testing are summarised below:

**Table 3 – In Situ Percolation Test Results**

| Test Location | Testing Depth | Soil Type | Permeability |
|---|---|---|---|
| 1 | 0 - 1.0m | SAND/Clayey SAND | 0.6m/day |
| 2 | 0 – 0.7m | SAND/Clayey SAND | 0.5m/day |
| 3 | 0 - 1.0m | SAND/Clayey SAND | 0.3m/day |
| 4 | 0 - 1.0m | SAND/Clayey SAND | 0.7m/day |
| 5 | 0 – 0.5m | SAND/Gravelly SAND | 1.0m/day |
| 6 | 0 - 1.0m | SAND/Clayey SAND | 1.2m/day |
| 7 | 0 – 0.6m | SAND/Clayey SAND | 0.9m/day |

# Appendix C

## Floodway Modelling Report

# MEMORANDUM

| Project: | Muchea Employment Node P3 Waterways | | | Project No: | P18311 |
|---|---|---|---|---|---|
| To: | Copy: | Name: | Organisation: | Facsimile: | |
| ☒ | ☐ | Phil Bayley | Bayley Environmental Services | | |
| ☒ | ☐ | Tom Carmody | Tomahawk Property | | |
| ☐ | ☐ | | | | |
| From: | Brett Stinton | | Date: 25 January 2019 | Total Pages: | 9 |

| Subject: | Muchea Employment Node P3 – Floodway Definition |
|---|---|

If you do not receive all pages, or some are unclear, please advise immediately

BG&E Pty Limited (BG&E) has been engaged by the Muchea Employment Node Precinct 3 Landowners Group to carry out a waterways assessment for Ellen Brook to inform the development of the Muchea Employment Node Precinct 3.

As part of the Northlink Stage 3 project, BG&E prepared a TUFLOW hydraulic model for the new Perth to Darwin National Highway (PDNH) bridge which crosses Ellen Brook. This model has been utilised and updated to incorporate the boundary of the concept plan for the Muchea Employment Node Precinct prepared by Urbis. The southern section of the development layout is directly adjacent to the Ellen Brook floodplain where public open space and drainage reserve areas are proposed.

## SCOPE

The following scope of works was carried out:

1. Review modelling assumptions in accordance with 2016 edition of Australian Rainfall and Runoff
2. Simulate 1 in 100 annual exceedance probability (AEP) event under current day scenario (including new PDNH)
3. Preliminary definition of floodway based on review of hydraulic model results (depths, velocities etc)
4. Meet with representatives from DWER and Main Roads WA to discuss the project and agree on allowable backwater criteria
5. Update hydraulic model to include earthworks up to the preliminary floodway and review 1 in 100 AEP backwater
6. Refine the floodway and update the hydraulic model with revised earthworks extents to achieve suitable backwater (up to 5 post-development iterations have been assumed)
7. Prepare a memo report summarising the methodology and findings of the project, including polygons for floodway and flood fringe areas similar to those provided by DWER for other areas within Ellen Brook.

The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.

## TUFLOW MODEL

The TUFLOW 2D hydraulic has been updated to include the outline of the proposed development that lies within the flood extents of the Ellen Brook flood plain and other scenarios where the boundary encroaches further toward the main Ellen Brook channel.

## MEETING WITH MAIN ROADS AND DWER

A meeting was held on 15th January 2019 with Simon Rodgers (Supervising Engineer - Floodplain Management) from the Department of Water and Environmental Regulation (DWER) and Eric Cheung (Senior Waterways Engineer) from Main Roads WA, to discuss any potential impacts the development may have. Preliminary results showing the impact on flood levels were tabled. The DWER representative indicated that the impacts were not of concern from a DWER perspective. The Main Roads WA representative was concerned of any potential impacts to the recently constructed PDNH alignment that passes adjacent to the proposed development.

## FLOODWAY DEFINITION

The Department of Water and Environmental Regulation (DWER) define the Floodway as *"the river channel and a portion of the floodplain where a significant flow or storage of water occurs during floods. If the floodway is even partially blocked then the natural flooding regime of the area may be detrimentally impacted with flood levels being raised and affecting areas which may not have been previously affected"*.

The following items were considered when defining the floodway:

- 1% AEP pre-development velocity and depth mapping (attached) used to identify areas where higher depths and velocities occur which provide an indication of flood conveyance
- The presence of existing flowpaths within the floodplain which includes the main channel and breakout channel downstream of the PDNH culvert crossing to the north of the bridge. These flowpaths should be maintained to avoid redistribution of flow
- Potential impacts to flood levels as a result of partially blocking the floodplain, based on the hydraulic model results
- The floodway extent adopted by DWER for Ellen Brook to the south of the site. Shapefiles were provided by DWER which show the floodway extending to the edge of the floodplain in some areas. Flood behaviour in the northern section of the dataset is expected to be similar to that within the project site (Figure 1).

Refer to attached plots for 1% AEP pre-development and post-development flood extents. These include the proposed floodway and flood fringe extents. The proposed development footprint is close to but does not encroach into the floodway. The results indicate a maximum increase in flood level of approximately 30 mm near the proposed road, reducing to approximately 10mm at the PDNH PSP.

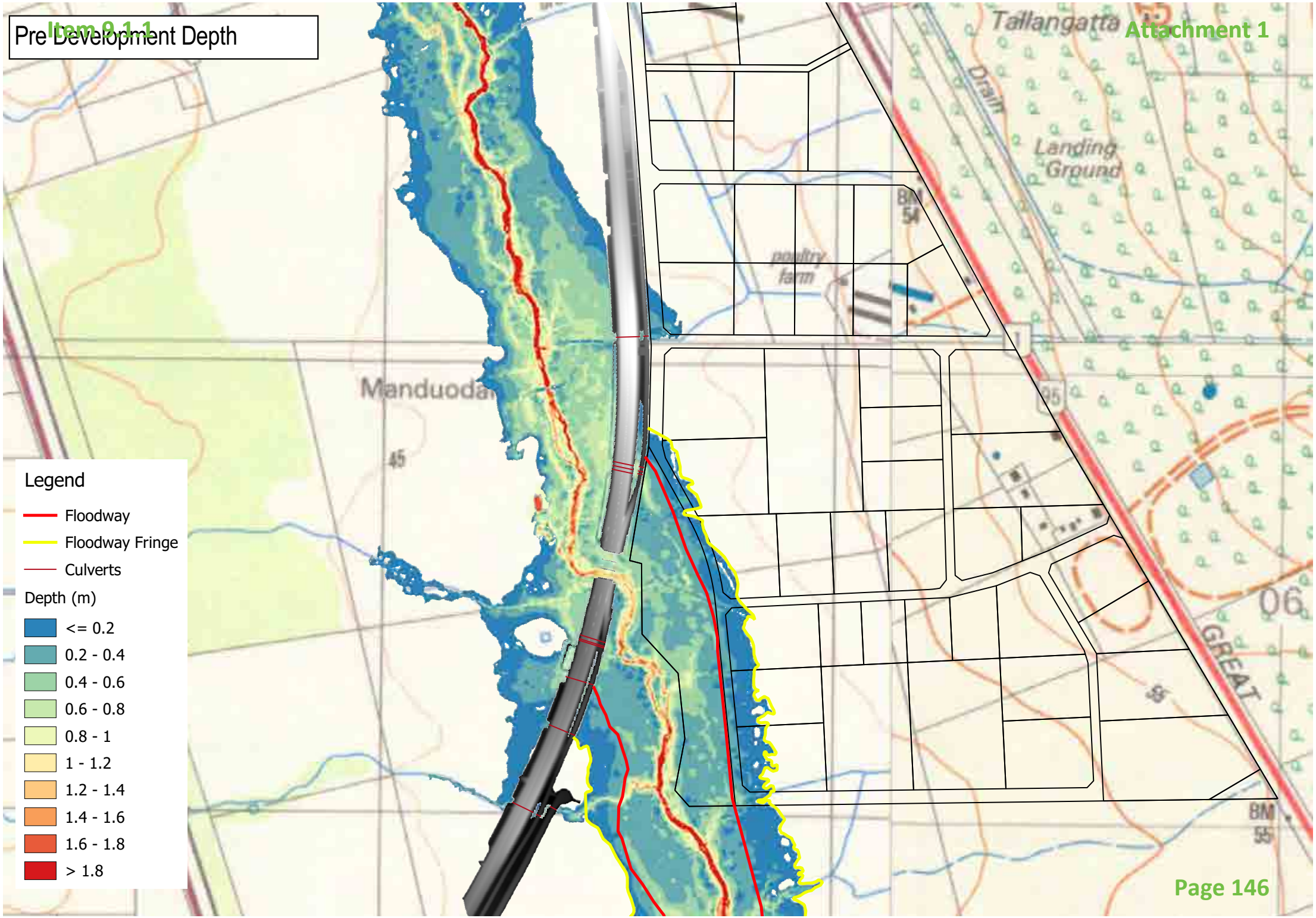
Scenarios where the earthworks footprint encroaches further into the floodway with offsets ranging from 20m to 80m were also simulated in the hydraulic model to assess potential impacts on the adjacent PDNH. The results indicate an increase in flood levels along the PDNH alignment varying between 40mm for a 40m offset to 90mm for an 80m offset.

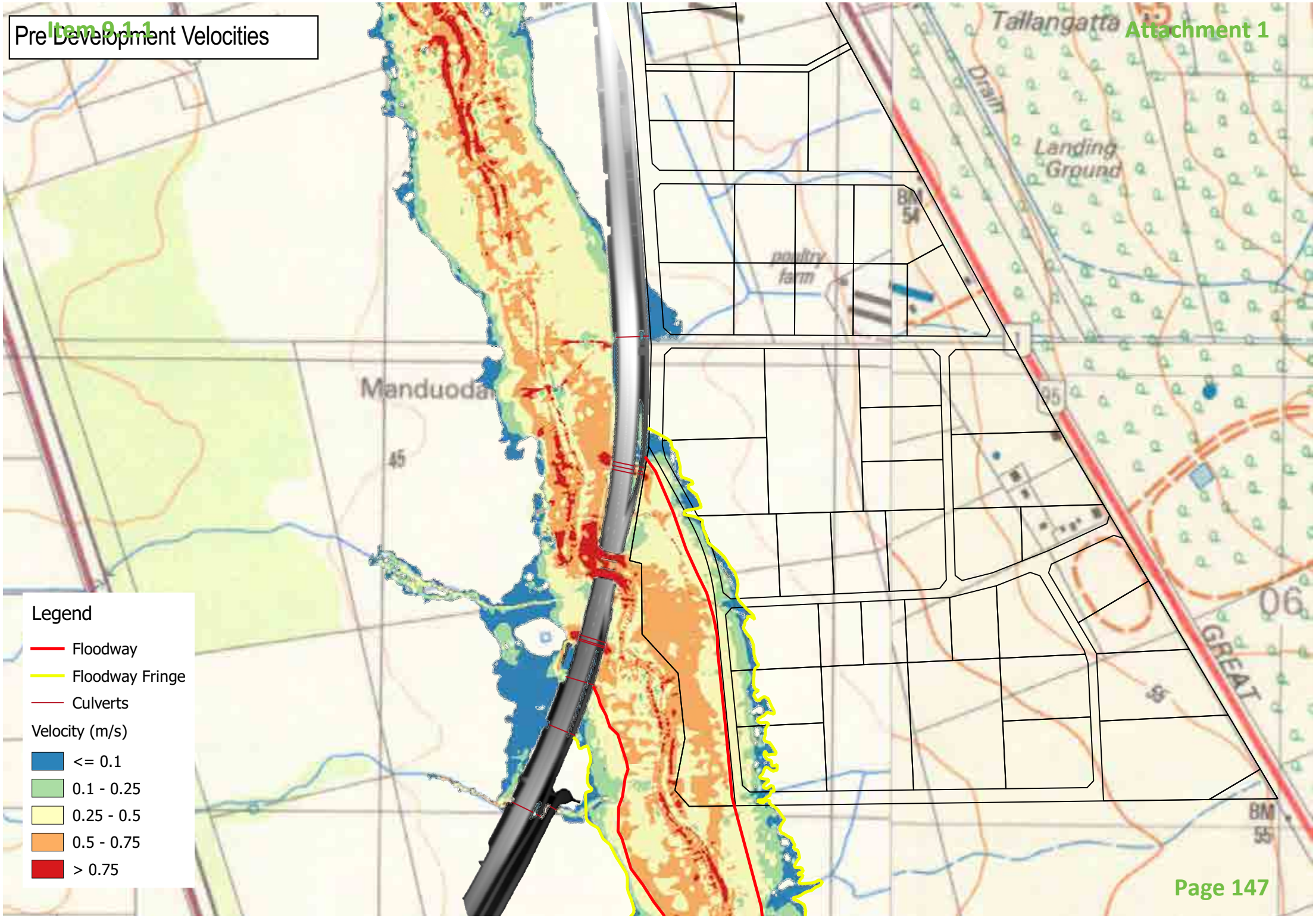
**Figure 1 – Downstream floodway definition by DWER**

## LIMITATIONS

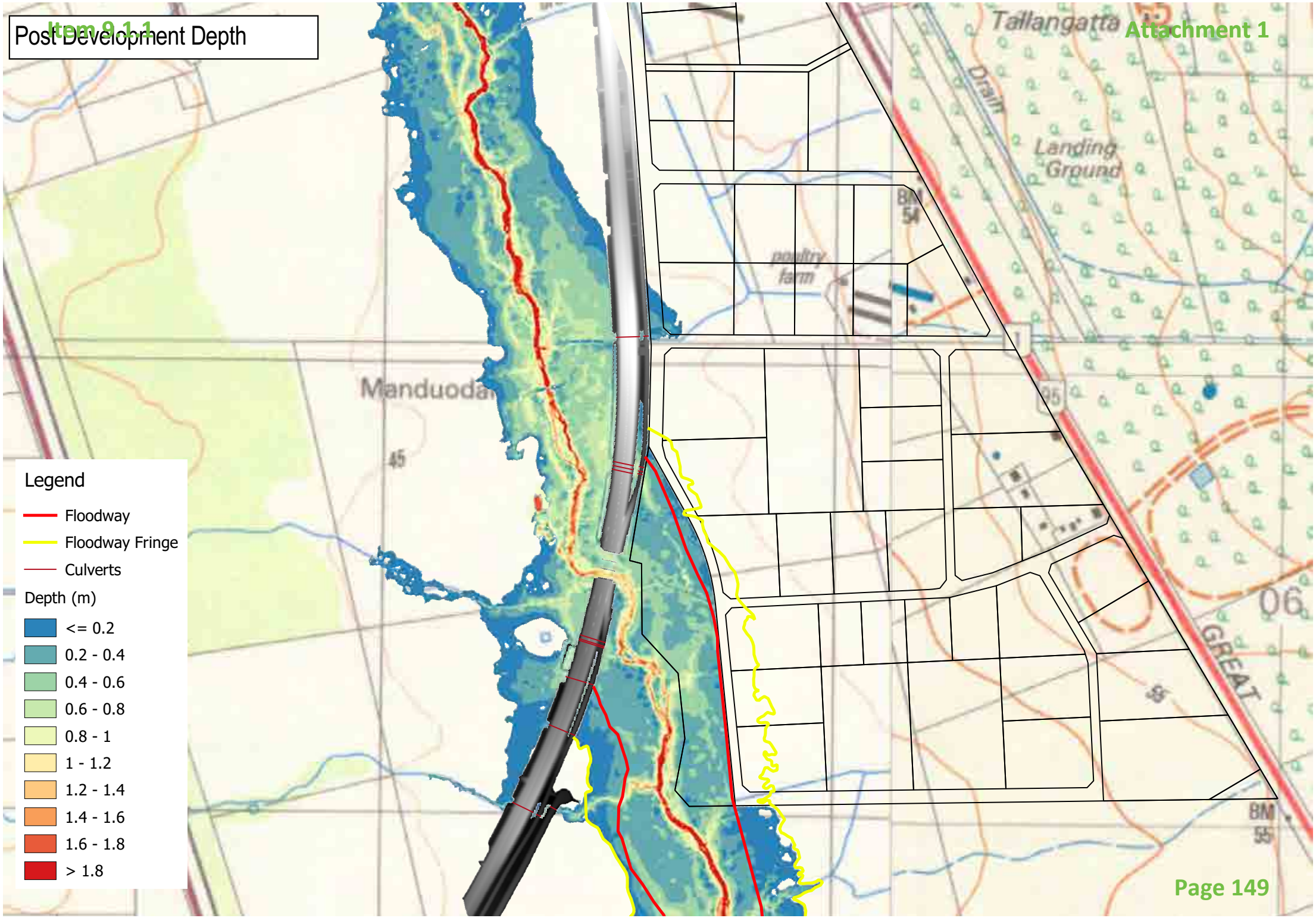
The findings of this study are subject to the following limitations:

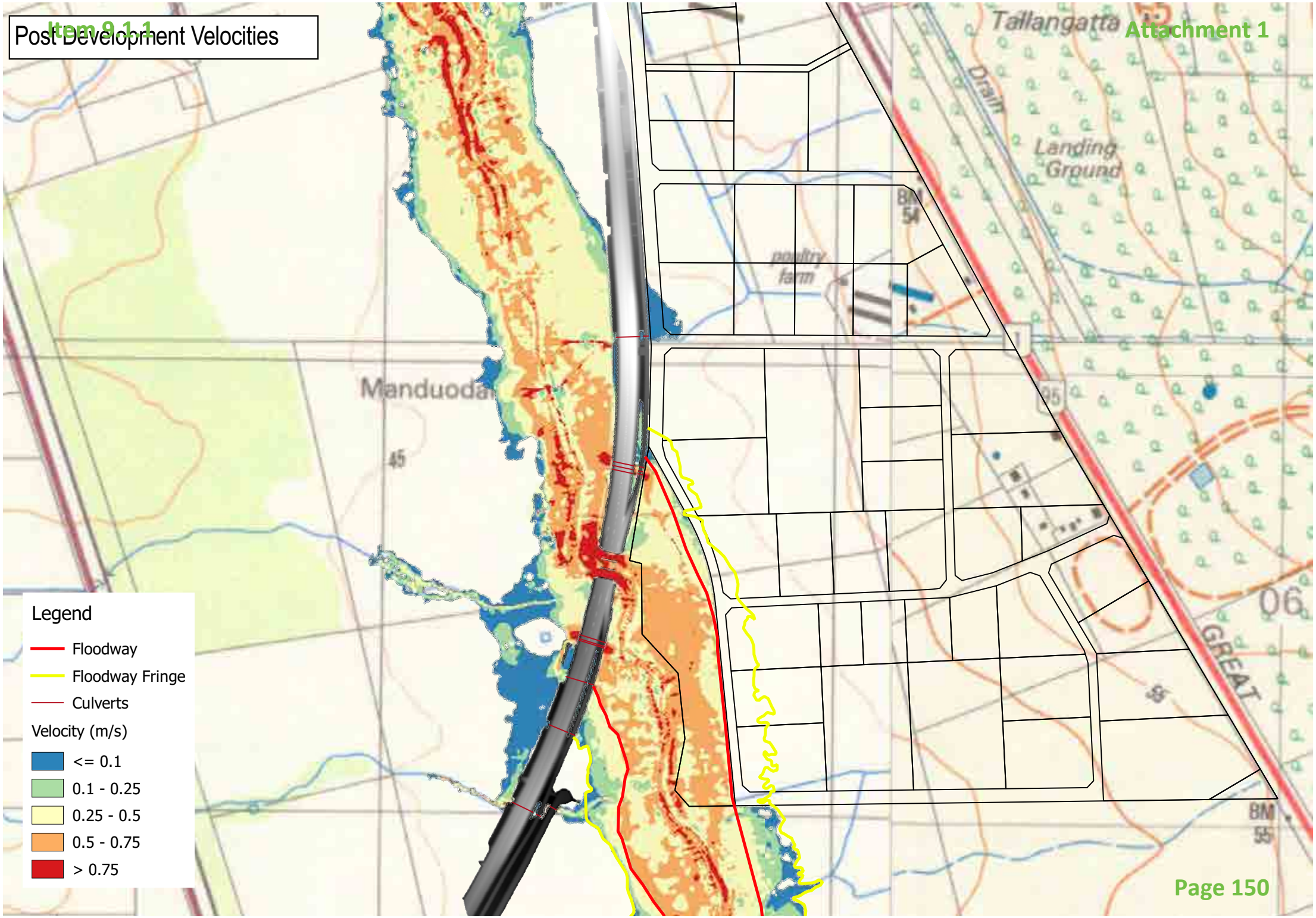
- The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.
- No allowance has been made for blockage of drainage infrastructure or increasing flows due to climate change.

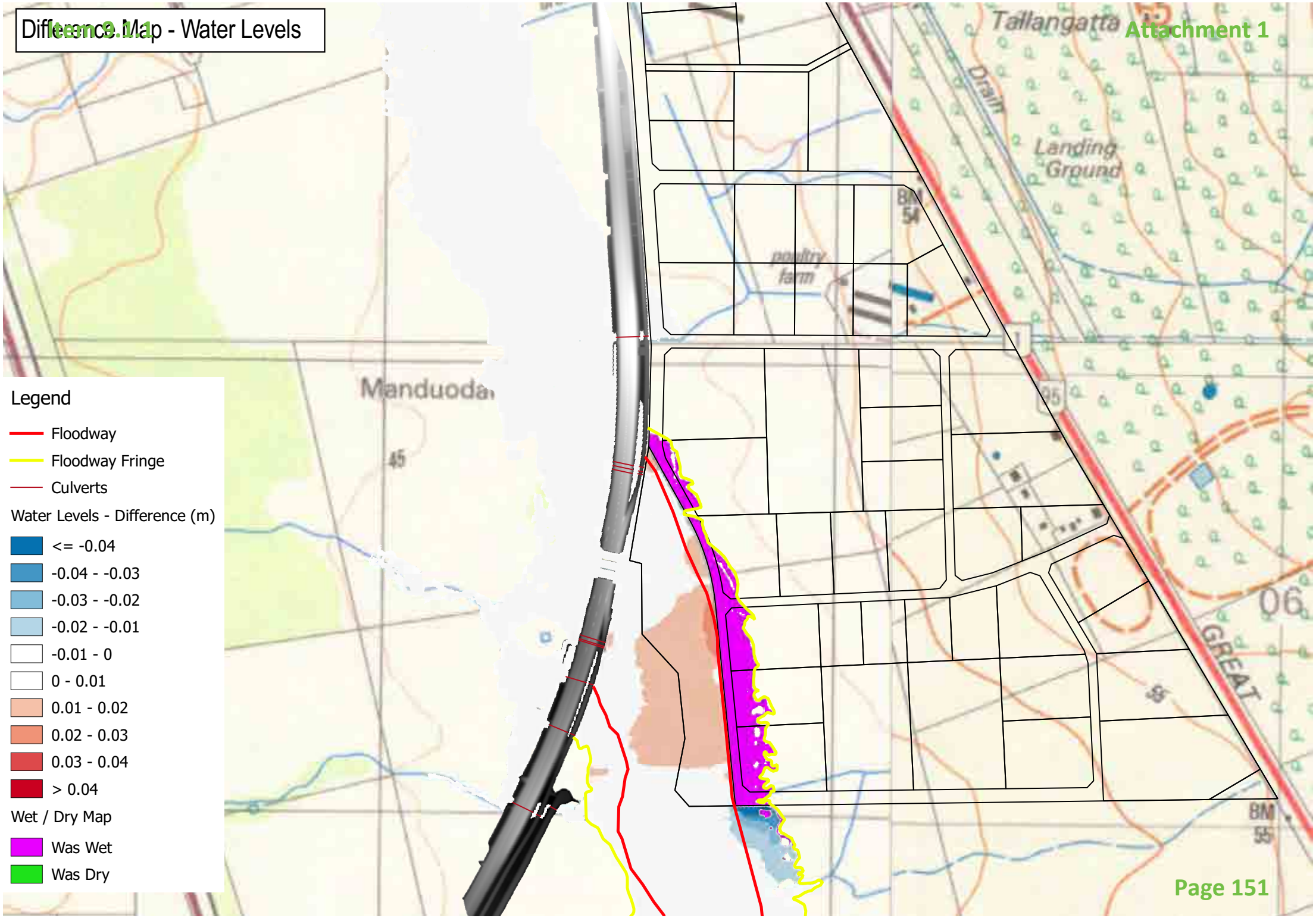

Pre Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Pre Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
06
GREAT
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75

Pre Development Velocity x Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity x Depth
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
> 1


Post Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Post Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Difference Map - Water Levels
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Water Levels - Difference (m)
<= -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
> 0.04
Wet / Dry Map
Was Wet
Was Dry

# Appendix D

## Aboriginal Sites Search Report

Department of Planning, Lands and Heritage

# Aboriginal Heritage Inquiry System

## List of Registered Aboriginal Sites



For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/

### Search Criteria

4 Registered Aboriginal Sites in Custom search area - Polygon - 115.989217491191°E, 31.5787889106247°S (GDA94) : 115.992071361583°E, 31.5777926323064°S (GDA94) : 115.994109840434°E, 31.5771345343663°S (GDA94) : 115.995322198909°E, 31.5769243076562°S (GDA94) : 115.995837183039°E, 31.5771253940844°S (GDA94) : 115.997028083842°E, 31.5805529369397°S (GDA94) : 115.997843475383°E, 31.5832766011182°S (GDA94) : 116.001641483348°E, 31.5892903159333°S (GDA94) : 116.010527060032°E, 31.6024501222606°S (GDA94) : 115.996558115483°E, 31.6026328780459°S (GDA94) : 115.996515200138°E, 31.6000194362091°S (GDA94) : 115.995592520237°E, 31.599233561734°S (GDA94) : 115.99572126627°E, 31.5985938915682°S (GDA94) : 115.994498178959°E, 31.5972414316111°S (GDA94) : 115.988296911717°E, 31.5789081794479°S (GDA94) : 115.988637552262°E, 31.5788634854024°S (GDA94) : 115.989217491191°E, 31.5787889106247°S (GDA94)

#### Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at heritageenquiries@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

#### South West Settlement ILUA Disclaimer

Your heritage enquiry is on land **within or adjacent to** the following Indigenous Land Use Agreement(s): Whadjuk People ILUA.

On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will 'impact' (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines, Industry Regulation and Safety (DMIRS) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMIRS, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.dpc.wa.gov.au/swnts/South-West-Native-Title-Settlement/Pages/default.aspx.

Further advice can also be sought from the Department of Planning, Lands and Heritage at heritageenquiries@dplh.wa.gov.au.

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#### Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Department of Planning, Lands and Heritage

# Aboriginal Heritage Inquiry System

List of Other Heritage Places



For further important information on using this information please see the Department of Planning, Lands and Heritage's Terms of Use statement at http://www.daa.wa.gov.au/Terms-Of-Use/

## Search Criteria

7 Other Heritage Places in Custom search area - Polygon - 115.989217491191°E, 31.5787889106247°S (GDA94) : 115.992071361583°E, 31.5777926323064°S (GDA94) : 115.994109840434°E, 31.5771345343663°S (GDA94) : 115.995322198909°E, 31.5769243076562°S (GDA94) : 115.995837183039°E, 31.5771253940844°S (GDA94) : 115.997028083842°E, 31.5805529369397°S (GDA94) : 115.997843475383°E, 31.5832766011182°S (GDA94) : 116.001641483348°E, 31.5892903159333°S (GDA94) : 116.010527060032°E, 31.6024501222606°S (GDA94) : 115.996558115483°E, 31.6026328780459°S (GDA94) : 115.996515200138°E, 31.6000194362091°S (GDA94) : 115.995592520237°E, 31.599233561734°S (GDA94) : 115.99572126627°E, 31.5985938915682°S (GDA94) : 115.994498178959°E, 31.5972414316111°S (GDA94) : 115.988296911717°E, 31.5789081794479°S (GDA94) : 115.988637552262°E, 31.5788634854024°S (GDA94) : 115.989217491191°E, 31.5787889106247°S (GDA94)

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The Aboriginal Heritage Act 1972 preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

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On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will 'impact' (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines, Industry Regulation and Safety (DMIRS) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMIRS, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.dpc.wa.gov.au/swnts/South-West-Native-Title-Settlement/Pages/default.aspx.

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## List of Other Heritage Places



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|---|---|---|---|---|---|---|---|---|---|
| 19138 | Wetlands & Watercourses Moore River to Bullsbrook | No | No | No Gender Restrictions | Stored Data / Not a Site | Mythological | *Registered Knowledge Holder names available from DAA | 396128mE 6561778mN Zone 50 [Reliable] | |
| 19183 | Red Gully Creek | No | No | No Gender Restrictions | Stored Data / Not a Site | Mythological, Plant Resource | *Registered Knowledge Holder names available from DAA | 396128mE 6561778mN Zone 50 [Reliable] | |
| 20650 | Lennard Brook | No | No | No Gender Restrictions | Lodged | Mythological, Natural Feature, Water Source, Other: Creek | *Registered Knowledge Holder names available from DAA | 389582mE 6549648mN Zone 50 [Reliable] | |
| 21616 | Boonanarring Brook | No | No | No Gender Restrictions | Lodged | Mythological | *Registered Knowledge Holder names available from DAA | 396128mE 6561778mN Zone 50 [Reliable] | |
| 21617 | Wallering Brook | No | No | No Gender Restrictions | Lodged | Mythological | *Registered Knowledge Holder names available from DAA | 396128mE 6561778mN Zone 50 [Reliable] | |
| 21618 | Nullilla Brook | No | No | No Gender Restrictions | Lodged | Mythological | *Registered Knowledge Holder names available from DAA | 396128mE 6561778mN Zone 50 [Reliable] | |
| 21619 | Breera Brook | No | No | No Gender Restrictions | Lodged | Mythological | *Registered Knowledge Holder names available from DAA | 396128mE 6561778mN Zone 50 [Reliable] | |

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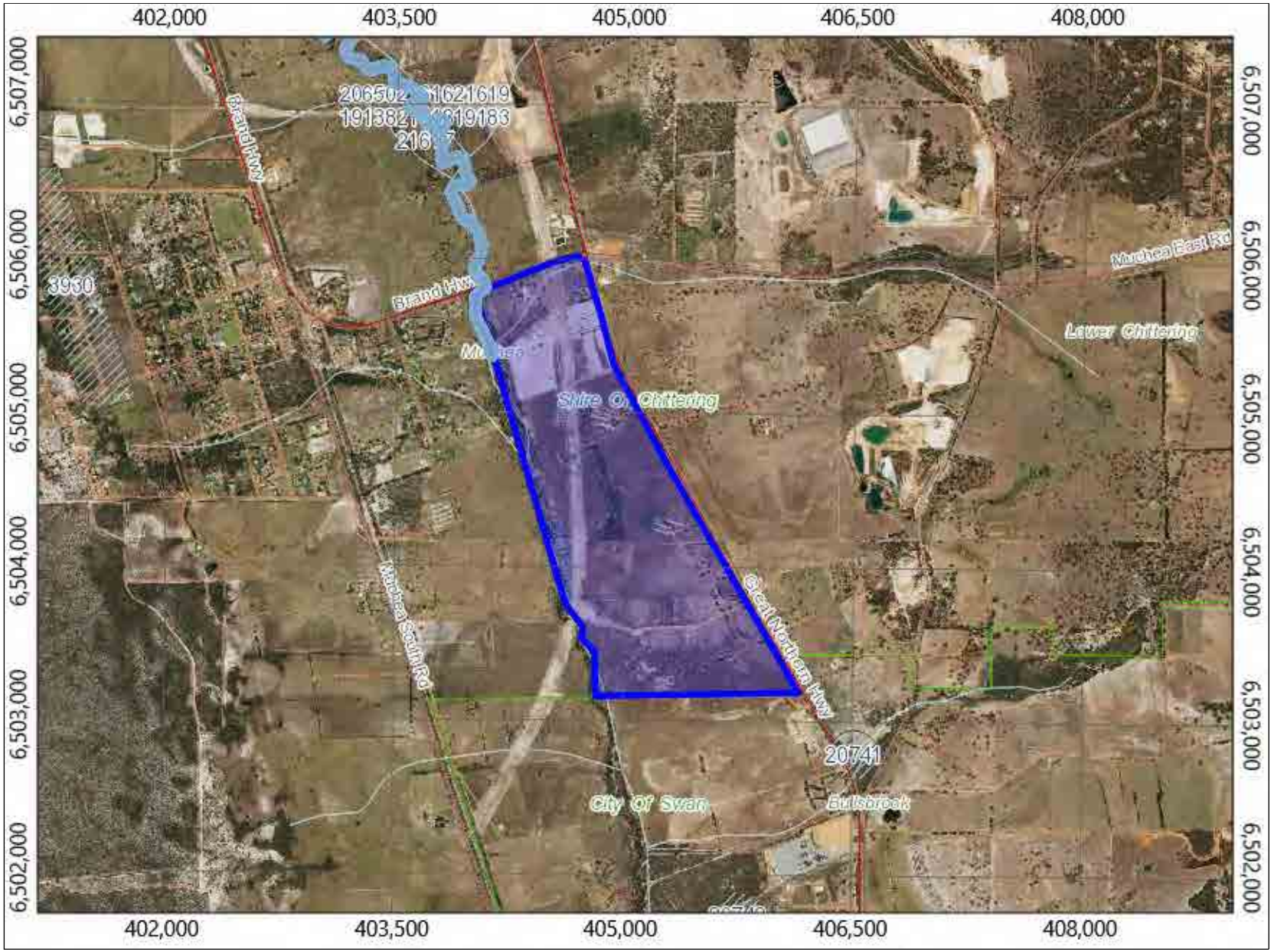


## Legend

- Other Heritage Place
- Search Area
- Town
- Road
- River
- Local Government Authority

1.46 kilometres

Map Scale 1 : 44,300

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|---|---|---|---|---|---|---|---|---|---|
| 3525 | ELLEN BROOK: UPPER SWAN | Yes | Yes | No Gender Restrictions | Registered Site | Mythological | *Registered Knowledge Holder names available from DAA | Not available when location is restricted | S02516 |
| 20008 | Gingin Brook Waggyl Site | Yes | Yes | No Gender Restrictions | Registered Site | Historical, Mythological, Camp, Hunting Place, Plant Resource, Water Source | *Registered Knowledge Holder names available from DAA | Not available when location is restricted | |
| 20749 | MOORE RIVER WAUGAL | No | No | No Gender Restrictions | Registered Site | Mythological | *Registered Knowledge Holder names available from DAA | 389623mE 6549812mN Zone 50 [Reliable] | |
| 21620 | Chandala Brook | No | No | No Gender Restrictions | Registered Site | Mythological | *Registered Knowledge Holder names available from DAA | 389626mE 6549540mN Zone 50 [Reliable] | |

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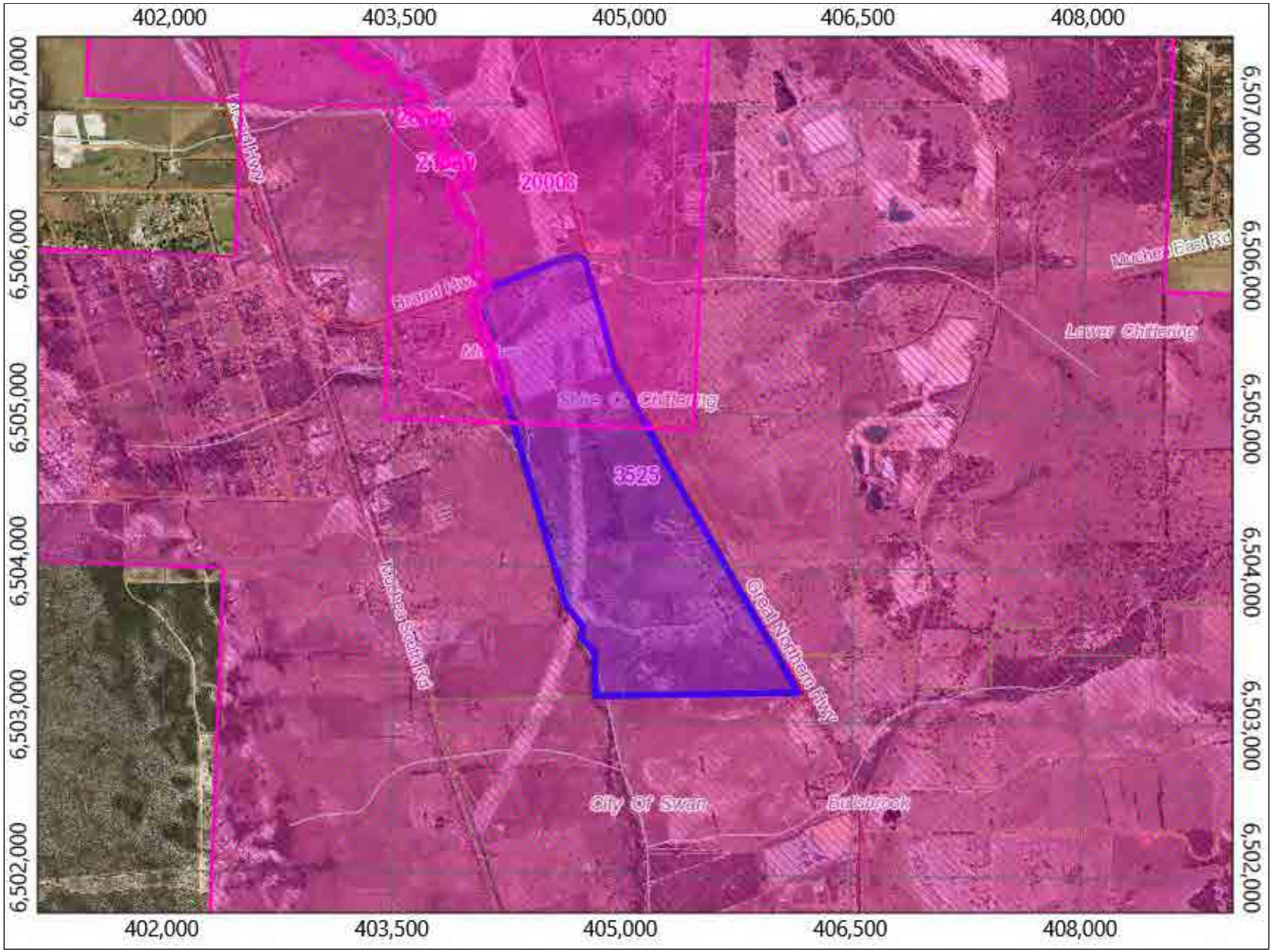


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- Registered Aboriginal Site
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- Town
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- River
- Local Government Authority

1.46 kilometres

Map Scale 1 : 44,300

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GOVERNMENT OF WESTERN AUSTRALIA

Department of **Planning, Lands and Heritage**

Our ref: PLH0014-2018A/01
Enquiries: Katrina Bott 65517918

Mr Phil Bayley
Bayley Environmental Services
30 Thomas Street
SOUTH FREMANTLE WA 6162

Dear Mr Bayley

**ADVICE REGARDING PROPOSED REZONING MUCHEA**

Thank you for your email dated 16 November seeking comment from Department of Planning, Land and Heritage (DPLH) regarding rezoning of land near Muchea.

A review of the Register of Places and Objects, the DPLH Aboriginal Heritage Database and information provided by yourself concludes that the area in question intersects with the boundary of Registered Site ID 3525 (Ellen Brook: Upper Swan), however rezoning of land does not impact heritage. Therefore based on the information held by DPLH no approvals under the *Aboriginal Heritage Act 1972* (AHA) are required at this time.

Future physical works planned as a result of the rezoning may impact heritage, namely tributaries which form part of Registered Site ID 3525 (Ellen Brook: Upper Swan). When possible, please submit plans for works.

DPLH encourages proponents to refer to the State's Aboriginal Heritage Due Diligence Guidelines (Guidelines) which can be found on the DPLH website at the following link:

http://www.dplh.wa.gov.au/heritage/land-use/

The Guidelines allow proponents to undertake their own risk assessment regarding any proposal's potential to impact Aboriginal heritage.

If you have any questions regarding the above, please contact Ms Katrina Bott on 65517918 or email katrina.bott@dplh.wa.gov.au

Yours sincerely

Katrina Bott

**SENIOR HERITAGE OFFICER**

28 November 2018

Postal address: Locked Bag 2506 Perth WA 6001 Street address: 140 William Street Perth WA 6000
Tel: (08) 655 18002 Fax: (08) 655 19001 info@dplh.wa.gov.au www.dplh.wa.gov.au
ABN 68 565 723 484
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# MUCHEA EMPLOYMENT NODE
# PRECINCT 3

# LOCAL WATER MANAGEMENT STRATEGY

**Prepared for**

**Muchea Employment Node**
**Precinct 3 Landowner Group**
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Report No. J18015b
23 January 2020

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

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# 1.0 INTRODUCTION

## 1.1 Background

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the subject site) have applied to the WAPC for the lots to be rezoned from Agricultural Resource to Light Industrial. The Muchea Employment Node Structure Plan (MENSP) was adopted by the WAPC in August 2011 and provides a twenty-year planning framework for industrial development within the Shire of Chittering. The subject site forms Precinct 3 of the MENSP, bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH) and Ellen Brook. Figure 1 shows the location of the site within the Muchea Employment Node.

The total area of the rezoning is approximately 185 hectares. Figure 2 shows an aerial view of the site and surroundings. The Structure Plan proposes approximately 51 Light Industrial lots within Precinct 3, with lot sizes nominally ranging from 1.3ha to 7.6ha.

The MENSP concept for Precinct 3 is for low water-use industries, with effluent disposed on-site using aerobic treatment units. This recognises the site constraints posed by the land's low elevation and high winter water table. Figure 3 shows a preliminary conceptual plan of subdivision for the site.

The Local Structure Plan for Precinct 3 has been submitted to the Department of Planning, Lands & Heritage and the Shire of Chittering, and is currently being considered by these agencies.

## 1.2 Previous Studies

### 1.2.1 Water Management Strategy – Muchea Employment Node

A Water Management Strategy (WMS) was prepared by Connell Wagner in 2008 in support of the District Structure Plan for the Muchea Employment Node. The WMS documented the existing environment of the MEN in broad terms, including soils and geology, topography, hydrology, vegetation and land uses. The WMS examined:

- the possible impacts of development on surface water and groundwater
- water demand and supply options;
- wastewater treatment and disposal, including leach drains, evaporation ponds and reuse.

The WMS recommended, among other things:

- Geotechnical investigations should be undertaken in the western part (Precinct 3) to determine soil permeability and phosphorus retention index for the purposes of on-site effluent disposal.
- Groundwater monitoring over at least two winter seasons should be undertaken to provide information on groundwater levels and quality.
- The preferred method of effluent disposal, based on desktop studies, was treatment by Aerobic Treatment Units (ATU) followed by disposal in evaporation ponds.
- Flood modelling of Ellen Brook should be undertaken to establish the boundaries of the 100-year ARI floodway and flood fringe.
- Development should be set back from waterways in accordance with Water and Rivers Commission Note 23: *Determining Foreshore Reserves* (2001), with a default minimum setback of 30m.
- Stormwater runoff from lots and roads should be managed by infiltration and detention so that the runoff from a 1-year 1-hour storm is retained and infiltrated, and that peak flows from critical storms up to 100-year ARI are limited to pre-development rates.
- Water sensitive urban design measures should be implemented to meet catchment water quality targets as set out in the Swan-Canning Water Quality Improvement Plan (2009).

### 1.2.2 Regional Water Management Strategy – Muchea

The Muchea Regional Water Management Strategy (RWMS) was prepared by Emerge Associates for the Department of Planning, Lands & Heritage in 2019. The RWMS deals with the entire Muchea Employment Node, covering an area of 6,580 hectares.

The RWMS identifies environmental values, documents the hydrological regime and identifies requirements for wastewater management. The RWMS recommends furhter assessments prior to development including geotechnical, flora and fauna, wetlands, waterways, land capability and flooding.

The draft RWMS was completed in June 2019, after the draft LWMS for Precinct 3 had been submitted. The final RWMS was completed in November 2019. This LWMS pre-empts many of the recommendations of the RWMS in examining the environmental factors at a greater level of detail than undertaken in the RWMS.

## 1.3 Relevant Guidelines and Policies

### 1.3.1 State Planning Policy 2.9

State Planning Policy 2.9: *Water Resources* (WAPC, 2006) lists the following key principles for total water cycle management:

- Consideration of all water sources (including wastewater) in water planning, maximising the value of water resources.
- Integration of water and land use planning.
- Sustainable and equitable use of all water sources, having consideration of the needs of all water users including the community, industry and the environment.
- Integration of water use and natural water processes.
- A whole-of-catchment integration of natural resource use and management.

SPP 2.9 also lists the following general objectives for water-sensitive urban design:

- to manage a water regime;
- to maintain and, where possible, enhance water quality;
- to encourage water conservation;
- to enhance water-related environmental values; and
- to enhance water-related recreational and cultural values.

Element 5 of *Liveable Neighbourhoods* Edition 3 (WAPC, 2004) identifies specific objectives and requirements for Urban Water Management. These are based on Best Planning Practices which are defined as the best practical approach for achieving water resource management objectives within an urban framework.

### 1.3.2 Better Urban Water Management

*Better Urban Water Management* (WAPC, 2008) sets out the following objectives for water sensitive urban design:

*Water Conservation*

- Consumption of 100kL/p/yr including less than 40-60 kL/p/yr scheme water.

*Water Quantity*

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.

- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

*Water Quality*

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).

- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.

- As compared to a development that does not actively manage stormwater quality, achieve:

  - at least 80% reduction of Total Suspended Solids;
  - at least 60% reduction of Total Phosphorus;
  - at least 45% reduction of Total Nitrogen; and
  - at least 70% reduction of gross pollutants.

*Mosquitoes and Midges*

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DWER) to maximise predation of mosquito larvae by native fauna.

1.3.3 Shire of Chittering Town Planning Scheme No. 6

"The following development requirements shall apply to the development and subdivision of land within industrial zones and to industrial land uses –

(a) the effect on the environment by means of discharge of pollutants or contaminants into the air, ground and water be avoided, or managed within acceptable limits;

(b) where an on-site wastewater disposal system is proposed –

i. land capability assessment may be required to demonstrate the capability of the site to manage wastewater and the suitability of the proposed system;
ii. the use of fill and drains to achieve the required separation from groundwater is to be limited; and

iii. a suitable and unencumbered land application area is to be set aside to distribute treated sewage, where required;

(c) within sewerage sensitive areas secondary treatment systems with nutrient removal are to be utilised;

(d) notwithstanding any other provisions of this scheme, industrial development not connected to reticulated sewerage (for treatment on-site or off-site) is to be restricted to 'dry industry' being land uses that intend to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building at a daily volume of less than 540 litres per 1,000m$^2$ of the site area [R10 equivalent];

(e) where trade waste is to be managed and/or disposed of on-site or off-site the associated risks must be identified and addressed, including the vulnerability of the receiving environment where relevant."

The Scheme shows Precinct 3 and its surroundings as part of a Water Prone Area (Ellen Brook Palusplain), within which the following special provisions apply:

"5.3.3 Planning Requirements

The local government will impose conditions on any Development approval relating to -

a) the construction and occupation of any dwelling or outbuilding;

b) the type of effluent disposal system used in this area shall be high performance with bacterial and nutrient stripping capabilities to the specifications of local government and the Health Department and shall be located in a position determined by local government.;

c) minimum floor levels for any building above the highest known water levels;

d) any land use that may contribute to the degradation of the surface or sub-surface water quality.

e) no development other than for conservation purposes will be permitted within 30 metres of any natural water body; AMD 21 GG 3/4/09

f) damming, draining or other developments which may alter the natural flow of surface water will not be permitted unless such works are part of an approved Catchment Management Plan."

Schedule 11 of the Scheme contains the following provisions that apply to the Muchea Employment Node:

"2.2 Environmental Management Plans

The following Environmental Management Plans shall be prepared and used to inform the design and proposed subdivision and development within the Structure Plan area. They shall be submitted as an additional detail of a Structure Plan unless otherwise determined by the Western Australian Planning Commission.

2.2.1 Local Water Management Strategy

The developer shall submit to the Local Authority a Local Water Management Strategy (LWMS) for approval as an additional detail of a Structure Plan pursuant to clause 5.19 in order to ensure that surface and ground waters are managed with the aim of maintaining the natural water balance. The Local Authority must notify and consult with the authority responsible for water and the environment on the proposed strategy in advertising the Local Structure Plan(s) pursuant to Part 4 of the deemed provisions.

The LWMS shall be prepared in accordance with Better Urban Water Management or its successor document.

The Structure Plan design shall respond to the LWMS required by 2.2.1 and shall be implemented to the satisfaction of the Local Authority, having regard to any advice from the Department of Water."

1.3.4 Government Sewerage Policy

The Government Sewerage Policy (2019) requires that all new subdivision and development should be deep-sewered unless it is exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and, where appropriate, density limits. In these cases, on-site effluent disposal may be approved where the responsible authority is satisfied that:

- each lot is capable of accommodating on-site sewage disposal without endangering public health or the environment; and
- the minimum site requirements for on-site sewage disposal as set out in the Policy can be met.

1.3.5 DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas

DoW Operational Policy 4.3 was published in 2012 and sets out the Department of Water's policy on defining and protecting foreshore reserves. It is intended to apply to all waterways within development areas. The policy sets out procedures for identifying, delineating and protecting foreshore areas.

The procedure may vary depending on the size and nature of the waterway and the nature of the proposed adjacent development. The policy provides for standard or nominal

foreshore widths to be employed in some cases, such as small subdivisions and/or minor tributary creeks where the waterway is adequately protected and the proposed development poses an insignificant additional risk to the waterway.

### 1.3.6 DoW Interim Guideline: Developing a Local Water Management Strategy

The DoW LWMS guideline was published in 2008 and sets out the DoW's preferred format and content for LWMS documents. The guideline expands on the LWMS guidance provided in *Better Urban Water Management* (2008).

This LWMS has been prepared in accordance with the principles set out in the DoW guideline. Appendix A shows a completed checklist from the DWER guideline.

## 1.4 Scope of the LWMS

The scope of this LWMS is to:

- Document the existing environment on the site, in relation to soils, drainage, erosion, watercourses, groundwater and water-dependent ecosystems.
- Briefly describe the proposed development in relation to water management.
- Examine the capability of the site for on-site effluent disposal.
- Address relevant regulatory requirements and design criteria for water harvesting, setbacks to watercourses, groundwater management and drainage.
- Describe the strategies to be implemented for water conservation, watercourse protection, groundwater management and stormwater drainage.
- Outline the proposed monitoring program.
- Outline what is to be addressed in future Urban Water Management Plans.

## 1.5 Design Objectives

Table 1.1 summarises the water-related design objectives for Precinct 3 and the means by which they will be achieved in the LWMS and subsequent management plans.

**Table 1.1 Design Objectives**

| *Design Aspect* | *Design Objective* | *How Objective is to be Achieved* |
|---|---|---|
| Water Conservation | Ensure efficient and sustainable use of water resources | Only low water use industries permitted in precinct.<br>Use water efficient fixtures.<br>Limit wastewater generation to 5.4 KL/ha/day.<br>Use non-potable water for irrigation.<br>Purchase groundwater licence(s) from existing holders within or outside Precinct 3.<br>Use water-efficient native species for landscaping.<br>Irrigate landscape plantings only for 2 years. |
| Groundwater Management | Minimise impacts on groundwater level and flows<br>Minimise impacts on groundwater quality | Subsoil drains set at or above pre-existing AAMGL, with fill used to provide additional clearance if required.<br>Finished floor levels of habitable buildings set at least 0.5m above controlled groundwater level.<br>Treat runoff from minor storms in bioretention swales.<br>Minimise fertiliser and chemical use in landscaping areas.<br>Use nutrient-removing alternative treatment systems for effluent disposal. |
| Surface Water Management | Minimise impacts on surface water flow rates, volumes and quality | Retain and infiltrate runoff from 1-year ARI 1-hour storms in bioretention swales.<br>Detain runoff from larger storms and control release from lots and overall site to pre-development flow rates.<br>Convey existing flows through the site in roadside swales at pre-development rates.<br>Set effluent disposal facilities at least 100m back from natural waterways.<br>Sweep streets regularly to remove accumulated contaminants. |
| Floodplain Management | Minimise impacts of development on flows in Ellen Brook.<br>Protect developed lots and structures from flooding. | Protect all of 100-year floodway in foreshore reserve.<br>Finished floor levels of habitable buildings in flood fringe set at least 0.5m above 100-year flood level. |

## 2.0 EXISTING ENVIRONMENT

### 2.1 Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 13.6km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Figure 4 shows a rainfall occurrence chart for Pearce. Table 2.1 shows rainfall intensity, frequency and duration for Muchea.

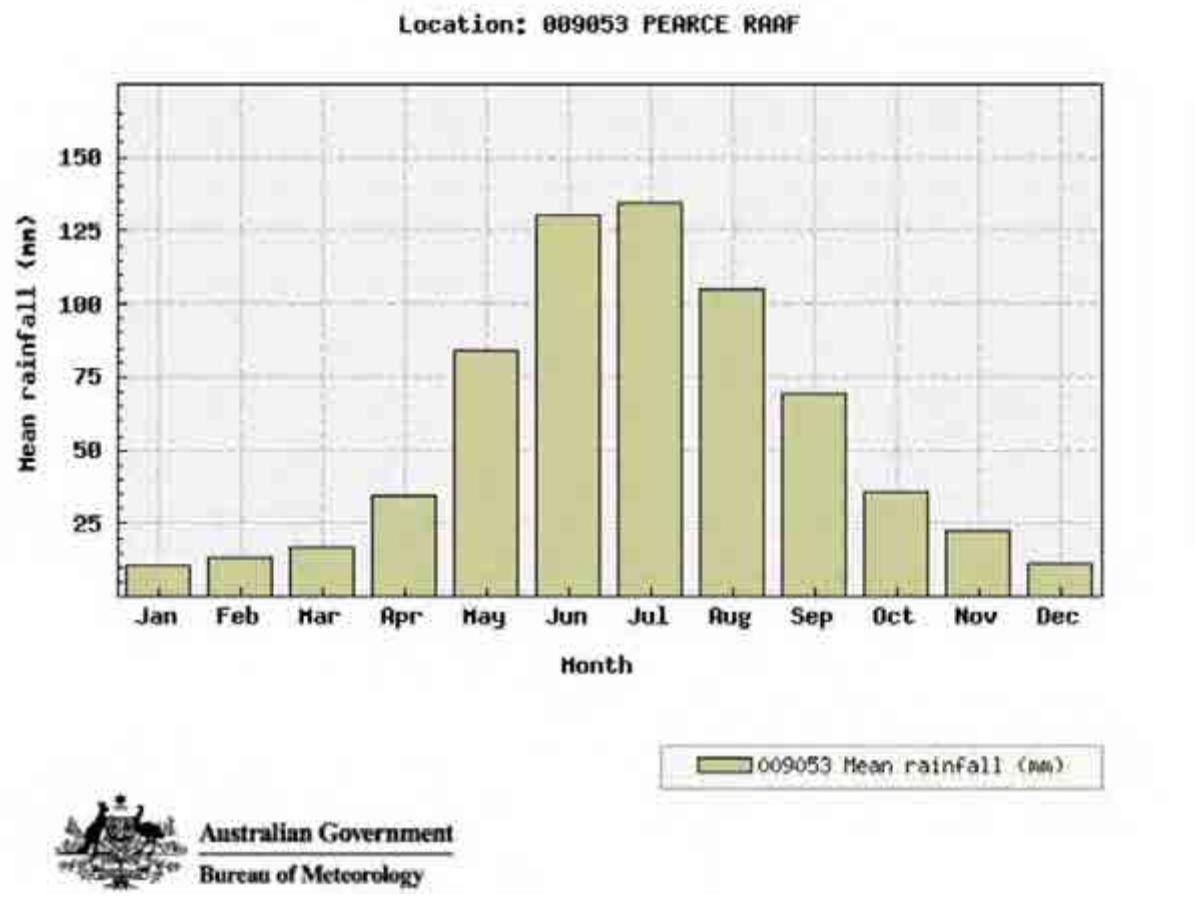


**Figure 4 Pearce RAAF Mean Rainfall**

## IFD Design Rainfall Depth (mm)

Issued: 31 October 2018

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

| | Annual Exceedance Probability (AEP) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Duration** | **63.2%** | **50%#** | **20%*** | **10%** | **5%** | **2%** | **1%** |
| **1 min** | 1.51 | 1.68 | 2.26 | 2.69 | 3.14 | 3.77 | 4.29 |
| **2 min** | 2.61 | 2.89 | 3.82 | 4.49 | 5.18 | 6.18 | 7.00 |
| **3 min** | 3.52 | 3.90 | 5.17 | 6.11 | 7.07 | 8.47 | 9.62 |
| **4 min** | 4.28 | 4.75 | 6.34 | 7.50 | 8.72 | 10.5 | 11.9 |
| **5 min** | 4.92 | 5.48 | 7.34 | 8.71 | 10.1 | 12.2 | 13.9 |
| **10 min** | 7.23 | 8.07 | 10.9 | 13.0 | 15.2 | 18.2 | 20.8 |
| **15 min** | 8.75 | 9.76 | 13.2 | 15.7 | 18.3 | 22.0 | 25.1 |
| **20 min** | 9.90 | 11.0 | 14.9 | 17.7 | 20.6 | 24.8 | 28.2 |
| **25 min** | 10.8 | 12.1 | 16.2 | 19.3 | 22.5 | 27.0 | 30.7 |
| **30 min** | 11.6 | 13.0 | 17.4 | 20.7 | 24.0 | 28.8 | 32.8 |
| **45 min** | 13.6 | 15.1 | 20.1 | 23.9 | 27.7 | 33.3 | 37.9 |
| **1 hour** | 15.1 | 16.7 | 22.2 | 26.4 | 30.7 | 36.9 | 42.1 |
| **1.5 hour** | 17.4 | 19.3 | 25.6 | 30.4 | 35.4 | 42.8 | 49.1 |
| **2 hour** | 19.3 | 21.3 | 28.3 | 33.6 | 39.4 | 47.8 | 55.1 |
| **3 hour** | 22.3 | 24.6 | 32.7 | 39.0 | 45.9 | 56.3 | 65.2 |
| **4.5 hour** | 25.8 | 28.5 | 37.9 | 45.4 | 53.8 | 66.4 | 77.6 |
| **6 hour** | 28.7 | 31.6 | 42.1 | 50.6 | 60.1 | 74.7 | 87.7 |
| **9 hour** | 33.1 | 36.5 | 48.7 | 58.7 | 70.0 | 87.5 | 103 |
| **12 hour** | 36.6 | 40.3 | 53.9 | 65.0 | 77.5 | 96.9 | 114 |
| **18 hour** | 42.0 | 46.3 | 61.7 | 74.2 | 88.1 | 110 | 129 |
| **24 hour** | 46.1 | 50.8 | 67.5 | 80.8 | 95.3 | 118 | 138 |
| **30 hour** | 49.5 | 54.5 | 72.1 | 85.8 | 101 | 124 | 143 |
| **36 hour** | 52.4 | 57.7 | 75.9 | 89.8 | 105 | 128 | 147 |
| **48 hour** | 57.2 | 62.9 | 82.1 | 96.1 | 111 | 133 | 152 |
| **72 hour** | 64.9 | 71.2 | 91.5 | 106 | 120 | 141 | 158 |
| **96 hour** | 71.4 | 78.2 | 99.4 | 114 | 128 | 148 | 164 |
| **120 hour** | 77.4 | 84.6 | 107 | 122 | 136 | 157 | 173 |
| **144 hour** | 83.4 | 91.0 | 115 | 131 | 146 | 168 | 185 |
| **168 hour** | 89.4 | 97.3 | 123 | 140 | 157 | 181 | 200 |

Note:
# The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

**Table 2.1 Rainfall Intensity for Muchea**

## 2.2 Physiography

### 2.2.1 Topography

The site lies on a very gently sloping plain on the eastern side of Ellen Brook. The site slopes gently to the west-southwest at gradients of up to 2.5%, decreasing to less than 0.4% near Ellen Brook. Figure 5 shows the topography of the site.

### 2.2.2 Geology, Landforms and Soils

Precinct 3 is located on the Pinjarra Plain, with soils of pebbly silt belonging to the Guildford Formation. These soils originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams.

The Guildford Formation soils are described by the Geological Survey of Western Australia (Gozzard, 1982) as "Strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin".

Drilling at six sites across the project area for this LWMS found silty soils containing varying proportions of clay, with the clay content increasing with depth. The low-lying western parts of the site are underlain in places by an ironstone (laterite) hardpan at depths of around one metre. Bore logs from the drilling are attached in Appendix B.

At the western edge of the site the alluvial deposits are overlain by a thin veneer of grey sand transported by floods in Ellen Brook. Figure 5 shows the site geology.

### 2.2.3 Soil Permeability

The permeability of the site soils is variable, depending on the clay content. Test pumping during sampling of the on-site bores indicated hydraulic conductivities in the top few metres ranging from about 1 m/day to over 5 m/day.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken by BES at six sites at depths of 0.5m to 1m in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.25m/day to 4.2m/day with a mean of 1.8m/day. Details of the BES permeability tests are attached in Appendix C.

Structerre Consulting Engineers carried out falling-head permeability tests at depths of up to 1m at seven sites in November 2018. The falling-head tests returned hydraulic conductivity values ranging from 0.3m/day to 1.2m/day with a mean of 0.7m/day. Details of the Structerre permeability tests are shown in the Geotechnical Report (Appendix D).

Figure 5 shows the locations of the BES and Structerre permeability tests

The ironstone hardpan in low-lying areas would impede vertical groundwater movement but its restricted extent means that its effect would be localised. In the east of the site, the clay subsoils impede rainfall infiltration and cause a perched surface water table to develop in winter.

The presence of a water table at the ground surface in winter across much of the site (see Section 2.3.2) means that all infiltration of drainage and effluent will be in fill, so the permeability of the natural soils is of reduced importance.

### 2.2.4 Acid Sulphate Soils

The DBCA maps most of the site as Low to Nil risk of Acid Sulphate Soils (ASS). Areas within 50-250m of Ellen Brook (corresponding to the alluvial sand S11 and ironstone) are

mapped as Low to Moderate risk. The nearest mapped High ASS risks are an area of palusplain about 850m to the south-east and a sumpland about 900m to the west of the site. Bore sampling in August 2018 found no indications of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary, although monitoring should be undertaken during any dewatering activities, with lime dosing of water and/or soil if required.

### 2.2.5 Phosphorus Retention Index

Previous experience has shown that the gravelly and silty soils of the Guildford Formation generally have moderate to high PRI.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

| *PRI Range* | *Rating* | *Typical soils* |
|---|---|---|
| 0 – 0.5 | Very Low | Bassendean Sand |
| 2 – 4 | Low – Moderate | Karrakatta Sands |
| 5 – 12 | Moderate – High | Cottesloe Sands |
| 12 – 20 | High | Crushed Limestone, Limesand |
| 20 – 1000+ | Very High | Clay |

The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins. The Health Department's draft *Code of Practice for Onsite Sewage Management* (2001) recommends a PRI of at least 20 for soils beneath effluent irrigation areas.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

## 2.3 Hydrology

The hydrology of the project area is complex, with soils of varying permeability, shallow and deep groundwater, runoff and surface discharge. Figure 6 depicts the overall hydrology of the site.

### 2.3.1 Groundwater

Groundwater occurs at shallow depth across the site. The DWER maps minimum groundwater levels at 39-48m AHD (2-7m below ground), flowing south-west towards Ellen Brook.

In winter, the groundwater rises to the ground surface across the lower western parts of the site and creates surface discharge to creeks, drainage lines and Ellen Brook. In the higher

eastern parts of the site, rainfall infiltration is impeded by the low-permeability subsoils, creating a perched water table which flows downslope and discharges as surface flow on the lower parts of the site. The net result of these two processes is that groundwater is at or near the ground surface over much of the site in winter.

Bores installed and measured in August 2018 (Figure 7), during a wetter than average winter, gave water depths and levels shown in Table 2.2. Simultaneous measurements of DWER bores located 480m south-east (Swan GWA 2-98) and 580m north-east (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated. Figure 7 shows the calculated AAMGL and depth to AAMGL contours across the site. Figure 8 shows hydrographs for the DWER bores.

Table 2.2 shows that the groundwater levels measured on 22 August 2018 were slightly above the AAMGL. The table also shows that the estimated MGL is above the ground surface over much of the site. This does not take into account the effects of existing drains and surface runoff, which would generally limit the groundwater levels to at or just below the ground surface.

**Table 2.2 Groundwater Depths and Levels 22 August 2018**

| *Bore* | *Depth (mbgl)* | *Level (m AHD)* | *AAMGL (m AHD)* | *MGL (m AHD)* | *Depth to AAMGL (m)* | *Depth to MGL (m)* |
|---|---|---|---|---|---|---|
| MB1 | 0.2 | 51.39 | 51.14 | 51.72 | 0.45 | -0.13 |
| MB2 | 0.34 | 45.29 | 45.04 | 45.62 | 0.59 | 0.01 |
| MB3 | 0.21 | 52.37 | 52.12 | 52.70 | 0.46 | -0.12 |
| MB4 | 0.02 | 42.58 | 42.33 | 42.91 | 0.27 | -0.31 |
| MB5 | 0.69 | 56.1 | 55.85 | 56.43 | 0.94 | 0.36 |
| MB6 | -0.08 | 42.98 | 42.73 | 43.31 | 0.17 | -0.41 |
| MB7 | 0.32 | 55.19 | 54.94 | 55.52 | 0.57 | -0.01 |
| MB8 | 0.23 | 42.64 | 42.39 | 42.97 | 0.48 | -0.10 |
| 399 | 0.02 | 48.42 | 48.17 | 48.75 | 0.27 | -0.31 |
| GD20 | 0.12 | 61.36 | 59.85 | 61.35 | 1.63 | 0.13 |
| 2-98 | 1.44 | 56.85 | 56.6 | 57.18 | 1.69 | 1.11 |

### 2.3.2 Surface Drainage

The high water tables and low permeability subsoils result in surface flow in channels and sheet flow across the ground surface during wet winters.

Several natural and artificial drainage lines cross the site from fifteen culverts beneath Great Northern Highway. The largest of these is a creek at the northern end, which has a catchment of 384ha east of Great Northern Highway. Historical Landgate aerial photography shows that between 1965 and 1977 this creek was diverted within the project area to run along a fenceline drain within Lot 804.

Two other drainage lines enter on the mid eastern boundary, draining catchments of 67ha and 121ha east of Great Northern Highway. Historical Landgate aerial photography shows that the southern and larger of these two drainage lines was constructed between 1965 and 1974. The smaller northern drainage line has been modified and cleared over the years so that it now retains no natural attributes.

Several other culverts beneath the highway drain into minor drainage lines within the site. Other small drainage lines rise within the site and flow west. Figure 9 shows the drainage within the site.

All drainage from the site flows into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow in the system, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715 $km^2$ (WRC, 2012). The Brook rises as Chandala Brook about 20km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. BG&E Pty Ltd modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project on behalf of Main Roads Western Australia (MRWA) in 2018. Figure 9 shows the 100-year ARI floodplain as modelled by BG&E.

Emerge (2019) modelled combined flows in Ellen Brook and the minor drainages across the site for the Muchea Regional Water Management Strategy. The boundary of the floodplain modelled by Emerge (2019) agrees closely with the floodplain boundary modelled by BG&E for MRWA.

Further flood modelling was carried out by BG&E for this project, in order to map the 100-year floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area adjoins the Brook. The BG&E floodway modelling report is attached in Appendix E. Figure 9 shows the floodway as mapped by BG&E, which falls within the foreshore and drainage/landscape reserve.

### 2.3.3 Foreshore Definition

The Muchea Employment Node Structure Plan (WA Govt, 2011) designated a nominal 15-40m foreshore reserve east of Ellen Brook. The Structure Plan noted that the reserve could be modified at the Urban Water Management Plan stage in accordance with DoW Foreshore Protection Policy No. 1 – *Identifying the Foreshore Area* and Water Note 23 – *Determining Foreshore Reserves*.

A Foreshore Definition Study was undertaken for this LWMS in accordance with the above DoW policies to better define the foreshore reserve of Ellen Brook in the light of detailed flood modelling in 2018. The Foreshore Definition report is attached in Appendix F.

The Foreshore Definition Study found that a foreshore setback of between 120m and 204m east of Ellen Brook was necessary to accommodate the 100-year ARI floodway. This foreshore setback is reflected in the Local Structure Plan.

The foreshore setback will be reserved for public open space and drainage under the Scheme. The reserve will be densely revegetated with local native species and used for landscaping, passive recreation and overflow drainage management.

### 2.3.4 Water Resources

The project area is within the Lake Mungala sub-area of the Gingin Groundwater Area for the superficial and semi-confined (Mirrabooka) aquifers, and the SA 3 South sub-area for the confined Leederville and Yarragadee aquifers. Groundwater allocations within the Lake Mungala and SA 3 South sub-areas are managed under the Gnangara Groundwater Areas Allocation Plan. Under the plan, all of the aquifers within the Lake Mungala and SA 3 South sub-areas are fully or over allocated, and no new allocations are available. The DWER advised in 2018 that it intended to release a new Gnangara Groundwater Allocation Plan in late 2018 (G. Chandler, 2018 pers. comm.). However, in January 2020 the DWER indicated that the draft was not expected to be released until 2021. The revised allocation plan is likely to further reduce allocation limits within the plan area.

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows a number of licensed bores within the project area, abstracting water from the superficial and Leederville aquifers. The total licensed allocations within the project area are 81,500 KL/a from the Leederville and 35,000 KL/a from the superficial aquifer. A Leederville allocation of 180,000 KL/a is licensed to CPB Contractors for the construction of the Perth-Darwin National Highway (PDNH). This allocation is expected to be surrendered when the PDNH construction is completed. Figure 10 shows the existing groundwater licences in Precinct 3. Table 2.3 shows the owners and licensed volumes.

**Table 2.3 Groundwater Licences**

| *Licence No.* | *Lot No.* | *Owner* | *Aquifer* | *Allocation (KL/yr)* |
|---|---|---|---|---|
| 53081 | 804 | A. Quince | Leederville | 30,000 |
| 59401 | 803 | Karratha Enterprises Pty Ltd | Leederville | 1,500 |
| 53084 | 801 | Inghams Enterprises Pty Ltd | Superficial | 35,000 |
| 53083 | 800 | Inghams Enterprises Pty Ltd | Leederville | 50,000 |

## 2.4 Water Quality

### 2.4.1 Groundwater

Groundwater samples were collected from eight bores within the project area (Figure 7) on 22 August 2018, when groundwater levels were at or near their peak for the year. The results of the analysis are shown in Table 2.3 and summarised below.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally moderate with the exception of a notably high reading for total phosphorus in Bore MB2, in the north-west of the project area. This bore is downstream of a heavily-stocked special rural lot and also has sandy surface soils. The high Total Phosphorus concentration is not reflected in the dissolved (reactive) phosphorus concentration.

The groundwater shows low acidity and sulphate levels, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are low except for aluminium and zinc, which are slightly elevated across much of the site.

### 2.4.2 Surface Water

Surface water samples were collected on 22 August 2018 from ten drainage lines flowing into the project area from culverts beneath Great Northern Highway (Figure 9). A further six samples were collected from drains flowing out of the project area into Ellen Brook. Samples were also collected from Ellen Brook immediately upstream and downstream of the project area, and from two small dams in the south of the project area (Figure 9). The results of the analysis are shown in Tables 2.4 and 2.5 and summarised below.

Surface water quality upstream of the project area is variable, with total phosphorus in ten drains and creeklines flowing into the site (Figure 9) ranging from 0.04mg/L to 0.31mg/L (the ANZECC target for freshwater ecosystems is 0.065mg/L). Total nitrogen in these watercourses ranged from 0.6mg/L to 2.1mg/L, against an ANZECC target of 1.2mg/L.

Water quality downstream of the project area was generally poorer, with six outflowing drains (Figure 9) having total phosphorus of 0.07 - 1.8 mg/L and total nitrogen of 1.3 - 3.0 mg/L.

The most notable feature of surface water quality is Ellen Brook itself, which showed total phosphorus of 0.59mg/L upstream of the project area and 0.54mg/L downstream. Coupled with the high flow at the time, this emphasises the primary role of Ellen Brook in the water quality issues facing the Swan-Canning River system.

Suspended sediment levels in surface water upstream and downstream were generally low except at Site 369 (Figure 9) in Ellen Brook immediately downstream of the confluence of a small drain carrying sediment-laden water from the PDNH roadworks. The effect of this drain was not apparent in samples further down Ellen Brook.

The two dams sampled in the south of the project area, which held a blend of surface and ground water, gave mixed water quality results, with low phosphorus but elevated nitrogen levels.

**Table 2.4 Groundwater Quality 22/8/2018**

(see Figure 7 for bore locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *MB1* | *MB2* | *MB3* | *MB4* | *MB5* | *MB7* | *MB8* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **1.7** | **4.3** | **3** | <0.2 | **2** | 1.2 | 0.5 |
| | NOx | mg/L | 0.15 | ng | **1.5** | **2.5** | **3** | <0.01 | **2** | **0.21** | 0.07 |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 0.2 | 1.8 | <0.2 | <0.2 | <0.2 | 1 | 0.4 |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | 0.04 | **0.99** | 0.03 | **0.15** | **0.2** | **0.2** | **0.25** |
| | Reactive Phosphorus | mg/L | 0.04 | ng | <0.01 | 0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.03 |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 6.5 | 6.9 | 6.7 | **4.7** | 6.6 | **6.3** | **5.5** |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **4.8** | **1.6** | **0.82** | **2.8** | 0.25 | **3.5** | **4.4** |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **2880** | **960** | **492** | **1680** | 150 | **2100** | **2640** |
| | Acidity | mg/L | 40[c] | ng | 15 | 20 | 9 | **63** | 15 | **77** | **67** |
| | Alkalinity | mg/L | ng | ng | 29 | 70 | 22 | <5 | 27 | 65 | <5 |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.52 | 0.11 | 0.18 | 0.57 | 0.29 | 0.45 | 0.37 |
| | Hardness | mg/L | ng | 60-350 | 140 | 190 | 51 | 110 | 52 | 170 | 180 |
| | Sulphate | mg/L | ng | ng | 240 | 130 | 13 | 120 | 12 | 130 | 120 |
| | Chloride | mg/L | ng | 350 | 1400 | 400 | 230 | 850 | 44 | 1100 | 1400 |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.17 | 0.33 | 0.06 | 0.14 | 0.27 | 0.12 | 0.09 |
| Major Ions | Calcium | mg/L | ng | ng | 54 | 44 | 20 | 23 | 17 | 54 | 32 |
| | Sodium | mg/L | ng | 230 | 820 | 300 | 110 | 420 | 29 | 630 | 710 |
| | Potassium | mg/L | ng | ng | 1.7 | 19 | 0.3 | 13 | 2.3 | 8 | 24 |
| | Magnesium | mg/L | ng | ng | 160 | 28 | 23 | 83 | 8.8 | 67 | 140 |
| | Iron | mg/L | ng | 10 | 0.16 | 0.19 | 0.08 | 0.39 | 0.08 | 4.3 | 18 |

**Notes**

ng denotes "no guideline". na denotes "not analysed"

a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)

b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)

c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.

d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | <0.1 | **0.2** | **0.2** | **0.1** | **0.2** | **0.2** | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | 0.006 | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | 0.003 | <0.002 | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | |
| | Zinc | mg/L | 0.015 | 2 | <0.01 | 0.01 | 0.01 | **0.06** | <0.01 | **0.07** | **0.02** | |

**Table 2.5 Upstream Surface Water Quality 22/8/2018**

(see Figure 9 for sample locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *Ellen Brook Upstream* | *407* | *405* | *395* | *393* | *392* | *391* | *410* | *409* | *415* | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **3** | 0.7 | **2.1** | 1.2 | **1.7** | 0.6 | 0.6 | **1.7** | **1.7** | **1.7** | ng denotes "no guideline", na denotes "not analysed" |
| | NOx | mg/L | 0.15 | ng | 0.01 | 0.06 | <0.01 | 0.02 | 0.12 | <0.01 | 0.01 | **0.45** | **0.32** | <0.01 | a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 3 | 0.6 | 2.1 | 1.2 | 1.6 | 0.6 | 0.6 | 1.2 | 1.4 | 1.7 | b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years) |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | **0.59** | **0.11** | **0.27** | **0.08** | **0.09** | 0.04 | 0.04 | 0.05 | **0.24** | **0.31** | c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater. |
| | Reactive Phosphorus | mg/L | 0.04 | ng | **0.47** | <0.01 | **0.13** | 0.01 | 0.01 | <0.01 | <0.01 | <0.01 | **0.18** | **0.22** | d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals. |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 7.2 | | | | | | | | | | |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **1.7** | | | | | | | | | | |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **1020** | | | | | | | | | | |
| | Acidity | mg/L | 40[c] | ng | 8 | | | | | | | | | | |
| | Alkalinity | mg/L | ng | ng | 62 | | | | | | | | | | |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.04 | | | | | | | | | | |
| | Hardness | mg/L | ng | 60-350 | 180 | | | | | | | | | | |
| | TSS | mg/L | ng | ng | 7 | 6 | 14 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | |
| | Sulphate | mg/L | ng | ng | 49 | | | | | | | | | | |
| | Chloride | mg/L | ng | 350 | 470 | | | | | | | | | | |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.10 | | | | | | | | | | |
| Major Ions | Calcium | mg/L | ng | ng | 56 | | | | | | | | | | |
| | Sodium | mg/L | ng | 230 | 220 | | | | | | | | | | |
| | Potassium | mg/L | ng | ng | 10 | | | | | | | | | | |
| | Magnesium | mg/L | ng | ng | 53 | | | | | | | | | | |
| | Iron | mg/L | ng | 10 | 2.8 | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | | | | | | | | | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | | | | | | | | | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | | | | | | | | | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | | | | | | | | | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | | | | | | | | | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | | | | | | | | | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | | | | | | | | | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | | | | | | | | | |
| | Zinc | mg/L | 0.015 | 2 | **0.03** | | | | | | | | | |

**Table 2.6 Downstream Surface Water Quality 22/8/2018**

(see Figure 9 for sample locations)

| Parameter | | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *Ellen Brook Down -stream* | *AMS1* | *Ingham1* | *Ingham2* | *MD* | *369* | *362* | *Dam1* | *Dam2* | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **2.6** | **1.5** | **2.3** | **1.7** | **1.6** | **3** | **1.3** | **3.2** | **2.9** | ng denotes "no guideline", na denotes "not analysed"<br>a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)<br>b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)<br>c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.<br>d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals. |
| | NOx | mg/L | 0.15 | ng | 0.02 | **0.23** | <0.01 | <0.01 | <0.01 | **0.34** | <0.01 | **2.4** | **2.9** | |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 2.6 | 1.3 | 2.3 | 1.7 | 1.6 | 2.7 | 1.3 | 0.8 | <0.2 | |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | **0.54** | **0.12** | **0.14** | **0.07** | **0.16** | **0.18** | **0.12** | 0.05 | 0.04 | |
| | Reactive Phosphorus | mg/L | 0.04 | ng | **0.45** | <0.01 | 0.04 | <0.01 | 0.02 | 0.04 | 0.02 | <0.01 | <0.01 | |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 7.3 | | | | | | | | | |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **1.7** | | | | | | | | | |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **1020** | | | | | | | | | |
| | Acidity | mg/L | 40[c] | ng | 7 | | | | | | | | | |
| | Alkalinity | mg/L | ng | ng | 65 | | | | | | | | | |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.04 | | | | | | | | | |
| | Hardness | mg/L | ng | 60-350 | 200 | | | | | | | | | |
| | TSS | mg/L | ng | ng | <5 | 7 | 10 | <5 | 7 | 51 | <5 | <5 | <5 | |
| | Sulphate | mg/L | ng | ng | 51 | | | | | | | | | |
| | Chloride | mg/L | ng | 350 | 480 | | | | | | | | | |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.11 | | | | | | | | | |
| Major Ions | Calcium | mg/L | ng | ng | 64 | | | | | | | | | |
| | Sodium | mg/L | ng | 230 | 220 | | | | | | | | | |
| | Potassium | mg/L | ng | ng | 10 | | | | | | | | | |
| | Magnesium | mg/L | ng | ng | 53 | | | | | | | | | |
| | Iron | mg/L | ng | 10 | 2.9 | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | | | | | | | | | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | | | | | | | | | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | | | | | | | | | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | | | | | | | | | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | | | | | | | | | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | | | | | | | | | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | | | | | | | | | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | | | | | | | | | |
| | Zinc | mg/L | 0.015 | 2 | <0.01 | | | | | | | | | |

## 2.5 Vegetation

### 2.5.1 Vegetation Type and Condition

The project area is mostly cleared of native vegetation, consisting of current and former farm paddocks and industrial sites. Figure 11 shows the vegetation of the project area.

Remnant native vegetation consists of a few mature paddock trees (Marri, Flooded Gum and Wandoo), including several very large Marri trees that have been retained within the AMS site (Lots 802 & 803) and a few large Wandoo trees in Lot 804.

Native regrowth is present near the large drain on Lot 800 in the form of a small (0.5ha) thicket of species including *Allocasuarina fraseriana, Melaleuca preissiana, Eucalyptus rudis, Astartea fascicularis* and *Acacia ?rostellifera* over grasses. Nearby is a smaller thicket on a drainage line with regrowth of *Juncus ?kraussii*, *M. preissiana, A. fascicularis* and *E. rudis*.

The area around the large drain on Lot 800 has been planted densely with native tree species including *E. rudis, A. fraseriana, M. preissiana, M. cuticularis* and *Corymbia calophylla.* The drain itself contains a heavy growth of sedges, Bulrush (*Typha orientalis*) and Kikuyu and Couch grasses.

Other areas near the large drain and in other low-lying parts of the site contain dense growths of Cape Tulip (*Moraea flaccida*), Spiny Rush (*Juncus acutus*) and Narrow-leaf Cotton Bush (*Gomphocarpus fruticosus*), all of which are declared pests in Western Australia (www.agric.wa.gov.au/pests-weeds-diseases/weeds/declared-plants). The native rush *Juncus kraussii* occurs along with the introduced *J. acutus* in some areas.

In the west of Lot 35 in the south of the project area are a few large isolated Flooded Gums. In the central south of the site (Lot 35) is a 2.5ha patch of open woodland of young *E. rudis* regrowth over grass.

Elsewhere on the site there are lines and clumps of planted trees, mostly Flooded Gums, Bluegums (*Eucalyptus globulus*), River Red Gums (*E. camaldulensis*) and other non-local eucalypts. There is also scattered regrowth of sedges (*Juncus* ?*kraussii*) and isolated shrubs.

Overall the condition of the vegetation within the project area is classed as Cleared to Completely Degraded. There is no vegetation in Good or better condition.

Adjacent to Ellen Brook there is a sparse to dense woodland of *Eucalyptus rudis, Allocasuarina fraseriana, Melaleuca preissiana, M. rhaphiophylla, Astartea affinis, Jacksonia furcellata and Acacia saligna.* This woodland thins rapidly with distance from the Brook and is mostly outside of the project area. The ground cover over most of this area consists of a heavy growth of pasture grasses and weeds, which extend into the waterway itself.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas of Good condition. The central part (Lots 800 & 801) is accessible to cattle and is in poorer condition than the rest due to grazing. In the northern part (Lots 802-804) there is a dense growth of *Watsonia meriana* var. *bulbillifera* in areas not accessed by cattle.

### 2.5.2 Vegetation Complexes

The vegetation of the site is mapped as Yanga Complex, described by Heddle *et al.* (1980) as a low open-forest of *Casuarina obesa*, *Actinostrobus* (now *Callitris*) *pyramidalis, Melaleuca* spp. (including *M. lateritia, M. hamulosa*, *M. preissiana and M. rhaphiophylla*) and *Eucalyptus rudis* in the lower-lying areas, with *Banksia* spp., *Eucalyptus todtiana* and *Corymbia calophylla* open-woodland in the higher areas.

## 2.6 Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been largely cleared and used for farming since at least 1965.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area. The nearest mapped contaminated site is a service station in Muchea, 700m west of the northern end of the project area and on the other side of Ellen Brook. There is no potential for this contamination to directly affect the project area.

The DWER (DoE, 2004) considers intensive agriculture such as the poultry farming operation on Lots 800 and 801 to be a potentially contaminating land use, with potential contaminants including organochlorine, organophosphate and carbamate pesticides, herbicides, metals, salinity and nutrients. Residual soil contamination is most likely to be present around the poultry sheds. Groundwater contamination by nutrients and salinity may be present downgradient of the sheds but would diminish and eventually clear once the sheds were removed. There is no visual or olfactory evidence of soil or groundwater contamination at the poultry farm.

Given the proposed use of the land for industry, and assuming the poultry farm has been operating in according with its licence, there should be no need for a site contamination assessment before the land is redeveloped.

There is no visual evidence of other potentially contaminating activities such as piggeries, hydrocarbon storage or landfill.

# 3.0 WATER USE SUSTAINABILITY

## 3.1 Water Supply

Water will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand is likely to be limited to landscape irrigation, as industries within the Precinct will be restricted to those with low water usage.

Potable water will be supplied to the Precinct by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Precinct 3 with potable water. Discussions with Aqua Ferre are ongoing. A letter from Aqua Ferre confirming this understanding is attached in Appendix G.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the Precinct is likely to be necessary. The landowners group will negotiate with existing licence holders within and outside of the Precinct with a view to purchasing an existing groundwater allocation, and will submit a groundwater licence application to the DWER in due course.

## 3.2 Water Efficiency Measures

Precinct 3 will be designed as a low water-use precinct. Only industries with low water consumption will be permitted. This is driven largely by the hydrology of the site and its proximity to Ellen Brook, which demands that wastewater disposal be minimised.

Potable water use within the Precinct will be limited to consumption for domestic use in toilets, bathrooms and kitchens. The Shire of Chittering Town Planning Scheme No. 6 limits wastewater generation in industrial zones to 5,400 litres per hectare per day. If it is assumed that all potable water used will ultimately become wastewater, it can be calculated that the maximum allowable potable water demand for the 185ha precinct will be approximately 1,000 KL per day.

Cossill & Webley (2018) estimated total potable water demand for the Precinct at 228.6 ML per year, based on a study by GHD (20__) for a similar industrial estate in Karratha.

Groundwater will be used mainly for irrigation of landscape plantings and swales. These areas will be irrigated only during the establishment stage (one or two years).

The Landscape Master Plan estimates total plantings of 31.5ha of sedges, shrubs and trees within the precinct.

The water demand for irrigation in a given year will depend on the staging of subdivision and development. If the precinct were developed over ten years, the demand for irrigation water (at the DWER's default rate of 4,500 KL/ha/yr) over that ten year period would be in the order of 14 – 20 ML/yr, decreasing in subsequent years.

## 4.0 LAND CAPABILITY FOR ON-SITE EFFLUENT DISPOSAL

### 4.1 Published Land Capability Ratings and Constraints

The proposed lots are located on land mapped mostly as Guildford Formation (Gozzard, 1982). King & Wells (1990) rated the capability of the more elevated parts of the Guildford Formation as Fair to High, while the lower-lying parts were rated as Low to Very Low. The main constraints to effluent disposal in the lower areas are high water tables and poor drainage.

The Government Sewerage Policy maps the project area as being within a Sewage Sensitive Area (SSA) due to its location within the catchment of the Swan-Canning Estuary. The Policy places additional site requirements in terms of groundwater clearance and lot density on effluent disposal within SSAs.

### 4.2 Soil Permeability

Australian Standard AS1947:2012 recommends a minimum hydraulic conductivity of 0.06m/day for on-site effluent disposal without special design. The testing method set out in the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974* implies a minimum conductivity of 0.11m/day without specific approval by the Director-General of Public Health. Permeabilities of this order are generally found in weakly structured or massive clays.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken at 0.5m depth at five sites (Figure 5) in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.5 m/day to 4.2 m/day. Details of the permeability tests are attached in Appendix C.

### 4.3 Phosphorus Retention Index

The Health Department's draft *Code of Practice for Onsite Sewage Management* (2012) recommends a PRI of at least 20 for soils beneath effluent irrigation areas.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

Fill used in effluent disposal areas will have a PRI of at least 20, in line with the Health Department's draft Code of Practice (2012).

### 4.4 Depth to Groundwater

The Government Sewerage Policy (GSP) (WA Govt, 2019) requires that land used for effluent disposal in sewage sensitive areas must have a minimum clearance of 1.5m from the effluent discharge point (e.g. base of leach drain or ATU drip lines) to the highest groundwater level. Under the Policy, the required clearance can be achieved by filling but not by drainage.

The groundwater measurements carried out in August 2018 indicate that the average annual maximum groundwater level (AAMGL) is within 1.5m of the ground surface over the entire project area, and effectively at the ground surface in lower-lying areas (Figure 7). This means that up to 1.5m of fill will be required in effluent disposal areas.

Where filling is used to achieve the necessary groundwater clearance, subsoil drains will be installed at the AAMGL to minimise groundwater rise into the fill. Because drainage is not being used to create the required clearance, this is believed to comply with the GSP.

### 4.5 Slope

The Government Sewerage Policy prohibits on-site effluent disposal on land with a slope of more than 1 in 5 (20%), in order to prevent runoff of effluent.

The slope of the subject land does not exceed 2.5% (Figure 5). Therefore effluent disposal on the site is not constrained by slope.

### 4.6 Watercourse Setbacks

The Department of Water & Environmental Regulation (DWER, 2016) recommends that effluent disposal systems should be located at least 100m from waterways and wetlands. The Government Sewerage Policy requires a 100m setback from waterways, significant wetlands and drains discharging directly into waterways or significant wetlands without treatment.

For the purposes of these requirements, “waterway” is defined as a natural watercourse. Ellen Brook is a waterway under this definition. Based on site inspections and historical aerial photography, the minor drainages crossing the project area are regarded as drains, being either wholly artificial in origin or having been so modified over decades of farming that they retain no natural attributes.

The Government Sewerage Policy provides that reduced setbacks from drains may be allowed where it can be demonstrated that the reduced setbacks will not have a significant impact on the environment or public health. In this case, a reduced setback of 6m from subsoil drains is considered necessary and justified because:

- the subsoil drains will be located upslope of the effluent disposal fields (Section 4.8) and will drain only clean groundwater that has been filtered through the soil profile;
- all effluent disposal will be by means of alternative effluent disposal systems with nutrient removal capability (Section 4.7);
- the drained water will be treated by infiltration and vegetation uptake within the roadside swales before being released to Ellen Brook (Section 5.5.2);
- a greater separation would reduce the effectiveness of the subsoil drains in limiting groundwater rise within the effluent disposal areas; and
- the clayey soils and high PRI of the site (Section 2.2.5) mean that the drained water will be of high quality.

It is therefore concluded that the proposed system of effluent disposal in Precinct 3 will meet all setback requirements set out in current government policies.

### 4.7 System Selection and Location

All effluent generated within the subdivision will be treated and disposed by means of individual on-site effluent disposal systems. All lots will be required to employ nutrient-attenuating alternative systems such as aerobic treatment units (ATUs) with high-PRI irrigation areas or modified leach drain systems (e.g. Filtrex).

ATU irrigation areas will be filled to approximately 2m above the AAMGL (Figure 7) in order to provide 1.5m clearance from the AAMGL to the effluent drip lines as required under the Government Sewerage Policy (2019), allowing for 0.3m groundwater mounding and 0.2m soil cover over the drip lines. The effluent irrigation areas will be filled with soil either sourced from on site or imported. The soil will be tested to confirm a PRI of at least 20.

The ATU irrigation area on each lot will be sized to suit the expected population of the lot. As a rough rule of thumb, each full-time employee on site will require approximately $23m^2$ of effluent irrigation area. Alternatively, the treated ATU effluent may be disposed of via leach drains, which may reduce the area required for disposal by up to two thirds at the cost of a greater height of fill (2.3m total above the AAMGL).

The effluent disposal requirements of each lot will vary depending on the soil profile, groundwater depth, risk of saturation and expected site population. Site testing on each lot prior to development will be required to determine the location and type of effluent disposal system.

### 4.8 Subsoil Drainage

Where fill is used to raise pads for effluent disposal, subsoil drains will be placed upslope of the filled pad to prevent groundwater rise into the fill. The drains will be placed at least 6m upslope from the drip lines or leach drains. The drains will be set

with their inverts at or above the AAMGL and will discharge via free-draining outlets into the roadside swales, where the water will be further treated by infiltration and vegetation uptake within the swales. Because the water will be draining from high-PRI soil (see Section 2.2.5), it will be of high quality.

# 5.0 STORMWATER MANAGEMENT STRATEGY

## 5.1 Principles and Objectives

The stormwater management strategy aims to comply with the principles and objectives for stormwater management identified in the *Stormwater Management Manual for WA* (DoW, 2004) and *Better Urban Water Management* (WAPC, 2008).

Nutrient concentrations and loads in water leaving the site will be managed to comply with the targets of the draft *Swan Canning Water Quality Improvement Plan* (SRT, 2009) for the Ellen Brook catchment, as follows:

- Winter median TP concentration: 0.1 mg/L
- Winter median TN concentration: 1.0 mg/L
- Annual TP yield: 0.03 kg/ha
- Annual TN yield: 0.31 kg/ha.

## 5.2 Drainage Management System

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at their pre-development levels. The drainage design presented here is conceptual and will be refined in the detailed subdivision designs.

The priorities for managing the various sizes of storm event will be:

- 1 year ARI — Infiltrate all flows as close to the source as possible. Maintain pre-development flow rates and volumes. Minimise export of nutrients and sediments.
- 5 year ARI — Detain water prior to discharge. Maintain pre-development flow rates and volumes. Maintain amenity and serviceability. Prevent scouring and damage.
- 100 year ARI — Maintain pre-development flow rates and volumes. Prevent flooding and damage.

### 5.2.1 Through Drainage

Water enters the project area from external catchments to the east via fifteen culverts beneath Great Northern Highway. Some of these flow directly into defined drainage lines across the site, while others dissipate within the site and become part of the general overland and subsurface flow. Figure 9 shows the existing drainage across the site.

If and when the land to the east (some of which is within Precinct 2 of the Muchea Employment Node) becomes subdivided and developed, it is expected that runoff from storms up to 1-year ARI 1-hour will be retained within each subdivision, and runoff from larger storms up to 100-year ARI will be suitably detained so that the flow rates into the project area will be no greater than the current rates.

The existing drainage lines will be either preserved within easements or realigned and consolidated in vegetated swales within road reserves, which will be wider than normal to accommodate the swales. Figure 12 shows the proposed through-drainage at full development of the site. Figure 13 shows a conceptual profile of the swales.

The swales will be sized to accommodate the flow from a 100-year ARI critical storm from the upstream and internal catchments. A series of low weirs within the swales will capture and infiltrate road runoff from storms up to 1-year ARI 1-hour. The inverts of the swales will be at or above the AAMGL.

The swales will be configured as living streams and densely planted with sedges and shrubs to slow the water flow and help to remove sediments and nutrients from the water.

### 5.2.2 Internal Drainage

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, swales and/or landscaping areas. These will be subject to detailed design on individual lots. Lot runoff from larger storms will overflow via pipes into the roadside swales. The overflow pipes will be sized to regulate the flow to pre-development rates.

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The inverts of the swales will be at or above the AAMGL.

The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm. In road reserves that also include a through-drainage swale, the weirs may incorporate underdrains to promote infiltration of the 1-year flows. Alternatively, the 1-year ARI swale may be formed in the bank of the through-swale to create a double swale. Figure 13 shows conceptual profiles of the alternative swale layouts.

The configuration of the swales and internal weirs will be subject to detailed design including:

- the height of the swale inverts at or above the AAMGL;
- the width and composition of the swale floors, designed to maximise nutrient uptake;
- planting of the swales with dense sedges and shrubs to maximise nutrient uptake;

- the possible inclusion of underdrains within the swales to promote infiltration of 1-year ARI flows; and
- the possible inclusion of secondary swales within throughflow swales to accommodate the 1-year ARI road runoff.

### 5.2.3 Major Storm Drainage

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where eleven culverts beneath the PDNH embankment will carry it across to Ellen Brook. Because the PDNH was designed in the context of a rural setting, the culverts are not large enough to carry the full flow from upstream in a 100-year storm event. The drainage design therefore incorporates a swale running adjacent to the southern part of the PDNH embankment. During a 100-year storm, flows that exceed the capacity of the PDNH culverts will be carried south within this swale to the next culvert or into the drainage/landscape reserve, where it will slowly make its way overland through dense vegetation to Ellen Brook.

Figure 12 shows the overall drainage layout and the 100-year ARI flow paths. Table 5.1 summarises the 100-year flows in the swales and PDNH culverts. The flow calculations are detailed in Appendix H.

**Table 5.1 100-year ARI Flows**

| *Culvert No. (Figure 12)* | *Culvert Dimensions* | *Culvert Invert (mAHD)* | *Culvert Slope* | *Pre Development* | | | *Post Development* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *100-yr ARI Inflow ($m^3/s$) [1]* | *Flow Through Culvert ($m^3/s$) [2]* | *Bypass Flow ($m^3/s$)* | *100-yr ARI Inflow ($m^3/s$) [1]* | *Flow Through Culvert ($m^3/s$) [2]* | *Bypass Flow ($m^3/s$)* |
| 2.20 | 1 x 0.45m Circular | 49.00 | .0085 | 2.23 | 0.26 | 1.97 | 2.23 | 0.26 | 1.97 |
| 2.28 | 2 x 2.4x0.6m Rectangular | 48.92 | .0105 | 8.87 | 8.87 | 0.00 | 15.48 | 14.57 | 0.91 |
| 2.39 | 1 x 0.9x0.375m Rectangular | 49.00 | .0186 | 0.92 | 0.92 | 0.00 | 1.82 | 1.45 | 0.36 |
| 2.60 | 5 x 1.2x0.45m Rectangular | 48.89 | .0066 | 1.12 | 1.12 | 0.00 | 1.50 | 1.50 | 0.00 |
| 2.89 | 1 x 1.2x0.375m Rectangular | 47.28 | .0119 | 1.92 | 1.68 | 0.24 | 1.96 | 1.68 | 0.28 |
| 3.11 | 1 x 0.9x0.375m Rectangular | 46.22 | .0095 | 2.61 | 1.04 | 1.57 | 2.96 | 1.04 | 1.92 |
| 3.14 | 1 x 1.2x0.375m Rectangular | 45.47 | .0083 | 1.78 | 1.40 | 0.38 | 2.02 | 1.40 | 0.62 |
| 3.20 | 1 x 0.9x0.375m Rectangular | 45.70 | .0078 | 0.00 | 0.00 | 0.00 | 1.06 | 0.94 | 0.12 |
| 3.52 | 1 x 0.9x0.375m Rectangular | 44.40 | .0047 | 0.39 | 0.39 | 0.00 | 4.88 | 0.73 | 4.15 |
| 3.64 | 3 x 1.2x0.375m Rectangular | 43.69 | .0014 | 0.45 | 0.45 | 0.00 | 8.21 | 1.73 | 6.49 |
| 3.89 | 4 x 1.2x0.45m Rectangular | 42.30 | .0019 | 14.76 | 3.46 | 11.30 | 12.50 | 3.46 | 9.04 |
| Ellen Brook | Brook Inflow | | | 18.86 | 18.86 | 0.00 | 17.54 | 17.54 | 0.00 |
| South | Offsite Flow | | | 8.38 | 8.38 | 0.00 | 8.59 | 8.59 | 0.00 |

1 Inflow includes any excess (bypass) flow from culvert above.

2. Culvert flows are calculated as follows:
   - Rectangular culverts: Manning's open channel formula (http://www.eng.auburn.edu/~xzf0001/Handbook/Channels.html)
   - Circular culverts: Hazen-Williams formula for full-pipe flow (http://www.calctool.org/CALC/eng/civil/hazen-williams_g)

### 5.3 Ellen Brook Floodplain

The 100-year ARI floodplain of Ellen Brook was modelled by BG&E in 2017 on behalf of MRWA for the Northlink (PDNH) project. The modelling mapped only the floodplain extent, and not the floodway. Figure 9 shows the 100-year floodplain mapped by BGE.

BG&E revisited the modelling in 2018 for this project to define the 100-year floodway of Ellen Brook. The modelling focussed only on the part of Ellen Brook south of the PDNH crossing and adjacent to the project area. The modelling was carried out in consultation with DWER and MRWA. Figure 9 shows the floodway modelled by BG&E.

The floodway is defined by the DWER as the area within which filling or development would cause an unacceptable rise in river levels (afflux) upstream during a 100-year ARI flood. The floodway is therefore taken as the minimum setback of development or filling (including roads) from the waterway.

The floodplain is the area expected to be inundated by a 100-year ARI flood. Development within the floodplain but outside the floodway is permitted provided that roads and other infrastructure are not damaged by floodwaters and all habitable buildings have a floor level at least 0.5m above the 100-year flood level.

### 5.4 Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots.
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15.
- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out.

### 5.5 Maintenance

The drainage system has been designed to require minimal maintenance. The following will be required to ensure that the system continues to function as designed:

- Regular (possibly annual) cleaning of side entry and junction pits, inlet pits and small culverts. More frequent cleaning may be required during the construction phase.

- Tending and maintenance of swales and other vegetated drainage features to remove litter, control weeds and encourage the growth of native species.

- Pruning, mulching or removal of vegetation in swales as necessary to maintain ground fuel loads below 8 tonnes/ha.

# 6.0 GROUNDWATER MANAGEMENT STRATEGY

## 6.1 Groundwater Levels

The average annual groundwater level (AAMGL) is at or near the ground surface over much of the site (Figure 7). In the west of the site, groundwater rise in winter is limited by intersecting the ground surface, giving rise to surface runoff.

The drainage system for the site is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their inverts at or above the AAMGL. Subsoil drainage within lots will be limited to filled areas used for buildings or effluent disposal.

## 6.2 Subsoil Drainage

Subsoil drainage will be employed within lots to maintain existing maximum groundwater levels beneath building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales via free-draining outlets.

Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement.

All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of the site will be minimal.

## 6.3 Groundwater Quality

The sampling undertaken to date indicates that the groundwater beneath the site contains low to moderate concentrations of nitrogen and phosphorus. This is to be expected given the nature of the soils and the land use history of the site.

The relationship between nutrient inputs and exports is complex, especially in the case of phosphorus, which travels through the soil profile as a “front” in a complex series of adsorption and desorption reactions. Nitrogen is subject to denitrification and mineralisation in the soil and groundwater. As a result, nutrient exports from the site at present will be a reflection of nutrient inputs over the last several decades, modified by soil hydrology and nutrient retention capacity.

The aim of nutrient management will be to limit nutrient inputs to the site so that nutrient outputs are minimised. As an industrial precinct, the area of fertilised gardens and lawns will be small. Landscaping areas including street trees, swales and vegetation buffers will be established with minimal fertilisers and irrigation.

Measures available to minimise nutrient inputs and exports in the development will include:

- regular street sweeping to remove accumulated contaminants; and
- selection of native species with low water and fertiliser requirements for public open space and landscape areas.

## 7.0 LANDSCAPING STRATEGY

Landscaping of the site will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot) and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation-tolerant species including sedges and low shrubs in order to stabilise the basins and maximise their ability to take up nitrogen from the water.

The immediate surrounds of Ellen Brook (extending up to 30m from the watercourse) and the drainage/landscape reserve will be densely planted with wetland-tolerant native sedges, low shrubs and other understorey species in order to slow and filter runoff that is not captured by the road drainage system.

The total area to be planted is approximately 31.5 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 142 ML of water would be required to irrigate the new plantings for the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year.

The density of planting will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (eco logical Australia, 2018).

Figure 14 shows the conceptual landscaping strategy.

## 8.0 MONITORING

Baseline water quality results for the site are shown in Tables 2.3, 2.4 and 2.5. Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in the creeklines and Ellen Brook will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

## 9.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Further planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) will be prepared as a condition of subdivision approval for each stage of subdivision. The UWMP will present the detailed design of the stormwater drainage system within that stage.

The developer of each stage of subdivision will maintain the drainage system, landscaped areas and water monitoring program within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for monitoring and management will be handed over to the Shire of Chittering.

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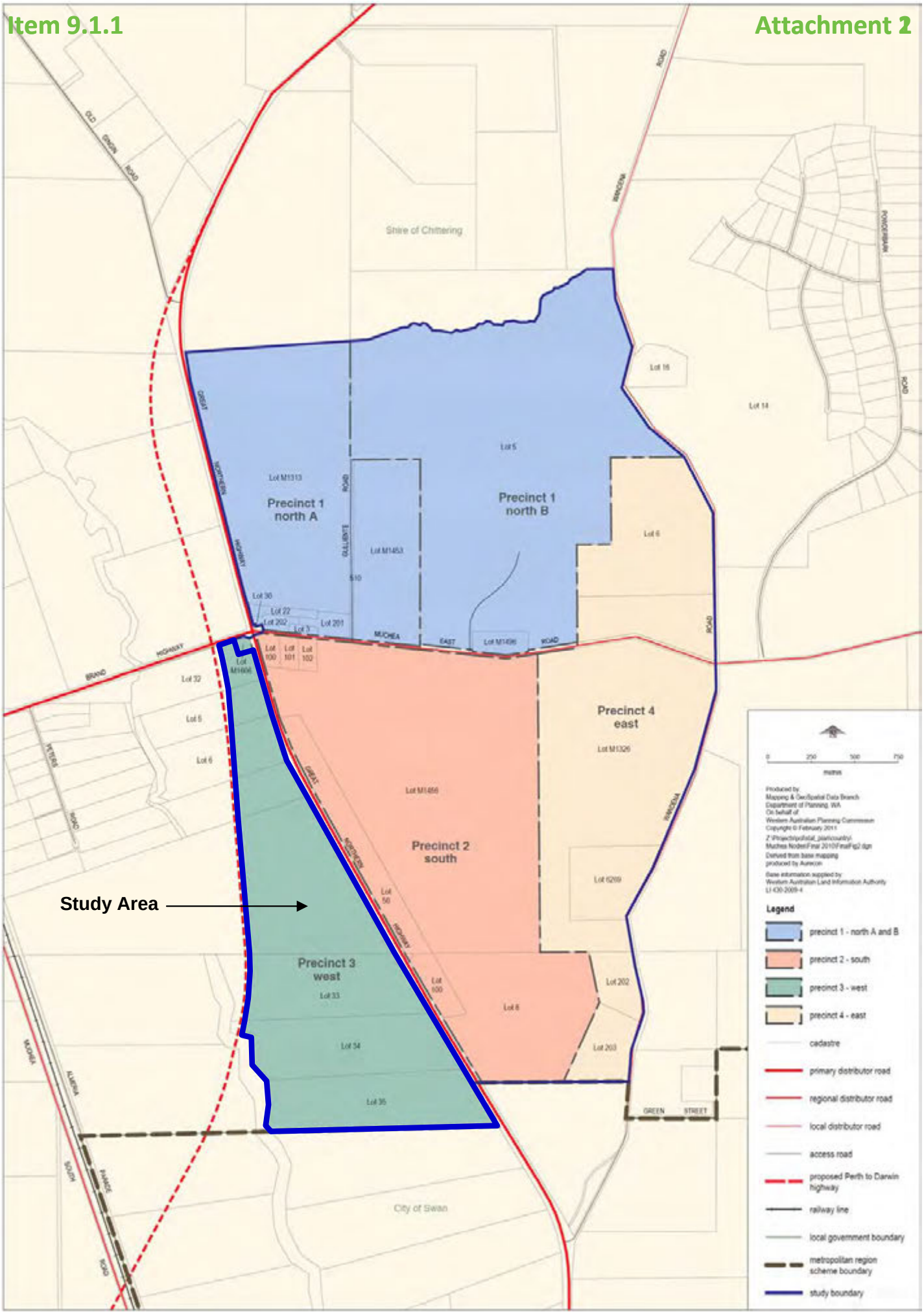
# Figures




Source: WAPC, 2011

**Figure 1**

**MUCHEA EMPLOYMENT NODE STRUCTURE PLAN**

**Figure 2**

**THE SITE AND SURROUNDINGS**

Image: Google Earth

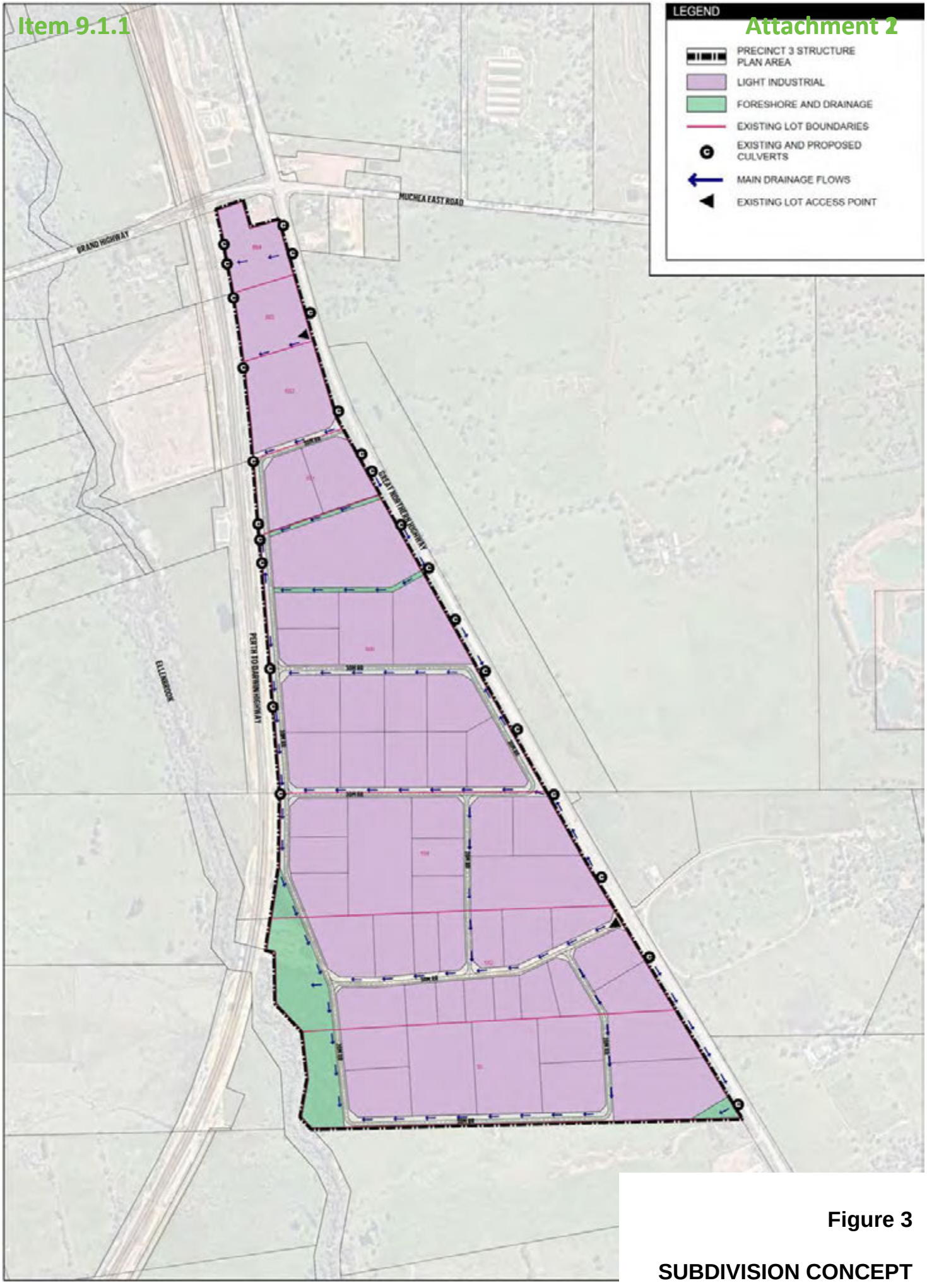



**Figure 3**

**SUBDIVISION CONCEPT**

URBIS

bayley environmental services

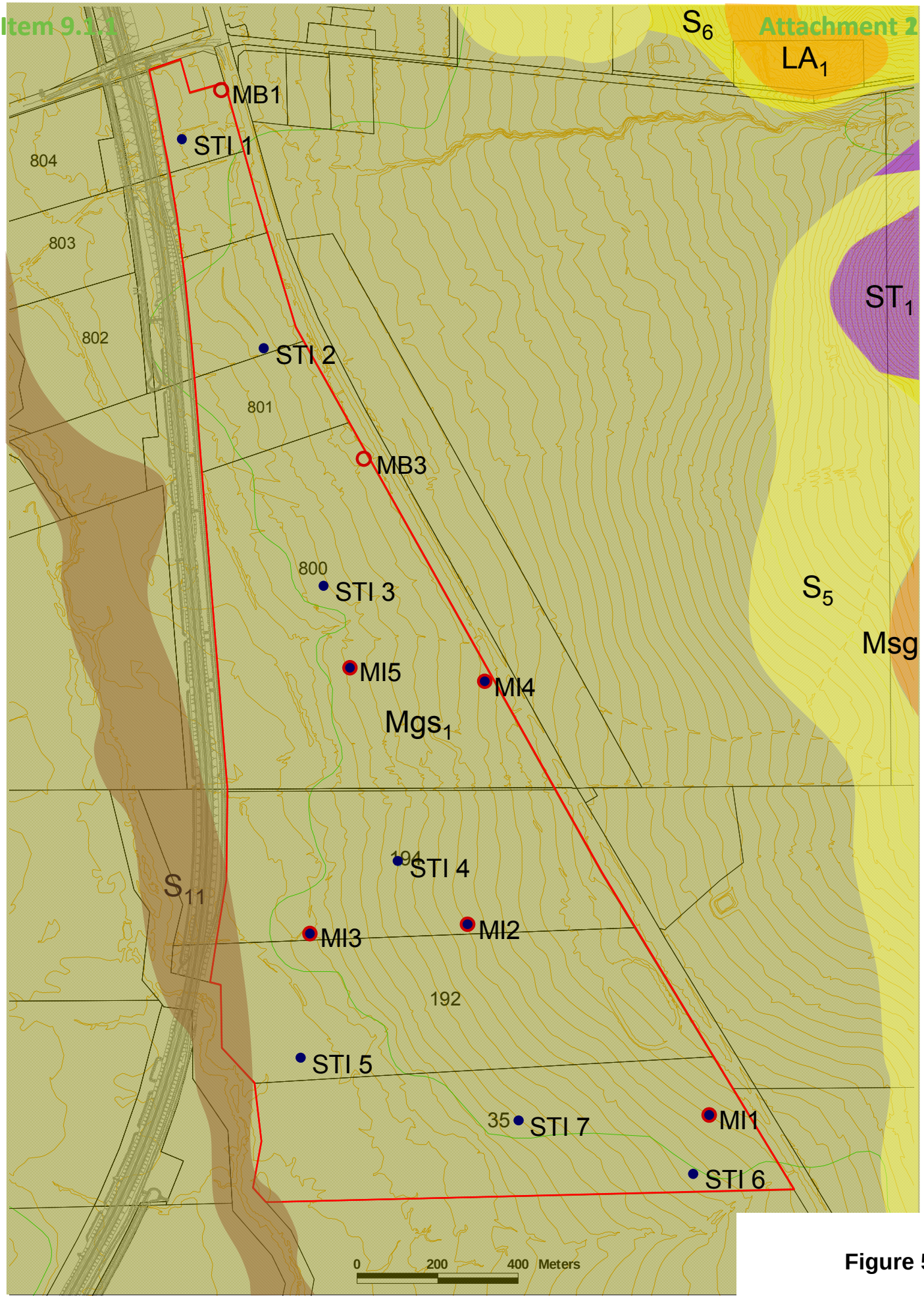



**Figure 5**

**PHYSIOGRAPHY**

Permeability Test
PRI Analysis

bayley environmental services

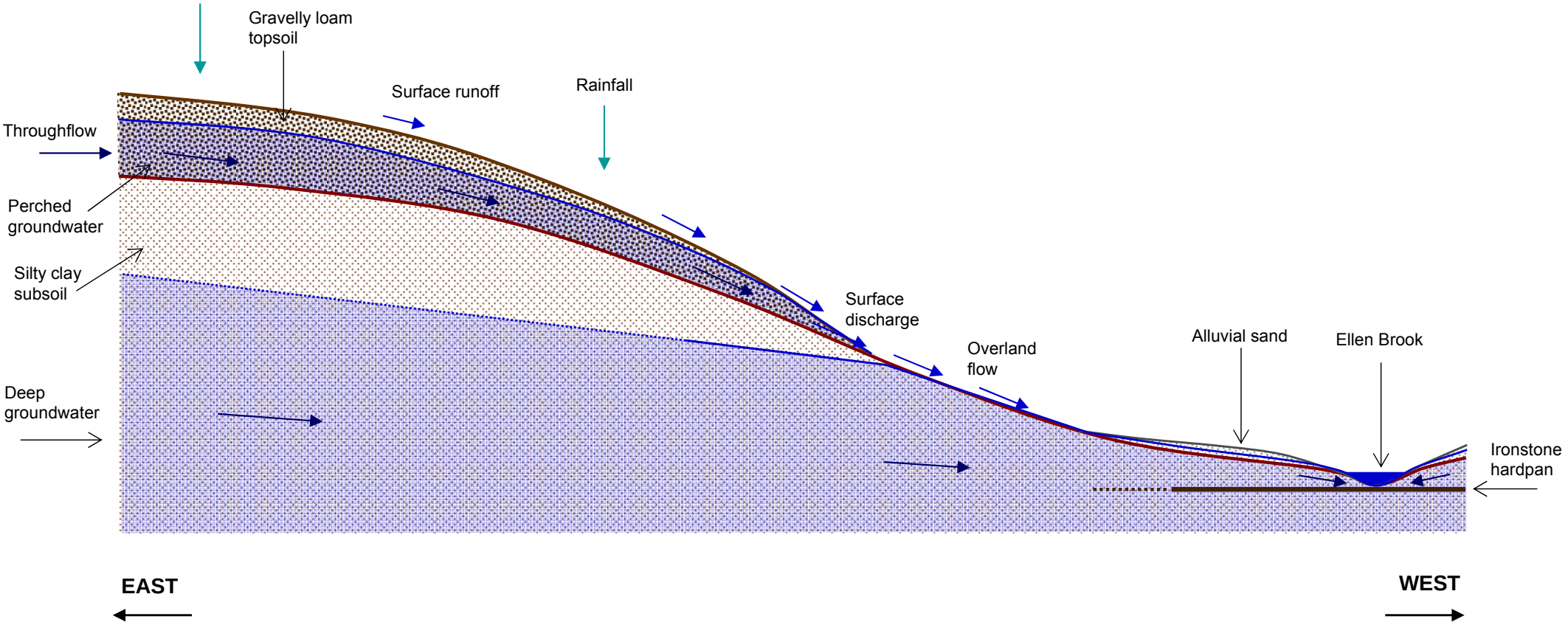
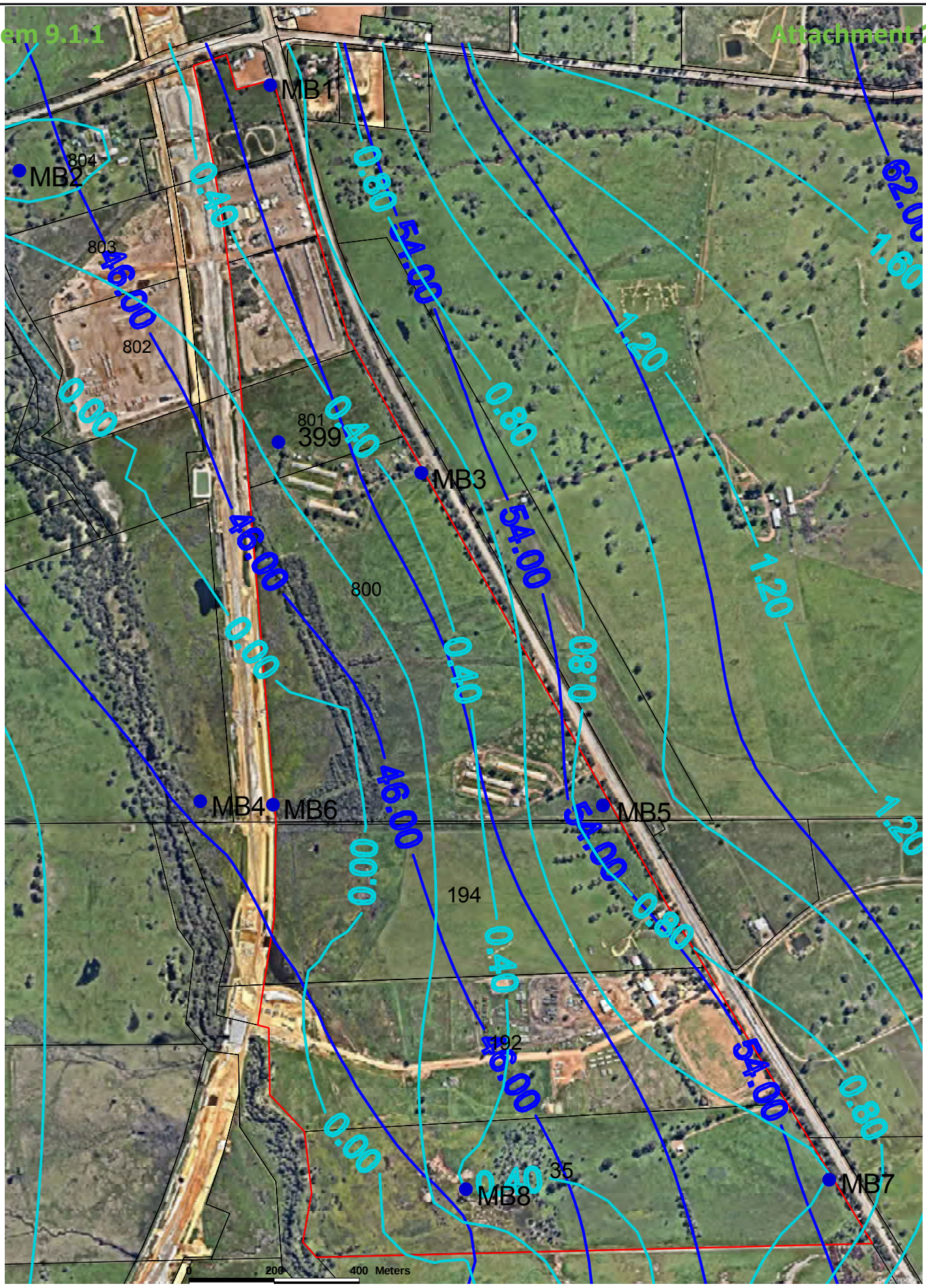



**Figure 6**

**HYDROLOGY OVERVIEW**

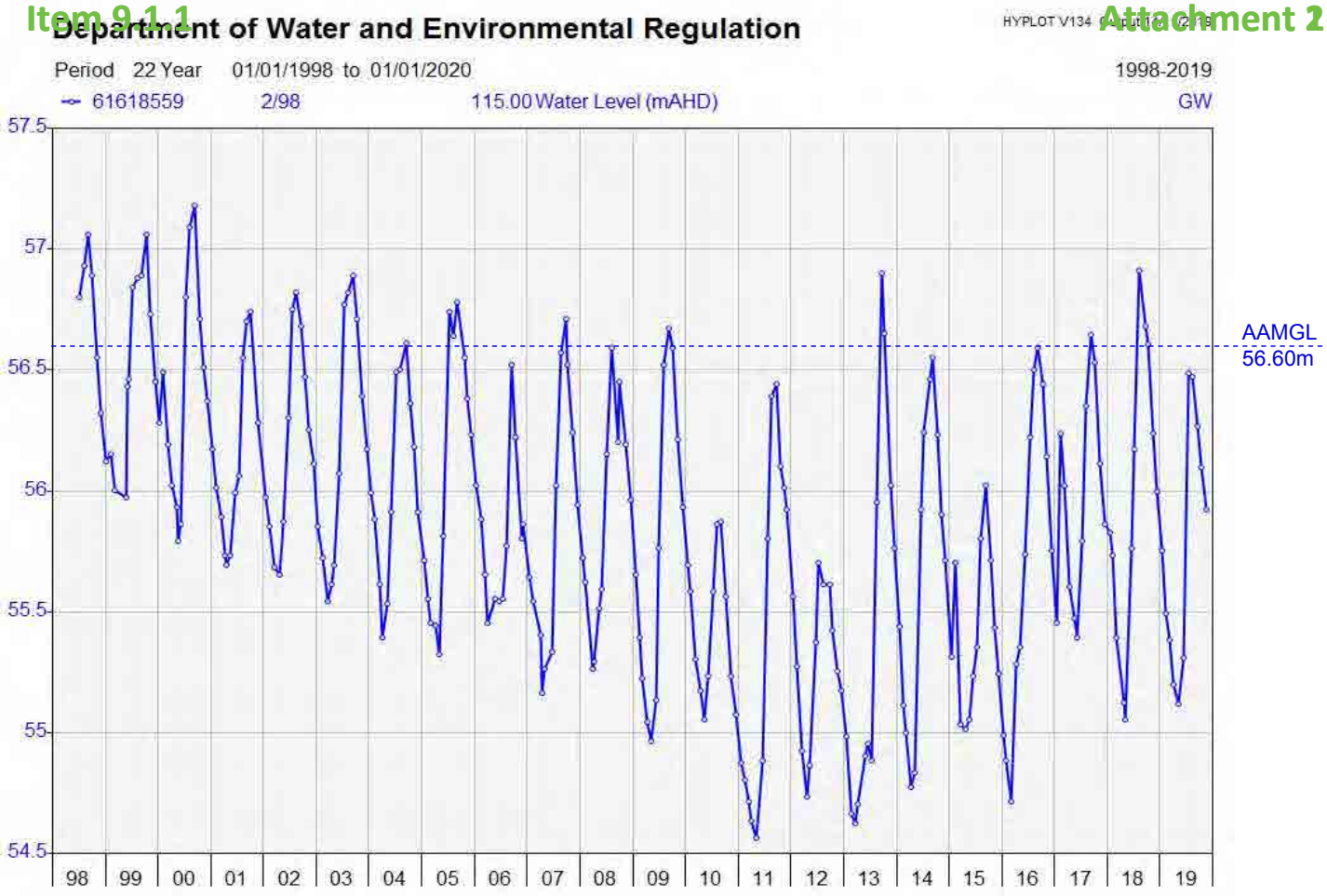
Not to scale




AAMGL Contour
Depth to AAMGL Contour
Bore

**Figure 7**

**GROUNDWATER**



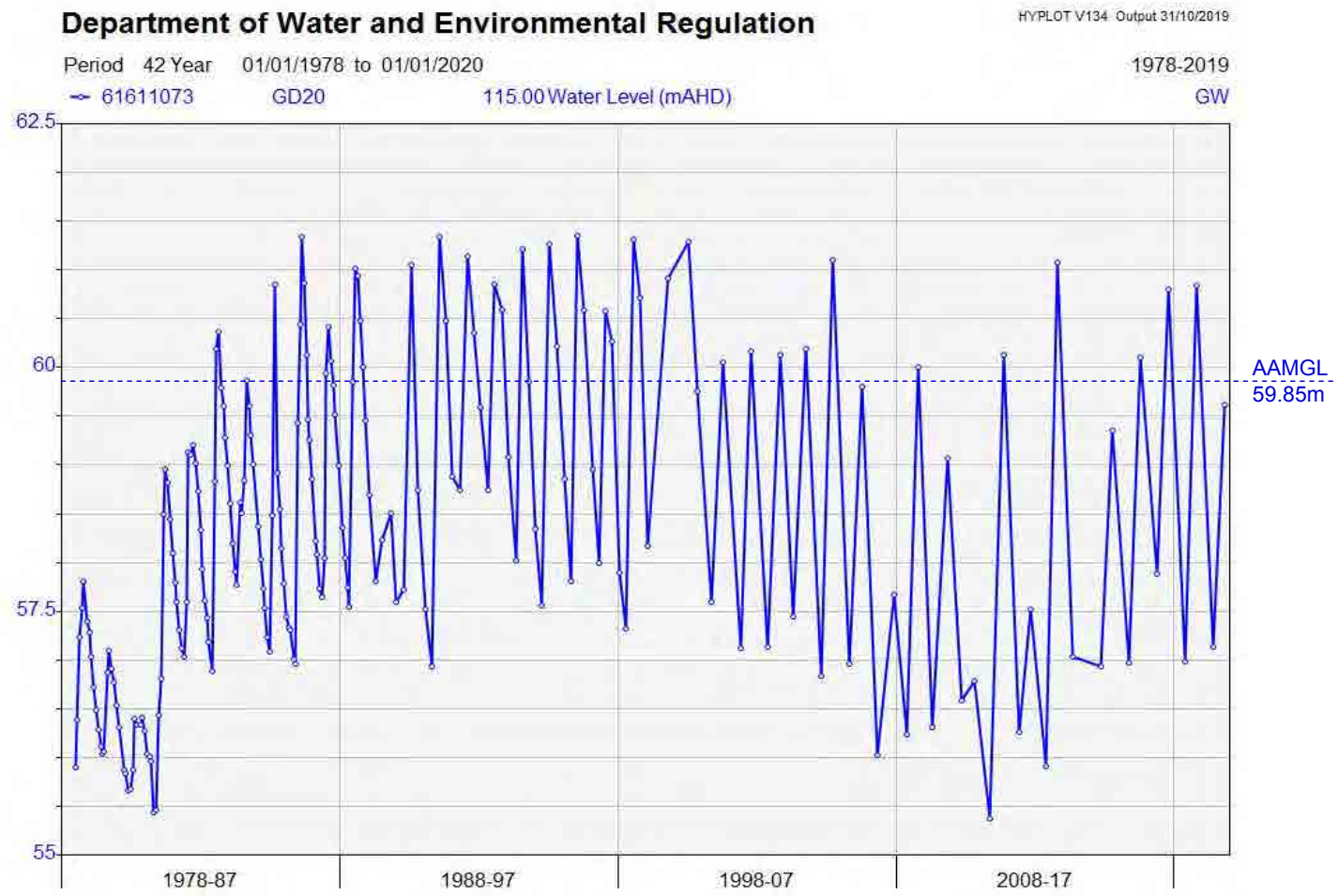




**Figure 8**

**DWER BORE HYDROGRAPHS**

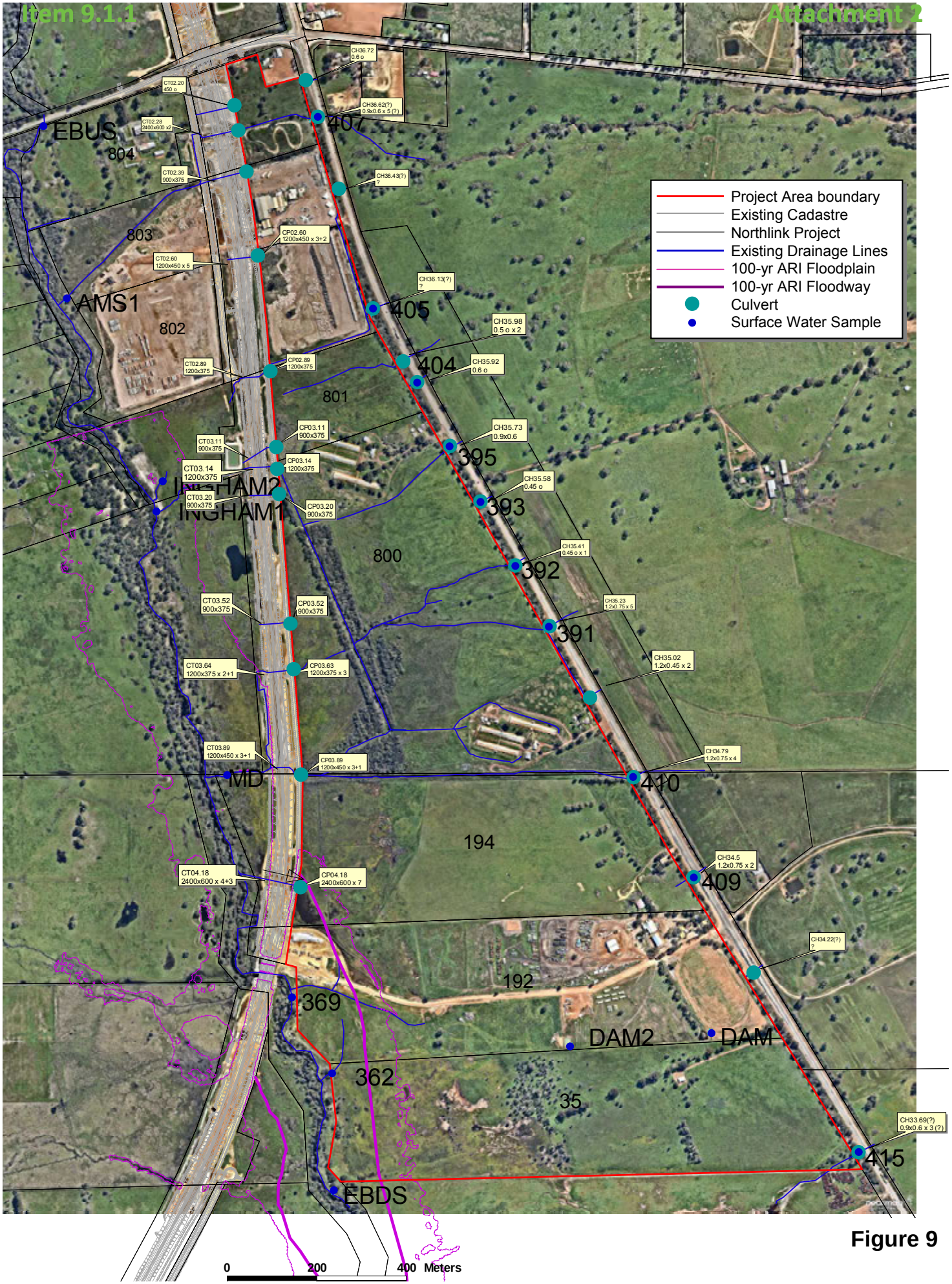



**Figure 9**

**SURFACE HYDROLOGY**

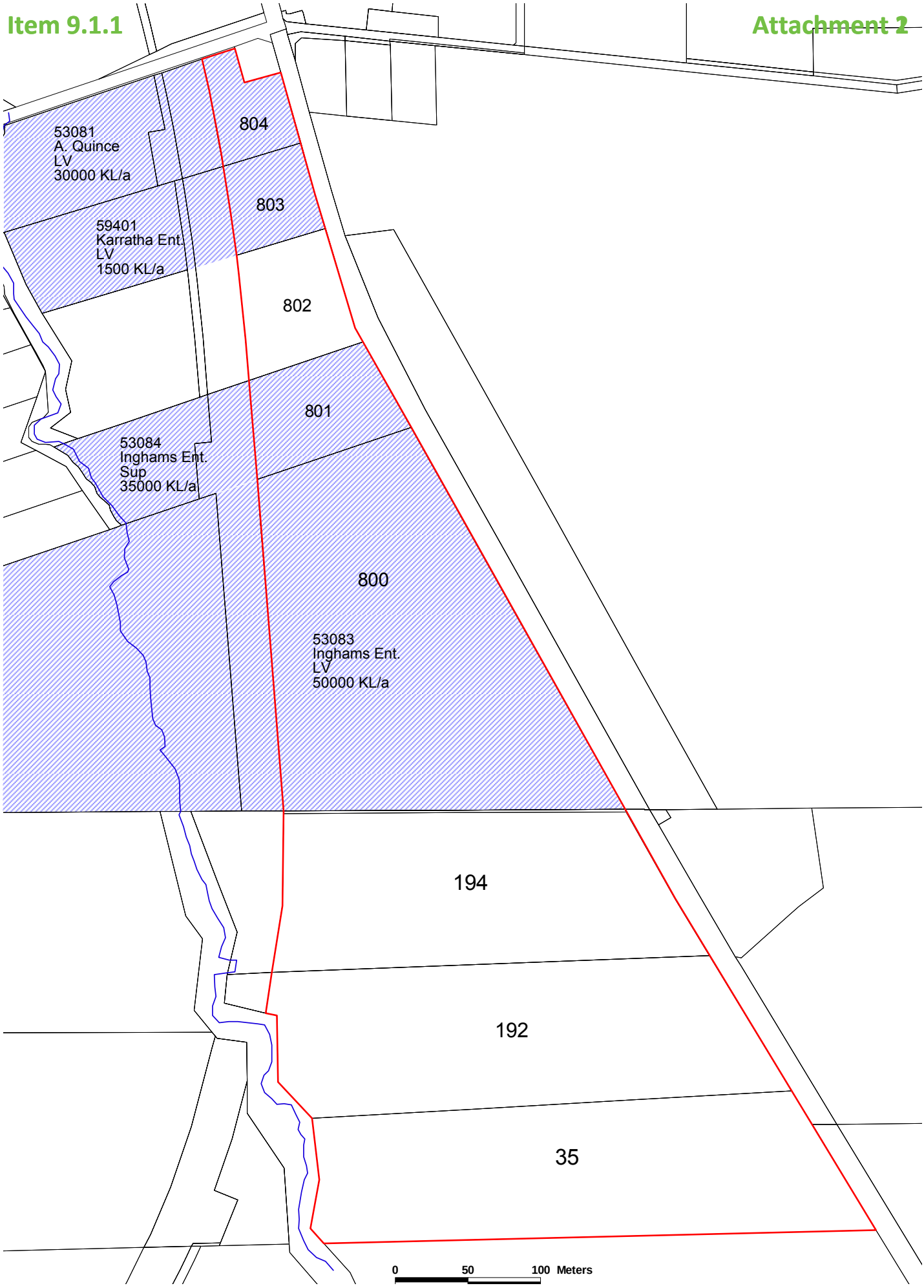



**Figure 10**

**GROUNDWATER LICENCES**

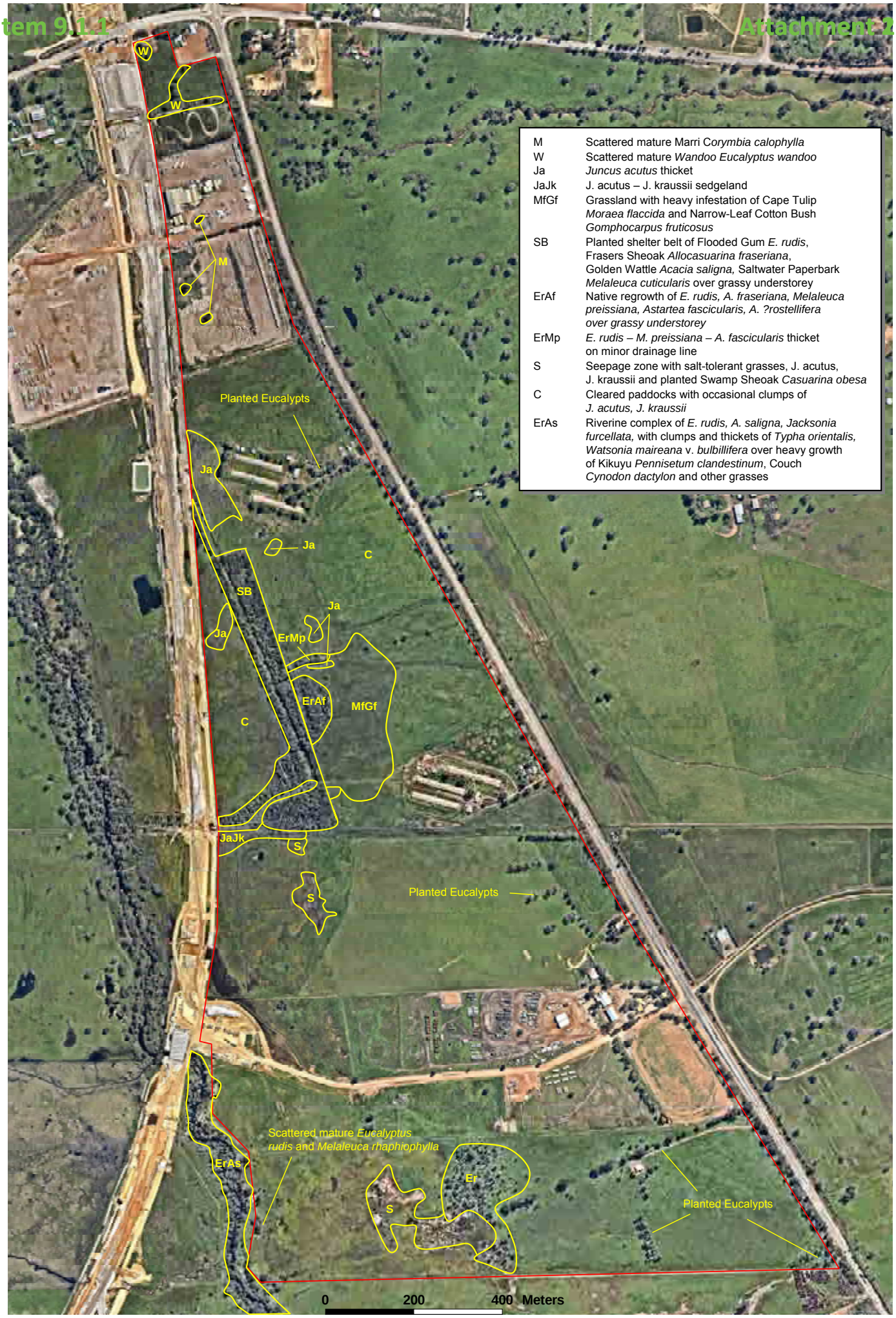



**Figure 11**

**VEGETATION**

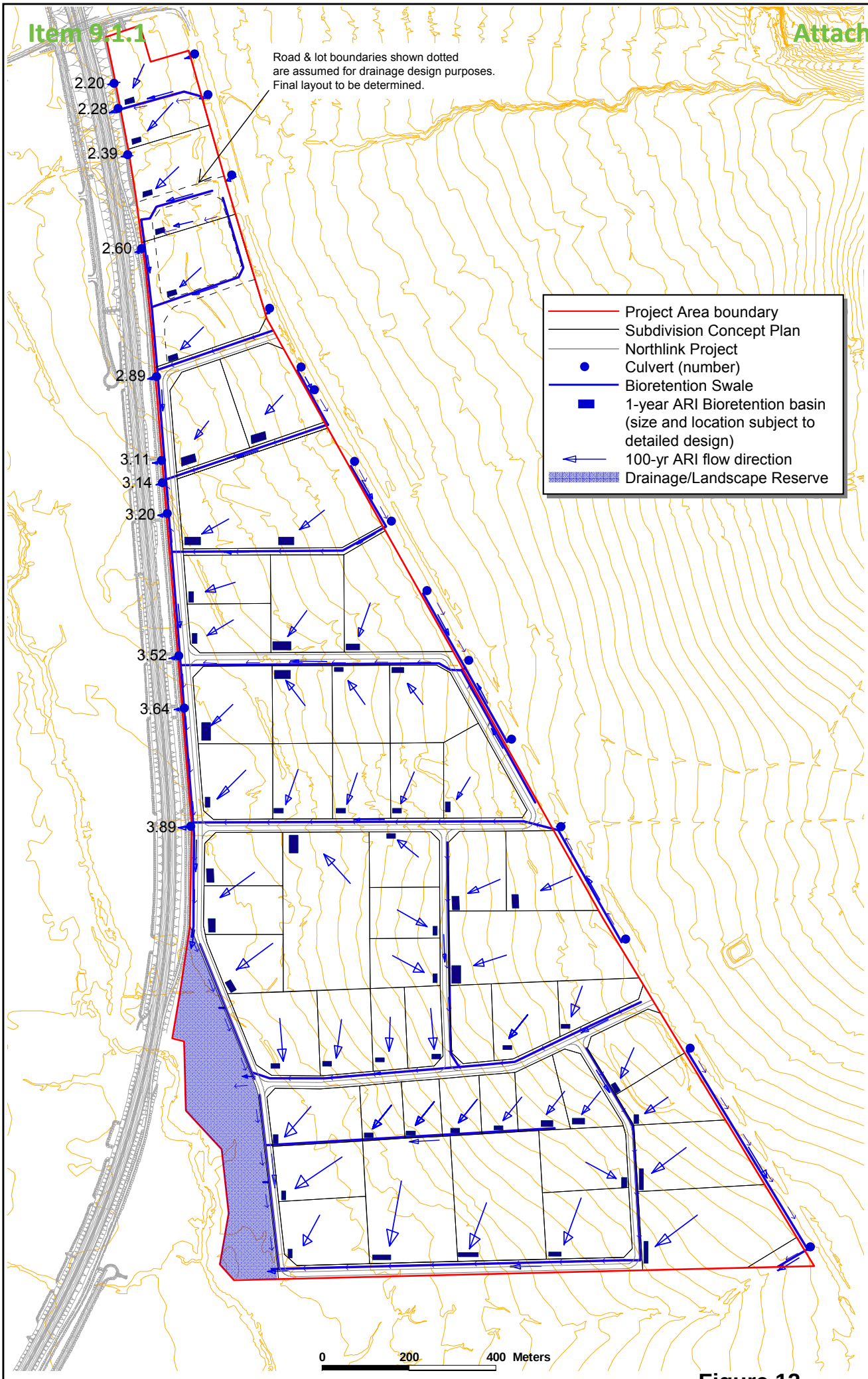



**Figure 12**

**DRAINAGE CONCEPT**

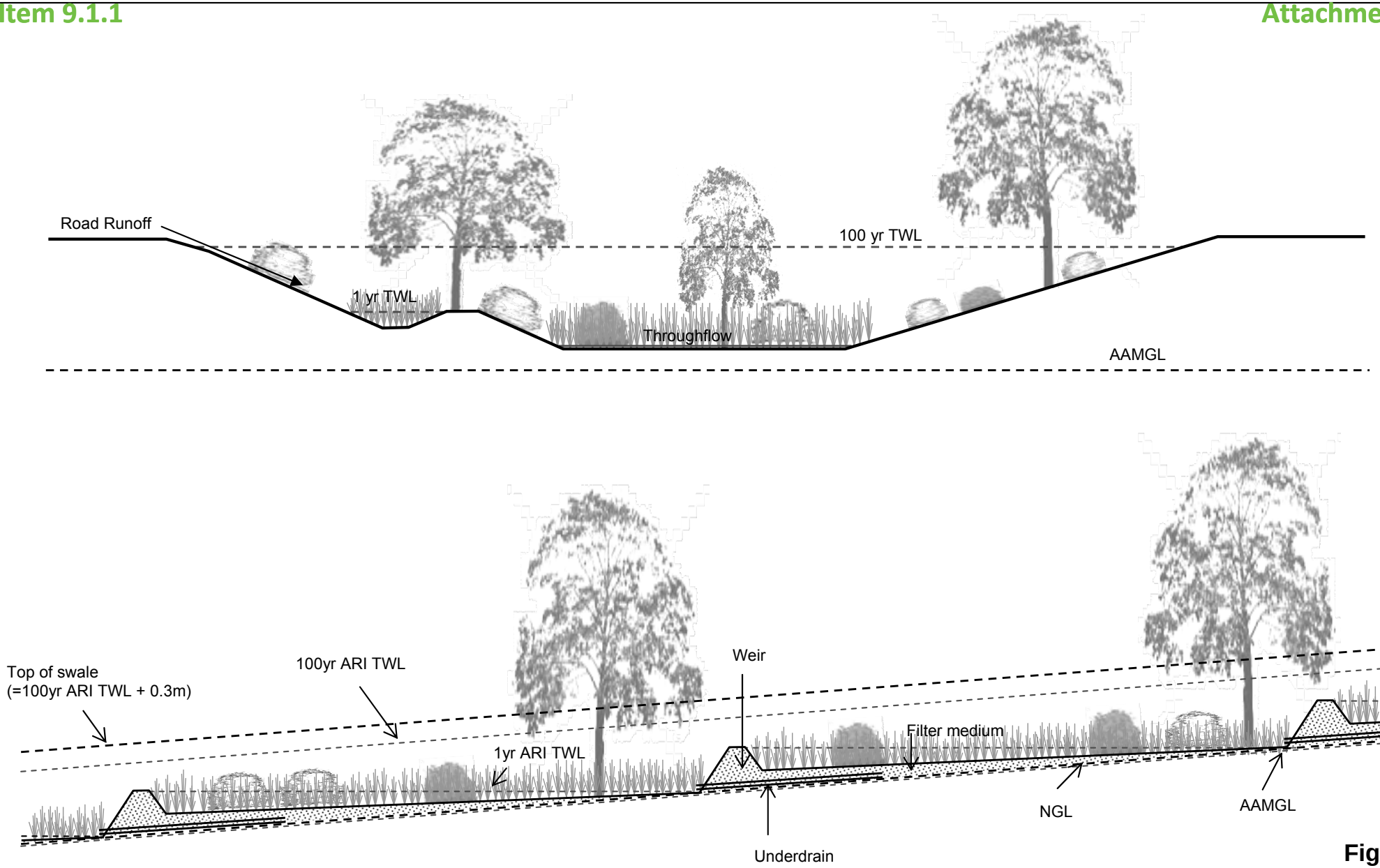



**Figure 13**

**SWALE OPTIONS**

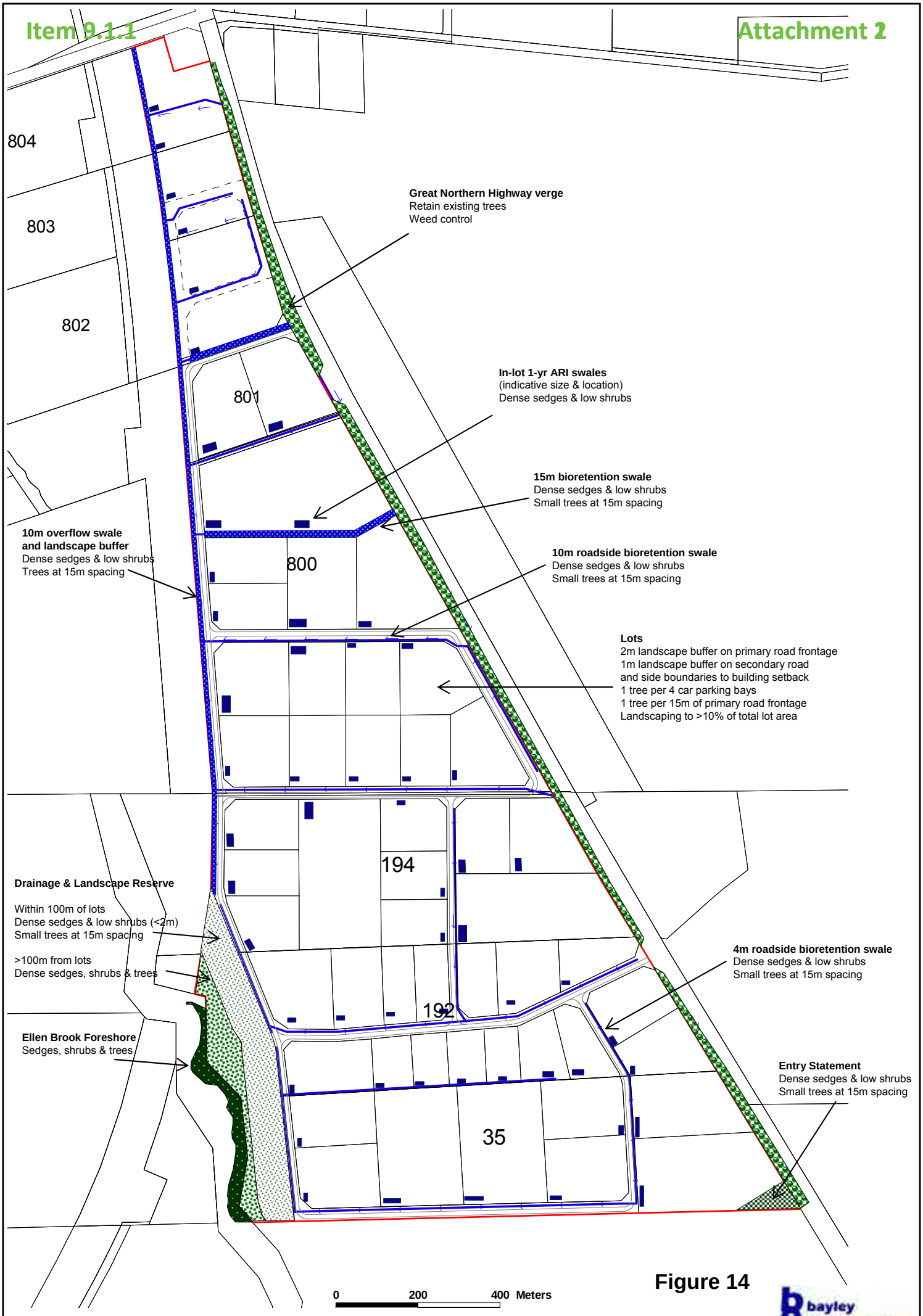



**Figure 14**

**LANDSCAPE MASTER PLAN**

# Appendix A

## DWER LWMS Checklist

# Appendix 2 Local water management strategy checklist

| Local water management strategy item | Deliverable | ☑ | Notes |
|---|---|---|---|
| **Executive summary** | | | |
| Summary of the development design strategy, outlining how the design objectives are proposed to be met | Table 1: Design elements and requirements for best management practices and critical control points | ☑ | Page 8 |
| **Introduction** | | | |
| Total water-cycle management – principles and objectives<br>Planning background<br>Previous studies | | ☑ | Section 1 |
| **Proposed development** | | | |
| Structure plan, zoning and land use<br>Key landscape features<br>Previous land use | Site context plan<br>Structure plan | ☑<br>☑ | Figures 1-3<br>Section 2 |
| Landscape – proposed public open space areas, public open space credits, water source, bore(s), lake details, irrigation areas (if applicable) | Landscape plan | ☑ | Sections 3, 7 |
| **Design criteria** | | | |
| Agreed design objectives and source of objectives | | ☑ | Section 1.5 |
| **Pre-development environment** | | | |
| Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design? | | ☑ | Section 2 |
| Site conditions – existing topography/contours, aerial photo underlay, major physical features | Site condition plan | ☑ | Section 2 |
| Geotechnical – topography, soils including acid sulfate soils and infiltration capacity, test pit locations | Geotechnical plan | ☑ | Section 2 |
| Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites | Environmental plan plus supporting data where appropriate | ☑ | Section 2 |
| Surface water – topography, 100-year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable) | Surface-water plan | ☑ | Section 2 |
| Groundwater – topography, pre-development groundwater levels and water quality, test bore locations | Groundwater plan plus site investigations | ☑ | Section 2 |

| Local water management strategy item | Deliverable | ☑ | Notes |
|---|---|---|---|
| **Water sustainability initiatives** | | | |
| Water efficiency measures – private and public open spaces including method of enforcement | | ☑ | Section 3 |
| Water supply (fit-for-purpose) strategy, agreed actions and implementation | | ☑ | Section 3 |
| Wastewater management | | ☑ | Section 4 |
| **Stormwater management strategy** | | | |
| Flood protection – peak flow rates, volumes and top water levels at control points, 100-year flowpaths and100-year detention storage areas | 100-year-event plan<br>Long section of critical points | ☑<br>☑ | Section 5 |
| Manage serviceability – storage and retention required for the critical 5-year ARI storm events<br>Minor roads should be passable in the 5-year ARI event | 5-year-event plan | ☑ | Section 5 |
| Protect ecology – detention areas for the 1-year 1-hour ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages | 1-year-event plan<br>Typical cross sections | ☑<br>☑ | Section 5 |
| **Groundwater management strategy** | | | |
| Post-development groundwater levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones | Groundwater/subsoil plan | ☑ | Section 6 |
| Actions to address acid sulfate soils or contamination | | ☑ | Sections 2.2.4 and 2.6 |
| **The next stage – subdivision and urban water management plans** | | | |
| Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before detailed design. | | ☑ | Section 9 |
| **Monitoring** | | | |
| Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions | | ☑ | Section 8 |
| **Implementation** | | | |
| Developer commitments | | ☑ | Section 9 |
| Roles, responsibilities, funding for | | ☑ | Section 9 |

| Local water management strategy item | Deliverable | ☑ | Notes |
|---|---|---|---|
| implementation | | | |
| Review | | ☑ | Section 9 |

# Appendix B

## Soil Logs

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB1 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.5 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 0.5 | Grey-brown gravelly silty loam | | |
| 1 - 1.5 | Yellow-brown clayey silt, wet | | |
| 2 - 3.5 | Yellow clayey silt, wet | | |
| 4 - 4.5 | Pink-grey silty clay, very wet | | |
| | | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB2 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 3.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 0.5 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Dk grey sandy topsoil | | |
| 0.5 - 1 | Grey silty sand, wet | | |
| 1.5 - 2 | Grey brown sandy silt, very wet | | |
| 2.5 | Yellow-brown clayey silt, very wet | | |
| 3 | Green-brown clayey silt, very wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB3 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 3.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Grey-brown gravelly loam | | |
| 0.5 | Brown pebbly silt | | |
| 1 - 2.5 | Orange-brown gravelly clayey silt | | |
| 3 - 3.5 | Pink-brown clayey silt, very wet | | |
| 4 | Pink-grey silty clay, very wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB5 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 0.5 | Yellow-brown silty loam, moist | | |
| 1 - 1.5 | Yellow-brown gravelly silt, very wet | | |
| 2 | Yellow-brown silt, very wet | | |
| 2.5 - 4 | Yellow-brown clayey silt, moist | | |
| | | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB7 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 6.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 0.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Brown gravelly loam, wet | | |
| 0.5 | Orange-brown pebbly silt, moist | | |
| 1 | Red-brown pebbly clay, moist | | |
| 1.5 - 2 | Orange-brown silty clay, wet grading to moist | | |
| 2.5 - 3 | Orange-brown clay, moist | | |
| 3.5 - 6 | Brown clay, wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB8 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 5.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 1.5 | Brown silty clayey gravel, moist | | |
| 2 - 2.5 | Pale yellow-brown silt, wet | | |
| 3 - 5 | Grey silty clay, very wet | | |

# Appendix C

## BES Permeability Test Results

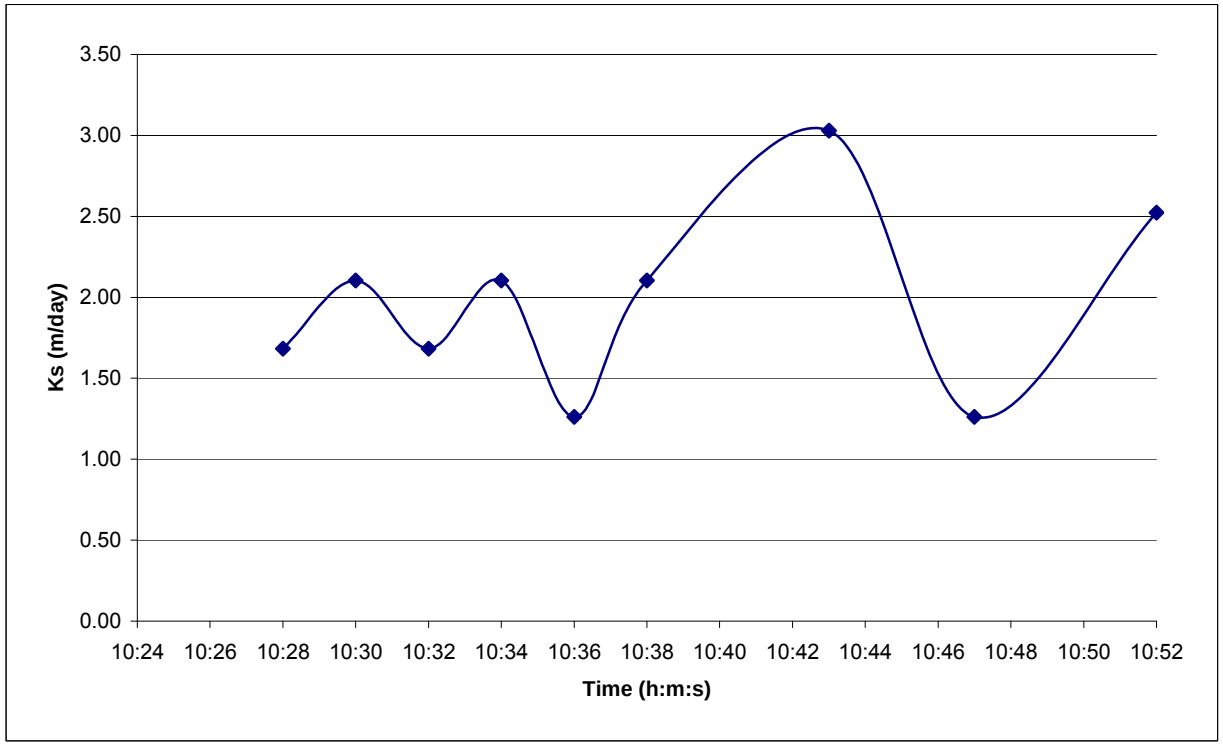
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI1-S |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 10:26:00 | 39.8 | | |
| 10:28:00 | 39.4 | 0.4 | **1.68** |
| 10:30:00 | 38.9 | 0.5 | **2.10** |
| 10:32:00 | 38.5 | 0.4 | **1.68** |
| 10:34:00 | 38 | 0.5 | **2.10** |
| 10:36:00 | 37.7 | 0.3 | **1.26** |
| 10:38:00 | 37.2 | 0.5 | **2.10** |
| 10:43:00 | 35.4 | 1.8 | **3.03** |
| 10:47:00 | 34.8 | 0.6 | **1.26** |
| 10:52:00 | 33.3 | 1.5 | **2.52** |
| | | 33.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 1.9 m/d**



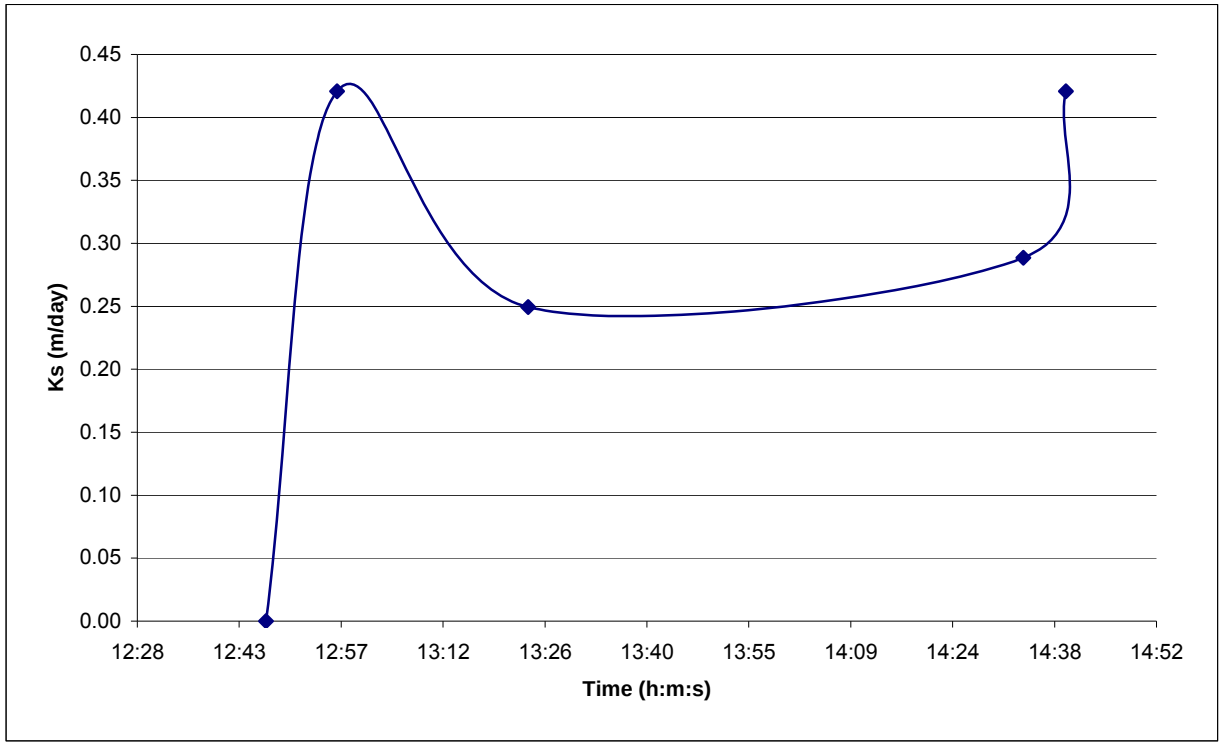
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI1-D |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 1m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 12:42:00 | 40.4 | | |
| 12:47:00 | 40.4 | | |
| 12:57:00 | 39.9 | 0.5 | **0.42** |
| 13:24:00 | 39.1 | 0.8 | **0.25** |
| 14:34:00 | 36.7 | 2.4 | **0.29** |
| 14:40:00 | 36.4 | 0.3 | **0.42** |
| | | 36.4 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 0.25 m/d**



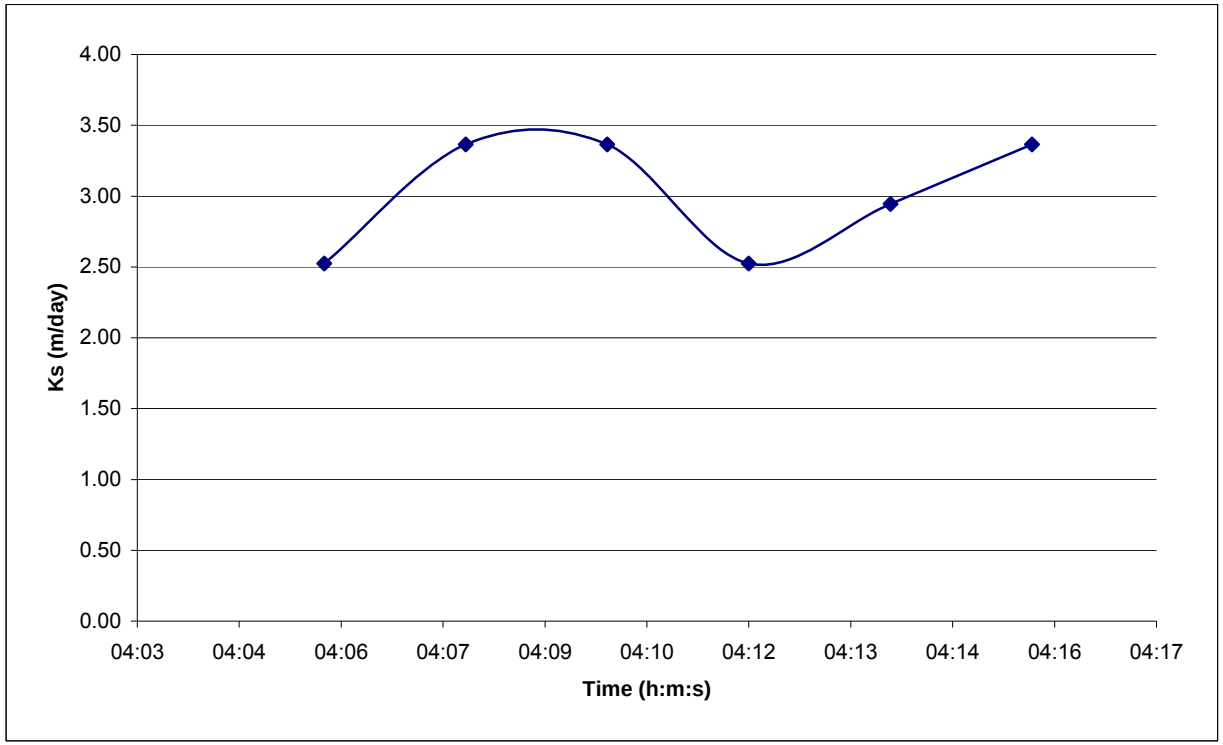
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI2 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 04:05:00 | 36.3 | | |
| 04:06:00 | 36 | 0.3 | **2.52** |
| 04:08:00 | 35.2 | 0.8 | **3.37** |
| 04:10:00 | 34.4 | 0.8 | **3.37** |
| 04:12:00 | 33.8 | 0.6 | **2.52** |
| 04:14:00 | 33.1 | 0.7 | **2.94** |
| 04:16:00 | 32.3 | 0.8 | **3.37** |
| | | 32.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 3.0 m/d**



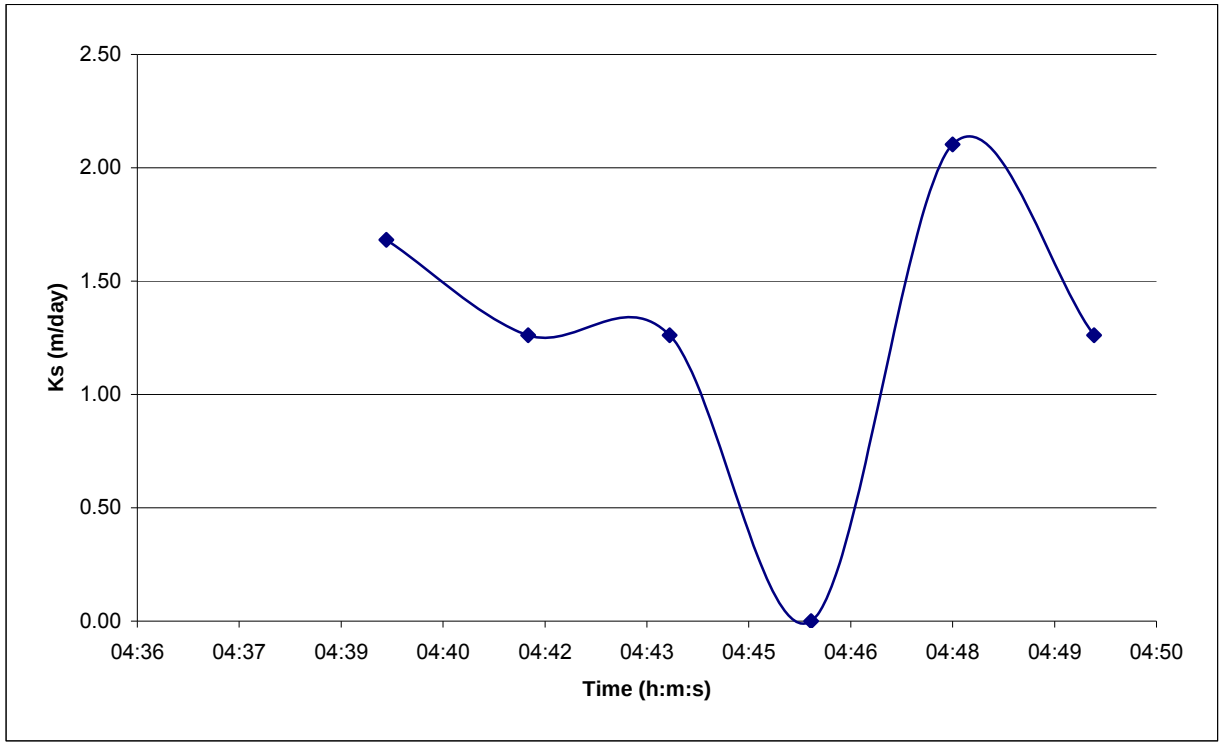
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI3 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 04:38:00 | 27.1 | | |
| 04:40:00 | 26.7 | 0.4 | **1.68** |
| 04:42:00 | 26.4 | 0.3 | **1.26** |
| 04:44:00 | 26.1 | 0.3 | **1.26** |
| 04:46:00 | 26.1 | | |
| 04:48:00 | 25.6 | 0.5 | **2.10** |
| 04:50:00 | 25.3 | 0.3 | **1.26** |
| | | 25.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 1.25 m/d**



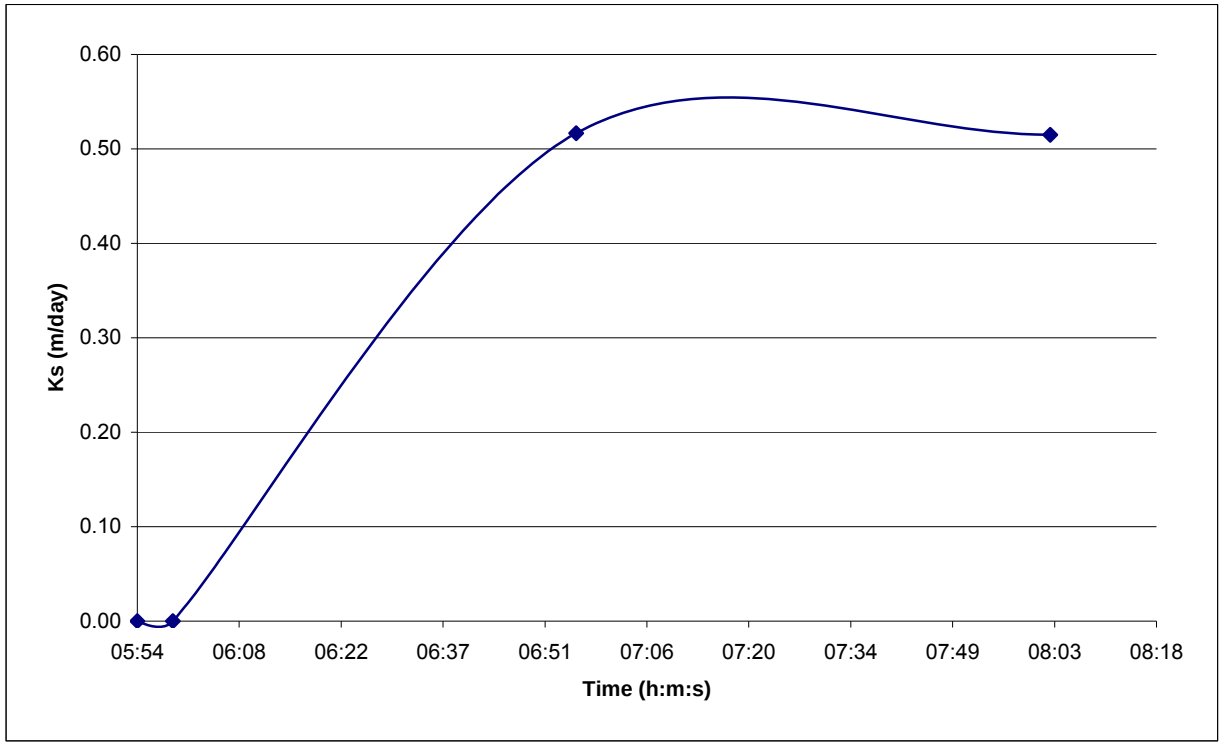
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI4 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 05:49:00 | 34 | | |
| 05:54:00 | 34 | | |
| 05:59:00 | 34 | | |
| 06:56:00 | 30.5 | 3.5 | **0.52** |
| 08:03:00 | 26.4 | 4.1 | **0.51** |
| | | 26.4 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 0.5 m/d**



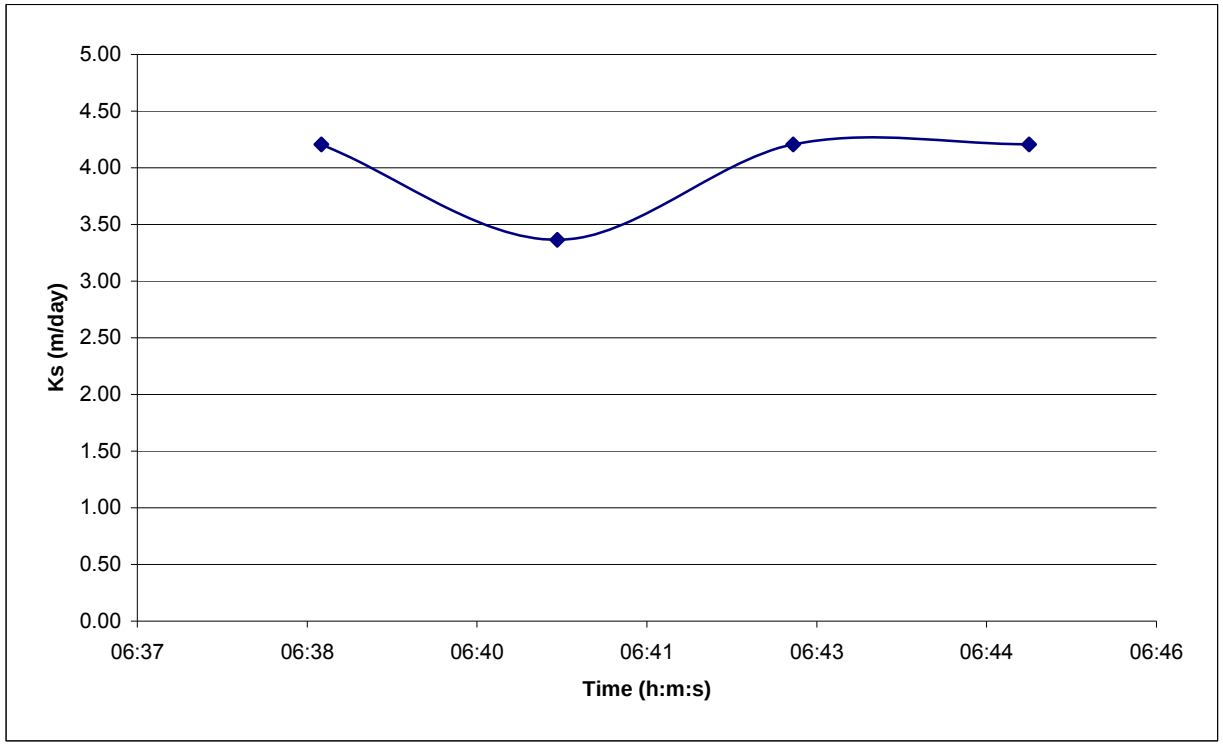
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI5 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5 |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 06:36:00 | 22.9 | | |
| 06:39:00 | 21.4 | 1.5 | **4.21** |
| 06:41:00 | 20.6 | 0.8 | **3.37** |
| 06:43:00 | 19.6 | 1 | **4.21** |
| 06:45:00 | 18.6 | 1 | **4.21** |
| | | 18.6 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 4.2 m/d**



# Appendix D

## Geotechnical Report

Doc GE2.2.1

# GEOTECHNICAL INVESTIGATION

**For:** Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners

**Project Address:** Muchea Employment Node - Precinct 3 - Muchea

**Project Number:** D206263

**Job Number:** J315642

**Revision Number:** 1

**Author:** David Harding

**Date:** 20/12/2018

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# 1. PROJECT DETAILS

## 1.1. Introduction

At the request of Tom Carmody of Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners, Structerre Consulting Engineers (Structerre) have conducted a Geotechnical Investigation at Muchea Employment Node Precinct 3, Muchea, WA. The purpose of the investigation was to provide the following for industrial purposes:

- Desk top study including a summary of geology, groundwater, site history (obtained from historical photographs) and potential presence of Acid Sulfate Soils (ASS)
- Summary of encountered ground and groundwater conditions
- Site Classification in accordance with AS2870
- Earthquake site factor in accordance with AS1170.4
- Recommendations for stormwater drainage design
- Site preparation requirements (earthworks), including site traffic, excavation, reuse of materials and batter slopes
- Ground bearing capacity and estimated settlements for pad and strip footings founded at 0.5m and 1.0m
- Geotechnical design parameters for retaining structures and or deep foundations
- Preliminary pavement design parameter, indicative California Bearing Ratio (CBR) values determined from penetrometer results and ground conditions encountered

This report details the scope of the geotechnical investigation, presents an interpretation of ground conditions and material properties across the site, provides geotechnical design parameters for the design of the proposed infrastructure, and evaluates the suitability of materials for use in earthworks. Interpretation of site conditions is based on the subsurface lithology revealed during the investigation programme, visual assessments of the in situ materials and the results of in situ field tests.

Terms of reference for this investigation were presented in a Structerre Consulting Engineers proposal reference Q78062 (dated 21 November 2018), which was submitted to and accepted by Muchea Employment Node Precinct 3 Land Owners.

## 1.2. Site Description & Proposed Development

The site is located at Muchea Employment Node Precinct 3, Muchea, Shire of Chittering. Great Northern Highway lies to the east of the site, Brand Highway to the north, Perth To Darwin Highway to the west and rural properties to the south.

The site gently sloping towards the western section. At the time of the field investigation existing industrial/farm buildings occupied the site. The land is largely cleared farmland with some vegetation and trees existing.

We understand that the site is to be used for an industrial development.

### 1.3. Field Investigation – Scope of Works

The field investigation was carried out on 26 and 27 November 2018 and comprised:

- 37 x Sample Retrieval Probe boreholes (BH) to a depth of 2.5m over the site for material assessment and soil profiling;
- 7 x In situ percolation tests to determine the permeability of the materials within the upper 1.0m; and
- 37 x Dynamic Cone Penetrometer (DCP) tests in accordance with AS 1289.6.3.2 (1997) to a depth of 1.0m for evaluation of relative densities of the upper layers.

The borehole, percolation and DCP test locations are shown on the attached site plan in Appendix 1.

A suitability qualified geotechnical personnel from Structerre supervised the fieldwork and all fieldwork, interpretation and terminology used in this report are in accordance with the guidelines presented in AS1726-2017 Geotechnical Site Investigations.

## 2. DESK STUDY

### 2.1. Geological Setting

The Muchea sheet 1: 50,000 Environmental Geology Series (Sheet 2034 I and Part of 2134 IV, 1986) prepared by the Geological Survey of Western Australia indicates that the following geological layer underlies the site:

- Pebbly SILT (Mgs1) – strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin (Guildford Formation Qpa)

### 2.2. Ground Surface and Groundwater Level

The Perth Groundwater Atlas (Waters & Rivers Commission) indicates the ground surface level at this site was approximately 58.0m at southeast to 41.0m at southwest.

Department of Water and Environment Regulation has published minimum groundwater levels for this site.

### 2.3. Acid Sulphate Soils

Information from publicly available Landgate website indicates that the site lies within a zone of no known risk of ASS occurring within 3m of natural surface.

### 2.4. Site History

Historical aerial photographs dating back to 1965 are publicly available through Landgate Map Viewer were assessed and a summary is presented in Table 1.

**Table 1 – Historical Site Information**

| Date | Description |
|---|---|
| 1965 | The site is fully cleared |
| 1977 | Industrial/Farm buildings constructed |
| 2012 | A small portion of the site was cleared being Lot 802 & 803 |
| 2018 | Construction started on the Perth To Darwin Highway to the west of the site |
| 2018 | Site remains relatively unchanged to the current day |

## 3. RESULTS OF THE INVESTIGATION

### 3.1. Subsurface Soil Profile

The subsurface soil profile presented below was determined from the ground conditions encountered within the boreholes and through the interpretation of the DCP test results:

**Table 2 – Subsurface Soil Profile**

| Depth to Base of Strata (m) | Material Description |
|---|---|
| 0.1 | TOPSOIL |
| 0.2 – 1.0 (Ave. 0.5) | NATURAL: SAND/Gravelly SAND (fine to coarse grained), trace silt, loose to very dense |
| Not Penetrated (>2.5m) | NATURAL: Clayey SAND/Sandy CLAY/Clayey GRAVEL (medium to high plasticity), trace gravel, dense to very dense |

The soils encountered are consistent with the expected site conditions as predicted from the Environmental Geology Map. It is important to note that there may be pockets of fill on site that are deeper than that encountered by the investigation boreholes. The subsurface soil conditions encountered are presented in the bore logs, within Appendix 3.

### 3.2. Groundwater

Groundwater was encountered in boreholes BH01, BH02, BH05 and BH12 at an approximate depth of 1.0m below the existing ground level. Groundwater is expected to perch above the impermeable materials.

### 3.3. Percolation Testing

Percolation testing of the in situ soils was undertaken in seven locations. Results of the testing are summarised below:

**Table 3 – In Situ Percolation Test Results**

| Test Location | Testing Depth | Soil Type | Permeability |
|---|---|---|---|
| 1 | 0 - 1.0m | SAND/Clayey SAND | 0.6m/day |
| 2 | 0 – 0.7m | SAND/Clayey SAND | 0.5m/day |
| 3 | 0 - 1.0m | SAND/Clayey SAND | 0.3m/day |
| 4 | 0 - 1.0m | SAND/Clayey SAND | 0.7m/day |
| 5 | 0 – 0.5m | SAND/Gravelly SAND | 1.0m/day |
| 6 | 0 - 1.0m | SAND/Clayey SAND | 1.2m/day |
| 7 | 0 – 0.6m | SAND/Clayey SAND | 0.9m/day |

## 3.4. Laboratory Test Results

Selected representative soil samples were tested by Structerre's in-house NATA accredited laboratory for Atterberg Limits, shrink-swell index, phosphate retention index and soil compaction. The results are attached in Appendix 4, 5 & 6.

### 3.4.1. Atterberg Limits

Atterberg Limits were tested by Structerre's in-house NATA accredited laboratory. Results of the testing are summarised below:

**Table 4 – Atterberg Limit Test Results**

| Sample | Test Hole | Depth (m) | Soil Description | Liquid Limit % AS1289 3.1.2 | Plastic Limit % AS1289 3.2.1 | Plasticity Index % AS1289 3.3.1 | Linear Shrinkage % AS1289 3.4.1 |
|---|---|---|---|---|---|---|---|
| 1 | BH01 | 0.1-1.0 | Sandy CLAY with gravel | 52 | 20 | 32 | 9 |
| 2 | BH07 | 0.7-1.0 | Clayey GRAVEL with sand | 36 | 17 | 19 | 6.5 |
| 3 | BH12 | 0.7-1.3 | Clayey GRAVEL with sand | 34 | 14 | 20 | 7 |
| 4 | BH20 | 0.4-0.9 | Clayey SAND with gravel | 37 | 15 | 22 | 9 |

Test results indicate that the natural clay has moderate shrink swell capacity or degree of expansion.

A copy of the results are presented in Appendix 4.

### 3.4.1. Phosphorus Retention Index

Six samples were submitted to CSBP Soil & Plant Analysis Laboratory for analysis of phosphate retention and calculation of Phosphorus Retention Index (PRI). The results are summarised below, with the certificate provided in Appendix 5.

**Table 5 – Phosphorus Retention Index Results**

| Sample No. | Soil Type | PRI | Classification |
|---|---|---|---|
| BH02_ 0.1-0.4 | SAND | 4.5 | Weakly |
| BH04_ 0.1-0.4 | SAND | 1.8 | Very Weakly |
| BH05_ 0.1-0.4 | Clayey SAND | 185.8 | Very Strongly |
| BH11_ 0.1-0.4 | Sandy GRAVEL | 6.4 | Moderately |
| BH18_ 0.1-0.4 | Sandy GRAVEL | 445.7 | Very Strongly |
| BH23_ 0.1-0.4 | SAND | 1.1 | Very Weakly |

The soil samples tested within the site areas indicate that the soil tested can be described as varying from very weakly to very strongly adsorbing (reference Method for Analysis of Phosphorus in Western Australia Soils, DG Allen & RC Jeffery, March 1990, Chemistry Centre, Agricultural Chemistry Laboratory).

### 3.4.2. California Bearing Ratio (CBR)

Representative samples were tested by Structerre's in-house NATA accredited laboratory in accordance with AS1289.5.2.1 (2003). The test certificates are presented in Appendix 6 and are summarised below.

**Table 5 – CBR Results**

| Test Hole | Depth (m) | Soil Description | Optimum Moisture Content % | Maximum Dry Density t/m3 | CBR @ 2.5mm Penetration (%) | CBR @ 5mm Penetration (%) |
|---|---|---|---|---|---|---|
| BH02 | 0.1 - 0.4 | SAND | 8.5 | 1.95 | 30 | - |
| BH04 | 0.1 - 0.4 | SAND | 10.0 | 1.81 | 18 | - |
| BH11 | 0.1 - 0.4 | Sandy GRAVEL | 7.0 | 2.20 | - | 50 |
| BH05 | 0.2 - 0.6 | SAND | 12.0 | 1.73 | 30 | - |

Based on the above results a conservative soaked CBR of 18% would be recommended for design purposes.

# 4. GEOTECHNICAL CONSTRUCTION CONSIDERATIONS

## 4.1. Site Classification

AS 2870-2011 Residential Slabs and Footings provides guidance on site classification for residential slabs and footing design based on the expected ground surface movement and depth of expected moisture changes.

Although the proposed development falls outside the scope of AS 2870, site classification can be used to assist in the design of foundations. The foundation design should be undertaken by a Structural Engineer, taking into consideration ground bearing capacity and the acceptable total and differential settlements of the proposed foundation system.

Based on results of this investigation the building areas can be classified as an Class “S” provided that all unsuitable materials are removed and replaced with engineer-controlled sand fill materials in accordance with earthwork recommendations outlined in Section 4.3 in this report. The site in its current condition is classified as Class “P”.

## 4.2. Drainage

The existing ground conditions are not suitable for on-site disposal of stormwater runoff through the use of soakwells.

The design of the drainage system, is unknown at this time, but may include:

- Rainwater Tanks;
- Dams / Compensation basin;
- Overland flow paths; and
- Soakwells, if permeable cover and / or design are appropriate.

Sub soil drainage may be required to control groundwater perching in the upper soil layers within the building footprint.

## 4.3. Seismic Site Subsoil Class

The seismic subsoil site class has been assessed in accordance with AS 1170.4-2007, using the results of this investigation and published information.

**Table 6 – Summary of Seismic Parameters**

| Hazard Factor | Site Sub-soil Class |
|---|---|
| 0.1 | Class Ce –shallow soil site |

## 4.4. Earthworks

The building areas can be classified as Class "S", provided that the recommended earthworks are undertaken.

All earthworks shall be undertaken in accordance with AS 3798-2007 Guidelines on Earthworks For Commercial and Residential Developments and are to include the following:

- All unsuitable materials to be stripped and removed from the site. Unsuitable materials include topsoil, deleterious and organic materials.
- It is considered that the near surface loose sand materials require improvement. Therefore, it is proposed to excavate and stockpile the materials for reuse, provided it is dry, free from clay/silt (i.e. <5%), organic and deleterious materials. The depth of excavation may vary depending on conditions encountered (i.e. groundwater) and is subject to inspection.
- Excavations should not exceed 2.0m and / or undermine surrounding structures. A 1V:2H slope should be maintained for temporary excavations. If excavation is required closer than the 1V:2H slope would allow, it is recommended that this office be contacted for retaining design.
- Proof compact the exposed base. The compaction requirements are set out in the table below, as per AS 3798-2007:

**Table 7 – Compaction Requirements**

| Item | Application | Minimum relative compaction, % | |
|---|---|---|---|
| | | Minimum density ratio (Standard Compaction Effort) (Cohesive soils) | Minimum density index (Cohesionless soils) |
| 1 | Residential - lot, fill, house, sites | 95 | 70 |
| 2 | Commercial – fills to support minor loadings, including floor loading of up to 20kPa and isolated pad or strip footings to 100kPa | 98 | 75 |
| 3 | Fill to support pavements<br>a) General fill<br>b) Subgrade (to a depth of 0.3m) | <br>95<br>98 | <br>70<br>75 |

- After excavation and proof compaction, the excavated base is to be inspected and approved by a representative from this office prior to backfilling. At this stage it can be

assessed whether any further materials need to be removed or whether further compaction of the base is required.

- The ground level should be built up to design levels with the stockpiled sand materials and imported fill. If required, the imported fill should consist of free draining sand with not more than 5% passing a 75µm sieve and be free of organic matter and other deleterious materials. The fill sand materials should be placed in layers not exceeding 300mm loose thickness and compacted to achieve the values stated in the table above. As a guide a minimum of 8 PSP blows over the interval 150 – 450mm, 9 PSP blows over the interval 450 – 750mm and 11 PSP blows over the interval 750 – 1050mm should be achieved, however its is recommended that this be verified with appropriate laboratory testing.
- A minimum of 0.6m of sand cover is required to be maintained above the reactive material in order to achieve a Class "S".
- After remedial earthworks have been completed, the earthworks should be inspected and approved by a representative from this office.

It is considered that standard small to medium sized earthmoving equipment would be appropriate for the proposed development. The near surface ground was generally competent and should not pose an issue to site traffic movements.

The material encountered on site can be deemed as 'easy' to excavate with medium sized earthwork equipment (i.e. a 20t excavator). Should excavations be required below groundwater level, dewatering will be necessary.

### 4.5. Geotechnical Design Parameters

Based on the on site observations and the DCP results, the interpreted geotechnical soil parameters of the encountered materials are presented in Table 9:

**Table 8 – Soil Parameters**

| Soil Type | Depths (m) | Friction Angle Ø' ($^0$) | Cohesion c' (kPa) | Density Y (t/m$^3$) | Elastic Modulus E (MPa) |
|---|---|---|---|---|---|
| FILL: SAND to silty SAND | 0 – 0.6 | 32 | 0 | 1.85 | 15 |
| Clayey SAND to Sandy CLAY | 0.6 – 2.5 | 32 | 20 | 1.80 | 20 |

## 4.6. Shallow Footings – Allowable Soil Bearing Capacities

Based on the findings of the current preliminary geotechnical investigation, shallow pad and strip footings are considered appropriate for the proposed development. Allowable bearing capacities for shallow footings at the site have been calculated under the following assumptions:

- The site preparation procedures specified in Section 4.4 have been carried out;
- The specified level of compaction has been achieved below the base of each footing;
- Loads are vertical and not eccentric;
- Isolated footings (i.e. interaction of foundations has not been considered);
- The foundations are flexible;
- A factor of safety (FoS) of 3.0 against bearing capacity failure;
- Maximum allowable settlement of 20mm.

The tables below present the allowable bearing pressures for pad and strip footings of various dimensions, with embedment depths of 0.5m and 1.0m below finished surface levels.

**Table 9 – Allowable Bearing Capacities for Pad Footings**

| Minimum Depth of Embedment (m) | Minimum Plan Dimension (m) | Allowable Bearing Capacities (kPa) | Settlement (mm) |
|---|---|---|---|
| 0.5 | 0.5 | 140 | < 20 |
| | 1.0 | 155 | |
| | 1.5 | 165 | |
| | 2.0 | 140 | |
| 1.0 | 0.5 | 245 | < 20 |
| | 1.0 | 250 | |
| | 1.5 | 190 | |
| | 2.0 | 160 | |

* Note: it is recommended to limit these values to 250kPa.

**Table 10 – Allowable Bearing Capacities for Strip Footings**

| Minimum Depth of Embedment (m) | Minimum Plan Dimension (m) | Allowable Bearing Capacities (kPa) | Settlement (mm) |
|---|---|---|---|
| 0.5 | 0.5 | 115 | < 20 |
| | 1.0 | 135 | |
| | 1.5 | 150 | |
| 1.0 | 0.5 | 160 | < 20 |
| | 1.0 | 180 | |
| | 1.5 | 200 | |

The recommended allowable bearing capacities are dependent on the site being dry and well drained, so that the foundation material does not become saturated.

The actual allowable bearing capacity of a particular foundation will be dependent on its location, geometry and founding depth, as well as the founding horizon. Therefore, once specific foundation geometries have been determined and the earthworks completed, it is recommended that the allowable bearing capacity and associated settlements be verified.

Additionally, should undermining issue prevent the excavation of the near surface loose materials, it is recommended that the allowable bearing capacity be reviewed. However, this will likely result in lower allowable bearing capacities.

## 5. CONCLUSIONS

A site investigation was carried out at the proposed commercial development site to assess the geotechnical conditions. Parameter and design recommendations are incorporated in the body of the report. The following conclusions have been drawn from the site investigation:

- The subsurface soil profile encountered comprised of topsoil to 0.1m, loose to dense sand / gravelly sand / sandy gravel from the surface to 1.0m, underlain by clayey sand/sandy clay to the investigated depth of 2.5m.
- The water table was encountered at the approximately 1.0m below the existing surface in boreholes BH01, BH02, BH05 and BH12.
- The building areas can be classified as a Class “S” in accordance with AS 2870-2011 provided the recommended earthworks are undertaken.
- It is considered that the site is not suitable for on-site drainage.
- Recommended earthworks for the building areas, include stripping of fill sand and unsuitable materials, excavation of loose materials, proof compaction of the base, placement of engineered fill and compaction of final level.
- Allowable bearing capacity for pad footings range from 140kPa to 250kPa and from 115kPa to 200kPa for strip footings. The estimation of settlement of the footings is limited to 20mm.

## 6. LIMITATION OF FIELD INVESTIGATIONS

This report has been prepared in accordance with generally accepted consulting practice for Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners using information supplied at the time and for the project specific requirements as understood by Structerre. To the best of our knowledge the information contained in this report is accurate at the date of issue, however it should be emphasised that any changes to ground conditions and/or the proposed structures may invalidate the recommendations given herein.

The conclusions and recommendations in this report are based on the site conditions revealed through selective point sampling, representing the conditions of the site in total, although the area investigated represents only a small portion of the site. The actual characteristics may vary significantly between successive test locations and sample intervals other than where observations, explorations and investigations have been made.

The materials and their geotechnical properties presented in this report may not represent the full range of materials and strengths that actually exist on site and the recommendations should be regarded as preliminary in nature. Allowances should be made for variability in ground conditions and any consequent impact on the development. Structerre accepts no responsibility and shall not be liable for any consequence of variations in ground conditions.

If ground conditions encountered during construction are different to that described in this report, this office should be notified immediately.

For and behalf of

STRUCTERRE CONSULTING ENGINEERS

Author: David Harding
Title: Geotechnical Supervisor

Checked By: Daniel Smith
Title: Geotechnical Engineer
Credentials: BEng Civil, MIEAust, AGS

Disclaimer
This report is at the request of the addressee and no liability is accepted by Structerre Consulting Engineers to any third person reading or relying upon the report, not withstanding any rule of law and/or equity to the contrary and that this report is strictly confidential and intended to be read and relied upon only be the addressee.

| Job # | Revision | Authored | Checked | Authorised |
|---|---|---|---|---|
| J315642 | 0 | DO | DAS | MEC |
| J315642 | 1 | DO | DAS | MEC |

## 7. REFERENCES

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Geological Survey of Western Australia 1:50,000 Environmental Geology Series

AS 1170.4-2007 Structural design actions – Earthquake actions in Australia

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AS 1289.3.2.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the plastic limit of a soil

AS 1289.3.3.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Calculation of the plasticity index of a soil

AS 1289.3.4.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the linear shrinkage of a soil

AS 1289.5.2.1-2009 Soil compaction and density tests – Soil classification tests – Determination of the dry density/moisture content relation of a soil using modified compactive effort

AS 1289.6.1.1-2009 Soil strength and consolidation tests – Soil classification tests – Determination of the California Bearing Ratio of a soil

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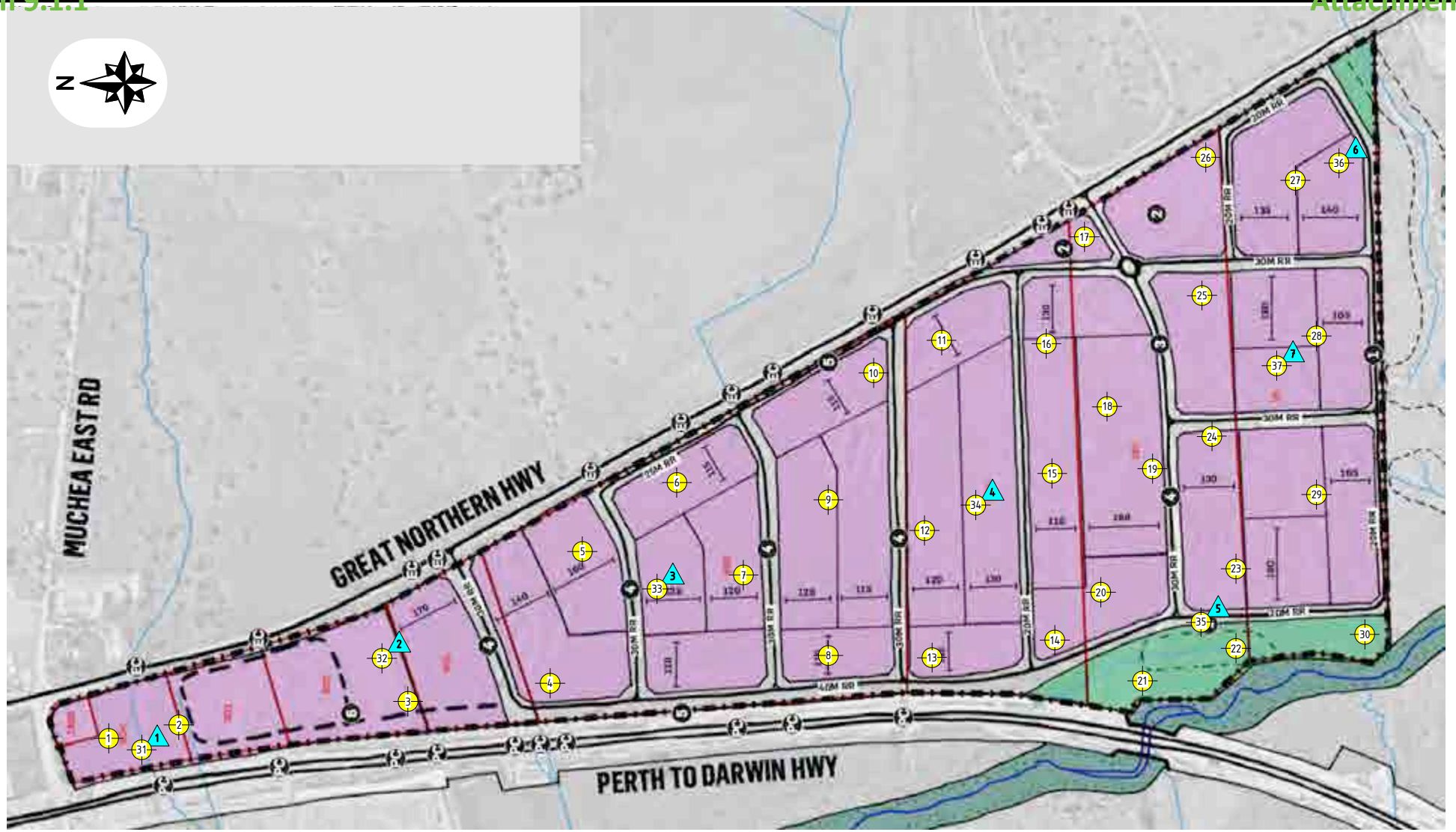
AS 1726-2017 Geotechnical site investigation

AS 2870-2011 Residential slabs and footings

AS 3798-2007 Guidelines on earthworks for commercial and residential developments

AS 4055-2012 Wind loads for housing

# APPENDIX 1 – SITE LOCATION MAP




Note: Showing approximate test locations only

**LEGEND**

BH: Borehole

PERC: Percolation Test

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| | |
|---|---|
| PROJECT: | Muchea Employment Node - Precinct 3 - Muchea |
| PROJECT #: | D206263 |
| JOB #: | J315642 |
| CLIENT: | **Muchea Employment Node Precinct 3 Land Owners** |
| SCALE: | NTS |
| TITLE: | Geotechnical Investigation Site Plan |
| DATE: | 26 Nov '18 |
| DRAWN BY: | MM |
| CHECKED BY: | DH |

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# APPENDIX 2 – SITE PHOTOS

PHOTO 1

PHOTO 2

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Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

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PROJECT #: D206263

JOB #: J315642

CLIENT: **Muchea Employment Node Precinct 3 Land Owners**

SCALE: NTS

TITLE: Site Photographs

DATE: 26 Nov '18

DRAWN BY: MM

CHECKED BY: DH

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PHOTO 3 - Sample taken BH1

PHOTO 4 - Sample taken BH28

| | | |
|---|---|---|
| STRUCterre consulting engineers | PROJECT: Muchea Employment Node - Precinct 3 - Muchea | |
| | PROJECT #: D206263 | CLIENT: **Muchea Employment Node Precinct 3 Land Owners** |
| | JOB #: J315642 | |
| Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers<br>1 ERINDALE ROAD, BALCATTA, WA 6021<br>TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au | SCALE: NTS | TITLE: Site Photographs |
| | DATE: 26 Nov '18 | DRAWN BY: MM / CHECKED BY: DH |

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# APPENDIX 3 – BORELOGS

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH01**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404631 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6505901 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | 0.1 - 1.0 | B | D to M | |
| | | CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, grey (Guildford Formation) | | | | | | |
| | | *mottled grey/brown* | St-VSt | | | | M | |
| 1 | | | | | | | | |
| | | | | | | | S | |
| | | *trace gravel* | | | 1.8 - 2.3 | B | | |
| 2 | | | | | | | | |
| | | Terminated at 2.30 m | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH02**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404659 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6505814 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace clay, grey/brown (Guildford Formation) | L | | | | D to M | |
| | | | MD - D | | | | | |
| | | | L | | | | M | ▼ |
| 1 | | SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown | | | | | S | |
| 2 | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | | | | | |
| | | Terminated at 2.50 m | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH03**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404781 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6505225 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation) | L | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | MD | | | | | |
| | | | D - VD | | | | | |
| 1 | | | | | | | M | |
| | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | | | | | |
| | | Terminated at 1.90 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH04**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404762 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504830 |

| Depth | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|
| | Topsoil: | D | | | | D to M | |
| | SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation) | L - MD | | | | | |
| | SP: Gravelly SAND: coarse grained, non-plastic, trace silt, mottled red/brown | | | | | | |
| 1 | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled red/brown | | | | | M | |
| | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | | | | | |
| | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH05**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405086 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504857 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | 0.1 - 1.0 | B | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey (Guildford Formation) | L | | | | M | |
| | | *brown* | | | | | | |
| 1 | | | D - VD | | | | W | ▼ |
| | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | | | | S | |
| 2 | | | | | | | | |
| | | Terminated at 2.50 m | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH06**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405259 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504622 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown (Guildford Formation) | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | D - VD | | | | D to M | |
| 1 | | | | | | | | |
| | | Terminated at 1.30 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH07**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404994 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504472 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | D - VD | | 0.5 - 1.0 | B | D to M | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown | | | | | | |
| | | GC: Clayey GRAVEL: medium to coarse grained, medium plasticity, with sand, mottled red/brown | | | | | | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH08**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404755 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504337 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | L | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, low plasticity, with clay, red/brown | D - VD | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | | | | | | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH09**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405126 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504288 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | D - VD | | | | D to M | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, medium plasticity, with clay, mottled grey/brown | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | | | | | | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH10**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405415 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504305 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil: | L | | | | D | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown | D - VD | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | | |
| | | Terminated at 0.70 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH11**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405519 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504153 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil: | L | | | | D | |
| | | GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation) | D - VD | | | | | |
| | | *brown* | | | | | | |
| | | Terminated at 0.60 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH12**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405023 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504163 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation) | L - MD | | | | D | |
| | | *brown* | | | | | | |
| | | GC: Clayey GRAVEL: medium to coarse grained, low plasticity, with sand, brown | MD - D | | 0.7 - 1.3 | B | D to M | ▼ |
| 1 | | | | | | | S | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH13**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404781 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504129 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | VL | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | MD | | | | D to M | |
| | | | VD | | | | | |
| 1 | | SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown | | | | | M | |
| | | SM: Silty SAND: fine to medium grained, grey/brown | | | | | | |
| | | Terminated at 1.10 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH14**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404762 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503876 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace clay, grey (Guildford Formation) | D | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, grey/brown | | | | | M | |
| | | SM: Silty SAND: fine to medium grained, grey/brown | | | | | | |
| | | Terminated at 0.60 m | VD | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH15**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405114 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503886 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | *brown* | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH16**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405541 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503958 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | Terminated at 1.10 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH17**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405694 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503838 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH18**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405441 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503828 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | 0.5 - 1.0 | B | M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH19**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405139 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503673 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | D - VD | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.20 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH20**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404895 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503792 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey | L - MD | | 0.4 - 0.9 | B | | |
| 1 | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, red/brown | St | | 0.9 - 1.4 | B | M | |
| | | Terminated at 1.40 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH21**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404757 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503652 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | VL | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | D | | | | | |
| | | GP: Sandy GRAVEL: medium to coarse grained, non-plastic to low plasticity, with silt, trace clay, brown | VD | | | | W | |
| | | Terminated at 0.90 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH22**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404782 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503525 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown | | | | | | |
| | | Terminated at 0.50 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH23**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404883 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503505 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey<br>(Guildford Formation) | L - MD | | | | D to M | |
| | | *pale brown* | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown | D - VD | | | | M | |
| 1 | | GP: Sandy GRAVEL: medium to course grained, low to medium plasticity, with clay, grey/brown | | | | | | |
| | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH24**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405259 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503609 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | D - VD | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, trace silt, pale brown | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH25**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405659 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503544 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | *mottled red/brown* | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.20 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH26**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405858 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503568 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, mottled red/brown (Guildford Formation) | VD | | | | | |
| | | *trace clay,* | | | | | D to M | |
| | | Terminated at 0.70 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH27**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405874 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503343 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | *trace clay, mottled grey/brown* | VD | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | D to M | |
| 1 | | CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, brown | | | | | M | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH28**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405419 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503299 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown | | | | | | |
| | | Terminated at 0.60 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH29**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405018 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503272 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | L - MD | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, grey | D - VD | | | | M | |
| | | SP: Silty SAND: fine to medium grained, grey/brown | | | | | D | |
| | | Terminated at 0.80 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH30**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404849 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503206 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | D | | 0.6 - 1.0 | B | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, grey | MD | | | | | |
| | | | VD | | | | M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH31**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Hand Auger | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, with silt, trace gravel, brown (Guildford Formation) | MD - D | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown | L - MD | | | | D to M | |
| 1 | | Terminated at 1.00 m | D | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH32**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Hand Auger | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace gravel, trace organic material (fine roots), grey/brown (Guildford Formation) | MD - D | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown | | | | | | |
| | | Terminated at 0.70 m | VD | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH33**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Hand Auger | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, trace gravel, grey/brown (Guildford Formation) | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown | D - VD | | | | D to M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH34**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, grey/brown (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown | | | | | D to M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH35**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown | | | | | | |
| | | Terminated at 0.50 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH36**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | | |
| | | SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, pale grey/brown (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, brown | | | | | D to M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH37**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown | | | | | | |
| | | Terminated at 0.60 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

# APPENDIX 4 – LABORATORY TEST RESULTS

| | | | |
|---|---|---|---|
| **Sample No.** | **32126** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3, Muchea |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 1 0.1-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 52 |
| Plastic Limit | AS 1289.3.2.1 | 20 |
| Plasticity Index | AS 1289.3.3.1 | 32 |
| Linear Shrinkage | AS 1289.3.4.1 | 9 |
| Nature of Shrinkage | | Flat |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 98 |
| 2.36 | 73 |
| 0.425 | 59 |
| 0.075 | 42 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Sandy CLAY with gravel
**AS Group Symbol:** CH or OH

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STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

**Date:** 07-Dec-18

Soils Analysis Workbook V 3.15 22-Nov-18

AS 1289.3.6.1 Report Feb 18



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| | | | |
|---|---|---|---|
| **Sample No.** | **32127** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 7 0.7-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 36 |
| Plastic Limit | AS 1289.3.2.1 | 17 |
| Plasticity Index | AS 1289.3.3.1 | 19 |
| Linear Shrinkage | AS 1289.3.4.1 | 6.5 |
| Nature of Shrinkage | | Flat |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 88 |
| 2.36 | 59 |
| 0.425 | 52 |
| 0.075 | 33 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Clayey GRAVEL with sand
**AS Group Symbol:** GC

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Wayne Rozmianiec
Laboratory Manager

**Date:** 07-Dec-18

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| | | | |
|---|---|---|---|
| **Sample No.** | **32128** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 12 0.7-1.3m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 34 |
| Plastic Limit | AS 1289.3.2.1 | 14 |
| Plasticity Index | AS 1289.3.3.1 | 20 |
| Linear Shrinkage | AS 1289.3.4.1 | 7 |
| Nature of Shrinkage | | Flat |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 100 |
| 2.36 | 56 |
| 0.425 | 50 |
| 0.075 | 33 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Clayey GRAVEL with sand
**AS Group Symbol:** GC

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Wayne Rozmianiec
Laboratory Manager

**Date:** 10-Dec-18



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| | | | |
|---|---|---|---|
| **Sample No.** | **32129** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 20 0.4-0.9m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 37 |
| Plastic Limit | AS 1289.3.2.1 | 15 |
| Plasticity Index | AS 1289.3.3.1 | 22 |
| Linear Shrinkage | AS 1289.3.4.1 | 9 |
| Nature of Shrinkage | | Cracked |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 100 |
| 2.36 | 71 |
| 0.425 | 62 |
| 0.075 | 33 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Clayey SAND with gravel
**AS Group Symbol:** SC

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Laboratory Manager

**Date:** 10-Dec-18

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# APPENDIX 5 – PRI TEST RESULTS

# Analysis Results

CSBP Soil and Plant Laboratory



88282
Structerre Consulting Engineers

| | Lab No | 5IS18042 | 5IS18043 | 5IS18044 | 5IS18045 | 5IS18046 | 5IS18047 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | Name | BH2_0.1-0.4M | BH4_0.1-0.4M | BH5_0.1-0.4M | BH11_0.1-0.4M | BH18_0.1-0.4M | BH23_0.1-0.4M |
| | Code | J315642 | J315642 | J315642 | J315642 | J315642 | J315642 |
| | Customer | Structerre | Structerre | Structerre | Structerre | Structerre | Structerre |
| | Depth | 0-10 | 0-10 | 0-10 | 0-10 | 0-10 | 0-10 |
| Phosphorus Retention Index | | 4.5 | 1.8 | 185.8 | 6.4 | 445.7 | 1.1 |

CSBP Lab. Extract Value.

# APPENDIX 6 – CBR RESULTS

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# Material Test Certificate

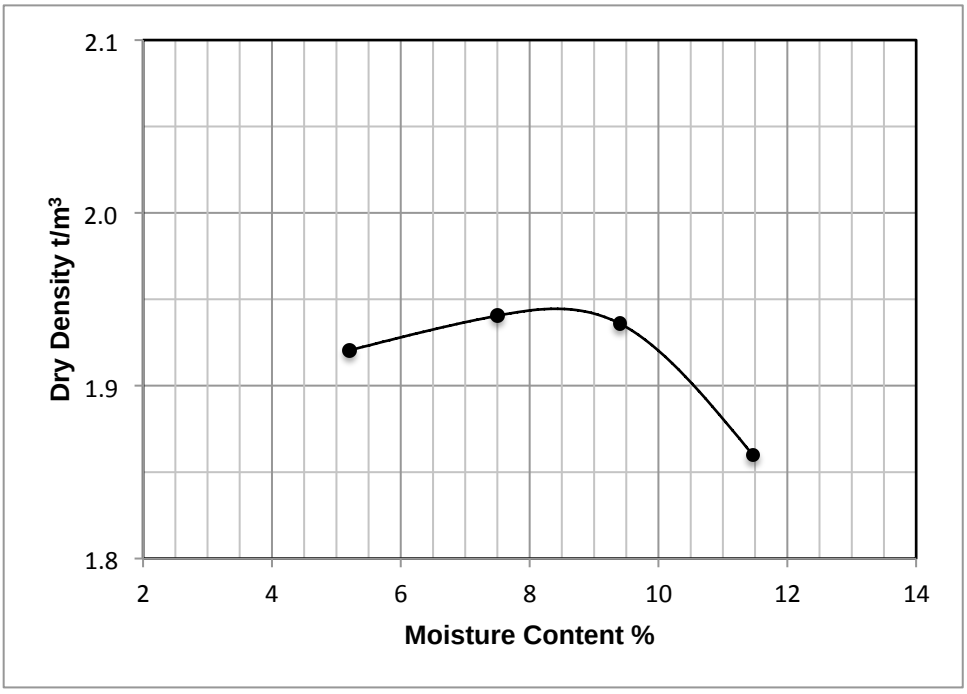
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH2_0.1-0.4m | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-1 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 1.94 | **Optimum Moisture Content %** | 8.5 |
| **% Retained 19mm Sieve** | 0 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |




**Notes:**

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**Approved Signatory:** Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

MDD Report AS 1289.5.2.1 R Rev. 3.0 Jan-18

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# Material Test Certificate

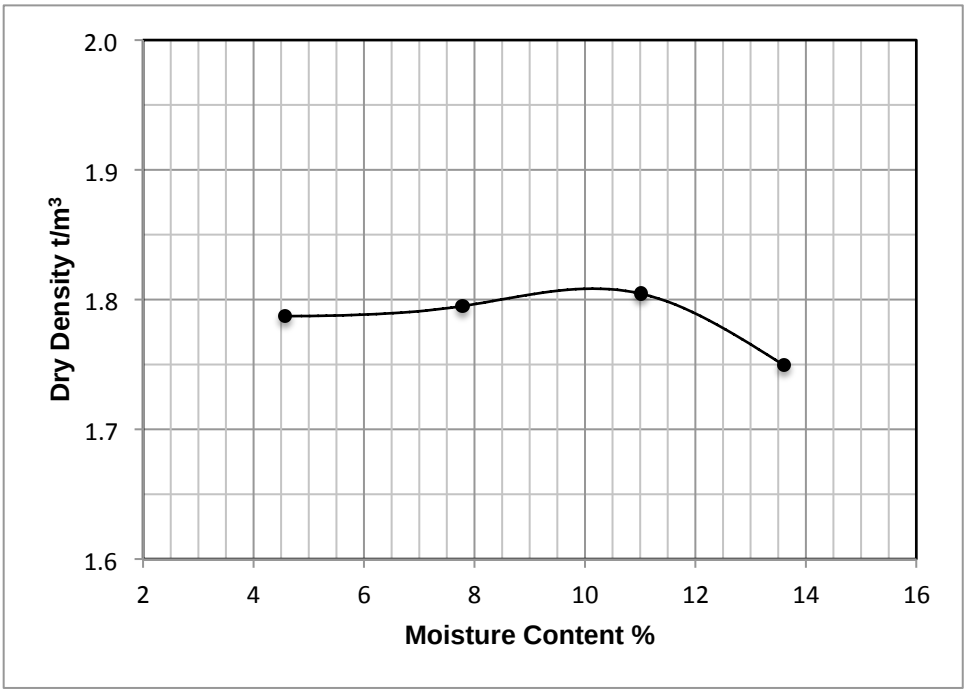
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH4_0.1-0.4m | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-2 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 1.81 | **Optimum Moisture Content %** | 10.0 |
| **% Retained 19mm Sieve** | 0 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |

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**Approved Signatory:** Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

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# Material Test Certificate

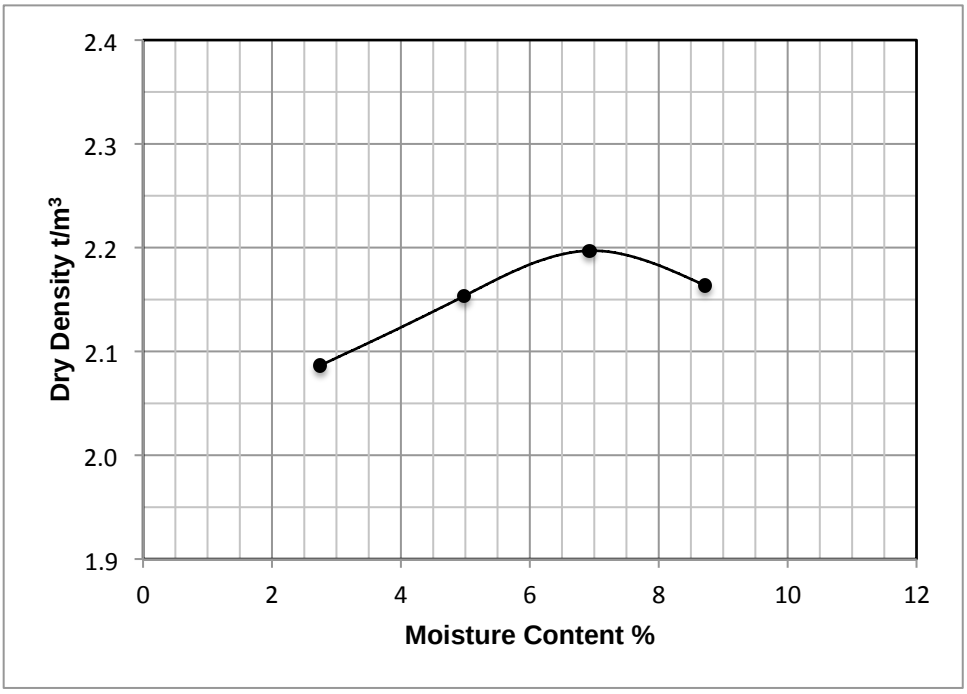
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH11_0.1-0.4 | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-3 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 2.20 | **Optimum Moisture Content %** | 7.0 |
| **% Retained 19mm Sieve** | 1 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |




**Notes:**

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ACCREDITATION NUMBER 18742

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

MDD Report AS 1289.5.2.1 R Rev. 3.0 Jan-18

STRUCterre consulting

# Material Test Certificate

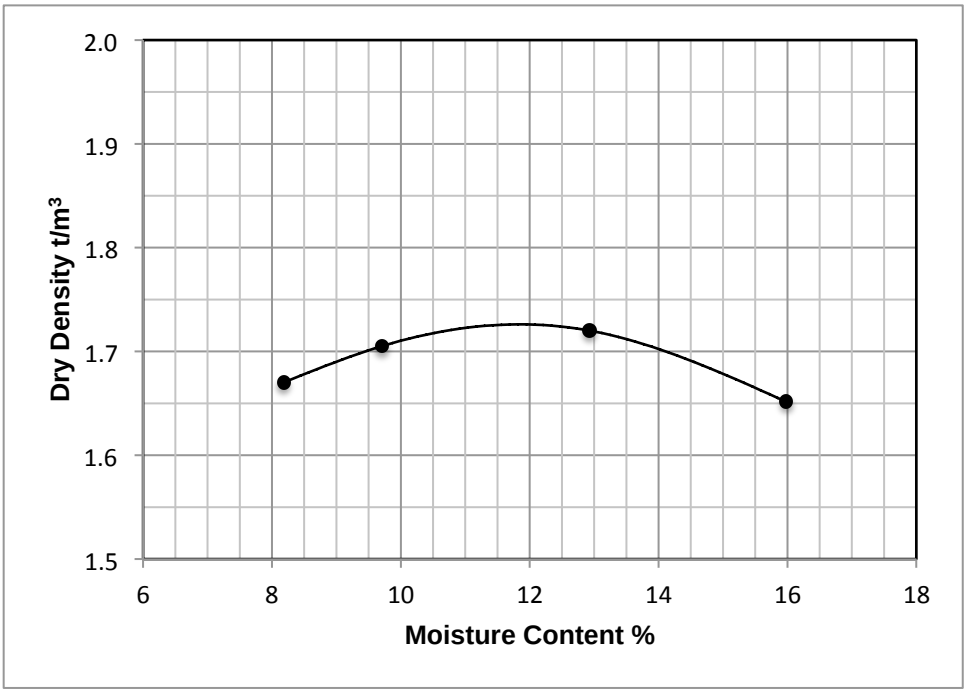
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH23_0.1-0.4m | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-4 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 1.73 | **Optimum Moisture Content %** | 12.0 |
| **% Retained 19mm Sieve** | 0 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |




**Notes:**

NATA Accredited for compliance with ISO/IEC 17025 — testing

STRUCTERRE CONSULTING ENGINEERS
BALCATTA LABORATORY
ACCREDITATION NUMBER 18742

**Approved Signatory:**
Laboratory Manager

Wayne Rozmianiec

Date: 5 Dec 2018

MDD Report

AS 1289.5.2.1 R Rev. 3.0 Jan-18

STRUCterre consulting

# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH2_0.1-0.4m | **Date Tested:** | 30 Nov 2018 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-1 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 1.95 |
| Optimum moisture content | % | 8.5 |
| Moisture content at compaction | % | 8.0 |
| Laboratory density ratio | % | 95.0 |
| Laboratory moisture ratio | % | 95.0 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 0 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 1.85 |

**Penetration**

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 12.1 |
| Moisture content of remainder | % | 11.7 |
| California Bearing Ratio | % | 30 |
| Penetration | mm | 2.5 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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STRUCterre consulting

# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH4_0.1-0.4m | **Date Tested:** | 30 Nov 2018 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-2 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 1.81 |
| Optimum moisture content | % | 10.0 |
| Moisture content at compaction | % | 9.7 |
| Laboratory density ratio | % | 95.5 |
| Laboratory moisture ratio | % | 96.0 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 0 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 1.73 |

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 15.3 |
| Moisture content of remainder | % | 34.0 |
| California Bearing Ratio | % | 18 |
| Penetration | mm | 2.5 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH11_0.1-0.4m | **Date Tested:** | 30-Nov-18 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-3 |
| **Material Type:** | Sandy Gravel | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 2.20 |
| Optimum moisture content | % | 7.0 |
| Moisture content at compaction | % | 6.8 |
| Laboratory density ratio | % | 94.5 |
| Laboratory moisture ratio | % | 97.5 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 1 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 2.08 |

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 10.3 |
| Moisture content of remainder | % | 9.8 |
| California Bearing Ratio | % | 50 |
| Penetration | mm | 5.0 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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STRUCterre consulting

# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH23_0.1-0.4m | **Date Tested:** | 30 Nov 2018 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-4 |
| **Material Type:** | Sandy Gravel | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 1.73 |
| Optimum moisture content | % | 12.0 |
| Moisture content at compaction | % | 11.7 |
| Laboratory density ratio | % | 95.0 |
| Laboratory moisture ratio | % | 98.5 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 0 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 1.64 |

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 18.7 |
| Moisture content of remainder | % | 18.0 |
| California Bearing Ratio | % | 30 |
| Penetration | mm | 2.5 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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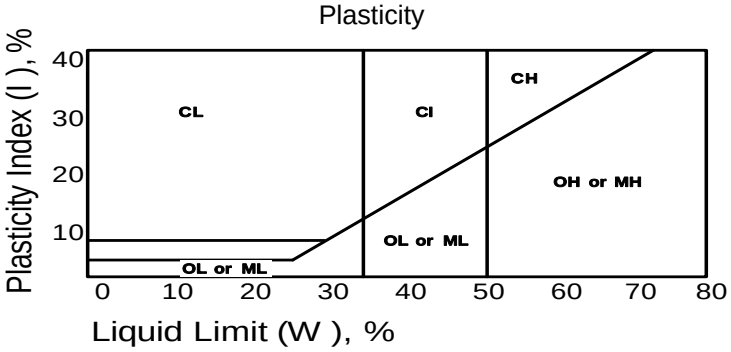
# APPENDIX 7 – BORELOG TERMINOLOGY

# BORELOG TERMINOLOGY

## Particle Size Distribution

| Major Division | Subdivision | Size |
|---|---|---|
| Boulders | | >200mm |
| Cobbles | | 200 - 63mm |
| Gravel | Coarse | 63 - 20mm |
| | Medium | 20- 6mm |
| | Fine | 6 - 2.36mm |
| Sand | Coarse | 2.36 - 0.6mm |
| | Medium | 0.6 - 0.2mm |
| | Fine | 0.2 - 0.075mm |

## Plasticity




## Consistency of Cohesive Soils

| Term | Undrained Strength Su (kPa) | Field Guide |
|---|---|---|
| Very Soft | < 12 | Exudes between the fingers when squeezed in hand |
| Soft | 12 - 25 | Can be moulded by light finger pressure |
| Firm | 25 - 50 | Can be moulded by strong finger pressure |
| Stiff | 50 - 100 | Cannot be moulded by Fingers. Can be indented by thumb. |
| Very Stiff | 100 - 200 | Can be indented by thumb nail |
| Hard | > 200 | Can be indented with difficulty by thumb nail. |
| Friable | - | Crumbles or powders when scraped by thumbnail |

## Consistency/Density of Non-Cohesive Soils

| Term | Density Index (%) | SPT "N" Value Comparison |
|---|---|---|
| Very Loose | < 15 | 0 - 4 |
| Loose | 15 - 35 | 4 - 10 |
| Medium Dense | 35 - 65 | 10 - 30 |
| Dense | 65 - 85 | 30 - 50 |
| Very Dense | > 85 | > 50 |

## Moisture Content

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| S | Saturated |

## Minor Components

| Term | Assessment Guide | Proportion of Minor Component In: |
|---|---|---|
| Trace | Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component | Coarse grained soils: < 5 %<br>Fine grained soils: <15% |
| With | Presence easily detected by feel or eye, soil properties little different to general properties of primary component | Coarse grained soils: 5 - 12 %<br>Fine grained soils: 15 - 30% |

## Soil Legend

| | | | |
|---|---|---|---|
| FILL | CLAY | GRAVEL | CONCRETE |
| TOPSOIL | SILT | LIMESTONE | COMBINATIONS |
| PEAT | SAND | BEDROCK | eg: Clay, Silty, Sandy |

## USCS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GW | Well graded gravel | SC | Clayey sand | OL | Organic low plasticity silt | CL | Low plasticity clay |
| GP | Poorly graded gravel | SM | Silty sand | ML | Low plasticity silt | CI | Intermediate plasticity clay |
| SW | Well graded sand | | | MH | High plasticity silt | CH | High plasticity clay |
| SP | Poorly graded sand | | | OH | Organic high plasticity silt | PT | Peat |

DOC:GE:3.003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# Appendix E

## Floodway Modelling Report

# MEMORANDUM

| Project: | Muchea Employment Node P3 Waterways | | | Project No: | P18311 |
|---|---|---|---|---|---|
| To: | Copy: | Name: | Organisation: | Facsimile: | |
| ☒ | ☐ | Phil Bayley | Bayley Environmental Services | | |
| ☒ | ☐ | Tom Carmody | Tomahawk Property | | |
| ☐ | ☐ | | | | |
| From: | Brett Stinton | | Date: 25 January 2019 | Total Pages: | 9 |

| Subject: | Muchea Employment Node P3 – Floodway Definition |
|---|---|

If you do not receive all pages, or some are unclear, please advise immediately

BG&E Pty Limited (BG&E) has been engaged by the Muchea Employment Node Precinct 3 Landowners Group to carry out a waterways assessment for Ellen Brook to inform the development of the Muchea Employment Node Precinct 3.

As part of the Northlink Stage 3 project, BG&E prepared a TUFLOW hydraulic model for the new Perth to Darwin National Highway (PDNH) bridge which crosses Ellen Brook. This model has been utilised and updated to incorporate the boundary of the concept plan for the Muchea Employment Node Precinct prepared by Urbis. The southern section of the development layout is directly adjacent to the Ellen Brook floodplain where public open space and drainage reserve areas are proposed.

## SCOPE

The following scope of works was carried out:

1. Review modelling assumptions in accordance with 2016 edition of Australian Rainfall and Runoff
2. Simulate 1 in 100 annual exceedance probability (AEP) event under current day scenario (including new PDNH)
3. Preliminary definition of floodway based on review of hydraulic model results (depths, velocities etc)
4. Meet with representatives from DWER and Main Roads WA to discuss the project and agree on allowable backwater criteria
5. Update hydraulic model to include earthworks up to the preliminary floodway and review 1 in 100 AEP backwater
6. Refine the floodway and update the hydraulic model with revised earthworks extents to achieve suitable backwater (up to 5 post-development iterations have been assumed)
7. Prepare a memo report summarising the methodology and findings of the project, including polygons for floodway and flood fringe areas similar to those provided by DWER for other areas within Ellen Brook.

The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.

## TUFLOW MODEL

The TUFLOW 2D hydraulic has been updated to include the outline of the proposed development that lies within the flood extents of the Ellen Brook flood plain and other scenarios where the boundary encroaches further toward the main Ellen Brook channel.

## MEETING WITH MAIN ROADS AND DWER

A meeting was held on 15th January 2019 with Simon Rodgers (Supervising Engineer - Floodplain Management) from the Department of Water and Environmental Regulation (DWER) and Eric Cheung (Senior Waterways Engineer) from Main Roads WA, to discuss any potential impacts the development may have. Preliminary results showing the impact on flood levels were tabled. The DWER representative indicated that the impacts were not of concern from a DWER perspective. The Main Roads WA representative was concerned of any potential impacts to the recently constructed PDNH alignment that passes adjacent to the proposed development.

## FLOODWAY DEFINITION

The Department of Water and Environmental Regulation (DWER) define the Floodway as *"the river channel and a portion of the floodplain where a significant flow or storage of water occurs during floods. If the floodway is even partially blocked then the natural flooding regime of the area may be detrimentally impacted with flood levels being raised and affecting areas which may not have been previously affected"*.

The following items were considered when defining the floodway:

- 1% AEP pre-development velocity and depth mapping (attached) used to identify areas where higher depths and velocities occur which provide an indication of flood conveyance
- The presence of existing flowpaths within the floodplain which includes the main channel and breakout channel downstream of the PDNH culvert crossing to the north of the bridge. These flowpaths should be maintained to avoid redistribution of flow
- Potential impacts to flood levels as a result of partially blocking the floodplain, based on the hydraulic model results
- The floodway extent adopted by DWER for Ellen Brook to the south of the site. Shapefiles were provided by DWER which show the floodway extending to the edge of the floodplain in some areas. Flood behaviour in the northern section of the dataset is expected to be similar to that within the project site (Figure 1).

Refer to attached plots for 1% AEP pre-development and post-development flood extents. These include the proposed floodway and flood fringe extents. The proposed development footprint is close to but does not encroach into the floodway. The results indicate a maximum increase in flood level of approximately 30 mm near the proposed road, reducing to approximately 10mm at the PDNH PSP.

Scenarios where the earthworks footprint encroaches further into the floodway with offsets ranging from 20m to 80m were also simulated in the hydraulic model to assess potential impacts on the adjacent PDNH. The results indicate an increase in flood levels along the PDNH alignment varying between 40mm for a 40m offset to 90mm for an 80m offset.

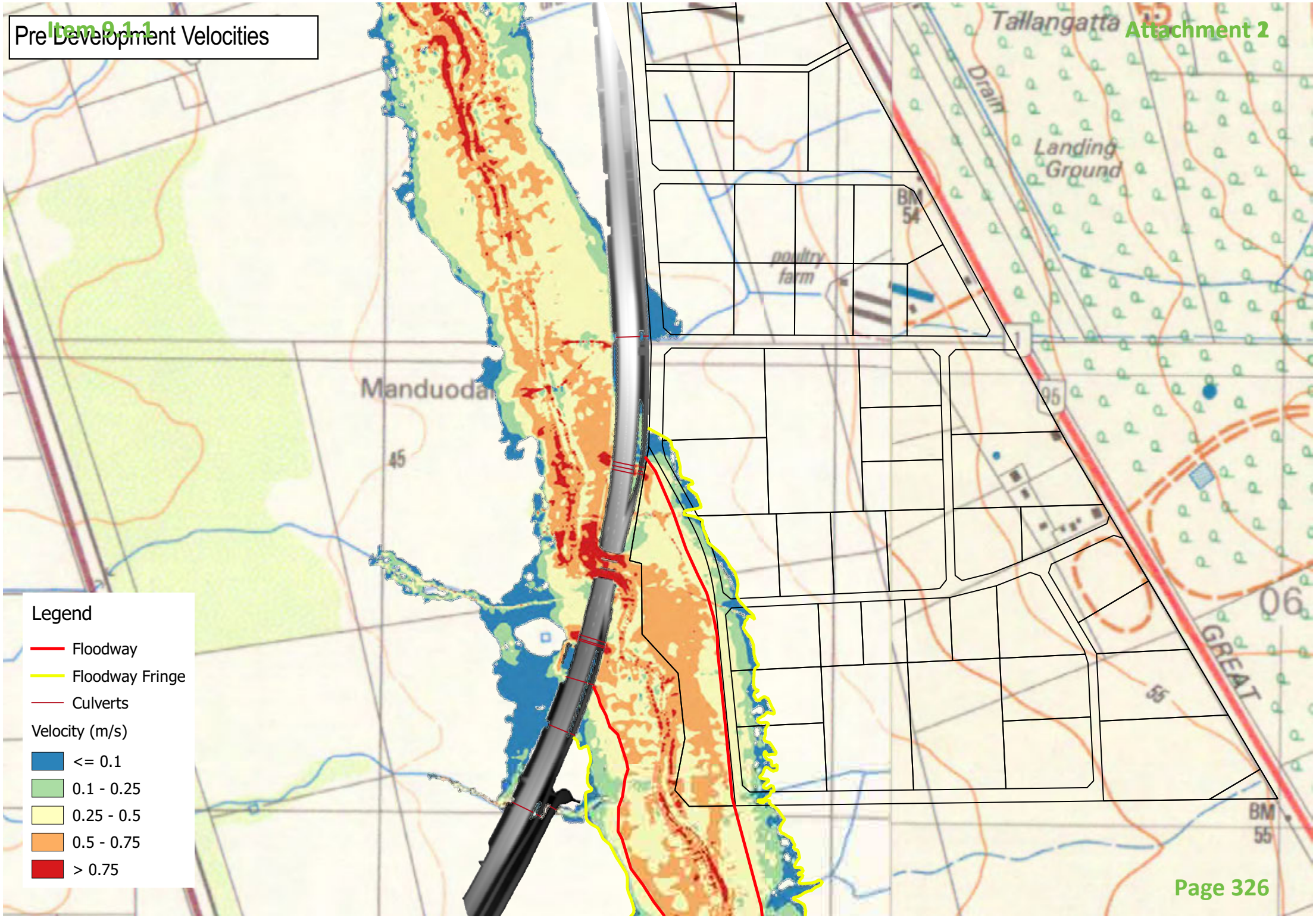
**Figure 1 – Downstream floodway definition by DWER**

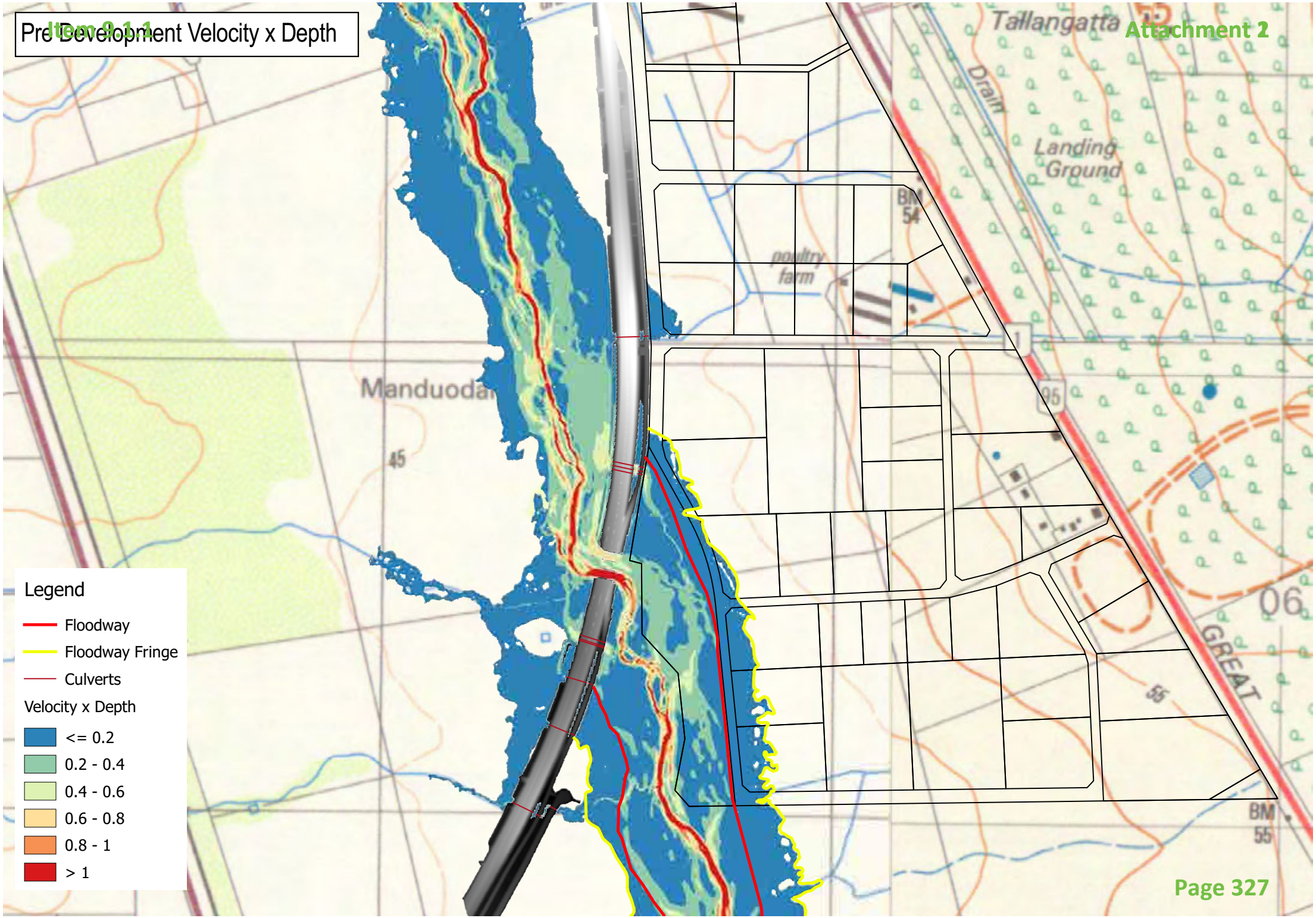
## LIMITATIONS

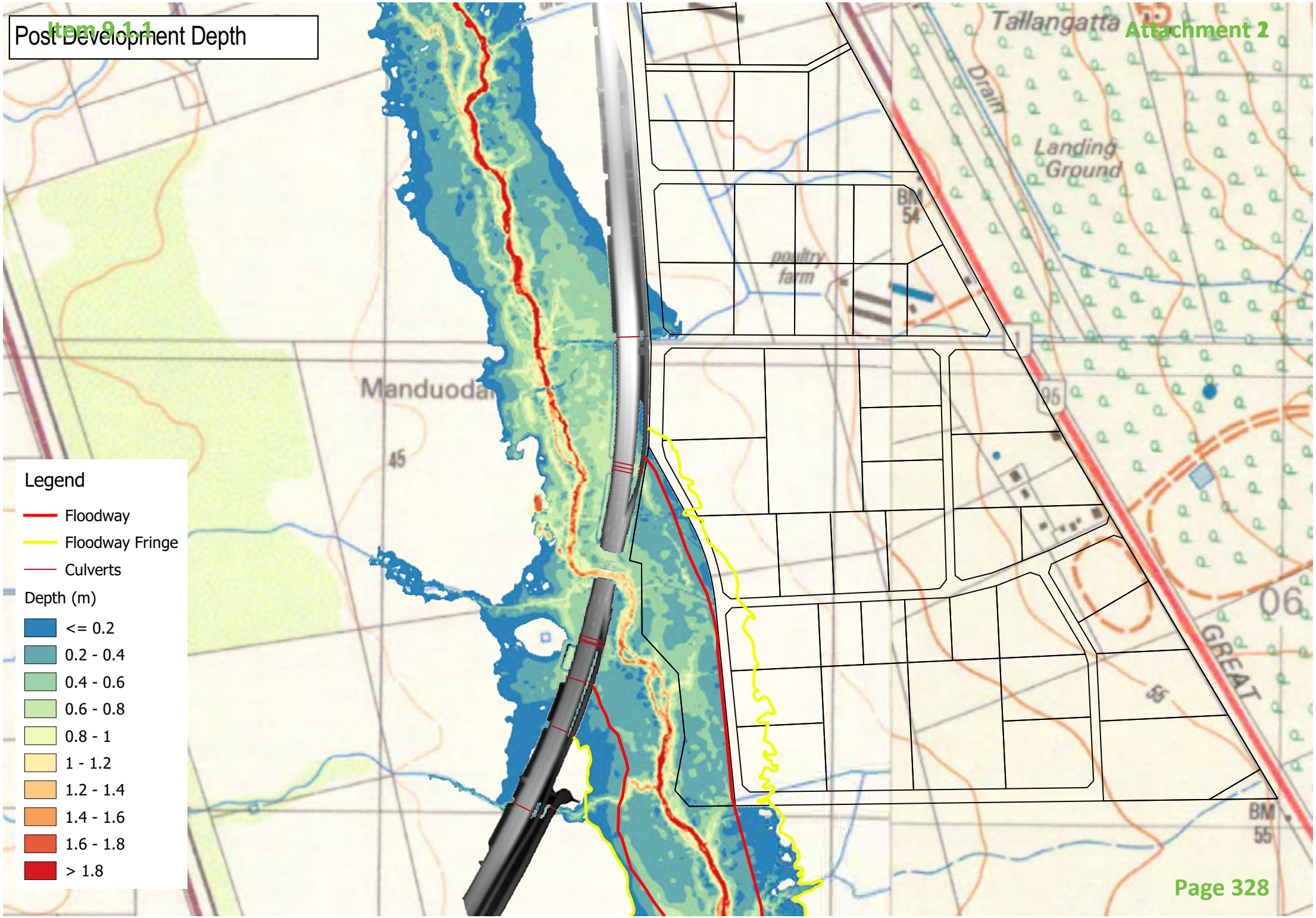
The findings of this study are subject to the following limitations:

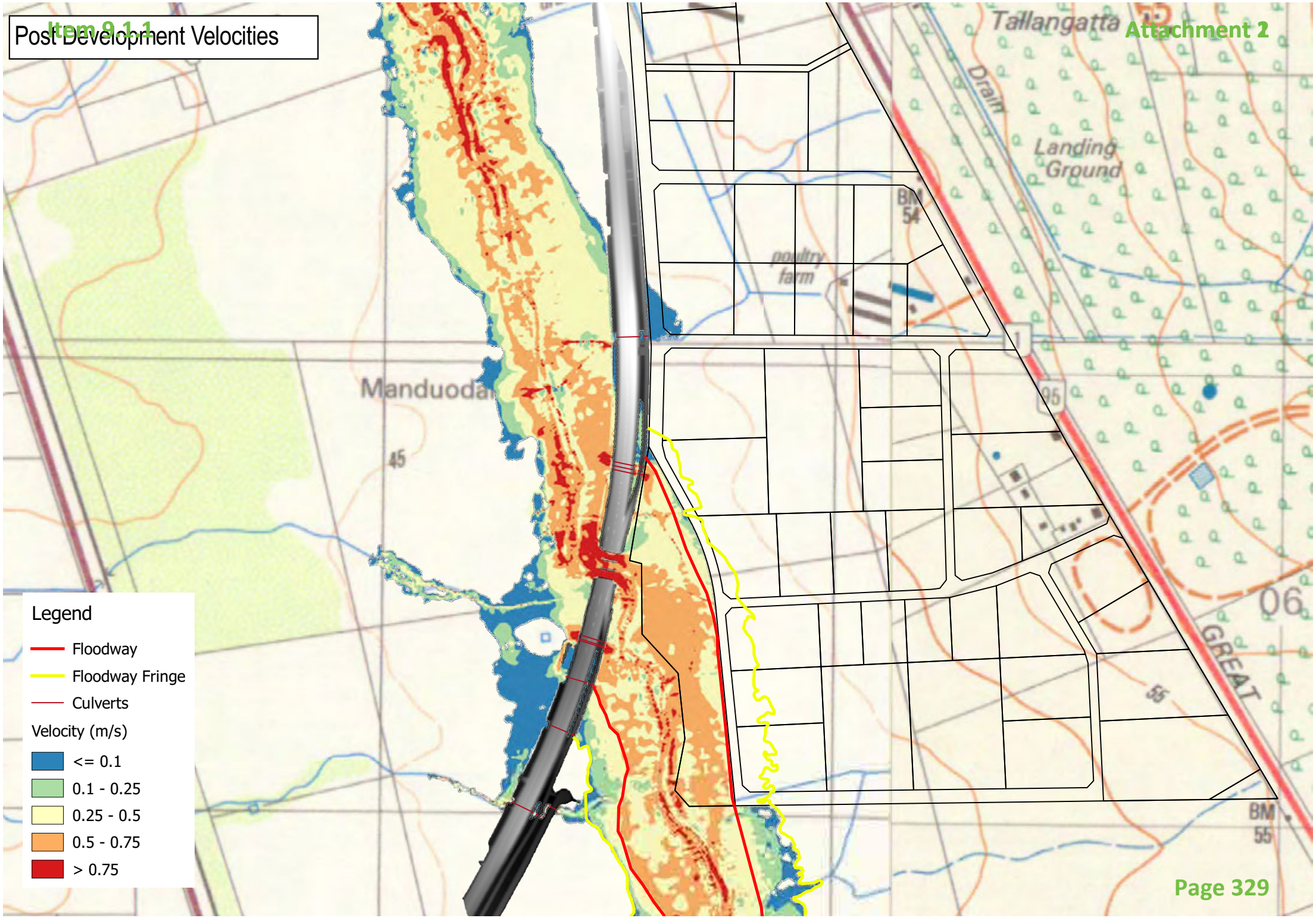
- The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.
- No allowance has been made for blockage of drainage infrastructure or increasing flows due to climate change.

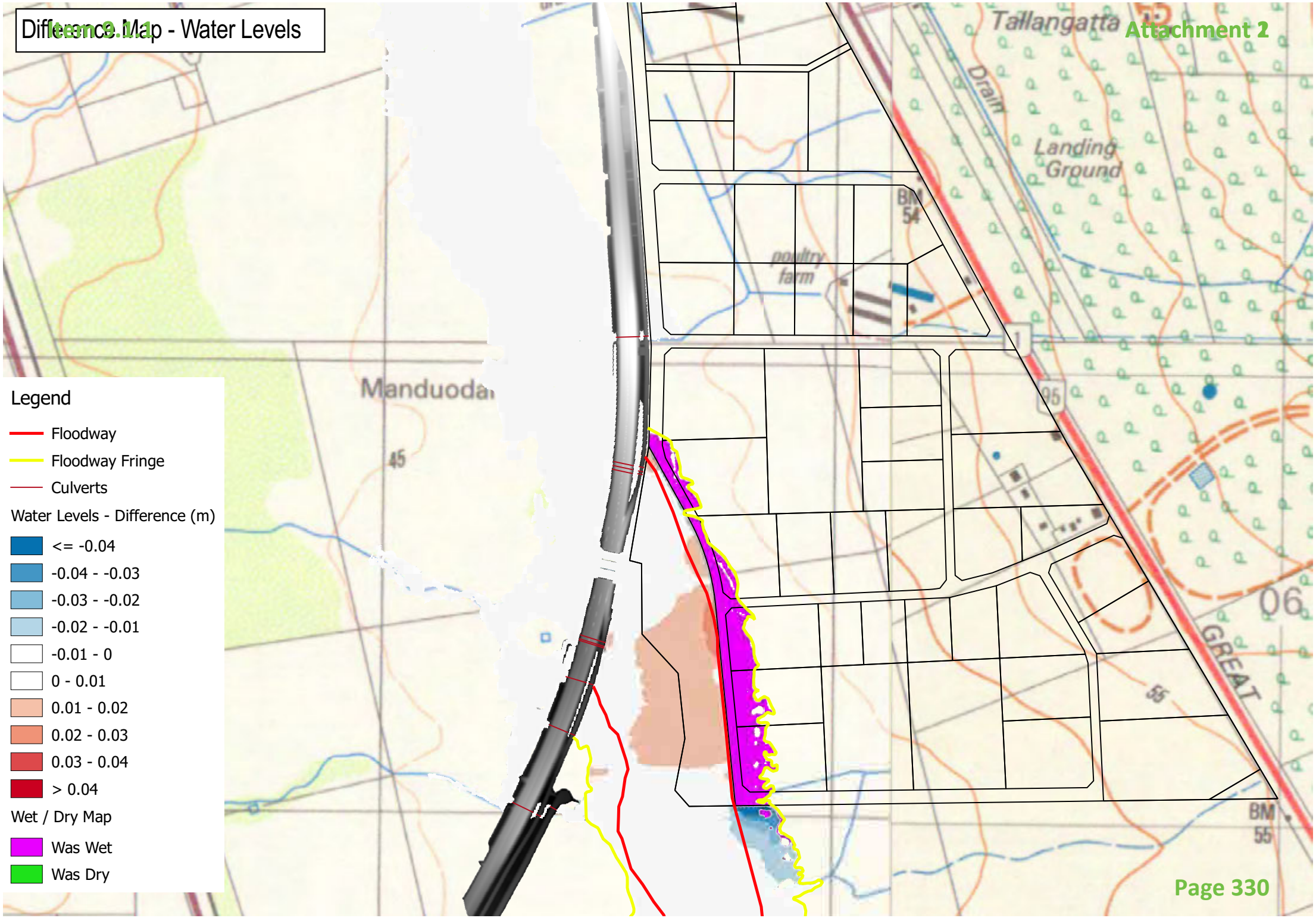
Pre Development Depth
Tallangatta
Drain
Landing Ground
BM 54
poultry farm
Manduodan
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Pre Development Velocities
Tallangatta
Drain
Landing Ground
BM 54
poultry farm
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Pre Development Velocity x Depth
Tallangatta
Drain
Landing Ground
BM 54
poultry farm
Manduodan
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity x Depth
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
> 1


Post Development Depth
Tallangatta
Drain
Landing Ground
BM 54
poultry farm
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Post Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
55
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Difference Map - Water Levels
Tallangatta
Drain
Landing Ground
BM 54
poultry farm
Manduoda
45
95
06
55
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Water Levels - Difference (m)
<= -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
> 0.04
Wet / Dry Map
Was Wet
Was Dry

# Appendix F

## Foreshore Definition Report

# MUCHEA EMPLOYMENT NODE
# PRECINCT 3

# ELLEN BROOK FORESHORE RESERVE DEFINITION

**Prepared for**

**Muchea Employment Node**
**Precinct 3 Landowner Group**
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Draft Report No. J18015d
22 January 2020

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

## INTRODUCTION

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the subject site) have applied to the WAPC for the lots to be rezoned from Agricultural Resource to Light Industrial. The subject site is bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH) and Ellen Brook. Figure 1 shows the location of the site.

Foreshore reserve requirements for waterways are governed by WAPC Development Control Policy No. DC2.3: *Public Open Space in Residential Areas.* DC2.3 specifies a default foreshore reserve width of 30 metres for waterways but includes provision to vary the default setback for reasons of topography, condition of banks or floodway protection. DWER policy on foreshore setbacks is set out in Operational Policy River Restoration Series No. RR16 – *Determining Foreshore Reserves* (WRC, 2001) and Foreshore Policy 1 - *Identifying the Foreshore Area* (WRC, 2002a). These documents also set out a methodology for determining the foreshore setback in each case.

The Muchea Employment Node Structure Plan (WA Govt, 2011) designated a nominal 15-40m foreshore reserve in the subject site east of Ellen Brook. The Structure Plan noted that the reserve could be modified at the Urban Water Management Plan stage in accordance with DWER *Operational Policy 4.3: Determining foreshore reserves* (DoW, 2012), *Water Note 23 – Determining Foreshore Reserves* (DoW, 2001) and *River Restoration Manual Chapter 16 – Determining foreshore reserves* (DoW, 2001).

This Foreshore Definition Study was undertaken in accordance with the above DoW policies to better define the foreshore reserve of Ellen Brook in the light of detailed flood modelling in 2018.

**DETERMINATION OF FORESHORE SETBACK**
**USING THE METHODOLOGY SET OUT IN RIVER RESTORATION SERIES 16**

**Step 1: Background information and preliminary investigations**

*Waterway significance and management issues*
Ellen Brook is a major tributary of the Swan-Canning River system, which is the major river of the Perth Region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow in the system, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715 $km^2$ (WRC, 2012). The Brook rises as Chandala Brook about 20km north-northwest of the subject site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. BG&E Pty Ltd modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project on behalf of Main Roads Western Australia (MRWA) in 2018. Figure 2 shows the 100-year ARI floodplain as modelled by BG&E.

Further flood modelling was carried out by BG&E for this project, in order to map the 100-year floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area adjoins the Brook. Figure 2 shows the floodway as mapped by BG&E.

Ellen Brook is significant in ecological, hydrological and amenity terms. The principal management issues facing the river are water quality, which has suffered as a result of nutrient inputs from development in its catchment, and the loss of riparian vegetation due to agricultural clearing in the lower reaches of the river.

*Aerial photography*
Figure 1 shows an aerial photograph of Ellen Brook where it adjoins the subject land.

*Maps of extent of floodway and floodplains, topographical features, cadastral boundaries, soils, underlying geology and vegetation complexes.*
These features are shown on Figure 2.

*Relevant reports on the river and region*
In 1999 the Water & Rivers Commission commissioned a foreshore condition assessment of a 2.8km section of Ellen Brook in Upper Swan, about 17km downstream of the subject site. The assessment focussed on bank stability, vegetation cover, habitat diversity and surrounding land uses. The report included recommendations on

weed control, native vegetation protection, sediment management and fencing of the foreshore reserve.

In 2002 the WRC produced *Hydrogeological Information for Management Planning in the Ellen Brook Catchment* (WRC, 2002b). This report identified nutrient loads (particularly very high levels of phosphorus), inundation, salinisation and erosion as key issues for the Ellen Brook catchment. The report made management recommendations including:

- reduction of groundwater recharge through increased tree cover (tree crops and native vegetation);
- reduction of nutrient loads through improved fertiliser and irrigation management and soil amendment;
- runoff reduction through streamlining and vegetation planting;
- sediment controls through planting, fencing and other stock controls; and
- salinity controls through increased tree cover and drainage works to lower groundwater levels.

The *Swan Canning Water Quality Improvement Program* (Swan River Trust, 2009) identified Ellen Brook as a major contributor of phosphorus and nitrogen contamination to the Swan-Canning River system, mostly originating from grazing on sandy soils in its catchment. The WQIP recommended management strategies including land use changes, increased native vegetation planting, fencing of foreshore reserves and soil modification to reduce nutrient loads, but recognised that any nutrient reductions achieved in the foreseeable future were likely to be modest.

*Site Visit*
A detailed inspection of Ellen Brook adjacent to the project site was carried out in July 2018. Figure 3 shows photographs of the river and its fringing vegetation.

*Relevant stakeholders*
The owners of the lots fronting the river, David and Barton Jones (Lot 192) and Neil Bovenizer (Lot 35), are proponents of the structure plan and are involved in the planning of the site.

**Step 2: Biophysical criteria of the waterway**

*Riparian vegetation*
The riparian vegetation of Ellen Brook is mostly restricted to the immediate banks and flats of the Brook, with the remainder of the subject land being mostly cleared. The native fringing vegetation is mostly confined to within 10-15m of the main channel.

The fringing vegetation consists of a sparse to dense woodland of *Eucalyptus rudis, Melaleuca preissiana, Jacksonia furcellata and Acacia saligna.* This woodland thins rapidly with distance from the Brook. The ground cover over most of this area consists

of a heavy growth of pasture grasses and weeds, which extends into the waterway itself. In places there are dense patches of *Watsonia maireana bulbillifera* and bulrush, either the native *Typha domingensis* or the introduced *T. orientalis*. The Typha has not colonised the watercourse itself, possibly because wet conditions coincide with fast-flowing water that prevents establishment. There are also occasional native sedges (*Juncus* or *Baumea*) and a heavy infestation of one-leaf cape tulip (*Morea flaccida*), a declared pest species in Western Australia.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas of Good condition. The *Jacksonia furcellata* and smaller Acacias are heavily browsed by cattle.

The riparian vegetation of the subject land, including Ellen Brook and its foreshore, is mapped by Heddle *et al.* (1980) as "Yanga Complex: low open-forest of *Casuarina obesa*, *Actinostrobus* (now *Callitris*) *pyramidalis, Melaleuca* spp. (including *M. lateritia, M. hamulosa*, *M. preissiana and M. rhaphiophylla*) and *Eucalyptus rudis* in the lower-lying areas, with *Banksia* spp., *Eucalyptus todtiana* and *Corymbia calophylla* open-woodland in the higher areas. The Yanga Complex has been moderately heavily cleared since European settlement, with 17.75% of its original extent remaining and less than 1% formally protected.

*Soils that support riparian vegetation*
The Geological Survey of Western Australia (GSWA, 1978) maps the Ellen Brook bed and surrounds as Qpa: Guildford Formation, with sandy soils (S11) in the immediate vicinity of the Brook and pebbly silt ($Mgs_1$) further away from the Brook.

*Floodway and floodplain – 1 in 100 yr flood levels, peak flow and river hydrology*
Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. BG&E Pty Ltd modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project on behalf of Main Roads Western Australia (MRWA) in 2018. Figure 2 shows the 100-year ARI floodplain as modelled by BG&E.

Emerge (2019) modelled combined flows in Ellen Brook and the minor drainages across the site for the Muchea Regional Water Management Strategy. The boundary of the floodplain modelled by Emerge (2019) agrees closely with the floodplain boundary modelled by BG&E for MRWA.

Further flood modelling was carried out by BG&E in 2018 in order to map the 100-year floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area adjoins the Brook. The BG&E floodway modelling report is attached in Appendix D of the LWMS. Figure 2 shows the floodway as mapped by BG&E.

*Soil types prone to erosion*

Ellen Brook follows a slightly meandering course adjacent to the subject land for a distance of about 600 metres. The channel appears stable, with little evidence of undercutting or erosion on bends. The channel splits in some places, with sand banks in the middle isolated by high flows.

The soils surrounding the river channel are predominantly sands transported by past flood flows overlain on Guildford Formation pebbly silts. This profile suggests that deposition, rather than erosion, is the dominant soil process occurring in this part of the watercourse.

Landgate aerial photography since 1965 shows that the alignment of the watercourse has shifted a few metres to the east or west with changes in water levels and sand banks, but there has been no significant or long-term change in the alignment.

*Landforms and drainage lines important to watercourse function*

The bed of the Brook falls from an elevation of about 41m AHD at the PDNH crossing to 40m AHD at the southern boundary of the project area, at a gradient of about 1 in 600 (0.16%). The top of the bank is generally less than 1m above the level of the bed. Away from the Brook, the land rises very slowly to the east, reaching 42m AHD between 170m and 33m from the Brook at a gradient of about 0.6%.

Two small drains enter the Brook from the subject land, draining runoff from low-lying paddocks. One of these also carries runoff from the access road constructed to service the PDNH roadworks and laydown areas east of the PDNH. In July 2018 this was observed to be carrying heavy sediment loads into the Brook. A silt curtain had been installed in the Brook downstream of the drain inflow but was being overtopped by the high flow in the Brook. The sediment inflow was not reflected in water samples collected downstream in the Brook.

*Habitat areas*

The vegetation in and immediately adjacent to the main channel of Ellen Brook provides habitat for waterbirds including ducks as well as dryland birds including (observed) twenty eight parrots, rosellas, willie wagtails and grey fantails. In the paddock near the Brook are a few isolated large flooded gums containing small hollows that might provide nesting sites for small birds. Signs of kangaroos were observed near the Brook. There is probably not enough dense ground cover to provide habitat for quenda, and no evidence of quenda was observed.

*Adjacent land use with potential to affect the foreshore*

The current grazing land use on the subject land has had significant impacts on Ellen Brook, including clearing of fringing vegetation, trampling and bank erosion. Cattle have historically had access to the Brook, which has resulted in bank erosion, grazing of native vegetation and trampling and spread of weeds.

Development of the subject land as planned will benefit the Brook by removing the impact of cattle and allowing native vegetation to regenerate, thereby helping to stabilise the river banks. Development will also provide opportunities for rehabilitation of degraded parts of the foreshore.

*Aboriginal Heritage Sites*
The Department of Aboriginal Affairs' online database shows the whole of Ellen Brook and its surrounds up to 5.6km east as part of a registered Aboriginal Heritage Site, ID 3525 (Ellen Brook: Upper Swan). Site 3525 is a mythological site associated with the Waugal mythology, and is understood to relate to the watercourse of Ellen Brook. In other similar cases, a reserve of 50m either side of the watercourse has been considered sufficient protection for the mythological site.

**Step 3: Other factors**

*Fire Management*
The vegetation in the foreshore zone presents a low to moderate fire hazard due to the absence of heavy understorey or middle storey vegetation. With the removal of cattle grazing there could be heavy growth of grasses and weeds, which could pose a high fire risk unless it were managed. Therefore, weed control, mowing of grasses and/or replacement with native low understorey species will be required to manage the fire hazard.

*Risks and consequences resulting from the proposed foreshore alignment*
The principal consequence of establishing a foreshore setback in this location will be the opportunity to undertake rehabilitation of the foreshore. This will improve the ecological value of the foreshore as well as providing increased social amenity.

The main risk in the proposed alignment is the possibility of flooding above the modelled 100 year flood level, which could affect development outside the foreshore setback. However, any buildings within the flood fringe will have a floor level at least 0.5m above the modelled 100-year flood level so the risk of property damage is low.

**Step 4: Finalisation of the alignment**

*Rationale for the alignment*
The key factors in the delineation of the foreshore setback are:

- Compliance with policy - The WAPC's Development Control Policy 2.3 specifies a default minimum setback of 30m from waterways. The proposed foreshore reserve extends a minimum of 125m from the edge of the main channel.

- 100 year floodway - The proposed foreshore reserve coincides with the outside edge of the modelled 100-year ARI floodway.

- Vegetation - The proposed foreshore reserve includes all remaining riparian vegetation.

- Shoreline processes - The proposed foreshore reserve is more than sufficiently wide to accommodate any foreseeable variations in the alignment of the watercourse.

- Fire protection - Fire protection will be achieved by a combination of separation from the edge the foreshore reserve and control of revegetation height and density in the part of the foreshore reserve closest to development areas. The zoning of vegetation plantings within the foreshore reserve is shown on Figure 4. A detailed treatment of fire hazard and fire protection measures is presented in the Bushfire Management Plan (Appendix G to the Structure Plan report).

- Aboriginal heritage - The registered Aboriginal mythological site no. 3525 extends up to 5.6km east of the Brook. Previous experience suggests that the site can be protected by a foreshore reserve at least 50m wide. This is easily accommodated within the proposed minimum 125m foreshore reserve. Approval under Section 18 of the *Aboriginal Heritage Act 1945* will be required for any earthworks within the registered Aboriginal heritage site, which extends beyond the boundaries of the project area.

*Map of Foreshore Setback*
Figure 4 shows the proposed boundary of the foreshore reserve.

## FORESHORE TENURE AND MANAGEMENT

The river and foreshore within the subject land are currently privately owned and zoned Agricultural Resource under the Shire of Chittering Town Planning Scheme (TPS). With the subdivision of the subject land, the river and foreshore reserve are expected to be ceded as Public Open Space to the Shire and rezoned accordingly.

The owners of the foreshore at the time of subdivision will manage the foreshore reserve for at least two years after the completion subdivision adjacent to the reserve and revegetation works in the reserve. After two years the foreshore reserve will be handed over to the Shire of Chittering to be managed primarily for conservation.

**REFERENCES**

Swan River Trust (2009). *Swan Canning Water Quality Improvement Plan.* Swan River Trust, Perth.

WA Govt (2011). *Muchea Employment Node Structure Plan.* WAPC, Perth.

Water & Rivers Commission (1999). *Foreshore Assessment in the Ellen Brook Catchment.* Water Resource Management Series No. 16. Water & Rivers Commission, Perth.

WRC (2001). *Water Note 23: Determining Foreshore Reserves*. Water & Rivers Commission, Perth.

WRC (2002a). *Foreshore Policy 1: "Identifying the Foreshore Area".* Water & Rivers Commission, Perth.

WRC (2002b). *Hydrogeological Information for Management Planning in the Ellen Brook Catchment*. Salinity and Land Use Impacts Series No. SLUI 11. Water & Rivers Commission, Perth.

# Figures

Figure 1

LOCATION AND LAYOUT

bayley environmental services

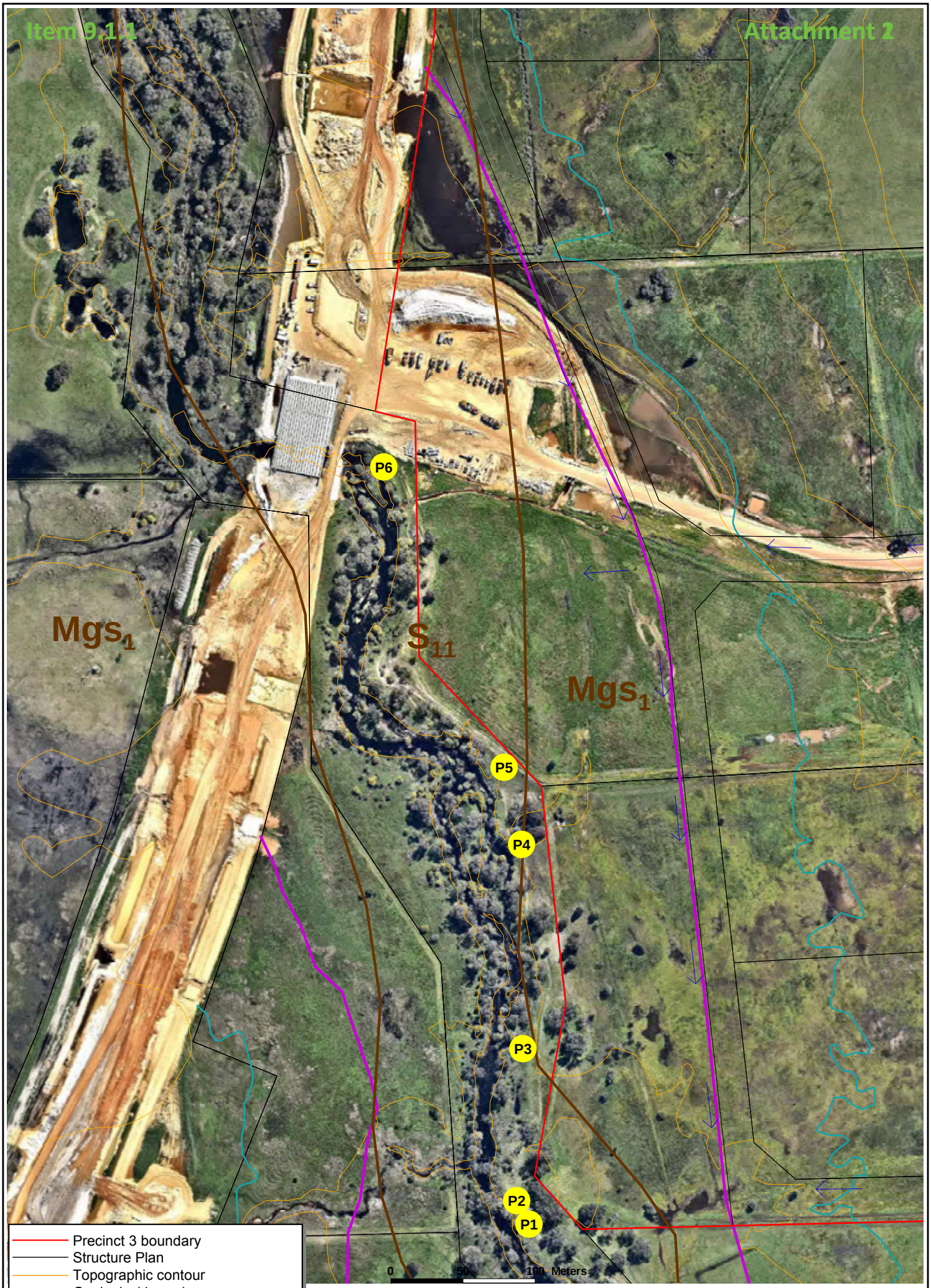



**Figure 2**

**ENVIRONMENTAL FEATURES**

**P1**

**P2**

**P3**

**P4**

**P5**

**P6**

**Figure 3**

**GROUND LEVEL PHOTOGRAPHS**

See Figure 2 for photo locations

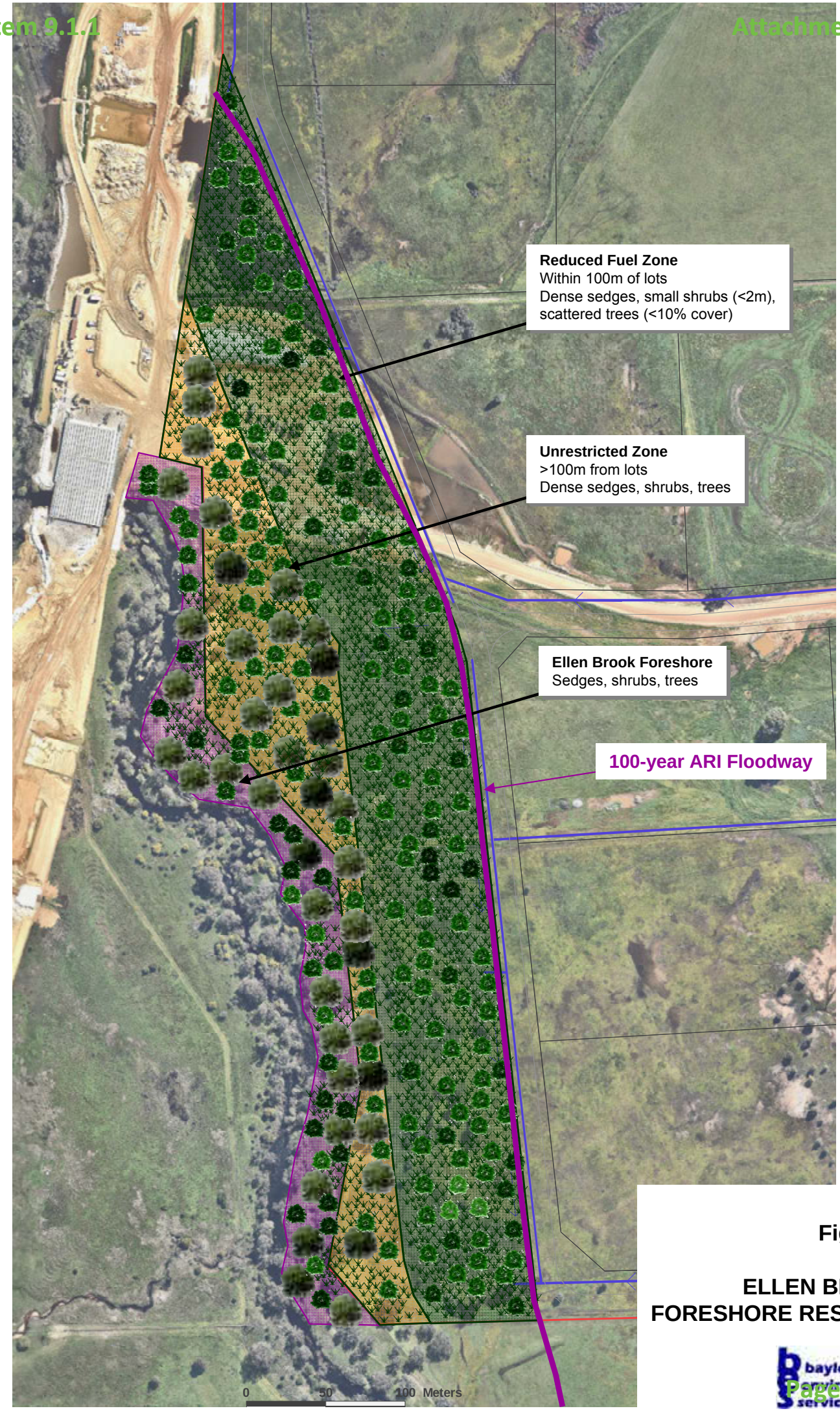



**Figure 4**

**ELLEN BROOK FORESHORE RESERVE**

# Appendix G

## Letter from Aqua Ferre Pty Ltd

AQUA FERRE PTY LTD
ACN 121 146 772
PO Box 1982 West Perth WA 6872
Level 1, 5 Ord Street West Perth WA 6005
Tel: 08 9282 5400
Fax: 08 9282 5484

29 January 2018

Tom Carmody
Director and Licensee
Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group
8/355 Stirling Highway
Claremont WA 6010

Dear Mr Carmody

Muchea Employment Node Precinct 3 Landowner Group

I refer to your enquiries to Aqua Ferre Pty Ltd (Aqua Ferre) regarding the availability of water and the potential future supply of water, within the Muchea region.

You have advised that you represent a number of landowners with properties on Great Northern Highway and Brand Highway in Muchea (collectively described as the Muchea Employment Node Precinct 3 Landowner Group or more generally the landowner group).

On behalf of the landowner group you have requested information from Aqua Ferre in support of two planning documents:

- Shire of Chittering Town Planning Scheme No 6 Amendment No.67 - Rezoning Lots M1601, 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Industrial Development' zone, and amending the Scheme Maps accordingly; and
- Precinct 3 Muchea Industrial Park Structure Plan.

In particular you have sought information regarding Aqua Ferre's water entitlements, the prospect that some of Aqua Ferre's water entitlement may be allocated to the landowner group properties, and whether the water can be practically supplied from Aqua Ferre's operations to the landowner group properties.

## 1 MEN & Precinct 3

The Muchea Employment Node Structure Plan (MENSP) was adopted by the WAPC in August 2011, and provides a 20-year planning framework for industrial development within the Shire of Chittering. We understand that the MENSP is currently under review and a revised document is expected to be released during 2019.

You have advised that the subject land is located within Precinct 3, which forms the eastern portion of the MENSP, to the west of Great Northern Highway (GNH).

Precinct 3 of the Muchea Employment Node (more recently referred to as the Muchea Industrial Park (MIP)) ('the Structure Plan area') is approximately 185ha in area and located to the south east of the

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townsite of Muchea. Precinct 3 is triangular in shape and extends in a lineal pattern from Brand Highway in the north, along Great Northern Highway (GNH) in the east, to the southern boundary of the Shire of Chittering, and along the Perth-Darwin Highway (PDNH) to the west, which is currently under construction.

Figure 1 below shows the proposed Precinct 3 development boundaries (Urbis 2019, LPS Amendment, Muchea Employment Node, DWG-11).

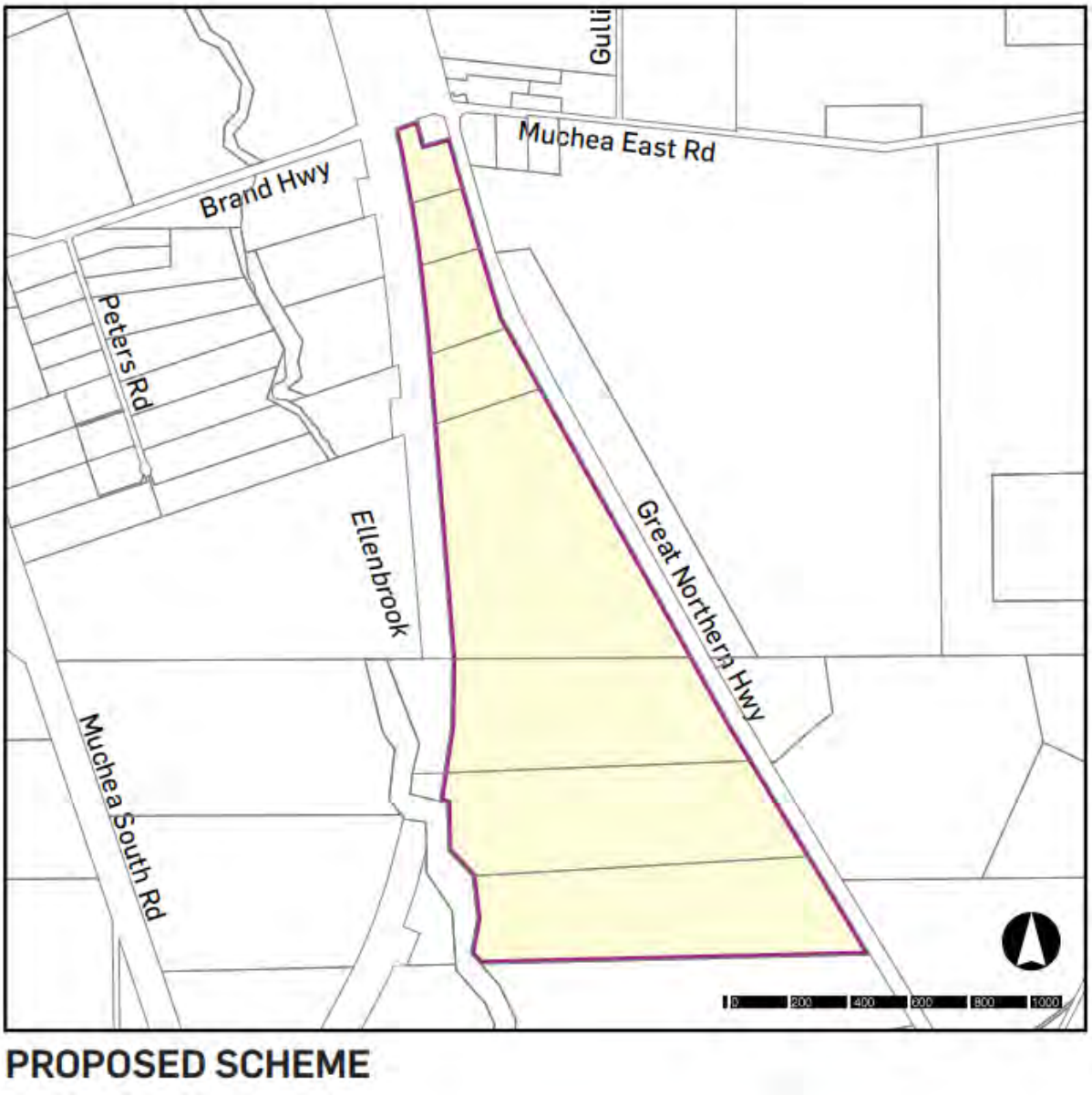


**Figure 1 Proposed Precinct 3 development**

Urbis[1] have indicated that the land has largely been historically cleared for agricultural purposes and contains stands of large, mature trees with degraded understorey, and a number of rural drainage lines.

[1] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

You have advised that the Structure Plan[2] will provide approximately 51 lots of approximately 1.3ha to 7.6ha providing flexibility for a range of industrial uses, expected to be primarily transport logistics related.

We understand that the Structure Plan is being progressed concurrently with Amendment No.67 to LPS6 which proposes to rezone the land from 'Agricultural Resource Zone' to the 'Industrial Development' zone, to introduce land use permissibility for Precinct 3; clarify requirements for the preparation of Management Plans, and introduce provisions relating to provision of reticulated water and construction of the loop road.

## 2 Aqua Ferre

Aqua Ferre was established to be an independent water service provider following approaches by property development groups seeking water services in the Chittering/Muchea region. Aqua Ferre is proposing to build and operate a potable water supply system at Reserve Road, Chittering (as shown in Figure 2).

The proposed water treatment plant (WTP) would be operated as a constant flow rate to promote a stable process with the intention of producing reliable potable water that meets the Australian Drinking Water Guidelines.

Figure 2 below broadly shows the Precinct 3 development (outlined in red) to the south of Harvis' proposed MEN (Phase 1) development (outlined in yellow) and Aqua Ferre's proposed water facility to the north.

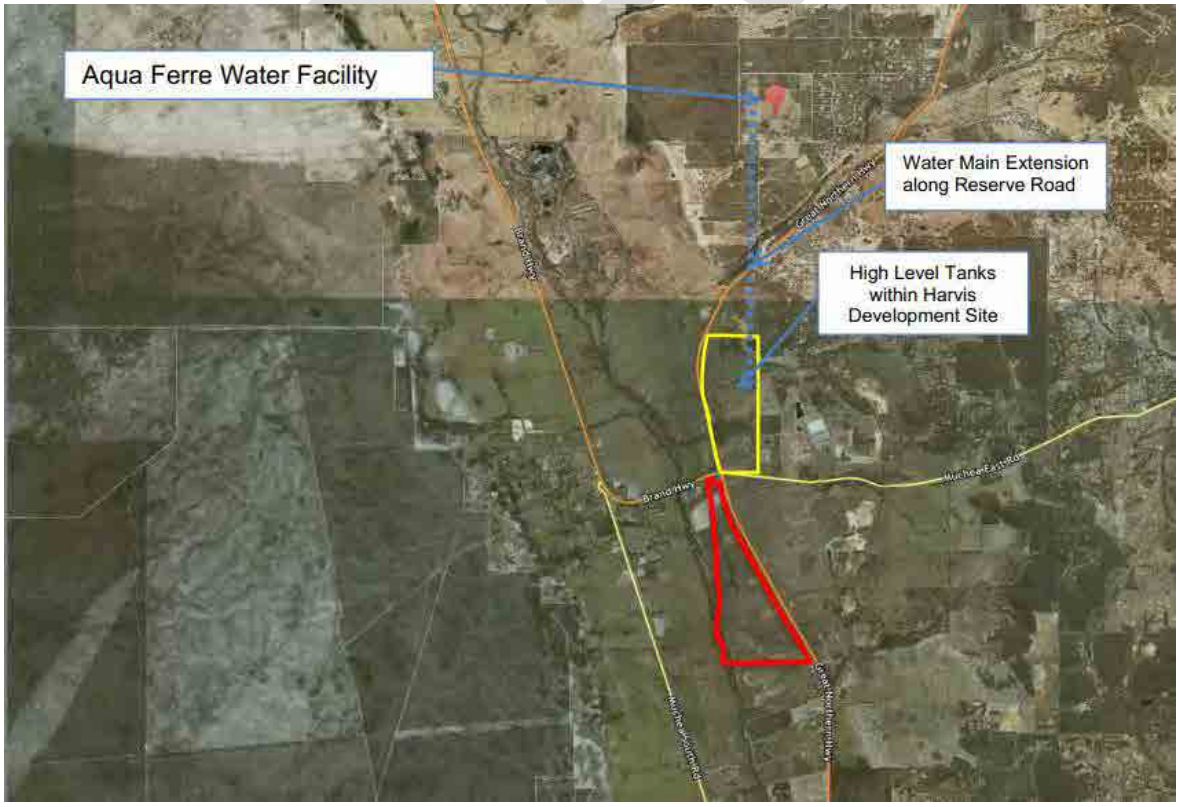


**Figure 2 Development boundaries**

[2] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

## 2.1 Water Entitlement

The Reserve Road (Chittering) property currently has a total water entitlement or allocation (licence to abstract water from an artesian aquifer) of 288,800 kL per annum. The developer of the Reserve Road residential development, Riverside, has transferred the Water Licence GWL 59907(3) to the Water Corporation to enable the licence to be changed from an agricultural extraction to public water supply. It is intended that this water entitlement will be transferred to Aqua Ferre when a water service licence has been granted.

Aqua Ferre has similar entitlement rights to a further 362,900 kL per annum licence, originally GWL 102502(4) which is now part of GWL 65011.

In total, it is intended that Aqua Ferre will have access to 651,700 kL of water per annum.

There is an existing production bore located within the proposed Reserve Road development that was previously used for wildflower irrigation, where the proposed potable WTP would be located.

## 2.2 Existing water supply commitments

Aqua Ferre intends supplying approximately 153 ML of treated potable water to the residential development at Reserve Road, Chittering, and to a commercial/industrial development at the adjacent MEN (northern Precinct 1 only). It is intended that a further 75 ML will be set aside for future demand across these two developments.

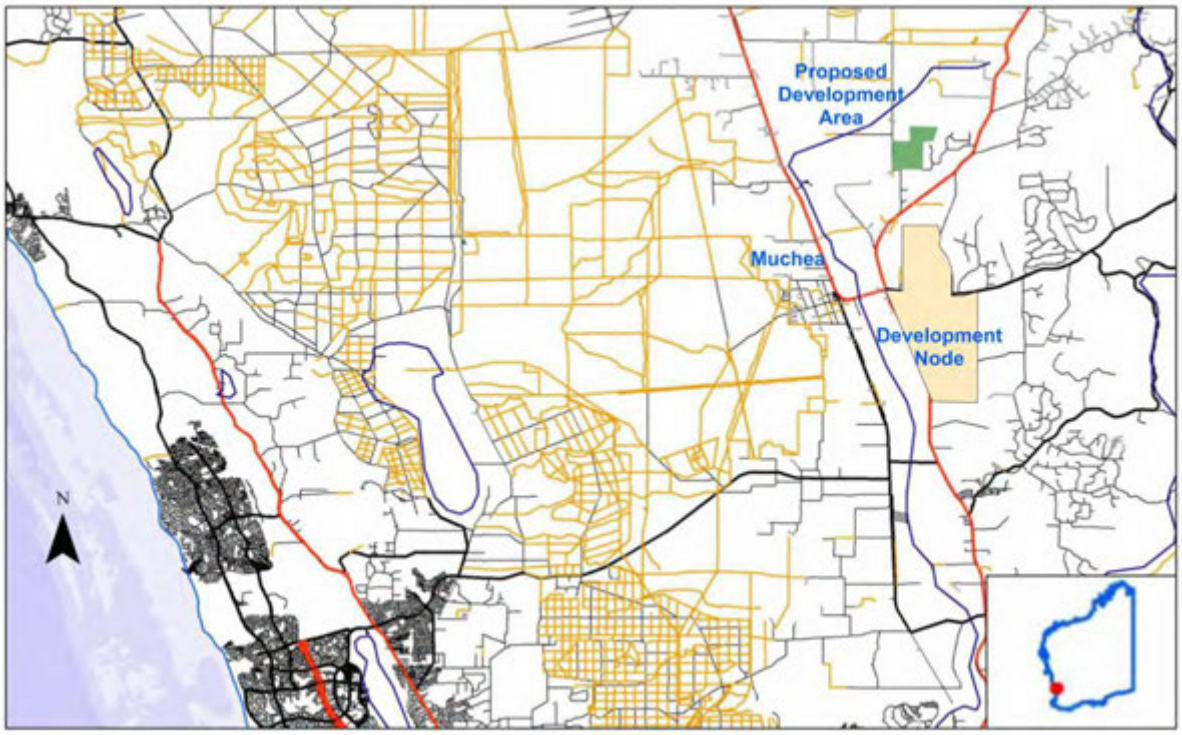


**Figure 3 Location of Reserve Road residential development and MEN**

The new Reserve Road rural living allotment development is located 8km north east of the Muchea town site and 80km north of the Perth central business district. It is also in close proximity (4km) to the

proposed MEN on the eastern side of Great Northern Highway. The development is in accordance with the Shire of Chittering's planning scheme (2004). The Reserve Road development covers an area of approximately 160 hectares and involves the creation of approximately 245 rural residential allotments in progressive stages. It is a requirement of the development approval that potable reticulated water is available.

**Figure 4 Contour map (5m contour lines) of the Harvis MEN development showing ephemeral swale**

Phase 1 of the MEN development is being undertaken by development group Harvis Capital Pty Ltd (Harvis). The Harvis development is located on the northern end of the proposed MEN. The site is slightly undulating with an ephemeral swale running through the development (Figure 4). The development is well placed and has been planned around the proposed Perth Darwin Highway.

It is the intention of the MEN development that these lots also have a reticulated water resource. Currently, the area does not have a public water supply scheme. Aqua Ferre is finalising documentation to allow the Economic Regulation Authority Western Australia to consider an application for a water services licence.

It is proposed that the water supply for the Harvis MEN development will have a standalone delivery and network system, to ensure that the demand of both systems can meet peak demand and firefighting requirements.

After treatment, it is intended that the water required for the Harvis MEN site will be delivered to a 500kL holding tank with aeration. Water would be reticulated to customers using a standard, continually pressurised water reticulation network. The piping would follow the general topography and alignment of the development streets and will have 600mm coverage.

## 3 Precinct 3 water requirement

You have advised that the intention is that the land the subject of the Structure Plan would be serviced with reticulated water provided by a licensed water provider.

The total area of supply is for an industrial development totalling approximately 185 hectares. No indication of staging of development has been provided at this point.

Estimated annual water usage has been provided (based on preliminary modelling by Cossill & Webley) as 203ML per annum on a net area of 139 hectares (after allowing for a 25% reduction in land area calculation to accommodate roads/drainage). The proposed system has been modelled at 4kL/day per hectare based on advice from Cossill & Webley of studies of similar industry types and uses. It is noted that this compares to the Water Corporation design standard for industrial land of approximately 17 kL/ha/day.

Based on your advice of estimated water usage, Aqua Ferre would have capacity under its entitlements to meet the demand of the subject land. This is not an undertaking to commit an allocation of water, or to supply water, to the Muchea Employment Node Precinct 3 Landowner Group. Any such arrangements would be the subject to future commercial negotiation, agreement on terms including pricing and remaining water availability under Aqua Ferre's entitlements.

## 4 Supply assessment

Aqua Ferre has conducted a preliminary desktop assessment of the potential supply route from its planned water treatment plant at Reserve Road to the proposed Precinct 3 development via Harvis' phase 1 MEN development. This represents a distance of approximately 3.5 kilometres.

The assessment did not highlight any major engineering impediments to the provision of water to the proposed development. (This is not to say, however, that any impediments would not become apparent on more detailed analysis.)

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Any proposal for supply would be inclusive of the requirements of:

- Water Corporation Design Standard DS 63 – Water Reticulation Standard Design and Construction Requirements for Water Reticulation Systems or Water Reticulation Systems up to DN250
- DFES requirements for firefighting services
- Hydraulic modelling using EPANET 2 for system hydraulics.

Hydraulic modelling would require topographical mapping at 0.5m.

Additionally, there would be a requirement for a water reserve for tanks, pumps, sumps, generator and chlorination which would need to be met by the subject landowners' group.

## 5 Disclaimer

This report is dated 29 January 2019 and incorporates information available to Aqua Ferre up to that date only. It excludes consideration of any information arising, or event occurring, after that date which may impact opinions expressed or statements made by Aqua Ferre in this report.

Aqua Ferre has prepared this report on the instructions, and for the sole benefit, of Tomahawk Property (Instructing Party), for inclusion within a rezoning application and Structure Plan as described in paragraph 3 of this letter (Purpose) and not for any other purpose or use. To the extent permitted by applicable law, Aqua Ferre expressly disclaims all liability, whether direct or indirect:

- to the Instructing Party, which may arise in connection with any reliance or purported reliance on this report for any purpose other than the Purpose, and
- to any other person, which may arise in connection with any reliance or purported reliance on this report for any purpose whatsoever (including the Purpose).

All statements and opinions contained in or associated with this report are made on the basis of information supplied to Aqua Ferre as at the date of this report, and upon which Aqua Ferre has relied. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with any errors or omissions in this report arising from information provided to Aqua Ferre by the Instructing Party or by any other person.

Achievement of any proposed or intended events or circumstances described in this report will depend, among other things, on the actions of others, over which Aqua Ferre has no control. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with the delay in, or failure to occur of, any proposed or intended events or circumstances described in this report.

Yours sincerely

Peter Fogarty
Director

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# Appendix H

## Runoff Calculations

**1 YEAR ARI 1 HOUR FLOWS**

| | | |
|---|---|---|
| Rainfall Intensity i (mm/h) | 15.1 | (1 Yr, 1 Hr Storm) |
| Runoff Coefficients | | |
| Buildings | 0 | |
| Lowlands | 0 | |
| Hardstand | 0 | |
| Cleared Palusplain | 0 | |
| Vegetated Palusplain | 0 | |
| Cleared Uplands | 0 | |
| Forested Uplands | 0 | |
| Road Reserve | 0.8 | |

Permeability k (m/hr) 0.0417

| Catchment | Buildings | Lowlands | Hardstand | Cleared Palusplain | Vegetated Palusplain | Cleared Uplands | Forested Uplands | Road Reserve | Ai | Q (L/s) | Vinflow (m3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| North Pl 1 | 2926 | 0 | 23406 | 0 | 2926 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| North Pl 2 | 968 | 0 | 7741 | 0 | 968 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| AMS Pl 1 | 3014 | 0 | 24110 | 0 | 3014 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| AMS Pl 2 | 4530 | 757 | 35228 | 0 | 4502 | 0 | 0 | 11531 | 9225 | 38.72 | 139 |
| AMS Pl 3 | 380 | 0 | 31914 | 0 | 2240 | 0 | 0 | 14270 | 11416 | 47.92 | 173 |
| Ingham Pl 1 | 5810 | 0 | 46477 | 0 | 5810 | 0 | 0 | 16003 | 12802 | 53.74 | 193 |
| Ingham Pl 2 | 1243 | 0 | 9943 | 0 | 1243 | 0 | 0 | 1177 | 942 | 3.95 | 14 |
| Ingham Pl 3 | 2143 | 0 | 17146 | 0 | 2143 | 0 | 0 | 2240 | 1792 | 7.52 | 27 |
| Ingham Pl 4 | 12461 | 0 | 99687 | 0 | 12461 | 0 | 0 | 10215 | 8172 | 34.30 | 123 |
| Ingham Pl 5 | 9381 | 0 | 75044 | 0 | 9381 | 0 | 0 | 23070 | 18456 | 77.47 | 279 |
| Ingham Pl 6 | 22286 | 0 | 178285 | 0 | 22286 | 0 | 0 | 42438 | 33950 | 142.52 | 513 |
| Amuse | 19440 | 0 | 155522 | 0 | 19440 | 0 | 0 | 10962 | 8770 | 36.81 | 133 |
| RTA | 65731 | 0 | 525851 | 0 | 65731 | 0 | 0 | 61273 | 49018 | 205.77 | 741 |
| South | 12769 | 0 | 102149 | 0 | 12769 | 0 | 0 | 17793 | 14234 | 59.75 | 215 |

**Swale Sizing**

| | Storm Event | Depth | Slope 1:x | Base Width | Base Length | Top Width (m) | Top Length (m) | Volume | Effective Volume | Surface Area (m2) | Volume check | 2% Area | Base Length Available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North Pl 1 | 1 | 0.3 | 4 | **0** | **0** | 2 | 2 | 1 | 1 | 6 | ok | 0 | 0 |
| North Pl 2 | 1 | 0.3 | 4 | **0** | **0** | 2 | 2 | 1 | 1 | 6 | ok | 0 | 0 |
| AMS Pl 1 | 1 | 0.3 | 4 | **0** | **0** | 2 | 2 | 1 | 1 | 6 | ok | 0 | 0 |
| AMS Pl 2 | 1 | 0.3 | 4 | **1** | **196** | 3 | 198 | 123 | 141 | 675 | ok | 184 | 330 |
| AMS Pl 3 | 1 | 0.3 | 4 | **1** | **242** | 3 | 244 | 152 | 173 | 830 | ok | 228 | 308 |
| Ingham Pl 1 | 1 | 0.3 | 4 | **1** | **271** | 3 | 273 | 170 | 194 | 930 | ok | 256 | 288 |
| Ingham Pl 2 | 1 | 0.3 | 4 | **1** | **19** | 3 | 21 | 13 | 15 | 73 | ok | 19 | 43 |
| Ingham Pl 3 | 1 | 0.3 | 4 | **1** | **37** | 3 | 39 | 24 | 27 | 134 | ok | 36 | 71 |
| Ingham Pl 4 | 1 | 0.3 | 4 | **1** | **172** | 3 | 174 | 108 | 124 | 593 | ok | 163 | 325 |
| Ingham Pl 5 | 1 | 0.3 | 4 | **1** | **391** | 3 | 393 | 245 | 279 | 1338 | ok | 369 | 640 |
| Ingham Pl 6 | 1 | 0.3 | 4 | **1** | **720** | 3 | 722 | 451 | 513 | 2456 | ok | 679 | 1314 |
| Amuse | 1 | 0.3 | 4 | **1** | **185** | 3 | 187 | 117 | 133 | 637 | ok | 175 | 390 |
| RTA | 1 | 0.3 | 4 | **1** | **1040** | 3 | 1042 | 650 | 741 | 3544 | ok | 980 | 2054 |
| South | 1 | 0.3 | 4 | **1** | **301** | 3 | 303 | 189 | 215 | 1032 | ok | 285 | 550 |

**100 YEAR ARI DRAINAGE PROPERTIES - UPSTREAM**

| CATCHMENT | AREAS (m2) | | | | | | | | | | | | | | | | EFFECTIVE AREA (m2) | | TIME OF CONCENTRATION PRE-DEVELOPMENT | | | | | TIME OF CONCENTRATION POST-DEVELOPMENT | | | | | CRITICAL STORM INTENSITY (mm/h) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Buildings | | Lowlands | | Hardstand, unsealed roads | | Cleared Palusplain | | Vegetated Palusplain | | Cleared Uplands | | Forested Uplands | | Road Reserve | | Total | | Pre Dev | Post Dev | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope (m/km) | TC (min) | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope | TC (min) | Pre-Dev | Post-Dev |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | | | | | | | | | | | | | |
| **North 1** | 8542 | 8542 | 67975 | 67975 | 16885 | 16885 | 53602 | 53602 | 0 | 0 | 0 | 0 | 0 | 0 | 73179 | 73179 | 220183 | 220183 | 163406 | 163406 | 1500 | 85 | 53 | 21.00 | 56.7 | 1500 | 85 | 53 | 21.00 | 56.7 | 43.96 | 43.96 |
| **North 2** | 0 | 0 | 142617 | 142617 | 5392 | 5392 | 64500 | 64500 | 70603 | 70603 | 2879828 | 2879828 | 634745 | 634745 | 995 | 995 | 3798680 | 3798680 | 1175539 | 1175539 | 6316 | 235 | 52 | 28.97 | 183.8 | 6316 | 235 | 52 | 28.97 | 183.8 | 21.25 | 21.25 |
| **AMS** | 0 | 0 | 167304 | 167304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6056 | 6056 | 173360 | 173360 | 105227 | 105227 | 1448 | 70 | 52 | 12.43 | 63.5 | 1448 | 70 | 52 | 12.43 | 63.5 | 40.55 | 40.55 |
| **Inghams 1** | 0 | 0 | 302181 | 302181 | 0 | 0 | 0 | 0 | 0 | 0 | 75326 | 75326 | 0 | 0 | 4410 | 4410 | 381917 | 381917 | 207434 | 207434 | 2351 | 128 | 53 | 31.90 | 79.8 | 2351 | 128 | 53 | 31.90 | 79.8 | 36.64 | 36.64 |
| **Inghams 2** | 1371 | 1371 | 460463 | 460463 | 0 | 0 | 0 | 0 | 0 | 0 | 469488 | 469488 | 0 | 0 | 4800 | 4800 | 936122 | 936122 | 422198 | 422198 | 2216 | 129 | 53 | 34.30 | 69.1 | 2216 | 129 | 53 | 34.30 | 69.1 | 39.22 | 39.22 |
| **Inghams 3 a** | 540 | 540 | 522370 | 522370 | 0 | 0 | 0 | 0 | 0 | 0 | 422640 | 422640 | 0 | 0 | 7111 | 7111 | 952661 | 952661 | 446389 | 446389 | 3157 | 125 | 53 | 22.81 | 106.2 | 3157 | 125 | 53 | 22.81 | 106.2 | 30.31 | 30.31 |
| **Inghams 3 b** | 0 | 0 | 80404 | 80404 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3554 | 3554 | 83958 | 83958 | 51086 | 51086 | 923 | 74 | 57 | 18.96 | 40.0 | 923 | 74 | 57 | 18.96 | 40.0 | 56.99 | 56.99 |
| **Inghams 4** | 0 | 0 | 150325 | 150325 | 0 | 0 | 56142 | 56142 | 0 | 0 | 1161350 | 1161350 | 13741 | 13741 | 4350 | 4350 | 1385908 | 1385908 | 489742 | 489742 | 2911 | 145 | 58 | 30.06 | 91.8 | 2911 | 145 | 58 | 30.06 | 91.8 | 33.77 | 33.77 |
| **Amuse** | 600 | 600 | 54719 | 54719 | 2525 | 2525 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3465 | 3465 | 61309 | 61309 | 38163 | 38163 | 835 | 74 | 59 | 17.96 | 37.7 | 835 | 74 | 59 | 17.96 | 37.7 | 58.81 | 58.81 |
| **RTA** | 460 | 460 | 28914 | 28914 | 1294 | 1294 | 0 | 0 | 0 | 0 | 5150 | 5150 | 0 | 0 | 805 | 805 | 36623 | 36623 | 20987 | 20987 | 1024 | 87 | 60 | 26.86 | 45.3 | 1024 | 87 | 60 | 26.86 | 45.3 | 52.90 | 52.90 |
| **South** | 2432 | 2432 | 565560 | 565560 | 8045 | 8045 | 46611 | 46611 | 0 | 0 | 114641 | 114641 | 23577 | 23577 | 44784 | 44784 | 805650 | 805650 | 460185 | 460185 | 1528 | 111 | 55 | 36.65 | 46.6 | 1528 | 111 | 55 | 36.65 | 46.6 | 51.85 | 51.85 |

| **Runoff Coefficients** | **Pre-Dev** | **Post-Dev** |
|---|---|---|
| Buildings | 0.9 | 0.9 |
| Lowlands | 0.6 | 0.6 |
| Hardstand, unsealed roads | 0.8 | 0.8 |
| Cleared Palusplain | 0.8 | 0.8 |
| Vegetated Palusplain | 0.6 | 0.6 |
| Cleared Uplands | 0.3 | 0.3 |
| Forested Uplands | 0.2 | 0.2 |
| Road Reserve | 0.8 | 0.8 |

**Rainfall IFD**

| **Event** | **Duration (mins)** | **Intensity (mm/hr)** |
|---|---|---|
| 5 min | 5 | 164.4 |
| 6 min | 6 | 154 |
| 10 min | 10 | 123.6 |
| 20 min | 20 | 83.7 |
| 30 min | 30 | 64.8 |
| 1 hr | 60 | 41.4 |
| 2 hr | 120 | 27 |
| 3 hr | 180 | 21.4 |
| 6 hr | 360 | 14.4 |
| 12 hr | 720 | 9.5 |
| 24 hr | 1440 | 5.75 |
| 48 hr | 2880 | 3.2 |
| 72 hr | 4320 | 2.2 |

**100 YEAR ARI FLOWS - UPSTREAM**

| Storm Duration (mins) | North 1 Upstream | | | North 2 Upstream | | | AMS Upstream | | | Inghams 1 Upstream | | | Inghams 2 Upstream | | | Inghams 3a Upstream | | | Inghams 3b Upstream | | | Inghams 4 Upstream | | | Amuse Upstream | | | RTA Upstream | | | South Upstream | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) |
| 5 | 1995.23 | 7462.19 | 5466.96 | 6939.14 | 7462.19 | 523.05 | 1185.24 | 4805.38 | 3620.13 | 2111.10 | 9472.84 | 7361.73 | 4599.51 | 19280.38 | 14680.87 | 3758.63 | 20385.09 | 16626.46 | 808.68 | 20385.09 | 19576.41 | 4593.52 | 22364.88 | 17771.36 | 623.47 | 1742.80 | 1119.33 | 308.36 | 958.39 | 650.02 | 6627.56 | 21015.09 | 14387.54 |
| 6 | 1995.23 | 6990.13 | 4994.89 | 6939.14 | 6990.13 | 50.99 | 1185.24 | 4501.39 | 3316.14 | 2111.10 | 8873.58 | 6762.48 | 4599.51 | 18060.70 | 13461.19 | 3758.63 | 19095.52 | 15336.89 | 808.68 | 19095.52 | 18286.84 | 4593.52 | 20950.07 | 16356.55 | 623.47 | 1632.55 | 1009.08 | 308.36 | 897.76 | 589.40 | 6627.56 | 19685.67 | 13058.11 |
| 10 | 1995.23 | 5610.26 | 3615.03 | 6939.14 | 5610.26 | -1328.88 | 1185.24 | 3612.80 | 2427.56 | 2111.10 | 7121.91 | 5010.81 | 4599.51 | 14495.47 | 9895.96 | 3758.63 | 15326.02 | 11567.39 | 808.68 | 15326.02 | 14517.34 | 4593.52 | 16814.47 | 12220.95 | 623.47 | 1310.28 | 686.81 | 308.36 | 720.54 | 412.18 | 6627.56 | 15799.67 | 9172.11 |
| 20 | 1995.23 | 3799.18 | 1803.95 | 6939.14 | 3799.18 | -3139.96 | 1185.24 | 2446.53 | 1261.29 | 2111.10 | 4822.85 | 2711.75 | 4599.51 | 9816.11 | 5216.60 | 3758.63 | 10378.54 | 6619.91 | 808.68 | 10378.54 | 9569.86 | 4593.52 | 11386.50 | 6792.98 | 623.47 | 887.30 | 263.83 | 308.36 | 487.94 | 179.57 | 6627.56 | 10699.29 | 4071.73 |
| 30 | 1995.23 | 2941.30 | 946.07 | 6939.14 | 2941.30 | -3997.84 | 1185.24 | 1894.09 | 708.85 | 2111.10 | 3733.82 | 1622.72 | 4599.51 | 7599.57 | 3000.06 | 3758.63 | 8035.00 | 4276.37 | 808.68 | 8035.00 | 7226.32 | 4593.52 | 8815.35 | 4221.83 | 623.47 | 686.94 | 63.47 | 308.36 | 377.76 | 69.39 | 6627.56 | 8283.32 | 1655.76 |
| 60 | 1995.23 | 1879.16 | -116.07 | 6939.14 | 1879.16 | -5059.97 | 1185.24 | 1210.11 | 24.87 | 2111.10 | 2385.50 | 274.39 | 4599.51 | 4855.28 | 255.77 | 3758.63 | 5133.47 | 1374.84 | 808.68 | 5133.47 | 4324.79 | 4593.52 | 5632.03 | 1038.51 | 623.47 | 438.88 | -184.59 | 308.36 | 241.35 | -67.02 | 6627.56 | 5292.12 | -1335.43 |
| 120 | 1995.23 | 1225.54 | -769.69 | 6939.14 | 1225.54 | -5713.60 | 1185.24 | 789.20 | -396.04 | 2111.10 | 1555.76 | -555.34 | 4599.51 | 3166.49 | -1433.02 | 3758.63 | 3347.92 | -410.71 | 808.68 | 3347.92 | 2539.24 | 4593.52 | 3673.06 | -920.45 | 623.47 | 286.23 | -337.24 | 308.36 | 157.40 | -150.96 | 6627.56 | 3451.38 | -3176.17 |
| 180 | 1995.23 | 971.36 | -1023.88 | 6939.14 | 971.36 | -5967.78 | 1185.24 | 625.52 | -559.73 | 2111.10 | 1233.08 | -878.02 | 4599.51 | 2509.73 | -2089.77 | 3758.63 | 2653.53 | -1105.10 | 808.68 | 2653.53 | 1844.85 | 4593.52 | 2911.24 | -1682.28 | 623.47 | 226.86 | -396.61 | 308.36 | 124.75 | -183.61 | 6627.56 | 2735.54 | -3892.02 |
| 360 | 1995.23 | 653.62 | -1341.61 | 6939.14 | 653.62 | -6285.52 | 1185.24 | 420.91 | -764.33 | 2111.10 | 829.74 | -1281.37 | 4599.51 | 1688.79 | -2910.71 | 3758.63 | 1785.56 | -1973.07 | 808.68 | 1785.56 | 976.88 | 4593.52 | 1958.97 | -2634.55 | 623.47 | 152.65 | -470.81 | 308.36 | 83.95 | -224.42 | 6627.56 | 1840.74 | -4786.82 |
| 720 | 1995.23 | 431.21 | -1564.02 | 6939.14 | 431.21 | -6507.93 | 1185.24 | 277.68 | -907.56 | 2111.10 | 547.40 | -1563.71 | 4599.51 | 1114.13 | -3485.37 | 3758.63 | 1177.97 | -2580.66 | 808.68 | 1177.97 | 369.29 | 4593.52 | 1292.37 | -3301.14 | 623.47 | 100.71 | -522.76 | 308.36 | 55.38 | -252.98 | 6627.56 | 1214.38 | -5413.18 |
| 1440 | 1995.23 | 261.00 | -1734.24 | 6939.14 | 261.00 | -6678.14 | 1185.24 | 168.07 | -1017.17 | 2111.10 | 331.32 | -1779.78 | 4599.51 | 674.34 | -3925.16 | 3758.63 | 712.98 | -3045.65 | 808.68 | 712.98 | -95.70 | 4593.52 | 782.23 | -3811.29 | 623.47 | 60.96 | -562.51 | 308.36 | 33.52 | -274.84 | 6627.56 | 735.02 | -5892.54 |
| 2880 | 1995.23 | 145.25 | -1849.98 | 6939.14 | 145.25 | -6793.89 | 1185.24 | 93.54 | -1091.71 | 2111.10 | 184.39 | -1926.72 | 4599.51 | 375.29 | -4224.22 | 3758.63 | 396.79 | -3361.84 | 808.68 | 396.79 | -411.89 | 4593.52 | 435.33 | -4158.19 | 623.47 | 33.92 | -589.54 | 308.36 | 18.65 | -289.71 | 6627.56 | 409.05 | -6218.50 |
| 4320 | 1995.23 | 99.86 | -1895.37 | 6939.14 | 99.86 | -6839.28 | 1185.24 | 64.31 | -1120.94 | 2111.10 | 126.77 | -1984.34 | 4599.51 | 258.01 | -4341.50 | 3758.63 | 272.79 | -3485.84 | 808.68 | 272.79 | -536.89 | 4593.52 | 299.29 | -4294.23 | 623.47 | 23.32 | -600.15 | 308.36 | 12.83 | -295.54 | 6627.56 | 281.22 | -6346.33 |
| **Critical Storm** | **1995.23** | **1995.23** | **0.00** | **6939.14** | **1995.23** | **-4943.90** | **1185.24** | **1185.24** | **0.00** | **2111.10** | **2111.10** | **0.00** | 4599.51 | **4599.51** | **0.00** | 3758.63 | **3758.63** | **0.00** | **808.68** | **3758.63** | **2949.95** | 4593.52 | **4593.52** | **0.00** | 623.47 | **623.47** | **0.00** | **308.36** | **308.36** | **0.00** | 6627.56 | **6627.56** | **0.00** |
| Duration (min) | 56.72 | 56.72 | | 183.84 | 0.00 | | 63.55 | 63.55 | | 79.84 | 79.84 | | 69.09 | 69.09 | | 106.20 | 106.20 | | 40.02 | 106.20 | | 91.81 | 91.81 | | 37.68 | 37.68 | | 45.26 | 45.26 | | 46.61 | 46.61 | |
| Intensity (mm/h) | 43.96 | 43.96 | | 21.25 | 0.00 | | 40.55 | 40.55 | | 36.64 | 36.64 | | 39.22 | 39.22 | | 30.31 | 30.31 | | 56.99 | 30.31 | | 33.77 | 33.77 | | 58.81 | 58.81 | | 52.90 | 52.90 | | 51.85 | 51.85 | |

**100 YEAR ARI DRAINAGE PROPERTIES - INTERNAL**

| CATCHMENT | AREAS (m2) | | | | | | | | | | | | | | | | EFFECTIVE AREA (m2) | | TIME OF CONCENTRATION PRE-DEVELOPMENT | | | | | TIME OF CONCENTRATION POST-DEVELOPMENT | | | | | CRITICAL STORM INTENSITY (mm/h) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Buildings | | Lowlands | | Hardstand, unsealed roads | | Cleared Palusplain | | Vegetated Palusplain | | Cleared Uplands | | Forested Uplands | | Road Reserve | | Total | | Pre Dev | Post Dev | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope (m/km) | TC (min) | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope | TC (min) | Pre-Dev | Post-Dev |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | | | | | | | | | | | | | |
| **North PI 1** | 493 | 2926 | 0 | 0 | 5774 | 23406 | 22991 | 0 | 0 | 2926 | 0 | 0 | 0 | 0 | 11113 | 11113 | 40371 | 40371 | 32346 | 32004 | 246 | 53 | 49 | 16.26 | 11.5 | 246 | 53 | 49 | 16.26 | 11.5 | 117.57 | 117.52 |
| **North PI 2** | 0 | 968 | 0 | 0 | 0 | 7741 | 9676 | 0 | 0 | 968 | 0 | 0 | 0 | 0 | 1880 | 1880 | 11556 | 11556 | 9245 | 9148 | 225 | 53 | 49 | 17.78 | 11.7 | 225 | 53 | 49 | 17.78 | 11.7 | 116.72 | 116.68 |
| **AMS PI 1** | 2776 | 3014 | 576 | 0 | 17122 | 24110 | 9663 | 0 | 0 | 3014 | 0 | 0 | 0 | 0 | 3556 | 3556 | 33693 | 33693 | 27117 | 26653 | 247 | 53 | 49 | 16.19 | 11.8 | 247 | 53 | 49 | 16.19 | 11.8 | 116.52 | 116.44 |
| **AMS PI 2** | 4530 | 4530 | 3052 | 1668 | 35228 | 23939 | 2207 | 0 | 0 | 3349 | 0 | 0 | 0 | 0 | 0 | 11531 | 45017 | 45017 | 35856 | 35463 | 263 | 53 | 49 | 13.31 | 12.7 | 550 | 53 | 49 | 6.36 | 30.8 | 112.91 | 64.20 |
| **AMS PI 3** | 380 | 380 | 16336 | 0 | 31914 | 31914 | 0 | 0 | 0 | 2240 | 0 | 0 | 0 | 0 | 12294 | 26390 | 60924 | 60924 | 45510 | 48329 | 630 | 53 | 48 | 7.62 | 33.2 | 630 | 53 | 48 | 7.62 | 33.0 | 62.34 | 62.49 |
| **Ingham PI 1** | 479 | 5810 | 65979 | 0 | 0 | 46477 | 4396 | 0 | 3641 | 5810 | 0 | 0 | 0 | 0 | 7970 | 24369 | 82465 | 82465 | 52096 | 65391 | 471 | 54 | 46 | 16.35 | 21.0 | 428 | 53 | 46 | 14.49 | 19.1 | 81.82 | 87.27 |
| **Ingham PI 2** | 1691 | 1243 | 8974 | 0 | 0 | 9943 | 834 | 0 | 2083 | 1243 | 0 | 0 | 0 | 0 | 0 | 1153 | 13582 | 13582 | 8823 | 10741 | 370 | 53 | 46 | 18.92 | 19.1 | 370 | 53 | 46 | 18.92 | 18.8 | 87.18 | 88.66 |
| **Ingham PI 3** | 1942 | 2143 | 13029 | 0 | 0 | 17146 | 3037 | 0 | 5597 | 2143 | 0 | 0 | 0 | 0 | 1467 | 3640 | 25072 | 25072 | 16527 | 19843 | 480 | 54 | 46 | 16.67 | 23.9 | 480 | 54 | 46 | 16.67 | 23.5 | 76.32 | 77.14 |
| **Ingham PI 4** | 1592 | 12461 | 80327 | 0 | 0 | 99687 | 42086 | 0 | 10294 | 12461 | 0 | 0 | 0 | 0 | 9243 | 18933 | 143542 | 143542 | 96869 | 113588 | 745 | 54 | 44 | 12.89 | 32.7 | 794 | 54 | 44 | 12.09 | 34.8 | 59.64 | 61.08 |
| **Ingham PI 5** | 0 | 9381 | 79851 | 0 | 0 | 75044 | 29773 | 0 | 7720 | 9381 | 0 | 0 | 0 | 0 | 11868 | 35407 | 129212 | 129212 | 85855 | 102432 | 738 | 55 | 45 | 13.96 | 32.3 | 834 | 54 | 45 | 11.15 | 37.5 | 63.01 | 58.95 |
| **Ingham PI 6** | 5735 | 22286 | 167415 | 0 | 0 | 178285 | 54819 | 0 | 37893 | 22286 | 0 | 0 | 0 | 0 | 12863 | 55869 | 278725 | 278725 | 182492 | 220751 | 876 | 55 | 43 | 13.70 | 35.7 | 876 | 58 | 43 | 16.55 | 33.7 | 60.37 | 61.91 |
| **Amuse** | 294 | 19440 | 151680 | 0 | 0 | 155522 | 49073 | 0 | 0 | 19440 | 0 | 0 | 0 | 0 | 11151 | 17795 | 212198 | 212198 | 139452 | 167814 | 1118 | 60 | 42 | 16.10 | 45.3 | 725 | 54 | 42 | 15.86 | 28.9 | 52.87 | 66.84 |
| **RTA** | 3334 | 65731 | 319119 | 0 | 121156 | 525851 | 275010 | 0 | 0 | 65731 | 0 | 0 | 0 | 0 | 11922 | 73227 | 730541 | 730541 | 520942 | 577860 | 1228 | 59 | 41 | 14.66 | 44.4 | 1212 | 60 | 41 | 15.68 | 42.8 | 53.54 | 54.80 |
| **South** | 0 | 12769 | 73662 | 0 | 0 | 102149 | 71196 | 0 | 0 | 12769 | 0 | 0 | 0 | 0 | 13085 | 30257 | 157943 | 157943 | 111622 | 125078 | 812 | 59 | 43 | 19.70 | 32.3 | 1362 | 59 | 41 | 13.22 | 58.0 | 63.00 | 42.93 |

| **Runoff Coefficients** | **Pre-Dev** | **Post-Dev** |
|---|---|---|
| Buildings | 0.9 | 0.9 |
| Lowlands | 0.6 | 0.6 |
| Hardstand, unsealed roads | 0.8 | 0.8 |
| Cleared Palusplain | 0.8 | 0.8 |
| Vegetated Palusplain | 0.6 | 0.6 |
| Cleared Uplands | 0.3 | 0.3 |
| Forested Uplands | 0.2 | 0.2 |
| Road Reserve | 0.8 | 0.8 |

**Rainfall IFD**

| **Event** | **Duration (mins)** | **Intensity (mm/hr)** |
|---|---|---|
| 5 min | 5 | 164.4 |
| 6 min | 6 | 154 |
| 10 min | 10 | 123.6 |
| 20 min | 20 | 83.7 |
| 30 min | 30 | 64.8 |
| 1 hr | 60 | 41.4 |
| 2 hr | 120 | 27 |
| 3 hr | 180 | 21.4 |
| 6 hr | 360 | 14.4 |
| 12 hr | 720 | 9.5 |
| 24 hr | 1440 | 5.75 |
| 48 hr | 2880 | 3.2 |
| 72 hr | 4320 | 2.2 |

**100 YEAR ARI FLOWS - INTERNAL**

| Storm Duration (mins) | North A | | | North B | | | AMS A | | | AMS B | | | AMS C | | | Ingham PI 1 | | | Ingham PI 2 | | | Ingham PI 3 | | | Ingham PI 4 | | | Ingham PI 5 | | | Ingham PI 6 | | | Amuse | | | RTA | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) |
| 5 | 1056.34 | 1461.53 | 405.19 | 299.75 | 1461.53 | 1161.78 | 877.69 | 1217.16 | 339.47 | 1124.57 | 1217.16 | 92.58 | 788.05 | 1217.16 | 429.11 | 1184.07 | 2986.19 | 1802.12 | 213.66 | 490.52 | 276.86 | 350.37 | 906.18 | 555.81 | 1604.81 | 5187.16 | 3582.35 | 1502.68 | 4677.71 | 3175.02 | 3060.11 | 10080.98 | 7020.87 | 2047.97 | 7663.52 | 5615.56 | 7747.59 | 26388.92 | 18641.34 | 1953.40 | 5711.87 | 3758.47 |
| 6 | 1056.34 | 1369.07 | 312.73 | 299.75 | 1369.07 | 1069.32 | 877.69 | 1140.16 | 262.47 | 1124.57 | 1140.16 | 15.58 | 788.05 | 1140.16 | 352.11 | 1184.07 | 2797.28 | 1613.21 | 213.66 | 459.49 | 245.83 | 350.37 | 848.85 | 498.49 | 1604.81 | 4859.02 | 3254.21 | 1502.68 | 4381.79 | 2879.11 | 3060.11 | 9443.26 | 6383.14 | 2047.97 | 7178.73 | 5130.76 | 7747.59 | 24719.55 | 16971.96 | 1953.40 | 5350.54 | 3397.14 |
| 10 | 1056.34 | 1098.81 | 42.47 | 299.75 | 1098.81 | 799.06 | 877.69 | 915.09 | 37.40 | 1124.57 | 915.09 | -209.49 | 788.05 | 915.09 | 127.04 | 1184.07 | 2245.09 | 1061.02 | 213.66 | 368.78 | 155.12 | 350.37 | 681.29 | 330.92 | 1604.81 | 3899.84 | 2295.03 | 1502.68 | 3516.82 | 2014.13 | 3060.11 | 7579.13 | 4519.02 | 2047.97 | 5761.63 | 3713.66 | 7747.59 | 19839.85 | 12092.26 | 1953.40 | 4294.33 | 2340.93 |
| 20 | 1056.34 | 744.10 | -312.24 | 299.75 | 744.10 | 444.35 | 877.69 | 619.68 | -258.01 | 1124.57 | 619.68 | -504.89 | 788.05 | 619.68 | -168.37 | 1184.07 | 1520.34 | 336.27 | 213.66 | 249.74 | 36.07 | 350.37 | 481.36 | 110.99 | 1604.81 | 2640.91 | 1036.10 | 1502.68 | 2381.53 | 878.85 | 3060.11 | 5132.47 | 2072.36 | 2047.97 | 3901.68 | 1853.72 | 7747.59 | 13439.24 | 5687.65 | 1953.40 | 2908.05 | 954.65 |
| 30 | 1056.34 | 576.08 | -480.26 | 299.75 | 576.08 | 276.33 | 877.69 | 479.75 | -397.94 | 1124.57 | 479.75 | -644.82 | 788.05 | 479.75 | -308.29 | 1184.07 | 1177.04 | -7.03 | 213.66 | 193.34 | -20.32 | 350.37 | 357.18 | 6.81 | 1604.81 | 2044.58 | 439.77 | 1502.68 | 1843.77 | 341.08 | 3060.11 | 3973.53 | 913.41 | 2047.97 | 3020.66 | 972.69 | 7747.59 | 10401.47 | 2653.89 | 1953.40 | 2251.40 | 297.99 |
| 60 | 1056.34 | 368.05 | -688.29 | 299.75 | 368.05 | 68.30 | 877.69 | 306.51 | -571.18 | 1124.57 | 306.51 | -818.06 | 788.05 | 306.51 | -481.54 | 1184.07 | 752.00 | -432.07 | 213.66 | 123.53 | -90.14 | 350.37 | 228.20 | -122.17 | 1604.81 | 1306.26 | -298.55 | 1502.68 | 1177.96 | -324.72 | 3060.11 | 2538.64 | -521.47 | 2047.97 | 1929.87 | -118.10 | 7747.59 | 6845.39 | -1102.20 | 1953.40 | 1438.39 | -515.01 |
| 120 | 1056.34 | 240.03 | -816.31 | 299.75 | 240.03 | -59.72 | 877.69 | 199.90 | -677.79 | 1124.57 | 199.90 | -924.68 | 788.05 | 199.90 | -588.15 | 1184.07 | 490.43 | -693.64 | 213.66 | 80.56 | -133.10 | 350.37 | 148.82 | -201.54 | 1604.81 | 851.91 | -752.90 | 1502.68 | 768.24 | -734.45 | 3060.11 | 1655.64 | -1404.48 | 2047.97 | 1258.61 | -789.36 | 7747.59 | 4333.95 | -3413.64 | 1953.40 | 938.08 | -1015.32 |
| 180 | 1056.34 | 190.25 | -866.09 | 299.75 | 190.25 | -109.50 | 877.69 | 158.44 | -719.25 | 1124.57 | 158.44 | -966.14 | 788.05 | 158.44 | -629.61 | 1184.07 | 388.71 | -795.36 | 213.66 | 63.85 | -149.81 | 350.37 | 117.96 | -232.41 | 1604.81 | 675.21 | -929.59 | 1502.68 | 608.90 | -893.78 | 3060.11 | 1312.24 | -1747.87 | 2047.97 | 997.56 | -1050.40 | 7747.59 | 3435.05 | -4312.53 | 1953.40 | 743.52 | -1209.89 |
| 360 | 1056.34 | 128.02 | -928.32 | 299.75 | 128.02 | -171.73 | 877.69 | 106.61 | -771.08 | 1124.57 | 106.61 | -1017.96 | 788.05 | 106.61 | -681.44 | 1184.07 | 261.56 | -922.51 | 213.66 | 42.97 | -170.70 | 350.37 | 79.37 | -270.99 | 1604.81 | 454.35 | -1150.46 | 1502.68 | 409.73 | -1092.96 | 3060.11 | 883.01 | -2177.11 | 2047.97 | 671.26 | -1376.71 | 7747.59 | 2311.44 | -5436.15 | 1953.40 | 500.31 | -1453.09 |
| 720 | 1056.34 | 84.46 | -971.88 | 299.75 | 84.46 | -215.29 | 877.69 | 70.33 | -807.36 | 1124.57 | 70.33 | -1054.24 | 788.05 | 70.33 | -717.71 | 1184.07 | 172.56 | -1011.51 | 213.66 | 28.35 | -185.32 | 350.37 | 52.36 | -298.00 | 1604.81 | 299.74 | -1305.06 | 1502.68 | 270.31 | -1232.38 | 3060.11 | 582.54 | -2477.57 | 2047.97 | 442.84 | -1605.12 | 7747.59 | 1524.91 | -6222.68 | 1953.40 | 330.07 | -1623.34 |
| 1440 | 1056.34 | 51.12 | -1005.22 | 299.75 | 51.12 | -248.63 | 877.69 | 42.57 | -835.12 | 1124.57 | 42.57 | -1082.00 | 788.05 | 42.57 | -745.48 | 1184.07 | 104.44 | -1079.63 | 213.66 | 17.16 | -196.51 | 350.37 | 31.69 | -318.67 | 1604.81 | 181.42 | -1423.39 | 1502.68 | 163.61 | -1339.08 | 3060.11 | 352.59 | -2707.52 | 2047.97 | 268.04 | -1779.93 | 7747.59 | 922.97 | -6824.62 | 1953.40 | 199.78 | -1753.63 |
| 2880 | 1056.34 | 28.46 | -1027.89 | 299.75 | 28.46 | -271.30 | 877.69 | 23.69 | -854.00 | 1124.57 | 23.69 | -1100.88 | 788.05 | 23.69 | -764.36 | 1184.07 | 58.13 | -1125.95 | 213.66 | 9.55 | -204.11 | 350.37 | 17.64 | -332.73 | 1604.81 | 100.97 | -1503.84 | 1502.68 | 91.05 | -1411.63 | 3060.11 | 196.22 | -2863.89 | 2047.97 | 149.17 | -1898.80 | 7747.59 | 513.65 | -7233.93 | 1953.40 | 111.18 | -1842.22 |
| 4320 | 1056.34 | 19.56 | -1036.78 | 299.75 | 19.56 | -280.19 | 877.69 | 16.29 | -861.40 | 1124.57 | 16.29 | -1108.29 | 788.05 | 16.29 | -771.76 | 1184.07 | 39.96 | -1144.11 | 213.66 | 6.56 | -207.10 | 350.37 | 12.13 | -338.24 | 1604.81 | 69.41 | -1535.39 | 1502.68 | 62.60 | -1440.09 | 3060.11 | 134.90 | -2925.21 | 2047.97 | 102.55 | -1945.41 | 7747.59 | 353.14 | -7394.45 | 1953.40 | 76.44 | -1876.97 |
| **Critical Storm** | **1056.34** | **1044.74** | **-11.60** | 299.75 | **1044.74** | **744.99** | 877.69 | **862.08** | **-15.61** | 1124.57 | **862.08** | **-262.50** | 788.05 | **862.08** | **74.03** | **1184.07** | **1585.26** | **401.19** | 213.66 | **264.54** | **50.88** | 350.37 | **425.19** | **74.83** | 1604.81 | **1927.14** | **322.33** | 1502.68 | **1677.21** | **174.53** | 3060.11 | **3796.04** | **735.93** | 2047.97 | **3115.73** | **1067.77** | **7747.59** | **8795.74** | **1048.15** | **1953.40** | **1491.72** | **-461.68** |
| Duration (min) | 11.51 | 11.52 | | 11.72 | 11.74 | | 11.77 | 11.79 | | 12.68 | 30.77 | | 33.16 | 32.96 | | 20.99 | 19.10 | | 19.13 | 18.76 | | 23.90 | 23.47 | | 32.73 | 34.77 | | 32.30 | 37.50 | | 35.68 | 33.71 | | 45.30 | 28.92 | | 44.44 | 42.83 | | 32.31 | 58.03 | |
| Intensity (mm/h) | 117.57 | 117.52 | | 116.72 | 116.68 | | 116.52 | 116.44 | | 112.91 | 64.20 | | 62.34 | 62.49 | | 81.82 | 87.27 | | 87.18 | 88.66 | | 76.32 | 77.14 | | 59.64 | 61.08 | | 63.01 | 58.95 | | 60.37 | 61.91 | | 52.87 | 66.94 | | 53.54 | 54.80 | | 63.00 | 42.93 | |

Total Peak Flows
Pre Development 23811.06 m3/s
Post Development 27754.30 m3/s

**100 YEAR ARI DRAINAGE PROPERTIES - COMBINED**

| Culvert | AREAS (m2) | | | | | | | | | | | | | | | | EFFECTIVE AREA (m2) | | TIME OF CONCENTRATION PRE-DEVELOPMENT | | | | | TIME OF CONCENTRATION POST-DEVELOPMENT | | | | | CRITICAL STORM INTENSITY (mm/h) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Buildings | | Lowlands | | Hardstand, unsealed roads | | Cleared Palusplain | | Vegetated Palusplain | | Cleared Uplands | | Forested Uplands | | Road Reserve | | Total | | Pre Dev | Post Dev | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope (m/km) | TC (min) | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope | TC (min) | Pre-Dev | Post-Dev |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | | | | | | | | | | | | | |
| **2.20** | 9035 | 11468 | 67975 | 67975 | 22659 | 40291 | 76593 | 53602 | 0 | 2926 | 0 | 0 | 0 | 0 | 84292 | 84292 | 260554 | 260554 | 195752 | 195410 | 1660 | 85 | 49 | 21.39 | 61.4 | 1660 | 85 | 49 | 21.39 | 61.4 | 41.06 | 41.06 |
| **2.28** | 0 | 968 | 142617 | 142617 | 5392 | 13133 | 74176 | 64500 | 70603 | 71571 | 2879828 | 2879828 | 634745 | 634745 | 2875 | 2875 | 3810236 | 3810236 | 1184784 | 1184687 | 6542 | 235 | 49 | 28.43 | 191.0 | 6542 | 235 | 49 | 28.43 | 191.0 | 20.97 | 20.97 |
| **2.39** | 2776 | 3014 | 576 | 0 | 17122 | 24110 | 9663 | 0 | 0 | 3014 | 0 | 0 | 0 | 0 | 3556 | 3556 | 33693 | 33693 | 27117 | 26653 | 218 | 53 | 49 | 16.06 | 10.4 | 218 | 53 | 49 | 16.06 | 10.4 | 121.97 | 121.89 |
| **2.60** | 4530 | 4530 | 3052 | 1668 | 35228 | 23939 | 2207 | 0 | 0 | 3349 | 0 | 0 | 0 | 0 | 0 | 13385 | 45017 | 46871 | 35856 | 36946 | 263 | 53 | 49 | 13.31 | 12.7 | 263 | 53 | 49 | 13.31 | 12.6 | 112.91 | 113.06 |
| **2.89** | 380 | 380 | 183640 | 167304 | 31914 | 31914 | 0 | 0 | 0 | 2240 | 0 | 0 | 0 | 0 | 18350 | 32446 | 234284 | 234284 | 150737 | 153556 | 1355 | 70 | 48 | 16.24 | 54.4 | 1355 | 70 | 48 | 16.24 | 54.3 | 45.78 | 45.86 |
| **3.11** | 479 | 5810 | 368160 | 302181 | 0 | 46477 | 4396 | 0 | 3641 | 5810 | 75326 | 75326 | 0 | 0 | 12380 | 28779 | 464382 | 464382 | 259530 | 272825 | 2822 | 128 | 47 | 28.88 | 95.6 | 2575 | 128 | 47 | 31.65 | 85.2 | 32.86 | 35.35 |
| **3.14** | 1691 | 1243 | 8974 | 0 | 0 | 9943 | 834 | 0 | 2083 | 1243 | 0 | 0 | 0 | 0 | 0 | 1153 | 13582 | 13582 | 8823 | 10741 | 378 | 53 | 46 | 18.52 | 19.6 | 378 | 53 | 46 | 18.52 | 19.2 | 85.19 | 86.72 |
| **3.20** | 0 | 2143 | 0 | 0 | 0 | 17146 | 0 | 0 | 0 | 2143 | 0 | 0 | 0 | 0 | 0 | 3640 | 0 | 25072 | 1 | 19843 | 20 | 46 | 46 | 0.50 | 5.3 | 456 | 54 | 46 | 17.54 | 22.1 | 161.23 | 79.79 |
| **3.52** | 0 | 13832 | 0 | 460463 | 0 | 99687 | 15914 | 0 | 7190 | 12461 | 0 | 469488 | 0 | 0 | 0 | 23733 | 23104 | 1079664 | 17045 | 535786 | 340 | 46 | 44 | 5.59 | 21.0 | 3116 | 129 | 44 | 27.28 | 99.3 | 81.80 | 31.97 |
| **3.64** | 0 | 9921 | 0 | 522370 | 0 | 75044 | 15208 | 0 | 2532 | 9381 | 0 | 422640 | 0 | 0 | 0 | 42518 | 17740 | 1081873 | 13686 | 548820 | 200 | 46 | 44 | 9.50 | 11.4 | 3715 | 125 | 44 | 21.86 | 123.5 | 118.18 | 26.68 |
| **3.89** | 11180 | 22286 | 1554184 | 244371 | 4605 | 178285 | 145713 | 56142 | 59586 | 22286 | 2053478 | 1161350 | 13741 | 13741 | 62387 | 63773 | 3904874 | 1762233 | 1767280 | 769764 | 3756 | 141 | 43 | 26.09 | 107.2 | 3725 | 141 | 43 | 26.31 | 115.3 | 30.08 | 28.12 |
| **Ebrook** | 4688 | 86232 | 554432 | 83633 | 124975 | 685193 | 324083 | 0 | 0 | 85172 | 5150 | 5150 | 0 | 0 | 27343 | 95292 | 1040671 | 1040671 | 719544 | 804824 | 2280 | 87 | 41 | 20.18 | 74.9 | 2280 | 87 | 41 | 20.18 | 74.1 | 37.82 | 38.02 |
| **South** | 2432 | 15201 | 639222 | 565560 | 8045 | 110194 | 117807 | 46611 | 0 | 12769 | 114641 | 114641 | 23577 | 23577 | 57869 | 75041 | 963593 | 963593 | 571807 | 585262 | 1528 | 111 | 54 | 37.30 | 45.4 | 1528 | 111 | 54 | 37.30 | 45.3 | 52.75 | 52.84 |

| **Runoff Coefficients** | **Pre-Dev** | **Post-Dev** |
|---|---|---|
| Buildings | 0.9 | 0.9 |
| Lowlands | 0.6 | 0.6 |
| Hardstand, unsealed roads | 0.8 | 0.8 |
| Cleared Palusplain | 0.8 | 0.8 |
| Vegetated Palusplain | 0.6 | 0.6 |
| Cleared Uplands | 0.3 | 0.3 |
| Forested Uplands | 0.2 | 0.2 |
| Road Reserve | 0.8 | 0.8 |

**Rainfall IFD**

| **Event** | **Duration (mins)** | **Intensity (mm/hr)** |
|---|---|---|
| 5 min | 5 | 164.4 |
| 6 min | 6 | 154 |
| 10 min | 10 | 123.6 |
| 20 min | 20 | 83.7 |
| 30 min | 30 | 64.8 |
| 1 hr | 60 | 41.4 |
| 2 hr | 120 | 27 |
| 3 hr | 180 | 21.4 |
| 6 hr | 360 | 14.4 |
| 12 hr | 720 | 9.5 |
| 24 hr | 1440 | 5.75 |
| 48 hr | 2880 | 3.2 |
| 72 hr | 4320 | 2.2 |

**100 YEAR ARI FLOWS - COMBINED**

| Storm Duration (mins) | 2.20 | | | 2.28 | | | 2.39 | | | 2.60 | | | 2.89 | | | 3.11 | | | 3.14 | | | 3.20 | | | 3.52 | | | 3.64 | | | 3.89 | | | Ebrook | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) |
| 5 | 2232.55 | 8923.72 | 6691.16 | 6902.21 | 54100.71 | 47198.50 | 918.70 | 1217.16 | 298.46 | 1124.57 | 1687.22 | 562.64 | 1916.99 | 7012.41 | 5095.42 | 2368.69 | 12459.03 | 10090.34 | 208.80 | 490.52 | 281.72 | 0.04 | 906.18 | 906.13 | 387.32 | 24467.54 | 24080.22 | 449.28 | 25082.80 | 24613.52 | 14764.76 | 35152.56 | 20387.79 | 7558.27 | 36753.63 | 29195.36 | 8379.14 | 26726.97 | 18347.82 |
| 6 | 2232.55 | 8359.20 | 6126.64 | 6902.21 | 50678.28 | 43776.07 | 918.70 | 1140.16 | 221.46 | 1124.57 | 1580.48 | 455.91 | 1916.99 | 6568.80 | 4651.81 | 2368.69 | 11670.87 | 9302.17 | 208.80 | 459.49 | 250.69 | 0.04 | 848.85 | 848.81 | 387.32 | 22919.72 | 22532.40 | 449.28 | 23477.31 | 23028.04 | 14764.76 | 32928.80 | 18164.03 | 7558.27 | 34428.58 | 26870.32 | 8379.14 | 25036.21 | 16657.07 |
| 10 | 2232.55 | 6709.07 | 4476.52 | 6902.21 | 40674.26 | 33772.05 | 918.70 | 915.09 | -3.61 | 1124.57 | 1268.49 | 143.92 | 1916.99 | 5272.10 | 3355.12 | 2368.69 | 9367.01 | 6998.32 | 208.80 | 368.78 | 159.99 | 0.04 | 681.29 | 681.24 | 387.32 | 18395.31 | 18007.99 | 449.28 | 18842.83 | 18393.55 | 14764.76 | 26428.57 | 11663.80 | 7558.27 | 27632.29 | 20074.02 | 8379.14 | 20094.00 | 11714.85 |
| 20 | 2232.55 | 4543.28 | 2310.72 | 6902.21 | 27543.97 | 20641.77 | 918.70 | 619.68 | -299.01 | 1124.57 | 859.00 | -265.57 | 1916.99 | 3570.19 | 1653.20 | 2368.69 | 6343.19 | 3974.50 | 208.80 | 249.74 | 40.94 | 0.04 | 461.36 | 461.31 | 387.32 | 12457.02 | 12069.69 | 449.28 | 12760.07 | 12310.79 | 14764.76 | 17897.01 | 3132.25 | 7558.27 | 18712.16 | 11153.89 | 8379.14 | 13607.34 | 5228.20 |
| 30 | 2232.55 | 3517.38 | 1284.82 | 6902.21 | 21324.37 | 14422.16 | 918.70 | 479.75 | -438.94 | 1124.57 | 665.04 | -459.54 | 1916.99 | 2764.02 | 847.03 | 2368.69 | 4910.86 | 2542.17 | 208.80 | 193.34 | -15.45 | 0.04 | 357.18 | 357.13 | 387.32 | 9644.14 | 9256.82 | 449.28 | 9878.77 | 9429.49 | 14764.76 | 13855.75 | -909.01 | 7558.27 | 14486.83 | 6928.56 | 8379.14 | 10534.72 | 2155.57 |
| 60 | 2232.55 | 2247.21 | 14.66 | 6902.21 | 13623.90 | 6721.70 | 918.70 | 306.51 | -612.19 | 1124.57 | 424.88 | -699.69 | 1916.99 | 1765.90 | -151.09 | 2368.69 | 3137.49 | 768.80 | 208.80 | 123.53 | -85.27 | 0.04 | 228.20 | 228.15 | 387.32 | 6161.53 | 5774.21 | 449.28 | 6311.43 | 5862.15 | 14764.76 | 8852.29 | -5912.48 | 7558.27 | 9255.48 | 1697.21 | 8379.14 | 6730.51 | -1648.63 |
| 120 | 2232.55 | 1465.57 | -766.98 | 6902.21 | 8885.15 | 1982.95 | 918.70 | 199.90 | -718.80 | 1124.57 | 277.10 | -847.48 | 1916.99 | 1151.67 | -765.31 | 2368.69 | 2046.19 | -322.50 | 208.80 | 80.56 | -128.24 | 0.04 | 148.82 | 148.78 | 387.32 | 4018.39 | 3631.07 | 449.28 | 4116.15 | 3666.87 | 14764.76 | 5773.23 | -8991.53 | 7558.27 | 6036.18 | -1522.09 | 8379.14 | 4389.47 | -3989.68 |
| 180 | 2232.55 | 1161.60 | -1070.95 | 6902.21 | 7042.31 | 140.10 | 918.70 | 158.44 | -760.26 | 1124.57 | 219.63 | -904.95 | 1916.99 | 912.81 | -1004.18 | 2368.69 | 1621.80 | -746.90 | 208.80 | 63.85 | -144.95 | 0.04 | 117.96 | 117.91 | 387.32 | 3184.95 | 2797.63 | 449.28 | 3262.43 | 2813.15 | 14764.76 | 4575.82 | -10188.94 | 7558.27 | 4784.23 | -2774.04 | 8379.14 | 3479.06 | -4900.09 |
| 360 | 2232.55 | 781.64 | -1450.92 | 6902.21 | 4738.75 | -2163.46 | 918.70 | 106.61 | -812.08 | 1124.57 | 147.79 | -976.79 | 1916.99 | 614.23 | -1302.76 | 2368.69 | 1091.30 | -1277.39 | 208.80 | 42.97 | -165.83 | 0.04 | 79.37 | 79.33 | 387.32 | 2143.14 | 1755.82 | 449.28 | 2195.28 | 1746.00 | 14764.76 | 3079.06 | -11685.71 | 7558.27 | 3219.30 | -4338.97 | 8379.14 | 2341.05 | -6038.10 |
| 720 | 2232.55 | 515.66 | -1716.89 | 6902.21 | 3126.26 | -3775.95 | 918.70 | 70.33 | -848.36 | 1124.57 | 97.50 | -1027.08 | 1916.99 | 405.22 | -1511.77 | 2368.69 | 719.96 | -1648.74 | 208.80 | 28.35 | -180.45 | 0.04 | 52.36 | 52.32 | 387.32 | 1413.88 | 1026.56 | 449.28 | 1448.28 | 999.00 | 14764.76 | 2031.32 | -12733.44 | 7558.27 | 2123.94 | -5434.43 | 8379.14 | 1544.44 | -6834.70 |
| 1440 | 2232.55 | 312.11 | -1920.44 | 6902.21 | 1892.21 | -5010.00 | 918.70 | 42.57 | -876.13 | 1124.57 | 59.01 | -1065.56 | 1916.99 | 245.26 | -1671.72 | 2368.69 | 435.76 | -1932.93 | 208.80 | 17.16 | -191.64 | 0.04 | 31.69 | 31.65 | 387.32 | 855.77 | 468.45 | 449.28 | 876.59 | 427.31 | 14764.76 | 1229.48 | -13535.28 | 7558.27 | 1285.48 | -6272.78 | 8379.14 | 934.79 | -7444.35 |
| 2880 | 2232.55 | 171.70 | -2058.86 | 6902.21 | 1053.06 | -5849.15 | 918.70 | 23.69 | -895.01 | 1124.57 | 32.84 | -1091.73 | 1916.99 | 136.49 | -1780.49 | 2368.69 | 242.51 | -2126.18 | 208.80 | 9.55 | -199.26 | 0.04 | 17.64 | 17.59 | 387.32 | 476.26 | 88.93 | 449.28 | 487.84 | 38.56 | 14764.76 | 684.23 | -14080.53 | 7558.27 | 715.40 | -6842.87 | 8379.14 | 520.23 | -7858.91 |
| 4320 | 2232.55 | 119.42 | -2113.14 | 6902.21 | 723.98 | -6178.23 | 918.70 | 16.29 | -902.41 | 1124.57 | 22.58 | -1102.00 | 1916.99 | 93.84 | -1823.15 | 2368.69 | 166.73 | -2201.96 | 208.80 | 6.56 | -202.23 | 0.04 | 12.13 | 12.08 | 387.32 | 327.42 | -59.90 | 449.28 | 335.39 | -113.89 | 14764.76 | 470.41 | -14294.35 | 7558.27 | 491.84 | -7066.43 | 8379.14 | 357.66 | -8021.48 |
| **Critical Storm** | **2232.55** | **2228.52** | **-4.04** | **6902.21** | **13510.55** | **6608.34** | **918.70** | **902.45** | **-16.24** | **1124.57** | **1160.32** | **35.75** | 1916.99 | **1956.19** | **39.20** | 2368.69 | **2678.79** | **310.09** | **208.80** | **105.47** | **-103.33** | 0.04 | **439.79** | **439.74** | 387.32 | **4757.67** | **4370.35** | **449.28** | **4066.93** | **3617.65** | 14764.76 | **6013.48** | **-8751.28** | 7558.27 | **8498.85** | **940.58** | 8379.14 | **8589.71** | **210.56** |
| Duration (min) | 61.42 | 61.44 | | 190.99 | 0.00 | | 10.41 | 10.43 | | 12.68 | 12.64 | | 54.38 | 54.28 | | 95.60 | 85.22 | | 19.63 | 85.22 | | 5.30 | 22.07 | | 21.00 | 99.30 | | 11.36 | 123.46 | | 107.18 | 115.32 | | 43.00 | 74.10 | | 30.08 | 45.34 | |
| Intensity (mm/h) | 41.06 | 41.06 | | 20.97 | 0.00 | | 121.97 | 121.89 | | 112.91 | 113.06 | | 45.78 | 45.86 | | 32.86 | 35.35 | | 85.19 | 35.35 | | 161.23 | 79.79 | | 81.80 | 31.97 | | 118.18 | 26.68 | | 30.08 | 28.12 | | 0.00 | 38.02 | | 0.00 | 52.84 | |

Total Peak Flows
Pre Development 47211.33 m3/s
Post Development 54908.71 m3/s

| Culvert Flows | Max Flow | Pre Development Inflow(1) | Flow Through | Bypass | Post Development Inflow(1) | Flow Through | Bypass |
|---|---|---|---|---|---|---|---|
| **2.20** | 0.26 | 2.23 | 0.26 | 1.97 | 2.23 | 0.26 | 1.97 |
| **2.28** | 14.57 | 8.87 | 8.87 | 0.00 | 15.48 | 14.57 | 0.91 |
| **2.39** | 1.45 | 0.92 | 0.92 | 0.00 | 1.82 | 1.45 | 0.36 |
| **2.60** | 8.06 | 1.12 | 1.12 | 0.00 | 1.52 | 1.52 | 0.00 |
| **2.89** | 1.68 | 1.92 | 1.68 | 0.24 | 1.96 | 1.68 | 0.28 |
| **3.11** | 1.04 | 2.61 | 1.04 | 1.57 | 2.96 | 1.04 | 1.92 |
| **3.14** | 1.40 | 1.78 | 1.40 | 0.38 | 2.02 | 1.40 | 0.62 |
| **3.20** | 0.94 | 0.00 | 0.00 | 0.00 | 1.06 | 0.94 | 0.12 |
| **3.52** | 0.73 | 0.39 | 0.39 | 0.00 | 4.88 | 0.73 | 4.15 |
| **3.64** | 1.73 | 0.45 | 0.45 | 0.00 | 8.21 | 1.73 | 6.49 |
| **3.89** | 3.46 | 14.76 | 3.46 | 11.30 | 12.50 | 3.46 | 9.04 |
| **Ebrook** | 0.00 | 18.86 | 18.86 | 0.00 | 17.54 | 17.54 | 0.00 |
| **South** | 0.00 | 8.38 | 8.38 | 0.00 | 8.59 | 8.59 | 0.00 |

(1) Inflow includes bypass from previous culvert

# APPENDIX C TRANSPORT IMPACT ASSESSMENT

# Muchea Employment Node Precinct 3

## Structure Plan
## Transport Impact Assessment

Prepared by: GTA Consultants (WA) Pty Ltd for Tomahawk Property on behalf of the Muchea Precinct 3 Landowners

on 12/12/18

Reference: W150400

Issue #: A-F

GTAconsultants

# Muchea Employment Node Precinct 3

## Structure Plan
## Transport Impact Assessment

Client: Tomahawk Property on behalf of the Muchea Precinct 3 Landowners

on 12/12/18

Reference: W150400

Issue #: A-F

### Quality Record

| Issue | Date | Description | Prepared By | Checked By | Approved By | Signed |
|---|---|---|---|---|---|---|
| A-F | 11/12/18 | Final | AZ/RD | TM | TM | |

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GTA Report ()

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# EXECUTIVE SUMMARY

# EXECUTIVE SUMMARY

A Structure Plan is currently being prepared for Precinct 3 of the Muchea Employment Node Structure Plan (MENSP) area. The Structure Plan proposes an industrial development consisting of approximately 52 lots of varying size in a total land area of approximately 150Ha.

The Structure Plan area will include a proportion of river foreshore for Ellen Brook proposed to be located in the south west corner of the Structure Plan area.

Overall traffic volumes expected to be generated by the Structure Plan area is to be approximately 4,400 vehicle movements per day, with most of these vehicles accessing Great Northern Highway via the main proposed access loop road at the southern end of the Structure Plan area.

Total traffic volumes expected on Great Northern Highway with the advent of the entire MENSP by 2031 are expected to be significantly less than traffic volumes recorded in 2012/13. This is due to the opening of the Perth-Darwin National Highway (Northlink) in 2019 which will redistribute traffic off the Great Northern Highway.

The Structure Plan's internal road network has been designed to allow RAV7 and RAV10 vehicles to turn lane correct at intersections and to stay lane correct on road bends.

No footpath or bike network facilities are proposed, owing to the transport logistics uses anticipated.

Great Northern Highway will be upgraded to accommodate these new intersections with left and right turn deceleration lanes. No acceleration lanes are proposed on Great Northern Highway due to the proximity of the northern intersection to Brand Highway/Muchea East Road and the access to overtaking lanes near the southern intersection.

Assessment of the proposed traffic and transport network has shown that the proposed connectivities will function adequately when the Structure Plan area is fully developed, assumed and estimated to be by 2031.

The proposed unsignalised T-junction intersections of the main access loop road with Great Northern Highway have been shown to operate satisfactorily under estimated future PM peak traffic flows.

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# 1. INTRODUCTION

01

## 1.1. Background & Proposal

A Structure Plan is currently being prepared for land identified in the Muchea Employment Node Structure Plan (MENSP) as Precinct 3 - West. The Structure Plan is for a predominantly Industrial development as well as supporting land reserved for conservation recreation, foreshore management and/or regional open space.

GTA Consultants (GTA) was engaged by Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group in October 2018 to undertake a transport impact assessment of the proposed development.

## 1.2. Purpose of this Report

*Volume 2 of the Western Australian Planning Commission Transport Assessment Guidelines (WAPC Guidelines)* provide direction on the preparation of a Transport Impact Assessment (TIA) for Planning Schemes and Structure Plans. The WAPC Guidelines identify that a TIA for a Structure Plan is to provide a broad-brush assessment.

The current WAPC policy requires all structure plans to be supported by a transport assessment.

In accordance with the WAPC Guidelines, this TIA outlines:

- Existing transport conditions proximate to the site
- The adequacy of the proposed site layout
- The traffic generating characteristics of the proposed development
- The anticipated impact of the proposed development on the surrounding road network.

## 1.3. Summary of key issues

From a traffic and transport point of view, the following key provisions are immediately identified for this TIA:

- Suitable internal road network for the expected maximum sized Restricted Access Vehicle (RAV)
- Suitable modification to the external road network to accommodate RAVs to and from the Structure Plan area.

## 1.4. Previous Studies

The following studies were previously prepared and are relevant to the subject site due to their proximity:

- Muchea Employment Node Structure Plan (DoP/WAPC, August 2011).

## 1.5. References

In preparing this report, reference has been made to the following:

- Shire of Chittering Town Planning Scheme No.6 (TPS 6)
- Development Control Policy 4.1 – Industrial Subdivision
- WAPC Transport Assessment Guidelines for Development
- Australian Standard, Parking Facilities, Part 2: Off-Street Commercial Vehicle Facilities AS 2890.2:2002
- plans for the proposed structure plan dated 21 November 2018 prepared by Urbis
- traffic surveys undertaken by GTA Consultants as referenced in the context of this report
- various technical data as referenced in this report
- an inspection of the site and its surrounds
- other documents as nominated.

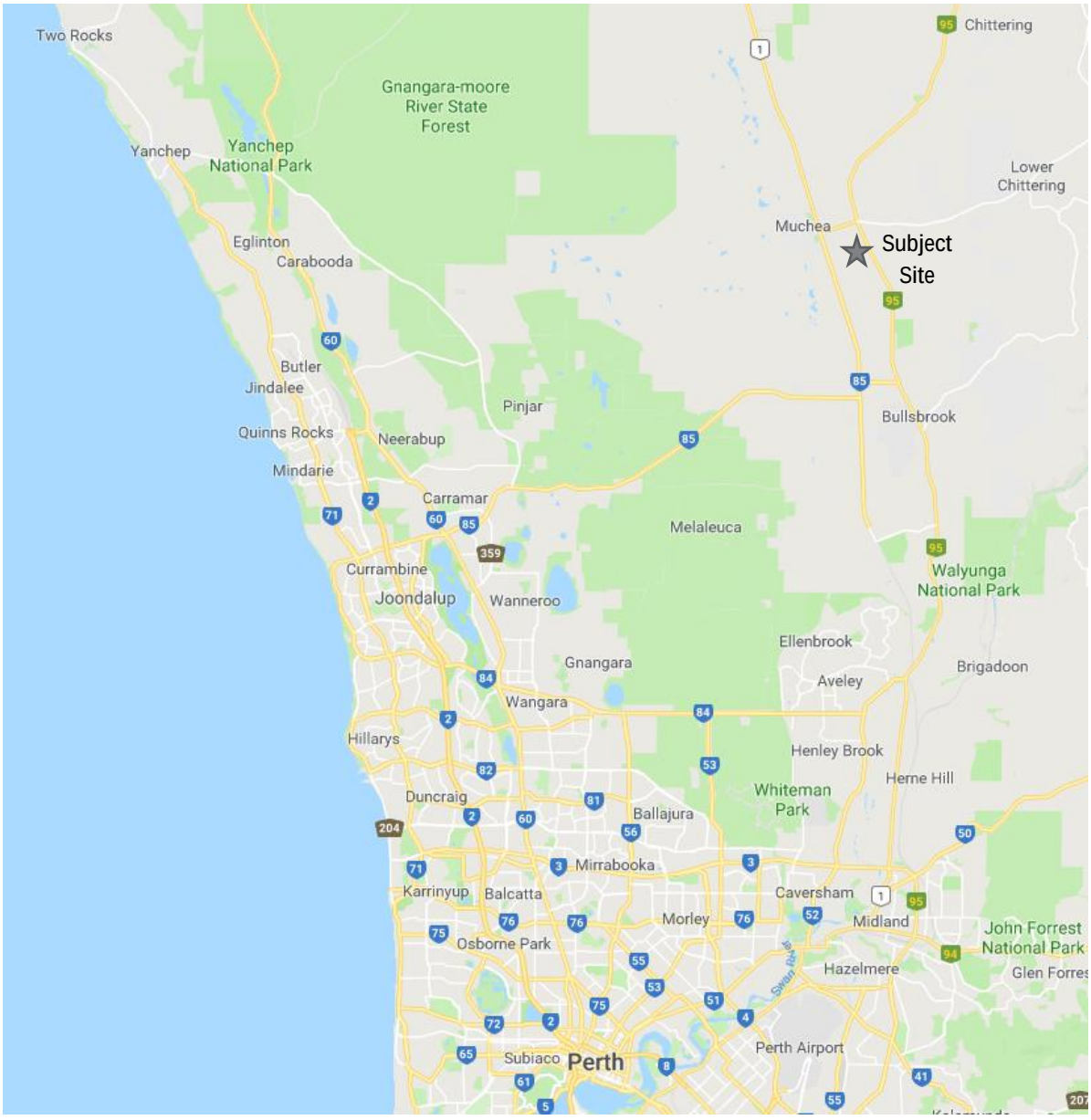
# 2. STRUCTURE PLAN OUTLINE

02

## 2.1. Regional Context

The subject site is located on the western side of Great Northern Highway, in Muchea, approximately 3km south-east of the Muchea Town Site, and approximately 55km north-east of the Perth CBD. The subject site is approximately 12km north of Bullsbrook, approximately 26km north of Ellenbrook and approximately 39km north of Midland. The State Government's Perth-Darwin National Highway (PDNH / Northlink) will bound the subject site to the west and south-west.

Figure 2.1: Location Map




(PhotoMap courtesy of GoogleMaps)

## 2.2. Proposed Land Uses

The structure plan proposes Industrial zoning which is consistent with the MENSP. The use of the lots will be typically for road transport purposes with RAV vehicles accessing the site from both north and south of Great Northern Highway. The

overall structure plan area is approximately 150 hectares, and this is proposed to be developed into lots ranging in size from 1.6Ha to 7.7Ha with the varying lot sizes spread throughout the structure plan area. The layout of the Structure Plan Area is shown in Appendix A.

Table 2.1: Land Uses

| Land Use | No./Area |
|---|---|
| Industrial/Road Transport Purposes | 52 lots with a total area of ~150Ha |

## 2.3. Attractors or Generators of Traffic (non-residential)

Given that the structure plan area is Industrial, a major employment attractor, there are numerous generators of traffic within this structure plan area. The intensity of the traffic generation however is expected to be low given the anticipated business type carried out by transport operators using the area for transport logistics uses.

## 2.4. Specific issues

Access to the Structure Plan area will be via Great Northern Highway. This access is proposed to be via two intersections, a northern intersection closer to Brand Highway and a southern intersection near the southern boundary of the Structure Plan Area. In discussion with the Shire of Chittering and the client, there is a desire to provide access to the site for vehicles up to RAV10 size. Vehicles of this size can be up to 53.5m in length and would be the largest vehicle ordinarily permitted on the road system under permit. Specific provision for RAV10 vehicles has been allowed for the "loop" road within the site connecting the northern intersection with the southern intersection (showed marked in blue in Appendix A), with the remainder of the roads within the area designed with the intention to provide RAV7 access (vehicles up to 36.5m length).

When the PDNH is opened vehicles up to RAV7 combination access will be allowed on the PDNH placing less reliance on Great Northern Highway for RAV use. However, Great Northern Highway in the vicinity of the Structure Plan Area is proposed to remain under the control of Main Roads WA as a Primary Distributor.

RAV10 vehicles are expected to travel to and from the wider MEN structure plan area via the northern approaches (PDNH and Muchea East Road), whilst RAV7 vehicles would be able to approach the site from both north and south approaches of Great Northern Highway.

# 3. EXISTING SITUATION

03

## 3.1. Subject Site

The subject site comprises of 8 existing lots to the west of Great Northern Highway in Muchea with the alignment of the new PDNH forming the western edge. The Structure Plan has changed slightly to the MENSP to now include a longer internal loop road connecting the northern and southern intersections on Great Northern Highway. The adjustment to the road alignment has resulted from a site-specific analysis which identified drainage requirements necessitating a realignment of roads in the Structure Plan Area.

TPS 2 states that the Industrial Development Zone requires a structure plan to further guide development, and as such this Structure Plan was prepared.

The surrounding properties include a mix of zones including the Rural Water Resource, Parks and Recreation and Rural Agricultural Zones.

The location of the subject site and the surrounding environs is shown in Figure 3.1.

Figure 3.1: Subject Site and its Environs

(PhotoMap courtesy of NearMap Pty Ltd)

## 3.2. Existing Movement Network

### 3.2.1. Roads (inc RAV Networks)

The development of the Muchea area is limited and the land is currently largely rural. Current development on the existing lots includes chicken farms, transport depot and other low impact land uses.

#### Perth-Darwin National Highway (Northlink)

The State Government has committed to the Perth-Darwin National Highway, which is a new 37km link from the intersection of Reid and Tonkin Highways to Great Northern Highway and Brand Highway at Muchea, adjacent to the structure plan area. This new route will increase efficiency and support the development of the Muchea Employment Node. The project is currently being developed by Main Roads Western Australia (MRWA).

Works on the route started in 2017 and is expected to be completed by the end of 2019.

Once complete this road is expected to carry in the order of 11,500vpd by 2031 south of Brand Highway[1].

#### Great Northern Highway

Great Northern Highway is a Primary Distributor road which runs north-south and forms the eastern frontage of the structure plan area. It has a posted speed limit of 110km/h as per the MRWA Road Information Mapping System except on the southern approach to the intersection of Brand Highway/Muchea East Road where it drops to 80km/h approximately 500m south of this intersection. It is also currently the key route to the Perth Metropolitan Region. Traffic volumes in 2018/19 recorded by MRWA showed 8,605 vehicles per day (vpd) with 25.6% heavy vehicles (including RAVs). Great Northern Highway has a typical carriageway of width of 7.2m and includes sealed shoulders either side of this within a 40m wide road reserve. There are overtaking lanes for both northbound and southbound traffic flows near the proposed location of the new southern intersection with these being approximately:

- Southbound: 1.2km long (500m is south of proposed intersection)
- Northbound: 800m long (800m is north of proposed intersection).

#### Muchea East Road

Muchea East Road continues east from Brand Highway at the Great Northern Highway intersection, at the northernmost part of the structure plan area. Muchea East Road is a Regional Distributor and has a posted speed limit of 80km/h for approximately 1.5km east from the Great Northern Highway intersection then 100km/h and 90km/h when it reaches Lower Chittering.

#### RAV Network

Most major roads in the vicinity of the site allow the movement of RAVs. Presently the largest size vehicle permitted are vehicles up to RAV7 size which can be up to 36.5m length. These vehicles are referred to as triple road trains and include combinations of:

- Prime mover, semi-trailer and B-double
- B-double towing a dog trailer.

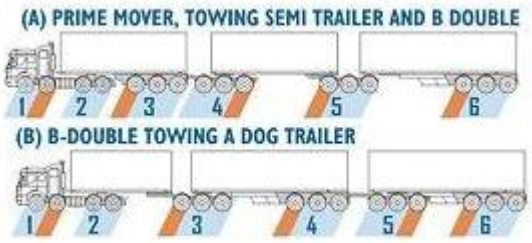
Refer to Figure 3.2 below.

In addition to the above, Great Northern Highway is presently a high/wide load route for the transit of over-dimensional loads.

[1] Muchea Employment Node Structure Plan (DoP/WAPC, August 2011).

Discussed elsewhere in this report, this section of Great Northern Highway is proposed to be incorporated in the RAV10 network. An application for this use would need to be made once intersection modifications and new roads have been constructed.

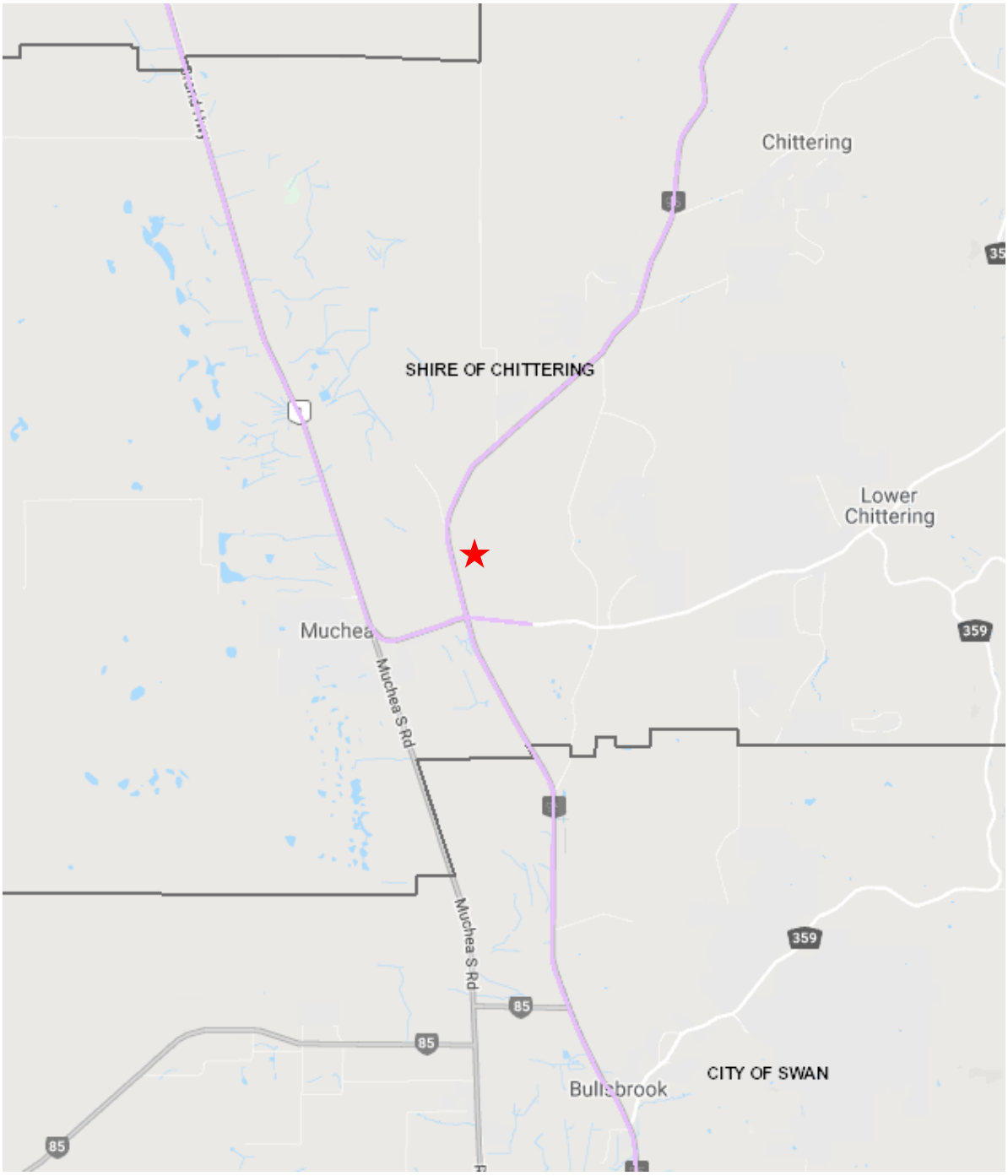
Figure 3.2: RAV7 Prime Mover, Trailer Combinations




(Source: Main Roads WA)

These routes are shown below in Figure 3.3, an excerpt from the Main Roads RAV Mapping tool.

Figure 3.3: RAV7 Network in Vicinity on SP Area




### 3.2.2. Pedestrian and Cyclist Network

There are limited pedestrian and cycling facilities in the network due to the rural location of the structure plan area. The MENSP also sets out that no formal cycle or pedestrian facilities are provided in the structure plan, however it recommends a sealed shoulder which could be used by cyclists. With 10m wide carriageways within the Structure Plan Area, where kerbed, cyclists are expected to ride on the carriageway and where unkerbed, they will be expected to ride on the sealed shoulder.

### 3.2.3. Public Transport

The MENSP sets out that the provision of public transport facilities has not been included in the structure plan, and notes that the nature of the land uses within the structure plan would make it difficult to provide public transport. However, given that the network is to be designed by trucks, buses would have the geometric road space to also use the network.

TransWA runs services once daily to Muchea from the East Perth Terminal to Kalbarri route.

## 3.3. Existing Road Network (Within 2km)

In addition to roads discussed above which directly abut the structure plan area, there are also a number of other roads within a 2km radius of the site.

#### Brand Highway

Brand Highway runs east-west at the northernmost portion of the site and continues north to Geraldton. It is a Primary Distributor road and has a posted speed limit of 80km/h from the intersection to Chittering Street as per the MRWA Road Information Mapping System.

#### Muchea South Road

Muchea South Road runs south off Brand Highway, and north-south adjacent to the structure plan area. It is currently identified as a Regional Distributor road and has a posted speed limit of 60km/h between Brand Highway and Porter Street, and then 90km/h south of Porter Street as per the MRWA Road Information Mapping System.

#### Muchea East Road

Muchea East Road runs west to east from the intersection of Brand Highway and Great Northern Highway. It is currently identified as a Regional Distributor road and has a posted speed limit of 60km/h near Great Northern Highway and 80km/h further to the east as per the MRWA Road Information Mapping System. Approximately 800vpd (2018/19) utilise Muchea East Road, just east of Great Northern Highway.

## 3.4. Traffic Counts (within 2km)

Figure 3.4: Location of Counters

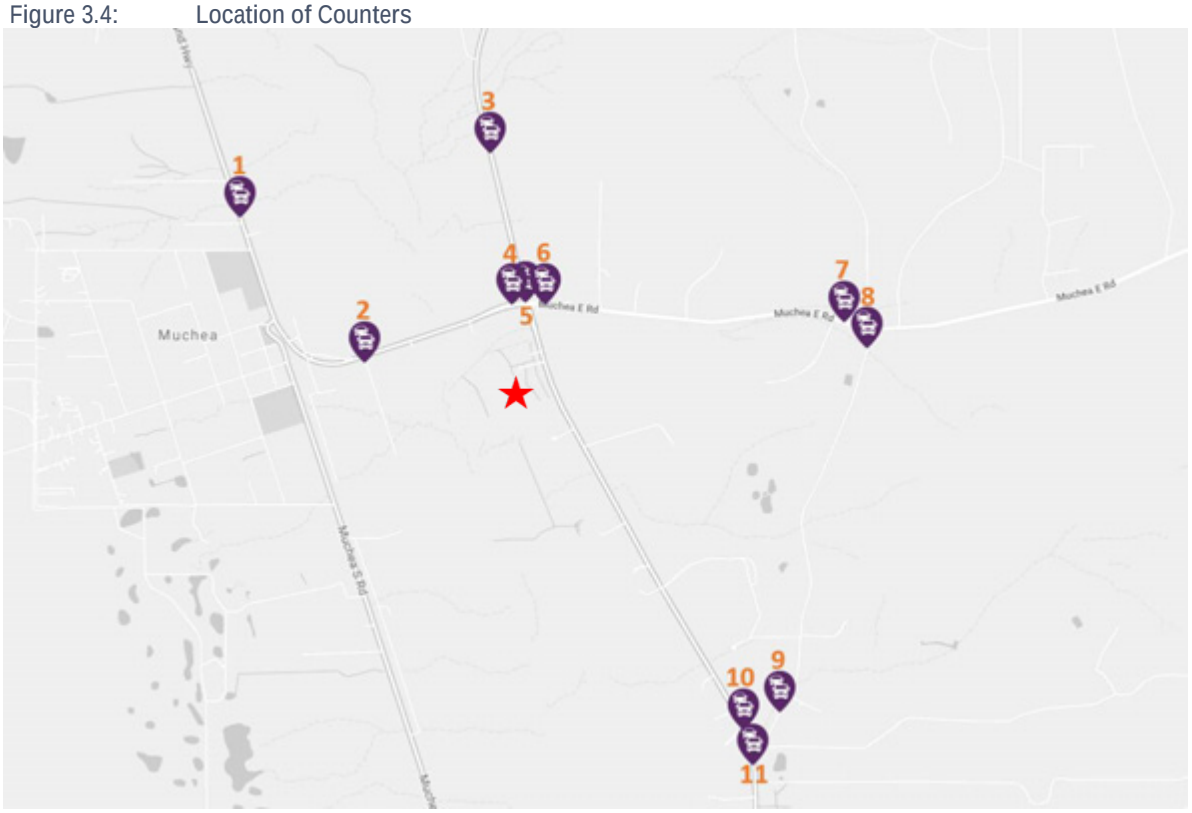



Table 3.1: Traffic Counts;

| | Location | Monday to Sunday Average | Year | % Cars | % Trucks |
|---|---|---|---|---|---|
| 1 | Brand Hwy (North of Muchea South Rd) | 4,524 | 2017/18 | 74.4% | 26.6% |
| 2 | Peters Rd (South of Brand Hwy) | 150 | 2013/14 | 86.7% | 13.3% |
| 3 | Great Northern Hwy (North of Muchea East Rd) | 3,965 | 2015/16 | 77% | 23% |
| 4 | Brand Hwy (East of Great Northern Hwy) | 3,700 | 2014/15 | 76.8% | 23.2% |
| 5 | Brand Hwy (West of Great Northern Hwy) | 3,655 | 2014/15 | 77% | 23% |
| 6 | Muchea East Rd (East of Great Northern Hwy) | 804 | 2018/19 | 80.7% | 19.3% |
| 7 | Muchea East Rd (West of Wandena Rd) | 597 | 2015/16 | 49.1% | 50.9% |
| 8 | Wandena Rd (South of Muchea East Rd) | 2,108 | 2015/16 | 62% | 38% |
| 9 | Wandena Rd (North of Great Northern Hwy) | 2,347 | 2015/16 | 81.6% | 18.4% |
| 10 | Great Northern Hwy (North of Wandena Rd) | 8,605 | 2018/19 | 74.4% | 25.6% |
| 11 | Great Northern Hwy (South of Wandena Rd) | 9,014 | 2015/16 | 73% | 27% |

# 4. PROPOSED INTERNAL TRANSPORT NETWORKS (MOVEMENT NETWORK)

04

## 4.1. Changes to Existing Road Network

The current Structure Plan area does not have any public roads within it. The Structure Plan area only abuts the existing road network at Great Northern Highway to the east, Brand Highway to the north and the new PDNH to the west. None of these roads are proposed to change in configuration in the foreseeable future. Great Northern Highway is expected to be maintained as a Primary Distributor under the control of Main Roads WA. The main access to and from the Structure Plan area is proposed to be via two new intersections constructed to intersect with Great Northern Highway. Each of these are proposed to be T-junctions under either Stop of Give Way sign control.

The intersections will require the construction of right and left turn deceleration lanes on Great Northern Highway as discussed in Section 6.6.

The southern access would merely formalise the current access at this location into an intersection design format suitable for RAV10 access to and from the north and RAV7 access to and from the south of Great Northern Highway.

There is not a requirement to provide acceleration lanes for the southern access as there is presently overtaking lanes at this location which will allow faster moving vehicles to pass slower moving and accelerating RAVs travelling both north and south along Great Northern Highway. The northern access should not require acceleration lanes for the northbound direction as the intersection of Brand Highway/Muchea East Road is in close proximity to the site. The southern departure for the northern intersection would also operate satisfactorily without an acceleration lane as there are overtaking lanes located approximately 650m south of this intersection which is considered to be near the point of entry of road trains from the intersection onto Great Northern Highway.

## 4.2. Proposed Road Hierarchy, Road Reserve Widths and Speed Limits

The Structure Plan area identifies an indicative loop road network and local access streets within the Structure Plan area. There is proposed to be a main loop road connecting the northern intersection with the southern intersection. This route is proposed to have a near 90-degree bend in the road and then an intersection back onto the southern intersection.

### 4.2.1. Local Distributor

#### Loop Road

The internal loop road connecting the northern intersection to the southern intersection is a proposed is proposed to be a Local Distributor under the Functional Road Hierarchy. It is intended to be a two-lane single carriageway road with an operating speed of 50-60km/h. It is proposed to be a 20m wide road reserve (augmented with 10m wide drainage area as required) incorporating a 10m wide two-way single carriageway.

### 4.2.2. Local Access Roads

The Structure Plan area comprises largely of local access roads due to its Industrial nature. The local roads proposed as part of this area are detailed below and are in accordance with DCP 4.1.

- 20m wide road reserve (augmented with 10m wide drainage area as required) incorporating a 10m wide two-way single carriageway. These roads are intended to have a speed limit of 50km/h.

## 4.3. Road Cross Sections

As this Structure Plan area is to be an Industrial development, under Development Control Policy 4.1 (DCP 4.1), a minimum road reserve of 20m is required and this will allow a typical 10m wide two-lane single carriageway. This has been generally adopted, but with the augmentation of an additional 10m for drainage purposes.

With the large size of vehicles access the site (RAV10 for the "loop" road and RAV7 for the remainder of the road network, unless amended by individual landowners at the subdivision stage) these cross-sections will allow vehicles of RAV7/10 size

to drive along them. The only exception is at intersections or right angle bends where the swept paths of these vehicles will require intersection widenings and larger than normal truncations to suit. These intersection widenings allow for RAV10s to turn and be lane correct in such a manner that other RAV10 vehicles stopped at intersections or negotiating right angle bends in the roadway, will not impede the movement of other RAV10 vehicles.

Examples of these are shown at Appendix B.

When accessing properties directly adjacent to the RAV10 network vehicles of this size will be able to utilise the full width of both the crossovers and the roadway.

Examples of this are shown at Appendix C, from work undertaken by Porter Consulting Engineers.

## 4.4. Intersection Controls

No formal signage is proposed to be installed for roads within the Structure Plan area. Intersections will all be T-junctions with the standard road rules applying for right of way. To assist to correct positioning of vehicles within the road network, holding lines are recommended at these intersections.

## 4.5. Interim and Ultimate Access

In discussion with MRWA, the current authority under which Great Northern Highway is under, access to and from the site will ultimately be required to be from the internal road network with no lot access direct to/from Great Northern Highway. This will be achievable for all proposed lots, with one exception. There will be required to be direct access to either Brand Highway, west of Great Northern Highway or Great Northern Highway, south of Brand Highway for the northern most lot proposed north of the proposed drainage way. This site presently has direct access and it is intended the site will continue to maintain this access once the Structure Plan area is fully developed.

Advice from MRWA is that interim access could be permitted to allow the Structure Plan area to be developed over time. Once access from an internal access road could be achieved, then the direct access would need to be removed from Great Northern Highway.

## 4.6. Pedestrian/Cycle Networks and Crossing Facilities

There being no desire lines for internal pedestrian movements between land uses and no access to public transport network, there is no plan to provide a footpath network at this stage. The type of land use proposed within the development would not lend the wider Structure Plan area to have and support a footpath network.

Similarly, no specific cycling facilities are proposed. The 10m wide proposed road network would allow employees to ride their bikes if so desired, but the probability of their use is expected to be low given the remoteness of the MENSP area to residential areas. The nearest residential area of note is Bullsbrook, approximately 8-9km via Great Northern Highway.

## 4.7. Public Transport Routes

No public transport routes are proposed within the structure plan area. However, should the current Route 311 to Bullsbrook, or any other route, be extended to Muchea, then the development could take advantage of such a route. The current and proposed road geometries would not preclude such an extension or new bus route and would allow the wider MENSP area to be less reliant on private motor vehicles travel to and from the area.

## 4.8. Proposed Road Access Strategies

The lots proposed as part of this structure plan area will not have any direct access onto Great Northern Highway, with the exception of the northern most lots previously discussed. All access will be via internal roads, and two new access points/intersections onto Great Northern Highway.

Access of the internal lots onto the internal road network will be direct via typical crossovers designed to allow access for the required vehicles. These could be up to RAV10 vehicles for the loop road but would be no greater than for RAV7 vehicles for the remainder of the road network, unless amended by individual landowners at subdivision stage.

# 5. EXTERNAL TRANSPORT NETWORKS

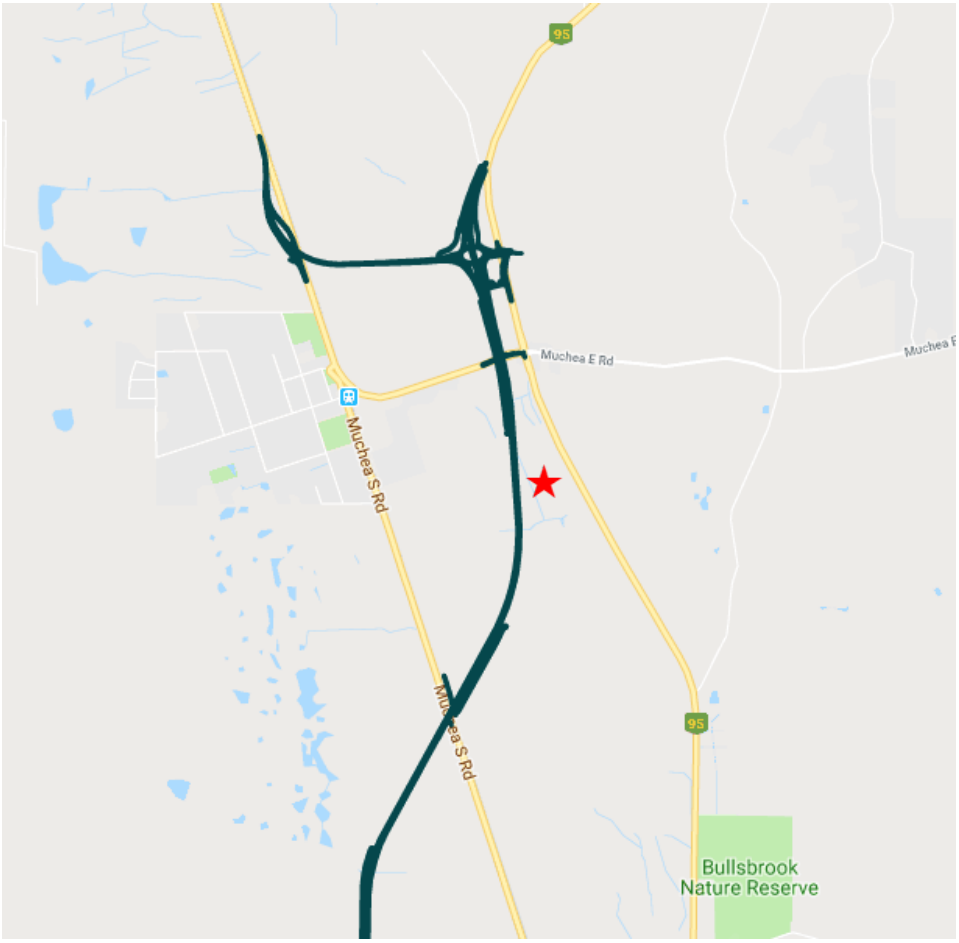
05

## 5.1. Changes to External Transport Networks

Other than the proposed full movement T-junction at the northern and southern intersections leading into the structure plan area, this development will not result in any other changes to the external transport network.

The other major changes proposed in the vicinity of the development include the construction of the new PDNH, refer to Figure 5.1 below. This work will not impact the access nor the current form of Great Northern Highway, but there will be a decrease in traffic volumes on Great Northern Highway. Currently there is approximately 8,600vpd utilising this section of Great Northern Highway travelling at speeds up to the 110km/h posted speed limit.

Figure 5.1: Northlink WA works in Vicinity of SP Area




Once completed at the end of 2019, traffic volumes on Great Northern Highway are expected to decrease. Estimates for 2031 have indicated that there would be approximately 2,250vpd on this section of Great Northern Highway (this prior to any consideration of MENSP traffic effects). Even with this substantial drop from 8,600 to 2,250vpd in traffic, the function of Great Northern Highway is expected be retained as a Primary Distributor under the control of Main Roads WA. It is expected the speed limit may also decrease so as to act a deterrent so that vehicles do not use Great Northern Highway in lieu of the new PDNH. An appropriate speed limit would be in the order of 80-90km/h.

The RAV10 network presently only extends from the northern areas of the state as far south as Wubin, via the Great Northern Highway. The initial concept was for a road train assemble area to be located within the south-east quadrant of the new PDNH/Brand Highway interchange. In discussion with the Shire of Chittering there is now a desire to allow these vehicles to extend further and utilise the road network within the wide MENSP. To allow this use to be considered, once

roads have been constructed, the road network within the MENSP should be designed allow these vehicles to access to and from the north.

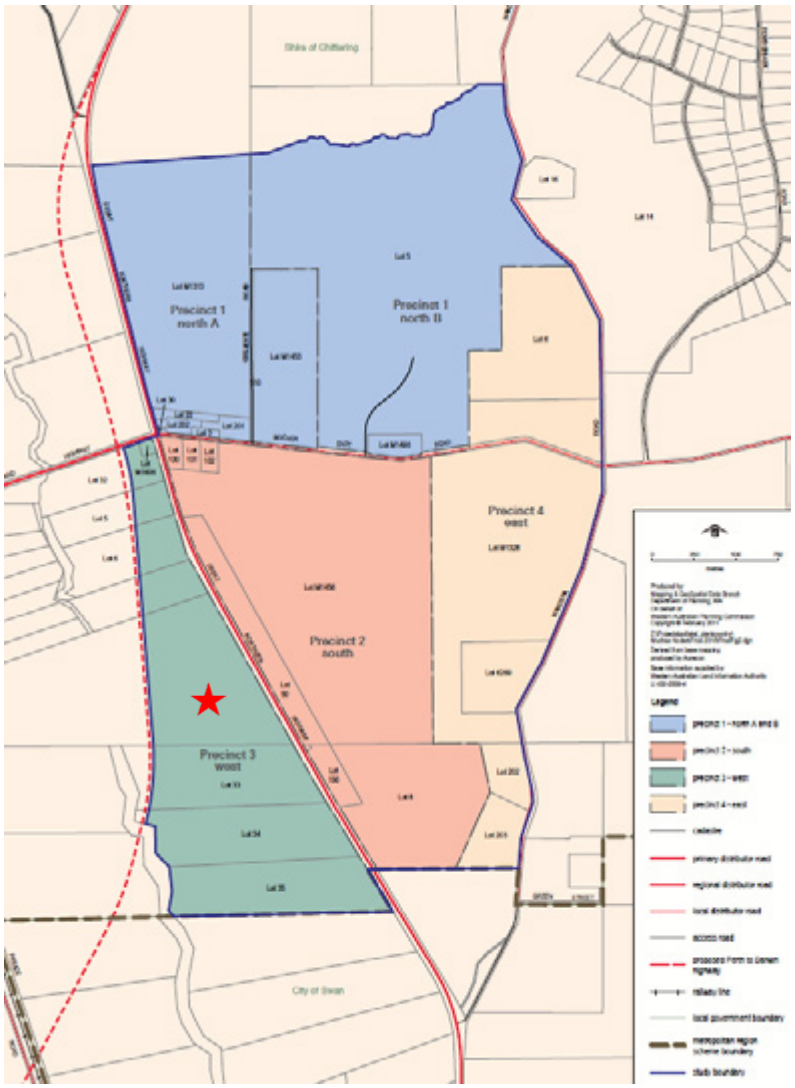
# 6. INTEGRATION WITH SURROUNDING AREA

06

## 6.1. Surrounding Attractors

Other than the current structure plan, the MENSP identifies three other industrial precincts Precinct 1 (north), 2 (south) and 4 (east), comprising of new long-term development area. This is located east of Great Northern Highway and further to the north, north of Muchea East Road. Refer to Figure 6.1 below.

Figure 6.1: MENSP Precincts




(Source: MENSP Final Report 2011)

In terms of wider regional access to and from the Structure Plan area, the majority of traffic to and from the Structure Plan is expected to be via the northern approaches of Great Northern Highway, via the PDNH. It is estimated[2] that this will account for approximately 67% of vehicle movements with the remaining 33% travelling to and from the south via Great Northern Highway in its downgraded classification format.

[2] Based on Muchea Employment Node Structure Plan (DoP/WAPC, August 2011).

## 6.2. Trip Attractors/Generators within 800m

The Industrial areas identified in the MENSP will be a key generator of traffic (both car and truck). There may be some trips to and from sites within 800m of the Structure Plan area, but as the Structure Plan area is more of a regional transport hub, these trips are likely to be insignificant with most trips to and from the Structure Plan area expected to be to areas outside the MENSP.

## 6.3. Proposed Changes to Land Uses within 800m

The Structure Plan area is intended to be developed from rural to Industrial as will be areas located east of Great Northern Highway and falling under the MENSP. The land uses permitted and total net area, as per Table 1 of MENSP is included as Figure 6.2 to provide an indication of the likely future uses within the Structure Plan.

Figure 6.2: Muchea employment node indicative land use area split (hectares) (MENSP 2011)

| Indicative land use split | WAMIA | Complementary Uses | Local | Strategic location | Metropolitan spill over | Total |
|---|---|---|---|---|---|---|
| primary/rural | 272 | | 7.0 | 0 | 0 | 279.0 |
| manufacturing/ processing/ fabrication | 1 | | 30.6 | 20 | 5 | 56.5 |
| storage/distribution | 18.7 | 1.75 | 48.7 | 52.3 | 22.5 | 143.9 |
| service industry | 10 | 2 | 41.7 | 20.9 | 20 | 94.6 |
| shop/retail | | 1 | 0.0 | 0 | 0 | 1.0 |
| other retail | | 5 | 1.4 | 0 | 0 | 6.4 |
| office/business | | 0.25 | 5.6 | 0 | 0 | 5.8 |
| health/welfare/ community services | | | 0.0 | 0 | 0 | 0.0 |
| entertainment/ recreation/ culture | | | 0.0 | 0 | 0 | 0.0 |
| residential | 0.3 | | 0.0 | 0 | 0 | 0.3 |
| utilities/ communications | | | 4.2 | 1.9 | 2.5 | 8.6 |
| TOTAL | 302 | 10 | 139 | 95 | 50 | 596 |

## 6.4. Travel Desire Lines from Structure Plan to these Attractors/Generators

The desire lines to and from the local attractions are expected to be via roads and intersections constructed as part of development in the wider MENSP. With access to the wider regional destinations, the current Great Northern Highway to the south and PDNH/Northlink will provide for those desire lines to the wider network.

## 6.5. Adequacy and Deficiencies in External Transport Networks

The provision of the new intersections on Great Northern Highway will need to be adequately designed so as not to create a hazard for vehicles travelling north and south. Due to the expected traffic entering and exiting these intersections, there will be occasions for vehicles to stop on Great Northern Highway to turn into the Structure Plan area, or to decelerate on Great Northern Highway and then turn left. Stopped vehicles on the highway would be extremely hazardous as would be vehicles decelerating when turning left into the site. As such, remedial measures are discussed in the next section.

## 6.6. Remedial Measures to Address Deficiencies

To address the access to the site via Great Northern Highway, the intersection designs would need to incorporate, as a minimum, left and right turn pockets on the north and south approaches to the new intersections. These should be designed in accordance with Austroads:

| | |
|---|---|
| Right turn Deceleration Lanes | 125m length (based on 90km/h speed) plus storage of 60m for one stopped RAV10 for a total of 185m. |
| Left turn Deceleration Lanes | 120m length (based on 90km/h approach speed and 20km/h speed at end of the lane). |

Also, there would typically be the requirement to consider acceleration lanes for RAVs exiting these intersections. However, due to the provision of existing overtaking lanes near the southern intersection and the proximity of the northern intersection to the intersection of Brand Highway/Muchea East Road, there would be insufficient spacing and no requirement to provide these. Therefore, RAVs exiting these two intersections would not impact adversely on traffic flow on Great Northern Highway due to the combination of the ability of traffic to overtake RAVs near the southern intersection and the lower expected traffic flows.

# 7. ANALYSIS OF INTERNAL TRANSPORT NETWORKS

07

## 7.1. Assessment Year(s) and Time Period(s)

The development has been assumed to be fully developed by 2031, or approximately in 13 years' time. As this is an Industrial area the assessment period should be the PM peak as recommended in the WAPC guidelines. This period would place the most stress on the internal road network exiting onto Great Northern Highway.

## 7.2. Structure Plan Generated Traffic

### 7.2.1. Trip Generation Rate

The MENSP Final Report 2011 was referenced and the traffic generation rate for this was approximately 23 trips per day per gross hectare for the 8,200 trips expected across the 356Ha of the MENSP. This trip rate has been adopted for the assessment of the internal road network and the effects of this traffic on the two new intersections on Great Northern Highway.

### 7.2.2. Trip Generation of Site

Based on the gross area to be developed in the Structure Plan area, approximately 150Ha, the Structure Plan area is expected to generate approximately 3,500 trips per day. To allow a robust assessment this traffic volume has been increased by approximately 25% to approximately 4,400 trips per day. With 10% of these trips occurring in the PM peak approximately 440 trips would occur in the PM peak. This would comprise of approximately 350 exiting the Structure Plan Area and 90 entering the Structure Plan Area.

## 7.3. Extraneous (Through) Traffic

No through traffic is expected through the actual Structure Plan area, but there is expected to be through traffic utilising Great Northern Highway.

Without consideration of the MENSP, the MENSP 2011 report for 2026 and 2037 years derived a traffic flow of approximately 2,250vpd on Great Northern Highway in 2031. This accounts for the effects of the new PDNH and other works associated with the Northlink WA project.

With the consideration of the MENSP, this is expected to add approximately 2,725vpd to this section of Great Northern Highway for a final traffic volume of approximately 5,000vpd. This traffic flow on Great Northern Highway is similar to traffic flow experienced well before 2012/13 when traffic volumes were recorded at 6,430vpd AADT (average annual daily traffic).

## 7.4. Design Traffic Flows (i.e. Total Traffic)

The internal road network and the proposed size and location of lots suggest that the southern intersection will carry the majority of traffic to and from the Structure Plan area. Approximately 3,000vpd are expected to utilise this intersection at the end of the loop road nearest Great Northern Highway. The northern intersection, although closer to the PDNH interchange, is expected to carry less traffic due to the smaller number of lots, with approximately 1,400vpd utilising this intersection and the section of the loop road. Internal traffic flows are expected to decrease from these maximum flows near Great Northern Highway as the local road network distributes the traffic in the Structure Plan area. Traffic flows on the loop road adjacent to the PDNH are expected to be approximately 800vpd with most other local roads having traffic flows less than 1,000vpd. These flows are shown at Appendix D.

## 7.5. Road Cross-Sections

All the above traffic flows are appropriate for the proposed road cross sections as discussed previously. The general 10.0m wide pavement road throughout the Structure Plan area can cater for daily flows up to 3,000 vpd.

Based on the calculated traffic volumes expected for the Structure Plan area, the proposed road cross sections discussed previously are considered appropriate.

## 7.6. Access Strategy and Intersection Controls

The Structure Plan area is proposed to have access to the existing road network via the two access roads connecting onto Great Northern Highway. These are proposed to be a T-junction format under either Give Way or Stop sign control. Assessing the expected traffic volumes in the Structure Plan area, the proposed intersection controls are still valid and appropriate. The traffic volumes estimated (refer Chapter 8) are within acceptable ranges for roads of the proposed width and there are no notable imbalances in traffic flows at T-junctions.

With regards to intersections, Table 2.4 from the Austroads publication, *Guide to Traffic Management Part 6 – Intersections, Interchanges and Crossings* provides advice as to intersection performance in peak flow conditions with regards to possible further analysis. This is summarised in Table 7.1.

Table 7.1: Austroads Guidelines

| Major Road Type | Major Road Flow (two-way, vph) | Minor Road Flow (two-way, vph) |
|---|---|---|
| Two-lane | 400 | 250 |
| | 500 | 200 |
| | 650 | 100 |
| Four-lane | 1,000 | 100 |
| | 1,500 | 50 |
| | 2,000 | 25 |

The peak volume per hour (vph) would be approximately 10% in the PM peak. The traffic volumes are low enough so as to not warrant further assessment for the structure plan internal roads. For example, the highest flow intersection would be near the southern intersection where the loop road would have a major road flow of approximately 300 vph and approximately 100 vph on the road immediately intersection to the south. This falls well below the first row of the above table and thus requires no further assessment. It is therefore concluded that all internal intersections are acceptable and should operate at a high level of service (LOS) A with minimal delays and queues.

## 7.7. Pedestrian / Cycle Networks

There is expected to be minimal pedestrian activity due to the transport depot nature of the proposed land uses within the Structure Plan area and the lack of public transport and thus no access requires to and from bus stops. If employees do decide to cycle to the Structure Plan area, the traffic flows the 10m wide carriageways and relatively low traffic volumes on these roads would not create an adverse cycling environment. The only issue would be the effects of the large RAVs as they traverse the road network. However, apart from along the main entry roads and intersections, there is expected to be low traffic flows.

## 7.8. Pedestrian Permeability & Efficiency

Being no bus stops nor neighbourhood centres, this assessment as per the WAPC Guidelines is not required. Suffice to say that the network would be permeable to some degree if bus stops were appropriately located on Great Northern Highway, approximately 50% of the lots would be located within 400m of Great Northern Highway, which would be below the requirement.

## 7.9. Access to Public Transport

In terms of the broad Transperth requirements of a bus stop within 500m of 95% of Perth's population, this distance measured in a straight line from the current bus stops, none of the Structure Plan area falls within this 500m straight line distance.

# 8. ANALYSIS OF EXTERNAL TRANSPORT NETWORKS

08

## 8.1. Extent of Analysis

With the reduction in traffic flows on Great Northern Highway with the advent of the PDNH and the additional of the MENSP traffic, generally traffic flows are expected to be well below current traffic flows on the wider road network. The only exceptions are the two new proposed intersections of the loop road with Great Northern Highway. As such, only these two new intersections are the subject of assessment.

## 8.2. Impact Assessment

### 8.2.1. Trip Distribution

Assessment of traffic flows to and from the wider MENSP has revealed that traffic flows to and from the Structure Plan area are expected to be along similar lines. Based on this the expected distribution is as follows:

- To and from the North via Great Northern Highway 67%
- To and from the South via Great Northern Highway 33%.

### 8.2.2. Traffic Impact of Development Traffic

All bordering and connecting roads are expected to have traffic volumes within their theoretical capacities. These volumes are not expected to exceed the maximum daily flow rates expected for roads of their classification and should be manageable (see the following intersection assessments). The maximum flows that these roads should carry are shown in Table 8.1 and Table 8.2.

Table 8.1: Current Traffic Flows

| Road | Indicative Maximum Daily Flow (two-way) | Actual Daily Flow (two-way) |
|---|---|---|
| Great Northern Highway | 16,000 | 8,600 |

Table 8.2: Expected Traffic Flows

| Road | Indicative Maximum Daily Flow (two-way) | Expected Daily Flow (two-way) |
|---|---|---|
| Great Northern Highway | 16,000 | 5,000 |
| Northern Loop Road | 3,000 | 1,400 |
| Southern Loop Road | 3,000 | 3,000 |

It can be seen that traffic is expected to decrease in Great Northern Highway near the Structure Plan area by about 3,600 to 5,000 vpd, this being less than traffic counts recorded on this section of road in 2012/13 when 6,430vpd was recorded.

#### Loop Road Intersections Performance

To further assess the performance of the road network within the Structure Plan area the two new intersections of the loop road with Great Northern Highway were assessed in the PM peaks. A computer program, SIDRA Intersection (Version 7), was utilised for this purpose. The summary of this analysis is from the output tables from SIDRA for the expected traffic flows are shown on the following page in Table 8.3. Details of this assessment are at Appendix E for reference.

Table 8.3: Future External Intersection & Structure Plan Area Intersection Performance – 2031 with Development

| Intersection | Peak Hour | Approach | DOS | Average Delay (sec) | LOS | 95th %tile Queue (m) |
|---|---|---|---|---|---|---|
| North | PM | Great Norther Highway (RT) | 0.03 | 9 | A | 1 |
| | | North Road (RT) | 0.08 | 9 | A | 3 |
| | | **Intersection** | **0.20** | **4** | - | **4** |
| South | PM | Great Norther Highway (RT) | 0.06 | 9 | A | 2 |
| | | North Road (RT) | 0.19 | 10 | A | 7 |
| | | **Intersection** | **0.20** | **5** | - | **9** |

With the proposed Structure Plan development traffic, the two intersections are expected to operate at a level of service A for the critical right turns across on-coming traffic. This assessment takes into account the acceleration profile of the larger RAVs with the actual percentage of heavy vehicles based on the current classification data recorded on Great Northern Highway.

### 8.2.3. Level of Service Concepts

The level of service concept describes the quality of traffic service in terms of six levels, designated A to F, with level of service A (LOS A) representing the best operating condition (i.e. at or close to free flow), and level of service F (LOS F) the worst (i.e. forced flow). More specifically:

- *LOS A*: Primarily free flow operations at average travel speeds, usually about 90% of the FFS (free flow speed) for the given street class. Vehicles are completely unimpeded in their ability to manoeuvre within the traffic stream. Control delay at signalised intersections is less than 10 seconds. At non-signalised movements at intersections the average control delay is less than 10 seconds;
- *LOS B*: Reasonably unimpeded operations at average travel speeds, usually about 70% of the FFS for the street class. The ability to manoeuvre within the traffic stream is only slightly restricted, and control delays at signalised intersections are between 10 and 20 seconds. At non-signalised movements at intersections the average control delay is between 10 and 15 seconds;
- *LOS C*: Stable operations; however, ability to manoeuvre and change lanes in mid-block locations may be more restricted than at LOS B, and longer queues, adverse signal coordination, or both may contribute to lower average travel speeds of about 50% of the FFS for the street class. Signalised intersection delays are between 20 and 35 seconds. At non-signalised movements at intersections the average control delay is between 15 and 25 seconds;
- *LOS D*: A range in which small increases in flow may cause substantial increases in delay and decreases in travel speed. LOS D may be due to adverse signal progression, inappropriate signal timing, high volumes, or a combination of these factors. Average travel speeds are about 40% of FFS. Signalised intersection delays are between 35 and 55 seconds. At non-signalised movements at intersections the average control delay is between 25 and 35 seconds;
- *LOS E:* Characterised by significant delays and average travel speeds of 33% of the FFS or less. Such operations are caused by a combination of adverse progression, high signal density, high volumes, extensive delays at critical intersections (between 55 and 80 seconds), and inappropriate signal timing. At non-signalised movements at intersections the average control delay is between 35 and 50 seconds; and,

- *LOS F*: Characterised by urban street flow at extremely low speeds, typically 25% to 33% of the FFS. Intersection congestion is likely at critical signalised locations, with high delays (in excess of 80 seconds), high volumes, and extensive queuing. At non-signalised movements at intersections the average control delay is greater than 50 seconds.

In addition to the above:

- Average Delay: is the average of all travel time delays for vehicles through the intersection; and,
- Queue: is the queue length below which 95% of all observed queue lengths fall.
- Degree of Saturation: Ratio of the traffic flow to the capacity for that particular lane/movement

The above is summarised below in Table 8.4 for reference.

Table 8.4: LOS/DOS Summary

| Level of Service | | Intersection Degree of Saturation (DOS) | | |
|---|---|---|---|---|
| | | Unsignalised Intersection | Signalised Intersection | Roundabout |
| A | Excellent | <=0.60 | <=0.60 | <=0.60 |
| B | Very Good | 0.60-0.70 | 0.60-0.70 | 0.60-0.70 |
| C | Good | 0.70-0.80 | 0.70-0.90 | 0.70-0.85 |
| D | Acceptable | 0.80-0.90 | 0.90-0.95 | 0.85-0.95 |
| E | Poor | 0.90-1.00 | 0.95-1.00 | 0.95-1.00 |
| F | Very Poor | >=1.0 | >=1.0 | >=1.0 |

### 8.2.4. Traffic Impact of Development on Local Area

Based on the above assessment it is concluded that the Structure Plan area will have an acceptable impact on the surrounding roads and intersections with no changes required to either the road network or geometry of intersections due to the amendment alone. There will be a need to install right turn and left turn pockets on Great Northern Highway for the approaches to the new intersections, but this is a requirement for good safe design and not a requirement to address any capacity concerns.

## 8.3. Road Cross-Sections

The current road geometry and cross section of Great Northern Highway will be adequate to cater for the reduced traffic flows expected as a result of both the new PDNH and the impacts of the additional traffic due to the wider MENSP and the traffic generated by this Structure Plan area.

## 8.4. Intersection Layouts & Controls

From the above assessments, the intersection layouts and controls proposed in earlier sections of this report are not required to be modified.

## 8.5. Pedestrian/Cycle Networks

With a lack of internal pedestrian and cycle network the traffic volumes on the road network adjacent to the site will have little effect on the pedestrian and cycle network on Great Northern Highway. If bus routes are modified and extended to the MENSP then provision of these should be provided to allow safe access across Great Northern Highway, if such bus routes are limited to Great Northern Highway. Traffic volumes on Great Northern Highway and speeds are expected to decrease and the combination of these effects will improve cyclist's safety, for those to choose to ride along Great Northern Highway.

# 9. CONCLUSION

9

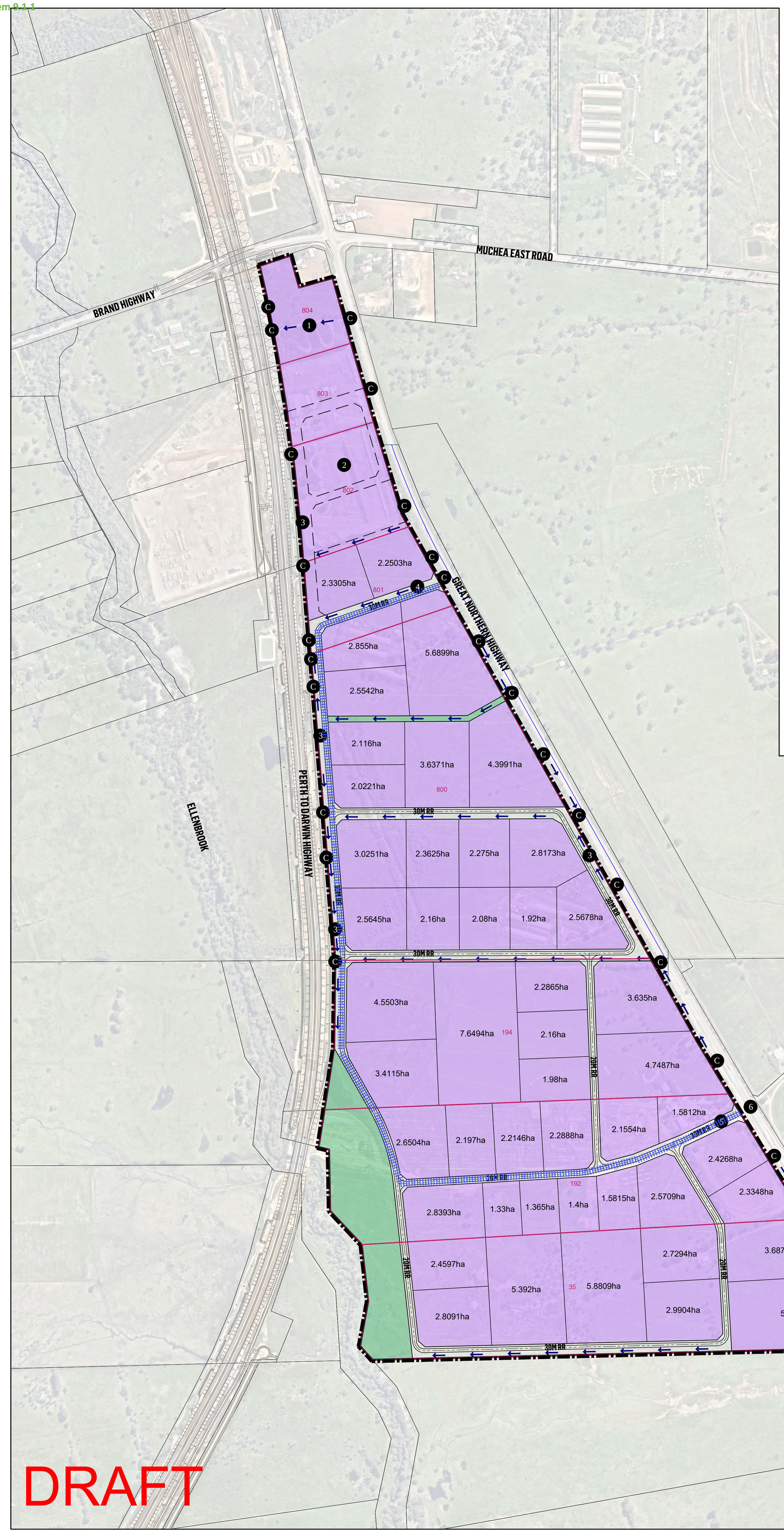
# CONCLUSION

As a result of the traffic analysis undertaken for the proposed development of Precinct 3 of the Muchea Employment Node, Muchea the following findings and recommendations are made:

- The proposed Structure Plan Area is expected generate in the order of 3,500 vehicular trips per day with and 350 in the PM peak;
- The assessed impacts of the traffic volumes associated with the Structure Plan Area on the road network are considered acceptable in the future. Total traffic volumes on Great Northern Highway including the development traffic and the wider MENSP traffic is expected to be less than the recorded 2012/13 figures, this effect due to the construction of Northlink;
- There is no requirement for any of the existing road network to be modified on the wider road network as a result of this development;
- The proposed intersection form and control (left and right turn deceleration lanes) on Great Northern Highway is appropriate as per the requirements of Austroads
- Acceleration lanes are not required due to the provision of overtaking lanes near the southern intersection and the proximity of the northern intersection to the Brand Highway/Muchea East Road intersection; and,
- Delays and queues at the main entries to the Structure Plan area are expected to be minimal with good levels of service to 2031.

The WAPC checklist is included at Appendix F.

# A. STRUCTURE PLAN AREA




## LEGEND

- PRECINCT 3 STRUCTURE PLAN AREA
- GENERAL INDUSTRY ZONE
- FORESHORE AND DRAINAGE
- EXISTING LOT BOUNDARIES
- C — EXISTING AND PROPOSED CULVERTS
- MAIN DRAINAGE FLOWS

NOTES:

1. TENURE OF DRAINAGE CONFIGURATION TO BE DETERMINED (RESERVE VS EASEMENT WITHIN LANDHOLDING)
2. INDICATIVE FUTURE DEVELOPMENT LAYOUT
3. TABLE DRAIN LOCATION TO BE DETERMINED AT SUBDIVISION LEVEL
4. ASSUMES ROAD SIDE SWALE CAN BE LOCATED IN ALIGNMENT OF EXISTING CULVERT UNDERNEATH GREAT NORTHERN HIGHWAY
5. SITE ENTRY AND ACCESS ROAD IN ACCORDANCE WITH CONSTRUCTED SITE ACCESS ALIGNMENT
6. RISK WHETHER 4 WAY CONFIGURATION WILL GET APPROVAL FROM MAIN ROADS

RAV 10 "LOOP" ROAD

DRAFT

URBIS

# Concept Plan

## Muchea Employment Node - Precinct 3

DATA SOURCE
Landgate & Bayley Environmental

PROJECTION
MGA Zone 50

Level 14, The Quadrant, 1 William Street | Perth WA 6000 Australia | +61 8 9346 0500 | URBIS Pty Ltd | ABN 50 105 256 228

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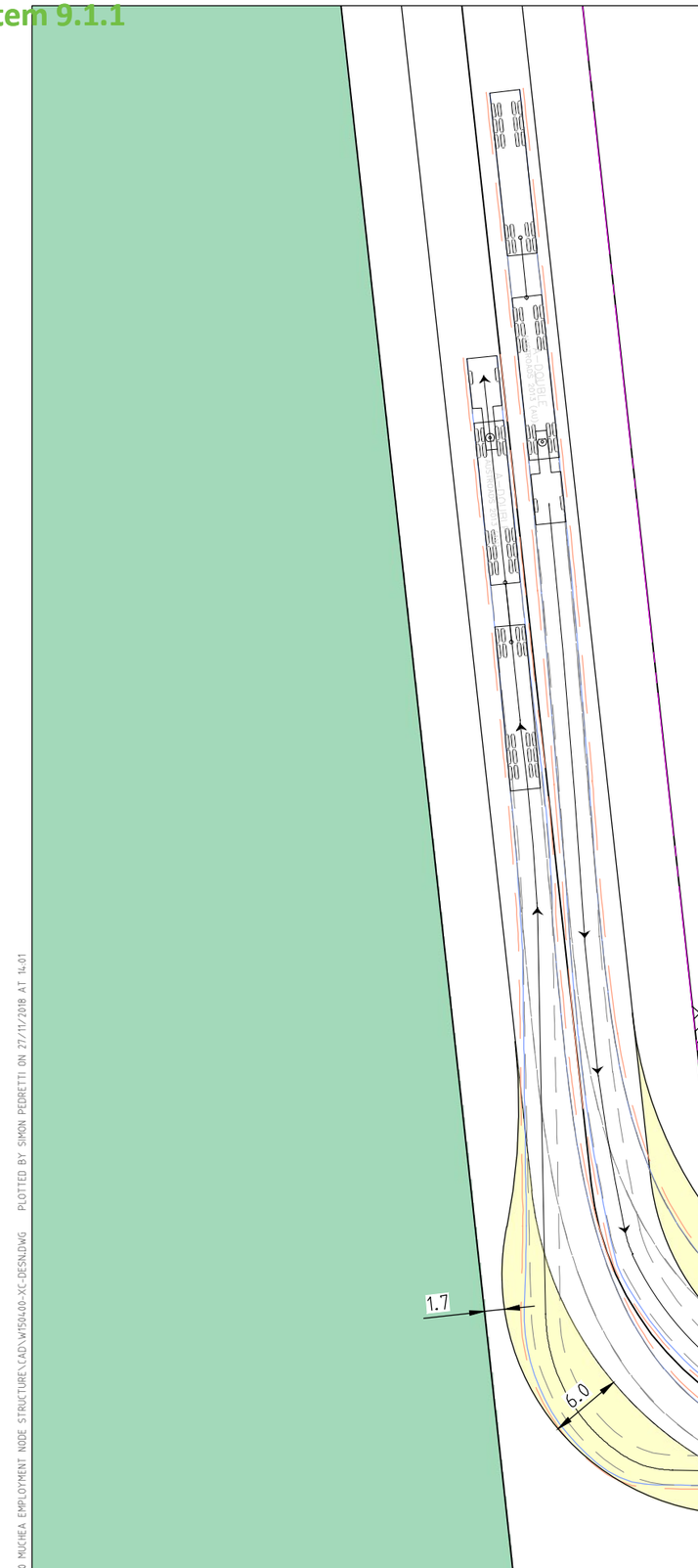
CLIENT
Tomahawk Property

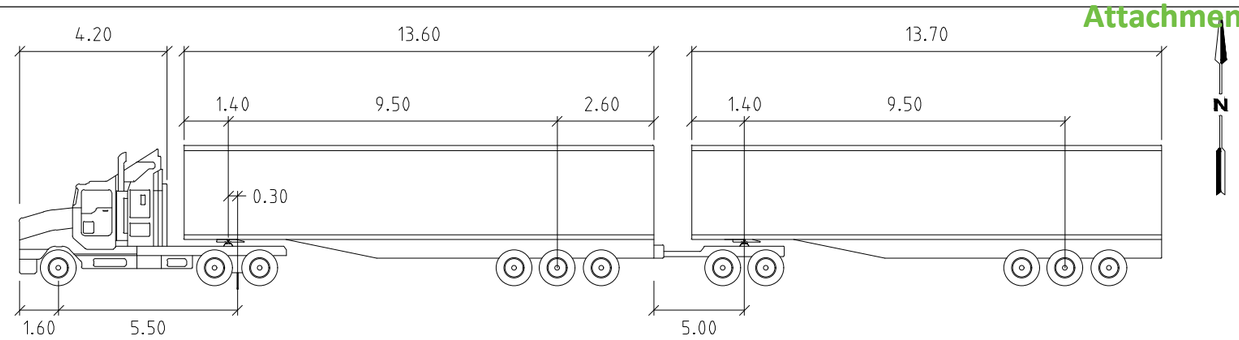
PROJECT NO. P0002540
DATE 22.11.18
DRAWING NO. 02
REVISION a

1:5000 @ A1 1:10000 @ A3
50 100 150 200 250 m

# B. RAV SWEPT PATHS

B

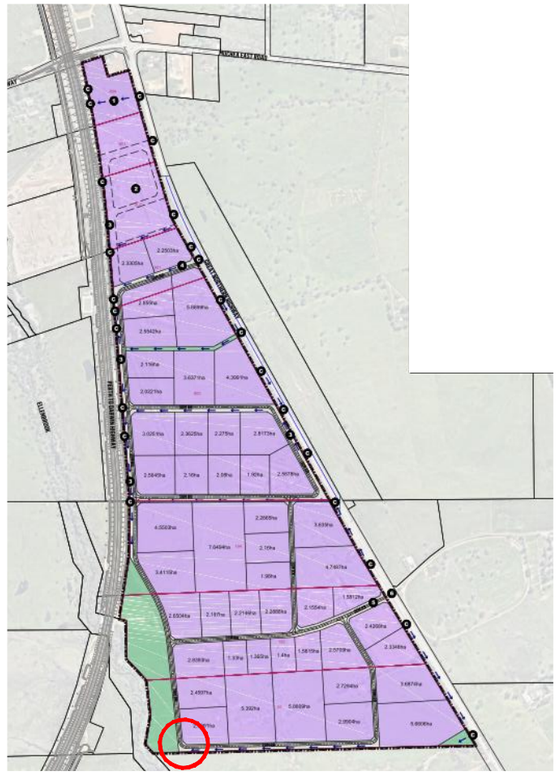



## A-DOUBLE

meters

| | | | |
|---|---|---|---|
| Tractor Width | : 2.50 | Lock to Lock Time | : 6.0 |
| Trailer Width | : 2.50 | Steering Angle | : 23.4 |
| Tractor Track | : 2.50 | Articulating Angle | : 70.0 |
| Trailer Track | : 2.50 | | |



SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

ASSUMED SPEED **5**km/h

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SUBJECT TO CHANGE WITHOUT NOTIFICATION

WARNING
BEWARE OF UNDERGROUND SERVICES
THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.

| | |
|---|---|
| DESIGNED S. PEDRETTI | DESIGN CHECK R.DING |
| APPROVED BY R.DING | DATE ISSUED 26.11.18 |

SCALE A3 0 2.5 5 10 1:500

CAD FILE NO. W150400-XC-DESN.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

DRAWING NO. W150400-SK01 SHEET 1 OF 6 ISSUE 1



T:\W15000-15099\W150400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN.DWG PLOTTED BY SIMON PEDRETTI ON 27/11/2018 AT 14:01

A-DOUBLE

meters

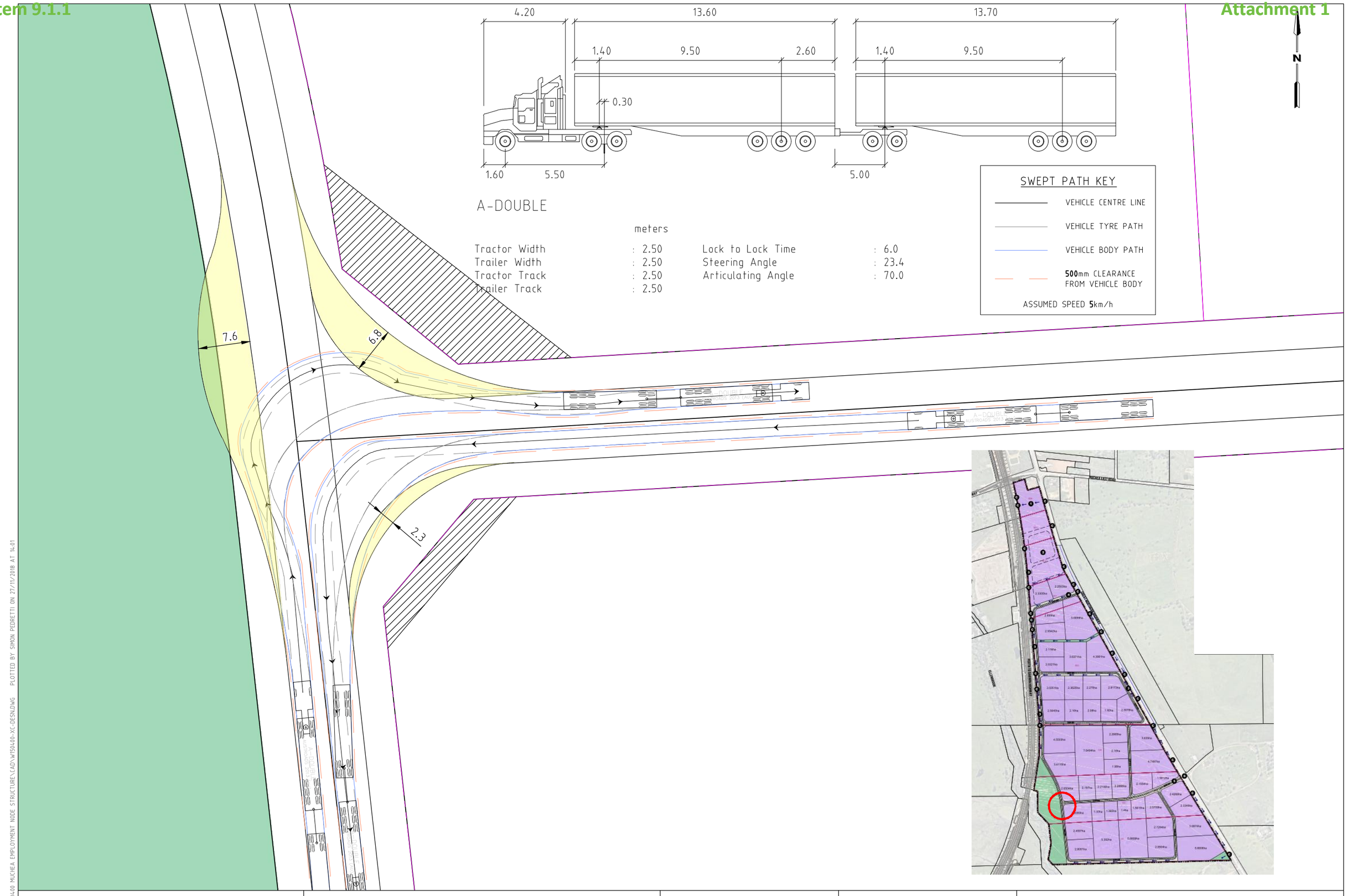
| | | | |
|---|---|---|---|
| Tractor Width | : 2.50 | Lock to Lock Time | : 6.0 |
| Trailer Width | : 2.50 | Steering Angle | : 23.4 |
| Tractor Track | : 2.50 | Articulating Angle | : 70.0 |
| Trailer Track | : 2.50 | | |

SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

ASSUMED SPEED **5**km/h

N



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| | |
|---|---|
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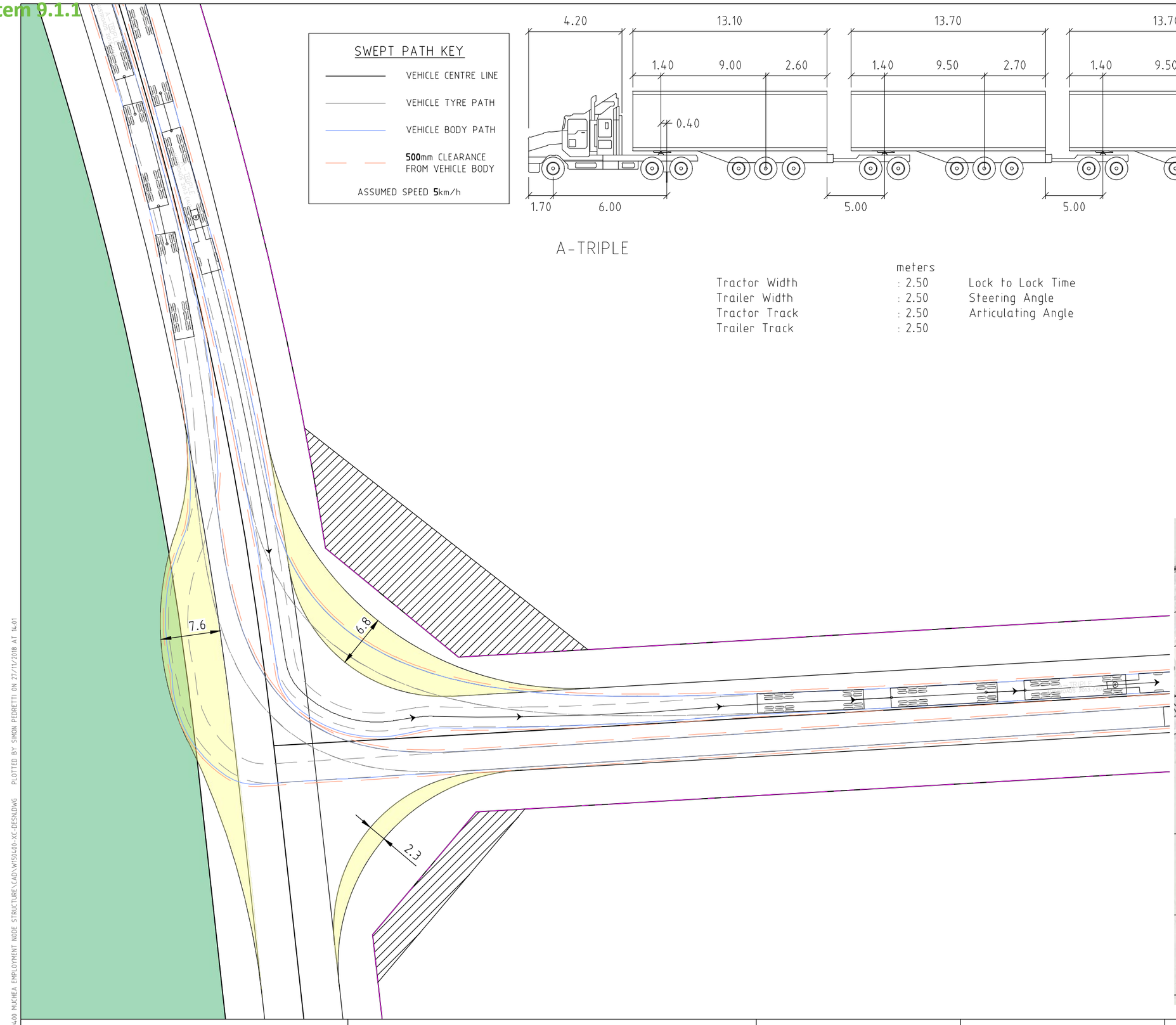
SCALE A3 0 2.5 5 10 1:500

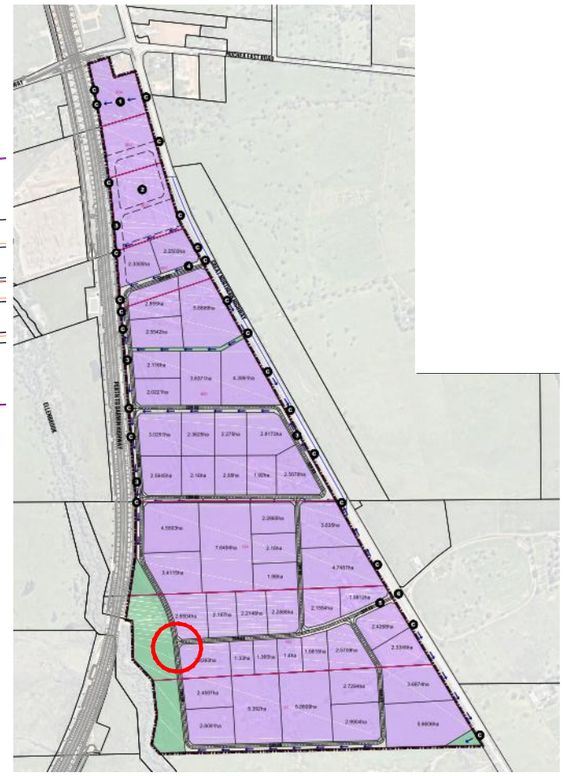
CAD FILE NO. W150400-XC-DESN.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

DRAWING NO. W150400-SK02 SHEET 2 OF 6 ISSUE 1




| | meters | | |
|---|---|---|---|
| Tractor Width | : 2.50 | Lock to Lock Time | : 6.0 |
| Trailer Width | : 2.50 | Steering Angle | : 25.6 |
| Tractor Track | : 2.50 | Articulating Angle | : 70.0 |
| Trailer Track | : 2.50 | | |



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DESIGN CHECK R.DING
APPROVED BY R.DING
DATE ISSUED 26.11.18

SCALE A3 0 2.5 5 10 1:500
CAD FILE NO. W150400-XC-DESN.DWG

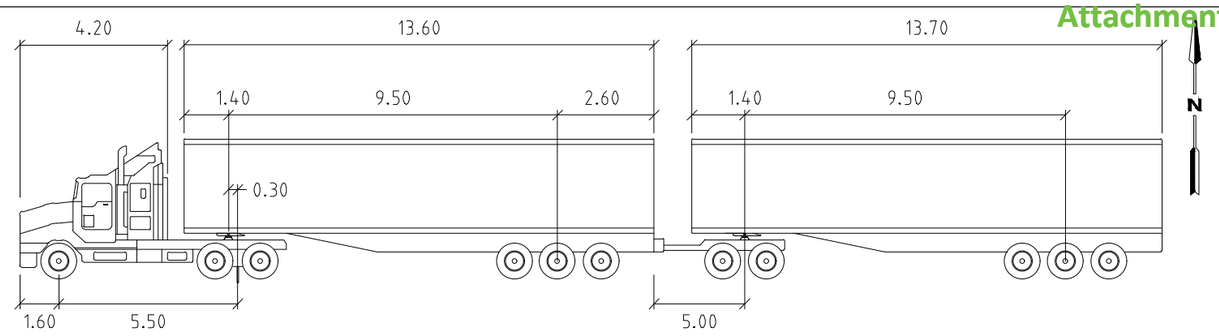
MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 10
SWEPT PATH

DRAWING NO. W150400-SK03
SHEET 3 OF 6
ISSUE F1

## SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

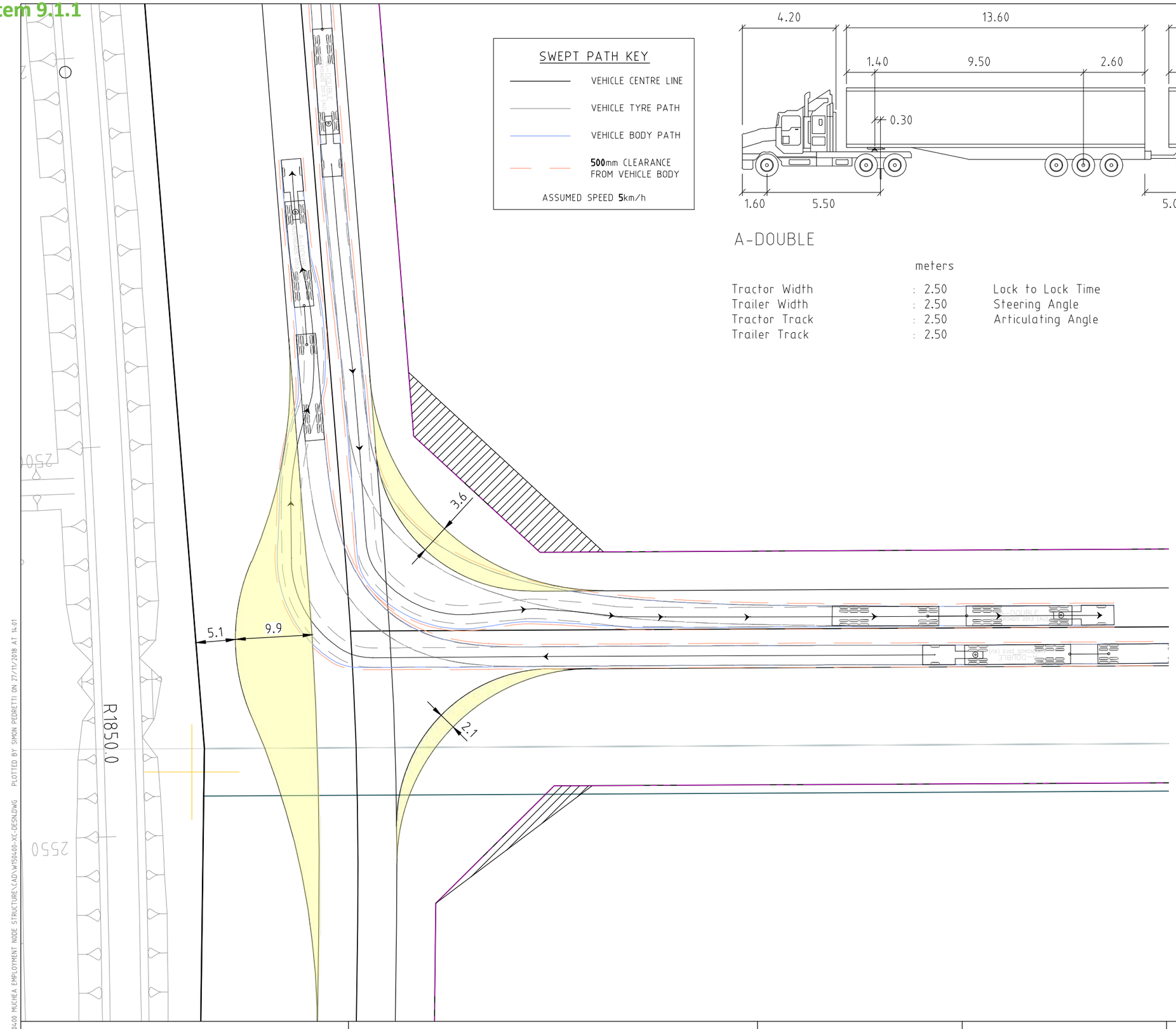
ASSUMED SPEED **5**km/h

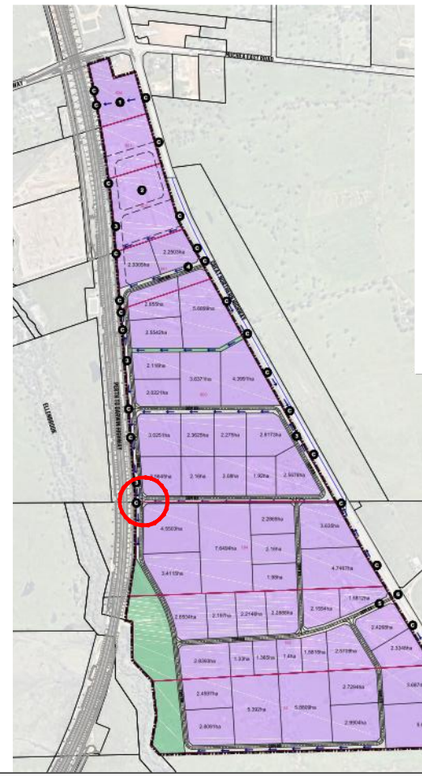



## A-DOUBLE

meters

| | | | |
|---|---|---|---|
| Tractor Width | : 2.50 | Lock to Lock Time | : 6.0 |
| Trailer Width | : 2.50 | Steering Angle | : 23.4 |
| Tractor Track | : 2.50 | Articulating Angle | : 70.0 |
| Trailer Track | : 2.50 | | |



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|---|---|
| DESIGNED S. PEDRETTI | DESIGN CHECK R.DING |
| APPROVED BY R.DING | DATE ISSUED 26.11.18 |

SCALE A3 0 2.5 5 10 1:500

CAD FILE NO. W150400-XC-DESN.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

DRAWING NO. W150400-SK04 SHEET 4 OF 6 ISSUE 1

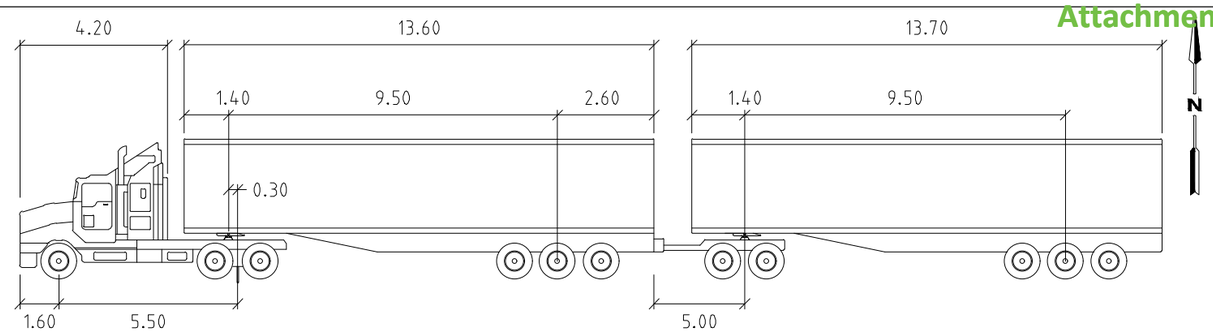


T:\W15000-15099\W150400 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN.DWG PLOTTED BY SIMON PEDRETTI ON 27/11/2018 AT 14:01

SWEPT PATH KEY

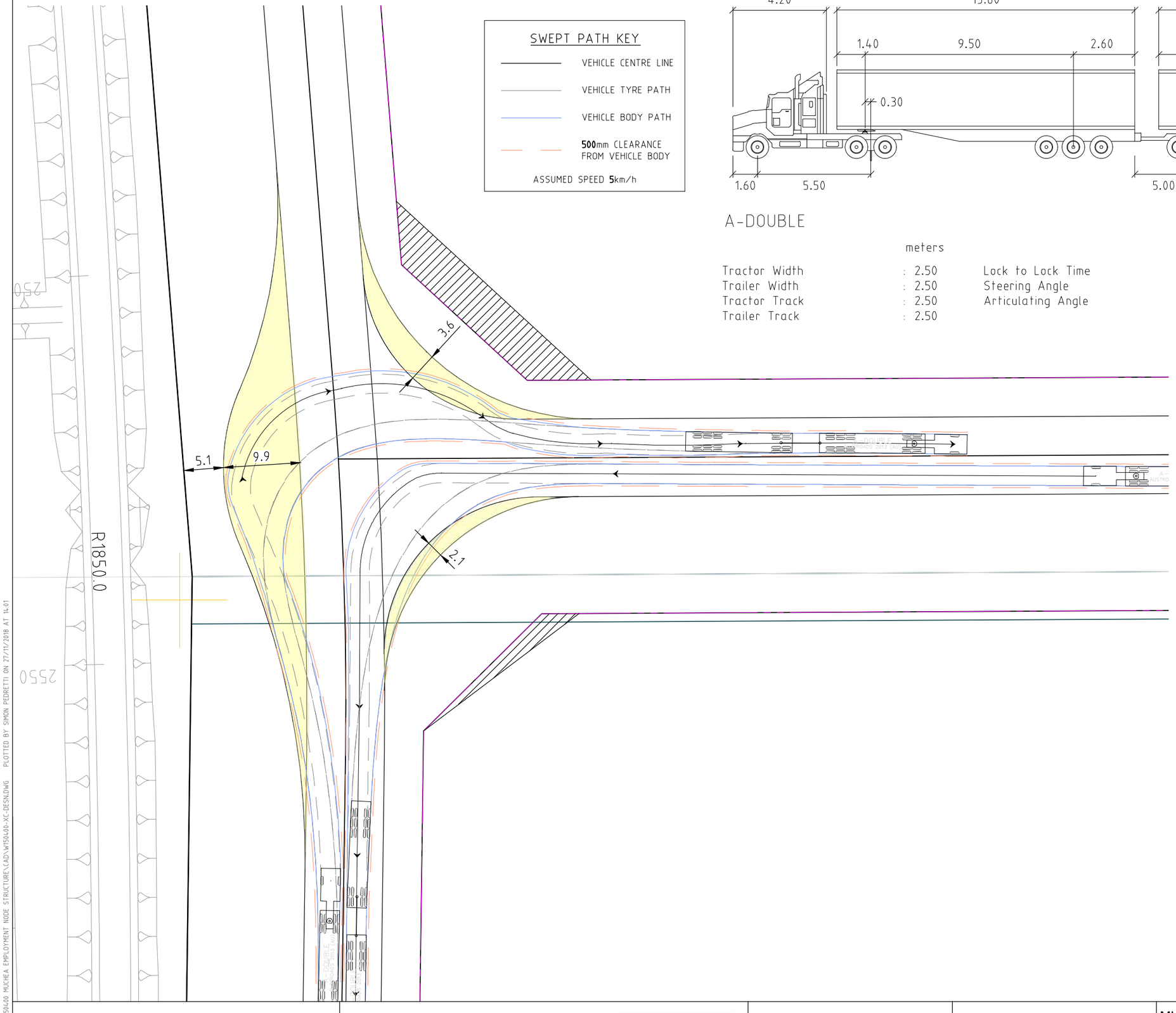
- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

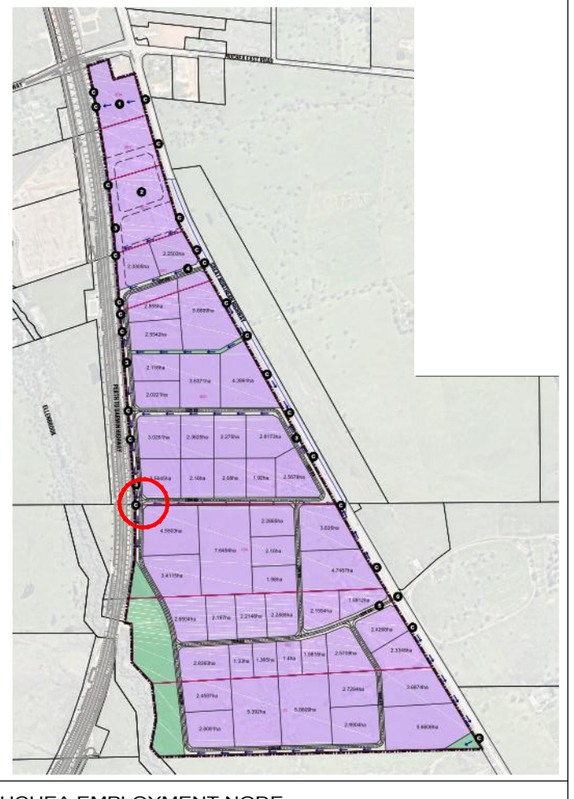
ASSUMED SPEED **5**km/h




A-DOUBLE

| | meters | | |
|---|---|---|---|
| Tractor Width | : 2.50 | Lock to Lock Time | : 6.0 |
| Trailer Width | : 2.50 | Steering Angle | : 23.4 |
| Tractor Track | : 2.50 | Articulating Angle | : 70.0 |
| Trailer Track | : 2.50 | | |



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| | |
|---|---|
| DESIGNED | DESIGN CHECK |
| S. PEDRETTI | R.DING |
| APPROVED BY | DATE ISSUED |
| R.DING | 26.11.18 |

SCALE A3 0 2.5 5 10 1:500

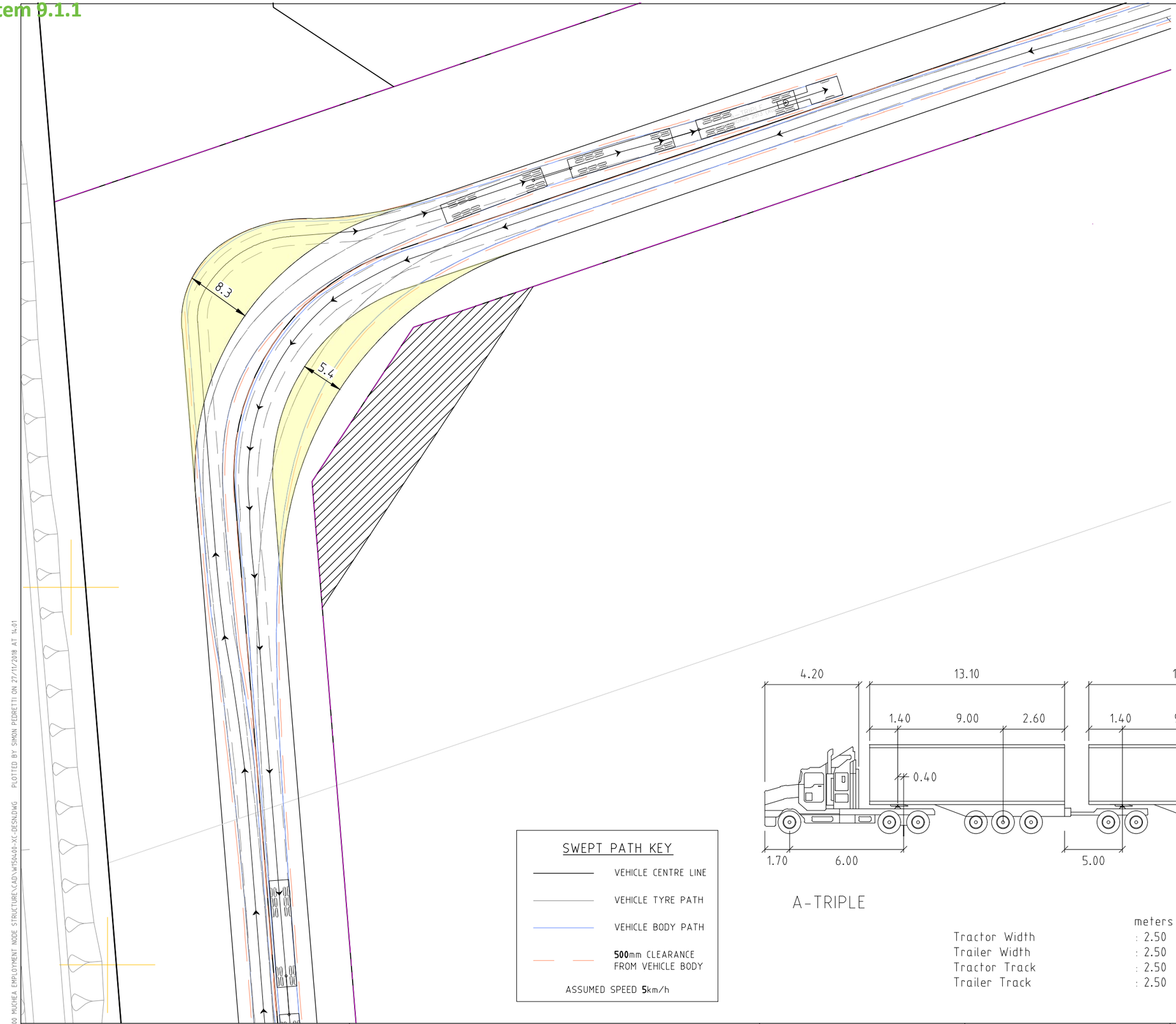
CAD FILE NO.
W150400-XC-DESN.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 7
SWEPT PATH

DRAWING NO. W150400-SK05

SHEET 5 OF 6

ISSUE 1

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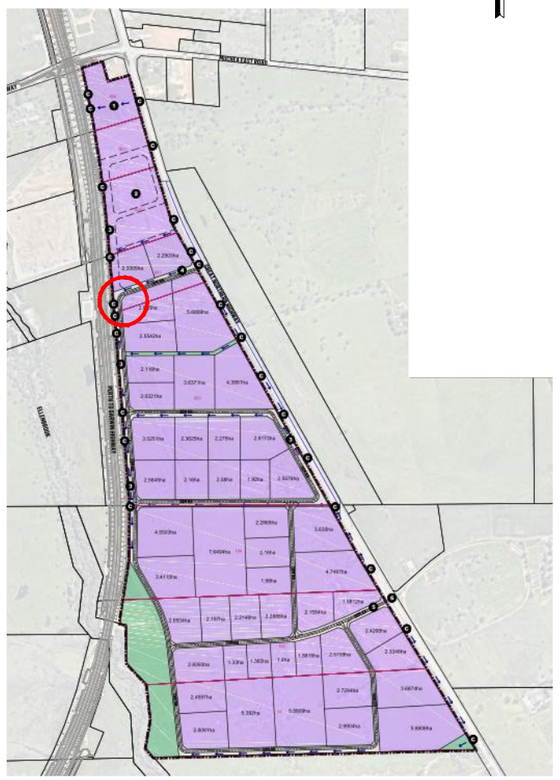
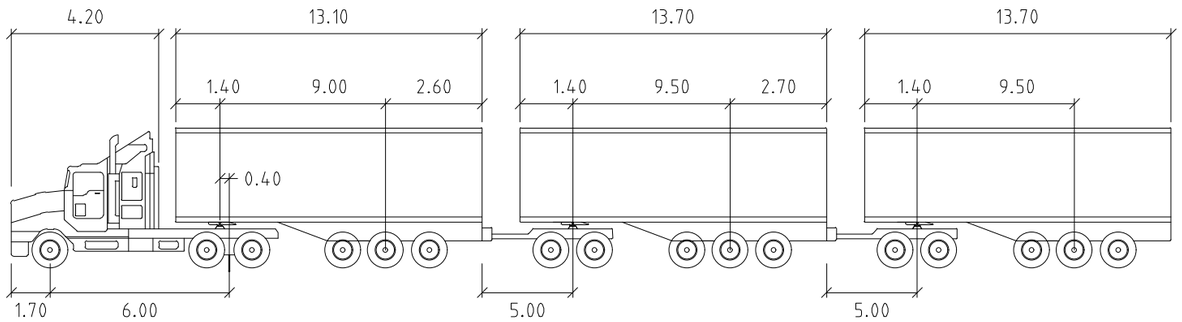


SWEPT PATH KEY

- VEHICLE CENTRE LINE
- VEHICLE TYRE PATH
- VEHICLE BODY PATH
- **500**mm CLEARANCE FROM VEHICLE BODY

ASSUMED SPEED **5**km/h




A-TRIPLE

| | meters | | |
|---|---|---|---|
| Tractor Width | : 2.50 | Lock to Lock Time | : 6.0 |
| Trailer Width | : 2.50 | Steering Angle | : 25.6 |
| Tractor Track | : 2.50 | Articulating Angle | : 70.0 |
| Trailer Track | : 2.50 | | |

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|---|---|
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| Brisbane | 07 3113 5000 |
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| | |
|---|---|
| DESIGNED | S. PEDRETTI |
| DESIGN CHECK | R.DING |
| APPROVED BY | R.DING |
| DATE ISSUED | 26.11.18 |

SCALE A3 0 2.5 5 10 1:500

CAD FILE NO. W150400-XC-DESN.DWG

MUCHEA EMPLOYMENT NODE
PRECINT 3
RAV 10
SWEPT PATH

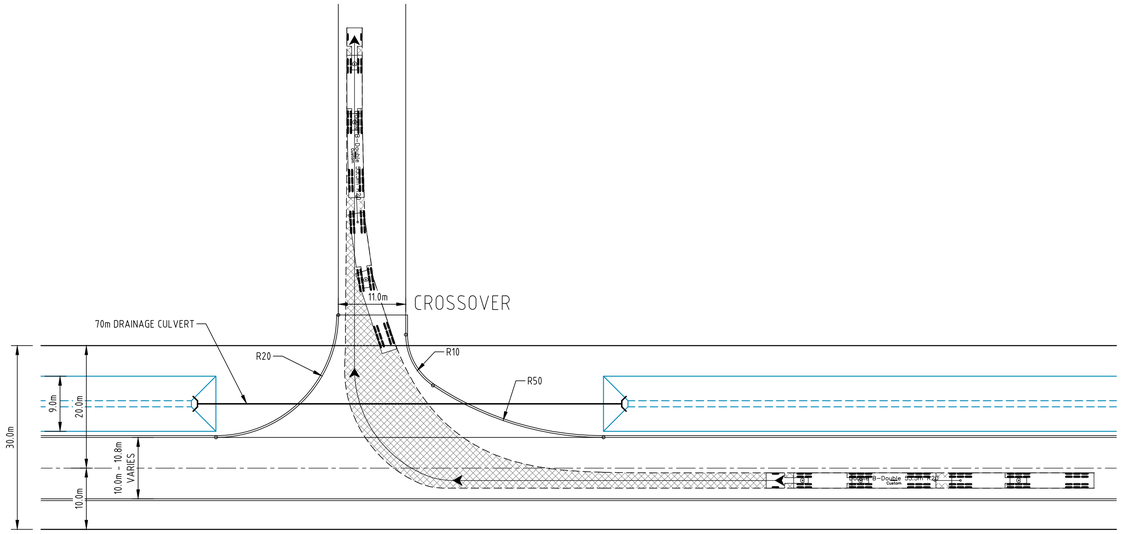
DRAWING NO. W150400-SK06 SHEET 6 OF 6 ISSUE P1



T:\W15000-15099\W15040 MUCHEA EMPLOYMENT NODE STRUCTURE\CAD\W150400-XC-DESN.DWG PLOTTED BY SIMON PEDRETTI ON 27/11/2018 AT 14:01

# C. PORTER CONSULTING CROSS SECTIONS

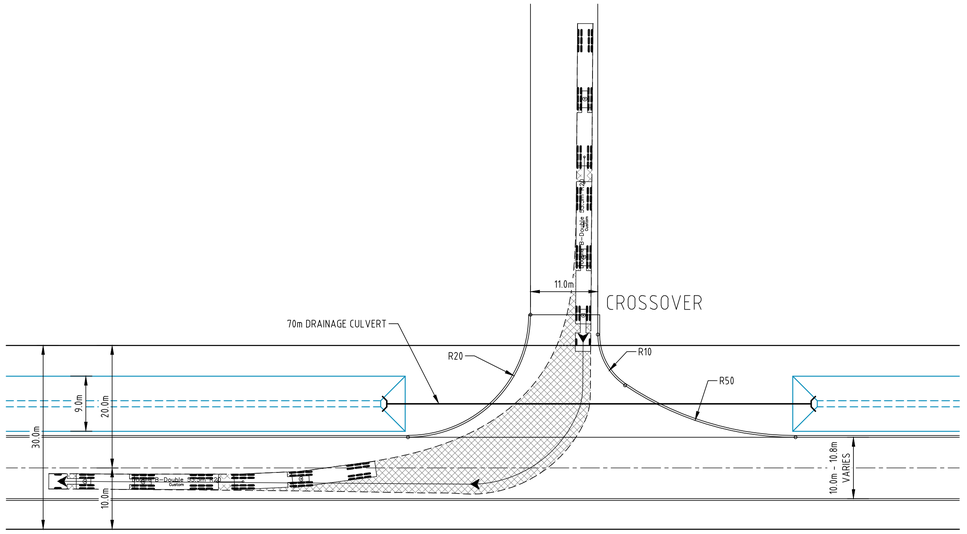
C




30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON SOUTHERN SIDE)

## CROSSOVER - RIGHT TURN ENTRY

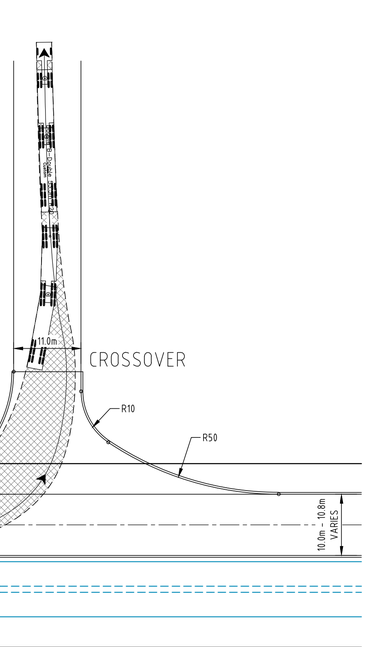
SCALE




30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON SOUTHERN SIDE)

## CROSSOVER - RIGHT TURN EXIT

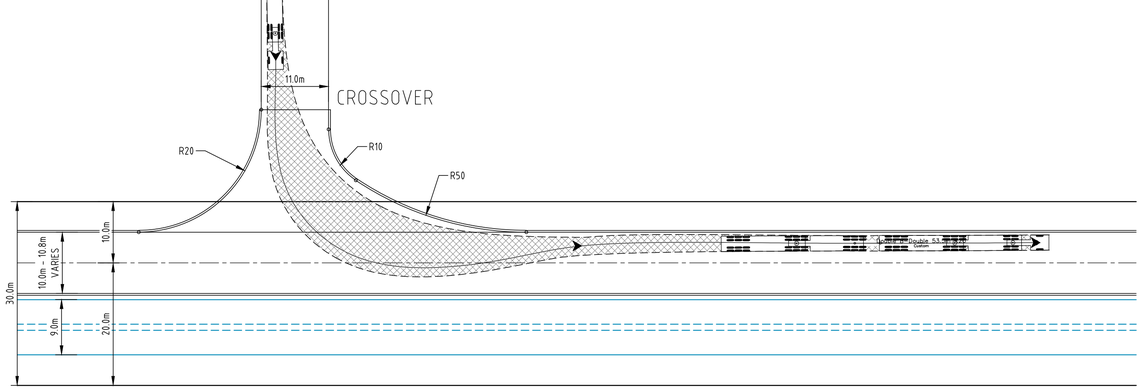
SCALE




30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON NORTHERN SIDE)

## CROSSOVER - LEFT TURN ENTRY

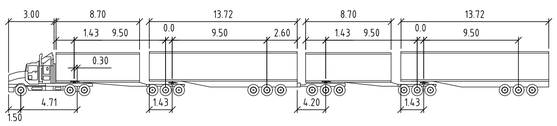
SCALE




30m ROAD RESERVE - LOCAL ROAD (CARRIAGEWAY ON NORTHERN SIDE)

## CROSSOVER - LEFT TURN EXIT

SCALE




Tandem Drive Double B-Double 53.5m R20

meters

| | | | | | |
|---|---|---|---|---|---|
| Tractor Width | : | 2.50 | Trailer Width | : | 2.50 |
| Tractor Track | : | 2.50 | Trailer Track | : | 2.50 |
| Lock to Lock Time | : | 6.0 | Articulating Angle | : | 70.0 |
| Steering Angle | : | 14.5 | | | |

1:500 0 5 10 20 30

Half Size 1:1000 - SCALE (m)

PROJECT:

**MUCHEA EMPLOYMENT NODE**

| No | DATE | REVISION | BY |
|---|---|---|---|
| A | 23-7-2018 | PRELIMINARY PLOT FOR COMMENT | MJV |

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Mt Pleasant 6153 WA

PO Box 1036
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Tel (08) 9315 9955
Fax (08) 9315 9959
Email office@porterseng.com.au
www.porterseng.com.au

YUSHO Pty Ltd ACN 010 091 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:

**SHIRE OF CHITTERING**

DRAWING:

**CROSSOVER SETOUT FOR RAV 10 VEHICLES**

STATUS: **FOR APPROVAL**

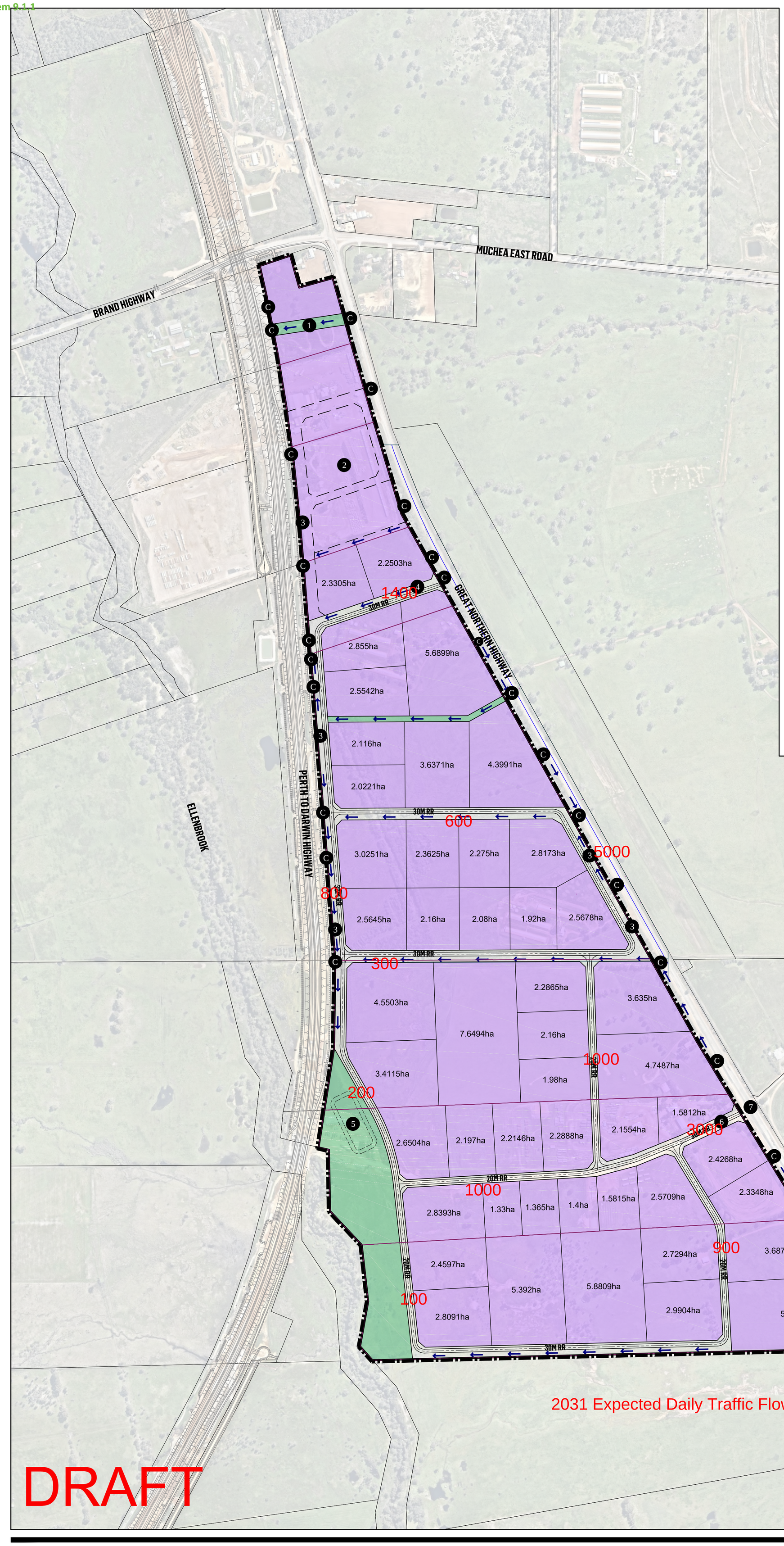
| | |
|---|---|
| SCALE | 1:500 |
| DATE | JULY 2018 |
| DESIGN | JH |
| DRAWN | MJV |
| CHECK | |
| APP'D | |

DRAWING No. **18-6-69/807** REV No. **A** ORIGINAL DRAWING SIZE **A1**

FILE NAME S:\ACTIVE PROJECTS\18-06-069\ACAD\18669-807.dwg

# D. TRAFFIC FLOWS

D




## LEGEND

- PRECINCT 3 STRUCTURE PLAN AREA
- GENERAL INDUSTRY ZONE
- FORESHORE AND DRAINAGE
- EXISTING LOT BOUNDARIES
- C — EXISTING AND PROPOSED CULVERTS
- MAIN DRAINAGE FLOWS

NOTES:

1. TENURE OF DRAINAGE CONFIGURATION TO BE DETERMINED (RESERVE VS EASEMENT WITHIN LANDHOLDING)
2. INDICATIVE FUTURE DEVELOPMENT LAYOUT
3. TABLE DRAIN LOCATION TO BE DETERMINED AT SUBDIVISION LEVEL
4. ASSUMES ROAD SIDE SWALE CAN BE LOCATED IN ALIGNMENT OF EXISTING CULVERT UNDERNEATH GREAT NORTHERN HIGHWAY
5. INDICATIVE DRAINAGE BASIN LOCATION
6. SITE ENTRY AND ACCESS ROAD IN ACCORDANCE WITH CONSTRUCTED SITE ACCESS ALIGNMENT
7. RISK WHETHER 4 WAY CONFIGURATION WILL GET APPROVAL FROM MAIN ROADS

URBIS

# Concept Plan

## Muchea Employment Node - Precinct 3

Level 14, The Quadrant, 1 William Street | Perth WA 6000 Australia | +61 8 9346 0500 | URBIS Pty Ltd | ABN 50 105 256 228

DATA SOURCE
Landgate & Bayley Environmental

PROJECTION
MGA Zone 50

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CLIENT
Tomahawk Property

1:5000 @ A1 | 1:10000 @ A3
50 100 150 200 250 m

PROJECT NO. P0002540
DATE 21.11.18
DRAWING NO. 02
REVISION -

# E. SIDRA INTERSECTION OUTPUT

E

# LANE SUMMARY

## Site: 101 [Intersection N]

New Site
Giveway / Yield (Two-Way)

**Lane Use and Performance**

| | Demand Flows Total veh/h | HV % | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Average Delay sec | Level of Service | 95% Back of Queue Veh | Dist m | Lane Config | Lane Length m | Cap. Adj. % | Prob. Block. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South: GNH | | | | | | | | | | | | | |
| Lane 1 | 11 | 25.5 | 1233 | 0.009 | 100 | 6.9 | LOS A | 0.0 | 0.0 | Short | 120 | 0.0 | NA |
| Lane 2 | 263 | 25.5 | 1319 | 0.199 | 100 | 3.7 | LOS A | 0.0 | 0.0 | Full | 500 | 0.0 | 0.0 |
| Approach | 274 | 25.5 | | 0.199 | | 3.8 | NA | 0.0 | 0.0 | | | | |
| North: GNH | | | | | | | | | | | | | |
| Lane 1 | 263 | 25.5 | 1319 | 0.199 | 100 | 3.7 | LOS A | 0.0 | 0.0 | Full | 500 | 0.0 | 0.0 |
| Lane 2 | 21 | 25.5 | 751 | 0.028 | 100 | 9.1 | LOS A | 0.1 | 1.2 | Short | 120 | 0.0 | NA |
| Approach | 284 | 25.5 | | 0.199 | | 4.1 | NA | 0.1 | 1.2 | | | | |
| West: Northern Road | | | | | | | | | | | | | |
| Lane 1 | 79 | 25.5 | 907 | 0.087 | 100 | 5.5 | LOS A | 0.3 | 3.9 | Short | 60 | 0.0 | NA |
| Lane 2 | 37 | 25.5 | 460 | 0.080 | 100 | 9.1 | LOS A | 0.3 | 2.9 | Full | 500 | 0.0 | 0.0 |
| Approach | 116 | 25.5 | | 0.087 | | 6.6 | LOS A | 0.3 | 3.9 | | | | |
| Intersection | 674 | 25.5 | | 0.199 | | 4.4 | NA | 0.3 | 3.9 | | | | |

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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# LANE SUMMARY

## Site: 101 [Intersection S]

New Site
Giveway / Yield (Two-Way)

**Lane Use and Performance**

| | Demand Flows Total veh/h | HV % | Cap. veh/h | Deg. Satn v/c | Lane Util. % | Average Delay sec | Level of Service | 95% Back of Queue Veh | Dist m | Lane Config | Lane Length m | Cap. Adj. % | Prob. Block. % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South: GNH | | | | | | | | | | | | | |
| Lane 1 | 21 | 25.5 | 1233 | 0.017 | 100 | 6.9 | LOS A | 0.0 | 0.0 | Short | 120 | 0.0 | NA |
| Lane 2 | 263 | 25.5 | 1319 | 0.199 | 100 | 3.7 | LOS A | 0.0 | 0.0 | Full | 500 | 0.0 | 0.0 |
| Approach | 284 | 25.5 | | 0.199 | | 3.9 | NA | 0.0 | 0.0 | | | | |
| North: GNH | | | | | | | | | | | | | |
| Lane 1 | 263 | 25.5 | 1319 | 0.199 | 100 | 3.7 | LOS A | 0.0 | 0.0 | Full | 500 | 0.0 | 0.0 |
| Lane 2 | 42 | 25.5 | 738 | 0.057 | 100 | 9.3 | LOS A | 0.2 | 2.5 | Short | 120 | 0.0 | NA |
| Approach | 305 | 25.5 | | 0.199 | | 4.5 | NA | 0.2 | 2.5 | | | | |
| West: Southern Road | | | | | | | | | | | | | |
| Lane 1 | 168 | 25.5 | 907 | 0.186 | 100 | 5.7 | LOS A | 0.8 | 8.9 | Short | 60 | 0.0 | NA |
| Lane 2 | 84 | 25.5 | 445 | 0.189 | 100 | 9.9 | LOS A | 0.6 | 7.1 | Full | 500 | 0.0 | 0.0 |
| Approach | 253 | 25.5 | | 0.189 | | 7.1 | LOS A | 0.8 | 8.9 | | | | |
| Intersection | 842 | 25.5 | | 0.199 | | 5.1 | NA | 0.8 | 8.9 | | | | |

Site Level of Service (LOS) Method: Delay (SIDRA). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Lane LOS values are based on average delay per lane.
Minor Road Approach LOS values are based on average delay for all lanes.
NA: Intersection LOS and Major Road Approach LOS values are Not Applicable for two-way sign control since the average delay is not a good LOS measure due to zero delays associated with major road lanes.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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# F. WAPC CHECKLIST

F

Transport Impact Assessment (Structure Plan) Checklist – Muchea Employment Node Precinct 3 LSP

| Item | Provided | Comments/Proposals |
|---|---|---|
| Summary | Yes | Section 1 |
| Introduction/Background | Yes | Section 1 |
| Structure plan proposal | Yes | Section 2 |
| regional context | Yes | Section 2.1 |
| proposed land uses | Yes | Section 2.2 |
| table of land uses and quantities | Yes | Section 2.2 |
| major attractors/generators | Yes | Section 2.3 |
| specific issues | Yes | Section 2.4 |
| Existing situation | Yes | Section 3 |
| existing land uses within structure plan | Yes | Section 3.1 |
| existing land uses within 800 metres of structure plan area | Yes | Section 3.1 |
| existing road network within structure plan area | N/A | No existing networks within structure plan area. |
| existing pedestrian/cycle networks within structure plan area | N/A | No existing networks within structure plan area. |
| existing public transport services within structure plan area | N/A | No existing networks within structure plan area. |
| existing road network within 2 (or 5) km of structure plan area | Yes | Section 3.2 |
| traffic flows on roads within structure plan area (PM and/or AM peak hours) | N/A | No existing network within the structure plan area. |
| traffic flows on roads within 2 (or 5) km of structure plan area (AM and/ or PM peak hours) | Yes | Section 3.3 |
| existing pedestrian/cycle networks within 800m of structure plan area | Yes | Section 3.2 |
| existing public transport services within 800m of structure plan area | Yes | Section 3.2 |
| Proposed internal transport networks | Yes | Yes 4 |
| changes/additions to existing road network or proposed new road network | Yes | Section 4.1 |
| road reservation widths | Yes | Sections 4.2 and 4.3 |
| road cross-sections & speed limits | Yes | Section 4.3 |
| intersection controls | Yes | Section 4.4 |
| pedestrian/cycle networks and crossing facilities | Yes | Section 4.6 |
| public transport routes | Yes | Section 4.8 |
| Changes to external transport networks | Yes | Section 5 |
| road network | Yes | Section 5.1 |
| intersection controls | Yes | Section 5.1 |
| pedestrian/cycle networks and crossing facilities | N/A | No changes to external network |
| public transport services | N/A | No changes to external network |
| Integration with surrounding area | Yes | Section 6 |

| | | |
|---|---|---|
| trip attractors/generators within 800 metres | Yes | Section 6.2 |
| proposed changes to land uses within 800 metres | Yes | Section 6.3 |
| travel desire lines from structure plan to these attractors/generators | Yes | Section 6.4 |
| adequacy of external transport networks | Yes | Section 6.5 |
| deficiencies in external transport networks | Yes | Section 6.5 |
| remedial measures to address deficiencies | Yes | Section 6.6 |
| Analysis of internal transport networks | Yes | Section 7 |
| assessment year(s) and time period(s) | Yes | Section 7.1 |
| structure plan generated traffic | Yes | Section 7.2 |
| extraneous (through) traffic | Yes | Section 7.3 |
| design traffic flows (that is, total traffic) | Yes | Section 7.4 |
| road cross-sections | Yes | Section 7.5 |
| intersection controls | Yes | Section 7.6 |
| access strategy | Yes | Section 7.6 |
| pedestrian/cycle networks | Yes | Section 7.7 |
| safe routes to schools | Yes | NA as it is industrial |
| pedestrian permeability & efficiency | Yes | Section 7.8 |
| access to public transport | Yes | Section 7.9 |
| Analysis of external transport networks | Yes | Section 8 |
| extent of analysis | Yes | Section 8.1 |
| base flows for assessment year(s) | Yes | Section 8.2 |
| total traffic flows | Yes | Section 8.2 |
| road cross-sections | Yes | Section 8.3 |
| intersection layouts & controls | Yes | Section 8.4 |
| pedestrian/cycle networks | Yes | Section 8.5 |
| Conclusions | Yes | Section 9 |

Proponent's Name: Tom Carmody

Company: Tomahawk Property Date: 11/12/2018

Transport Assessor's Name: Rodney Ding

Company: GTA Consultants (WA) Pty Ltd Date: 11/12/2018

# APPENDIX D ENGINEERING SERVICING REPORT

Cossill & Webley
CONSULTING ENGINEERS

# Muchea Industrial Precinct 3 Engineering Servicing Report

## Town Planning Scheme Amendment & Structure Plan

February 2019

Level 2, 431 Roberts Road,
Subiaco WA 6008.
PO Box 680 Subiaco, WA 6904

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Appendix A Typical Drainage Configuration
Appendix B Aqua Ferre Water Strategy Correspondence

# 1. EXECUTIVE SUMMARY

This report has been prepared by Cossill & Webley Pty Ltd (CW) for the Precinct 3 West Muchea Employment Node Town Planning Scheme Amendment (TPS) and Structure Plan (SP) preparation. It summarises the results of a review of the civil engineering issues which have influenced the form of the plan, as related to the future servicing of the developed land.

This report provides details for each major infrastructure type and a servicing strategy for implementation required for the development of the site. The level of detail is consistent with the requirements of a TPS Amendment and SP application and acknowledges further more detailed work will be required at the time of land subdivision.

The engineering review covers siteworks, roadworks, stormwater drainage, sewerage, water supply and utility services.

The investigation has found the land is capable of development in accordance with the proposed TPS with logical progressive extension of infrastructure and base capacity.

The ground conditions and past uses will not limit the proposed industrial development.

The existing road access, via Great Northern Highway will provide good road access with the external arterial road system.

Sewer infrastructure will be provided via Aerobic Treatment Units (ATUs).

Water supply will be provided via an extension of the water supply provided by Aqua Ferre for the Harvis development north of the Site.

Electrical supply can be provided via extensions off the existing high voltage network in Great Northern Highway.

Communications are available from existing services in Great Northern Highway. We understand there is capacity in the existing network to service the proposed development.

The investigations and preparation of this report is largely based on preliminary advice from the various service authorities. The information is current as of February 2019.

# 2. INTRODUCTION

The following report has been prepared by Cossill & Webley Pty Ltd (CW) and summarises the results of a servicing assessment of the engineering aspects of the potential industrial development of Lots 35, 192, 194, 800- 804 Great Northern Highway, Muchea ("the Site"). The lots collectively form Precinct 3 West of the Muchea Employment Node and collectively cover approximately 185 hectares as presented below in **Error! Reference source not found.**.

This report covers the engineering infrastructure requirements (siteworks, roads, stormwater drainage and utility services) for the future development of the Site.

The investigations and preparation of the report are largely based on preliminary advice from the various service authorities and is current as of February 2019.

*Figure 1: Existing Road Network (MNG, 2018)*

The Site is bound by Northlink to the west, Great Northern Highway to the east, Brand Highway to the north and large undeveloped lots to the south. The Site is currently accessed from Great Northern Highway to the east as presented above in Figure 1.

The landholding is currently zoned Agricultural Resource under the Shire of Chittering Town Planning Scheme No. 6, but has been identified as future industrial land within the Muchea Employment Node Structure Plan.

# 3. SITE DESCRIPTION

## 3.1 Site Vegetation

The Site is predominantly cleared, with some small pockets of vegetation scattered across the Site. An environmental assessment accompanies this TPS and SP, prepared by Bayley Environmental.

## 3.2 Existing Structures

There are a number of existing structures and sheds across the Site as presented above in Figure 1. A number of the lots are also currently being used for lay down and storage. Lots 800 & 801 contain existing poultry farms, which typically attract 500 metre buffers for sensitive land uses (see Figure 2 below).

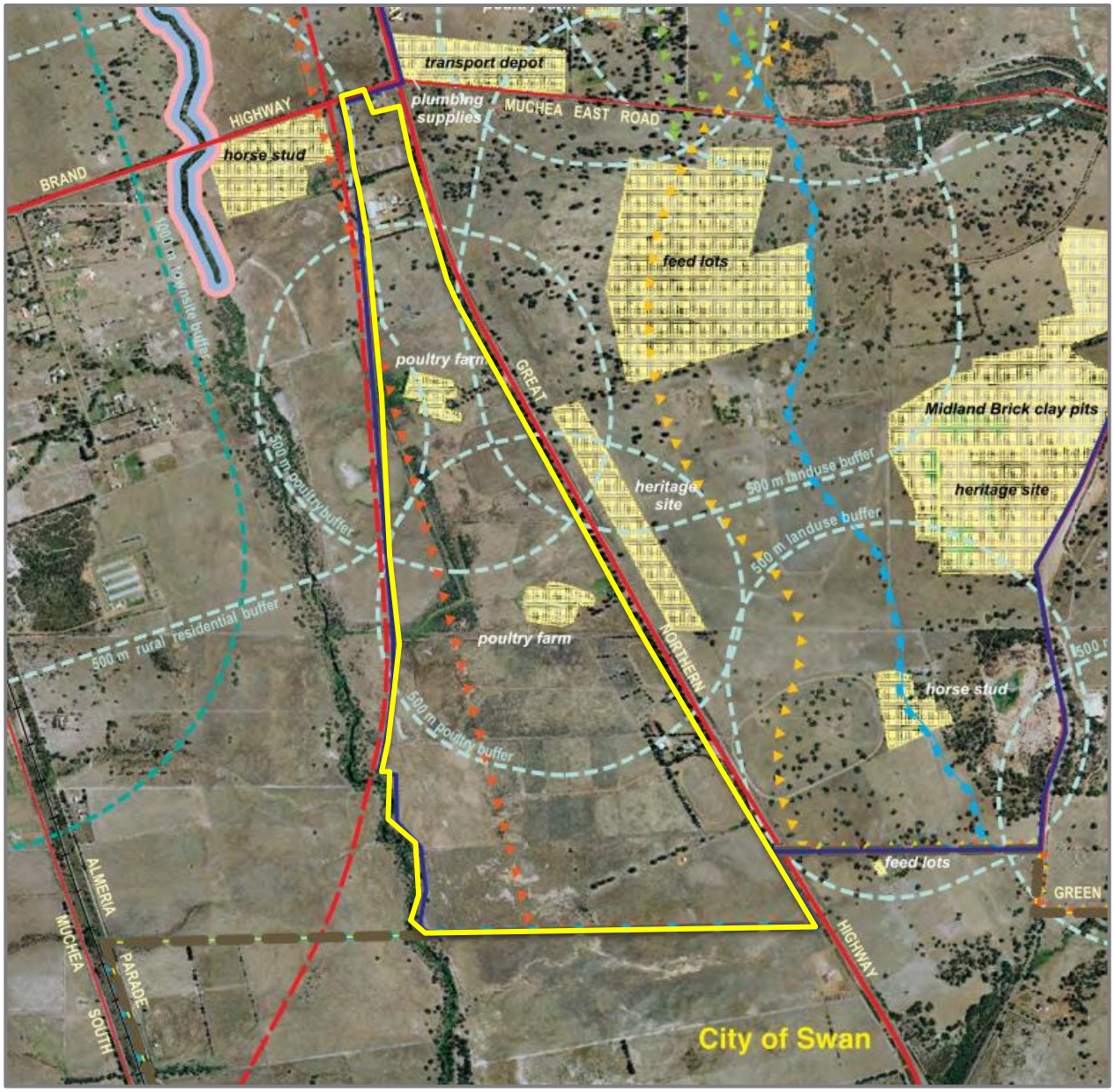



*Figure 2: Land Use Planning and Poultry Farm Buffers (Muchea Employment Node Structure Plan, Shire of Chittering, 2011)*

## 3.3 Geology

The Geological Survey of Western Australia Perth Metropolitan Region soils map for Muchea (part 2034I & 2134IV) indicates the majority of the Site is characterised by Pebbly Silt and Sand over Pebbly Silt, with a spine of Sand in the vicinity of the Ellen Brook (see below Figure 3). Pebbly Silt contains lower permeability material, and may increase the areas required for stormwater infiltration. They are also generally more reactive than sandy soils, resulting in greater movement with moisture changes, higher site classifications and resulting thicker foundations.

The soil conditions across the Site are consistent with the general Muchea area, and do not pose an impediment to industrial development.

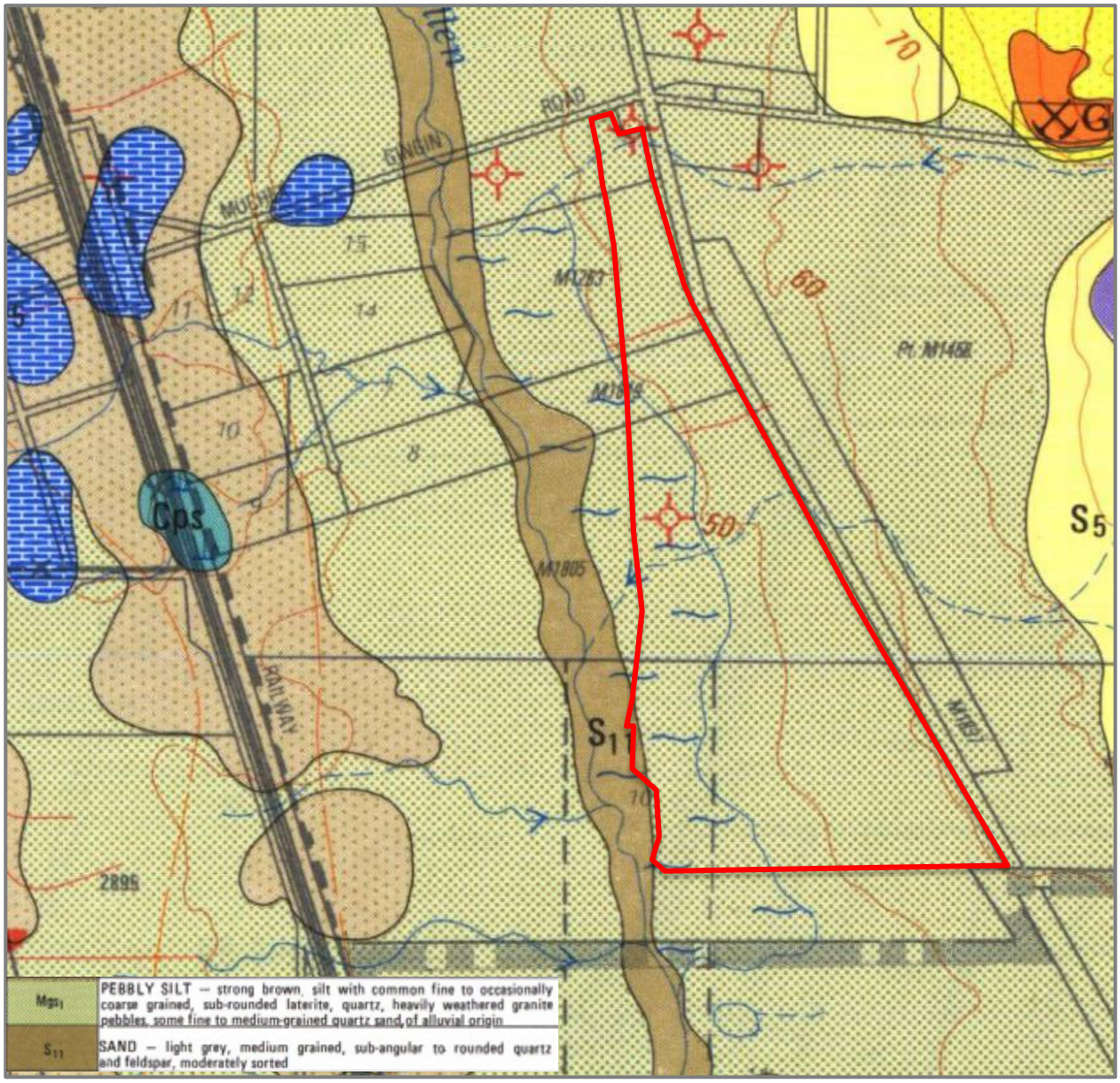



*Figure 3: Geotechnical Information (Geological Survey of WA)*

## 3.4 Acid Sulfate Soils

A desk top review of the ASS Risk Map for potential acid sulfate soils (ASS) indicates the Site is classed as having moderate to low risk of ASS occurring within 3m of the natural soil surface in the western and central portions of the site as depicted in Figure 4 below. The regions of varying ASS risk correspond to the different geologies across the Site, as presented in Figure 3 above.

Some treatment of acid sulfate soils or dewatering effluent may be required in the western portion of the Site, though this does not pose an impediment to future development.

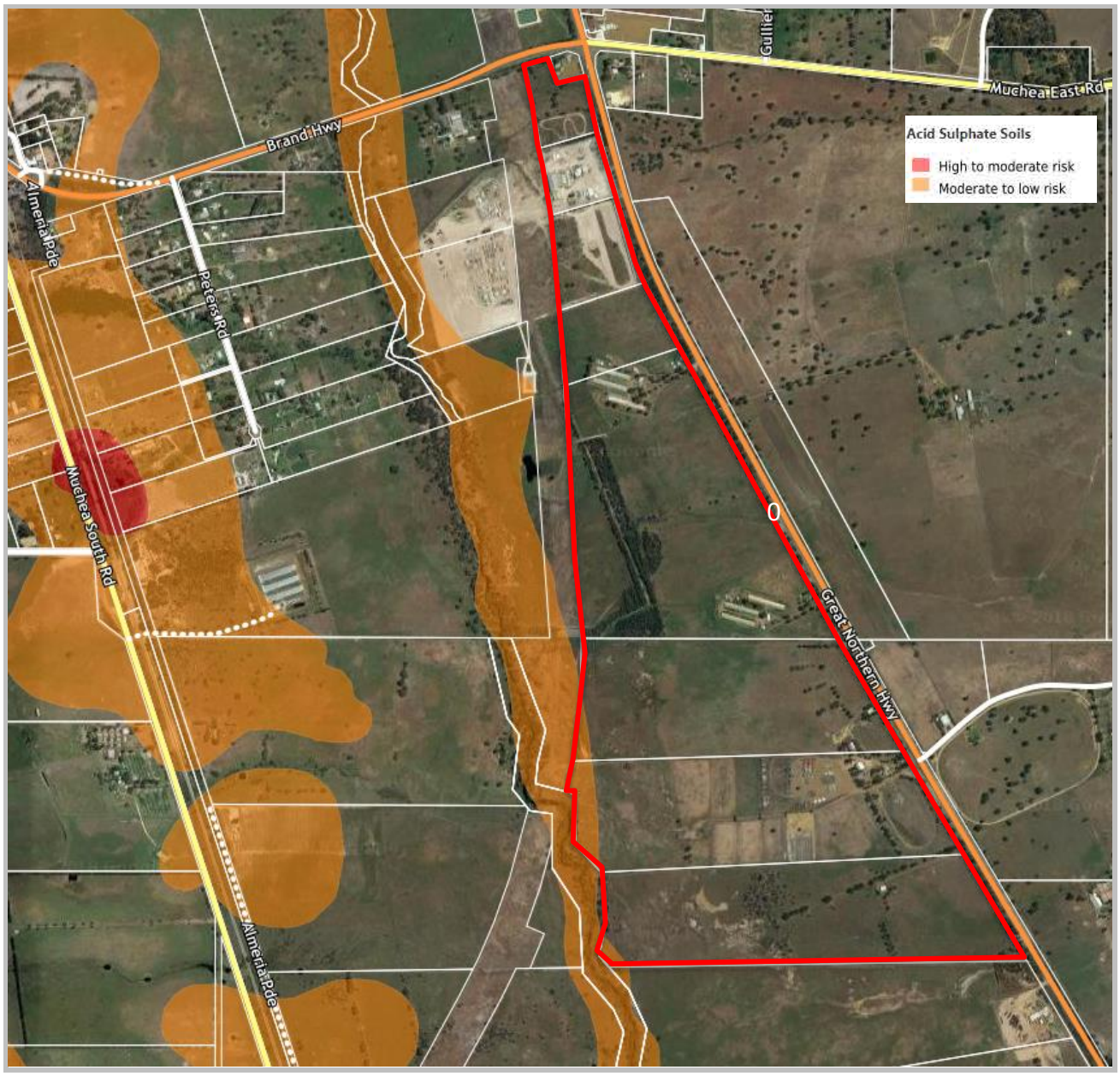



*Figure 4: Acid Sulphate Soils Risk Mapping (Department of Environment and Conservation, 2017)*

## 3.5 Site Contours

The Site ranges in elevation from RL59m AHD at the eastern boundary with Great Northern Highway to RL 42m AHD abutting Northlink as presented below in Figure 5.

The Site provides good grade for drainage purposes, though some regrading of the natural topography may be required for the proposed industrial land uses.

The planning layout provides good linkages in an east-west direction to convey runoff from west of the Site to the Ellen Brook.

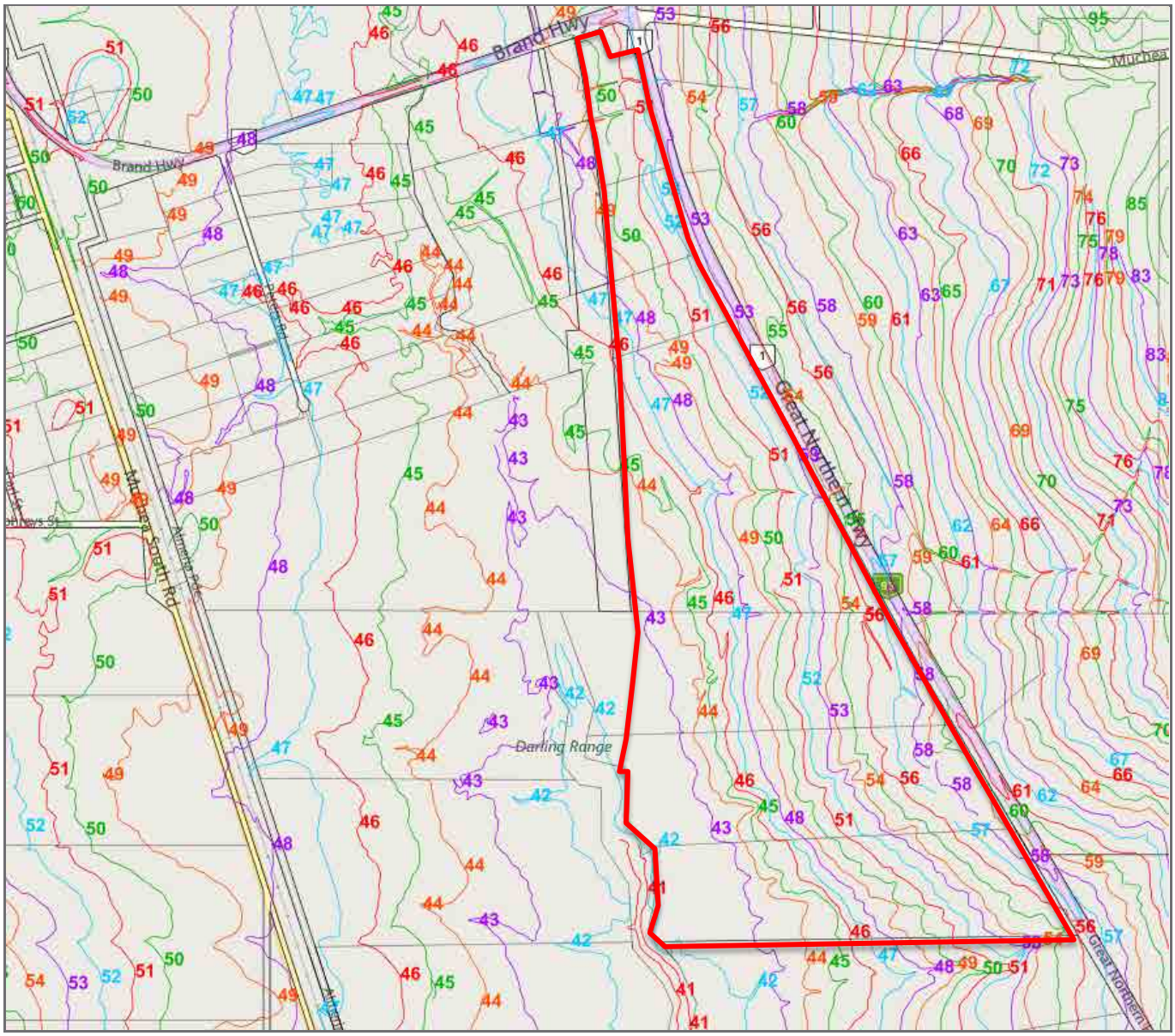



*Figure 5: Existing Ground Contours of the Site (Water Corporation 2018)*

# 4. SITEWORKS & EARTHWORKS

Siteworks for the proposed development will generally comprise clearing of existing vegetation and, where necessary, earthworking the existing ground to facilitate a required form of development.

Following clearing, topsoil is likely to be stripped, and if acid sulfate soils are present, this topsoil may require neutralisation treatment.

We note that the grades from east to west are generally about 2%, and typical industrial grades are preferred to be flatter, at approximately 1%. We anticipate the extent of siteworks and earthworks will be dictated by the proposed anticipated industrial usage, which may involve some filling of parts of the lot to provide flood protection from prevailing groundwater, level out grade across the lots and provide sufficient area for the effective disposal of treated effluent.

As a guide, the following earthworks are anticipated, which will be confirmed as part of the Subdivision Approval process, once further certainty on proposed land use, flood protection and effluent disposal requirements are known:

- Roads – we anticipate approximately 800mm separation between the finished road pavement and prevailing groundwater may be required to ensure the road pavement remains flood protected. This will be confirmed as part of the future detailed design, which will include the road pavement requirements and more accurately determine the depth to groundwater from the existing natural surface.
- Lots – the extent of fill is likely to vary across the lots depending on the sensitivity of the proposed land-use. We anticipate some fill may be provided to buildings areas (say 1 metre over the building pad), though this will be confirmed at the detailed design stage. Utilising the existing east/west grade across the site, there may be opportunity to minimise fill (to ensure adequate flood protection) by constructing cut-off diversion drains and grading the site to ensure any surface flows are directed away from proposed building pads.
- Effluent irrigation areas will be filled and sized to suit anticipated effluent disposal requirements.
- Subsoil drainage may be installed locally around existing building pads and effluent disposal areas to provide protection from prevailing groundwater.

A typical cross-section depicting a scenario for building pads and effluent irrigation areas is provided in Appendix A.

# 5. DRAINAGE AND GROUNDWATER MANAGEMENT

## 5.1 Groundwater

A review of groundwater levels across the Site has been undertaken by Bayley Environmental as part of this TPS & SP. Bayley Environmental has confirmed separation to groundwater varies from 0 at the south-western boundary to 0.8m at the eastern boundary. A plan depicting the Average Annual Maximum Groundwater Levels has been prepared by Bayley Environmental as part of the LWMS and is presented below in Figure 6.

At the detailed design stage, further consideration should be given to controlling groundwater through the incorporation of subsoil and cut-off drainage, or providing additional separation via the importation of fill. Further consideration could be given to providing a lower level of flood protection or only raising/protecting sensitive areas within each lot.

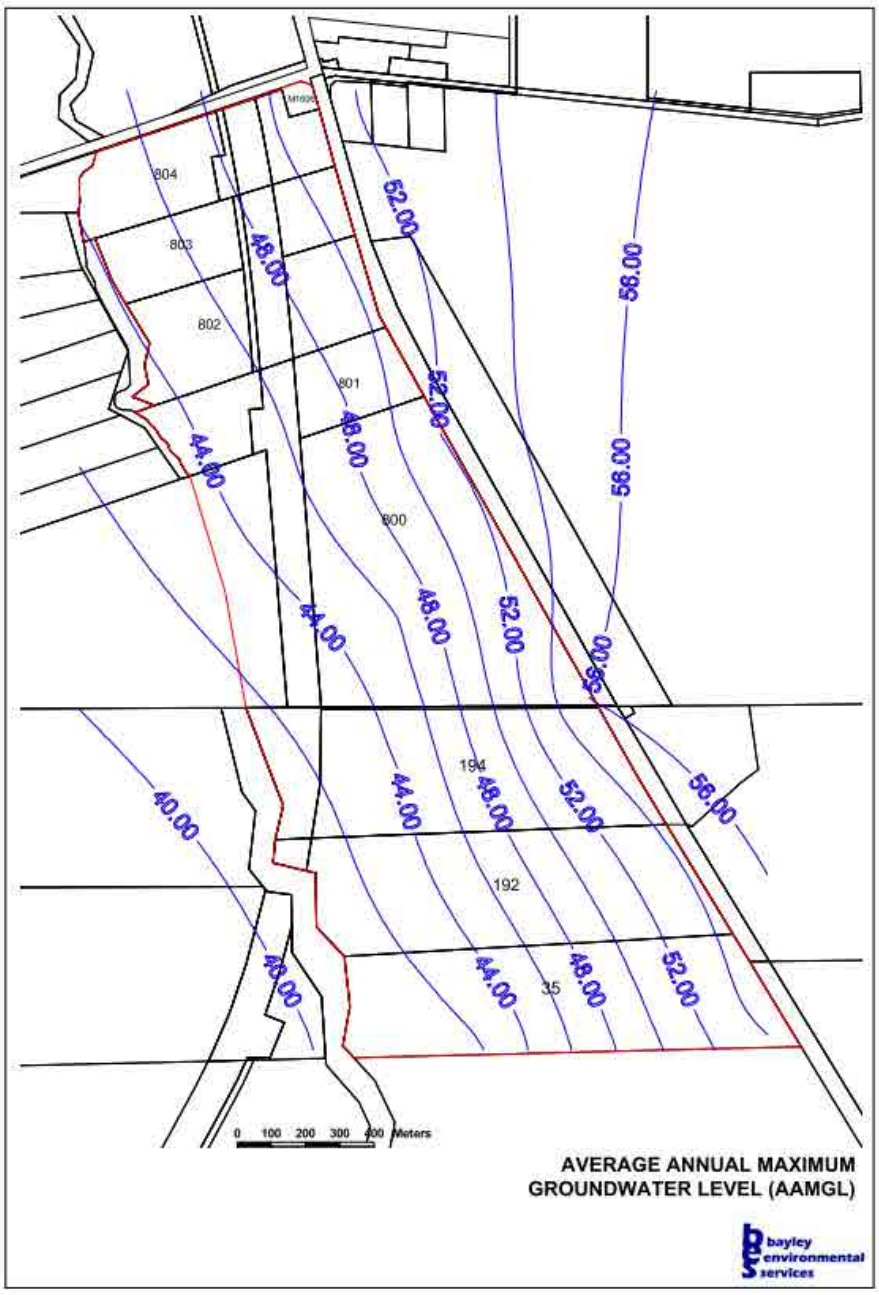



*Figure 6: Groundwater Contours (Bayley Environmental, 2018)*

## 5.2 Regional Through-flow

Bayley Environmental has confirmed there is regional through-flow from east of the Great Northern Highway through the Site, across Northlink to the Ellen Brook.

Drainage designs for the LSP have assumed this regional through-flow will be consolidated and diverted into roadside swales, which are sufficiently sized to convey local and external flows across the Site to the Ellen Brook.

Further details on the location of existing culverts under the Great Northern Highway abutting the Site and under Northlink are provided in the Local Water Management Strategy (LWMS).

The LWMS also confirms the anticipated external flows that will need to be conveyed through the Site as part of the development.

## 5.3 Stormwater

Ellen Brook is an ephemeral river which typically flows from May to December. The Site naturally grades towards Ellen Brook, hence it is anticipated discharge will be permitted from the Site at the pre-development flow rates as per the Local Water Management Strategy.

A typical plan and cross-section of the drainage strategy is presented in Sketch 1 in Appendix A for reference.

It is anticipated that stormwater runoff generated from the lots will be treated in swales at the front of the lots sized to retain the 1 hour 63.2% Average Exceedance Probability (AEP) storm event. Larger events will overtop to roadside drainage channels.

We anticipate all roads will include roadside treatment swales sized to treat the 1 hour 63.2% AEP storm event, with larger storm events from the roads and lots contained in the wider drainage swales within the road reserves, conveyed westward with the natural topography, towards the Ellenbrook. Road-side drainage swales will be sized to convey the critical 1% AEP event.

Some roadside swales will also be increased in size to cater for the regional through flow as outlined in the Local Water Management Strategy.

The drainage swales within the road reserves will be sized appropriately to convey the local runoff from roads and lots, as well as the external through-flows from east of the Site.

Some areas of piped drainage may be included where driveway cross-overs, or planning considerations do not support swale designs.

Flows to the Ellen Brook will be either via existing culverts constructed under Northlink, with any flow exceeding the culvert capacity diverted south to a detention basin at the southern area of the Site abutting Ellen Brook.

Further details of the proposed drainage strategy are provided in the Local Water Management Strategy prepared by Bayley Environmental.

# 6. ROADWORKS & FOOTPATHS

This Site is bound by Brand Highway to the north, Great Northern Highway to the east and the Perth Darwin Highway (Northlink) to the west as presented in Figure 1.

## 6.1 Great Northern Highway

Great Northern Highway is a Main Roads WA controlled Highway, which transitions from a four lane road at the south-eastern corner of the Site to a two lane road at the north-eastern corner. The pavement is in good condition and includes sealed shoulders and table drains both sides of the road.

There is an existing un-controlled T-intersection with passing lanes into Lot 192, with all other lots being accessed via standard driveway cross-overs.

## 6.2 Perth Darwin Highway

The Site is severed by an existing reserve for the future Perth-Darwin Highway (Northlink), which is currently under construction, due for completion mid-2019.

The proposed Highway will consist of a four-lane divided rural road, with an off-road Principle Shared Path (PSP) within the reserve to the east of the main road. Batters for the road and PSP are contained within the proposed reserve.

Construction of the Highway will sever access to a number of the parent lots within the development area, which Main Roads proposes to service with a slip road off Brand Highway.

There will be no access onto Northlink at Brand Highway, with the nearest interchange proposed an additional 1 kilometre north.

## 6.3 Brand Highway

The Brand Highway forms the northern boundary of the Site, and consists of a single carriageway two lane rural style unkerbed road. There is an existing intersection of Brand Highway and Great Northern Highway is controlled by traffic signals.

A fly-over of Northlink across Brand Highway is proposed as part of the Northlink construction, which will require reconstruction of a portion of the Brand Highway abutting the Site.

## 6.4 Development Roads

Road cross-sections will be designed to cater for utility services, on standard verge alignments, drainage requirements and on and off road pedestrian and cycle movements.

Further discussion on the RAV network and industrial road requirements is included in the Traffic Report accompanying the TPS and LSP.

The engineering design of roads will be carried out to comply with the Department of Planning, Lands & Heritage, and the Shire of Chittering.

Due to the proximity of the groundwater table, and the clay foundations of the Site, the inclusion of subsoil drainage adjacent to the road pavement may be required to protect the road base.

# 7. WATER RETICULATION

The Water Corporation has advised that the Site is not within a current water catchment, and there are no plans to extend the water catchment boundary at this stage.

A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre, which includes construction of a water treatment facility on Lot 2 Reserve Road, Chittering capable of supplying potable water to residential and commercial properties in the Lower Chittering-Muchea area.

Aqua Ferre is in the process of applying for a Water Service Provider Licence from the Economic Regulation Authority.

The project proposes to draw water from the Leederville Aquifer, with treatment to meet drinking water quality guidelines. Aqua Ferre has confirmed they have capacity within their proposed licence to service the proposed industrial development of the Site with potable water, and have advised the most likely strategy would include an extension of the proposed Harvis network depicted below in Figure 7 to service the proposed development.

Provision to the Muchea Precinct 3 Employment Node is still subject to mutually agreeable commercial terms with Aqua Ferre, though from the structure plan perspective, we confirm the site can be serviced with water reticulation by a licensed provider, as required by the MENSP, and that there are no engineering impediments to the provision of water to the proposed development.

Further details pertaining to Aqua Ferre's strategy for the provision of water to the site is provided in Appendix B.

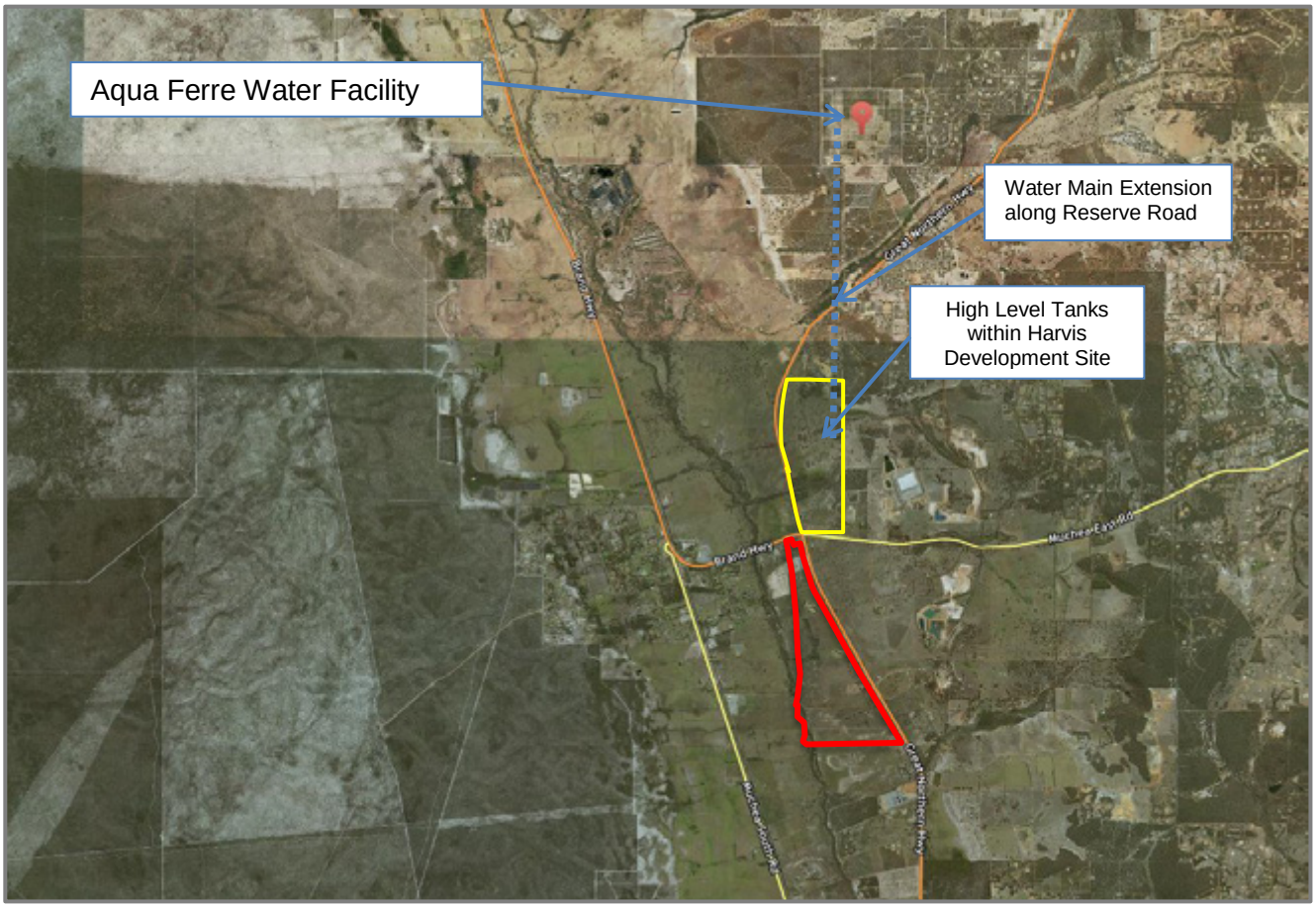



*Figure 7: Aqua Ferre Water Strategy (Aqua Ferre, 2018)*

# 8. SEWERAGE RETICULATION

The Water Corporation has advised that the Muchea LSP is not within a current wastewater catchment, and there is no proposal to extend the catchment boundary at this stage.

An alternative option proposed by the Precinct 3 West Muchea Employment Node is to manage general wastewater (wastewater from buildings/site offices) on an individual inter-allotment scale utilising Aerobic Treatment Units (ATUs). ATUs are small wastewater treatment plants, designed to treat wastewater to a quality suitable for irrigation. The individual lot must provide sufficient landscaped area to avoid inundation and surface runoff. A typical lot configuration showing the extent of landscaped area for the effective disposal of effluent is included in Appendix A.

- The ATUs must be maintained to ensure compliance with the Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Units
- Greater than or equal to 1.5m separation between the effluent discharge point (eg ATU drip lines) and the highest known groundwater level shall be provided;
- Wastewater disposal Site must be above 1:10 year flood level;
- Cannot discharge wastewater into the ground less than 30m from any water intended for human consumption;
- Cannot be located within 100m of a watercourse or wetland.

A land capability assessment (LCA) will be required prior to subdivision to determine the detailed design requirement for ATUs considering the underlying soil conditions, clearance to groundwater and environmental constraints specific to the lot.

Sewer reticulation and a centralised treatment system may be considered for parts of the Site where there are smaller industrial lots, which have reduced capacity for irrigation volumes, or lots with a requirement for a large volume of sewer treatment. There are alternatives for centralised treatment systems if required. These options have not been assessed, and will require the relevant approvals prior to any agreements with potential industrial developments.

Any wastewater produced on lots from industrial processes will be required to be treated appropriately on each lot, which is no different to industrial lots in areas with reticulated sewer. Where appropriate treatment is not achievable (due to the volumes or contaminants) industrial process wastewater will be captured and removed from site to an appropriate treatment facility.

# 9. POWER

There are existing overhead 22kV high voltage overhead power cables in the eastern verge of Great Northern Highway and southern verge of Brand Highway which are fed from the existing Muchea Zoned Sub-Station which are presented below in Figure 8.

The Western Power Network Capacity Mapping Tool was used to determine future forecast remaining capacity in the electricity network, which confirmed the network will have more than 30MVA remaining capacity in 2020. We anticipate this capacity will be sufficient to service the future power requirements of the development, though Western Power will need to confirm the connection locations and capacity of the existing system as part of a feasibility assessment at the next stage of the planning process.

A series of HV feeds, switch stations and transformers will be required throughout the development to meet individual site requirements.

Additional distribution mains from the Muchea Sub-Station may be required in the future to augment the existing supply network, depending on industrial uses proposed and likely power requirements.

*Figure 8: Existing Overhead Power Lines (Western Power, 2018)*

# 10. GAS SUPPLY

There is no proposed gas distribution within the vicinity of the Site. The supply of a gas distribution network in the future is not ruled out, however it will depend on economics and likely demand of the broader Muchea area.

# 11. TELECOMMUNICATIONS

The Site has not yet been served with NBN, but there is existing Telstra communications in Great Northern Highway servicing the Site.

As per the New Developments Policy announced by the Minister for Communications & The Digital Economy in December 2010, new developments with 100 premises or more will be prioritised by NBN Co to have optic fibre infrastructure installed. This development falls short of this threshold, and may not be prioritised by NBN Co.

Using the NBN Co 'Check your address', the Site is planned to be connected to the NBN network in January-June 2020 with a fixed wireless connection (this date is an estimate and could change). Based on the anticipated connection date, it is likely the Site will be connected to the NBN network by the time development commences and no offsite upgrade by the developer would be applicable. A Fixed Wireless communications connection uses wireless technology rather than cables, data travels from a transmission tower located as much as 14 kilometres from the premises to a rooftop antenna that has been fitted by an approved NBN installer.

At the time of development negotiations with NBN, Telstra, or alternative telecommunications service providers will be required to negotiate for the provision of this service to the Site. If the Site isn't yet served with telecommunications from the preferred provider it is likely that contributions to backhaul or headworks upgrades may be sought by the relevant telecommunications service provider for the service.

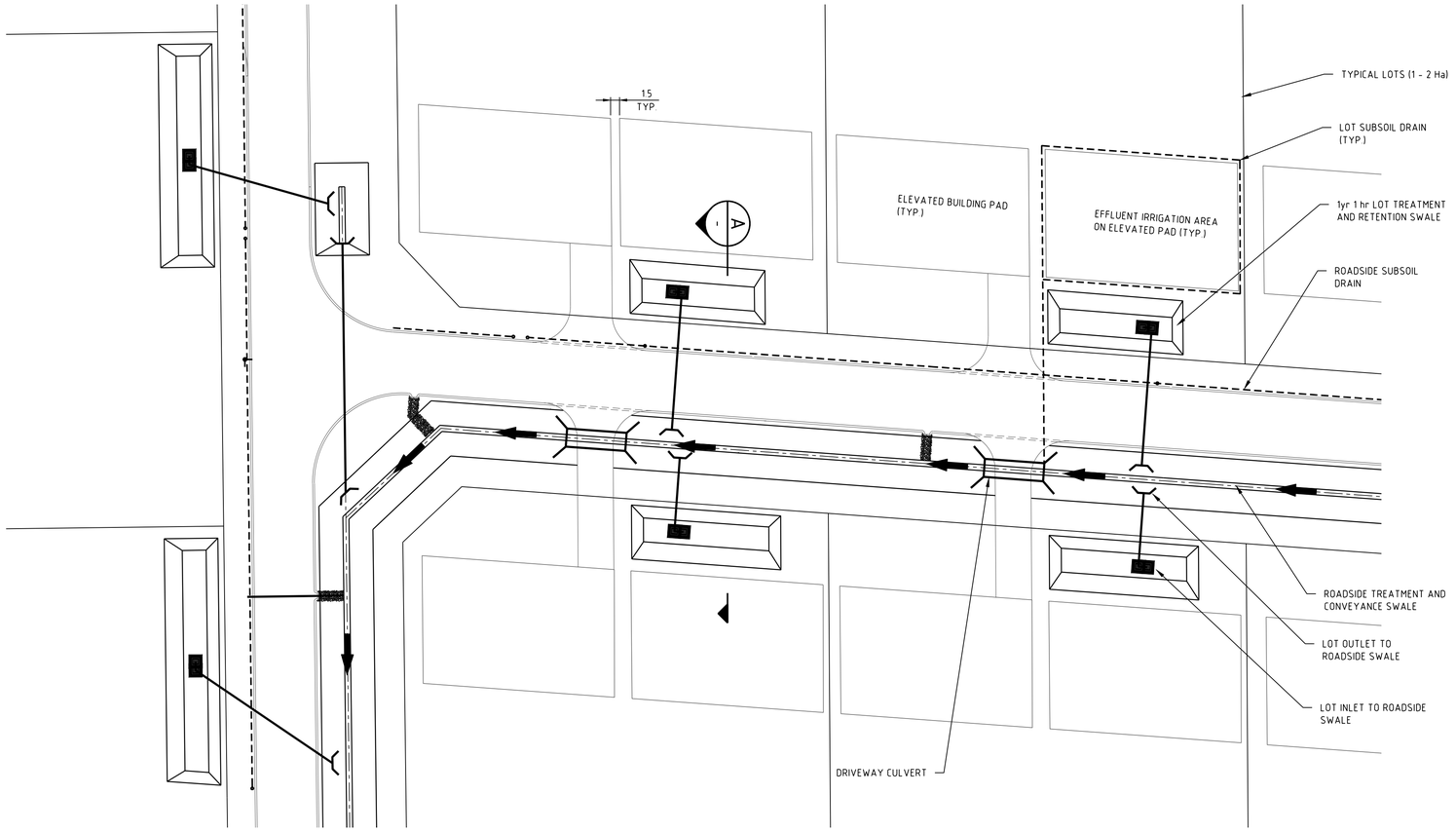
# 12. CONCLUSION

Precinct 3 West Muchea Employment Node has planned strategies for water and sewerage supply and other necessary public utility services are available or can easily be extended to service the proposed industrial area.

There are no engineering impediments to the development, though co-ordination and co-operation with the relevant Service Authorities will be required as the development progresses.

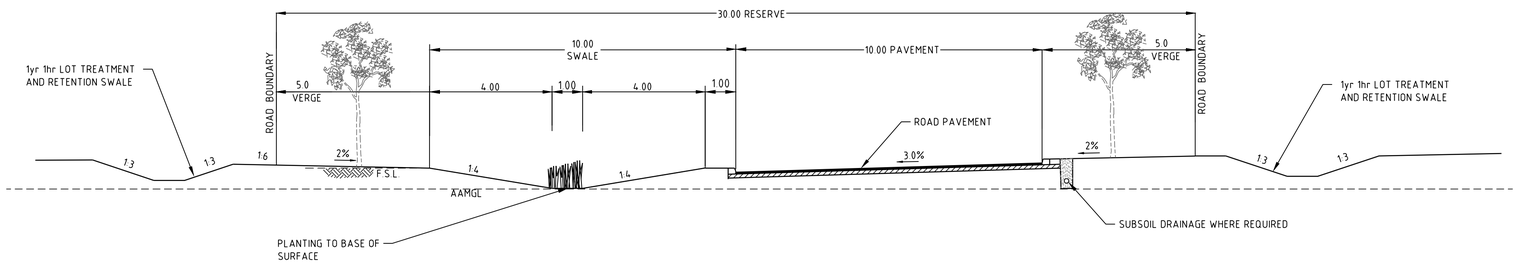
From an engineering perspective, the site is well suited to future development.

# APPENDIX A
## Typical Drainage & Lot Configuration




## TYPICAL ROAD AND LOT CONFIGURATION

(SCALE 1:500)




## TYPICAL CROSS SECTION OF LOCAL ROAD

SECTION A

(SCALE 1:100)

| REV | DATE | DRN | CKD | APP | AMENDMENT |
|---|---|---|---|---|---|
| A | 27.11.18 | RG | AT | | ISSUED FOR INFORMATION |

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CLIENT: TOMAHWAK PROPERTY

APPROVED: AT

DESIGNED: AT

SCALE: AS SHOWN

PROJECT: MUCHEA EMPLOYMENT NODE - PRECINCT 3

TITLE: TYPICAL ROAD AND LOT CONFIGURATION

WAPC No.: WAPC No.

DRAWING No.: 6331-00-SK03

REVISION: A

ORIGINAL SIZE: A1

O:\6331 Ingham Muchea\6331-00\Acad\6331-00-SK03.dwg, 27/11/2018 4:51:33 PM, rajiang, Digital Signing PDF.pc3, 1:1, - CW Reference

# APPENDIX B

## Aqua Ferre Water Strategy Correspondence

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29 January 2018

Tom Carmody
Director and Licensee
Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group
8/355 Stirling Highway
Claremont WA 6010

Dear Mr Carmody

Muchea Employment Node Precinct 3 Landowner Group

I refer to your enquiries to Aqua Ferre Pty Ltd (Aqua Ferre) regarding the availability of water and the potential future supply of water, within the Muchea region.

You have advised that you represent a number of landowners with properties on Great Northern Highway and Brand Highway in Muchea (collectively described as the Muchea Employment Node Precinct 3 Landowner Group or more generally the landowner group).

On behalf of the landowner group you have requested information from Aqua Ferre in support of two planning documents:

- Shire of Chittering Town Planning Scheme No 6 Amendment No.67 - Rezoning Lots M1601, 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Industrial Development' zone, and amending the Scheme Maps accordingly; and
- Precinct 3 Muchea Industrial Park Structure Plan.

In particular you have sought information regarding Aqua Ferre's water entitlements, the prospect that some of Aqua Ferre's water entitlement may be allocated to the landowner group properties, and whether the water can be practically supplied from Aqua Ferre's operations to the landowner group properties.

## 1 MEN & Precinct 3

The Muchea Employment Node Structure Plan (MENSP) was adopted by the WAPC in August 2011, and provides a 20-year planning framework for industrial development within the Shire of Chittering. We understand that the MENSP is currently under review and a revised document is expected to be released during 2019.

You have advised that the subject land is located within Precinct 3, which forms the eastern portion of the MENSP, to the west of Great Northern Highway (GNH).

Precinct 3 of the Muchea Employment Node (more recently referred to as the Muchea Industrial Park (MIP)) ('the Structure Plan area') is approximately 185ha in area and located to the south east of the

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townsite of Muchea. Precinct 3 is triangular in shape and extends in a lineal pattern from Brand Highway in the north, along Great Northern Highway (GNH) in the east, to the southern boundary of the Shire of Chittering, and along the Perth-Darwin Highway (PDNH) to the west, which is currently under construction.

Figure 1 below shows the proposed Precinct 3 development boundaries (Urbis 2019, LPS Amendment, Muchea Employment Node, DWG-11).

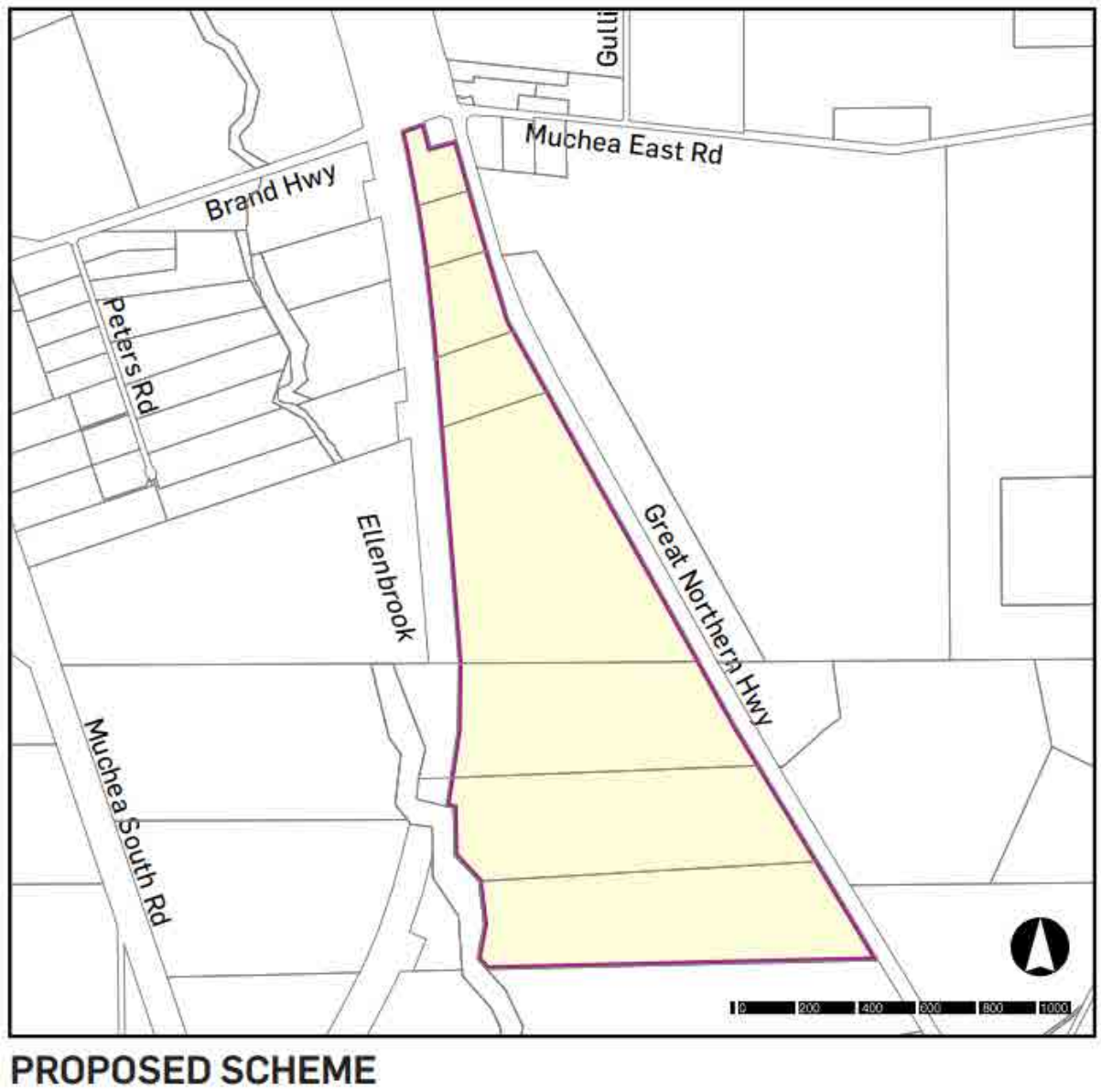


**Figure 1 Proposed Precinct 3 development**

Urbis[1] have indicated that the land has largely been historically cleared for agricultural purposes and contains stands of large, mature trees with degraded understorey, and a number of rural drainage lines.

[1] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

You have advised that the Structure Plan[2] will provide approximately 51 lots of approximately 1.3ha to 7.6ha providing flexibility for a range of industrial uses, expected to be primarily transport logistics related.

We understand that the Structure Plan is being progressed concurrently with Amendment No.67 to LPS6 which proposes to rezone the land from 'Agricultural Resource Zone' to the 'Industrial Development' zone, to introduce land use permissibility for Precinct 3; clarify requirements for the preparation of Management Plans, and introduce provisions relating to provision of reticulated water and construction of the loop road.

## 2 Aqua Ferre

Aqua Ferre was established to be an independent water service provider following approaches by property development groups seeking water services in the Chittering/Muchea region. Aqua Ferre is proposing to build and operate a potable water supply system at Reserve Road, Chittering (as shown in Figure 2).

The proposed water treatment plant (WTP) would be operated as a constant flow rate to promote a stable process with the intention of producing reliable potable water that meets the Australian Drinking Water Guidelines.

Figure 2 below broadly shows the Precinct 3 development (outlined in red) to the south of Harvis' proposed MEN (Phase 1) development (outlined in yellow) and Aqua Ferre's proposed water facility to the north.

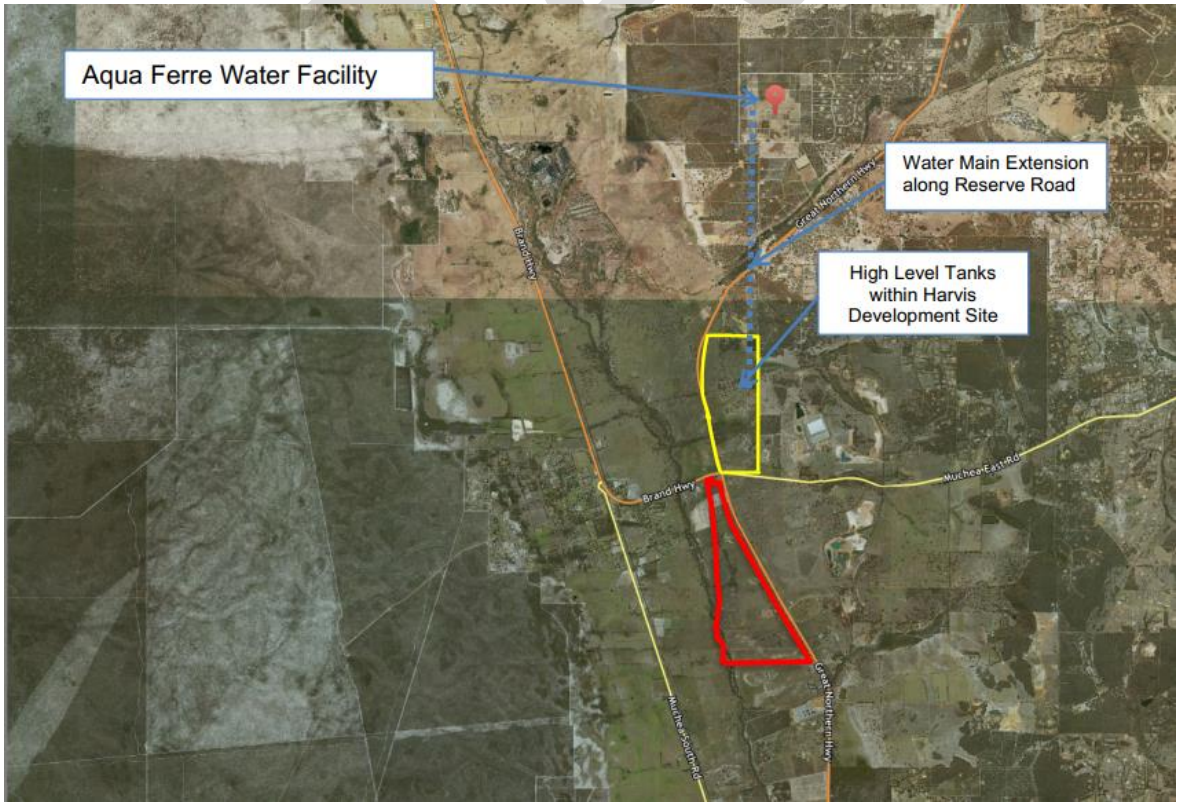


**Figure 2 Development boundaries**

[2] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

## 2.1 Water Entitlement

The Reserve Road (Chittering) property currently has a total water entitlement or allocation (licence to abstract water from an artesian aquifer) of 288,800 kL per annum. The developer of the Reserve Road residential development, Riverside, has transferred the Water Licence GWL 59907(3) to the Water Corporation to enable the licence to be changed from an agricultural extraction to public water supply. It is intended that this water entitlement will be transferred to Aqua Ferre when a water service licence has been granted.

Aqua Ferre has similar entitlement rights to a further 362,900 kL per annum licence, originally GWL 102502(4) which is now part of GWL 65011.

In total, it is intended that Aqua Ferre will have access to 651,700 kL of water per annum.

There is an existing production bore located within the proposed Reserve Road development that was previously used for wildflower irrigation, where the proposed potable WTP would be located.

## 2.2 Existing water supply commitments

Aqua Ferre intends supplying approximately 153 ML of treated potable water to the residential development at Reserve Road, Chittering, and to a commercial/industrial development at the adjacent MEN (northern Precinct 1 only). It is intended that a further 75 ML will be set aside for future demand across these two developments.

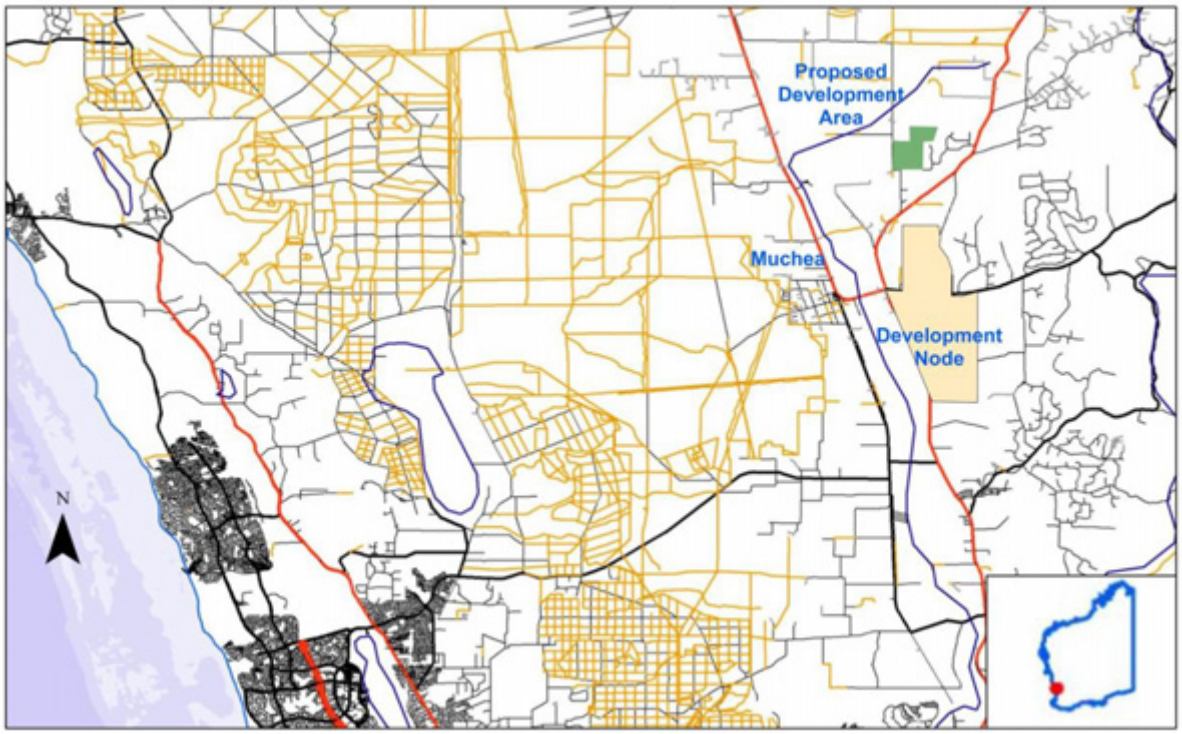


**Figure 3 Location of Reserve Road residential development and MEN**

The new Reserve Road rural living allotment development is located 8km north east of the Muchea town site and 80km north of the Perth central business district. It is also in close proximity (4km) to the

proposed MEN on the eastern side of Great Northern Highway. The development is in accordance with the Shire of Chittering's planning scheme (2004). The Reserve Road development covers an area of approximately 160 hectares and involves the creation of approximately 245 rural residential allotments in progressive stages. It is a requirement of the development approval that potable reticulated water is available.

**Figure 4 Contour map (5m contour lines) of the Harvis MEN development showing ephemeral swale**

Phase 1 of the MEN development is being undertaken by development group Harvis Capital Pty Ltd (Harvis). The Harvis development is located on the northern end of the proposed MEN. The site is slightly undulating with an ephemeral swale running through the development (Figure 4). The development is well placed and has been planned around the proposed Perth Darwin Highway.

It is the intention of the MEN development that these lots also have a reticulated water resource. Currently, the area does not have a public water supply scheme. Aqua Ferre is finalising documentation to allow the Economic Regulation Authority Western Australia to consider an application for a water services licence.

It is proposed that the water supply for the Harvis MEN development will have a standalone delivery and network system, to ensure that the demand of both systems can meet peak demand and firefighting requirements.

After treatment, it is intended that the water required for the Harvis MEN site will be delivered to a 500kL holding tank with aeration. Water would be reticulated to customers using a standard, continually pressurised water reticulation network. The piping would follow the general topography and alignment of the development streets and will have 600mm coverage.

## 3 Precinct 3 water requirement

You have advised that the intention is that the land the subject of the Structure Plan would be serviced with reticulated water provided by a licensed water provider.

The total area of supply is for an industrial development totalling approximately 185 hectares. No indication of staging of development has been provided at this point.

Estimated annual water usage has been provided (based on preliminary modelling by Cossill & Webley) as 203ML per annum on a net area of 139 hectares (after allowing for a 25% reduction in land area calculation to accommodate roads/drainage). The proposed system has been modelled at 4kL/day per hectare based on advice from Cossill & Webley of studies of similar industry types and uses. It is noted that this compares to the Water Corporation design standard for industrial land of approximately 17 kL/ha/day.

Based on your advice of estimated water usage, Aqua Ferre would have capacity under its entitlements to meet the demand of the subject land. This is not an undertaking to commit an allocation of water, or to supply water, to the Muchea Employment Node Precinct 3 Landowner Group. Any such arrangements would be the subject to future commercial negotiation, agreement on terms including pricing and remaining water availability under Aqua Ferre's entitlements.

## 4 Supply assessment

Aqua Ferre has conducted a preliminary desktop assessment of the potential supply route from its planned water treatment plant at Reserve Road to the proposed Precinct 3 development via Harvis' phase 1 MEN development. This represents a distance of approximately 3.5 kilometres.

The assessment did not highlight any major engineering impediments to the provision of water to the proposed development. (This is not to say, however, that any impediments would not become apparent on more detailed analysis.)

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Any proposal for supply would be inclusive of the requirements of:

- Water Corporation Design Standard DS 63 – Water Reticulation Standard Design and Construction Requirements for Water Reticulation Systems or Water Reticulation Systems up to DN250
- DFES requirements for firefighting services
- Hydraulic modelling using EPANET 2 for system hydraulics.

Hydraulic modelling would require topographical mapping at 0.5m.

Additionally, there would be a requirement for a water reserve for tanks, pumps, sumps, generator and chlorination which would need to be met by the subject landowners' group.

## 5 Disclaimer

This report is dated 29 January 2019 and incorporates information available to Aqua Ferre up to that date only. It excludes consideration of any information arising, or event occurring, after that date which may impact opinions expressed or statements made by Aqua Ferre in this report.

Aqua Ferre has prepared this report on the instructions, and for the sole benefit, of Tomahawk Property (Instructing Party), for inclusion within a rezoning application and Structure Plan as described in paragraph 3 of this letter (Purpose) and not for any other purpose or use. To the extent permitted by applicable law, Aqua Ferre expressly disclaims all liability, whether direct or indirect:

- to the Instructing Party, which may arise in connection with any reliance or purported reliance on this report for any purpose other than the Purpose, and
- to any other person, which may arise in connection with any reliance or purported reliance on this report for any purpose whatsoever (including the Purpose).

All statements and opinions contained in or associated with this report are made on the basis of information supplied to Aqua Ferre as at the date of this report, and upon which Aqua Ferre has relied. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with any errors or omissions in this report arising from information provided to Aqua Ferre by the Instructing Party or by any other person.

Achievement of any proposed or intended events or circumstances described in this report will depend, among other things, on the actions of others, over which Aqua Ferre has no control. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with the delay in, or failure to occur of, any proposed or intended events or circumstances described in this report.

Yours sincerely

Peter Fogarty
Director

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# APPENDIX E
# GEOTECHNICAL REPORT

Doc GE2.2.1

# GEOTECHNICAL INVESTIGATION

**For:** Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners

**Project Address:** Muchea Employment Node - Precinct 3 - Muchea

**Project Number:** D206263

**Job Number:** J315642

**Revision Number:** 1

**Author:** David Harding

**Date:** 20/12/2018

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# 1. PROJECT DETAILS

## 1.1. Introduction

At the request of Tom Carmody of Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners, Structerre Consulting Engineers (Structerre) have conducted a Geotechnical Investigation at Muchea Employment Node Precinct 3, Muchea, WA. The purpose of the investigation was to provide the following for industrial purposes:

- Desk top study including a summary of geology, groundwater, site history (obtained from historical photographs) and potential presence of Acid Sulfate Soils (ASS)
- Summary of encountered ground and groundwater conditions
- Site Classification in accordance with AS2870
- Earthquake site factor in accordance with AS1170.4
- Recommendations for stormwater drainage design
- Site preparation requirements (earthworks), including site traffic, excavation, reuse of materials and batter slopes
- Ground bearing capacity and estimated settlements for pad and strip footings founded at 0.5m and 1.0m
- Geotechnical design parameters for retaining structures and or deep foundations
- Preliminary pavement design parameter, indicative California Bearing Ratio (CBR) values determined from penetrometer results and ground conditions encountered

This report details the scope of the geotechnical investigation, presents an interpretation of ground conditions and material properties across the site, provides geotechnical design parameters for the design of the proposed infrastructure, and evaluates the suitability of materials for use in earthworks. Interpretation of site conditions is based on the subsurface lithology revealed during the investigation programme, visual assessments of the in situ materials and the results of in situ field tests.

Terms of reference for this investigation were presented in a Structerre Consulting Engineers proposal reference Q78062 (dated 21 November 2018), which was submitted to and accepted by Muchea Employment Node Precinct 3 Land Owners.

## 1.2. Site Description & Proposed Development

The site is located at Muchea Employment Node Precinct 3, Muchea, Shire of Chittering. Great Northern Highway lies to the east of the site, Brand Highway to the north, Perth To Darwin Highway to the west and rural properties to the south.

The site gently sloping towards the western section. At the time of the field investigation existing industrial/farm buildings occupied the site. The land is largely cleared farmland with some vegetation and trees existing.

We understand that the site is to be used for an industrial development.

### 1.3. Field Investigation – Scope of Works

The field investigation was carried out on 26 and 27 November 2018 and comprised:

- 37 x Sample Retrieval Probe boreholes (BH) to a depth of 2.5m over the site for material assessment and soil profiling;
- 7 x In situ percolation tests to determine the permeability of the materials within the upper 1.0m; and
- 37 x Dynamic Cone Penetrometer (DCP) tests in accordance with AS 1289.6.3.2 (1997) to a depth of 1.0m for evaluation of relative densities of the upper layers.

The borehole, percolation and DCP test locations are shown on the attached site plan in Appendix 1.

A suitability qualified geotechnical personnel from Structerre supervised the fieldwork and all fieldwork, interpretation and terminology used in this report are in accordance with the guidelines presented in AS1726-2017 Geotechnical Site Investigations.

## 2. DESK STUDY

### 2.1. Geological Setting

The Muchea sheet 1: 50,000 Environmental Geology Series (Sheet 2034 I and Part of 2134 IV, 1986) prepared by the Geological Survey of Western Australia indicates that the following geological layer underlies the site:

- Pebbly SILT (Mgs1) – strong brown silt with common, fine to occasionally coarse-grained, sub-rounded laterite quartz, heavily weathered granite pebble, some fine to medium-grained quartz sand, of alluvial origin (Guildford Formation Qpa)

### 2.2. Ground Surface and Groundwater Level

The Perth Groundwater Atlas (Waters & Rivers Commission) indicates the ground surface level at this site was approximately 58.0m at southeast to 41.0m at southwest.

Department of Water and Environment Regulation has published minimum groundwater levels for this site.

### 2.3. Acid Sulphate Soils

Information from publicly available Landgate website indicates that the site lies within a zone of no known risk of ASS occurring within 3m of natural surface.

### 2.4. Site History

Historical aerial photographs dating back to 1965 are publicly available through Landgate Map Viewer were assessed and a summary is presented in Table 1.

**Table 1 – Historical Site Information**

| Date | Description |
|---|---|
| 1965 | The site is fully cleared |
| 1977 | Industrial/Farm buildings constructed |
| 2012 | A small portion of the site was cleared being Lot 802 & 803 |
| 2018 | Construction started on the Perth To Darwin Highway to the west of the site |
| 2018 | Site remains relatively unchanged to the current day |

## 3. RESULTS OF THE INVESTIGATION

### 3.1. Subsurface Soil Profile

The subsurface soil profile presented below was determined from the ground conditions encountered within the boreholes and through the interpretation of the DCP test results:

**Table 2 – Subsurface Soil Profile**

| Depth to Base of Strata (m) | Material Description |
|---|---|
| 0.1 | TOPSOIL |
| 0.2 – 1.0 (Ave. 0.5) | NATURAL: SAND/Gravelly SAND (fine to coarse grained), trace silt, loose to very dense |
| Not Penetrated (>2.5m) | NATURAL: Clayey SAND/Sandy CLAY/Clayey GRAVEL (medium to high plasticity), trace gravel, dense to very dense |

The soils encountered are consistent with the expected site conditions as predicted from the Environmental Geology Map. It is important to note that there may be pockets of fill on site that are deeper than that encountered by the investigation boreholes. The subsurface soil conditions encountered are presented in the bore logs, within Appendix 3.

### 3.2. Groundwater

Groundwater was encountered in boreholes BH01, BH02, BH05 and BH12 at an approximate depth of 1.0m below the existing ground level. Groundwater is expected to perch above the impermeable materials.

### 3.3. Percolation Testing

Percolation testing of the in situ soils was undertaken in seven locations. Results of the testing are summarised below:

**Table 3 – In Situ Percolation Test Results**

| Test Location | Testing Depth | Soil Type | Permeability |
|---|---|---|---|
| 1 | 0 - 1.0m | SAND/Clayey SAND | 0.6m/day |
| 2 | 0 – 0.7m | SAND/Clayey SAND | 0.5m/day |
| 3 | 0 - 1.0m | SAND/Clayey SAND | 0.3m/day |
| 4 | 0 - 1.0m | SAND/Clayey SAND | 0.7m/day |
| 5 | 0 – 0.5m | SAND/Gravelly SAND | 1.0m/day |
| 6 | 0 - 1.0m | SAND/Clayey SAND | 1.2m/day |
| 7 | 0 – 0.6m | SAND/Clayey SAND | 0.9m/day |

## 3.4. Laboratory Test Results

Selected representative soil samples were tested by Structerre's in-house NATA accredited laboratory for Atterberg Limits, shrink-swell index, phosphate retention index and soil compaction. The results are attached in Appendix 4, 5 & 6.

### 3.4.1. Atterberg Limits

Atterberg Limits were tested by Structerre's in-house NATA accredited laboratory. Results of the testing are summarised below:

**Table 4 – Atterberg Limit Test Results**

| Sample | Test Hole | Depth (m) | Soil Description | Liquid Limit % AS1289 3.1.2 | Plastic Limit % AS1289 3.2.1 | Plasticity Index % AS1289 3.3.1 | Linear Shrinkage % AS1289 3.4.1 |
|---|---|---|---|---|---|---|---|
| 1 | BH01 | 0.1-1.0 | Sandy CLAY with gravel | 52 | 20 | 32 | 9 |
| 2 | BH07 | 0.7-1.0 | Clayey GRAVEL with sand | 36 | 17 | 19 | 6.5 |
| 3 | BH12 | 0.7-1.3 | Clayey GRAVEL with sand | 34 | 14 | 20 | 7 |
| 4 | BH20 | 0.4-0.9 | Clayey SAND with gravel | 37 | 15 | 22 | 9 |

Test results indicate that the natural clay has moderate shrink swell capacity or degree of expansion.

A copy of the results are presented in Appendix 4.

### 3.4.1. Phosphorus Retention Index

Six samples were submitted to CSBP Soil & Plant Analysis Laboratory for analysis of phosphate retention and calculation of Phosphorus Retention Index (PRI). The results are summarised below, with the certificate provided in Appendix 5.

**Table 5 – Phosphorus Retention Index Results**

| Sample No. | Soil Type | PRI | Classification |
|---|---|---|---|
| BH02_ 0.1-0.4 | SAND | 4.5 | Weakly |
| BH04_ 0.1-0.4 | SAND | 1.8 | Very Weakly |
| BH05_ 0.1-0.4 | Clayey SAND | 185.8 | Very Strongly |
| BH11_ 0.1-0.4 | Sandy GRAVEL | 6.4 | Moderately |
| BH18_ 0.1-0.4 | Sandy GRAVEL | 445.7 | Very Strongly |
| BH23_ 0.1-0.4 | SAND | 1.1 | Very Weakly |

The soil samples tested within the site areas indicate that the soil tested can be described as varying from very weakly to very strongly adsorbing (reference Method for Analysis of Phosphorus in Western Australia Soils, DG Allen & RC Jeffery, March 1990, Chemistry Centre, Agricultural Chemistry Laboratory).

### 3.4.2. California Bearing Ratio (CBR)

Representative samples were tested by Structerre's in-house NATA accredited laboratory in accordance with AS1289.5.2.1 (2003). The test certificates are presented in Appendix 6 and are summarised below.

**Table 5 – CBR Results**

| Test Hole | Depth (m) | Soil Description | Optimum Moisture Content % | Maximum Dry Density t/m3 | CBR @ 2.5mm Penetration (%) | CBR @ 5mm Penetration (%) |
|---|---|---|---|---|---|---|
| BH02 | 0.1 - 0.4 | SAND | 8.5 | 1.95 | 30 | - |
| BH04 | 0.1 - 0.4 | SAND | 10.0 | 1.81 | 18 | - |
| BH11 | 0.1 - 0.4 | Sandy GRAVEL | 7.0 | 2.20 | - | 50 |
| BH05 | 0.2 - 0.6 | SAND | 12.0 | 1.73 | 30 | - |

Based on the above results a conservative soaked CBR of 18% would be recommended for design purposes.

# 4. GEOTECHNICAL CONSTRUCTION CONSIDERATIONS

## 4.1. Site Classification

AS 2870-2011 Residential Slabs and Footings provides guidance on site classification for residential slabs and footing design based on the expected ground surface movement and depth of expected moisture changes.

Although the proposed development falls outside the scope of AS 2870, site classification can be used to assist in the design of foundations. The foundation design should be undertaken by a Structural Engineer, taking into consideration ground bearing capacity and the acceptable total and differential settlements of the proposed foundation system.

Based on results of this investigation the building areas can be classified as an Class “S” provided that all unsuitable materials are removed and replaced with engineer-controlled sand fill materials in accordance with earthwork recommendations outlined in Section 4.3 in this report. The site in its current condition is classified as Class “P”.

## 4.2. Drainage

The existing ground conditions are not suitable for on-site disposal of stormwater runoff through the use of soakwells.

The design of the drainage system, is unknown at this time, but may include:

- Rainwater Tanks;
- Dams / Compensation basin;
- Overland flow paths; and
- Soakwells, if permeable cover and / or design are appropriate.

Sub soil drainage may be required to control groundwater perching in the upper soil layers within the building footprint.

## 4.3. Seismic Site Subsoil Class

The seismic subsoil site class has been assessed in accordance with AS 1170.4-2007, using the results of this investigation and published information.

**Table 6 – Summary of Seismic Parameters**

| Hazard Factor | Site Sub-soil Class |
|---|---|
| 0.1 | Class Ce –shallow soil site |

## 4.4. Earthworks

The building areas can be classified as Class "S", provided that the recommended earthworks are undertaken.

All earthworks shall be undertaken in accordance with AS 3798-2007 Guidelines on Earthworks For Commercial and Residential Developments and are to include the following:

- All unsuitable materials to be stripped and removed from the site. Unsuitable materials include topsoil, deleterious and organic materials.
- It is considered that the near surface loose sand materials require improvement. Therefore, it is proposed to excavate and stockpile the materials for reuse, provided it is dry, free from clay/silt (i.e. <5%), organic and deleterious materials. The depth of excavation may vary depending on conditions encountered (i.e. groundwater) and is subject to inspection.
- Excavations should not exceed 2.0m and / or undermine surrounding structures. A 1V:2H slope should be maintained for temporary excavations. If excavation is required closer than the 1V:2H slope would allow, it is recommended that this office be contacted for retaining design.
- Proof compact the exposed base. The compaction requirements are set out in the table below, as per AS 3798-2007:

**Table 7 – Compaction Requirements**

| Item | Application | Minimum relative compaction, % | |
|---|---|---|---|
| | | Minimum density ratio (Standard Compaction Effort) (Cohesive soils) | Minimum density index (Cohesionless soils) |
| 1 | Residential - lot, fill, house, sites | 95 | 70 |
| 2 | Commercial – fills to support minor loadings, including floor loading of up to 20kPa and isolated pad or strip footings to 100kPa | 98 | 75 |
| 3 | Fill to support pavements<br>a) General fill<br>b) Subgrade (to a depth of 0.3m) | 95<br>98 | 70<br>75 |

- After excavation and proof compaction, the excavated base is to be inspected and approved by a representative from this office prior to backfilling. At this stage it can be

assessed whether any further materials need to be removed or whether further compaction of the base is required.

- The ground level should be built up to design levels with the stockpiled sand materials and imported fill. If required, the imported fill should consist of free draining sand with not more than 5% passing a 75µm sieve and be free of organic matter and other deleterious materials. The fill sand materials should be placed in layers not exceeding 300mm loose thickness and compacted to achieve the values stated in the table above. As a guide a minimum of 8 PSP blows over the interval 150 – 450mm, 9 PSP blows over the interval 450 – 750mm and 11 PSP blows over the interval 750 – 1050mm should be achieved, however its is recommended that this be verified with appropriate laboratory testing.
- A minimum of 0.6m of sand cover is required to be maintained above the reactive material in order to achieve a Class "S".
- After remedial earthworks have been completed, the earthworks should be inspected and approved by a representative from this office.

It is considered that standard small to medium sized earthmoving equipment would be appropriate for the proposed development. The near surface ground was generally competent and should not pose an issue to site traffic movements.

The material encountered on site can be deemed as 'easy' to excavate with medium sized earthwork equipment (i.e. a 20t excavator). Should excavations be required below groundwater level, dewatering will be necessary.

### 4.5. Geotechnical Design Parameters

Based on the on site observations and the DCP results, the interpreted geotechnical soil parameters of the encountered materials are presented in Table 9:

**Table 8 – Soil Parameters**

| Soil Type | Depths (m) | Friction Angle Ø' ($^0$) | Cohesion c' (kPa) | Density Y (t/m$^3$) | Elastic Modulus E (MPa) |
|---|---|---|---|---|---|
| FILL: SAND to silty SAND | 0 – 0.6 | 32 | 0 | 1.85 | 15 |
| Clayey SAND to Sandy CLAY | 0.6 – 2.5 | 32 | 20 | 1.80 | 20 |

## 4.6. Shallow Footings – Allowable Soil Bearing Capacities

Based on the findings of the current preliminary geotechnical investigation, shallow pad and strip footings are considered appropriate for the proposed development. Allowable bearing capacities for shallow footings at the site have been calculated under the following assumptions:

- The site preparation procedures specified in Section 4.4 have been carried out;
- The specified level of compaction has been achieved below the base of each footing;
- Loads are vertical and not eccentric;
- Isolated footings (i.e. interaction of foundations has not been considered);
- The foundations are flexible;
- A factor of safety (FoS) of 3.0 against bearing capacity failure;
- Maximum allowable settlement of 20mm.

The tables below present the allowable bearing pressures for pad and strip footings of various dimensions, with embedment depths of 0.5m and 1.0m below finished surface levels.

**Table 9 – Allowable Bearing Capacities for Pad Footings**

| Minimum Depth of Embedment (m) | Minimum Plan Dimension (m) | Allowable Bearing Capacities (kPa) | Settlement (mm) |
|---|---|---|---|
| 0.5 | 0.5 | 140 | < 20 |
| | 1.0 | 155 | |
| | 1.5 | 165 | |
| | 2.0 | 140 | |
| 1.0 | 0.5 | 245 | < 20 |
| | 1.0 | 250 | |
| | 1.5 | 190 | |
| | 2.0 | 160 | |

* Note: it is recommended to limit these values to 250kPa.

**Table 10 – Allowable Bearing Capacities for Strip Footings**

| Minimum Depth of Embedment (m) | Minimum Plan Dimension (m) | Allowable Bearing Capacities (kPa) | Settlement (mm) |
|---|---|---|---|
| 0.5 | 0.5 | 115 | < 20 |
| | 1.0 | 135 | |
| | 1.5 | 150 | |
| 1.0 | 0.5 | 160 | < 20 |
| | 1.0 | 180 | |
| | 1.5 | 200 | |

The recommended allowable bearing capacities are dependent on the site being dry and well drained, so that the foundation material does not become saturated.

The actual allowable bearing capacity of a particular foundation will be dependent on its location, geometry and founding depth, as well as the founding horizon. Therefore, once specific foundation geometries have been determined and the earthworks completed, it is recommended that the allowable bearing capacity and associated settlements be verified.

Additionally, should undermining issue prevent the excavation of the near surface loose materials, it is recommended that the allowable bearing capacity be reviewed. However, this will likely result in lower allowable bearing capacities.

## 5. CONCLUSIONS

A site investigation was carried out at the proposed commercial development site to assess the geotechnical conditions. Parameter and design recommendations are incorporated in the body of the report. The following conclusions have been drawn from the site investigation:

- The subsurface soil profile encountered comprised of topsoil to 0.1m, loose to dense sand / gravelly sand / sandy gravel from the surface to 1.0m, underlain by clayey sand/sandy clay to the investigated depth of 2.5m.
- The water table was encountered at the approximately 1.0m below the existing surface in boreholes BH01, BH02, BH05 and BH12.
- The building areas can be classified as a Class “S” in accordance with AS 2870-2011 provided the recommended earthworks are undertaken.
- It is considered that the site is not suitable for on-site drainage.
- Recommended earthworks for the building areas, include stripping of fill sand and unsuitable materials, excavation of loose materials, proof compaction of the base, placement of engineered fill and compaction of final level.
- Allowable bearing capacity for pad footings range from 140kPa to 250kPa and from 115kPa to 200kPa for strip footings. The estimation of settlement of the footings is limited to 20mm.

## 6. LIMITATION OF FIELD INVESTIGATIONS

This report has been prepared in accordance with generally accepted consulting practice for Tomahawk Property on behalf of Muchea Employment Node Precinct 3 Land Owners using information supplied at the time and for the project specific requirements as understood by Structerre. To the best of our knowledge the information contained in this report is accurate at the date of issue, however it should be emphasised that any changes to ground conditions and/or the proposed structures may invalidate the recommendations given herein.

The conclusions and recommendations in this report are based on the site conditions revealed through selective point sampling, representing the conditions of the site in total, although the area investigated represents only a small portion of the site. The actual characteristics may vary significantly between successive test locations and sample intervals other than where observations, explorations and investigations have been made.

The materials and their geotechnical properties presented in this report may not represent the full range of materials and strengths that actually exist on site and the recommendations should be regarded as preliminary in nature. Allowances should be made for variability in ground conditions and any consequent impact on the development. Structerre accepts no responsibility and shall not be liable for any consequence of variations in ground conditions.

If ground conditions encountered during construction are different to that described in this report, this office should be notified immediately.

For and behalf of

STRUCTERRE CONSULTING ENGINEERS

Author: David Harding
Title: Geotechnical Supervisor

Checked By: Daniel Smith
Title: Geotechnical Engineer
Credentials: BEng Civil, MIEAust, AGS

Disclaimer
This report is at the request of the addressee and no liability is accepted by Structerre Consulting Engineers to any third person reading or relying upon the report, not withstanding any rule of law and/or equity to the contrary and that this report is strictly confidential and intended to be read and relied upon only be the addressee.

| Job # | Revision | Authored | Checked | Authorised |
|---|---|---|---|---|
| J315642 | 0 | DO | DAS | MEC |
| J315642 | 1 | DO | DAS | MEC |

## 7. REFERENCES

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AS 1170.4-2007 Structural design actions – Earthquake actions in Australia

AS 1289.3.1.2-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the liquid limit of a soil

AS 1289.3.2.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the plastic limit of a soil

AS 1289.3.3.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Calculation of the plasticity index of a soil

AS 1289.3.4.1-2009 Methods of testing soils for engineering purposes – Soil classification tests – Determination of the linear shrinkage of a soil

AS 1289.5.2.1-2009 Soil compaction and density tests – Soil classification tests – Determination of the dry density/moisture content relation of a soil using modified compactive effort

AS 1289.6.1.1-2009 Soil strength and consolidation tests – Soil classification tests – Determination of the California Bearing Ratio of a soil

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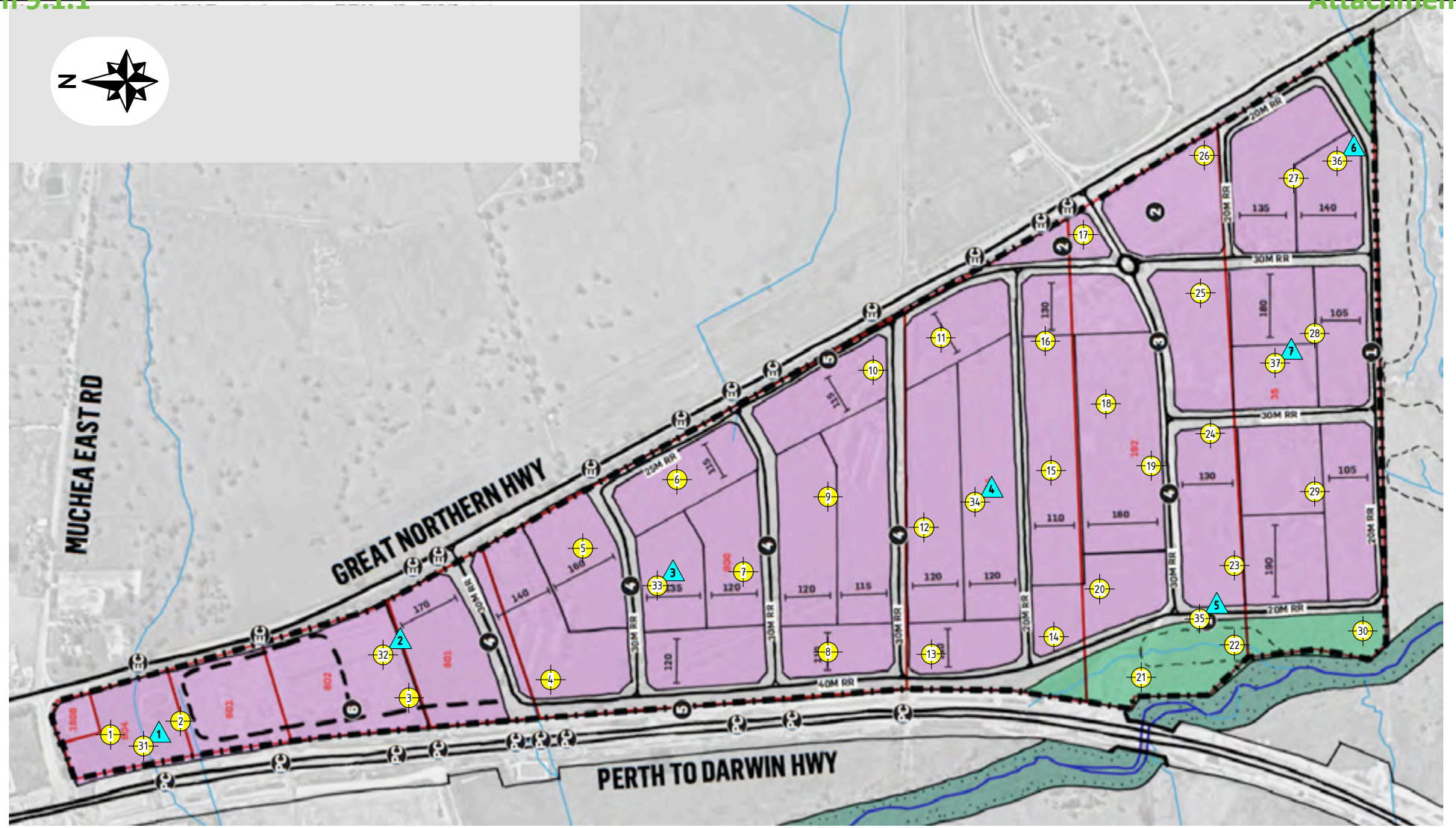
AS 1726-2017 Geotechnical site investigation

AS 2870-2011 Residential slabs and footings

AS 3798-2007 Guidelines on earthworks for commercial and residential developments

AS 4055-2012 Wind loads for housing

# APPENDIX 1 – SITE LOCATION MAP




Note: Showing approximate test locations only

**LEGEND**

BH: Borehole

PERC: Percolation Test

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| | |
|---|---|
| PROJECT: | Muchea Employment Node - Precinct 3 - Muchea |
| PROJECT #: | D206263 |
| JOB #: | J315642 |
| CLIENT: | **Muchea Employment Node Precinct 3 Land Owners** |
| SCALE: | NTS |
| TITLE: | Geotechnical Investigation Site Plan |
| DATE: | 26 Nov '18 |
| DRAWN BY: | MM |
| CHECKED BY: | DH |

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# APPENDIX 2 – SITE PHOTOS

PHOTO 1

PHOTO 2

STRUCterre consulting engineers

PROJECT: Muchea Employment Node - Precinct 3 - Muchea

PROJECT #: D206263

JOB #: J315642

CLIENT: **Muchea Employment Node Precinct 3 Land Owners**

Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

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TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

SCALE: NTS

TITLE: Site Photographs

DATE: 26 Nov '18

DRAWN BY: MM

CHECKED BY: DH

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PHOTO 3 - Sample taken BH1

PHOTO 4 - Sample taken BH28

| | | |
|---|---|---|
| STRUCterre consulting engineers | PROJECT: Muchea Employment Node - Precinct 3 - Muchea | |
| | PROJECT #: D206263 | CLIENT: **Muchea Employment Node Precinct 3 Land Owners** |
| | JOB #: J315642 | |
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| | DATE: 26 Nov '18 | DRAWN BY: MM / CHECKED BY: DH |

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# APPENDIX 3 – BORELOGS

STRUCterre consulting engineers

**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH01**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404631 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6505901 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | 0.1 - 1.0 | B | D to M | |
| | | CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, grey (Guildford Formation) | | | | | | |
| | | *mottled grey/brown* | St-VSt | | | | M | |
| 1 | | | | | | | | ▼ |
| | | | | | | | S | |
| | | *trace gravel* | | | 1.8 - 2.3 | B | | |
| 2 | | | | | | | | |
| | | Terminated at 2.30 m | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH02**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404659 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6505814 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace clay, grey/brown (Guildford Formation) | L | | | | D to M | |
| | | | MD - D | | | | | |
| | | | L | | | | M | ▼ |
| 1 | | SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown | | | | | S | |
| 2 | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | | | | | |
| | | Terminated at 2.50 m | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH03**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404781 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6505225 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation) | L | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | MD | | | | | |
| | | | D - VD | | | | | |
| 1 | | | | | | | M | |
| | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | | | | | |
| | | Terminated at 1.90 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH04**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404762 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504830 |

| Depth | Stratum Description | Consistency | Moisture |
|---|---|---|---|
| | Topsoil: | D | |
| | SP: SAND: fine to medium grained, non-plastic, grey (Guildford Formation) | L - MD | D to M |
| | SP: Gravelly SAND: coarse grained, non-plastic, trace silt, mottled red/brown | | |
| 1 | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled red/brown | | M |
| | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | |
| | Terminated at 1.50 m | | |
| 2 | | | |
| 3 | | | |

DCP Blows/150mm: 5 10 15 20

Samples: Depth | Type

Water Level

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH05**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405086 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504857 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | 0.1 - 1.0 | B | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey (Guildford Formation) | L | | | | M | |
| | | *brown* | | | | | | |
| 1 | | | D - VD | | | | W | ▼ |
| | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, mottled grey/brown | | | | | S | |
| 2 | | | | | | | | |
| | | Terminated at 2.50 m | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH06**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405259 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504622 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil: | D - VD | | | | D to M | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown (Guildford Formation) | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | | |
| 1 | | Terminated at 1.30 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH07**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404994 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504472 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | D - VD | | 0.5 - 1.0 | B | D to M | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown | | | | | | |
| | | GC: Clayey GRAVEL: medium to coarse grained, medium plasticity, with sand, mottled red/brown | | | | | | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH08**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404755 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504337 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | L | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, low plasticity, with clay, red/brown | D - VD | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | | | | | | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH09**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405126 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504288 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | D - VD | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, medium plasticity, with clay, mottled grey/brown | | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | | | | | | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH10**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405415 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504305 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil: | L | | | | D | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey/brown | D - VD | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | | |
| | | Terminated at 0.70 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH11**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405519 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504153 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil: | L | | | | D | |
| | | GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation) | D - VD | | | | | |
| | | *brown* | | | | | | |
| | | Terminated at 0.60 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH12**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405023 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504163 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: medium to coarse grained, non-plastic, trace silt, grey (Guildford Formation) | L - MD | | | | D | |
| | | *brown* | | | | | | |
| | | GC: Clayey GRAVEL: medium to coarse grained, low plasticity, with sand, brown | MD - D | | 0.7 - 1.3 | B | D to M | ▼ |
| 1 | | | | | | | S | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH13**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404781 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6504129 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | VL | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | MD | | | | D to M | |
| | | | VD | | | | | |
| 1 | | SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown | | | | | M | |
| | | SM: Silty SAND: fine to medium grained, grey/brown | | | | | | |
| | | Terminated at 1.10 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH14**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404762 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503876 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| 0 | | Topsoil: | L | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace clay, grey (Guildford Formation) | D | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, grey/brown | | | | | M | |
| | | SM: Silty SAND: fine to medium grained, grey/brown | | | | | | |
| | | Terminated at 0.60 m | VD | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH15**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405114 |
| **Job No.** | J315642 | **Date** | 26/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503886 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | *brown* | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH16**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405541 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503958 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | Terminated at 1.10 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH17**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405694 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503838 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH18**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405441 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503828 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | 0.5 - 1.0 | B | M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH19**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405139 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503673 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | D - VD | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.20 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH20**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404895 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503792 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, grey | L - MD | | 0.4 - 0.9 | B | | |
| 1 | | CH: Sandy CLAY: fine to medium grained, high plasticity, trace gravel, red/brown | St | | 0.9 - 1.4 | B | M | |
| | | Terminated at 1.40 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH21**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404757 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503652 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | VL | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | D | | | | | |
| | | GP: Sandy GRAVEL: medium to coarse grained, non-plastic to low plasticity, with silt, trace clay, brown | VD | | | | W | |
| | | Terminated at 0.90 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH22**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404782 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503525 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown | | | | | | |
| | | Terminated at 0.50 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH23**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404883 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503505 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey<br>(Guildford Formation) | L - MD | | | | D to M | |
| | | *pale brown* | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, trace gravel, grey/brown | D - VD | | | | M | |
| 1 | | GP: Sandy GRAVEL: medium to course grained, low to medium plasticity, with clay, grey/brown | | | | | | |
| | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH24**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405259 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503609 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | D - VD | | | | D | |
| | | SP: Gravelly SAND: medium grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, trace silt, pale brown | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, mottled grey/brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH25**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405659 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503544 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | D | |
| | | *mottled red/brown* | VD | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | M | |
| 1 | | | | | | | | |
| | | Terminated at 1.20 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH26**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405858 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503568 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, mottled red/brown (Guildford Formation) | VD | | | | | |
| | | *trace clay,* | | | | | D to M | |
| | | Terminated at 0.70 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH27**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405874 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503343 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | | | | | | |
| | | *trace clay, mottled grey/brown* | VD | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, brown | | | | | D to M | |
| 1 | | CH: Sandy CLAY: fine to medium grained, high plasticity, with gravel, brown | | | | | M | |
| | | Terminated at 1.50 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH28**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405419 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503299 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown | | | | | | |
| | | Terminated at 0.60 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH29**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 405018 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503272 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | L - MD | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, grey | D - VD | | | | M | |
| | | SP: Silty SAND: fine to medium grained, grey/brown | | | | | D | |
| | | Terminated at 0.80 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on cemented ground
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH30**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | 404849 |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | 6503206 |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, pale grey (Guildford Formation) | D | | 0.6 - 1.0 | B | D to M | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, grey | MD | | | | | |
| | | | VD | | | | M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole partially stable
3. Samples taken: As indicated
4. Co-ordinate system: WGS 84

STRUCterre consulting engineers

**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH31**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Hand Auger | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, with silt, trace gravel, brown (Guildford Formation) | MD - D | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown | L - MD | | | | D to M | |
| 1 | | Terminated at 1.00 m | D | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH32**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Hand Auger | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace gravel, trace organic material (fine roots), grey/brown (Guildford Formation) | MD - D | | | | D to M | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown | | | | | | |
| | | Terminated at 0.70 m | VD | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on dense gravel
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH33**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Hand Auger | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, trace gravel, grey/brown (Guildford Formation) | | | | | | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, yellow/brown | D - VD | | | | D to M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH34**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | | | | | | |
| | | SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, grey/brown (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, with gravel, mottled grey/brown | | | | | D to M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH35**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D to M | |
| | | SP: SAND: fine to medium grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | GP: Sandy GRAVEL: medium to course grained, non-plastic, trace silt, dark brown | | | | | | |
| | | Terminated at 0.50 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH36**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | MD | | | | | |
| | | SP: Gravelly SAND: fine to medium grained, non-plastic, with silt, pale grey/brown (Guildford Formation) | VD | | | | D | |
| | | SC: Clayey SAND: fine to medium grained, low plasticity, trace gravel, brown | | | | | D to M | |
| 1 | | Terminated at 1.00 m | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Target depth - permeability test
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84



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**Project** Muchea Employment Node - Precinct 3 - Muchea

**Client** Muchea Employment Node Precinct 3 Land Owners

Test No. **BH37**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project No.** | D206263 | **Logged By** | Craig Pummell | **Machine** | Soil Retrieval Probe | **Easting** | |
| **Job No.** | J315642 | **Date** | 27/11/2018 | **Hole Dia.** | 65mm | **Northing** | |

| Depth | Graphic | Stratum Description | Consistency | DCP Blows/150mm (5 10 15 20) | Samples Depth | Samples Type | Moisture | Water Level |
|---|---|---|---|---|---|---|---|---|
| | | Topsoil: | L | | | | D | |
| | | GP: Sandy GRAVEL: coarse grained, non-plastic, trace silt, grey (Guildford Formation) | VD | | | | | |
| | | SC: Clayey SAND: fine to medium grained, medium plasticity, with gravel, pale brown | | | | | | |
| | | Terminated at 0.60 m | | | | | | |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |

**Remarks**

1. Termination reason: Refusal - interpreted on stiff clay
2. Hole stability: Hole partially stable
3. Samples taken: None
4. Co-ordinate system: WGS 84

# APPENDIX 4 – LABORATORY TEST RESULTS

| | | | |
|---|---|---|---|
| **Sample No.** | **32126** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3, Muchea |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 1 0.1-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 52 |
| Plastic Limit | AS 1289.3.2.1 | 20 |
| Plasticity Index | AS 1289.3.3.1 | 32 |
| Linear Shrinkage | AS 1289.3.4.1 | 9 |
| Nature of Shrinkage | | Flat |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 98 |
| 2.36 | 73 |
| 0.425 | 59 |
| 0.075 | 42 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Sandy CLAY with gravel
**AS Group Symbol:** CH or OH

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STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

Wayne Rozmianiec
Laboratory Manager

**Date:** 07-Dec-18

Soils Analysis Workbook V 3.15 22-Nov-18

AS 1289.3.6.1 Report Feb 18



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| | | | |
|---|---|---|---|
| **Sample No.** | **32127** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 7 0.7-1m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 36 |
| Plastic Limit | AS 1289.3.2.1 | 17 |
| Plasticity Index | AS 1289.3.3.1 | 19 |
| Linear Shrinkage | AS 1289.3.4.1 | 6.5 |
| Nature of Shrinkage | | Flat |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 88 |
| 2.36 | 59 |
| 0.425 | 52 |
| 0.075 | 33 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Clayey GRAVEL with sand
**AS Group Symbol:** GC

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Laboratory Manager

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| | | | |
|---|---|---|---|
| **Sample No.** | **32128** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 12 0.7-1.3m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 34 |
| Plastic Limit | AS 1289.3.2.1 | 14 |
| Plasticity Index | AS 1289.3.3.1 | 20 |
| Linear Shrinkage | AS 1289.3.4.1 | 7 |
| Nature of Shrinkage | | Flat |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 100 |
| 2.36 | 56 |
| 0.425 | 50 |
| 0.075 | 33 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Clayey GRAVEL with sand
**AS Group Symbol:** GC

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Wayne Rozmianiec
Laboratory Manager

**Date:** 10-Dec-18



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| | | | |
|---|---|---|---|
| **Sample No.** | **32129** | **Client** | Geotechnical |
| **Job No.** | J315642 | **Project** | Muchea Employment Node - Precinct 3 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd, Balcatta WA 6021

## SAMPLE DETAILS

BH No. / Depth : 20 0.4-0.9m
Sample History : 50°C Oven Dried

Sampling Method Client
Sample Preparation AS 1289 1.1

## ATTERBERG LIMITS

| Description | Method | Result (%) |
|---|---|---|
| Liquid Limit | AS 1289.3.1.2 | 37 |
| Plastic Limit | AS 1289.3.2.1 | 15 |
| Plasticity Index | AS 1289.3.3.1 | 22 |
| Linear Shrinkage | AS 1289.3.4.1 | 9 |
| Nature of Shrinkage | | Cracked |

## PARTICLE SIZE DISTRIBUTION

**Method:** AS 1289.3.6.1
**Description:** Particle size distribution by sieve analysis

| Sieve Size (mm) | % Passing |
|---|---|
| 19.0 | 100 |
| 2.36 | 71 |
| 0.425 | 62 |
| 0.075 | 33 |

**AS 1726:2017 Clause 6.1**
**Material Description:** Clayey SAND with gravel
**AS Group Symbol:** SC

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Laboratory Manager

**Date:** 10-Dec-18

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# APPENDIX 5 – PRI TEST RESULTS

# Analysis Results

CSBP Soil and Plant Laboratory



88282
Structerre Consulting Engineers

| | Lab No | 5IS18042 | 5IS18043 | 5IS18044 | 5IS18045 | 5IS18046 | 5IS18047 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | Name | BH2_0.1-0.4M | BH4_0.1-0.4M | BH5_0.1-0.4M | BH11_0.1-0.4M | BH18_0.1-0.4M | BH23_0.1-0.4M |
| | Code | J315642 | J315642 | J315642 | J315642 | J315642 | J315642 |
| | Customer | Structerre | Structerre | Structerre | Structerre | Structerre | Structerre |
| | Depth | 0-10 | 0-10 | 0-10 | 0-10 | 0-10 | 0-10 |
| Phosphorus Retention Index | | 4.5 | 1.8 | 185.8 | 6.4 | 445.7 | 1.1 |

CSBP Lab. Extract Value.

# APPENDIX 6 – CBR RESULTS

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# Material Test Certificate

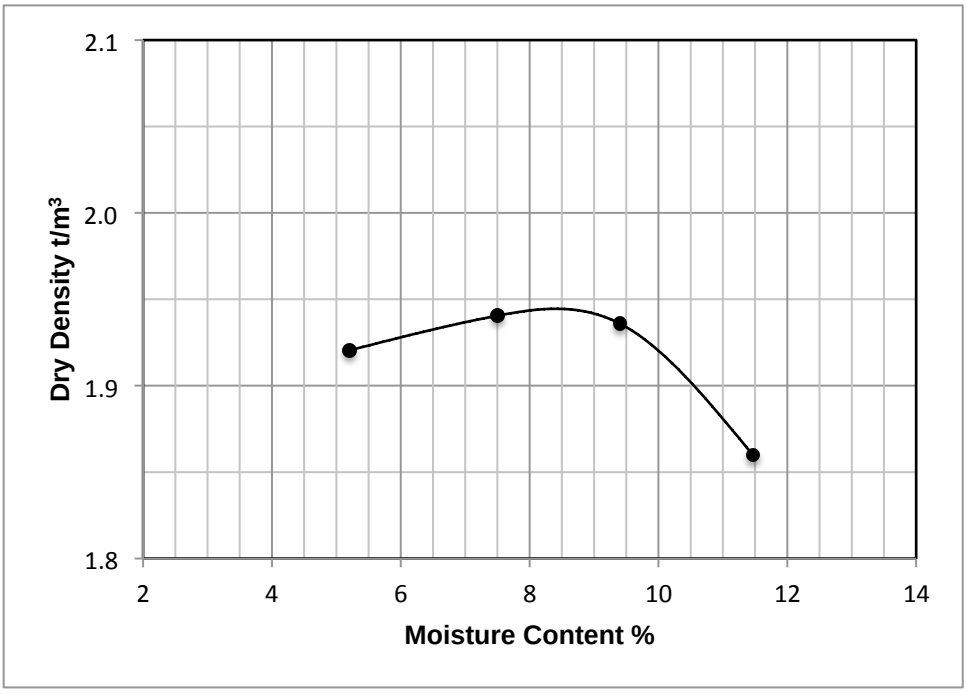
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH2_0.1-0.4m | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-1 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 1.94 | **Optimum Moisture Content %** | 8.5 |
| **% Retained 19mm Sieve** | 0 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |

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**Approved Signatory:** Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

MDD Report AS 1289.5.2.1 R Rev. 3.0 Jan-18

STRUCterre consulting

# Material Test Certificate

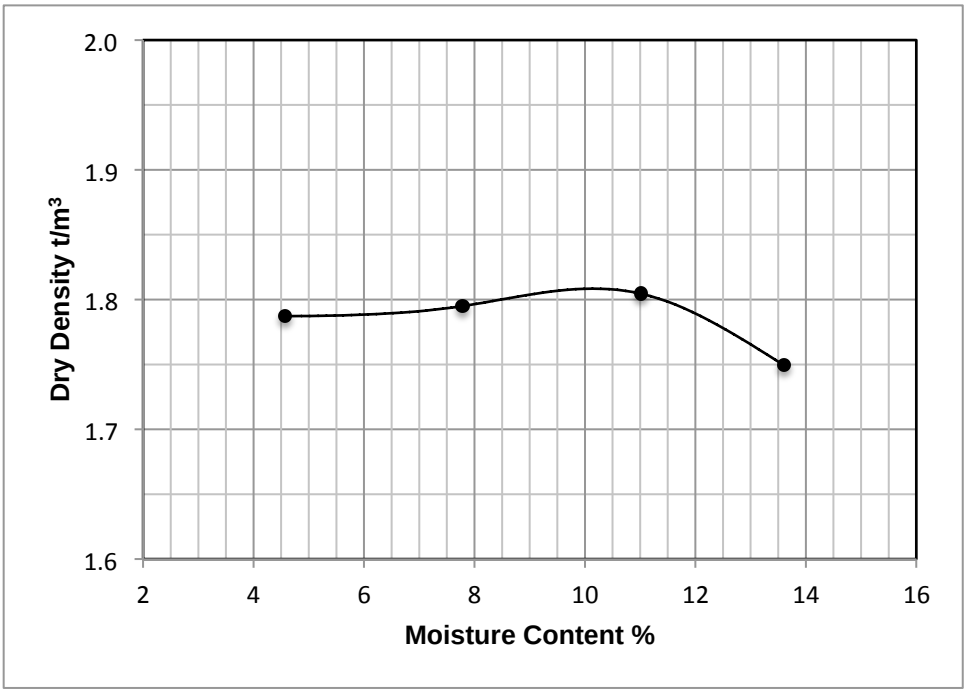
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH4_0.1-0.4m | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-2 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 1.81 | **Optimum Moisture Content %** | 10.0 |
| **% Retained 19mm Sieve** | 0 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |

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**Approved Signatory:** Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

MDD Report AS 1289.5.2.1 R Rev. 3.0 Jan-18

STRUCterre consulting

# Material Test Certificate

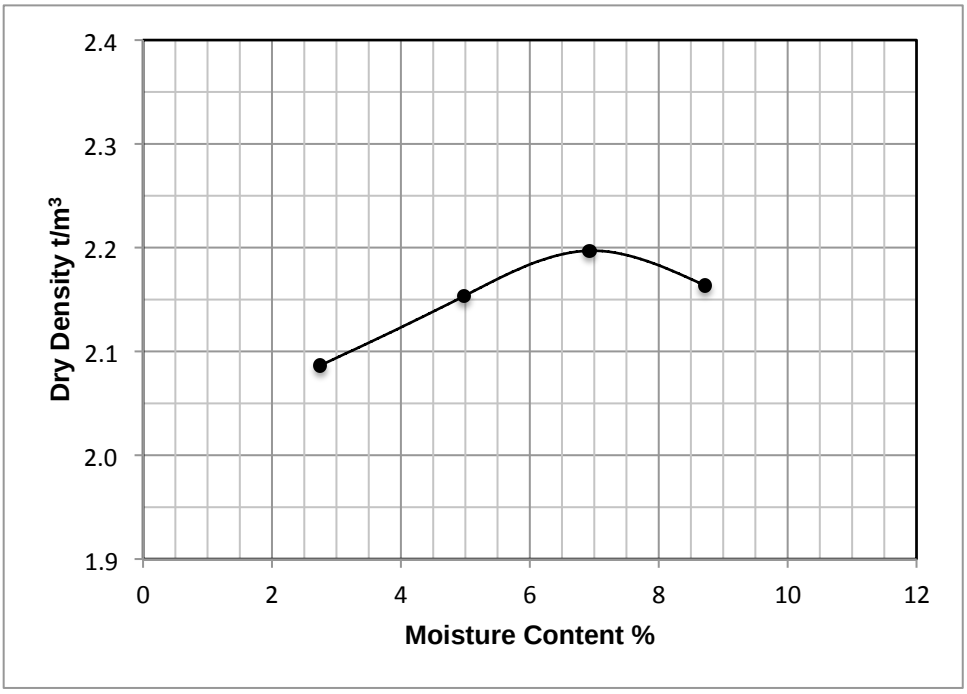
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH11_0.1-0.4 | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-3 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 2.20 | **Optimum Moisture Content %** | 7.0 |
| **% Retained 19mm Sieve** | 1 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |

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**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 5 Dec 2018

MDD Report AS 1289.5.2.1 R Rev. 3.0 Jan-18

STRUCterre consulting

# Material Test Certificate

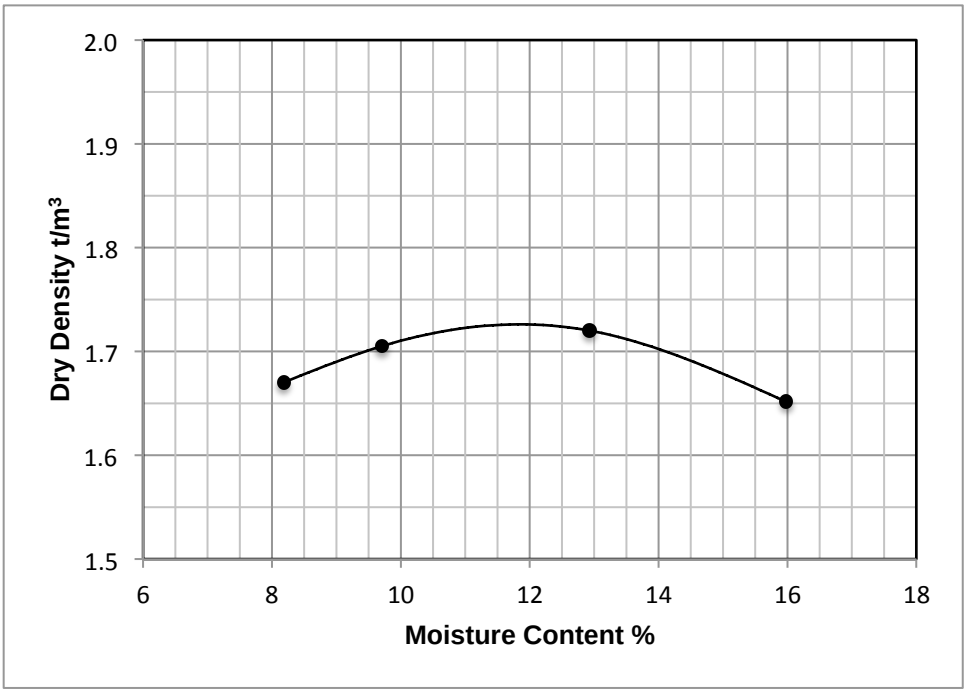
## AS 1289.5.2.1 Determination of the dry density/moisture content relation of a soil using modified compactive effort

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH23_0.1-0.4m | **Date Tested:** | 29 Nov 2018 |
| **Proposed Use:** | - | **Laboratory Number:** | S905648-A-4 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| | | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

| | | | |
|---|---|---|---|
| **Maximum Dry Density t/m³** | 1.73 | **Optimum Moisture Content %** | 12.0 |
| **% Retained 19mm Sieve** | 0 | **% Retained 37.5mm Sieve** | 0 |
| **Curing Time hrs** | 24 | **Method used to determine LL** | Visual/Tactile |




**Notes:**

NATA Accredited for compliance with ISO/IEC 17025 – Testing
WORLD RECOGNISED ACCREDITATION
STRUCTERRE CONSULTING ENGINEERS BALCATTA LABORATORY ACCREDITATION NUMBER 18742

**Approved Signatory:**
Laboratory Manager

Wayne Rozmianiec

Date: 5 Dec 2018



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ABN 71 349 772 837 Zemla Pty Ltd ACN 008 966 283 as trustee for the Young Purich and Higham Unit Trust trading as Structerre Consulting Engineers

STRUCterre consulting

# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Laboratory 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH2_0.1-0.4m | **Date Tested:** | 30 Nov 2018 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-1 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 1.95 |
| Optimum moisture content | % | 8.5 |
| Moisture content at compaction | % | 8.0 |
| Laboratory density ratio | % | 95.0 |
| Laboratory moisture ratio | % | 95.0 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 0 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 1.85 |

**Penetration**

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 12.1 |
| Moisture content of remainder | % | 11.7 |
| California Bearing Ratio | % | 30 |
| Penetration | mm | 2.5 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH4_0.1-0.4m | **Date Tested:** | 30 Nov 2018 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-2 |
| **Material Type:** | Sand | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 1.81 |
| Optimum moisture content | % | 10.0 |
| Moisture content at compaction | % | 9.7 |
| Laboratory density ratio | % | 95.5 |
| Laboratory moisture ratio | % | 96.0 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 0 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 1.73 |

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 15.3 |
| Moisture content of remainder | % | 34.0 |
| California Bearing Ratio | % | 18 |
| Penetration | mm | 2.5 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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STRUCterre consulting

# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH11_0.1-0.4m | **Date Tested:** | 30-Nov-18 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-3 |
| **Material Type:** | Sandy Gravel | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 2.20 |
| Optimum moisture content | % | 7.0 |
| Moisture content at compaction | % | 6.8 |
| Laboratory density ratio | % | 94.5 |
| Laboratory moisture ratio | % | 97.5 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 1 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 2.08 |

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 10.3 |
| Moisture content of remainder | % | 9.8 |
| California Bearing Ratio | % | 50 |
| Penetration | mm | 5.0 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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STRUCterre consulting

# Material Test Certificate

## AS 1289.6.1.1 Determination of the California Bearing Ratio of a soil - Standard laboratory method for a remoulded specimen

| | | | |
|---|---|---|---|
| **Client:** | INHAM RURAL PROPERTY GROUP PTY LTD | **Job Number:** | S905648 |
| **Project:** | Muchea Employment Node Precinct 3 - GREAT NORTHERN HWY MUCHEA | **Issue Number:** | 1 |
| **Report Number:** | S905648-A | **Page:** | 1 of 1 |

Laboratory testing carried out at Balcatta Lab 1 Erindale Rd Balcatta WA 6021

| | | | |
|---|---|---|---|
| **Sample ID:** | BH23_0.1-0.4m | **Date Tested:** | 30 Nov 2018 |
| **Proposed Use:** | Subgrade | **Laboratory Number** | S905648-A-4 |
| **Material Type:** | Sandy Gravel | **Depth of Test:** | - mm |
| **Moisture content method** | AS 1289.2.1.1 | **Layer Thickness:** | - mm |
| **Sampling Method :** | Client | **Site Selection Method:** | Client |

**Compaction**

| | | |
|---|---|---|
| Maximum dry density | $t/m^3$ | 1.73 |
| Optimum moisture content | % | 12.0 |
| Moisture content at compaction | % | 11.7 |
| Laboratory density ratio | % | 95.0 |
| Laboratory moisture ratio | % | 98.5 |
| Curing time | hrs | 2 |
| Method used to determine LL: | | Visual/Tactile |
| Percent retained on 19 mm | % | 0 |
| Excluded from compaction or retained | | Excluded |
| Hammer | | AS 1289.5.2.1 |

**Soaking**

| | | |
|---|---|---|
| Moisture condition | | Soaked |
| Period of soaking | days | 4 |
| Surcharge | kg | 4.50 |
| Swell | % | 0.0 |
| Dry density after soaking | $t/m^3$ | 1.64 |

| | | |
|---|---|---|
| Moisture content top 30 mm | % | 18.7 |
| Moisture content of remainder | % | 18.0 |
| California Bearing Ratio | % | 30 |
| Penetration | mm | 2.5 |

**Notes:**

**Approved Signatory:**
Laboratory Manager Wayne Rozmianiec Date: 19-Jan-18



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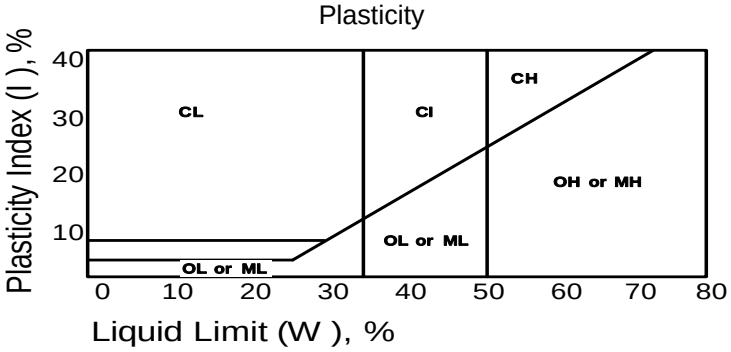
# APPENDIX 7 – BORELOG TERMINOLOGY

# BORELOG TERMINOLOGY

## Particle Size Distribution

| Major Division | Subdivision | Size |
|---|---|---|
| Boulders | | >200mm |
| Cobbles | | 200 - 63mm |
| Gravel | Coarse | 63 - 20mm |
| | Medium | 20- 6mm |
| | Fine | 6 - 2.36mm |
| Sand | Coarse | 2.36 - 0.6mm |
| | Medium | 0.6 - 0.2mm |
| | Fine | 0.2 - 0.075mm |

## Plasticity




## Consistency of Cohesive Soils

| Term | Undrained Strength Su (kPa) | Field Guide |
|---|---|---|
| Very Soft | < 12 | Exudes between the fingers when squeezed in hand |
| Soft | 12 - 25 | Can be moulded by light finger pressure |
| Firm | 25 - 50 | Can be moulded by strong finger pressure |
| Stiff | 50 - 100 | Cannot be moulded by Fingers. Can be indented by thumb. |
| Very Stiff | 100 - 200 | Can be indented by thumb nail |
| Hard | > 200 | Can be indented with difficulty by thumb nail. |
| Friable | - | Crumbles or powders when scraped by thumbnail |

## Consistency/Density of Non-Cohesive Soils

| Term | Density Index (%) | SPT "N" Value Comparison |
|---|---|---|
| Very Loose | < 15 | 0 - 4 |
| Loose | 15 - 35 | 4 - 10 |
| Medium Dense | 35 - 65 | 10 - 30 |
| Dense | 65 - 85 | 30 - 50 |
| Very Dense | > 85 | > 50 |

## Moisture Content

| | |
|---|---|
| D | Dry |
| M | Moist |
| W | Wet |
| S | Saturated |

## Minor Components

| Term | Assessment Guide | Proportion of Minor Component In: |
|---|---|---|
| Trace | Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component | Coarse grained soils: < 5 %<br>Fine grained soils: <15% |
| With | Presence easily detected by feel or eye, soil properties little different to general properties of primary component | Coarse grained soils: 5 - 12 %<br>Fine grained soils: 15 - 30% |

## Soil Legend

| | | | |
|---|---|---|---|
| FILL | CLAY | GRAVEL | CONCRETE |
| TOPSOIL | SILT | LIMESTONE | COMBINATIONS |
| PEAT | SAND | BEDROCK | eg: Clay, Silty, Sandy |

## USCS

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GW | Well graded gravel | SC | Clayey sand | OL | Organic low plasticity silt | CL | Low plasticity clay |
| GP | Poorly graded gravel | SM | Silty sand | ML | Low plasticity silt | CI | Intermediate plasticity clay |
| SW | Well graded sand | | | MH | High plasticity silt | CH | High plasticity clay |
| SP | Poorly graded sand | | | OH | Organic high plasticity silt | PT | Peat |

DOC:GE:3.003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# APPENDIX F
# ELLEN BROOK FLOOD MODELLING

# MEMORANDUM

| Project: | Muchea Employment Node P3 Waterways | | | Project No: | P18311 |
|---|---|---|---|---|---|
| To: | Copy: | Name: | Organisation: | Facsimile: | |
| ☒ | ☐ | Phil Bayley | Bayley Environmental Services | | |
| ☒ | ☐ | Tom Carmody | Tomahawk Property | | |
| ☐ | ☐ | | | | |
| From: | Brett Stinton | | Date: 25 January 2019 | Total Pages: | 9 |

| Subject: | Muchea Employment Node P3 – Floodway Definition |
|---|---|

If you do not receive all pages, or some are unclear, please advise immediately

BG&E Pty Limited (BG&E) has been engaged by the Muchea Employment Node Precinct 3 Landowners Group to carry out a waterways assessment for Ellen Brook to inform the development of the Muchea Employment Node Precinct 3.

As part of the Northlink Stage 3 project, BG&E prepared a TUFLOW hydraulic model for the new Perth to Darwin National Highway (PDNH) bridge which crosses Ellen Brook. This model has been utilised and updated to incorporate the boundary of the concept plan for the Muchea Employment Node Precinct prepared by Urbis. The southern section of the development layout is directly adjacent to the Ellen Brook floodplain where public open space and drainage reserve areas are proposed.

## SCOPE

The following scope of works was carried out:

1. Review modelling assumptions in accordance with 2016 edition of Australian Rainfall and Runoff
2. Simulate 1 in 100 annual exceedance probability (AEP) event under current day scenario (including new PDNH)
3. Preliminary definition of floodway based on review of hydraulic model results (depths, velocities etc)
4. Meet with representatives from DWER and Main Roads WA to discuss the project and agree on allowable backwater criteria
5. Update hydraulic model to include earthworks up to the preliminary floodway and review 1 in 100 AEP backwater
6. Refine the floodway and update the hydraulic model with revised earthworks extents to achieve suitable backwater (up to 5 post-development iterations have been assumed)
7. Prepare a memo report summarising the methodology and findings of the project, including polygons for floodway and flood fringe areas similar to those provided by DWER for other areas within Ellen Brook.

The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.

## TUFLOW MODEL

The TUFLOW 2D hydraulic has been updated to include the outline of the proposed development that lies within the flood extents of the Ellen Brook flood plain and other scenarios where the boundary encroaches further toward the main Ellen Brook channel.

## MEETING WITH MAIN ROADS AND DWER

A meeting was held on 15th January 2019 with Simon Rodgers (Supervising Engineer - Floodplain Management) from the Department of Water and Environmental Regulation (DWER) and Eric Cheung (Senior Waterways Engineer) from Main Roads WA, to discuss any potential impacts the development may have. Preliminary results showing the impact on flood levels were tabled. The DWER representative indicated that the impacts were not of concern from a DWER perspective. The Main Roads WA representative was concerned of any potential impacts to the recently constructed PDNH alignment that passes adjacent to the proposed development.

## FLOODWAY DEFINITION

The Department of Water and Environmental Regulation (DWER) define the Floodway as *"the river channel and a portion of the floodplain where a significant flow or storage of water occurs during floods. If the floodway is even partially blocked then the natural flooding regime of the area may be detrimentally impacted with flood levels being raised and affecting areas which may not have been previously affected"*.

The following items were considered when defining the floodway:

- 1% AEP pre-development velocity and depth mapping (attached) used to identify areas where higher depths and velocities occur which provide an indication of flood conveyance
- The presence of existing flowpaths within the floodplain which includes the main channel and breakout channel downstream of the PDNH culvert crossing to the north of the bridge. These flowpaths should be maintained to avoid redistribution of flow
- Potential impacts to flood levels as a result of partially blocking the floodplain, based on the hydraulic model results
- The floodway extent adopted by DWER for Ellen Brook to the south of the site. Shapefiles were provided by DWER which show the floodway extending to the edge of the floodplain in some areas. Flood behaviour in the northern section of the dataset is expected to be similar to that within the project site (Figure 1).

Refer to attached plots for 1% AEP pre-development and post-development flood extents. These include the proposed floodway and flood fringe extents. The proposed development footprint is close to but does not encroach into the floodway. The results indicate a maximum increase in flood level of approximately 30 mm near the proposed road, reducing to approximately 10mm at the PDNH PSP.

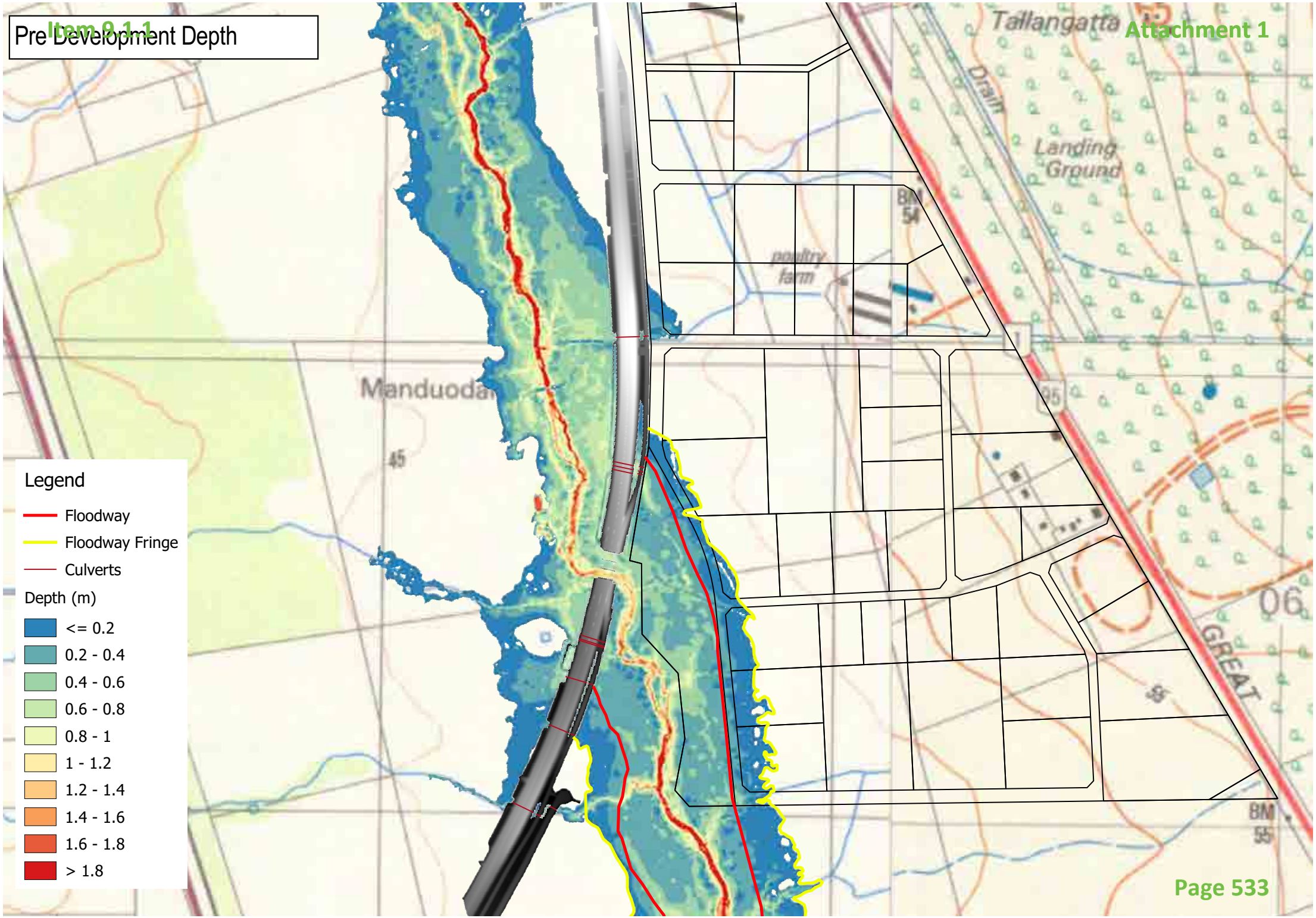
Scenarios where the earthworks footprint encroaches further into the floodway with offsets ranging from 20m to 80m were also simulated in the hydraulic model to assess potential impacts on the adjacent PDNH. The results indicate an increase in flood levels along the PDNH alignment varying between 40mm for a 40m offset to 90mm for an 80m offset.

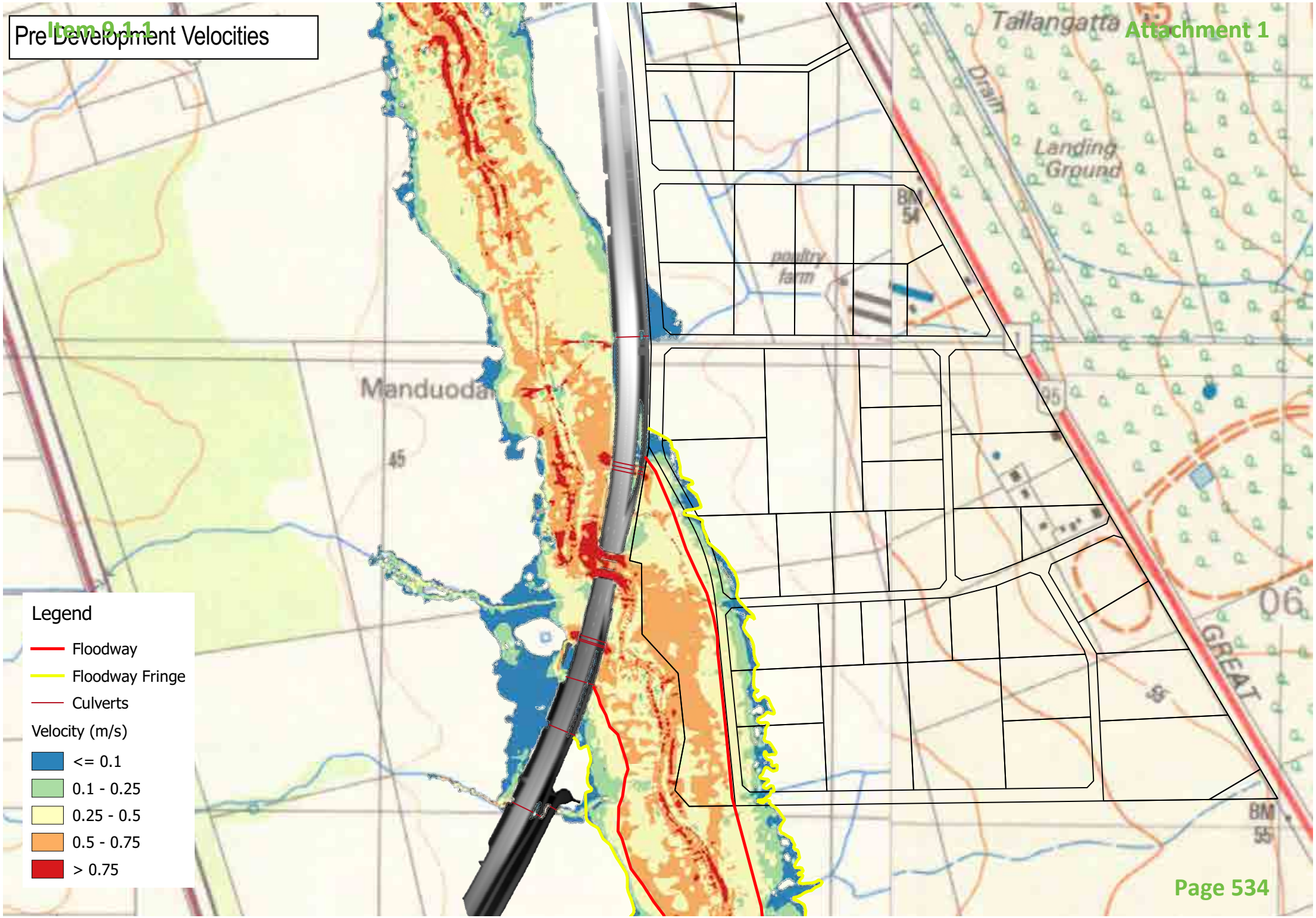
**Figure 1 – Downstream floodway definition by DWER**

## LIMITATIONS

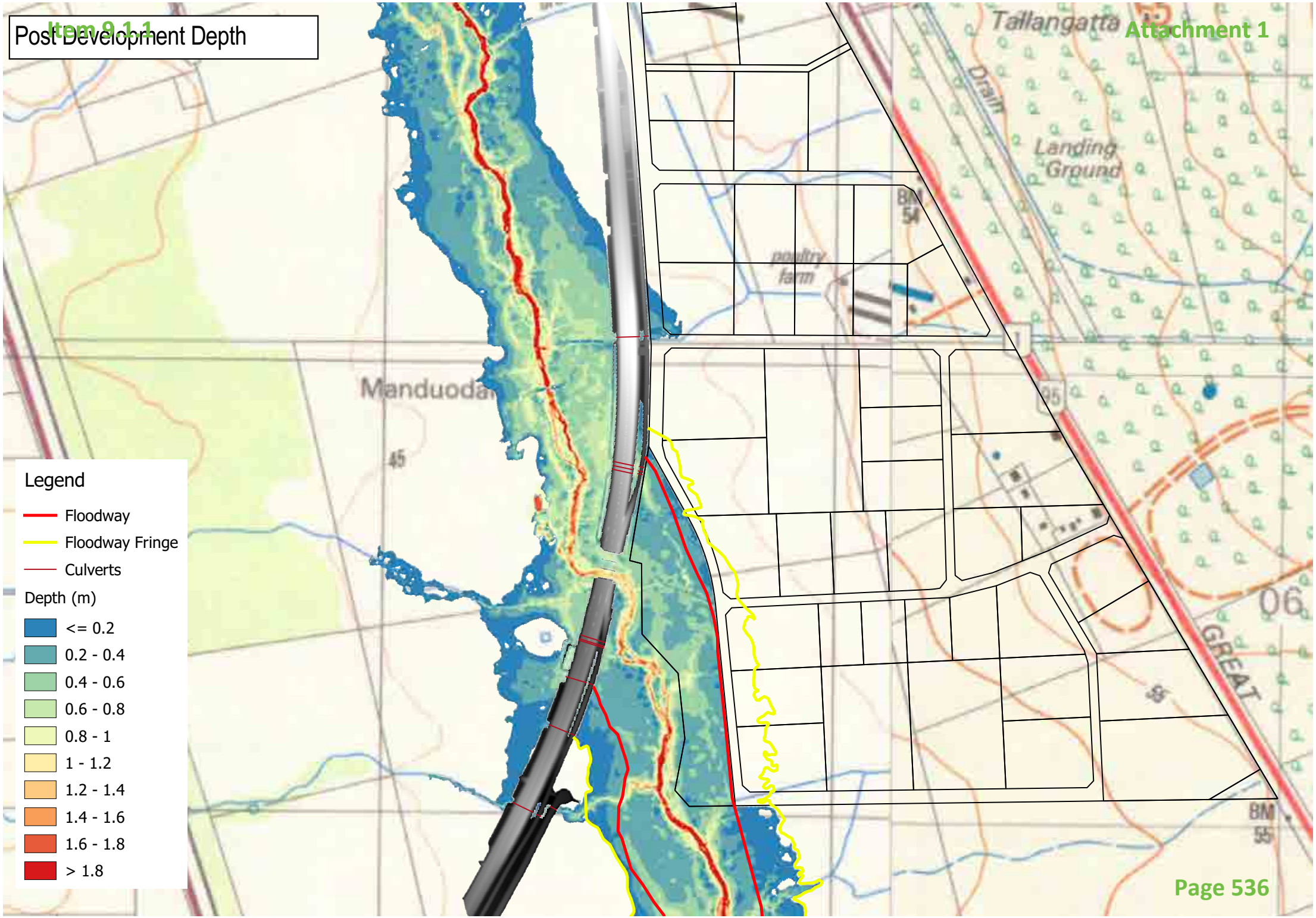
The findings of this study are subject to the following limitations:

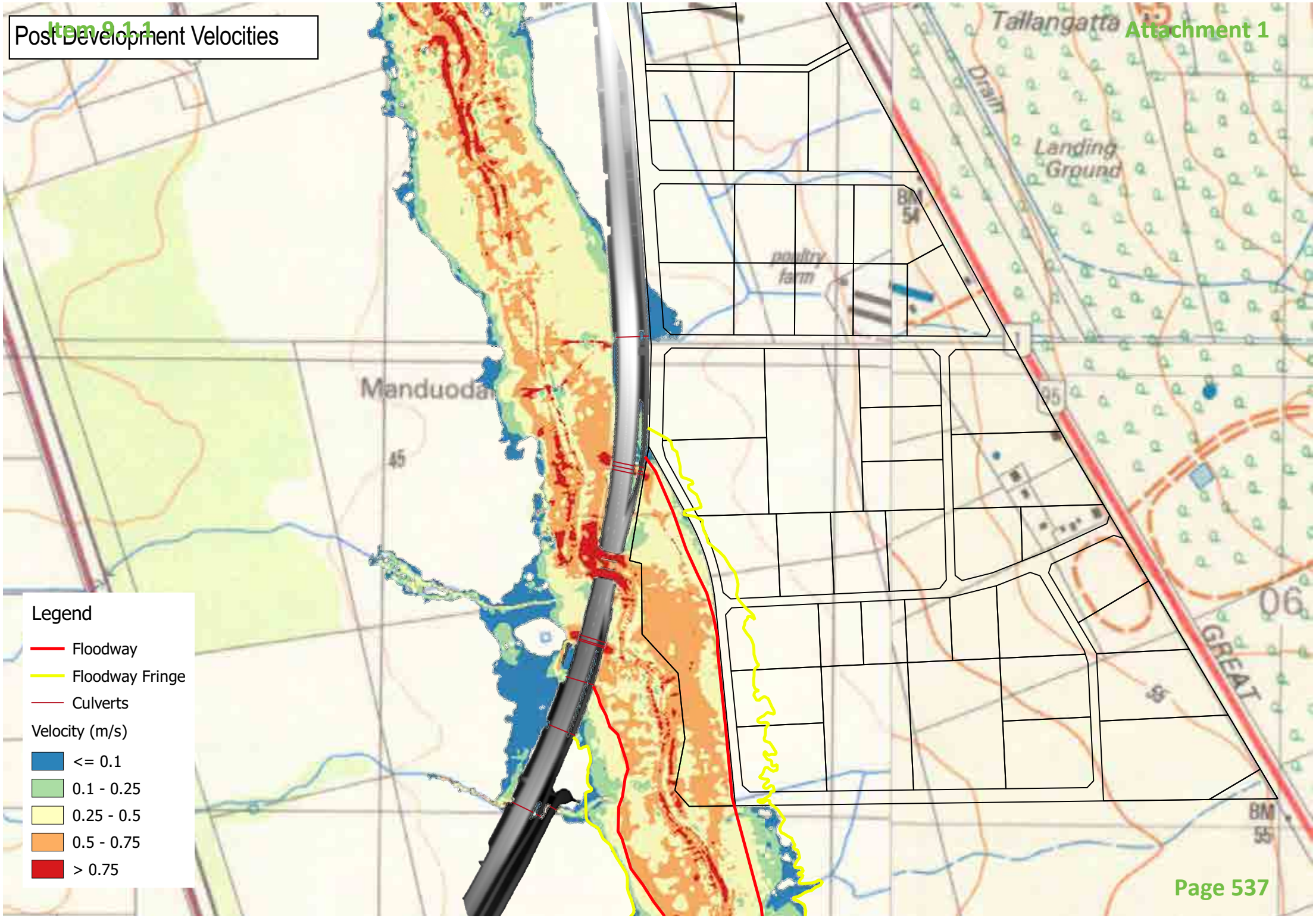
- The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.
- No allowance has been made for blockage of drainage infrastructure or increasing flows due to climate change.

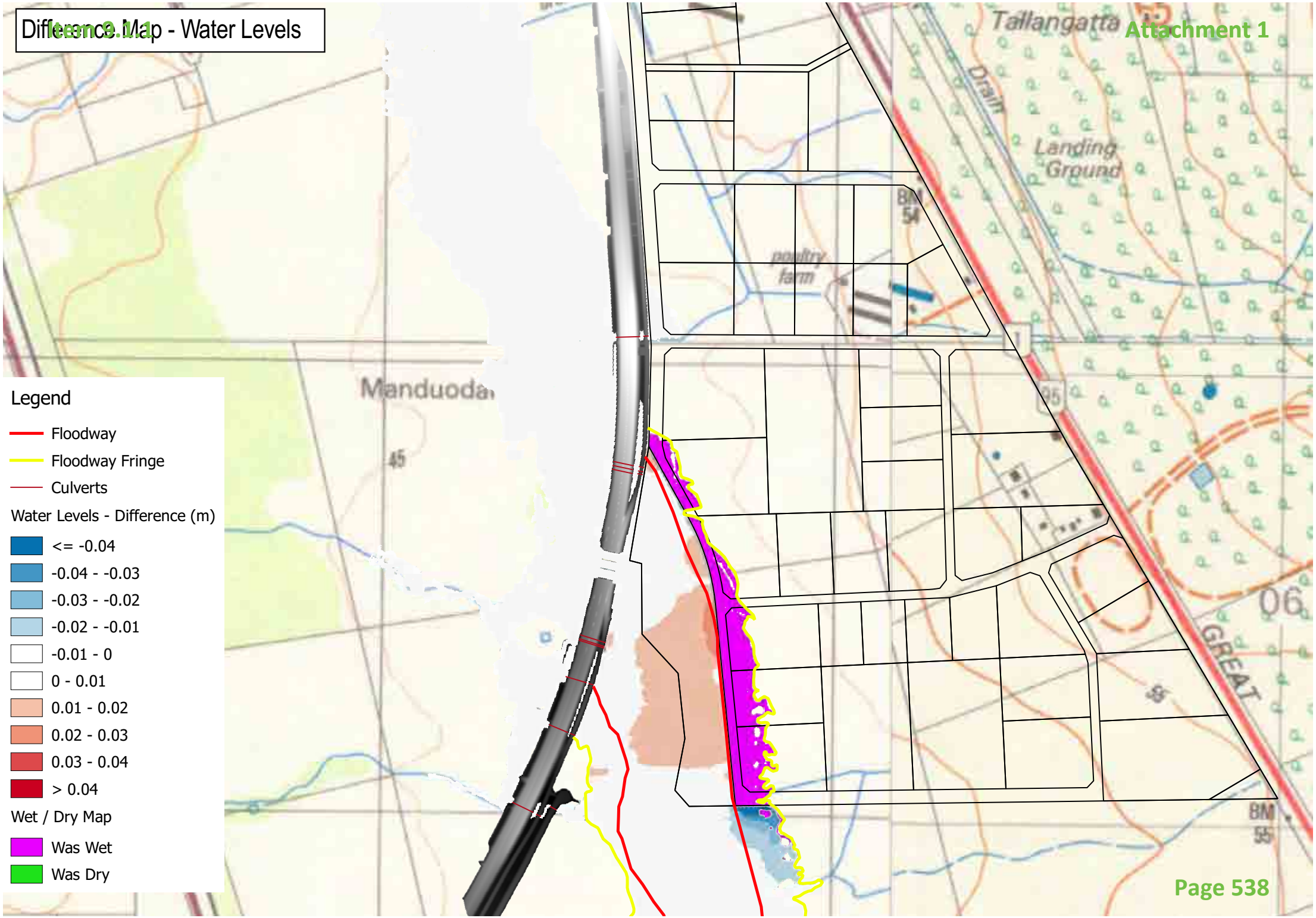

Pre Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Pre Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
GREAT
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75

Pre Development Velocity x Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity x Depth
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
> 1


Post Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
BM 54
95
06
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Post Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Difference Map - Water Levels
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Water Levels - Difference (m)
<= -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
> 0.04
Wet / Dry Map
Was Wet
Was Dry

# APPENDIX G
# BUSH FIRE MANAGEMENT PLAN

# Bushfire Management Plan

Lots 35, 192, 194, 800, 801, 802, 803 and 804 Great Northern Hwy, Muchea

Prepared for
**Tomahawk Properties**

30 November 2018

## DOCUMENT TRACKING

| Item | Detail |
|---|---|
| Project Name | Bushfire Management Plan, Lots 35, 192, 194, 800, 801, 802, 803 and 804 Great Northern |
| Project Number | 18PER-10856 |
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| Approved by | Daniel Panickar (BPAD37802-L2) |
| Status | FINAL |
| Version Number | V1 |
| Last saved on | 30 November 2018 |

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Template 29/9/2015

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# 1 Introduction

## 1.1 Proposal details

Eco Logical Australia (ELA) was commissioned by Bayley Environmental Services on behalf of Tomahawk Properties to prepare a Bushfire Management Plan (BMP) to support a Structure Plan amendment for Lots 35, 192, 194, 800, 801, 802, 803 and 804 Great Northern Hwy, Muchea (hereafter referred to as the subject site; **Figure 1**). The subject site is zoned as 'Industrial' in Precinct 3 of the Muchea Employment Node (WAPC 2011). It is also zoned as 'Industrial' in the Shire of Chittering Town Planning Scheme 6.

The entirety of the subject site is within a designated bushfire prone area as per the *Western Australia State Map of Bush Fire Prone Areas* (DFES 2018; **Figure 2**), which triggers bushfire planning requirements under *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; WAPC 2015) and reporting to accompany submission of the Structure Plan in accordance with the associated *Guidelines for Planning in Bushfire Prone Areas v 1.3* (the Guidelines; WAPC 2017). The south- eastern area of the 150 m assessment area is not designated as bushfire prone.

This assessment has been prepared by ELA Bushfire Consultant, James Leonard and quality assurance undertaken by ELA Senior Bushfire Consultant, Daniel Panickar (FPAA BPAD Level 2 Certified Practitioner No. BPAD37802-L2).

## 1.2 Purpose and application of the plan

The primary purpose of this BMP is to act as a technical supporting document to inform planning assessment.

This BMP is also designed to provide guidance on how to plan for and manage the bushfire risk to the subject site through implementation of a range of bushfire management measures in accordance with the Guidelines.

## 1.3 Environmental Considerations

Some bushfire prone areas also have high biodiversity values. SPP 3.7 policy objective 5.4 recognises the need to consider bushfire risk management measures alongside environmental, biodiversity and conservation values.

Environmental approvals for the development are currently in the process of being obtained. This BMP is not expected to trigger any additional requirements.

No revegetation is proposed within the subject site, however if this changes, it will be addressed in future BMPs.

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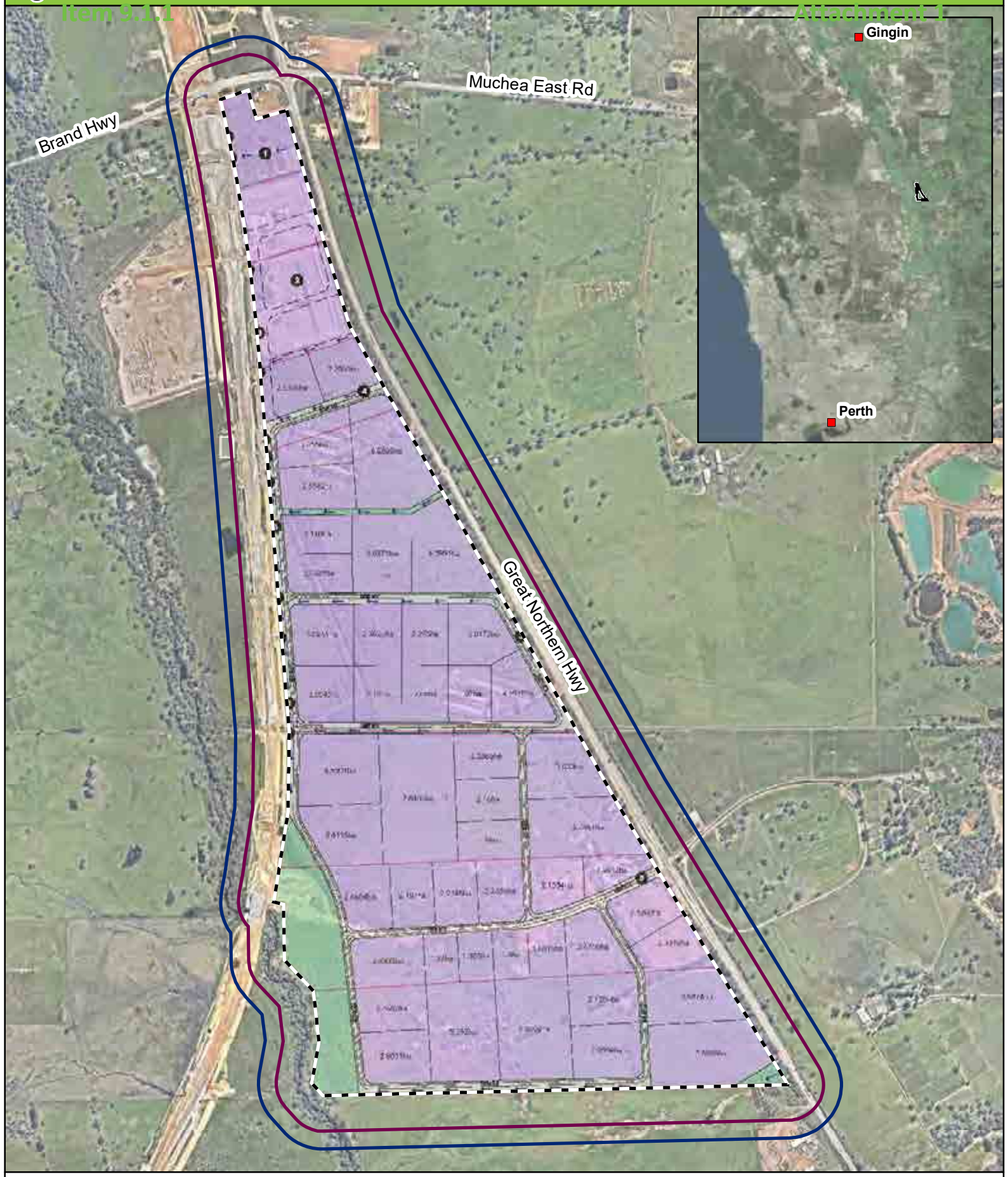
# Figure 1: Site Overview




**Legend**

- Subject site
- 100m assessment area
- 150m assessment area

0 112.5 225 450
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N



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# Figure 2: Bushfire Prone Areas for the subject site

**Legend**

- Subject site
- 100m assessment area
- 150m assessment area
- Bushfire Prone Mapping (DFES 2018)

0 112.5 225 450

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

N



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# 2 Bushfire Assessment Results

## 2.1 Assessment inputs

The following section is a consideration of spatial bushfire risk and has been used to inform the bushfire assessment in this report.

### 2.1.1 General

The subject site is located in the Shire of Chittering, and is bound by:

- Brand Hwy and agricultural lots in the north;
- Great Northern Hwy to the east,
- Private lots to the south; and
- The Northlink infrastructure corridor to the west.

Visual assessment of the surrounding vegetation within the assessment area did not identify any recent fire scars and fire history was not able to be determined. Accumulation of vegetative matter over time, combined with the moderate to high risk of ignition associated with high levels of public access and proximity to urban areas would potentially facilitate a bushfire occurrence in this area.

### 2.1.2 Vegetation classification

Vegetation within the subject site and surrounding 150 m (the assessment area) was assessed in accordance with the Guidelines and AS 3959-2009 *Construction of Buildings in Bushfire Prone Areas* (SA 2009) with regard given to the *Visual guide for bushfire risk assessment in Western Australia* (DoP 2016). The site inspection was undertaken on 26 November 2018.

The following vegetation classes and exclusions were identified within the assessment area as depicted in and listed below:

- Class B woodland;
- Class G grassland; and
- Exclusions as per clause 2.2.3.2 (e) and (f) (i.e. non-vegetated areas and low-threat vegetation).

Photographs relating to each vegetation type are included in **Appendix A.**

### 2.1.3 Topography and slope under vegetation

Effective slope under vegetation was assessed for a distance of 150 m from the subject site in accordance with the Guidelines and AS 3959-2009. Visual assessment on site determined that slope under classified vegetation in all directions was assessed as upslope/flat land (**Figure 3**).

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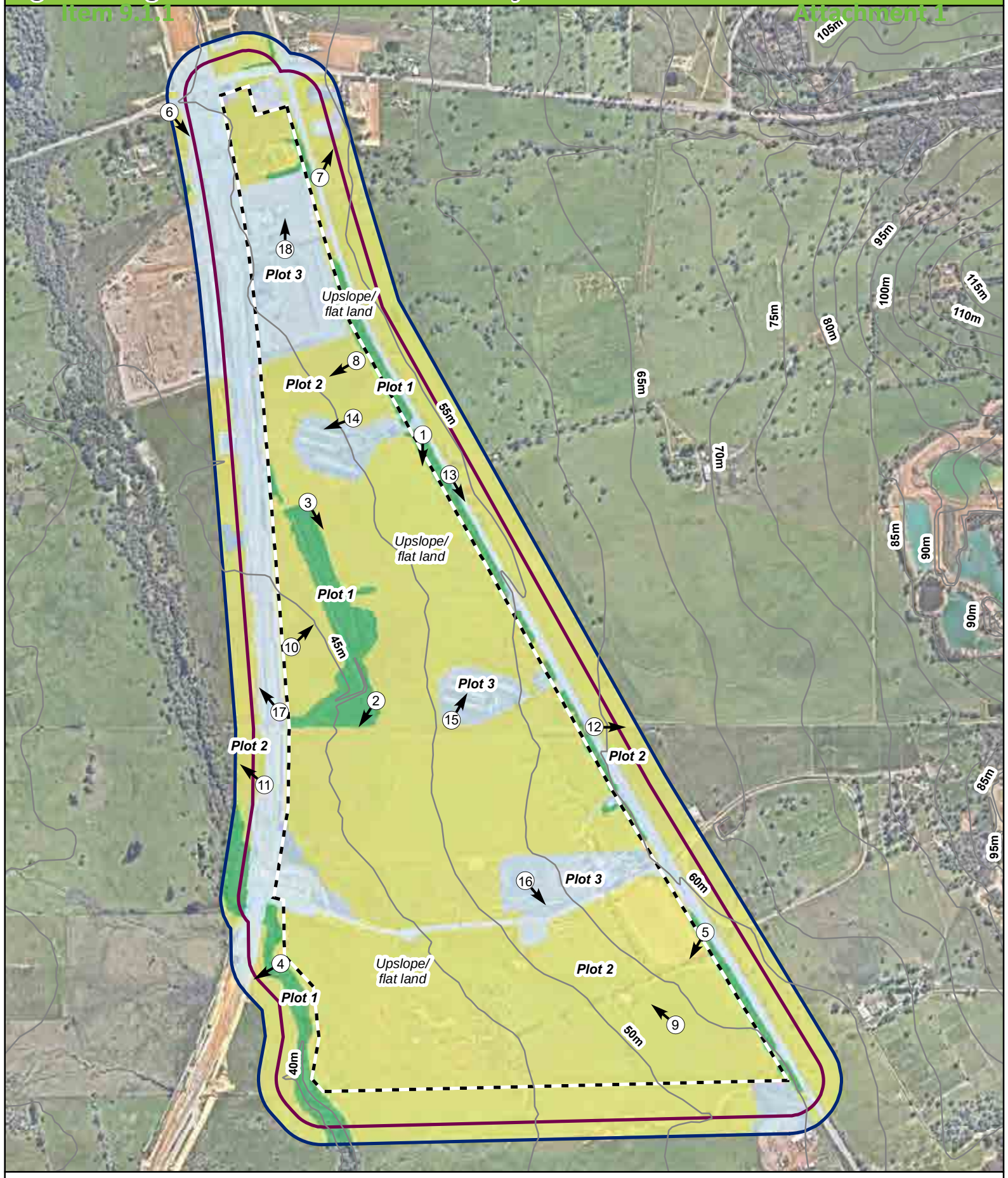
# Figure 3: Vegetation classification of the subject site




## Legend

- Subject site
- 100m assessment area
- 150m assessment area
- Contours 5m Intervals (Statewide)
- Photo_location

**Vegetation classification**

- Class B woodland
- Class G grassland
- Excluded under 2.2.3.2 (e) and (f)

0 112.5 225 450
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N



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## 2.2 Assessment outputs

A BHL assessment has been undertaken in accordance with SPP 3.7, the Guidelines and the bushfire assessment inputs in **Section 2.1**.

### 2.2.1 Bushfire Hazard Level (BHL) assessment

A BHL assessment is required for all land located within 150 m of the subject site in accordance with the Guidelines.

Pre-development BHLs have been assessed for the subject site in accordance with the methodology contained within the Guidelines and incorporates the following factors:

- Vegetation class; and
- Slope under classified vegetation.

**Table 1** contains a summary of the BHL assessment for each vegetation class or exclusion. All land within 100 m of Extreme and Moderate BHLs has also been mapped as a Moderate hazard as per the Guidelines, and the final result is depicted in **Figure 4**.

**Table 1: Bushfire Hazard Level (BHL) Assessment**

| Plot | Vegetation Classification | Effective Slope | Bushfire Hazard Level |
|---|---|---|---|
| 1 | Class B Woodland | Upslope/flat | Extreme |
| 2 | Class G Grassland | Upslope/flat | Moderate |
| 3 | Excluded as per clause 2.2.3.2 (e) & (f) | N/A | Low |

Clearing and revegetation will be undertaken within the subject site for development purposes, and consequently the pre-development BHLs are subject to change. A post-development BHL assessment is provided in **Figure 5** based on expected changes to vegetation within the subject site.

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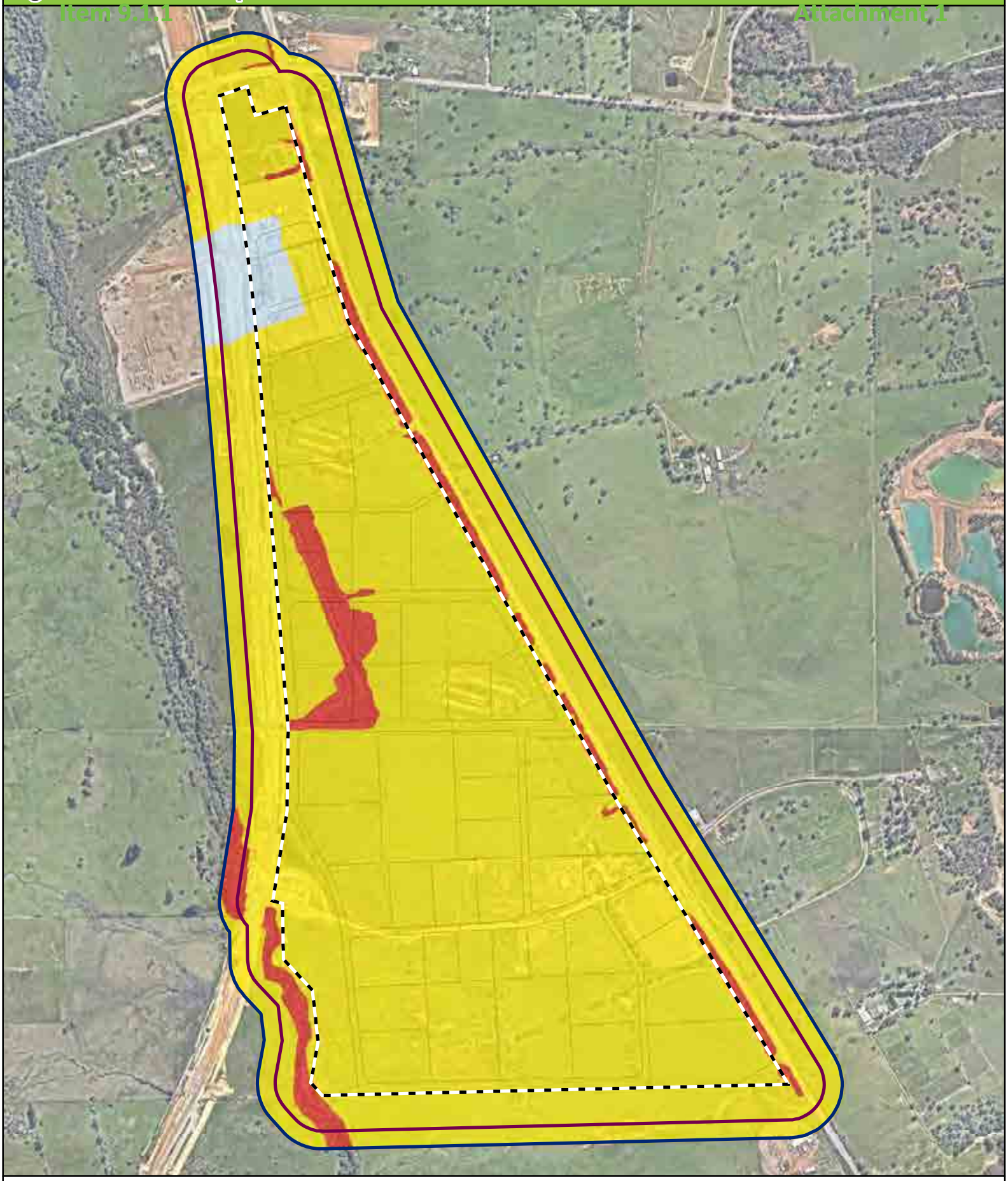
# Figure 4: Pre-development Bushfire Hazard Assessment



**Legend**

- Subject site
- 100m assessment area
- 150m assessment area
- Proposed Structure Plan

**Bushfire Hazard Level**

- Extreme
- Moderate
- Low

0 112.5 225 450
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N



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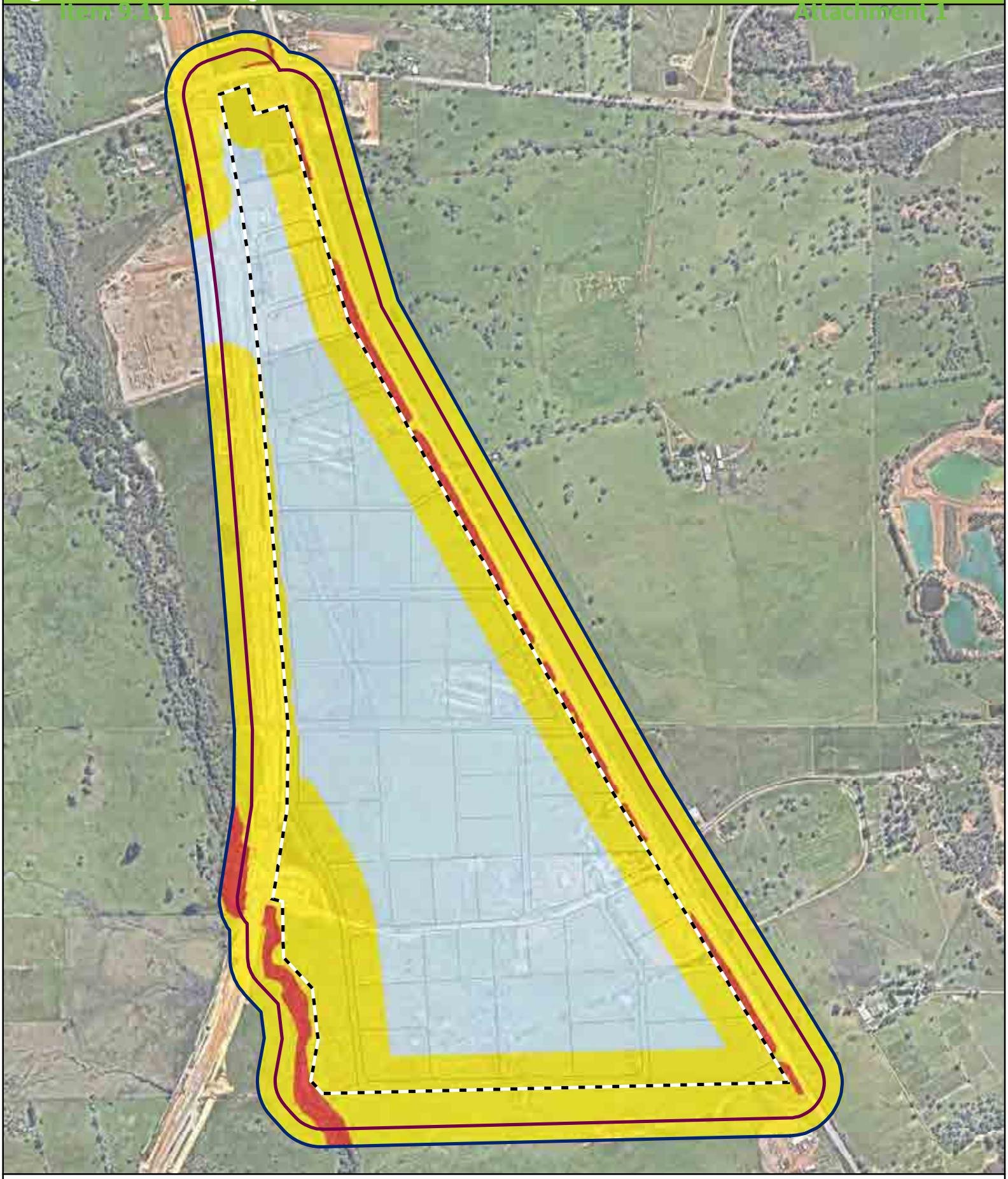
# Figure 5: Post-development Bushfire Hazard Level Assessment



**Legend**

- Subject site
- 100m assessment area
- 150m assessment area
- Proposed Structure Plan

**Bushfire Hazard Level**

- Extreme
- Moderate
- Low

0 112.5 225 450
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N



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# 3 Identification of Bushfire Hazard issues

The on-site vegetation extent is proposed to be cleared to enable development of a significant industrial development. Therefore, for the purposes of strategic level planning, ELA does not consider the current on-site vegetation extent to be a bushfire hazard issue post-development, since these hazards are to be cleared for development, can be managed through a staged clearing process, adequate separation of future built assets from classified vegetation, and ongoing fuel management that can be undertaken in and around individual development stages.

On the basis of the above information, ELA considers that the bushfire hazards within and adjacent to the subject site and the associated bushfire risk is readily manageable through standard management responses and compliance with acceptable solutions outlined in the Guidelines and AS 3959-2009. These management measures will need to be factored into the development design as early as possible to ensure a suitable, compliant and effective bushfire management outcome is achieved to ensure protection of future life and property assets.

Demonstration of compliance with the relevant requirements of SPP 3.7, the Guidelines and AS 3959-2009 at future planning stages will also depend on the developer's ability to coordinate the timing and staging of clearing and development works within the subject site with those developments proposed on adjacent landholdings in the aim of avoiding bushfire impacts from temporary retained vegetation.

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# 4 Assessment against the Bushfire Protection Criteria

## 4.1 Compliance

The proposed Structure Plan is required to comply with policy measures 6.2 and 6.3 of SPP 3.7 and the Guidelines. Implementation of this BMP is expected to meet objectives 5.1 - 5.4 of SPP 3.7.

Bushfire management measures have been devised for the proposed development in accordance with Guideline acceptable solutions to meet compliance with bushfire protection criteria.

The 'acceptable solutions assessment' is provided below to assess the proposed bushfire management measures against each bushfire protection criteria in accordance with the Guidelines. The assessment demonstrates that the proposed measures meet the intent of each element of the bushfire protection criteria. **Figure 6** depicts bushfire management strategies where necessary.

**Table 2: Summary of solutions used to achieve bushfire performance criteria**

| Bushfire Performance Criteria | AS | PS | N/A | Proposed bushfire management strategies |
|---|---|---|---|---|
| Element 1: Location<br>A1.1 Development location | ☒ | ☐ | ☐ | Post-development, all buildings within the subject site will be situated in areas subject to BHLs of moderate or low (refer to **Figure 6**). The proposed development is considered to be compliant with A1.1. |
| Element 2: Siting and design of development<br>A2.1 Asset Protection Zone (APZ) | ☒ | ☐ | ☐ | APZs can be accommodated between all future buildings and classified vegetation within the proposed subject site (refer to **Figure 6**). Future development would result in the majority of the proposed area being cleared of vegetation and APZs may not be required. This is to be assessed during future stages of planning.<br>The proposed development is considered to be compliant A2.1. |
| Element 3: Vehicular access<br>A3.1 Two access routes | ☒ | ☐ | ☐ | There are currently two vehicular access points within the proposed subject site that join onto Great Northern Highway (refer to **Figure 6**). This is a major highway and provides two-way access to different destinations. The proposed development is considered to be compliant with A3.1. |
| Element 3: Vehicular access<br>A3.2 Public Road | ☒ | ☐ | ☐ | All public roads will comply with vehicular access requirements (refer to **Appendix C**).<br>The proposed development is considered to be compliant with A3.2. |

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| Bushfire Performance Criteria | AS | PS | N/A | Proposed bushfire management strategies |
|---|---|---|---|---|
| Element 3: Vehicular access<br>A3.3 Cul-de-sac | ☐ | ☐ | ☒ | No cul-de-sacs are proposed as part of the development. |
| Element 3: Vehicular access<br>A3.4 Battle-axe | ☐ | ☐ | ☒ | No battle-axe lots are proposed as part of the development. |
| Element 3: Vehicular access<br>A3.5 Private Driveway longer than 50 m | ☐ | ☐ | ☒ | No private driveways longer than 50 m are proposed as part of the development. |
| Element 3: Vehicular access<br>A3.6 Emergency Access way | ☐ | ☐ | ☒ | No emergency access way routes are proposed or required as part of the development. |
| Element 3: Vehicular access<br>A3.7 Fire-service access route | ☐ | ☐ | ☒ | No fire service access routes are proposed or required as part of the development. |
| Element 3: Vehicular access<br>A3.8 Firebreak width | ☒ | ☐ | ☐ | There are currently 3 m wide firebreaks around the perimeter of the existing lots within the subject site that comply with the current Shire of Chittering Fire Control Notice. Future BMPs, to support subsequent planning applications, will address this requirement in greater detail.<br>The proposed development is considered to be compliant with A3.8. |
| Element 4: Water<br>A4.1 Reticulated areas | ☒ | ☐ | ☐ | The subject site will be connected to a reticulated water supply.<br>The proposed development is considered to be compliant with A4.1.<br>A4.2 and A4.3 are not applicable to this proposed development. |

## 4.2 Additional management strategies

Future demonstration of compliance with the relevant requirements of SPP 3.7, the Guidelines and AS 3959-2009 will depend on the developer's ability to coordinate the timing of development works within the subject site. Updated BMPs will be prepared to support subsequent planning applications where relevant and will contain re-assessments of bushfire risk including Bushfire Attack Level assessments etc.

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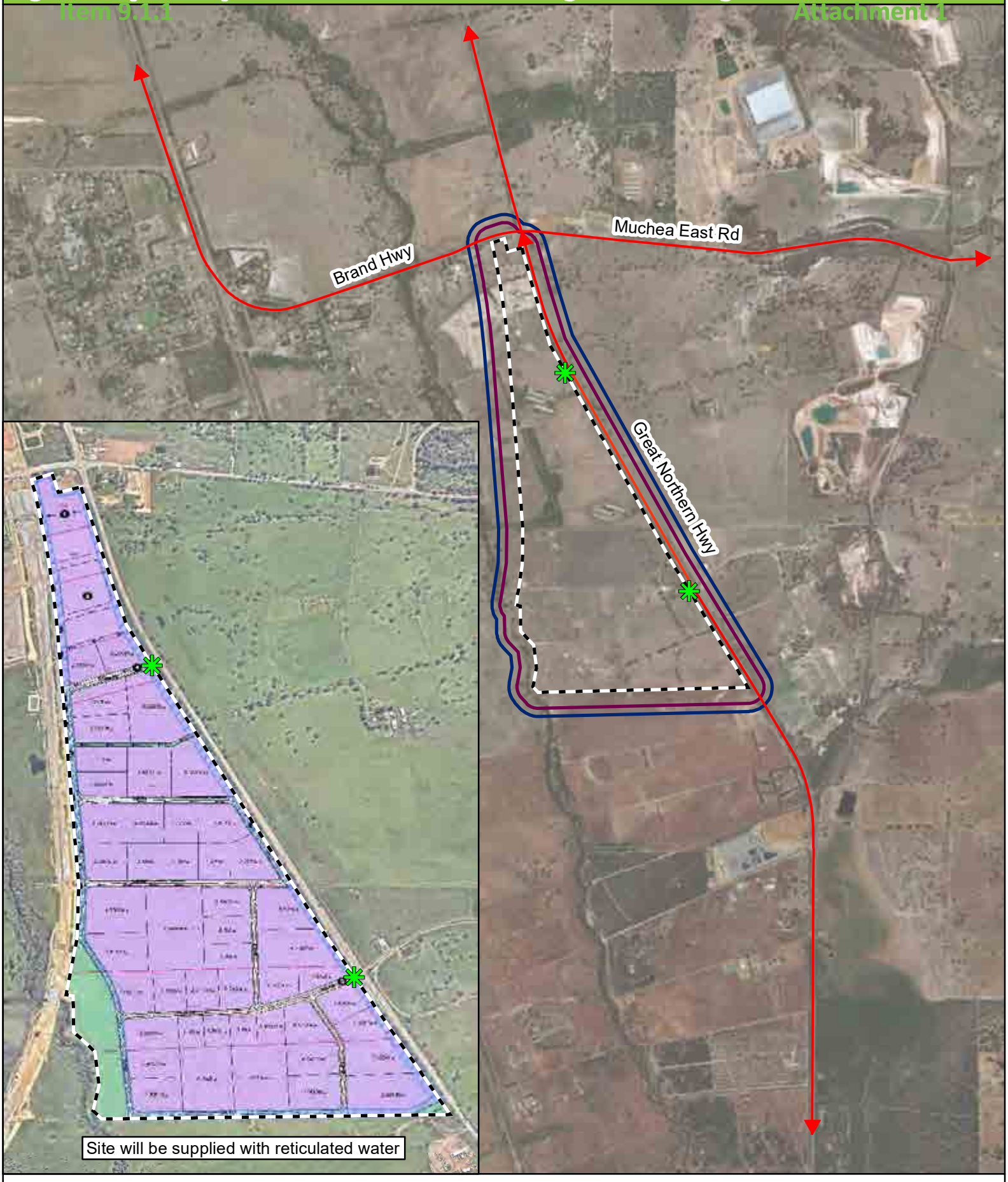
# Figure 6: Spatial representation of bushfire management strategies




**Legend**

- Subject site
- 100m assessment area
- 150m assessment area
- Access Route
- Access/ egress points
- Indicative Asset Protection Zone (APZ)

0 250 500 1,000
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N



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# 5 Responsibilities for Implementation and Management of Bushfire Measures

Implementation of the BMP applies to Tomahawk Properties, the Shire of Chittering, and future landowners to ensure bushfire management measures are adopted and implemented on an ongoing basis. This BMP has been prepared as a strategic guide to demonstrate how development compliance will be delivered at future planning stages in accordance with the Guidelines. In this respect, management measures documented in **Section 4**, where applicable, will be incorporated into development design as early as possible and confirmed through subdivision design. Therefore, aside from the revision of this BMP or preparation of a BMP addendum to accompany future subdivision applications, there are no further items to implement, enforce or review at this stage of the planning process.

The revised BMP or addendum to this BMP is required to meet the relevant commitments outlined in this strategic level BMP, address the relevant requirements of SPP 3.7 (i.e. Policy Measure 6.4) and demonstrate in detail how the proposed development will incorporate the relevant acceptable solutions to meet the performance requirements of the Guidelines.

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# 6 Conclusion

In the author's professional opinion, the bushfire protection requirements listed in this assessment provide an adequate standard of bushfire protection for the proposed development. As such, the proposed development is consistent with the aim and objectives of SPP 3.7 and associated guidelines and is recommended for approval.

Daniel Panickar
**Senior Bushfire Consultant**
**FPAA BPAD Certified Practitioner**
**No. BPAD37802-L2**

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# References

Department of Fire and Emergency Services (DFES). 2018. *Map of Bush Fire Prone Areas*, [Online], Government of Western Australia, available from: http://www.dfes.wa.gov.au/regulationandcompliance/bushfireproneareas/Pages/default.aspx

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Western Australian Planning Commission (WAPC). 2017. *Guidelines for Planning in Bushfire Prone Areas Version 1.3 (including appendices).* WAPC, Perth.

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# Appendix A Plates

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 1 | 1 | **Class B Woodland** |
| 1 | 2 | **Class B Woodland -** Classified vegetation within this plot is comprised of trees between 10 to 30 m tall with approximately 20 to 30% foliage cover. There is limited surface litter. Some grass is present at the base of the trees. Slope under vegetation was assessed as upslope/flat land. |

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| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 1 | 3 | **Class B Woodland** |
| 1 | 4 | **Class B Woodland** |

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 1 | 5 | **Class B Woodland** |
| 2 | 6 | **Class G Grassland** |

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 2 | 7 | **Class G Grassland** |
| 2 | 8 | **Class G Grassland** |

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 2 | 9 | <br>**Class G Grassland** |
| 2 | 10 | <br>**Class G Grassland** |

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 2 | 11 | **Class G Grassland** |
| 2 | 12 | **Class G Grassland** |

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 3 | 13 | **Excluded under Clause 2.2.3.2 (e) and (f)** |
| 3 | 14 | **Excluded under Clause 2.2.3.2 (e) and (f) (Background)** |

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 3 | 15 | **Excluded under Clause 2.2.3.2 (e) and (f)** |
| 3 | 16 | **Excluded under Clause 2.2.3.2 (e) and (f) (Background)** |

| Plot | Photo ID | Photo and vegetation class |
|---|---|---|
| 3 | 17 | <br>**Excluded under Clause 2.2.3.2 (e) and (f)** |
| 3 | 18 | <br>**Excluded under Clause 2.2.3.2 (e) and (f) (Background)** |

# Appendix B Standards for Asset Protection Zones

The following standards have been extracted from the *Guidelines for Planning in Bushfire Prone Areas v 1.3* (WAPC 2017).

Every habitable building is to be surrounded by, and every proposed lot can achieve, an APZ depicted on submitted plans, which meets the following requirements:

**a. Width:** Measured from any external wall or supporting post or column of the proposed building, and of sufficient size to ensure the potential radiant heat impact of a fire does not exceed 29kW/m² (BAL 29) in all circumstances.

**b. Location:** the APZ should be contained solely within the boundaries of the lot on which a building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity (see explanatory notes).

**c. Management:** the APZ is managed in accordance with the requirements of '*Standards for Asset Protection Zones*' (below):

- Fences: within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used
- Objects: within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors
- Fine Fuel load: combustible dead vegetation matter less than 6 millimetres in thickness reduced to and maintained at an average of two tonnes per hectare
- Trees (> 5 metres in height): trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy (**Figure 7**).

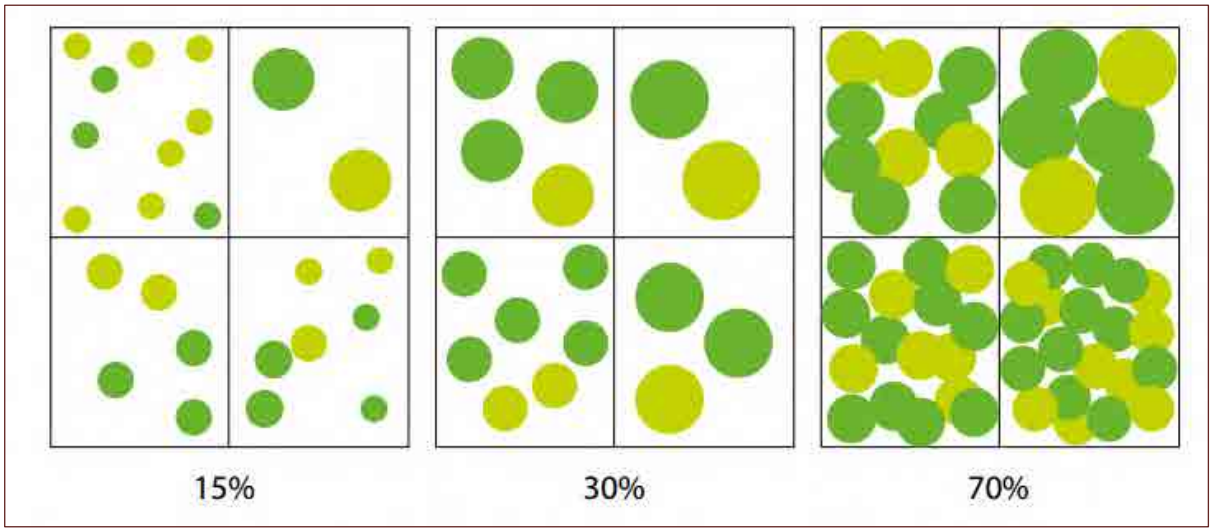


**Figure 7: Illustrated tree canopy cover projection (WAPC 2017)**

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- **Shrubs (0.5 metres to 5 metres in height):** should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees
- **Ground covers (<0.5 metres in height):** can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 millimetres in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs
- **Grass:** should be managed to maintain a height of 100 millimetres or less.

**Additional notes**

The Asset Protection Zone (APZ) is an area surrounding a building that is managed to reduce the bushfire hazard to an acceptable level. Hazard separation in the form of using subdivision design elements or excluded and low threat vegetation adjacent to the lot may be used to reduce the dimensions of the APZ within the lot.

The APZ should be contained solely within the boundaries of the lot on which the building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity. The APZ may include public roads, waterways, footpaths, buildings, rocky outcrops, golf courses, maintained parkland as well as cultivated gardens in an urban context, but does not include grassland or vegetation on a neighbouring rural lot, farmland, wetland reserves and unmanaged public reserves.

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# Appendix C Vehicular access technical requirements (WAPC 2017)

| Technical requirements | Public road | Cul-de-sac | Private driveway | Emergency access way | Fire service access route |
|---|---|---|---|---|---|
| Minimum trafficable surface (m) | 6* | 6 | 4 | 6* | 6* |
| Horizontal distance (m) | 6 | 6 | 6 | 6 | 6 |
| Vertical clearance (m) | 4.5 | N/A | 4.5 | 4.5 | 4.5 |
| Maximum grade <50 m | 1 in 10 | 1 in 10 | 1 in 10 | 1 in 10 | 1 in 10 |
| Minimum weight capacity (t) | 15 | 15 | 15 | 15 | 15 |
| Maximum crossfall | 1 in 33 | 1 in 33 | 1 in 33 | 1 in 33 | 1 in 33 |
| Curves minimum inner radius | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |

* Refer to E3.2 Public roads: Trafficable surface

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ISO 14001 Environmental Management

AS/NZS 4801:2001 Occupational Health and Safety Management

ISO 9001 Quality Management

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# APPENDIX H
# LOCAL WATER MANAGEMENT STRATEGY

# MUCHEA EMPLOYMENT NODE
# PRECINCT 3

# LOCAL WATER MANAGEMENT STRATEGY

**Prepared for**

**Muchea Employment Node**
**Precinct 3 Landowner Group**
c/- Tomahawk Property
8/355 Stirling Hwy
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Report No. J18015b
4 February 2019

BAYLEY ENVIRONMENTAL SERVICES
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# 1.0 INTRODUCTION

## 1.1 Background

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the site) have applied to the WAPC for the lots to be rezoned from Rural to Industrial Development. The Muchea Employment Node Structure Plan 2011 (MENSP) showed the eastern parts of the subject lots as future industrial Precinct 3, bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH) and Ellen Brook. Figure 1 shows the location of the site within the Muchea Employment Node Structure Plan.

The total area of the rezoning is approximately 185 hectares. Figure 2 shows an aerial view of the site and surroundings.

The MENSP concept for Precinct 3 is for low water-use industries with a minimum lot size of one hectare, with effluent disposed on-site using aerobic treatment units and evaporation ponds. This recognises the site constraints posed by the land's low elevation and high winter water table. Figure 3 shows a preliminary conceptual plan of subdivision for the site.

## 1.2 Scope of the LWMS

The scope of this LWMS is to:

- Document the existing environment on the site, in relation to soils, drainage, erosion, watercourses, groundwater and water-dependent ecosystems.
- Briefly describe the proposed development in relation to water management.
- Examine the capability of the site for on-site effluent disposal.
- Address relevant regulatory requirements and design criteria for water harvesting, setbacks to watercourses, groundwater management and drainage.
- Describe the strategies to be implemented for water conservation, watercourse protection, groundwater management and stormwater drainage.
- Outline the proposed monitoring program.
- Outline what is to be addressed in future Urban Water Management Plans.

## 1.3 Relevant Guidelines and Policies

### 1.3.1 State Planning Policy 2.9

State Planning Policy 2.9: *Water Resources* (WAPC, 2006) lists the following key principles for total water cycle management:

- Consideration of all water sources (including wastewater) in water planning, maximising the value of water resources.
- Integration of water and land use planning.
- Sustainable and equitable use of all water sources, having consideration of the needs of all water users including the community, industry and the environment.
- Integration of water use and natural water processes.
- A whole-of-catchment integration of natural resource use and management.

SPP 2.9 also lists the following general objectives for water-sensitive urban design:

- to manage a water regime;
- to maintain and, where possible, enhance water quality;
- to encourage water conservation;
- to enhance water-related environmental values; and
- to enhance water-related recreational and cultural values.

Element 5 of *Liveable Neighbourhoods* Edition 3 (WAPC, 2004) identifies specific objectives and requirements for Urban Water Management. These are based on Best Planning Practices which are defined as the best practical approach for achieving water resource management objectives within an urban framework.

### 1.3.2 Better Urban Water Management

*Better Urban Water Management* (WAPC, 2008) sets out the following objectives for water sensitive urban design:

*Water Conservation*

- Consumption of 100kL/p/yr including less than 40-60 kL/p/yr scheme water.

*Water Quantity*

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.

- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

*Water Quality*

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).

- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.

- As compared to a development that does not actively manage stormwater quality, achieve:

  - at least 80% reduction of Total Suspended Solids;
  - at least 60% reduction of Total Phosphorus;
  - at least 45% reduction of Total Nitrogen; and
  - at least 70% reduction of gross pollutants.

*Mosquitoes and Midges*

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DWER) to maximise predation of mosquito larvae by native fauna.

1.3.3 Shire of Chittering Town Planning Scheme No. 6

"The following development requirements shall apply to the development and subdivision of land within industrial zones and to industrial land uses –

(a) the effect on the environment by means of discharge of pollutants or contaminants into the air, ground and water be avoided, or managed within acceptable limits;

(b) where an on-site wastewater disposal system is proposed –

i. land capability assessment may be required to demonstrate the capability of the site to manage wastewater and the suitability of the proposed system;
ii. the use of fill and drains to achieve the required separation from groundwater is to be limited; and

iii. a suitable and unencumbered land application area is to be set aside to distribute treated sewage, where required;

(c) within sewerage sensitive areas secondary treatment systems with nutrient removal are to be utilised;

(d) notwithstanding any other provisions of this scheme, industrial development not connected to reticulated sewerage (for treatment on-site or off-site) is to be restricted to 'dry industry' being land uses that intend to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building at a daily volume of less than 540 litres per 1,000m$^2$ of the site area [R10 equivalent];

(e) where trade waste is to be managed and/or disposed of on-site or off-site the associated risks must be identified and addressed, including the vulnerability of the receiving environment where relevant."

The Scheme shows Precinct 3 and its surroundings as part of a Water Prone Area (Ellen Brook Palusplain), within which the following special provisions apply:

"5.3.3 Planning Requirements

The local government will impose conditions on any Development approval relating to -

a) the construction and occupation of any dwelling or outbuilding;

b) the type of effluent disposal system used in this area shall be high performance with bacterial and nutrient stripping capabilities to the specifications of local government and the Health Department and shall be located in a position determined by local government.;

c) minimum floor levels for any building above the highest known water levels;

d) any land use that may contribute to the degradation of the surface or sub-surface water quality.

e) no development other than for conservation purposes will be permitted within 30 metres of any natural water body; AMD 21 GG 3/4/09

f) damming, draining or other developments which may alter the natural flow of surface water will not be permitted unless such works are part of an approved Catchment Management Plan."

Schedule 11 of the Scheme contains the following provisions that apply to the Muchea Employment Node:

"2.2 Environmental Management Plans

The following Environmental Management Plans shall be prepared and used to inform the design and proposed subdivision and development within the Structure Plan area. They shall be submitted as an additional detail of a Structure Plan unless otherwise determined by the Western Australian Planning Commission.

2.2.1 Local Water Management Strategy

The developer shall submit to the Local Authority a Local Water Management Strategy (LWMS) for approval as an additional detail of a Structure Plan pursuant to clause 5.19 in order to ensure that surface and ground waters are managed with the aim of maintaining the natural water balance. The Local Authority must notify and consult with the authority responsible for water and the environment on the proposed strategy in advertising the Local Structure Plan(s) pursuant to Part 4 of the deemed provisions.

The LWMS shall be prepared in accordance with Better Urban Water Management or its successor document.

The Structure Plan design shall respond to the LWMS required by 2.2.1 and shall be implemented to the satisfaction of the Local Authority, having regard to any advice from the Department of Water."

1.3.4 Country Sewerage Policy

The draft Country Sewerage Policy requires that all new subdivision and development should be deep-sewered unless it is exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and, where appropriate, density limits.

Commercial and industrial development in towns where no sewer is available may be permitted subject to:

- the overall objectives of the Policy not being compromised; and
- the statutory authority being satisfied after considering the advice of consultative authorities that the intended wastewater disposal arrangements are acceptable.

In this situation, the Health Department does not put a fixed limit on development density but assesses each proposal on its merits including the nature of the proposal and the physical capability of the site to accept the effluent.

Land used for on-site effluent disposal must meet the following requirements:

- The slope must be less than 20% (1 in 5) and the land shall be engineered to prevent runoff.

- The site should not be subject to inundation or flooding at a probability greater than once in 10 years.

- The land should have a minimum depth to the seasonal or permanent water table from the natural ground surface of at least 0.5 metre.

- The site should have free-draining soil (i.e. free from bedrock, impervious clay or groundwater table ) to a depth of at least 1.2m below the base of a leach drain or 0.5m below the discharge point of an ATU subsoil dripper system.

- Where site modification involves blasting or fissuring of rock, an imported soil type is required to surround the disposal area unless the local authority grants an exemption.

### 1.3.5 DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas

DoW Operational Policy 4.3 was published in 2012 and sets out the Department of Water's policy on defining and protecting foreshore reserves. It is intended to apply to all waterways within development areas. The policy sets out procedures for identifying, delineating and protecting foreshore areas.

The procedure may vary depending on the size and nature of the waterway and the nature of the proposed adjacent development. The policy provides for standard or nominal foreshore widths to be employed in some cases, such as small subdivisions and/or minor tributary creeks where the waterway is adequately protected and the proposed development poses an insignificant additional risk to the waterway.

### 1.3.6 DoW Interim Guideline: Developing a Local Water Management Strategy

The DoW LWMS guideline was published in 2008 and sets out the DoW's preferred format and content for LWMS documents. The guideline expands on the LWMS guidance provided in *Better Urban Water Management* (2008).

This LWMS has been prepared in accordance with the principles set out in the DoW guideline.

## 2.0 EXISTING ENVIRONMENT

### 2.1 Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 13.6km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Figure 4 shows a rainfall occurrence chart for Pearce. Table 2.1 shows rainfall intensity, frequency and duration for Muchea.

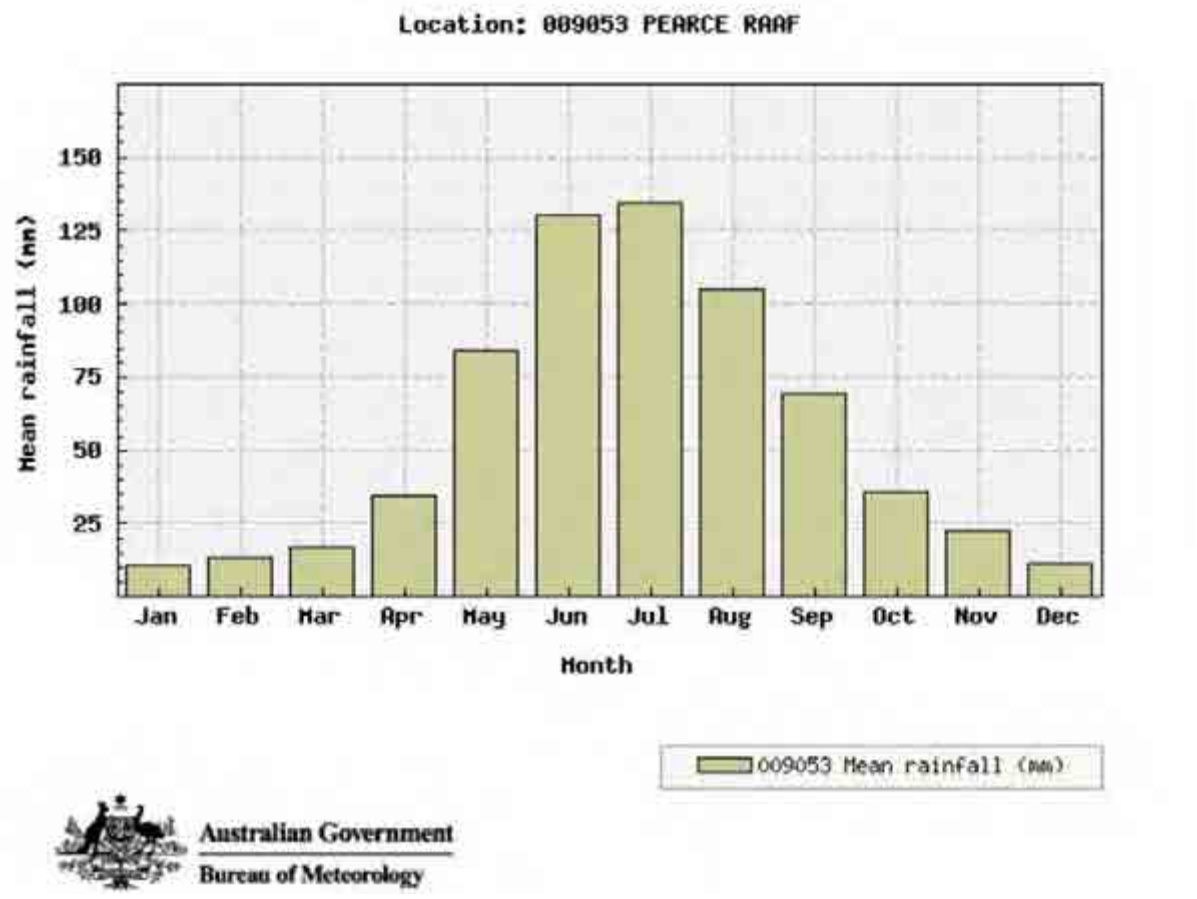


**Figure 4 Pearce RAAF Mean Rainfall**

**IFD Design Rainfall Depth (mm)** Issued: 31 October 2018

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

| | Annual Exceedance Probability (AEP) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Duration** | **63.2%** | **50%#** | **20%*** | **10%** | **5%** | **2%** | **1%** |
| **1 min** | 1.51 | 1.68 | 2.26 | 2.69 | 3.14 | 3.77 | 4.29 |
| **2 min** | 2.61 | 2.89 | 3.82 | 4.49 | 5.18 | 6.18 | 7.00 |
| **3 min** | 3.52 | 3.90 | 5.17 | 6.11 | 7.07 | 8.47 | 9.62 |
| **4 min** | 4.28 | 4.75 | 6.34 | 7.50 | 8.72 | 10.5 | 11.9 |
| **5 min** | 4.92 | 5.48 | 7.34 | 8.71 | 10.1 | 12.2 | 13.9 |
| **10 min** | 7.23 | 8.07 | 10.9 | 13.0 | 15.2 | 18.2 | 20.8 |
| **15 min** | 8.75 | 9.76 | 13.2 | 15.7 | 18.3 | 22.0 | 25.1 |
| **20 min** | 9.90 | 11.0 | 14.9 | 17.7 | 20.6 | 24.8 | 28.2 |
| **25 min** | 10.8 | 12.1 | 16.2 | 19.3 | 22.5 | 27.0 | 30.7 |
| **30 min** | 11.6 | 13.0 | 17.4 | 20.7 | 24.0 | 28.8 | 32.8 |
| **45 min** | 13.6 | 15.1 | 20.1 | 23.9 | 27.7 | 33.3 | 37.9 |
| **1 hour** | 15.1 | 16.7 | 22.2 | 26.4 | 30.7 | 36.9 | 42.1 |
| **1.5 hour** | 17.4 | 19.3 | 25.6 | 30.4 | 35.4 | 42.8 | 49.1 |
| **2 hour** | 19.3 | 21.3 | 28.3 | 33.6 | 39.4 | 47.8 | 55.1 |
| **3 hour** | 22.3 | 24.6 | 32.7 | 39.0 | 45.9 | 56.3 | 65.2 |
| **4.5 hour** | 25.8 | 28.5 | 37.9 | 45.4 | 53.8 | 66.4 | 77.6 |
| **6 hour** | 28.7 | 31.6 | 42.1 | 50.6 | 60.1 | 74.7 | 87.7 |
| **9 hour** | 33.1 | 36.5 | 48.7 | 58.7 | 70.0 | 87.5 | 103 |
| **12 hour** | 36.6 | 40.3 | 53.9 | 65.0 | 77.5 | 96.9 | 114 |
| **18 hour** | 42.0 | 46.3 | 61.7 | 74.2 | 88.1 | 110 | 129 |
| **24 hour** | 46.1 | 50.8 | 67.5 | 80.8 | 95.3 | 118 | 138 |
| **30 hour** | 49.5 | 54.5 | 72.1 | 85.8 | 101 | 124 | 143 |
| **36 hour** | 52.4 | 57.7 | 75.9 | 89.8 | 105 | 128 | 147 |
| **48 hour** | 57.2 | 62.9 | 82.1 | 96.1 | 111 | 133 | 152 |
| **72 hour** | 64.9 | 71.2 | 91.5 | 106 | 120 | 141 | 158 |
| **96 hour** | 71.4 | 78.2 | 99.4 | 114 | 128 | 148 | 164 |
| **120 hour** | 77.4 | 84.6 | 107 | 122 | 136 | 157 | 173 |
| **144 hour** | 83.4 | 91.0 | 115 | 131 | 146 | 168 | 185 |
| **168 hour** | 89.4 | 97.3 | 123 | 140 | 157 | 181 | 200 |

Note:
# The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

**Table 2.1 Rainfall Intensity for Muchea**

## 2.2 Physiography

### 2.2.1 Topography

The site lies on a very gently sloping plain on the eastern side of Ellen Brook. The site slopes gently to the west-southwest at gradients of up to 2.5%, decreasing to less than 0.4% near Ellen Brook. Figure 5 shows the topography of the site.

### 2.2.2 Geology, Landforms and Soils

Precinct 3 is located on the Pinjarra Plain, with soils of pebbly silt belonging to the Guildford Formation. These soils originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams.

The Guildford Formation soils are described by the Geological Survey of Western Australia (Gozzard, 1982) as "Strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin".

Drilling at six sites across the project area for this LWMS found silty soils containing varying proportions of clay, with the clay content increasing with depth. The low-lying western parts of the site are underlain in places by an ironstone (laterite) hardpan at depths of around one metre. Bore logs from the drilling are attached in Appendix A.

At the western edge of the site the alluvial deposits are overlain by a thin veneer of grey sand transported by floods in Ellen Brook. Figure 5 shows the site geology.

### 2.2.3 Soil Permeability

The permeability of the site soils is variable, depending on the clay content. Test pumping during sampling of the on-site bores indicated hydraulic conductivities in the top few metres ranging from about 1 m/day to over 5 m/day.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken at six sites at depths of 0.5m to 1m in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.25m/day to 4.2m/day with a mean of 1.8m/day.

Structerre Consulting Engineers carried out falling-head permeability tests at 1m depth at seven sites in November 2018. The falling-head tests returned hydraulic conductivity values ranging from 0.3m/day to 1.2m/day with a mean of 0.7m/day.

Figure 5 shows the locations of the permeability tests. Details of the tests tests are attached in Appendix B.

The ironstone hardpan in low-lying areas would impede vertical groundwater movement but its restricted extent means that its effect would be localised. In the east of the site, the clay subsoils impede rainfall infiltration and cause a perched surface water table to develop in winter.

The presence of a water table at the ground surface in winter across much of the site (see Section 2.3.2) means that all infiltration of drainage and effluent will be in fill, so the permeability of the natural soils is of reduced importance.

### 2.2.4 Acid Sulphate Soils

The DBCA maps most of the site as Low to Nil risk of Acid Sulphate Soils (ASS). Areas within 50-250m of Ellen Brook (corresponding to the alluvial sand S11 and ironstone) are mapped as Low to Moderate risk. The nearest mapped High ASS risks are an area of palusplain about 850m to the south-east and a sumpland about 900m to the west of the site.

Bore sampling in August 2018 found no indications of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary, although monitoring should be undertaken during any dewatering activities, with lime dosing of water and/or soil if required.

### 2.2.5 Phosphorus Retention Index

Previous experience has shown that the gravelly and silty soils of the Guildford Formation generally have moderate to high PRI.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

| *PRI Range* | *Rating* | *Typical soils* |
|---|---|---|
| 0 – 0.5 | Very Low | Bassendean Sand |
| 2 – 4 | Low – Moderate | Karrakatta Sands |
| 5 – 12 | Moderate – High | Cottesloe Sands |
| 12 – 20 | High | Crushed Limestone, Limesand |
| 20 – 1000+ | Very High | Clay |

The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins. The Health Department's draft *Code of Practice for Onsite Sewage Management* (2001) recommends a PRI of at least 20 for soils beneath effluent irrigation areas.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

## 2.3 Hydrology

The hydrology of the project area is complex, with soils of varying permeability, shallow and deep groundwater, runoff and surface discharge. Figure 6 depicts the overall hydrology of the site.

### 2.3.1 Groundwater

Groundwater occurs at shallow depth across the site. The DWER maps minimum groundwater levels at 39-48m AHD (2-7m below ground), flowing south-west towards Ellen Brook.

In winter, the groundwater rises to the ground surface across the lower western parts of the site and creates surface discharge to creeks, drainage lines and Ellen Brook. In the higher eastern parts of the site, rainfall infiltration is impeded by the low-permeability subsoils, creating a perched water table which flows downslope and discharges as surface flow on

the lower parts of the site. The net result of these two processes is that groundwater is at or near the ground surface over much of the site in winter.

Bores installed and measured in August 2018 (Figure 7), during a wetter than average winter, gave water depths and levels shown in Table 2.2. Simultaneous measurements of DWER bores located 480m south-east (Swan GWA 2-98) and 580m north-east (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated. Figure 7 shows the calculated AAMGL and depth to AAMGL contours across the site.

Table 2.2 shows that the groundwater levels measured on 22 August 2018 were slightly above the AAMGL. The table also shows that the estimated MGL is above the ground surface over much of the site. This does not take into account the effects of existing drains and surface runoff, which would generally limit the groundwater levels to at or just below the ground surface.

**Table 2.2 Groundwater Depths and Levels 22 August 2018**

| *Bore* | *Depth (mbgl)* | *Level (m AHD)* | *AAMGL (m AHD)* | *MGL (m AHD)* | *Depth to AAMGL (m)* | *Depth to MGL (m)* |
|---|---|---|---|---|---|---|
| MB1 | 0.2 | 51.39 | 51.14 | 51.72 | 0.45 | -0.13 |
| MB2 | 0.34 | 45.29 | 45.04 | 45.62 | 0.59 | 0.01 |
| MB3 | 0.21 | 52.37 | 52.12 | 52.70 | 0.46 | -0.12 |
| MB4 | 0.02 | 42.58 | 42.33 | 42.91 | 0.27 | -0.31 |
| MB5 | 0.69 | 56.1 | 55.85 | 56.43 | 0.94 | 0.36 |
| MB6 | -0.08 | 42.98 | 42.73 | 43.31 | 0.17 | -0.41 |
| MB7 | 0.32 | 55.19 | 54.94 | 55.52 | 0.57 | -0.01 |
| MB8 | 0.23 | 42.64 | 42.39 | 42.97 | 0.48 | -0.10 |
| 399 | 0.02 | 48.42 | 48.17 | 48.75 | 0.27 | -0.31 |
| GD20 | 0.12 | 61.36 | 59.85 | 61.35 | 1.63 | 0.13 |
| 2-98 | 1.44 | 56.85 | 56.6 | 57.18 | 1.69 | 1.11 |

### 2.3.2 Surface Drainage

The high water tables and low permeability subsoils result in surface flow in channels and sheet flow across the ground surface during wet winters.

Several natural and artificial drainage lines cross the site from fifteen culverts beneath Great Northern Highway. The largest of these is a creek at the northern end, which has a catchment of 384ha east of Great Northern Highway. Two other drainage lines enter on the mid eastern boundary, draining catchments of 67ha and 121ha east of Great Northern Highway. Several other culverts beneath the highway drain into minor drainage lines within the site. Other small drainage lines rise within the site and flow west. Figure 8 shows the drainage within the site.

All drainage from the site flows into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow in the system, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715 $km^2$ (WRC, 2012). The Brook rises as Chandala Brook about 20km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

Flows in Ellen Brook are normally confined to the defined channel of the Brook, although high flows can cause inundation of adjacent land. Main Roads Western Australia (MRWA) modelled the 100-year ARI floodplain of Ellen Brook for the Perth-Darwin National Highway (PDNH) project. Figure 8 shows the 100-year ARI floodplain as modelled by MRWA.

Further flood modelling was carried out by BG&E for this project, in order to map the 100-year floodway of the Brook for the purposes of defining the foreshore reserve. The floodway modelling was confined to the part of Ellen Brook south of the PDNH crossing, where the Structure Plan area adjoins the Brook. The BG&E floodway modelling report is attached in Appendix C. Figure 8 shows the floodway as mapped by BG&E, which falls within the foreshore and drainage/landscape reserve.

### 2.3.3 Water Resources

The project area is within the Lake Mungala sub-area of the Gingin Groundwater Area for the superficial and semi-confined (Mirrabooka) aquifers, and the SA 3 South sub-area for the confined Leederville and Yarragadee aquifers. Groundwater allocations within the Lake Mungala and SA 3 South sub-areas are managed under the Gnangara Groundwater Areas Allocation Plan. Under the plan, all of the aquifers within the Lake Mungala and SA 3 South sub-areas are fully or over allocated, and no new allocations are available. The DWER intends to release a new Gnangara Groundwater Allocation Plan in late 2018, which may further reduce allocation limits within the plan area (G. Chandler, 2018 pers. comm.).

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows a number of licensed bores within the project area, abstracting water from the superficial and Leederville aquifers. The total licensed allocations within the project area are 82,150 KL/a from the Leederville and 35,000 KL/a from the superficial aquifer.

## 2.4 Water Quality

### 2.4.1 Groundwater

Groundwater samples were collected from eight bores within the project area (Figure 7) on 22 August 2018, when groundwater levels were at or near their peak for the year. The results of the analysis are shown in Table 2.3 and summarised below.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally moderate with the exception of a notably high reading for total phosphorus in Bore MB2, in the north-west of the project area. This bore is downstream of a heavily-stocked special rural lot and also has sandy surface soils. The high Total Phosphorus concentration is not reflected in the dissolved (reactive) phosphorus concentration.

The groundwater shows low acidity and sulphate contents, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are low except for aluminium and zinc, which are slightly elevated across much of the site.

### 2.4.2 Surface Water

Surface water samples were collected on 22 August 2018 from ten drains and creeklines flowing into the project area from culverts beneath Great Northern Highway (Figure 8). A further six samples were collected from drains flowing out of the project area into Ellen Brook. Samples were also collected from Ellen Brook immediately upstream and downstream of the project area, and from two small dams in the south of the project area (Figure 8). The results of the analysis are shown in Tables 2.4 and 2.5 and summarised below.

Surface water quality upstream of the project area is variable, with total phosphorus in ten drains and creeklines flowing into the site (Figure 8) ranging from 0.04mg/L to 0.31mg/L (the ANZECC target for freshwater ecosystems is 0.065mg/L). Total nitrogen in these watercourses ranged from 0.6mg/L to 2.1mg/L, against an ANZECC target of 1.2mg/L.

Water quality downstream of the project area was generally poorer, with six outflowing drains (Figure 8) having total phosphorus of 0.07 - 1.8 mg/L and total nitrogen of 1.3 - 3.0 mg/L.

The most notable feature of surface water quality is Ellen Brook itself, which showed total phosphorus of 0.59mg/L upstream of the project area and 0.54mg/L downstream. Coupled with the high flow at the time, this emphasises the primary role of Ellen Brook in the water quality issues facing the Swan-Canning River system.

Suspended sediment levels in surface water upstream and downstream were generally low except at Site 369 (Figure 8) in Ellen Brook immediately downstream of the confluence of a small drain carrying sediment-laden water from the PDNH roadworks. The effect of this drain was not apparent in samples further down Ellen Brook.

The two dams sampled in the south of the project area, which held a blend of surface and ground water, gave mixed water quality results, with low phosphorus but elevated nitrogen levels.

**Table 2.3 Groundwater Quality 22/8/2018**

(see Figure 7 for bore locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *MB1* | *MB2* | *MB3* | *MB4* | *MB5* | *MB7* | *MB8* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **1.7** | **4.3** | **3** | <0.2 | **2** | 1.2 | 0.5 |
| | NOx | mg/L | 0.15 | ng | **1.5** | **2.5** | **3** | <0.01 | **2** | **0.21** | 0.07 |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 0.2 | 1.8 | <0.2 | <0.2 | <0.2 | 1 | 0.4 |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | 0.04 | **0.99** | 0.03 | **0.15** | **0.2** | **0.2** | **0.25** |
| | Reactive Phosphorus | mg/L | 0.04 | ng | <0.01 | 0.01 | <0.01 | 0.02 | <0.01 | 0.02 | 0.03 |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 6.5 | 6.9 | 6.7 | **4.7** | 6.6 | **6.3** | **5.5** |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **4.8** | **1.6** | **0.82** | **2.8** | 0.25 | **3.5** | **4.4** |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **2880** | **960** | **492** | **1680** | 150 | **2100** | **2640** |
| | Acidity | mg/L | 40[c] | ng | 15 | 20 | 9 | **63** | 15 | **77** | **67** |
| | Alkalinity | mg/L | ng | ng | 29 | 70 | 22 | <5 | 27 | 65 | <5 |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.52 | 0.11 | 0.18 | 0.57 | 0.29 | 0.45 | 0.37 |
| | Hardness | mg/L | ng | 60-350 | 140 | 190 | 51 | 110 | 52 | 170 | 180 |
| | Sulphate | mg/L | ng | ng | 240 | 130 | 13 | 120 | 12 | 130 | 120 |
| | Chloride | mg/L | ng | 350 | 1400 | 400 | 230 | 850 | 44 | 1100 | 1400 |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.17 | 0.33 | 0.06 | 0.14 | 0.27 | 0.12 | 0.09 |
| Major Ions | Calcium | mg/L | ng | ng | 54 | 44 | 20 | 23 | 17 | 54 | 32 |
| | Sodium | mg/L | ng | 230 | 820 | 300 | 110 | 420 | 29 | 630 | 710 |
| | Potassium | mg/L | ng | ng | 1.7 | 19 | 0.3 | 13 | 2.3 | 8 | 24 |
| | Magnesium | mg/L | ng | ng | 160 | 28 | 23 | 83 | 8.8 | 67 | 140 |
| | Iron | mg/L | ng | 10 | 0.16 | 0.19 | 0.08 | 0.39 | 0.08 | 4.3 | 18 |

**Notes**

ng denotes "no guideline". na denotes "not analysed"

a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)

b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)

c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.

d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | <0.1 | **0.2** | **0.2** | **0.1** | **0.2** | **0.2** | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | 0.006 | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | 0.003 | <0.002 | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | |
| | Zinc | mg/L | 0.015 | 2 | <0.01 | 0.01 | 0.01 | **0.06** | <0.01 | **0.07** | **0.02** | |

**Table 2.4 Upstream Surface Water Quality 22/8/2018**

(see Figure 8 for sample locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *Ellen Brook Upstream* | *407* | *405* | *395* | *393* | *392* | *391* | *410* | *409* | *415* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **3** | 0.7 | **2.1** | 1.2 | **1.7** | 0.6 | 0.6 | **1.7** | **1.7** | **1.7** |
| | NOx | mg/L | 0.15 | ng | 0.01 | 0.06 | <0.01 | 0.02 | 0.12 | <0.01 | 0.01 | **0.45** | **0.32** | <0.01 |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 3 | 0.6 | 2.1 | 1.2 | 1.6 | 0.6 | 0.6 | 1.2 | 1.4 | 1.7 |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | **0.59** | **0.11** | **0.27** | **0.08** | **0.09** | 0.04 | 0.04 | 0.05 | **0.24** | **0.31** |
| | Reactive Phosphorus | mg/L | 0.04 | ng | **0.47** | <0.01 | **0.13** | 0.01 | 0.01 | <0.01 | <0.01 | <0.01 | **0.18** | **0.22** |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 7.2 | | | | | | | | | |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **1.7** | | | | | | | | | |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **1020** | | | | | | | | | |
| | Acidity | mg/L | 40[c] | ng | 8 | | | | | | | | | |
| | Alkalinity | mg/L | ng | ng | 62 | | | | | | | | | |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.04 | | | | | | | | | |
| | Hardness | mg/L | ng | 60-350 | 180 | | | | | | | | | |
| | TSS | mg/L | ng | ng | 7 | 6 | 14 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| | Sulphate | mg/L | ng | ng | 49 | | | | | | | | | |
| | Chloride | mg/L | ng | 350 | 470 | | | | | | | | | |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.10 | | | | | | | | | |
| Major Ions | Calcium | mg/L | ng | ng | 56 | | | | | | | | | |
| | Sodium | mg/L | ng | 230 | 220 | | | | | | | | | |
| | Potassium | mg/L | ng | ng | 10 | | | | | | | | | |
| | Magnesium | mg/L | ng | ng | 53 | | | | | | | | | |
| | Iron | mg/L | ng | 10 | 2.8 | | | | | | | | | |

**Notes**

ng denotes "no guideline", na denotes "not analysed"
a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection)
b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years)
c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater.
d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | | | | | | | | | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | | | | | | | | | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | | | | | | | | | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | | | | | | | | | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | | | | | | | | | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | | | | | | | | | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | | | | | | | | | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | | | | | | | | | |
| | Zinc | mg/L | 0.015 | 2 | **0.03** | | | | | | | | | |

**Table 2.5 Downstream Surface Water Quality 22/8/2018**

(see Figure 8 for sample locations)

| | Parameter | Unit | Aquatic Ecosystems[a] | Irrigation Water[b] | *Ellen Brook Down -stream* | *AMS1* | *Ingham1* | *Ingham2* | *MD* | *369* | *362* | *Dam1* | *Dam2* | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nutrients | Total Nitrogen | mg/L | 1.2 | 5 | **2.6** | **1.5** | **2.3** | **1.7** | **1.6** | **3** | **1.3** | **3.2** | **2.9** | ng denotes "no guideline", na denotes "not analysed" |
| | NOx | mg/L | 0.15 | ng | 0.02 | **0.23** | <0.01 | <0.01 | <0.01 | **0.34** | <0.01 | **2.4** | **2.9** | a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) |
| | Total Kjeldahl Nitrogen | mg/L | ng | ng | 2.6 | 1.3 | 2.3 | 1.7 | 1.6 | 2.7 | 1.3 | 0.8 | <0.2 | b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years) |
| | Total Phosphorus | mg/L | 0.065 | 0.05 | **0.54** | **0.12** | **0.14** | **0.07** | **0.16** | **0.18** | **0.12** | 0.05 | 0.04 | c. DEC(20__) oxidation indicator triggers for ASS-affected groundwater. |
| | Reactive Phosphorus | mg/L | 0.04 | ng | **0.45** | <0.01 | 0.04 | <0.01 | 0.02 | 0.04 | 0.02 | <0.01 | <0.01 | d. ANZECC (2000) Irrigation trigger values for pasture and fodder for grazing animals except pigs and dairy animals. |
| Physical | pH | | 6.5-8.0 | 6-8.5 | 7.3 | | | | | | | | | |
| | Conductivity | mS/cm | 0.12-0.3 | 1.3 | **1.7** | | | | | | | | | |
| | Salinity (from EC) | mg/L | 72-180 | 780 | **1020** | | | | | | | | | |
| | Acidity | mg/L | 40[c] | ng | 7 | | | | | | | | | |
| | Alkalinity | mg/L | ng | ng | 65 | | | | | | | | | |
| | Acidity:Alkalinity Ratio | | 1[c] | ng | 0.04 | | | | | | | | | |
| | Hardness | mg/L | ng | 60-350 | 200 | | | | | | | | | |
| | TSS | mg/L | ng | ng | <5 | 7 | 10 | <5 | 7 | 51 | <5 | <5 | <5 | |
| | Sulphate | mg/L | ng | ng | 51 | | | | | | | | | |
| | Chloride | mg/L | ng | 350 | 480 | | | | | | | | | |
| | $SO_4$:Cl Ratio | | 0.5 | ng | 0.11 | | | | | | | | | |
| Major Ions | Calcium | mg/L | ng | ng | 64 | | | | | | | | | |
| | Sodium | mg/L | ng | 230 | 220 | | | | | | | | | |
| | Potassium | mg/L | ng | ng | 10 | | | | | | | | | |
| | Magnesium | mg/L | ng | ng | 53 | | | | | | | | | |
| | Iron | mg/L | ng | 10 | 2.9 | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved Metals | Aluminium | mg/L | 0.08 | 5 | **0.2** | | | | | | | | | |
| | Arsenic (III & V) | mg/L | 0.136 | 0.1 | <0.002 | | | | | | | | | |
| | Cadmium | mg/L | 0.0004 | 0.01 | <0.002 | | | | | | | | | |
| | Chromium (VI) | mg/L | 0.006 | 0.1 | <0.002 | | | | | | | | | |
| | Copper | mg/L | 0.0018 | 0.2 | <0.01 | | | | | | | | | |
| | Mercury | mg/L | 0.0019 | 0.002 | <0.0002 | | | | | | | | | |
| | Nickel | mg/L | 0.013 | 0.2 | <0.01 | | | | | | | | | |
| | Lead | mg/L | 0.0056 | 2 | <0.01 | | | | | | | | | |
| | Zinc | mg/L | 0.015 | 2 | <0.01 | | | | | | | | | |

## 2.5 Vegetation

### 2.5.1 Vegetation Type and Condition

The project area is mostly cleared of native vegetation, consisting of current and former farm paddocks and industrial sites. Figure 9 shows the vegetation of the project area.

Remnant native vegetation consists of a few mature paddock trees (Marri, Flooded Gum and Wandoo), including several very large Marri trees that have been retained within the AMS site (Lots 802 & 803) and a few large Wandoo trees in Lot 804.

Native regrowth is present near the large drain on Lot 800 in the form of a small (0.5ha) thicket of species including *Allocasuarina fraseriana, Melaleuca preissiana, Eucalyptus rudis, Astartea fascicularis* and *Acacia ?rostellifera* over grasses. Nearby is a smaller thicket on a drainage line with regrowth of *Juncus ?kraussii*, *M. preissiana, A. fascicularis* and *E. rudis*.

The area around the large drain on Lot 800 has been planted densely with native tree species including *E. rudis, A. fraseriana, M. preissiana, M. cuticularis* and *Corymbia calophylla.* The drain itself contains a heavy growth of sedges, Bulrush (*Typha orientalis*) and Kikuyu and Couch grasses.

Other areas near the large drain and in other low-lying parts of the site contain dense growths of Cape Tulip (*Moraea flaccida*), Spiny Rush (*Juncus acutus*) and Narrow-leaf Cotton Bush (*Gomphocarpus fruticosus*), all of which are declared pests in Western Australia (www.agric.wa.gov.au/pests-weeds-diseases/weeds/declared-plants). The native rush *Juncus kraussii* occurs along with the introduced *J. acutus* in some areas.

In the west of Lot 35 in the south of the project area are a few large isolated Flooded Gums. In the central south of the site (Lot 35) is a 2.5ha patch of open woodland of young *E. rudis* regrowth over grass.

Elsewhere on the site there are lines and clumps of planted trees, mostly Flooded Gums, Bluegums (*Eucalyptus globulus*), River Red Gums (*E. camaldulensis*) and other non-local eucalypts. There is also scattered regrowth of sedges (*Juncus* ?kraussii) and isolated shrubs.

Overall the condition of the vegetation within the project area is classed as Cleared to Completely Degraded. There is no vegetation in Good or better condition.

Adjacent to Ellen Brook there is a sparse to dense woodland of *Eucalyptus rudis, Allocasuarina fraseriana, Melaleuca preissiana, M. rhaphiophylla, Astartea affinis, Jacksonia furcellata and Acacia saligna.* This woodland thins rapidly with distance from the Brook and is mostly outside of the project area. The ground cover over most of this area consists of a heavy growth of pasture grasses and weeds, which extend into the waterway itself.

The condition of the Brook vegetation is mostly Degraded to Completely Degraded, with a few areas of Good condition. The central part (Lots 800 & 801) is accessible to cattle and is in poorer condition than the rest due to grazing. In the northern part (Lots 801-804) there is a dense growth of *Watsonia meriana* var. *bulbillifera* in areas not accessed by cattle.

### 2.5.2 Vegetation Complexes

The vegetation of the site is mapped as Yanga Complex, described by Heddle *et al.* (1980) as a low open-forest of *Casuarina obesa*, *Actinostrobus* (now *Callitris*) *pyramidalis, Melaleuca* spp. (including *M. lateritia, M. hamulosa*, *M. preissiana and M. rhaphiophylla*) and *Eucalyptus rudis* in the lower-lying areas, with *Banksia* spp., *Eucalyptus todtiana* and *Corymbia calophylla* open-woodland in the higher areas.

## 2.6 Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been largely cleared and used for farming since at least 1965.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area. The nearest mapped contaminated site is a service station in Muchea, 700m west of the northern end of the project area and on the other side of Ellen Brook. There is no potential for this contamination to directly affect the project area.

The DWER (DoE, 2004) considers intensive agriculture such as the poultry farming operation on Lots 800 and 801 to be a potentially contaminating land use, with potential contaminants including organochlorine, organophosphate and carbamate pesticides, herbicides, metals, salinity and nutrients. Residual soil contamination is most likely to be present around the poultry sheds. Groundwater contamination by nutrients and salinity may be present downgradient of the sheds but would diminish and eventually clear once the sheds were removed. There is no visual or olfactory evidence of soil or groundwater contamination at the poultry farm.

The DWER has advised that, given the proposed use of the land for industry, and assuming the poultry farm has been operating in according with its licence, there should be no need for a site contamination assessment before the land is redeveloped.

There is no visual evidence of other potentially contaminating activities such as piggeries, hydrocarbon storage or landfill.

# 3.0 WATER USE SUSTAINABILITY

## 3.1 Water Supply

The water requirement for the fully developed project area is unknown, although the Muchea Employment Node Structure Plan (WAPC, 2011) implies that the total combined requirement for the Employment Node and the Muchea townsite is less than 288 ML/a. From this it may be deduced, on a area basis, that the ultimate water requirement for the project area would be somewhat less than 60 ML/yr. This is roughly half of the currently licensed allocations within the project area.

Water supply will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand is likely to be limited to landscape irrigation, as industries within the Precinct will be limited to those with low water usage.

Potable water will be supplied to the Precinct by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Precinct 3 with potable water. Discussions with Aqua Ferre are ongoing.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the Precinct is likely to be necessary. The landowners group will negotiate with existing licence holders within and outside of the Precinct with a view to purchasing an existing groundwater allocation, and will submit a groundwater licence application to the DWER in due course.

## 3.2 Water Efficiency Measures

Precinct 3 will be designed as a low water-use precinct, with industries permitted being those with low water consumption. This is driven largely by the hydrology of the site and its proximity to Ellen Brook, which demands that wastewater disposal be minimised.

Potable water use within the Precinct will be limited to consumption for domestic use in toilets, bathrooms and kitchens. The Shire of Chittering Town Planning Scheme No. 6 limits wastewater generation in industrial zones to 5,400 litres per hectare per day. If it is assumed that all potable water used will ultimately become wastewater, it can be calculated that the maximum potable water demand for the 185ha precinct will be approximately 1,000 KL per day.

Groundwater will be used mainly for irrigation of landscape plantings and swales. These areas will be irrigated only during the establishment stage (one or two years). The Landscape Master Plan estimates total plantings of 31.5ha of sedges, shrubs and trees within the precinct.

The water demand for irrigation in a given year will depend on the staging of subdivision and development. If the precinct were developed over ten years, the demand for irrigation water (at the DWER's default rate of 4,500 KL/ha/yr) over that ten year period would be in the order of 14 – 20 ML/yr, falling in subsequent years.

## 4.0 LAND CAPABILITY FOR ON-SITE EFFLUENT DISPOSAL

### 4.1 Published Land Capability Ratings and Constraints

The proposed lots are located on land mapped mostly as Guildford Formation (Gozzard, 1982). King & Wells (1990) rated the capability of the more elevated parts of the Guildford Formation as Fair to High, while the lower-lying parts were rated as Low to Very Low. The main constraints to effluent disposal in the lower areas are high water tables and poor drainage.

The revised draft Government Sewerage Policy currently being considered by the WAPC identifies the project area as being within a Sewage Sensitive Area (SSA) due to its location within the catchment of the Swan-Canning Estuary. The draft Policy places additional site requirements in terms of groundwater clearance and lot density on effluent disposal within SSAs.

### 4.2 Soil Permeability

Australian Standard AS1947:2012 recommends a minimum hydraulic conductivity of 0.06m/day for on-site effluent disposal without special design. The testing method set out in the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974* implies a minimum conductivity of 0.11m/day without specific approval by the Director-General of Public Health. Permeabilities of this order are generally found in weakly structured or massive clays.

Constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* were undertaken at 0.5m depth at five sites (Figure 5) in November 2018. The tests returned saturated hydraulic conductivity values ranging from 0.5 m/day to 4.2 m/day. Details of the permeability tests are attached in Appendix B.

### 4.3 Phosphorus Retention Index

The Health Department's draft *Code of Practice for Onsite Sewage Management* (2012) recommends a PRI of at least 20 for soils beneath effluent irrigation areas.

Soil samples collected from eight boreholes and infiltration test holes on the site (Figure 5) at depths of 0.5m to 1m returned PRI values of 39.3 to 338.1, with an average of 146.8. This shows that the soils of the site have a very high capacity to bind phosphorus.

### 4.4 Depth to Groundwater

The current Country Sewerage Policy (WA Govt, 2002) requires that land used for effluent disposal have a minimum clearance of 0.5m from the natural ground surface to the highest seasonal or permanent water table. Under the Policy, the required clearance cannot be achieved solely by filling but can be achieved by subsoil drainage, provided that the land has sufficient fall and area to dispose of the drained water and the drainage does not affect water flows or quality downstream.

A revised Draft Government Sewerage Policy currently being considered by the WAPC applies the 0.5m natural ground surface clearance requirement only to lots smaller than 1ha. For larger lots in sewage sensitive areas (as is the project area), the revised draft Policy requires a separation of 1.5m from the effluent discharge point to the groundwater, which may be achieved by drainage, filling or a combination of both.

The groundwater measurements carried out in August 2018 indicate that the average annual maximum groundwater level (AAMGL) is within 0.5m of the ground surface over much of the project area (Figure 7). This means that a combination of subsoil drainage and fill will be required over most of the site where effluent disposal is proposed.

In lower parts of the project area where the AAMGL is at the ground surface, subsoil drains will be set at the existing ground level and fill will be used to achieve the required groundwater clearance. Fill used in effluent disposal areas will have a PRI of at least 20, in line with the Health Department's draft Code of Practice (2012).

### 4.5 Slope

The Country Sewerage Policy prohibits on-site effluent disposal on land with a slope of more than 1 in 5 (20%), in order to prevent runoff of effluent.

The slope of the subject land does not exceed 2.5% (Figure 5). Therefore effluent disposal on the site is not constrained by slope.

### 4.6 Watercourse Setbacks

The Department of Water & Environmental Regulation (DWER, 2006b) recommends that conventional effluent disposal systems (e.g. septic, ATU without auxiliary nutrient removal) should be located at least 30m from watercourses in soils with PRI greater than 5, or 100m in soils with PRI less than 5. Nutrient-removing systems (e.g. modified leach drain, ATU with nutrient removal) should be located at least 30m from watercourses in all soil types.

Ellen Brook and the streams crossing the site from the east are regarded as watercourses for the purpose of on-site effluent disposal. Figure 8 shows the minimum watercourse setbacks.

The Country Sewerage Policy states that on-site effluent disposal should not be carried out within 6m of any subsoil drain or open drainage channel. This includes subsoil drains used to control groundwater levels within filled effluent disposal areas.

The revised draft Government Sewerage Policy requires effluent disposal in Sewage Sensitive Areas to be set back at least 100m from any drainage system that discharges directly into a waterway without treatment. The draft Policy provides that reduced setbacks may be allowed where it can be demonstrated that the reduced setbacks will not have a significant impact on the environment or public health. In this case, a reduced setback of 6m from subsoil drains is considered necessary and justified because:

- the drained water will be treated by infiltration and vegetation uptake within the roadside swales before being released to Ellen Brook;
- six metres is the setback specified by the current government-approved Country Sewerage Policy;
- a greater separation would reduce the effectiveness of the subsoil drains in controlling groundwater levels within the effluent disposal areas;
- the subsoil drains will be upgradient of the effluent disposal areas, so will not be at risk of contamination from effluent;
- the clayey soils and high PRI of the site mean that the drained water will be of high quality; and

It is therefore concluded that the proposed system of effluent disposal in Precinct 3 will meet all setback requirements set out in current and proposed government policies.

### 4.7 System Selection and Location

All effluent generated within the subdivision will be treated and disposed by means of individual on-site effluent disposal systems. Given the hydrology of the site and its proximity to Ellen Brook, all lots will be required to employ nutrient-attenuating alternative systems such as aerobic treatment units (ATUs) with high-PRI irrigation areas or modified leach drain systems (e.g. Filtrex).

In accordance with DoW *Water Quality Protection Note No.70 - Waste Water Treatment for Onsite Domestic Systems* (2006), effluent disposal systems will be located at least 30m from watercourses.

ATU irrigation areas will be filled to approximately 2m above the AAMGL in order to provide 1.5m clearance from the AAMGL to the effluent drip lines as required under the revised Draft Government Sewerage Policy, allowing for 0.3m groundwater mounding

and 0.2m soil cover over the drip lines. The effluent irrigation areas will be filled with soil either sourced from on site or imported. The soil will be tested to confirm a PRI of at least 20.

The ATU irrigation area on each lot will be sized to suit the expected population of the lot. As a rough rule of thumb, each full-time employee on site will require approximately 23m$^2$ of effluent irrigation area. Alternatively, the treated ATU effluent may be disposed of via leach drains, which may reduce the area required for disposal by up to two thirds at the cost of a greater height of fill (2.3m total above the AAMGL).

The effluent disposal requirements of each lot will vary depending on the soil profile, groundwater depth, risk of saturation and expected site population. Site testing on each lot prior to development will be required to determine the location and type of effluent disposal system.

### 4.8 Subsoil Drainage

Where fill is used to raise pads for effluent disposal, surface cutoff drains and/or subsoil drains will be placed upslope of the pad to prevent groundwater rise into the fill. The drains will be placed at least 6m upslope from the drip lines or leach drains. The drains will be set with their inverts at or above the AAMGL and will discharge into the roadside swales, where the water will be further treated by infiltration and/or vegetation uptake within the swales. Because the water will be draining from high-PRI soil (see Section 2.2.5), it will be of high quality.

# 5.0 STORMWATER MANAGEMENT STRATEGY

## 5.1 Principles and Objectives

The stormwater management strategy aims to comply with the principles and objectives for stormwater management identified in the *Stormwater Management Manual for WA* (DoW, 2004) and *Better Urban Water Management* (WAPC, 2008).

Nutrient concentrations and loads in water leaving the site will be managed to comply with the targets of the draft *Swan Canning Water Quality Improvement Plan* (SRT, 2009) for the Ellen Brook catchment, as follows:

- Winter median TP concentration: 0.1 mg/L
- Winter median TN concentration: 1.0 mg/L
- Annual TP yield: 0.03 kg/ha
- Annual TN yield: 0.31 kg/ha.

## 5.2 Drainage Management System

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at their pre-development levels. The drainage design presented here is conceptual and will be refined in the detailed subdivision designs.

The priorities for managing the various sizes of storm event will be:

- 1 year ARI — Infiltrate all flows as close to the source as possible. Maintain pre-development flow rates and volumes. Minimise export of nutrients and sediments.
- 5 year ARI — Detain water prior to discharge. Maintain pre-development flow rates and volumes. Maintain amenity and serviceability. Prevent scouring and damage.
- 100 year ARI — Maintain pre-development flow rates and volumes. Prevent flooding and damage.

### 5.2.1 Through Drainage

Water enters the project area from external catchments to the east via fifteen culverts beneath Great Northern Highway. Some of these flow directly into defined drainage lines across the site, while others dissipate within the site and become part of the general overland and subsurface flow. Figure 8 shows the existing drainage across the site.

If and when the land to the east (some of which is within Precinct 2 of the Muchea Employment Node) becomes subdivided and developed, it is expected that runoff from storms up to 1-year ARI 1-hour will be retained within each subdivision, and runoff from larger storms up to 100-year ARI will be suitably detained so that the flow rates into the project area will be no greater than the current rates.

The existing drainage lines will be either preserved within easements or realigned and consolidated in vegetated swales within road reserves, which will be wider than normal to accommodate the swales. Figure 10 shows the proposed through-drainage at full development of the site. Figure 11 shows a conceptual profile of the swales.

The swales will be sized to accommodate the flow from a 100-year ARI critical storm from the upstream and internal catchments. A series of low weirs within the swales will capture and detain or infiltrate road runoff from storms up to 1-year ARI 1-hour. The invert of the swales will be at or above the AAMGL.

The swales will be configured as living streams and densely planted with sedges and shrubs to slow the water flow and help to remove sediments and nutrients from the water.

### 5.2.2 Internal Drainage

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, swales and/or landscaping areas. These will be subject to detailed design on individual lots. Lot runoff from larger storms will overflow via pipes into the roadside swales. The overflow pipes will be sized to regulate the flow to pre-development rates.

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The invert of the swales will be at or above the AAMGL.

The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm. In road reserves that also include a through-drainage swale, the weirs may incorporate underdrains to promote infiltration of the 1-year flows. Alternatively, the 1-year ARI swale may be formed in the bank of the through-swale to create a double swale. Figure 11 shows conceptual profiles of the alternative swale layouts.

The configuration of the swales and internal weirs will be subject to detailed design including:

- the height of the swale inverts at or above the AAMGL;
- the width and composition of the swale floors, designed to maximise nutrient uptake;
- planting of the swales with dense sedges and shrubs to maximise nutrient uptake;

- the possible inclusion of underdrains within the swales to promote infiltration of 1-year ARI flows; and
- the possible inclusion of secondary swales within throughflow swales to accommodate the 1-year ARI road runoff.

### 5.2.3 Major Storm Drainage

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where eleven culverts beneath the PDNH embankment will carry it across to Ellen Brook. Because the PDNH was designed in the context of a rural setting, the culverts are not large enough to carry the full flow from upstream in a 100-year storm event. The drainage design therefore incorporates a swale running adjacent to the southern part of the PDNH embankment. During a 100-year storm, flows that exceed the capacity of the PDNH culverts will be carried south within this swale to the next culvert or into the drainage/landscape reserve, where it will slowly make its way overland through dense vegetation to Ellen Brook.

Figure 10 shows the overall drainage layout and the 100-year ARI flow paths. Table 5.1 summarises the 100-year flows in the swales and PDNH culverts. The flow calculations are detailed in Appendix D.

**Table 5.1 100-year ARI Flows**

| *Culvert No. (Figure 10)* | *Culvert Dimensions* | *Culvert Invert (mAHD)* | *Culvert Slope* | *Pre Development* | | | *Post Development* | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *100-yr ARI Inflow ($m^3/s$) [1]* | *Flow Through Culvert ($m^3/s$) [2]* | *Bypass Flow ($m^3/s$)* | *100-yr ARI Inflow ($m^3/s$) [1]* | *Flow Through Culvert ($m^3/s$) [2]* | *Bypass Flow ($m^3/s$)* |
| 2.20 | 1 x 0.45m Circular | 49.00 | .0085 | 2.23 | 0.26 | 1.97 | 2.23 | 0.26 | 1.97 |
| 2.28 | 2 x 2.4x0.6m Rectangular | 48.92 | .0105 | 8.87 | 8.87 | 0.00 | 15.48 | 14.57 | 0.91 |
| 2.39 | 1 x 0.9x0.375m Rectangular | 49.00 | .0186 | 0.92 | 0.92 | 0.00 | 1.82 | 1.45 | 0.36 |
| 2.60 | 5 x 1.2x0.45m Rectangular | 48.89 | .0066 | 1.12 | 1.12 | 0.00 | 1.50 | 1.50 | 0.00 |
| 2.89 | 1 x 1.2x0.375m Rectangular | 47.28 | .0119 | 1.92 | 1.68 | 0.24 | 1.96 | 1.68 | 0.28 |
| 3.11 | 1 x 0.9x0.375m Rectangular | 46.22 | .0095 | 2.61 | 1.04 | 1.57 | 2.96 | 1.04 | 1.92 |
| 3.14 | 1 x 1.2x0.375m Rectangular | 45.47 | .0083 | 1.78 | 1.40 | 0.38 | 2.02 | 1.40 | 0.62 |
| 3.20 | 1 x 0.9x0.375m Rectangular | 45.70 | .0078 | 0.00 | 0.00 | 0.00 | 1.06 | 0.94 | 0.12 |
| 3.52 | 1 x 0.9x0.375m Rectangular | 44.40 | .0047 | 0.39 | 0.39 | 0.00 | 4.88 | 0.73 | 4.15 |
| 3.64 | 3 x 1.2x0.375m Rectangular | 43.69 | .0014 | 0.45 | 0.45 | 0.00 | 8.21 | 1.73 | 6.49 |
| 3.89 | 4 x 1.2x0.45m Rectangular | 42.30 | .0019 | 14.76 | 3.46 | 11.30 | 12.50 | 3.46 | 9.04 |
| Ellen Brook | Brook Inflow | | | 18.86 | 18.86 | 0.00 | 17.54 | 17.54 | 0.00 |
| South | Offsite Flow | | | 8.38 | 8.38 | 0.00 | 8.59 | 8.59 | 0.00 |

1 Inflow includes any excess (bypass) flow from culvert above.

2. Culvert flows are calculated as follows:
   - Rectangular culverts: Manning's open channel formula (http://www.eng.auburn.edu/~xzf0001/Handbook/Channels.html)
   - Circular culverts: Hazen-Williams formula for full-pipe flow (http://www.calctool.org/CALC/eng/civil/hazen-williams_g)

### 5.3 Ellen Brook Floodplain

The 100-year ARI floodplain of Ellen Brook was modelled by BG&E in 2017 on behalf of MRWA for the Northlink (PDNH) project. The modelling mapped only the floodplain extent, and not the floodway. Figure 8 shows the 100-year floodplain mapped by BGE.

BG&E revisited the modelling in 2018 for this project to define the 100-year floodway of Ellen Brook. The modelling focussed only on the part of Ellen Brook south of the PDNH crossing and adjacent to the project area. The modelling was carried out in consultation with DWER and MRWA. Figure 8 shows the floodway modelled by BG&E.

The floodway is defined by the DWER as the area within which filling or development would cause an unacceptable rise in river levels (afflux) upstream during a 100-year ARI flood. The floodway is therefore taken as the minimum setback of development or filling (including roads) from the waterway.

The floodplain is the area expected to be inundated by a 100-year ARI flood. Development within the floodplain but outside the floodway is permitted provided that roads and other infrastructure are not damaged by floodwaters and all habitable buildings have a floor level at least 0.5m above the 100-year flood level.

### 5.4 Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots.
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15.
- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out.

### 5.5 Maintenance

The drainage system has been designed to require minimal maintenance. The following will be required to ensure that the system continues to function as designed:

- Regular (possibly annual) cleaning of side entry and junction pits, inlet pits and small culverts. More frequent cleaning may be required during the construction phase.

- Tending and maintenance of swales and other vegetated drainage features to remove litter, control weeds and encourage the growth of native species.

- Pruning, mulching or removal of vegetation in swales as necessary to maintain ground fuel loads below 8 tonnes/ha.

# 6.0 GROUNDWATER MANAGEMENT STRATEGY

## 6.1 Groundwater Levels

The average annual groundwater level (AAMGL) is at or near the ground surface over much of the site (Figure 7). In the west of the site, groundwater rise in winter is limited by intersecting the ground surface, giving rise to surface runoff.

The drainage system for the site is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their invert at or above the AAMGL. Subsoil drainage within lots will be limited to filled areas used for buildings or effluent disposal.

## 6.2 Subsoil Drainage

Subsoil drainage will be employed within lots to maintain groundwater clearance for building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales.

Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement.

All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of the site will be minimal.

## 6.3 Groundwater Quality

The sampling undertaken to date indicates that the groundwater beneath the site contains low to moderate concentrations of nitrogen and phosphorus. This is to be expected given the nature of the soils and the land use history of the site.

The relationship between nutrient inputs and exports is complex, especially in the case of phosphorus, which travels through the soil profile as a “front” in a complex series of adsorption and desorption reactions. Nitrogen is subject to denitrification and mineralisation in the soil and groundwater. As a result, nutrient exports from the site at present will be a reflection of nutrient inputs over the last several decades, modified by soil hydrology and nutrient retention capacity.

The aim of nutrient management will be to limit nutrient inputs to the site so that nutrient outputs are minimised. As an industrial precinct, the area of fertilised gardens and lawns will be minimal. Landscaping areas including street trees, swales and vegetation buffers will be established with minimal fertilisers and irrigation.

Measures available to minimise nutrient inputs and exports in the development will include:

- regular street sweeping to remove accumulated contaminants; and
- selection of native species with low water and fertiliser requirements for public open space and landscape areas.

## 7.0 LANDSCAPING STRATEGY

Landscaping of the site will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot) and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation-tolerant species including sedges and low shrubs in order to stabilise the basins and maximise their ability to take up nitrogen from the water.

The immediate surrounds of Ellen Brook (extending up to 30m from the watercourse) and the drainage/landscape reserve will be densely planted with wetland-tolerant native sedges, low shrubs and other understorey species in order to slow and filter runoff that is not captured by the road drainage system.

The total area to be planted is approximately 31.5 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 142 ML of water would be required to irrigate the new plantings for the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year.

The density of planting will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (eco logical Australia, 2018).

Figure 12 shows the conceptual landscaping strategy.

## 8.0 MONITORING

Baseline water quality results for the site are shown in Tables 2.3, 2.4 and 2.5. Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in the creeklines and Ellen Brook will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

## 9.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Further planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) will be prepared as a condition of subdivision approval for each stage of subdivision. The UWMP will present the detailed design of the stormwater drainage system within that stage.

The developer of each stage of subdivision will maintain the drainage system, landscaped areas and water monitoring program within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for monitoring and management will be handed over to the Shire of Chittering.

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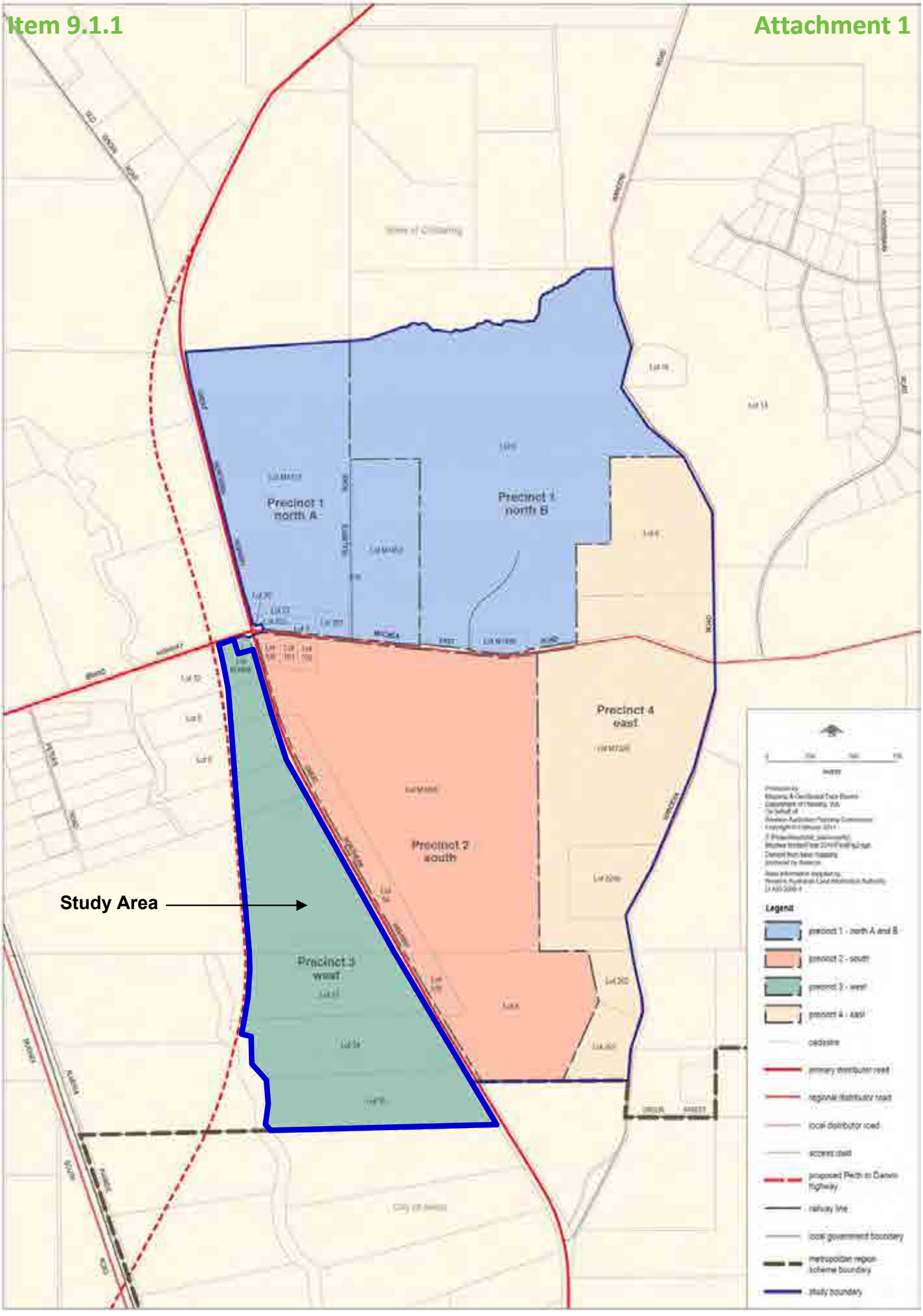
# Figures




Source: WAPC, 2011

**Figure 1**

**MUCHEA EMPLOYMENT NODE STRUCTURE PLAN**

bayley environmental services

**Figure 2**

**THE SITE AND SURROUNDINGS**

Image: Google Earth

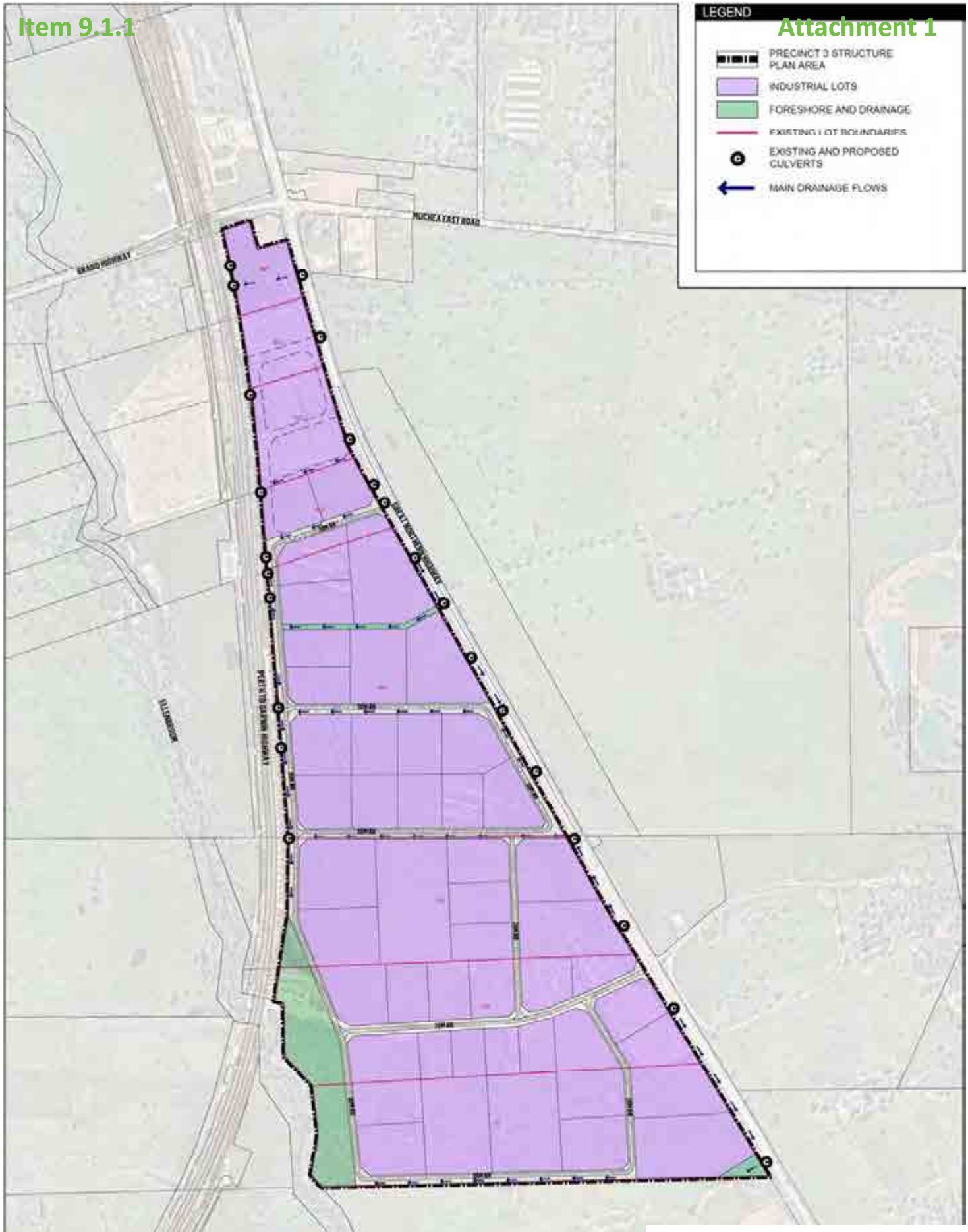
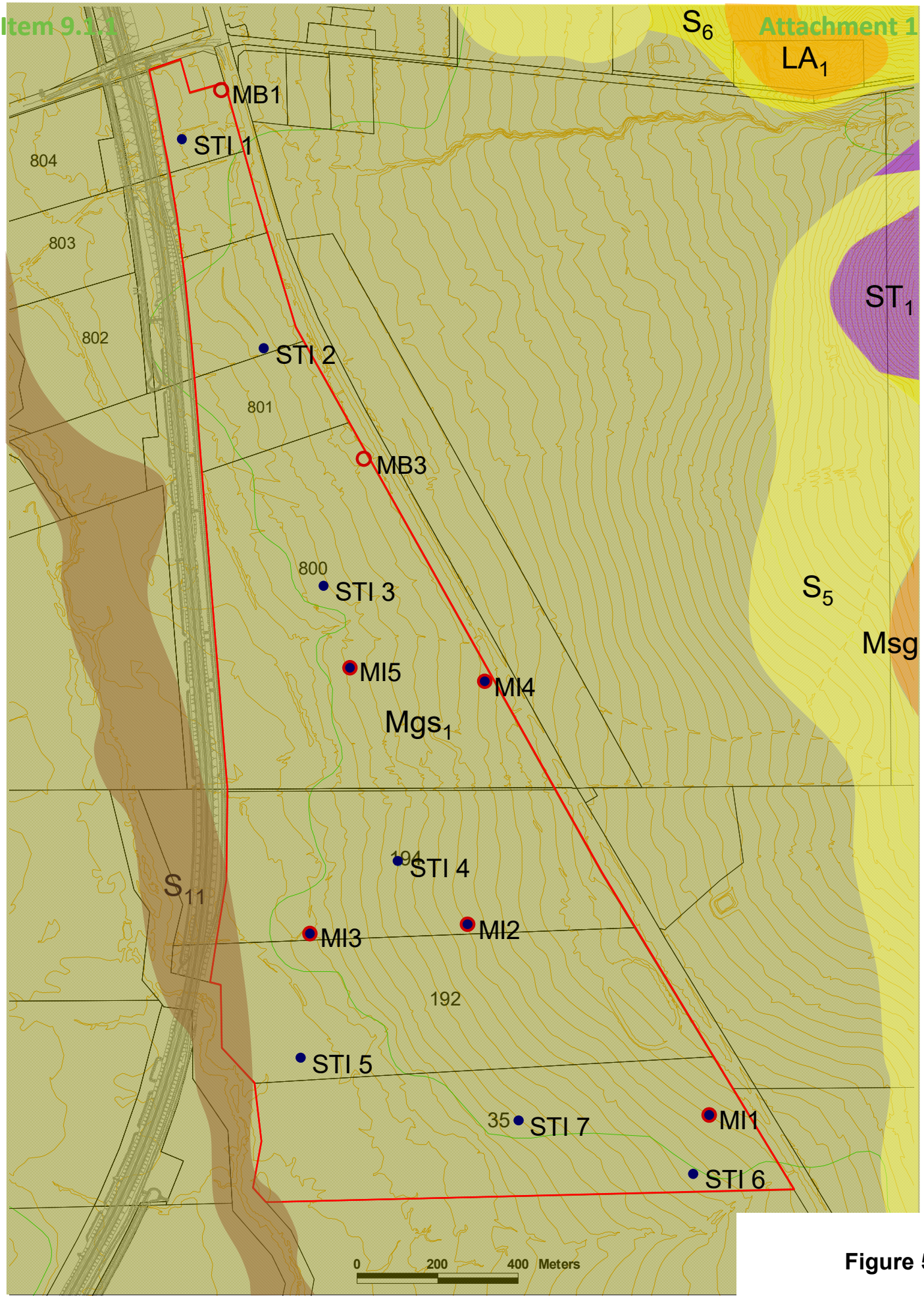



**Figure 3**

**SUBDIVISION CONCEPT**

URBIS

bayley environmental services




Permeability Test
PRI Analysis

**Figure 5**

**PHYSIOGRAPHY**

bayley Environmental Services

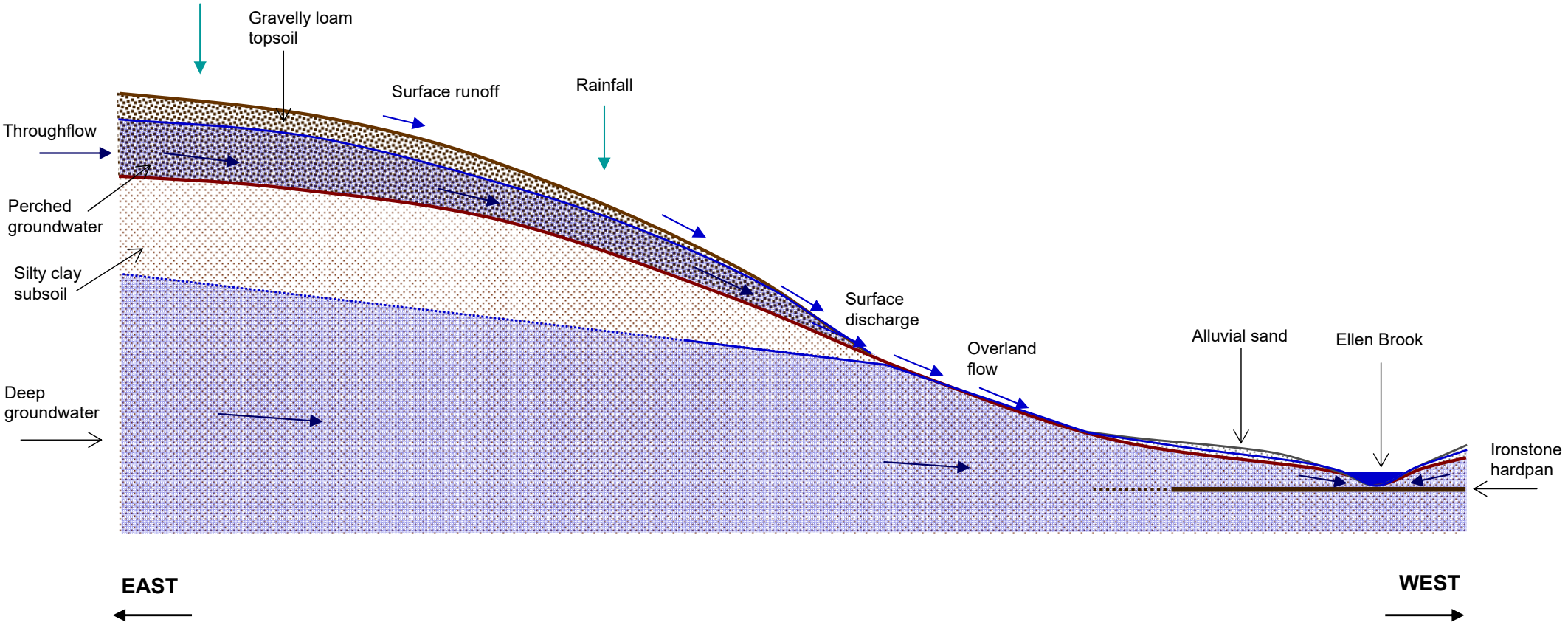
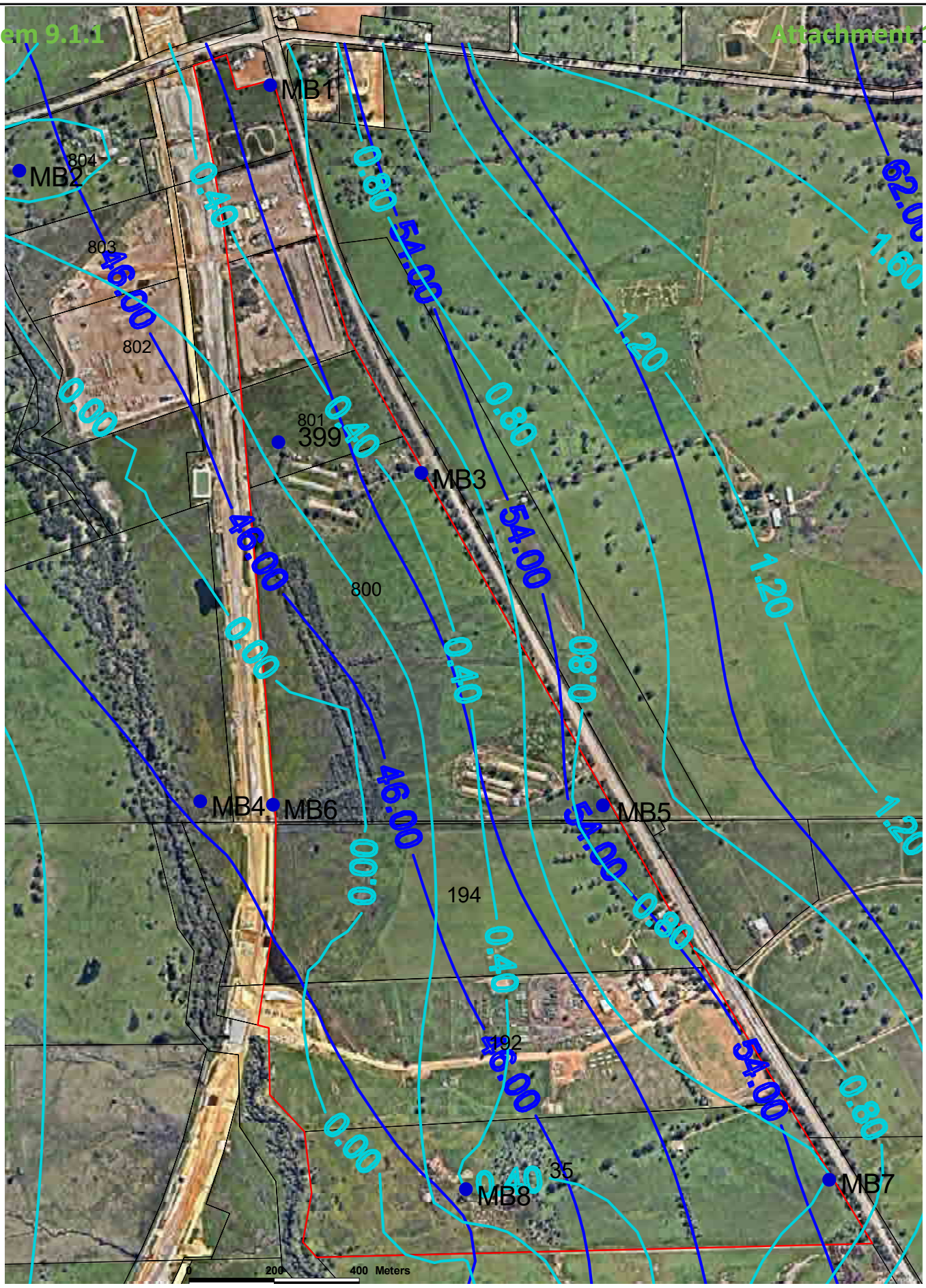



**Figure 6**

**HYDROLOGY OVERVIEW**

Not to scale




AAMGL Contour
Depth to AAMGL Contour
Bore

**Figure 7**

**GROUNDWATER**

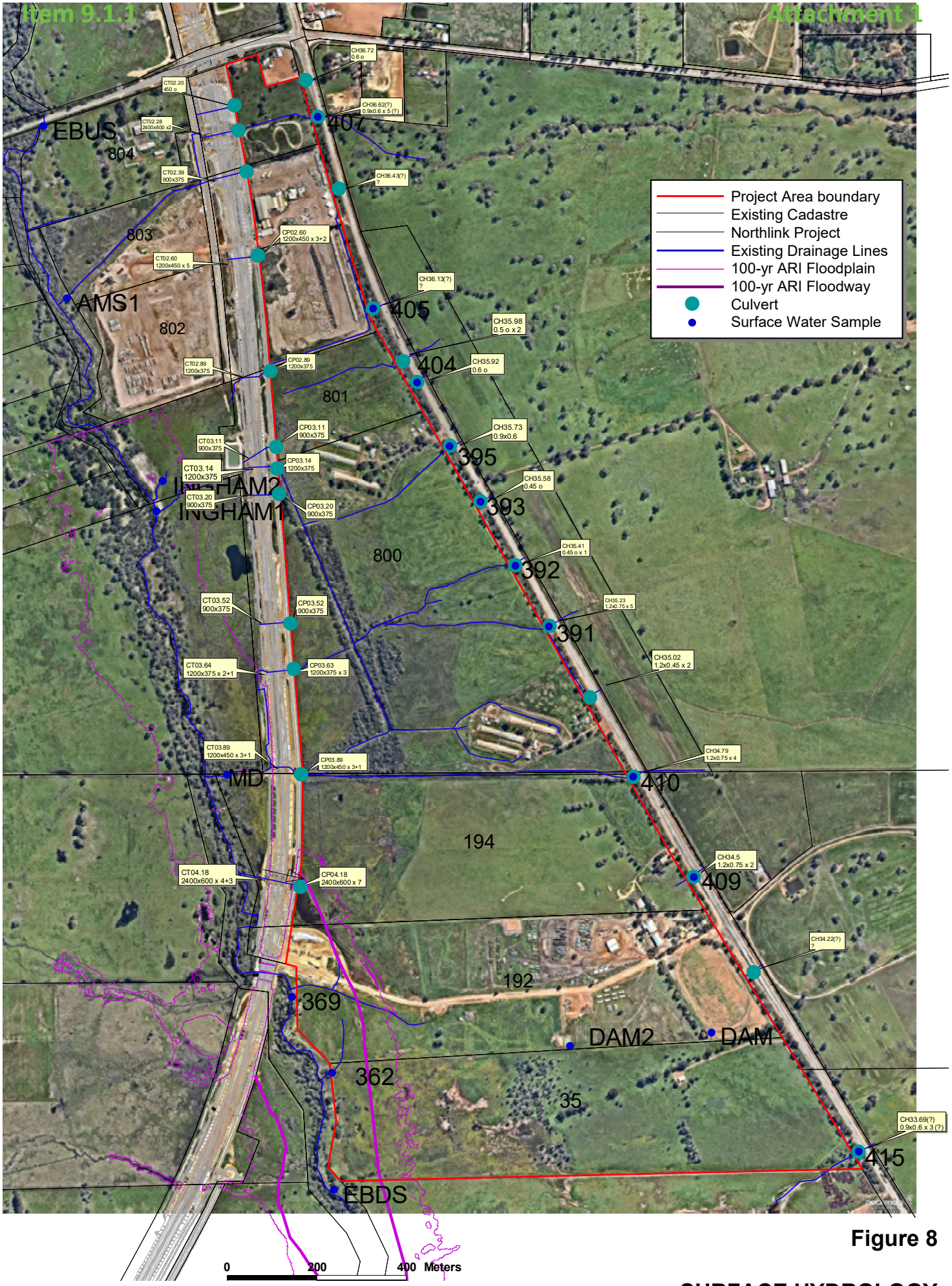



**Figure 8**

**SURFACE HYDROLOGY**

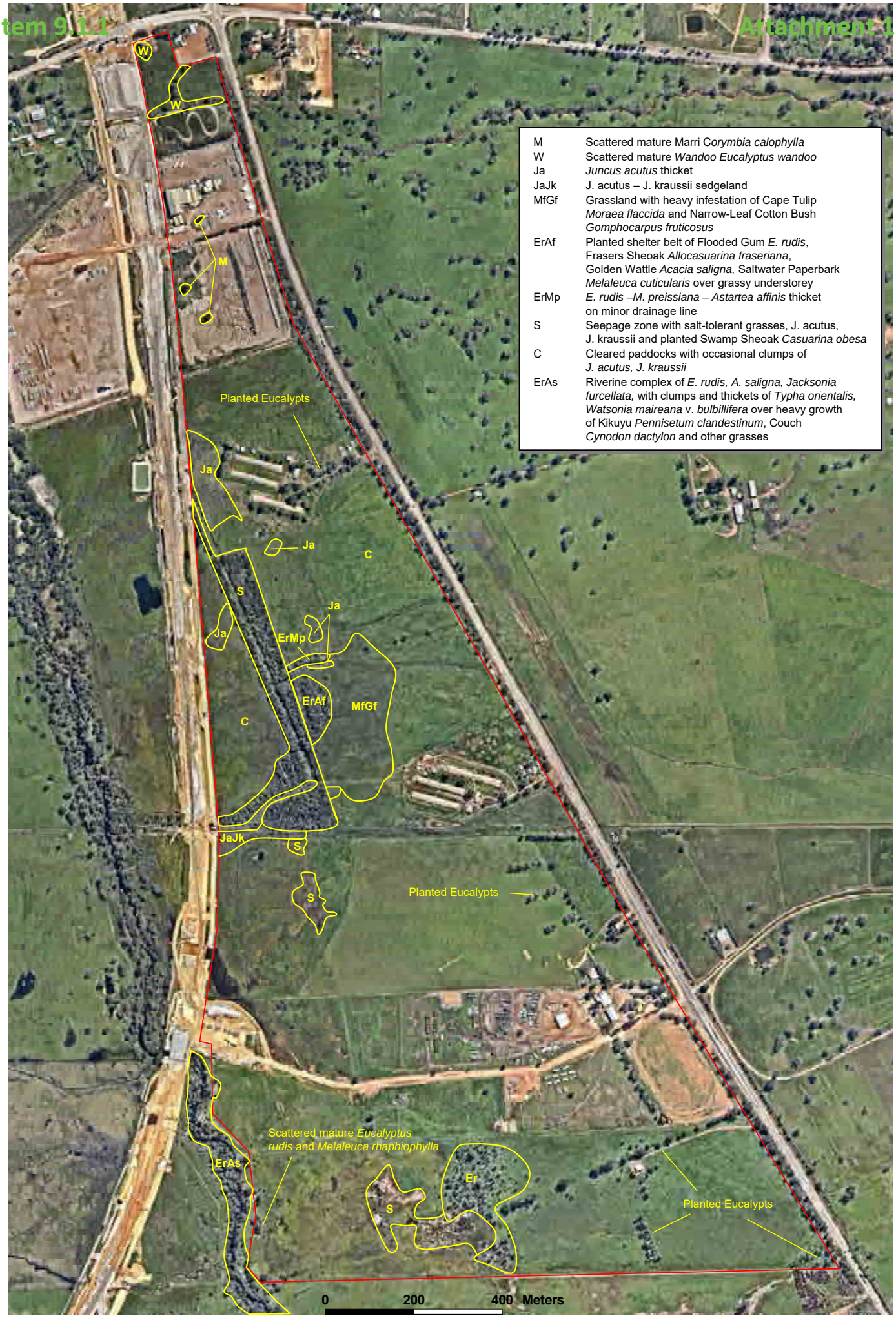



**Figure 9**

**VEGETATION**

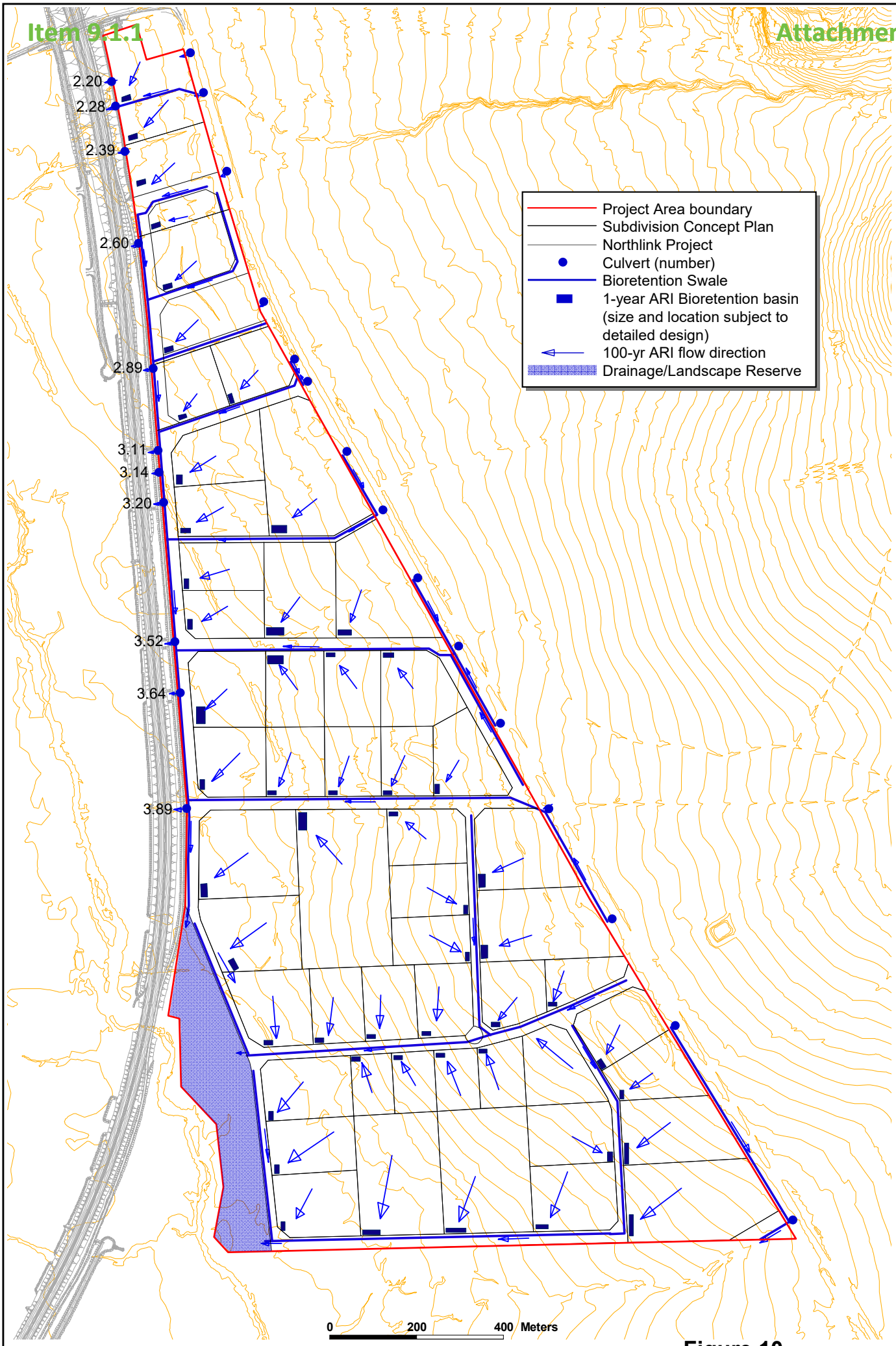



Figure 10

DRAINAGE CONCEPT

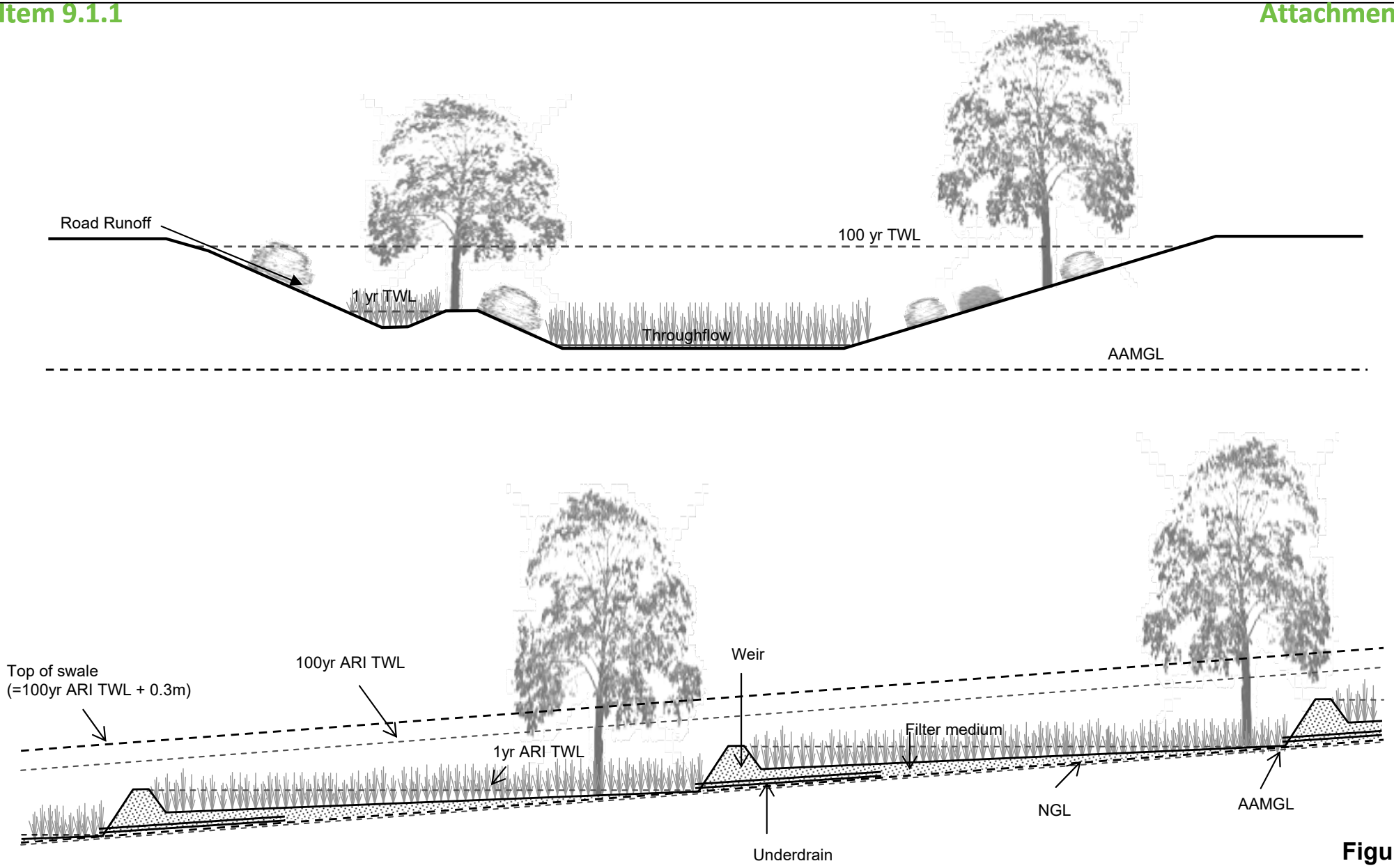



**Figure 11**

**SWALE OPTIONS**

# Appendix A

## Soil Logs

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB1 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.5 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 0.5 | Grey-brown gravelly silty loam | | |
| 1 - 1.5 | Yellow-brown clayey silt, wet | | |
| 2 - 3.5 | Yellow clayey silt, wet | | |
| 4 - 4.5 | Pink-grey silty clay, very wet | | |
| | | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB2 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 3.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 0.5 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Dk grey sandy topsoil | | |
| 0.5 - 1 | Grey silty sand, wet | | |
| 1.5 - 2 | Grey brown sandy silt, very wet | | |
| 2.5 | Yellow-brown clayey silt, very wet | | |
| 3 | Green-brown clayey silt, very wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB3 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 3.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Grey-brown gravelly loam | | |
| 0.5 | Brown pebbly silt | | |
| 1 - 2.5 | Orange-brown gravelly clayey silt | | |
| 3 - 3.5 | Pink-brown clayey silt, very wet | | |
| 4 | Pink-grey silty clay, very wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB5 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 4.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 0.5 | Yellow-brown silty loam, moist | | |
| 1 - 1.5 | Yellow-brown gravelly silt, very wet | | |
| 2 | Yellow-brown silt, very wet | | |
| 2.5 - 4 | Yellow-brown clayey silt, moist | | |
| | | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB7 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 6.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 0.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 | Brown gravelly loam, wet | | |
| 0.5 | Orange-brown pebbly silt, moist | | |
| 1 | Red-brown pebbly clay, moist | | |
| 1.5 - 2 | Orange-brown silty clay, wet grading to moist | | |
| 2.5 - 3 | Orange-brown clay, moist | | |
| 3.5 - 6 | Brown clay, wet | | |

# SOIL PROFILE LOG

| | |
|---|---|
| PROJECT NUMBER: | J18015 |
| SITE ID: | MB8 |
| EASTING: | |
| NORTHING: | |
| METHOD: | Auger Rig |
| TOTAL DEPTH (mbgl): | 5.0 |
| REFUSAL (Y/N): | N |
| DATE: | 3/08/2018 |
| DEPTH TO WATER (mbgl) | 1.0 |

| SOIL PROFILE | | SAMPLE DATA | |
|---|---|---|---|
| DEPTH (m) | SOIL DESCRIPTION | SAMPLE ID | INTERVAL (m) |
| 0 - 1.5 | Brown silty clayey gravel, moist | | |
| 2 - 2.5 | Pale yellow-brown silt, wet | | |
| 3 - 5 | Grey silty clay, very wet | | |

# Appendix B

## Permeability Test Results

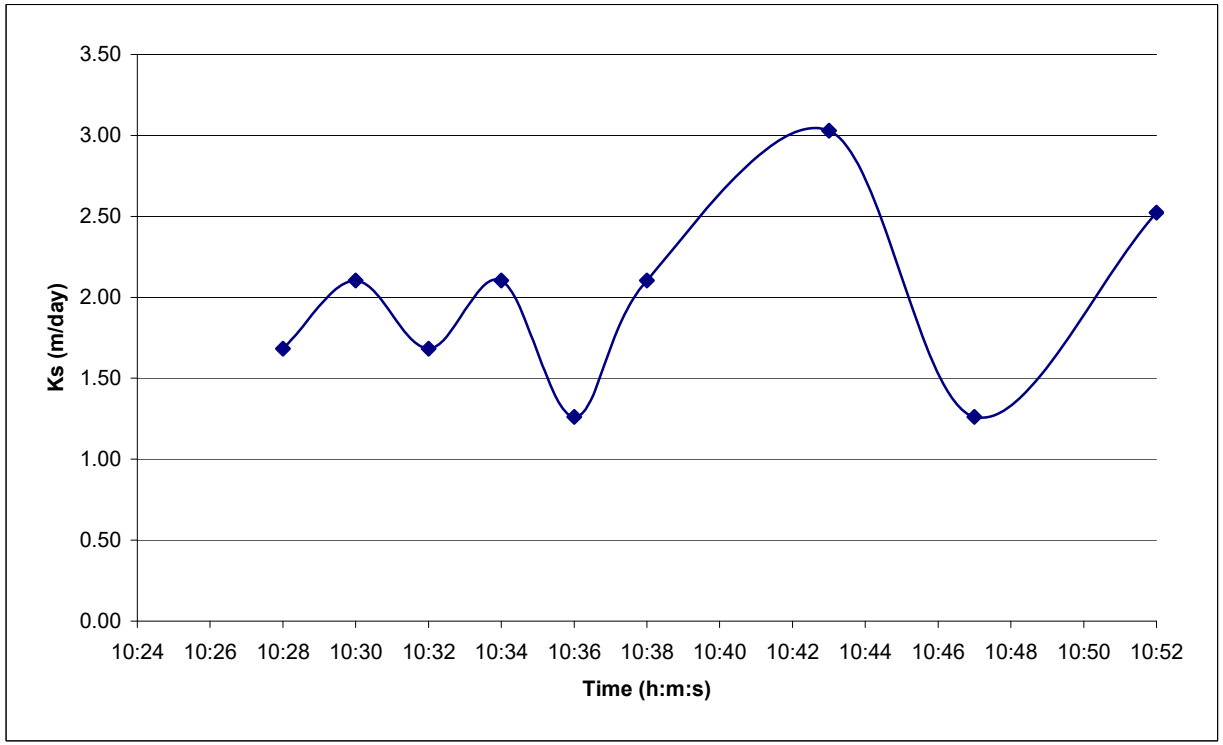
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI1-S |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 10:26:00 | 39.8 | | |
| 10:28:00 | 39.4 | 0.4 | **1.68** |
| 10:30:00 | 38.9 | 0.5 | **2.10** |
| 10:32:00 | 38.5 | 0.4 | **1.68** |
| 10:34:00 | 38 | 0.5 | **2.10** |
| 10:36:00 | 37.7 | 0.3 | **1.26** |
| 10:38:00 | 37.2 | 0.5 | **2.10** |
| 10:43:00 | 35.4 | 1.8 | **3.03** |
| 10:47:00 | 34.8 | 0.6 | **1.26** |
| 10:52:00 | 33.3 | 1.5 | **2.52** |
| | | 33.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 1.9 m/d**



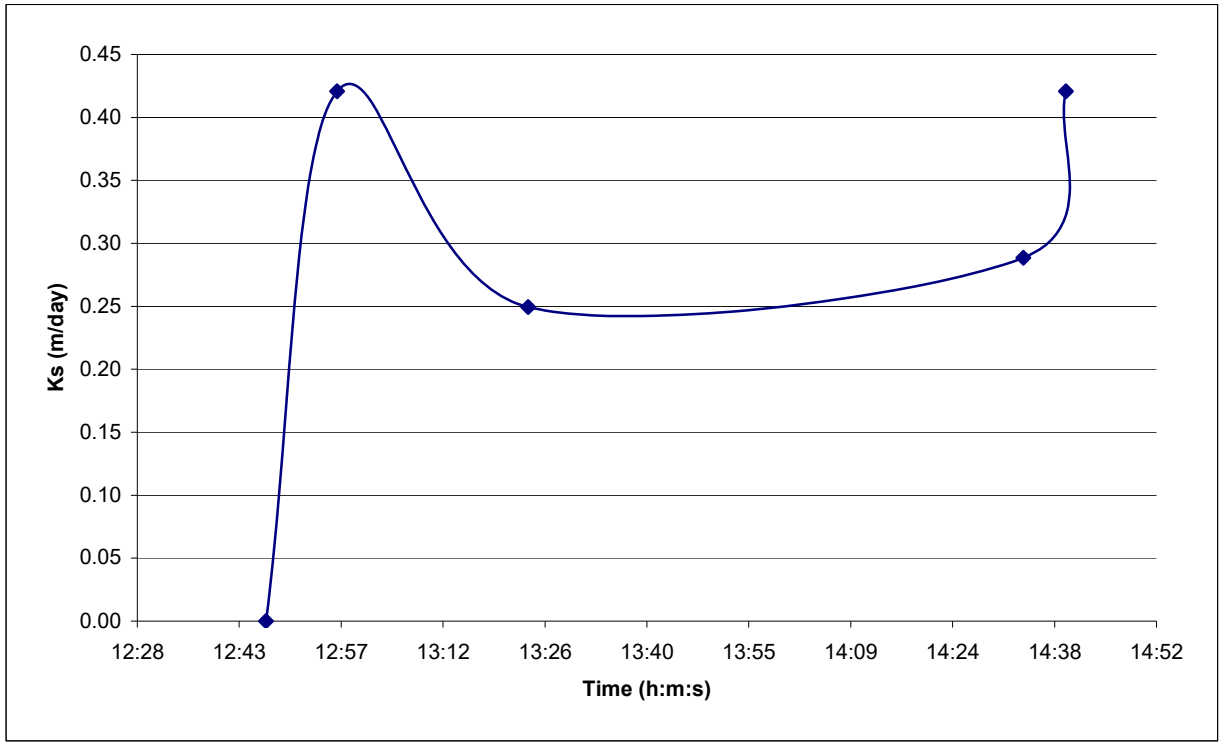
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI1-D |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 1m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 12:42:00 | 40.4 | | |
| 12:47:00 | 40.4 | | |
| 12:57:00 | 39.9 | 0.5 | **0.42** |
| 13:24:00 | 39.1 | 0.8 | **0.25** |
| 14:34:00 | 36.7 | 2.4 | **0.29** |
| 14:40:00 | 36.4 | 0.3 | **0.42** |
| | | 36.4 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 0.25 m/d**



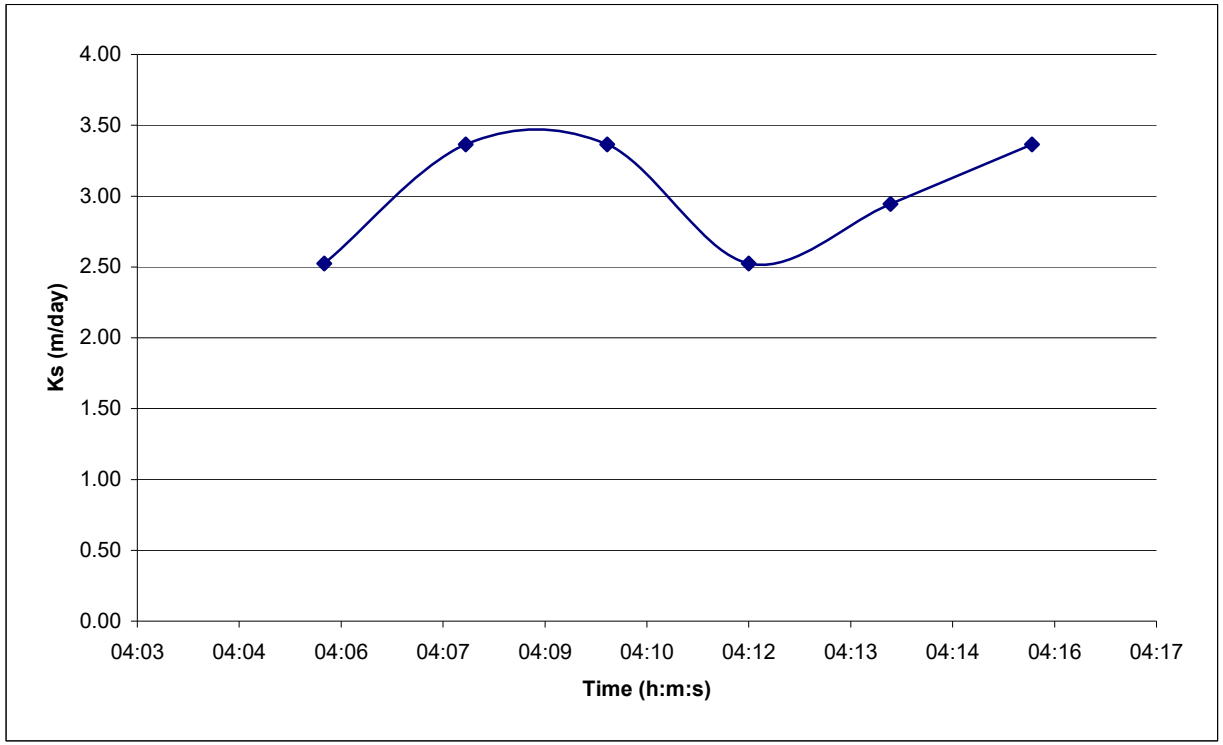
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI2 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 04:05:00 | 36.3 | | |
| 04:06:00 | 36 | 0.3 | **2.52** |
| 04:08:00 | 35.2 | 0.8 | **3.37** |
| 04:10:00 | 34.4 | 0.8 | **3.37** |
| 04:12:00 | 33.8 | 0.6 | **2.52** |
| 04:14:00 | 33.1 | 0.7 | **2.94** |
| 04:16:00 | 32.3 | 0.8 | **3.37** |
| | | 32.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 3.0 m/d**



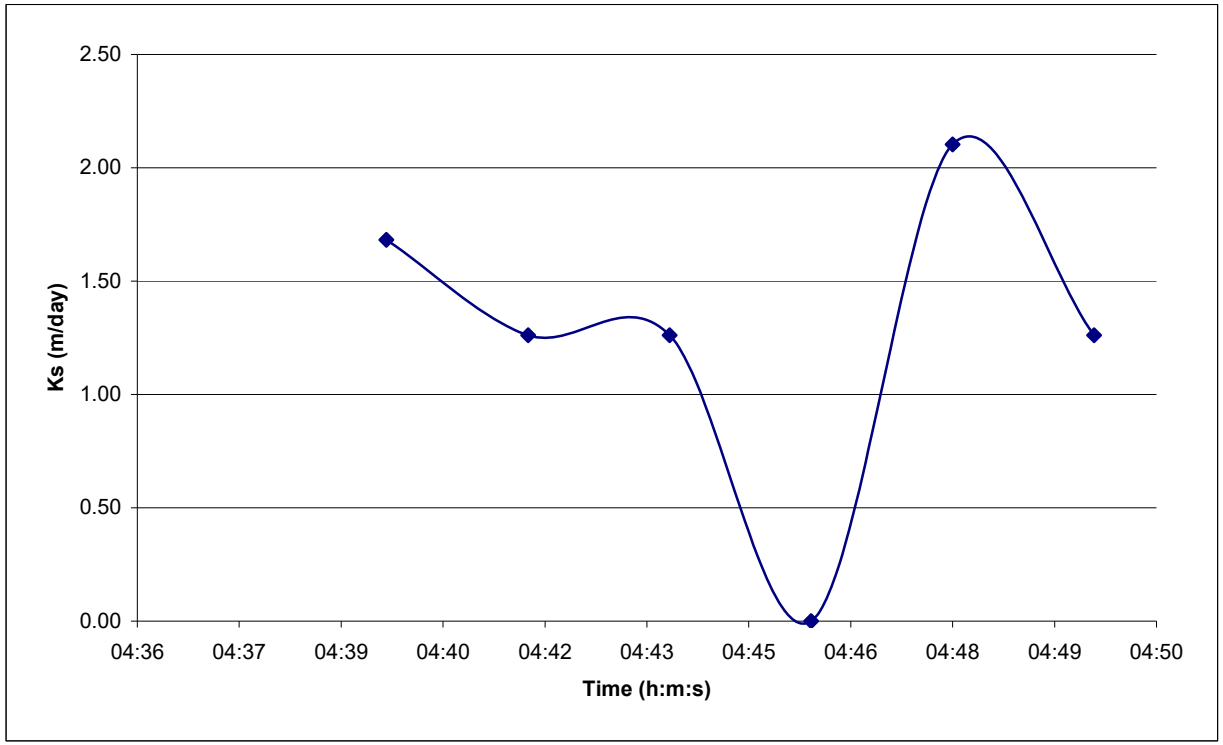
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI3 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 04:38:00 | 27.1 | | |
| 04:40:00 | 26.7 | 0.4 | **1.68** |
| 04:42:00 | 26.4 | 0.3 | **1.26** |
| 04:44:00 | 26.1 | 0.3 | **1.26** |
| 04:46:00 | 26.1 | | |
| 04:48:00 | 25.6 | 0.5 | **2.10** |
| 04:50:00 | 25.3 | 0.3 | **1.26** |
| | | 25.3 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 1.25 m/d**



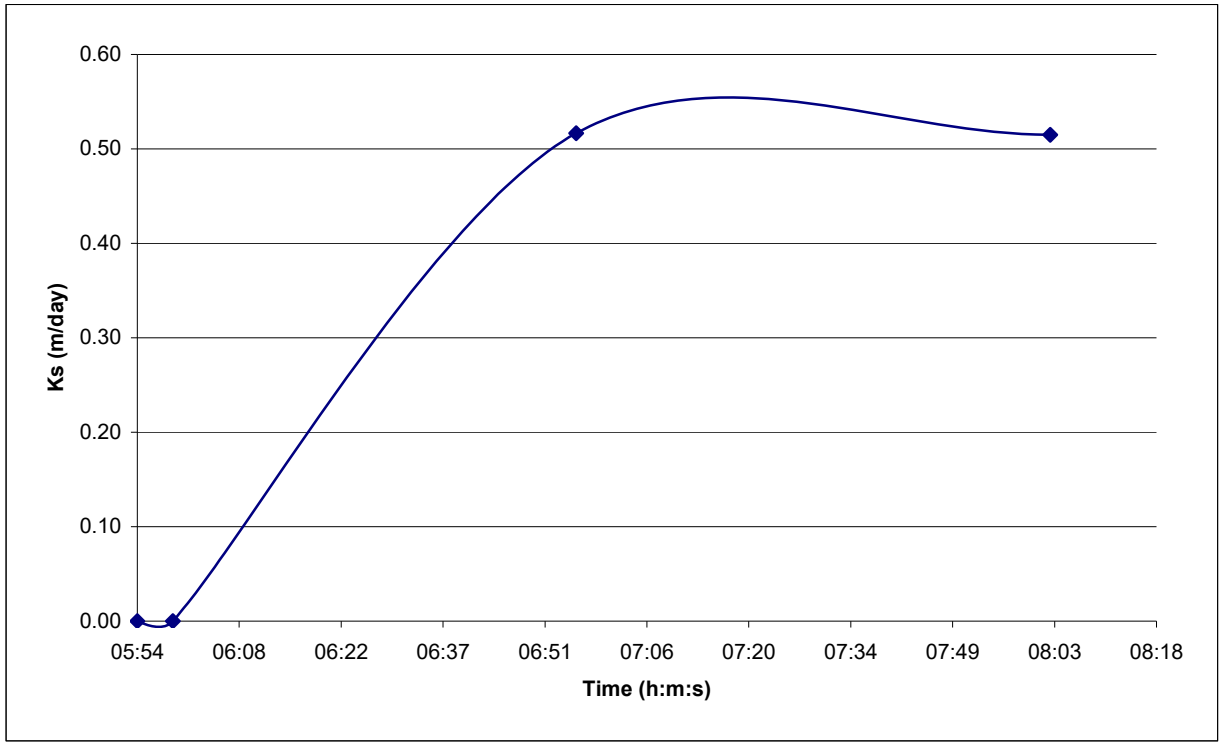
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI4 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5m |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 05:49:00 | 34 | | |
| 05:54:00 | 34 | | |
| 05:59:00 | 34 | | |
| 06:56:00 | 30.5 | 3.5 | **0.52** |
| 08:03:00 | 26.4 | 4.1 | **0.51** |
| | | 26.4 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 0.5 m/d**



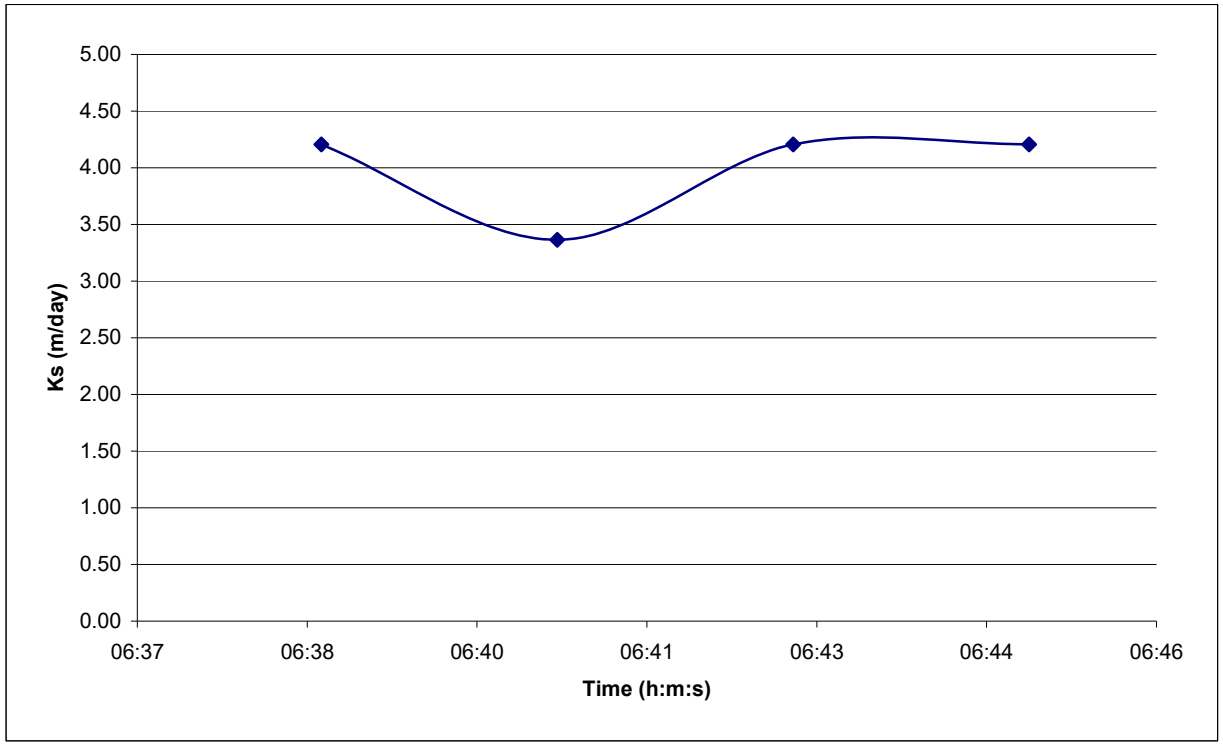
**SOIL PERMEABILITY TEST**

| | |
|---|---|
| Site No. | MI5 |
| Date | 26/11/18 |
| Easting | |
| Northing | |
| Depth | 0.5 |

| Time (h:m:s) | Weight (kg) | Change in Weight (kg) | Ks (m/d) |
|---|---|---|---|
| 06:36:00 | 22.9 | | |
| 06:39:00 | 21.4 | 1.5 | **4.21** |
| 06:41:00 | 20.6 | 0.8 | **3.37** |
| 06:43:00 | 19.6 | 1 | **4.21** |
| 06:45:00 | 18.6 | 1 | **4.21** |
| | | 18.6 | |

| | |
|---|---|
| **H =** | 25 |
| **r =** | **4.5** |

**Ks = 4.2 m/d**



## 3.2. Groundwater

Groundwater was encountered in boreholes BH01, BH02, BH05 and BH12 at an approximate depth of 1.0m below the existing ground level. Groundwater is expected to perch above the impermeable materials.

## 3.3. Percolation Testing

Percolation testing of the in situ soils was undertaken in two locations. Results of the testing are summarised below:

**Table 3 – In Situ Percolation Test Results**

| Test Location | Testing Depth | Soil Type | Permeability |
|---|---|---|---|
| 1 | 0 - 1.0m | SAND/Clayey SAND | 0.6m/day |
| 2 | 0 – 0.7m | SAND/Clayey SAND | 0.5m/day |
| 3 | 0 - 1.0m | SAND/Clayey SAND | 0.3m/day |
| 4 | 0 - 1.0m | SAND/Clayey SAND | 0.7m/day |
| 5 | 0 – 0.5m | SAND/Gravelly SAND | 1.0m/day |
| 6 | 0 - 1.0m | SAND/Clayey SAND | 1.2m/day |
| 7 | 0 – 0.6m | SAND/Clayey SAND | 0.9m/day |

# Appendix C

## Floodway Modelling Report

# MEMORANDUM

| Project: | Muchea Employment Node P3 Waterways | | | Project No: | P18311 |
|---|---|---|---|---|---|
| To: | Copy: | Name: | Organisation: | Facsimile: | |
| ☒ | ☐ | Phil Bayley | Bayley Environmental Services | | |
| ☒ | ☐ | Tom Carmody | Tomahawk Property | | |
| ☐ | ☐ | | | | |
| From: | Brett Stinton | | Date: 25 January 2019 | Total Pages: | 9 |

| Subject: | Muchea Employment Node P3 – Floodway Definition |
|---|---|

If you do not receive all pages, or some are unclear, please advise immediately

BG&E Pty Limited (BG&E) has been engaged by the Muchea Employment Node Precinct 3 Landowners Group to carry out a waterways assessment for Ellen Brook to inform the development of the Muchea Employment Node Precinct 3.

As part of the Northlink Stage 3 project, BG&E prepared a TUFLOW hydraulic model for the new Perth to Darwin National Highway (PDNH) bridge which crosses Ellen Brook. This model has been utilised and updated to incorporate the boundary of the concept plan for the Muchea Employment Node Precinct prepared by Urbis. The southern section of the development layout is directly adjacent to the Ellen Brook floodplain where public open space and drainage reserve areas are proposed.

## SCOPE

The following scope of works was carried out:

1. Review modelling assumptions in accordance with 2016 edition of Australian Rainfall and Runoff
2. Simulate 1 in 100 annual exceedance probability (AEP) event under current day scenario (including new PDNH)
3. Preliminary definition of floodway based on review of hydraulic model results (depths, velocities etc)
4. Meet with representatives from DWER and Main Roads WA to discuss the project and agree on allowable backwater criteria
5. Update hydraulic model to include earthworks up to the preliminary floodway and review 1 in 100 AEP backwater
6. Refine the floodway and update the hydraulic model with revised earthworks extents to achieve suitable backwater (up to 5 post-development iterations have been assumed)
7. Prepare a memo report summarising the methodology and findings of the project, including polygons for floodway and flood fringe areas similar to those provided by DWER for other areas within Ellen Brook.

The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.

## TUFLOW MODEL

The TUFLOW 2D hydraulic has been updated to include the outline of the proposed development that lies within the flood extents of the Ellen Brook flood plain and other scenarios where the boundary encroaches further toward the main Ellen Brook channel.

## MEETING WITH MAIN ROADS AND DWER

A meeting was held on 15th January 2019 with Simon Rodgers (Supervising Engineer - Floodplain Management) from the Department of Water and Environmental Regulation (DWER) and Eric Cheung (Senior Waterways Engineer) from Main Roads WA, to discuss any potential impacts the development may have. Preliminary results showing the impact on flood levels were tabled. The DWER representative indicated that the impacts were not of concern from a DWER perspective. The Main Roads WA representative was concerned of any potential impacts to the recently constructed PDNH alignment that passes adjacent to the proposed development.

## FLOODWAY DEFINITION

The Department of Water and Environmental Regulation (DWER) define the Floodway as *"the river channel and a portion of the floodplain where a significant flow or storage of water occurs during floods. If the floodway is even partially blocked then the natural flooding regime of the area may be detrimentally impacted with flood levels being raised and affecting areas which may not have been previously affected"*.

The following items were considered when defining the floodway:

- 1% AEP pre-development velocity and depth mapping (attached) used to identify areas where higher depths and velocities occur which provide an indication of flood conveyance
- The presence of existing flowpaths within the floodplain which includes the main channel and breakout channel downstream of the PDNH culvert crossing to the north of the bridge. These flowpaths should be maintained to avoid redistribution of flow
- Potential impacts to flood levels as a result of partially blocking the floodplain, based on the hydraulic model results
- The floodway extent adopted by DWER for Ellen Brook to the south of the site. Shapefiles were provided by DWER which show the floodway extending to the edge of the floodplain in some areas. Flood behaviour in the northern section of the dataset is expected to be similar to that within the project site (Figure 1).

Refer to attached plots for 1% AEP pre-development and post-development flood extents. These include the proposed floodway and flood fringe extents. The proposed development footprint is close to but does not encroach into the floodway. The results indicate a maximum increase in flood level of approximately 30 mm near the proposed road, reducing to approximately 10mm at the PDNH PSP.

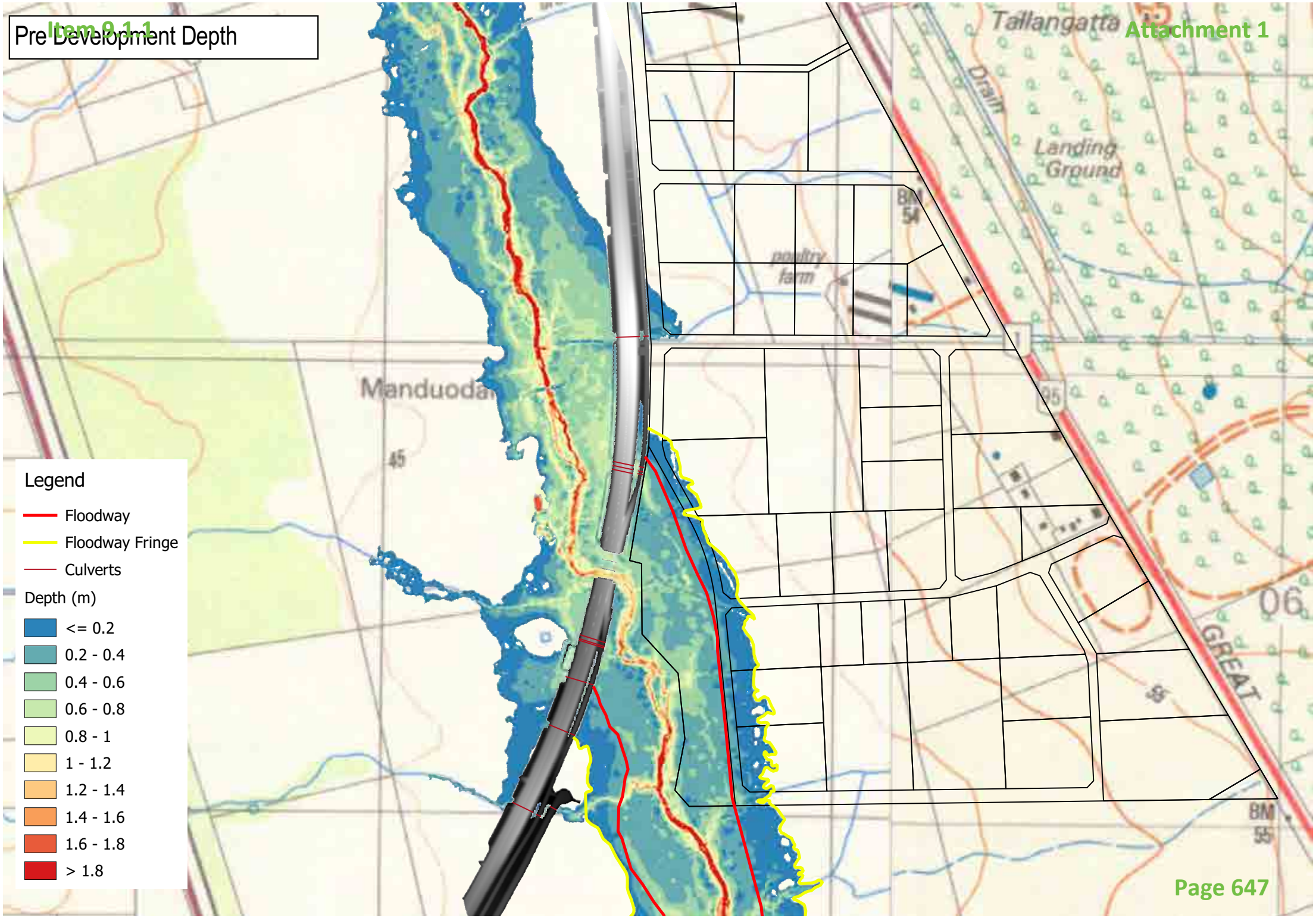
Scenarios where the earthworks footprint encroaches further into the floodway with offsets ranging from 20m to 80m were also simulated in the hydraulic model to assess potential impacts on the adjacent PDNH. The results indicate an increase in flood levels along the PDNH alignment varying between 40mm for a 40m offset to 90mm for an 80m offset.

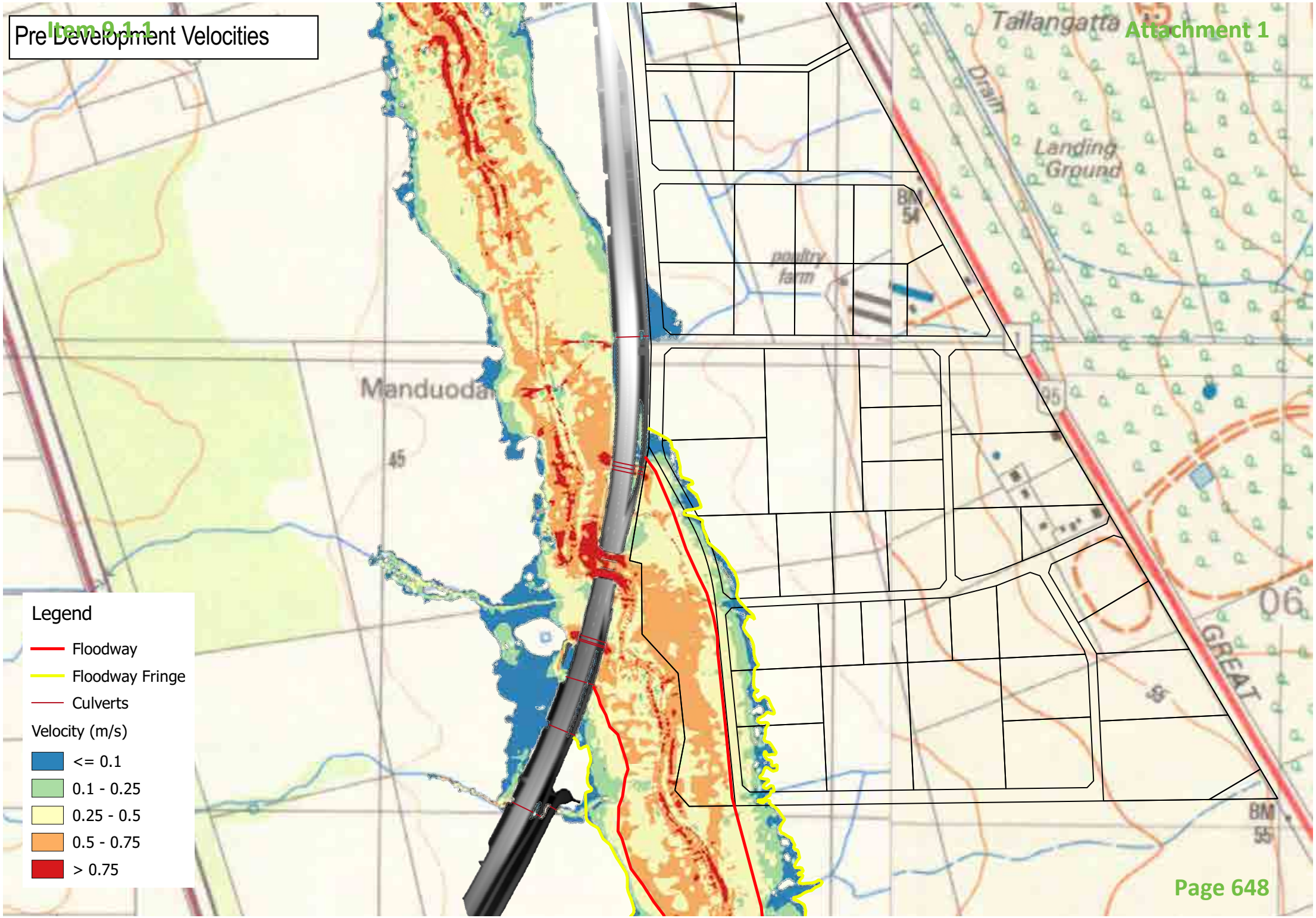
**Figure 1 – Downstream floodway definition by DWER**

## LIMITATIONS

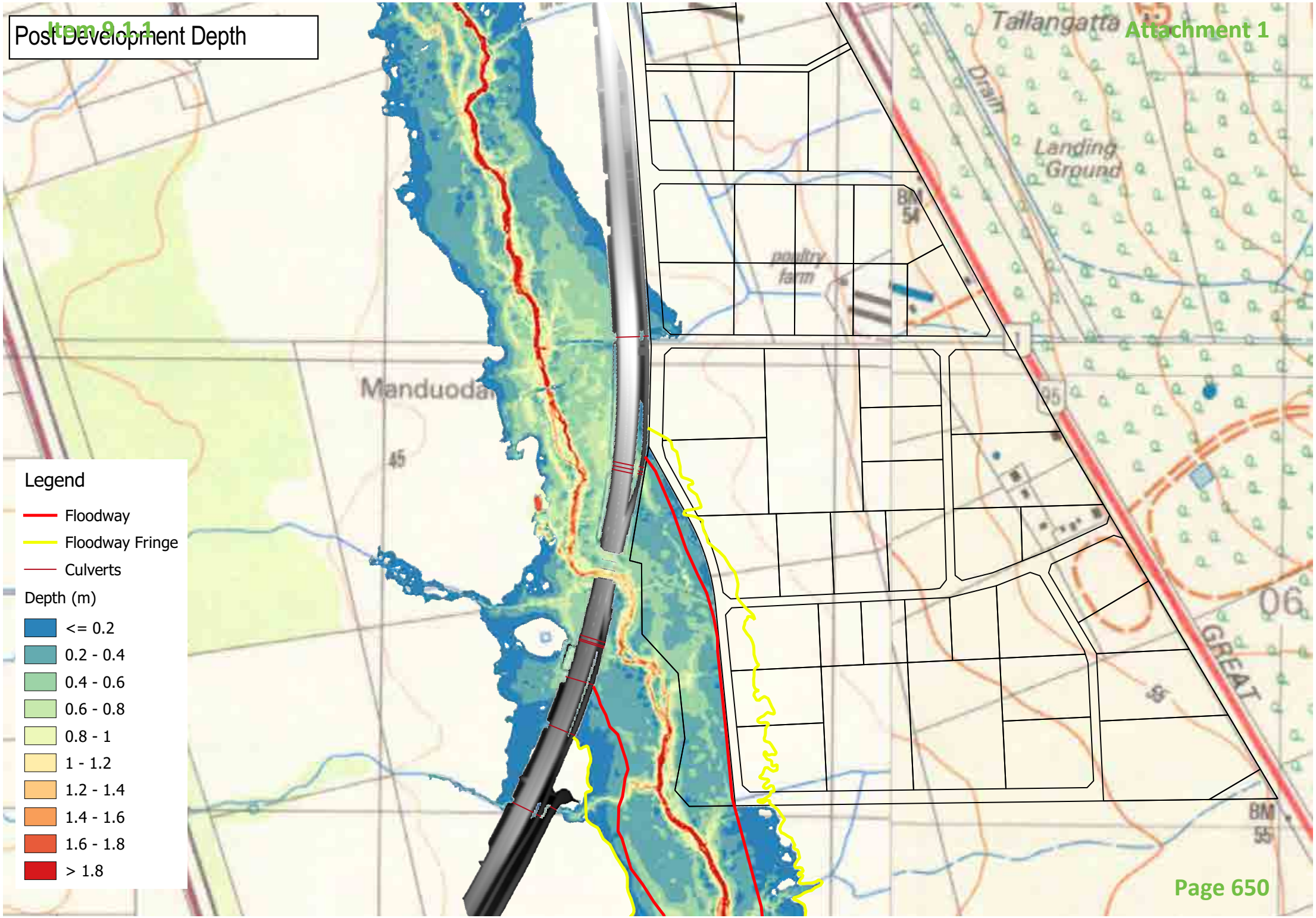
The findings of this study are subject to the following limitations:

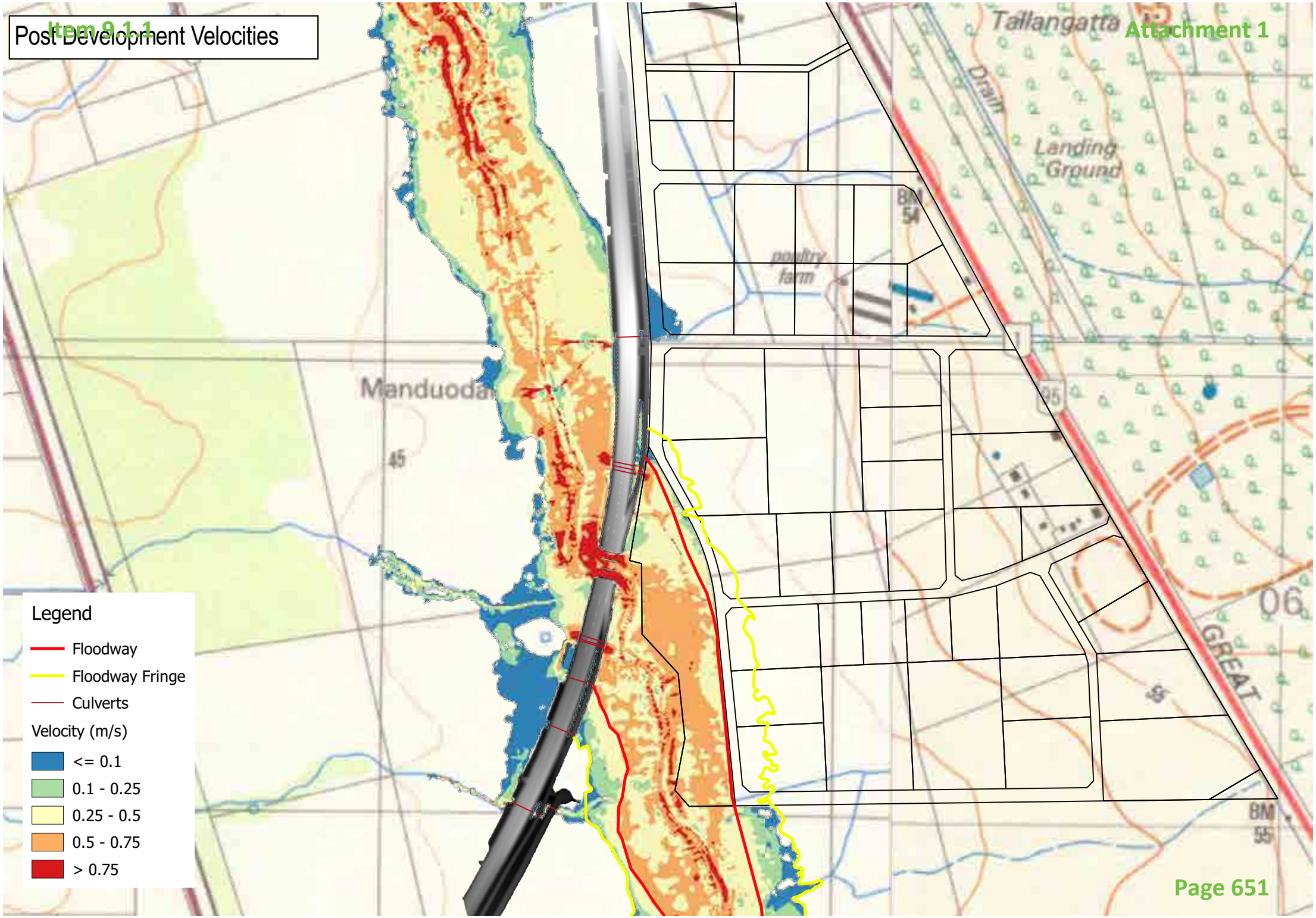
- The scope of works is limited to the Ellen Brook waterway and does not consider local catchment flows which occur throughout the site from the east via existing culverts beneath Great Eastern Highway. It is expected suitable drainage reserves and infrastructure would be required to manage local catchment flows which would need to be identified as part of a separate study.
- No allowance has been made for blockage of drainage infrastructure or increasing flows due to climate change.

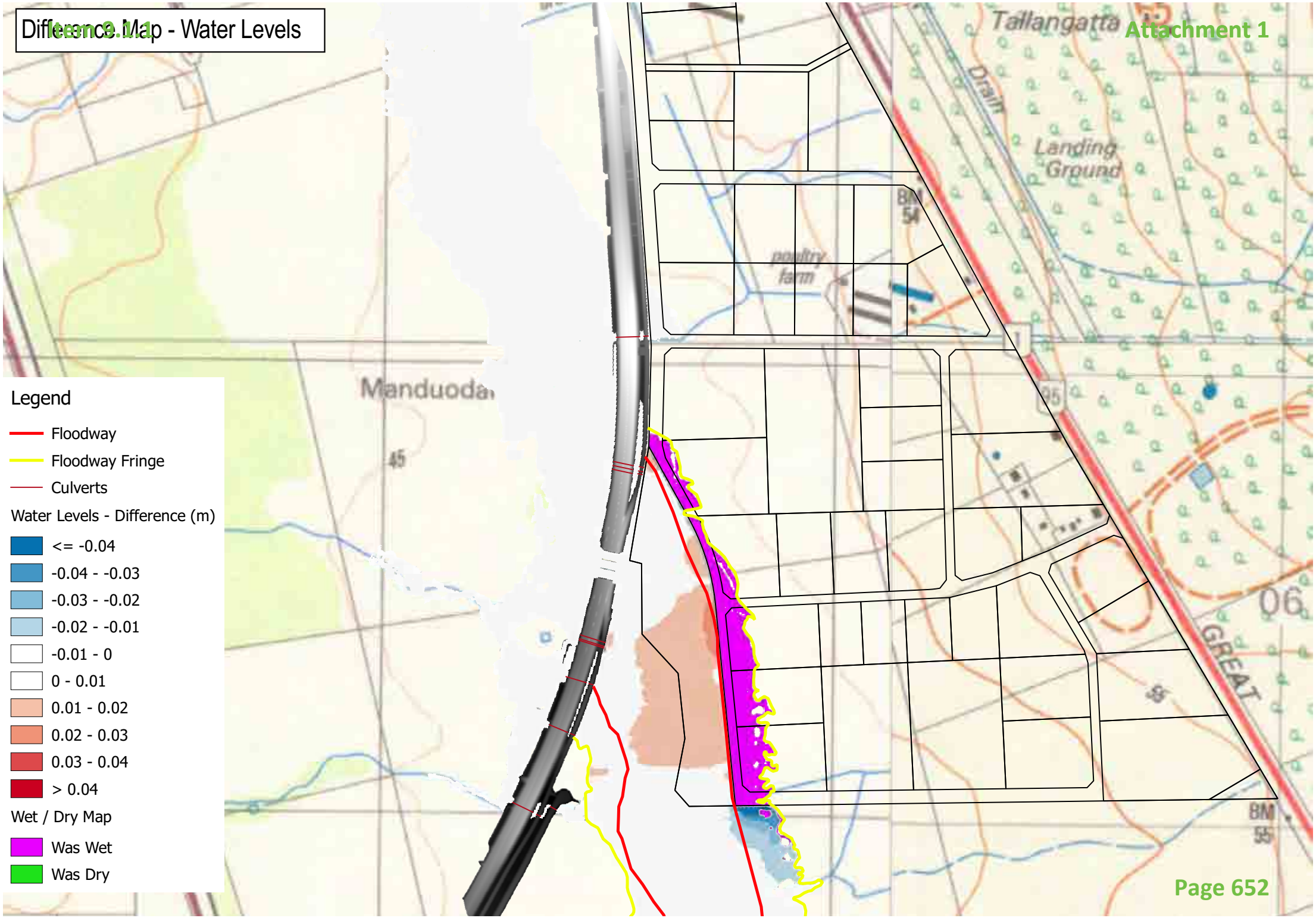

Pre Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Pre Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75

Pre Development Velocity x Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity x Depth
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
> 1


Post Development Depth
Tallangatta
Drain
Landing Ground
poultry farm
Manduoda
45
95
06
GREAT
BM 54
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Depth (m)
<= 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
1 - 1.2
1.2 - 1.4
1.4 - 1.6
1.6 - 1.8
> 1.8


Post Development Velocities
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Velocity (m/s)
<= 0.1
0.1 - 0.25
0.25 - 0.5
0.5 - 0.75
> 0.75


Difference Map - Water Levels
Tallangatta
Drain
Landing Ground
poultry farm
BM 54
Manduoda
45
95
06
GREAT
BM 55
Legend
Floodway
Floodway Fringe
Culverts
Water Levels - Difference (m)
<= -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0
0 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
> 0.04
Wet / Dry Map
Was Wet
Was Dry

# Appendix D

## Runoff Calculations

**1 YEAR ARI 1 HOUR FLOWS**

| | | |
|---|---|---|
| Rainfall Intensity i (mm/h) | 15.1 | (1 Yr, 1 Hr Storm) |
| Runoff Coefficients | | |
| Buildings | 0 | |
| Lowlands | 0 | |
| Hardstand | 0 | |
| Cleared Palusplain | 0 | |
| Vegetated Palusplain | 0 | |
| Cleared Uplands | 0 | |
| Forested Uplands | 0 | |
| Road Reserve | 0.8 | |

Permeability k (m/hr) 0.0417

| Catchment | Buildings | Lowlands | Hardstand | Cleared Palusplain | Vegetated Palusplain | Cleared Uplands | Forested Uplands | Road Reserve | Ai | Q (L/s) | Vinflow (m3) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| North Pl 1 | 2926 | 0 | 23406 | 0 | 2926 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| North Pl 2 | 968 | 0 | 7741 | 0 | 968 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| AMS Pl 1 | 3014 | 0 | 24110 | 0 | 3014 | 0 | 0 | 0 | 0 | 0.00 | 0 |
| AMS Pl 2 | 4530 | 757 | 35228 | 0 | 4502 | 0 | 0 | 11531 | 9225 | 38.72 | 139 |
| AMS Pl 3 | 380 | 0 | 31914 | 0 | 2240 | 0 | 0 | 14270 | 11416 | 47.92 | 173 |
| Ingham Pl 1 | 5810 | 0 | 46477 | 0 | 5810 | 0 | 0 | 16003 | 12802 | 53.74 | 193 |
| Ingham Pl 2 | 1243 | 0 | 9943 | 0 | 1243 | 0 | 0 | 1177 | 942 | 3.95 | 14 |
| Ingham Pl 3 | 2143 | 0 | 17146 | 0 | 2143 | 0 | 0 | 2240 | 1792 | 7.52 | 27 |
| Ingham Pl 4 | 12461 | 0 | 99687 | 0 | 12461 | 0 | 0 | 10215 | 8172 | 34.30 | 123 |
| Ingham Pl 5 | 9381 | 0 | 75044 | 0 | 9381 | 0 | 0 | 23070 | 18456 | 77.47 | 279 |
| Ingham Pl 6 | 22286 | 0 | 178285 | 0 | 22286 | 0 | 0 | 42438 | 33950 | 142.52 | 513 |
| Amuse | 19440 | 0 | 155522 | 0 | 19440 | 0 | 0 | 10962 | 8770 | 36.81 | 133 |
| RTA | 65731 | 0 | 525851 | 0 | 65731 | 0 | 0 | 61273 | 49018 | 205.77 | 741 |
| South | 12769 | 0 | 102149 | 0 | 12769 | 0 | 0 | 17793 | 14234 | 59.75 | 215 |

**Swale Sizing**

| | Storm Event | Depth | Slope 1:x | Base Width | Base Length | Top Width (m) | Top Length (m) | Volume | Effective Volume | Surface Area (m2) | Volume check | 2% Area | Base Length Available |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North Pl 1 | 1 | 0.3 | 4 | 0 | 0 | 2 | 2 | 1 | 1 | 6 | ok | 0 | 0 |
| North Pl 2 | 1 | 0.3 | 4 | 0 | 0 | 2 | 2 | 1 | 1 | 6 | ok | 0 | 0 |
| AMS Pl 1 | 1 | 0.3 | 4 | 0 | 0 | 2 | 2 | 1 | 1 | 6 | ok | 0 | 0 |
| AMS Pl 2 | 1 | 0.3 | 4 | 1 | 196 | 3 | 198 | 123 | 141 | 675 | ok | 184 | 330 |
| AMS Pl 3 | 1 | 0.3 | 4 | 1 | 242 | 3 | 244 | 152 | 173 | 830 | ok | 228 | 308 |
| Ingham Pl 1 | 1 | 0.3 | 4 | 1 | 271 | 3 | 273 | 170 | 194 | 930 | ok | 256 | 288 |
| Ingham Pl 2 | 1 | 0.3 | 4 | 1 | 19 | 3 | 21 | 13 | 15 | 73 | ok | 19 | 43 |
| Ingham Pl 3 | 1 | 0.3 | 4 | 1 | 37 | 3 | 39 | 24 | 27 | 134 | ok | 36 | 71 |
| Ingham Pl 4 | 1 | 0.3 | 4 | 1 | 172 | 3 | 174 | 108 | 124 | 593 | ok | 163 | 325 |
| Ingham Pl 5 | 1 | 0.3 | 4 | 1 | 391 | 3 | 393 | 245 | 279 | 1338 | ok | 369 | 640 |
| Ingham Pl 6 | 1 | 0.3 | 4 | 1 | 720 | 3 | 722 | 451 | 513 | 2456 | ok | 679 | 1314 |
| Amuse | 1 | 0.3 | 4 | 1 | 185 | 3 | 187 | 117 | 133 | 637 | ok | 175 | 390 |
| RTA | 1 | 0.3 | 4 | 1 | 1040 | 3 | 1042 | 650 | 741 | 3544 | ok | 980 | 2054 |
| South | 1 | 0.3 | 4 | 1 | 301 | 3 | 303 | 189 | 215 | 1032 | ok | 285 | 550 |

**100 YEAR ARI DRAINAGE PROPERTIES - UPSTREAM**

| CATCHMENT | AREAS (m2) | | | | | | | | | | | | | | | | | | EFFECTIVE AREA (m2) | | TIME OF CONCENTRATION PRE-DEVELOPMENT | | | | | TIME OF CONCENTRATION POST-DEVELOPMENT | | | | | CRITICAL STORM INTENSITY (mm/h) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Buildings | | Lowlands | | Hardstand, unsealed roads | | Cleared Palusplain | | Vegetated Palusplain | | Cleared Uplands | | Forested Uplands | | Road Reserve | | Total | | Pre Dev | Post Dev | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope (m/km) | TC (min) | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope | TC (min) | Pre-Dev | Post-Dev |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | | | | | | | | | | | | | |
| **North 1** | 8542 | 8542 | 67975 | 67975 | 16885 | 16885 | 53602 | 53602 | 0 | 0 | 0 | 0 | 0 | 0 | 73179 | 73179 | 220183 | 220183 | 163406 | 163406 | 1500 | 85 | 53 | 21.00 | 56.7 | 1500 | 85 | 53 | 21.00 | 56.7 | 43.96 | 43.96 |
| **North 2** | 0 | 0 | 142617 | 142617 | 5392 | 5392 | 64500 | 64500 | 70603 | 70603 | 2879828 | 2879828 | 634745 | 634745 | 995 | 995 | 3798680 | 3798680 | 1175539 | 1175539 | 6316 | 235 | 52 | 28.97 | 183.8 | 6316 | 235 | 52 | 28.97 | 183.8 | 21.25 | 21.25 |
| **AMS** | 0 | 0 | 167304 | 167304 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6056 | 6056 | 173360 | 173360 | 105227 | 105227 | 1448 | 70 | 52 | 12.43 | 63.5 | 1448 | 70 | 52 | 12.43 | 63.5 | 40.55 | 40.55 |
| **Inghams 1** | 0 | 0 | 302181 | 302181 | 0 | 0 | 0 | 0 | 0 | 0 | 75326 | 75326 | 0 | 0 | 4410 | 4410 | 381917 | 381917 | 207434 | 207434 | 2351 | 128 | 53 | 31.90 | 79.8 | 2351 | 128 | 53 | 31.90 | 79.8 | 36.64 | 36.64 |
| **Inghams 2** | 1371 | 1371 | 460463 | 460463 | 0 | 0 | 0 | 0 | 0 | 0 | 469488 | 469488 | 0 | 0 | 4800 | 4800 | 936122 | 936122 | 422198 | 422198 | 2216 | 129 | 53 | 34.30 | 69.1 | 2216 | 129 | 53 | 34.30 | 69.1 | 39.22 | 39.22 |
| **Inghams 3 a** | 540 | 540 | 522370 | 522370 | 0 | 0 | 0 | 0 | 0 | 0 | 422640 | 422640 | 0 | 0 | 7111 | 7111 | 952661 | 952661 | 446389 | 446389 | 3157 | 125 | 53 | 22.81 | 106.2 | 3157 | 125 | 53 | 22.81 | 106.2 | 30.31 | 30.31 |
| **Inghams 3 b** | 0 | 0 | 80404 | 80404 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3554 | 3554 | 83958 | 83958 | 51086 | 51086 | 923 | 74 | 57 | 18.96 | 40.0 | 923 | 74 | 57 | 18.96 | 40.0 | 56.99 | 56.99 |
| **Inghams 4** | 0 | 0 | 150325 | 150325 | 0 | 0 | 56142 | 56142 | 0 | 0 | 1161350 | 1161350 | 13741 | 13741 | 4350 | 4350 | 1385908 | 1385908 | 489742 | 489742 | 2911 | 145 | 58 | 30.06 | 91.8 | 2911 | 145 | 58 | 30.06 | 91.8 | 33.77 | 33.77 |
| **Amuse** | 600 | 600 | 54719 | 54719 | 2525 | 2525 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3465 | 3465 | 61309 | 61309 | 38163 | 38163 | 835 | 74 | 59 | 17.96 | 37.7 | 835 | 74 | 59 | 17.96 | 37.7 | 58.81 | 58.81 |
| **RTA** | 460 | 460 | 28914 | 28914 | 1294 | 1294 | 0 | 0 | 0 | 0 | 5150 | 5150 | 0 | 0 | 805 | 805 | 36623 | 36623 | 20987 | 20987 | 1024 | 87 | 60 | 26.86 | 45.3 | 1024 | 87 | 60 | 26.86 | 45.3 | 52.90 | 52.90 |
| **South** | 2432 | 2432 | 565560 | 565560 | 8045 | 8045 | 46611 | 46611 | 0 | 0 | 114641 | 114641 | 23577 | 23577 | 44784 | 44784 | 805650 | 805650 | 460185 | 460185 | 1528 | 111 | 55 | 36.65 | 46.6 | 1528 | 111 | 55 | 36.65 | 46.6 | 51.85 | 51.85 |

| **Runoff Coefficients** | **Pre-Dev** | **Post-Dev** |
|---|---|---|
| Buildings | 0.9 | 0.9 |
| Lowlands | 0.6 | 0.6 |
| Hardstand, unsealed roads | 0.8 | 0.8 |
| Cleared Palusplain | 0.8 | 0.8 |
| Vegetated Palusplain | 0.6 | 0.6 |
| Cleared Uplands | 0.3 | 0.3 |
| Forested Uplands | 0.2 | 0.2 |
| Road Reserve | 0.8 | 0.8 |

**Rainfall IFD**

| **Event** | **Duration (mins)** | **Intensity (mm/hr)** |
|---|---|---|
| 5 min | 5 | 164.4 |
| 6 min | 6 | 154 |
| 10 min | 10 | 123.6 |
| 20 min | 20 | 83.7 |
| 30 min | 30 | 64.8 |
| 1 hr | 60 | 41.4 |
| 2 hr | 120 | 27 |
| 3 hr | 180 | 21.4 |
| 6 hr | 360 | 14.4 |
| 12 hr | 720 | 9.5 |
| 24 hr | 1440 | 5.75 |
| 48 hr | 2880 | 3.2 |
| 72 hr | 4320 | 2.2 |

**100 YEAR ARI FLOWS - UPSTREAM**

| Storm Duration (mins) | North 1 Upstream | | | North 2 Upstream | | | AMS Upstream | | | Inghams 1 Upstream | | | Inghams 2 Upstream | | | Inghams 3a Upstream | | | Inghams 3b Upstream | | | Inghams 4 Upstream | | | Amuse Upstream | | | RTA Upstream | | | South Upstream | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) |
| 5 | 1995.23 | 7462.19 | 5466.96 | 6939.14 | 7462.19 | 523.05 | 1185.24 | 4805.38 | 3620.13 | 2111.10 | 9472.84 | 7361.73 | 4599.51 | 19280.38 | 14680.87 | 3758.63 | 20385.09 | 16626.46 | 808.68 | 20385.09 | 19576.41 | 4593.52 | 22364.88 | 17771.36 | 623.47 | 1742.80 | 1119.33 | 308.36 | 958.39 | 650.02 | 6627.56 | 21015.09 | 14387.54 |
| 6 | 1995.23 | 6990.13 | 4994.89 | 6939.14 | 6990.13 | 50.99 | 1185.24 | 4501.39 | 3316.14 | 2111.10 | 8873.58 | 6762.48 | 4599.51 | 18060.70 | 13461.19 | 3758.63 | 19095.52 | 15336.89 | 808.68 | 19095.52 | 18286.84 | 4593.52 | 20950.07 | 16356.55 | 623.47 | 1632.55 | 1009.08 | 308.36 | 897.76 | 589.40 | 6627.56 | 19685.67 | 13058.11 |
| 10 | 1995.23 | 5610.26 | 3615.03 | 6939.14 | 5610.26 | -1328.88 | 1185.24 | 3612.80 | 2427.56 | 2111.10 | 7121.91 | 5010.81 | 4599.51 | 14495.47 | 9895.96 | 3758.63 | 15326.02 | 11567.39 | 808.68 | 15326.02 | 14517.34 | 4593.52 | 16814.47 | 12220.95 | 623.47 | 1310.28 | 686.81 | 308.36 | 720.54 | 412.18 | 6627.56 | 15799.67 | 9172.11 |
| 20 | 1995.23 | 3799.18 | 1803.95 | 6939.14 | 3799.18 | -3139.96 | 1185.24 | 2446.53 | 1261.29 | 2111.10 | 4822.85 | 2711.75 | 4599.51 | 9816.11 | 5216.60 | 3758.63 | 10378.54 | 6619.91 | 808.68 | 10378.54 | 9569.86 | 4593.52 | 11386.50 | 6792.98 | 623.47 | 887.30 | 263.83 | 308.36 | 487.94 | 179.57 | 6627.56 | 10699.29 | 4071.73 |
| 30 | 1995.23 | 2941.30 | 946.07 | 6939.14 | 2941.30 | -3997.84 | 1185.24 | 1894.09 | 708.85 | 2111.10 | 3733.82 | 1622.72 | 4599.51 | 7599.57 | 3000.06 | 3758.63 | 8035.00 | 4276.37 | 808.68 | 8035.00 | 7226.32 | 4593.52 | 8815.35 | 4221.83 | 623.47 | 686.94 | 63.47 | 308.36 | 377.76 | 69.39 | 6627.56 | 8283.32 | 1655.76 |
| 60 | 1995.23 | 1879.16 | -116.07 | 6939.14 | 1879.16 | -5059.97 | 1185.24 | 1210.11 | 24.87 | 2111.10 | 2385.50 | 274.39 | 4599.51 | 4855.28 | 255.77 | 3758.63 | 5133.47 | 1374.84 | 808.68 | 5133.47 | 4324.79 | 4593.52 | 5632.03 | 1038.51 | 623.47 | 438.88 | -184.59 | 308.36 | 241.35 | -67.02 | 6627.56 | 5292.12 | -1335.43 |
| 120 | 1995.23 | 1225.54 | -769.69 | 6939.14 | 1225.54 | -5713.60 | 1185.24 | 789.20 | -396.04 | 2111.10 | 1555.76 | -555.34 | 4599.51 | 3166.49 | -1433.02 | 3758.63 | 3347.92 | -410.71 | 808.68 | 3347.92 | 2539.24 | 4593.52 | 3673.06 | -920.45 | 623.47 | 286.23 | -337.24 | 308.36 | 157.40 | -150.96 | 6627.56 | 3451.38 | -3176.17 |
| 180 | 1995.23 | 971.36 | -1023.88 | 6939.14 | 971.36 | -5967.78 | 1185.24 | 625.52 | -559.73 | 2111.10 | 1233.08 | -878.02 | 4599.51 | 2509.73 | -2089.77 | 3758.63 | 2653.53 | -1105.10 | 808.68 | 2653.53 | 1844.85 | 4593.52 | 2911.24 | -1682.28 | 623.47 | 226.86 | -396.61 | 308.36 | 124.75 | -183.61 | 6627.56 | 2735.54 | -3892.02 |
| 360 | 1995.23 | 653.62 | -1341.61 | 6939.14 | 653.62 | -6285.52 | 1185.24 | 420.91 | -764.33 | 2111.10 | 829.74 | -1281.37 | 4599.51 | 1688.79 | -2910.71 | 3758.63 | 1785.56 | -1973.07 | 808.68 | 1785.56 | 976.88 | 4593.52 | 1958.97 | -2634.55 | 623.47 | 152.65 | -470.81 | 308.36 | 83.95 | -224.42 | 6627.56 | 1840.74 | -4786.82 |
| 720 | 1995.23 | 431.21 | -1564.02 | 6939.14 | 431.21 | -6507.93 | 1185.24 | 277.68 | -907.56 | 2111.10 | 547.40 | -1563.71 | 4599.51 | 1114.13 | -3485.37 | 3758.63 | 1177.97 | -2580.66 | 808.68 | 1177.97 | 369.29 | 4593.52 | 1292.37 | -3301.14 | 623.47 | 100.71 | -522.76 | 308.36 | 55.38 | -252.98 | 6627.56 | 1214.38 | -5413.18 |
| 1440 | 1995.23 | 261.00 | -1734.24 | 6939.14 | 261.00 | -6678.14 | 1185.24 | 168.07 | -1017.17 | 2111.10 | 331.32 | -1779.78 | 4599.51 | 674.34 | -3925.16 | 3758.63 | 712.98 | -3045.65 | 808.68 | 712.98 | -95.70 | 4593.52 | 782.23 | -3811.29 | 623.47 | 60.96 | -562.51 | 308.36 | 33.52 | -274.84 | 6627.56 | 735.02 | -5892.54 |
| 2880 | 1995.23 | 145.25 | -1849.98 | 6939.14 | 145.25 | -6793.89 | 1185.24 | 93.54 | -1091.71 | 2111.10 | 184.39 | -1926.72 | 4599.51 | 375.29 | -4224.22 | 3758.63 | 396.79 | -3361.84 | 808.68 | 396.79 | -411.89 | 4593.52 | 435.33 | -4158.19 | 623.47 | 33.92 | -589.54 | 308.36 | 18.65 | -289.71 | 6627.56 | 409.05 | -6218.50 |
| 4320 | 1995.23 | 99.86 | -1895.37 | 6939.14 | 99.86 | -6839.28 | 1185.24 | 64.31 | -1120.94 | 2111.10 | 126.77 | -1984.34 | 4599.51 | 258.01 | -4341.50 | 3758.63 | 272.79 | -3485.84 | 808.68 | 272.79 | -535.89 | 4593.52 | 299.29 | -4294.23 | 623.47 | 23.32 | -600.15 | 308.36 | 12.83 | -295.54 | 6627.56 | 281.22 | -6346.33 |
| **Critical Storm** | **1995.23** | **1995.23** | **0.00** | **6939.14** | **1995.23** | **-4943.90** | **1185.24** | **1185.24** | **0.00** | **2111.10** | **2111.10** | **0.00** | 4599.51 | **4599.51** | **0.00** | 3758.63 | **3758.63** | **0.00** | **808.68** | **3758.63** | **2949.95** | 4593.52 | **4593.52** | **0.00** | 623.47 | **623.47** | **0.00** | **308.36** | **308.36** | **0.00** | 6627.56 | **6627.56** | **0.00** |
| Duration (min) | 56.72 | 56.72 | | 183.84 | 0.00 | | 63.55 | 63.55 | | 79.84 | 79.84 | | 69.09 | 69.09 | | 106.20 | 106.20 | | 40.02 | 106.20 | | 91.81 | 91.81 | | 37.68 | 37.68 | | 45.26 | 45.26 | | 46.61 | 46.61 | |
| Intensity (mm/h) | 43.96 | 43.96 | | 21.25 | 0.00 | | 40.55 | 40.55 | | 36.64 | 36.64 | | 39.22 | 39.22 | | 30.31 | 30.31 | | 56.99 | 30.31 | | 33.77 | 33.77 | | 58.81 | 58.81 | | 52.90 | 52.90 | | 51.85 | 51.85 | |

**100 YEAR ARI DRAINAGE PROPERTIES - INTERNAL**

| CATCHMENT | AREAS (m2) | | | | | | | | | | | | | | | | EFFECTIVE AREA (m2) | | TIME OF CONCENTRATION PRE-DEVELOPMENT | | | | | TIME OF CONCENTRATION POST-DEVELOPMENT | | | | | CRITICAL STORM INTENSITY (mm/h) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Buildings | | Lowlands | | Hardstand, unsealed roads | | Cleared Palusplain | | Vegetated Palusplain | | Cleared Uplands | | Forested Uplands | | Road Reserve | | Total | | Pre Dev | Post Dev | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope (m/km) | TC (min) | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope | TC (min) | Pre-Dev | Post-Dev |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | | | | | | | | | | | | | |
| **North PI 1** | 493 | 2926 | 0 | 0 | 5774 | 23406 | 22991 | 0 | 0 | 2926 | 0 | 0 | 0 | 0 | 11113 | 11113 | 40371 | 40371 | 32346 | 32004 | 246 | 53 | 49 | 16.26 | 11.5 | 246 | 53 | 49 | 16.26 | 11.5 | 117.57 | 117.52 |
| **North PI 2** | 0 | 968 | 0 | 0 | 0 | 7741 | 9676 | 0 | 0 | 968 | 0 | 0 | 0 | 0 | 1880 | 1880 | 11556 | 11556 | 9245 | 9148 | 225 | 53 | 49 | 17.78 | 11.7 | 225 | 53 | 49 | 17.78 | 11.7 | 116.72 | 116.68 |
| **AMS PI 1** | 2776 | 3014 | 576 | 0 | 17122 | 24110 | 9663 | 0 | 0 | 3014 | 0 | 0 | 0 | 0 | 3556 | 3556 | 33693 | 33693 | 27117 | 26653 | 247 | 53 | 49 | 16.19 | 11.8 | 247 | 53 | 49 | 16.19 | 11.8 | 116.52 | 116.44 |
| **AMS PI 2** | 4530 | 4530 | 3052 | 1668 | 35228 | 23939 | 2207 | 0 | 0 | 3349 | 0 | 0 | 0 | 0 | 0 | 11531 | 45017 | 45017 | 35856 | 35463 | 263 | 53 | 49 | 13.31 | 12.7 | 550 | 53 | 49 | 6.36 | 30.8 | 112.91 | 64.20 |
| **AMS PI 3** | 380 | 380 | 16336 | 0 | 31914 | 31914 | 0 | 0 | 0 | 2240 | 0 | 0 | 0 | 0 | 12294 | 26390 | 60924 | 60924 | 45510 | 48329 | 630 | 53 | 48 | 7.62 | 33.2 | 630 | 53 | 48 | 7.62 | 33.0 | 62.34 | 62.49 |
| **Ingham PI 1** | 479 | 5810 | 65979 | 0 | 0 | 46477 | 4396 | 0 | 3641 | 5810 | 0 | 0 | 0 | 0 | 7970 | 24369 | 82465 | 82465 | 52096 | 65391 | 471 | 54 | 46 | 16.35 | 21.0 | 428 | 53 | 46 | 14.49 | 19.1 | 81.82 | 87.27 |
| **Ingham PI 2** | 1691 | 1243 | 8974 | 0 | 0 | 9943 | 834 | 0 | 2083 | 1243 | 0 | 0 | 0 | 0 | 0 | 1153 | 13582 | 13582 | 8823 | 10741 | 370 | 53 | 46 | 18.92 | 19.1 | 370 | 53 | 46 | 18.92 | 18.8 | 87.18 | 88.66 |
| **Ingham PI 3** | 1942 | 2143 | 13029 | 0 | 0 | 17146 | 3037 | 0 | 5597 | 2143 | 0 | 0 | 0 | 0 | 1467 | 3640 | 25072 | 25072 | 16527 | 19843 | 480 | 54 | 46 | 16.67 | 23.9 | 480 | 54 | 46 | 16.67 | 23.5 | 76.32 | 77.14 |
| **Ingham PI 4** | 1592 | 12461 | 80327 | 0 | 0 | 99687 | 42086 | 0 | 10294 | 12461 | 0 | 0 | 0 | 0 | 9243 | 18933 | 143542 | 143542 | 96869 | 113588 | 745 | 54 | 44 | 12.89 | 32.7 | 794 | 54 | 44 | 12.09 | 34.8 | 59.64 | 61.08 |
| **Ingham PI 5** | 0 | 9381 | 79851 | 0 | 0 | 75044 | 29773 | 0 | 7720 | 9381 | 0 | 0 | 0 | 0 | 11868 | 35407 | 129212 | 129212 | 85855 | 102432 | 738 | 55 | 45 | 13.96 | 32.3 | 834 | 54 | 45 | 11.15 | 37.5 | 63.01 | 58.95 |
| **Ingham PI 6** | 5735 | 22286 | 167415 | 0 | 0 | 178285 | 54819 | 0 | 37893 | 22286 | 0 | 0 | 0 | 0 | 12863 | 55869 | 278725 | 278725 | 182492 | 220751 | 876 | 55 | 43 | 13.70 | 35.7 | 876 | 58 | 43 | 16.55 | 33.7 | 60.37 | 61.91 |
| **Amuse** | 294 | 19440 | 151680 | 0 | 0 | 155522 | 49073 | 0 | 0 | 19440 | 0 | 0 | 0 | 0 | 11151 | 17795 | 212198 | 212198 | 139452 | 167814 | 1118 | 60 | 42 | 16.10 | 45.3 | 725 | 54 | 42 | 15.86 | 28.9 | 52.87 | 66.84 |
| **RTA** | 3334 | 65731 | 319119 | 0 | 121156 | 525851 | 275010 | 0 | 0 | 65731 | 0 | 0 | 0 | 0 | 11922 | 73227 | 730541 | 730541 | 520942 | 577860 | 1228 | 59 | 41 | 14.66 | 44.4 | 1212 | 60 | 41 | 15.68 | 42.8 | 53.54 | 54.80 |
| **South** | 0 | 12769 | 73662 | 0 | 0 | 102149 | 71196 | 0 | 0 | 12769 | 0 | 0 | 0 | 0 | 13085 | 30257 | 157943 | 157943 | 111622 | 125078 | 812 | 59 | 43 | 19.70 | 32.3 | 1362 | 59 | 41 | 13.22 | 58.0 | 63.00 | 42.93 |

| Runoff Coefficients | Pre-Dev | Post-Dev |
|---|---|---|
| Buildings | 0.9 | 0.9 |
| Lowlands | 0.6 | 0.6 |
| Hardstand, unsealed roads | 0.8 | 0.8 |
| Cleared Palusplain | 0.8 | 0.8 |
| Vegetated Palusplain | 0.6 | 0.6 |
| Cleared Uplands | 0.3 | 0.3 |
| Forested Uplands | 0.2 | 0.2 |
| Road Reserve | 0.8 | 0.8 |

**Rainfall IFD**

| Event | Duration (mins) | Intensity (mm/hr) |
|---|---|---|
| 5 min | 5 | 164.4 |
| 6 min | 6 | 154 |
| 10 min | 10 | 123.6 |
| 20 min | 20 | 83.7 |
| 30 min | 30 | 64.8 |
| 1 hr | 60 | 41.4 |
| 2 hr | 120 | 27 |
| 3 hr | 180 | 21.4 |
| 6 hr | 360 | 14.4 |
| 12 hr | 720 | 9.5 |
| 24 hr | 1440 | 5.75 |
| 48 hr | 2880 | 3.2 |
| 72 hr | 4320 | 2.2 |

**100 YEAR ARI FLOWS - INTERNAL**

| Storm Duration (mins) | North A | | | North B | | | AMS A | | | AMS B | | | AMS C | | | Ingham PI 1 | | | Ingham PI 2 | | | Ingham PI 3 | | | Ingham PI 4 | | | Ingham PI 5 | | | Ingham PI 6 | | | Amuse | | | RTA | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) |
| 5 | 1056.34 | 1461.53 | 405.19 | 299.75 | 1461.53 | 1161.78 | 877.69 | 1217.16 | 339.47 | 1124.57 | 1217.16 | 92.58 | 788.05 | 1217.16 | 429.11 | 1184.07 | 2986.19 | 1802.12 | 213.66 | 490.52 | 276.86 | 350.37 | 906.18 | 555.81 | 1604.81 | 5187.16 | 3582.35 | 1502.68 | 4677.71 | 3175.02 | 3060.11 | 10080.98 | 7020.87 | 2047.97 | 7663.52 | 5615.56 | 7747.59 | 26388.92 | 18641.34 | 1953.40 | 5711.87 | 3758.47 | | | |
| 6 | 1056.34 | 1369.07 | 312.73 | 299.75 | 1369.07 | 1069.32 | 877.69 | 1140.16 | 262.47 | 1124.57 | 1140.16 | 15.58 | 788.05 | 1140.16 | 352.11 | 1184.07 | 2797.28 | 1613.21 | 213.66 | 459.49 | 245.83 | 350.37 | 848.85 | 498.49 | 1604.81 | 4859.02 | 3254.21 | 1502.68 | 4381.79 | 2879.11 | 3060.11 | 9443.26 | 6383.14 | 2047.97 | 7178.73 | 5130.76 | 7747.59 | 24719.55 | 16971.96 | 1953.40 | 5350.54 | 3397.14 | | | |
| 10 | 1056.34 | 1098.81 | 42.47 | 299.75 | 1098.81 | 799.06 | 877.69 | 915.09 | 37.40 | 1124.57 | 915.09 | -209.49 | 788.05 | 915.09 | 127.04 | 1184.07 | 2245.09 | 1061.02 | 213.66 | 368.78 | 155.12 | 350.37 | 681.29 | 330.92 | 1604.81 | 3899.84 | 2295.03 | 1502.68 | 3516.82 | 2014.13 | 3060.11 | 7579.13 | 4519.02 | 2047.97 | 5761.63 | 3713.66 | 7747.59 | 19839.85 | 12092.26 | 1953.40 | 4294.33 | 2340.93 | | | |
| 20 | 1056.34 | 744.10 | -312.24 | 299.75 | 744.10 | 444.35 | 877.69 | 619.68 | -258.01 | 1124.57 | 619.68 | -504.89 | 788.05 | 619.68 | -168.37 | 1184.07 | 1520.34 | 336.27 | 213.66 | 249.74 | 36.07 | 350.37 | 461.36 | 110.99 | 1604.81 | 2640.91 | 1036.10 | 1502.68 | 2381.53 | 878.85 | 3060.11 | 5132.47 | 2072.36 | 2047.97 | 3901.68 | 1853.72 | 7747.59 | 13435.24 | 5687.65 | 1953.40 | 2908.05 | 954.65 | | | |
| 30 | 1056.34 | 576.08 | -480.26 | 299.75 | 576.08 | 276.33 | 877.69 | 479.75 | -397.94 | 1124.57 | 479.75 | -644.82 | 788.05 | 479.75 | -308.29 | 1184.07 | 1177.04 | -7.03 | 213.66 | 193.34 | -20.32 | 350.37 | 357.18 | 6.81 | 1604.81 | 2044.58 | 439.77 | 1502.68 | 1843.77 | 341.08 | 3060.11 | 3973.53 | 913.41 | 2047.97 | 3020.66 | 972.69 | 7747.59 | 10401.47 | 2653.89 | 1953.40 | 2251.40 | 297.99 | | | |
| 60 | 1056.34 | 368.05 | -688.29 | 299.75 | 368.05 | 68.30 | 877.69 | 306.51 | -571.18 | 1124.57 | 306.51 | -818.06 | 788.05 | 306.51 | -481.54 | 1184.07 | 752.00 | -432.07 | 213.66 | 123.53 | -90.14 | 350.37 | 228.20 | -122.17 | 1604.81 | 1306.26 | -298.55 | 1502.68 | 1177.96 | -324.72 | 3060.11 | 2538.64 | -521.47 | 2047.97 | 1929.87 | -118.10 | 7747.59 | 6845.39 | -1102.20 | 1953.40 | 1438.39 | -515.01 | | | |
| 120 | 1056.34 | 240.03 | -816.31 | 299.75 | 240.03 | -59.72 | 877.69 | 199.90 | -677.79 | 1124.57 | 199.90 | -924.68 | 788.05 | 199.90 | -588.15 | 1184.07 | 490.43 | -693.64 | 213.66 | 80.56 | -133.10 | 350.37 | 148.82 | -201.54 | 1604.81 | 851.91 | -752.90 | 1502.68 | 768.24 | -734.45 | 3060.11 | 1655.64 | -1404.48 | 2047.97 | 1258.61 | -789.36 | 7747.59 | 4333.95 | -3413.64 | 1953.40 | 938.08 | -1015.32 | | | |
| 180 | 1056.34 | 190.25 | -866.09 | 299.75 | 190.25 | -109.50 | 877.69 | 158.44 | -719.25 | 1124.57 | 158.44 | -966.14 | 788.05 | 158.44 | -629.61 | 1184.07 | 388.71 | -795.36 | 213.66 | 63.85 | -149.81 | 350.37 | 117.96 | -232.41 | 1604.81 | 675.21 | -929.59 | 1502.68 | 608.90 | -893.78 | 3060.11 | 1312.24 | -1747.87 | 2047.97 | 997.56 | -1050.40 | 7747.59 | 3435.05 | -4312.53 | 1953.40 | 743.52 | -1209.89 | | | |
| 360 | 1056.34 | 128.02 | -928.32 | 299.75 | 128.02 | -171.73 | 877.69 | 106.61 | -771.08 | 1124.57 | 106.61 | -1017.96 | 788.05 | 106.61 | -681.44 | 1184.07 | 261.56 | -922.51 | 213.66 | 42.97 | -170.70 | 350.37 | 79.37 | -270.99 | 1604.81 | 454.35 | -1150.46 | 1502.68 | 409.73 | -1092.96 | 3060.11 | 883.01 | -2177.11 | 2047.97 | 671.26 | -1376.71 | 7747.59 | 2311.44 | -5436.15 | 1953.40 | 500.31 | -1453.09 | | | |
| 720 | 1056.34 | 84.46 | -971.88 | 299.75 | 84.46 | -215.29 | 877.69 | 70.33 | -807.36 | 1124.57 | 70.33 | -1054.24 | 788.05 | 70.33 | -717.71 | 1184.07 | 172.56 | -1011.51 | 213.66 | 28.35 | -185.32 | 350.37 | 52.36 | -298.00 | 1604.81 | 299.74 | -1305.06 | 1502.68 | 270.31 | -1232.38 | 3060.11 | 582.54 | -2477.57 | 2047.97 | 442.84 | -1605.12 | 7747.59 | 1524.91 | -6222.68 | 1953.40 | 330.07 | -1623.34 | | | |
| 1440 | 1056.34 | 51.12 | -1005.22 | 299.75 | 51.12 | -248.63 | 877.69 | 42.57 | -835.12 | 1124.57 | 42.57 | -1082.00 | 788.05 | 42.57 | -745.48 | 1184.07 | 104.44 | -1079.63 | 213.66 | 17.16 | -196.51 | 350.37 | 31.69 | -318.67 | 1604.81 | 181.42 | -1423.39 | 1502.68 | 163.61 | -1339.08 | 3060.11 | 352.59 | -2707.52 | 2047.97 | 268.04 | -1779.93 | 7747.59 | 922.97 | -6824.62 | 1953.40 | 199.78 | -1753.63 | | | |
| 2880 | 1056.34 | 28.45 | -1027.89 | 299.75 | 28.45 | -271.30 | 877.69 | 23.69 | -854.00 | 1124.57 | 23.69 | -1100.88 | 788.05 | 23.69 | -764.36 | 1184.07 | 58.13 | -1125.95 | 213.66 | 9.55 | -204.11 | 350.37 | 17.64 | -332.73 | 1604.81 | 100.97 | -1503.84 | 1502.68 | 91.05 | -1411.63 | 3060.11 | 196.22 | -2863.89 | 2047.97 | 149.17 | -1898.80 | 7747.59 | 513.65 | -7233.93 | 1953.40 | 111.18 | -1842.22 | | | |
| 4320 | 1056.34 | 19.56 | -1036.78 | 299.75 | 19.56 | -280.19 | 877.69 | 16.29 | -861.40 | 1124.57 | 16.29 | -1108.29 | 788.05 | 16.29 | -771.76 | 1184.07 | 39.96 | -1144.11 | 213.66 | 6.56 | -207.10 | 350.37 | 12.13 | -338.24 | 1604.81 | 69.41 | -1535.39 | 1502.68 | 62.60 | -1440.09 | 3060.11 | 134.90 | -2925.21 | 2047.97 | 102.55 | -1945.41 | 7747.59 | 353.14 | -7394.45 | 1953.40 | 76.44 | -1876.97 | | | |
| **Critical Storm** | **1056.34** | **1044.74** | **-11.60** | 299.75 | **1044.74** | **744.99** | 877.69 | **862.08** | **-15.61** | 1124.57 | **862.08** | **-262.50** | 788.05 | **862.08** | **74.03** | **1184.07** | **1585.26** | **401.19** | 213.66 | **264.54** | **50.88** | 350.37 | **425.19** | **74.83** | 1604.81 | **1927.14** | **322.33** | 1502.68 | **1677.21** | **174.53** | 3060.11 | **3796.04** | **735.93** | 2047.97 | **3115.73** | **1067.77** | **7747.59** | **8795.74** | **1048.15** | **1953.40** | **1491.72** | **-461.68** | | | |
| Duration (min) | 11.51 | 11.52 | | 11.72 | 11.74 | | 11.77 | 11.79 | | 12.68 | 30.77 | | 33.16 | 32.96 | | 20.99 | 19.10 | | 19.13 | 18.76 | | 23.90 | 23.47 | | 32.73 | 34.77 | | 32.30 | 37.50 | | 35.68 | 33.71 | | 45.30 | 28.92 | | 44.44 | 42.83 | | 32.31 | 58.03 | | | | |
| Intensity (mm/h) | 117.57 | 117.52 | | 116.72 | 116.68 | | 116.52 | 116.44 | | 112.91 | 64.20 | | 62.34 | 62.49 | | 81.82 | 87.27 | | 87.18 | 88.66 | | 76.32 | 77.14 | | 59.64 | 61.08 | | 63.01 | 58.95 | | 60.37 | 61.91 | | 52.87 | 66.94 | | 53.54 | 54.80 | | 63.00 | 42.93 | | | | |

Total Peak Flows Pre Development 23811.06 m3/s
Post Development 27754.30 m3/s

**100 YEAR ARI DRAINAGE PROPERTIES - COMBINED**

| Culvert | AREAS (m2) | | | | | | | | | | | | | | | | EFFECTIVE AREA (m2) | | TIME OF CONCENTRATION PRE-DEVELOPMENT | | | | | TIME OF CONCENTRATION POST-DEVELOPMENT | | | | | CRITICAL STORM INTENSITY (mm/h) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Buildings | | Lowlands | | Hardstand, unsealed roads | | Cleared Palusplain | | Vegetated Palusplain | | Cleared Uplands | | Forested Uplands | | Road Reserve | | Total | | | | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope (m/km) | TC (min) | Longest Path (m) | RL Top (mAHD) | RL Bottom (mAHD) | Slope | TC (min) | | |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre Dev | Post Dev | | | | | | | | | | Pre-Dev | Post-Dev |
| **2.20** | 9035 | 11468 | 67975 | 67975 | 22659 | 40291 | 76593 | 53602 | 0 | 2926 | 0 | 0 | 0 | 0 | 84292 | 84292 | 260554 | 260554 | 195752 | 195410 | 1660 | 85 | 49 | 21.39 | 61.4 | 1660 | 85 | 49 | 21.39 | 61.4 | 41.06 | 41.06 |
| **2.28** | 0 | 968 | 142617 | 142617 | 5392 | 13133 | 74176 | 64500 | 70603 | 71571 | 2879828 | 2879828 | 634745 | 634745 | 2875 | 2875 | 3810236 | 3810236 | 1184784 | 1184687 | 6542 | 235 | 49 | 28.43 | 191.0 | 6542 | 235 | 49 | 28.43 | 191.0 | 20.97 | 20.97 |
| **2.39** | 2776 | 3014 | 576 | 0 | 17122 | 24110 | 9663 | 0 | 0 | 3014 | 0 | 0 | 0 | 0 | 3556 | 3556 | 33693 | 33693 | 27117 | 26653 | 218 | 53 | 49 | 16.06 | 10.4 | 218 | 53 | 49 | 16.06 | 10.4 | 121.97 | 121.89 |
| **2.60** | 4530 | 4530 | 3052 | 1668 | 35228 | 23939 | 2207 | 0 | 0 | 3349 | 0 | 0 | 0 | 0 | 0 | 13385 | 45017 | 46871 | 35856 | 36946 | 263 | 53 | 49 | 13.31 | 12.7 | 263 | 53 | 49 | 13.31 | 12.6 | 112.91 | 113.06 |
| **2.89** | 380 | 380 | 183640 | 167304 | 31914 | 31914 | 0 | 0 | 0 | 2240 | 0 | 0 | 0 | 0 | 18350 | 32446 | 234284 | 234284 | 150737 | 153556 | 1355 | 70 | 48 | 16.24 | 54.4 | 1355 | 70 | 48 | 16.24 | 54.3 | 45.78 | 45.86 |
| **3.11** | 479 | 5810 | 368160 | 302181 | 0 | 46477 | 4396 | 0 | 3641 | 5810 | 75326 | 75326 | 0 | 0 | 12380 | 28779 | 464382 | 464382 | 259530 | 272825 | 2822 | 128 | 47 | 28.88 | 95.6 | 2575 | 128 | 47 | 31.65 | 85.2 | 32.86 | 35.35 |
| **3.14** | 1691 | 1243 | 8974 | 0 | 0 | 9943 | 834 | 0 | 2083 | 1243 | 0 | 0 | 0 | 0 | 0 | 1153 | 13582 | 13582 | 8823 | 10741 | 378 | 53 | 46 | 18.52 | 19.6 | 378 | 53 | 46 | 18.52 | 19.2 | 85.19 | 86.72 |
| **3.20** | 0 | 2143 | 0 | 0 | 0 | 17146 | 0 | 0 | 0 | 2143 | 0 | 0 | 0 | 0 | 0 | 3640 | 0 | 25072 | 1 | 19843 | 20 | 46 | 46 | 0.50 | 5.3 | 456 | 54 | 46 | 17.54 | 22.1 | 161.23 | 79.79 |
| **3.52** | 0 | 13832 | 0 | 460463 | 0 | 99687 | 15914 | 0 | 7190 | 12461 | 0 | 469488 | 0 | 0 | 0 | 23733 | 23104 | 1079664 | 17045 | 535786 | 340 | 46 | 44 | 5.59 | 21.0 | 3116 | 129 | 44 | 27.28 | 99.3 | 81.80 | 31.97 |
| **3.64** | 0 | 9921 | 0 | 522370 | 0 | 75044 | 15208 | 0 | 2532 | 9381 | 0 | 422640 | 0 | 0 | 0 | 42518 | 17740 | 1081873 | 13686 | 548820 | 200 | 46 | 44 | 9.50 | 11.4 | 3715 | 125 | 44 | 21.86 | 123.5 | 118.18 | 26.68 |
| **3.89** | 11180 | 22286 | 1554184 | 244371 | 4605 | 178285 | 145713 | 56142 | 59586 | 22286 | 2053478 | 1161350 | 13741 | 13741 | 62387 | 63773 | 3904874 | 1762233 | 1767280 | 769764 | 3756 | 141 | 43 | 26.09 | 107.2 | 3725 | 141 | 43 | 26.31 | 115.3 | 30.08 | 28.12 |
| **Ebrook** | 4688 | 86232 | 554432 | 83633 | 124975 | 685193 | 324083 | 0 | 0 | 85172 | 5150 | 5150 | 0 | 0 | 27343 | 95292 | 1040671 | 1040671 | 719544 | 804824 | 2280 | 87 | 41 | 20.18 | 74.9 | 2280 | 87 | 41 | 20.18 | 74.1 | 37.82 | 38.02 |
| **South** | 2432 | 15201 | 639222 | 565560 | 8045 | 110194 | 117807 | 46611 | 0 | 12769 | 114641 | 114641 | 23577 | 23577 | 57869 | 75041 | 963593 | 963593 | 571807 | 585262 | 1528 | 111 | 54 | 37.30 | 45.4 | 1528 | 111 | 54 | 37.30 | 45.3 | 52.75 | 52.84 |

| **Runoff Coefficients** | **Pre-Dev** | **Post-Dev** |
|---|---|---|
| Buildings | 0.9 | 0.9 |
| Lowlands | 0.6 | 0.6 |
| Hardstand, unsealed roads | 0.8 | 0.8 |
| Cleared Palusplain | 0.8 | 0.8 |
| Vegetated Palusplain | 0.6 | 0.6 |
| Cleared Uplands | 0.3 | 0.3 |
| Forested Uplands | 0.2 | 0.2 |
| Road Reserve | 0.8 | 0.8 |

**Rainfall IFD**

| **Event** | **Duration (mins)** | **Intensity (mm/hr)** |
|---|---|---|
| 5 min | 5 | 164.4 |
| 6 min | 6 | 154 |
| 10 min | 10 | 123.6 |
| 20 min | 20 | 83.7 |
| 30 min | 30 | 64.8 |
| 1 hr | 60 | 41.4 |
| 2 hr | 120 | 27 |
| 3 hr | 180 | 21.4 |
| 6 hr | 360 | 14.4 |
| 12 hr | 720 | 9.5 |
| 24 hr | 1440 | 5.75 |
| 48 hr | 2880 | 3.2 |
| 72 hr | 4320 | 2.2 |

**100 YEAR ARI FLOWS - COMBINED**

| Storm Duration (mins) | 2.20 | | | 2.28 | | | 2.39 | | | 2.60 | | | 2.89 | | | 3.11 | | | 3.14 | | | 3.20 | | | 3.52 | | | 3.64 | | | 3.89 | | | Ebrook | | | South | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) | Pre-Dev Flow (l/s) | Post-Dev Flow (l/s) | Excess Flow (l/s) |
| 5 | 2232.55 | 8923.72 | 6691.16 | 6902.21 | 54100.71 | 47198.50 | 918.70 | 1217.16 | 298.46 | 1124.57 | 1687.22 | 562.64 | 1916.99 | 7012.41 | 5095.42 | 2368.69 | 12450.03 | 10080.34 | 208.80 | 490.52 | 281.72 | 0.04 | 906.18 | 906.13 | 387.32 | 24467.54 | 24080.22 | 449.28 | 25082.80 | 24613.52 | 14764.76 | 35152.56 | 20387.79 | 7558.27 | 36753.63 | 29195.36 | 8379.14 | 26726.97 | 18347.82 |
| 6 | 2232.55 | 8359.20 | 6126.64 | 6902.21 | 50678.28 | 43776.07 | 918.70 | 1140.16 | 221.46 | 1124.57 | 1580.48 | 455.91 | 1916.99 | 6568.80 | 4651.81 | 2368.69 | 11670.87 | 9302.17 | 208.80 | 459.49 | 250.69 | 0.04 | 848.85 | 848.81 | 387.32 | 22919.72 | 22532.40 | 449.28 | 23477.31 | 23028.04 | 14764.76 | 32928.80 | 18164.03 | 7558.27 | 34428.58 | 26870.32 | 8379.14 | 25036.21 | 16657.07 |
| 10 | 2232.55 | 6709.07 | 4476.52 | 6902.21 | 40674.26 | 33772.05 | 918.70 | 915.09 | -3.61 | 1124.57 | 1268.49 | 143.92 | 1916.99 | 5272.10 | 3355.12 | 2368.69 | 9367.01 | 6998.32 | 208.80 | 368.78 | 159.99 | 0.04 | 681.29 | 681.24 | 387.32 | 18395.31 | 18007.99 | 449.28 | 18842.83 | 18393.55 | 14764.76 | 26428.57 | 11663.80 | 7558.27 | 27632.29 | 20074.02 | 8379.14 | 20094.00 | 11714.85 |
| 20 | 2232.55 | 4543.28 | 2310.72 | 6902.21 | 27543.97 | 20641.77 | 918.70 | 619.68 | -299.01 | 1124.57 | 859.00 | -265.57 | 1916.99 | 3570.19 | 1653.20 | 2368.69 | 6343.19 | 3974.50 | 208.80 | 249.74 | 40.94 | 0.04 | 461.36 | 461.31 | 387.32 | 12457.02 | 12069.69 | 449.28 | 12760.07 | 12310.79 | 14764.76 | 17897.01 | 3132.25 | 7558.27 | 18712.16 | 11153.89 | 8379.14 | 13607.34 | 5228.20 |
| 30 | 2232.55 | 3517.38 | 1284.82 | 6902.21 | 21324.37 | 14422.16 | 918.70 | 479.75 | -438.94 | 1124.57 | 665.04 | -459.54 | 1916.99 | 2764.02 | 847.03 | 2368.69 | 4910.86 | 2542.17 | 208.80 | 193.34 | -15.45 | 0.04 | 357.18 | 357.13 | 387.32 | 9644.14 | 9256.82 | 449.28 | 9878.77 | 9429.49 | 14764.76 | 13855.75 | -909.01 | 7558.27 | 14486.83 | 6928.56 | 8379.14 | 10534.72 | 2155.57 |
| 60 | 2232.55 | 2247.21 | 14.66 | 6902.21 | 13623.90 | 6721.70 | 918.70 | 306.51 | -612.19 | 1124.57 | 424.88 | -699.69 | 1916.99 | 1765.90 | -151.09 | 2368.69 | 3137.49 | 768.80 | 208.80 | 123.53 | -85.27 | 0.04 | 228.20 | 228.15 | 387.32 | 6161.53 | 5774.21 | 449.28 | 6311.43 | 5862.15 | 14764.76 | 8852.29 | -5912.48 | 7558.27 | 9255.48 | 1697.21 | 8379.14 | 6730.51 | -1648.63 |
| 120 | 2232.55 | 1465.57 | -766.98 | 6902.21 | 8885.15 | 1982.95 | 918.70 | 199.90 | -718.80 | 1124.57 | 277.10 | -847.48 | 1916.99 | 1151.67 | -765.31 | 2368.69 | 2046.19 | -322.50 | 208.80 | 80.56 | -128.24 | 0.04 | 148.82 | 148.78 | 387.32 | 4018.39 | 3631.07 | 449.28 | 4116.15 | 3666.87 | 14764.76 | 5773.23 | -8991.53 | 7558.27 | 6036.18 | -1522.09 | 8379.14 | 4389.47 | -3989.68 |
| 180 | 2232.55 | 1161.60 | -1070.95 | 6902.21 | 7042.31 | 140.10 | 918.70 | 158.44 | -760.26 | 1124.57 | 219.63 | -904.95 | 1916.99 | 912.81 | -1004.18 | 2368.69 | 1621.80 | -746.90 | 208.80 | 63.85 | -144.95 | 0.04 | 117.96 | 117.91 | 387.32 | 3184.95 | 2797.63 | 449.28 | 3262.43 | 2813.15 | 14764.76 | 4575.82 | -10188.94 | 7558.27 | 4784.23 | -2774.04 | 8379.14 | 3479.06 | -4900.09 |
| 360 | 2232.55 | 781.64 | -1450.92 | 6902.21 | 4738.75 | -2163.46 | 918.70 | 106.61 | -812.08 | 1124.57 | 147.79 | -976.79 | 1916.99 | 614.23 | -1302.76 | 2368.69 | 1091.30 | -1277.39 | 208.80 | 42.97 | -165.83 | 0.04 | 79.37 | 79.33 | 387.32 | 2143.14 | 1755.82 | 449.28 | 2195.28 | 1746.00 | 14764.76 | 3079.06 | -11685.71 | 7558.27 | 3219.30 | -4338.97 | 8379.14 | 2341.05 | -6038.10 |
| 720 | 2232.55 | 515.66 | -1716.89 | 6902.21 | 3126.26 | -3775.95 | 918.70 | 70.33 | -848.36 | 1124.57 | 97.50 | -1027.08 | 1916.99 | 405.22 | -1511.77 | 2368.69 | 719.96 | -1648.74 | 208.80 | 28.35 | -180.45 | 0.04 | 52.36 | 52.32 | 387.32 | 1413.88 | 1026.56 | 449.28 | 1448.28 | 999.00 | 14764.76 | 2031.32 | -12733.44 | 7558.27 | 2123.94 | -5434.43 | 8379.14 | 1544.44 | -6834.70 |
| 1440 | 2232.55 | 312.11 | -1920.44 | 6902.21 | 1892.21 | -5010.00 | 918.70 | 42.57 | -876.13 | 1124.57 | 59.01 | -1065.56 | 1916.99 | 245.26 | -1671.72 | 2368.69 | 435.76 | -1932.93 | 208.80 | 17.16 | -191.64 | 0.04 | 31.69 | 31.65 | 387.32 | 855.77 | 468.45 | 449.28 | 876.59 | 427.31 | 14764.76 | 1229.48 | -13535.28 | 7558.27 | 1285.48 | -6272.78 | 8379.14 | 934.79 | -7444.35 |
| 2880 | 2232.55 | 171.70 | -2058.86 | 6902.21 | 1053.06 | -5849.15 | 918.70 | 23.69 | -895.01 | 1124.57 | 32.84 | -1091.73 | 1916.99 | 136.49 | -1780.49 | 2368.69 | 242.51 | -2126.18 | 208.80 | 9.55 | -199.26 | 0.04 | 17.64 | 17.59 | 387.32 | 476.26 | 88.93 | 449.28 | 487.84 | 38.56 | 14764.76 | 684.23 | -14080.53 | 7558.27 | 715.40 | -6842.87 | 8379.14 | 520.23 | -7858.91 |
| 4320 | 2232.55 | 119.42 | -2113.14 | 6902.21 | 723.98 | -6178.23 | 918.70 | 16.29 | -902.41 | 1124.57 | 22.58 | -1102.00 | 1916.99 | 93.84 | -1823.15 | 2368.69 | 166.73 | -2201.96 | 208.80 | 6.56 | -202.23 | 0.04 | 12.13 | 12.08 | 387.32 | 327.42 | -59.90 | 449.28 | 335.39 | -113.89 | 14764.76 | 470.41 | -14294.35 | 7558.27 | 491.84 | -7066.43 | 8379.14 | 357.66 | -8021.48 |
| **Critical Storm** | **2232.55** | **2228.52** | **-4.04** | **6902.21** | **13510.55** | **6608.34** | **918.70** | **902.45** | **-16.24** | **1124.57** | **1160.32** | **35.75** | 1916.99 | **1956.19** | **39.20** | 2368.69 | **2678.79** | **310.09** | **208.80** | **105.47** | **-103.33** | 0.04 | **439.79** | **439.74** | 387.32 | **4757.67** | **4370.35** | **449.28** | **4066.93** | **3617.65** | 14764.76 | **6013.48** | **-8751.28** | 7558.27 | **8498.85** | **940.58** | 8379.14 | **8589.71** | **210.56** |
| Duration (min) | 61.42 | 61.44 | | 190.99 | 0.00 | | 10.41 | 10.43 | | 12.68 | 12.64 | | 54.38 | 54.28 | | 95.60 | 85.22 | | 19.63 | 85.22 | | 5.30 | 22.07 | | 21.00 | 99.30 | | 11.36 | 123.46 | | 107.18 | 115.32 | | 43.00 | 74.10 | | 30.08 | 45.34 | |
| Intensity (mm/h) | 41.06 | 41.06 | | 20.97 | 0.00 | | 121.97 | 121.89 | | 112.91 | 113.06 | | 45.78 | 45.86 | | 32.86 | 35.35 | | 85.19 | 35.35 | | 161.23 | 79.79 | | 81.80 | 31.97 | | 118.18 | 26.68 | | 30.08 | 28.12 | | 0.00 | 38.02 | | 0.00 | 52.84 | |

Total Peak Flows
Pre Development 47211.33 m3/s
Post Development 54968.71 m3/s

| Culvert Flows | Max Flow | Pre Development | | | Post Development | | |
|---|---|---|---|---|---|---|---|
| | | Inflow(1) | Flow Through | Bypass | Inflow(1) | Flow Through | Bypass |
| **2.20** | 0.26 | 2.23 | 0.26 | 1.97 | 2.23 | 0.26 | 1.97 |
| **2.28** | 14.57 | 8.87 | 8.87 | 0.00 | 15.48 | 14.57 | 0.91 |
| **2.39** | 1.45 | 0.92 | 0.92 | 0.00 | 1.82 | 1.45 | 0.36 |
| **2.60** | 8.06 | 1.12 | 1.12 | 0.00 | 1.52 | 1.52 | 0.00 |
| **2.89** | 1.68 | 1.92 | 1.68 | 0.24 | 1.96 | 1.68 | 0.28 |
| **3.11** | 1.04 | 2.61 | 1.04 | 1.57 | 2.96 | 1.04 | 1.92 |
| **3.14** | 1.40 | 1.78 | 1.40 | 0.38 | 2.02 | 1.40 | 0.62 |
| **3.20** | 0.94 | 0.00 | 0.00 | 0.00 | 1.06 | 0.94 | 0.12 |
| **3.52** | 0.73 | 0.39 | 0.39 | 0.00 | 4.88 | 0.73 | 4.15 |
| **3.64** | 1.73 | 0.45 | 0.45 | 0.00 | 8.21 | 1.73 | 6.49 |
| **3.89** | 3.46 | 14.76 | 3.46 | 11.30 | 12.50 | 3.46 | 9.04 |
| **Ebrook** | 0.00 | 18.86 | 18.86 | 0.00 | 17.54 | 17.54 | 0.00 |
| **South** | 0.00 | 8.38 | 8.38 | 0.00 | 8.59 | 8.59 | 0.00 |

(1) Inflow includes bypass from previous culvert

# APPENDIX I LANDSCAPE MASTER PLAN

# MUCHEA EMPLOYMENT NODE
# PRECINCT 3

# LANDSCAPE MASTER PLAN

**Prepared for**

**Muchea Employment Node**
**Precinct 3 Landowner Group**
c/- Tomahawk Property
8/355 Stirling Hwy
CLAREMONT WA 6010

Report No. J18015c
4 February 2019

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

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## 1.0 INTRODUCTION

The owners of Lots 35, 192, 194 and 800-804 Great Northern Highway, Muchea (the Project Area) have applied to the WAPC for the lots to be rezoned from Rural to Industrial Development. The Muchea Employment Node Structure Plan 2011 (MENSP) showed the eastern parts of the subject lots as future industrial Precinct 3, bordered on the east by Great Northern Highway and on the west by the new Perth-Darwin National Highway (PDNH). Figure 1 shows the location of the Project Area within the Muchea Employment Node Structure Plan.

The owners have submitted a Local Structure Plan (LSP) for Precinct 3. The total area of the rezoning and LSP is approximately 185 hectares. Figure 2 shows an aerial view of the Project Area and surroundings.

The MENSP concept for Precinct 3 is for low water-use industries with a minimum lot size of one hectare. Figure 3 shows a preliminary conceptual plan of subdivision for the Project Area.

Precinct 3 will constitute the southern gateway to the Shire of Chittering. A priority of the Shire Council is that the precinct should present an attractive visual landscape for observers travelling on the main approaches into Chittering. This includes preserving native vegetation where it occurs (mostly roadside trees), landscape plantings within the precinct, building design and layout of development within lots.

The Shire of Chittering has set out its priorities in its *Muchea Industrial Park Design Guidelines* (2018). The Guidelines deal with development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. The Shire of Chittering Town Planning Scheme No. 6 also contains provisions relating to landscape within industrial zones. This Landscape Master Plan recognises and reflects the recommendations of the Design Guidelines and the Scheme provisions.

## 2.0 EXISTING LANDSCAPE

The project area is visible from Great Northern Highway and Brand Highway. The view is screened in part by roadside trees and vegetation within the Project Area. Figure 4 shows views from Great Northern Highway and Brand Highway.

The landscape consists mostly of a mix of cleared paddocks with scattered trees and existing intensive commercial operations including Road Trains of Australia (RTA), Aussie Modular Solutions (AMS) and Inghams' poultry farms. The Perth-Darwin National Highway (PDNH) works have caused a major change to the landscape, particularly near the northern end of the project area.

## 3.0 LANDSCAPING STRATEGY

Landscaping of the Project Area will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot) and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted in public areas, although individual lot owners may choose to plant grass. Lawn areas will not count towards the landscaping requirement on each lot.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation and drought tolerant native species including sedges and low shrubs in order to stabilise the swales and maximise their ability to immobilise nutrients and sediments from the water.

The immediate surrounds of Ellen Brook (extending up to 30m from the watercourse) and the drainage/landscape reserve will be densely planted with native trees, sedges, shrubs and other understorey species in order to slow and filter runoff that is not captured by the road drainage system.

The total area to be planted is approximately 32 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 144 ML of water would be required to irrigate the new plantings in the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year.

The density of planting within 100m of lots will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (Eco Logical Australia, 2018).

Figure 5 shows an overview of the Landscape Master Plan.

## 4.0 LANDSCAPING ZONES

### 4.1 Great Northern Highway

The Great Northern Highway road reserve includes a partly-vegetated verge 15m to 30m wide adjacent to Precinct 3. The verge supports remnant native trees including mature Wandoo, Marri and Flooded Gum. The understorey is degraded and consists mostly of weeds including Veldt Grass, Watsonia and pasture grasses.

With the completion of the PDNH, Great Northern Highway is likely to experience a substantial reduction in traffic, although it will still be used for oversize vehicles and will retain its Main Roads status.

The road verge trees play an important role in breaking up and softening the view of the industrial area from the Highway. There are, however, a number of gaps ranging from a few tens of metres up to 100m where no trees remain. The priority for landscaping in the road reserve is to protect and retain the existing trees and to control weeds in the understorey.

The road reserve is currently classed as “Grassland” under the Bushfire Management Plan, with a moderate fire hazard rating. This classification is due to the spacing of the existing trees, the separation of canopies and the absence of a mid-storey. The fire hazard would be increased by any substantial increase in the overstorey canopy density or by an increased understorey. The hazard could be reduced if the road reserve were managed to reduce the height of the grass ground cover.

### 4.2 Perth-Darwin National Highway

The PDNH, to be opened in 2019, will be the new major arterial route from Perth to the north and is expected to carry the majority of both heavy and light vehicle traffic (except oversize vehicles). Lots within Precinct 3 will not have frontage or direct access to the PDNH; all access will be via the interchange located about 1km north of the Precinct.

The PDNH is being constructed on a substantial embankment and as a result will offer views over much of Precinct 3.

The landscape objective for the PDNH is to create partial screening to break up and soften the views into the Precinct, without blocking the views altogether. This will be achieved by planting shrubs and widely-spaced trees in the overflow drainage swale within the subdivisional road adjacent to the PDNH and, in the north, at the rear of lots adjacent to the PDNH.

The density of planting in the PDNH buffer will be constrained by the need to limit flammable fuel loads as set out in the Bushfire Management Plan (Eco Logical Australia, 2018).

### 4.3 Entry Statement

A small (0.5ha) triangular reserve in the south-east corner of the precinct will act as the entry statement to the Precinct from the south, as well as protecting a small creek line crossing the corner of the Project Area. This reserve will be planted with sedges, small shrubs and scattered trees.

### 4.4 Bioretention Swales

Bioretention swales varying in width from 4m to 10m will be located on one side of all roads within the Precinct, as well as two dedicated 15m wide drainage corridors. The swales will carry runoff from the roads, excess lot runoff and, in some cases, flows from catchments to the east.

The swales will be densely planted with native sedges, small (<2m) shrubs and widely-spaced small trees to stabilise the swales, slow the water flows and maximise the uptake of sediments and nutrients from the water. Figure 6 shows conceptual profiles of the roadside swales.

### 4.5 Lots

The Shire of Chittering's Design Guidelines set out the Shire's requirements and recommendations for landscaping within lots. Other requirements arise from provisions for drainage and effluent disposal within the lots.

The general landscaping within lots will include:

- a minimum 2m wide landscape buffer on the primary road frontage;
- a minimum 1m wide landscape buffer on secondary road interface and side boundaries extending to the building setback line;
- one shade tree per four car parking bays;
- one tree per 10m of road frontage;
- a bioretention swale to hold the 1-year ARI 1-year storm, typically measuring about 3% of the total area of the lot;
- an effluent disposal area (probably ATU irrigation area) planted with low shrubs, with size depending on the lot workforce (about 23m$^2$ per full-time employee); and
- other landscape plantings to a total of 10% of the area of the lot.

Plantings within lots will generally feature sedges and other ground covers, low shrubs (<2m) and widely spaced trees in order to comply with the requirements of the Bushfire Management Plan. It is noted that the Design Guidelines requirement for one tree every 10m of road frontage may, depending on the size of the trees, exceed the permissible canopy density for "Shrubland" under the Bushfire Management Plan. It is proposed instead to space trees 15m apart in all areas within 100m of lots.

Figure 7 shows an indicative layout of landscape plantings for a typical lot.

### 4.6 Drainage/Landscape Reserve

The drainage/landscape reserve in the south-west of the Project Area, measuring 8.4ha, will accommodate the 100-year floodway of Ellen Brook as well as excess runoff from the industrial area during a 100-year storm. The reserve will be planted in a similar way to the swales, with dense sedges, shrubs and trees.

In the eastern part of the reserve within 100m of lots, shrub plantings will be limited to species less than 2m in height and trees will be spaced at least 15m apart to create less than 10% canopy cover, in line with the recommendations of the Bushfire Management Plan. In areas more than 100m from lots, the planting will be unrestricted and will include larger shrubs and a greater density of trees. Figure 8 shows the planting zones within the reserve.

### 4.7 Ellen Brook Foreshore Reserve

The Project Area abuts Ellen Brook for a length of about 600m south and east of the PDNH crossing. The foreshore supports remnant native vegetation but is degraded due to past clearing and cattle grazing, with high levels of weed invasion and loss of most native understorey species.

The priorities for landscaping in the foreshore reserve will be to maintain and improve the stability of the watercourse, control invasive weeds and re-establish native riparian species. Figure 8 shows the foreshore area to be rehabilitated.

## 5.0 SPECIES SELECTION AND PLANTING DENSITY

Species to be planted in the Project Area will be local native species, with species for specific areas selected for their height and inundation and/or drought tolerance. Recommended species for each situation are listed below:

### 5.1 Entry Statement

- Planting area approx. 0.5ha.
- Planted with sedges & herbs, small shrubs and scattered trees.

*Sedges & Herbs*

- Planting density 2,500/ha (2m spacing).
- Recommended species:

| | |
|---|---|
| *Hypolaena exsulca* | *Lyginia imberbis* |
| *Juncus kraussii* | *Patersonia occidentalis* |
| *Lepidosperma longitudinale* | *Phlebocarya ciliata* |

*Low Shrubs (<2m)*

- Planting density 2,500/ha (2m spacing).
- Recommended species:

| | |
|---|---|
| *Acacia lasiocarpa* | *Phyllanthus calycinus* |
| *Hibbertia hypericoides* | *Xanthorrhoea preissii* |
| *Hypocalymma angustifolium* | |

*Tall Shrubs (>2m) and Trees*

- Planting density <50/ha (15m spacing).
- Recommended species:

| | |
|---|---|
| *Allocasuarina fraseriana* | *M. teretifolia* |
| *Corymbia calophylla* | *M. preissiana* |
| *Eucalyptus wandoo* | *M. rhaphiophylla* |
| *Gastrolobium ebracteolatum* | *Viminaria juncea* |
| *Melaleuca incana* | |

### 5.2 Swales and Basins

- Includes in-lot 1-yr ARI basins, roadside swales and through-flow swales.
- Planting area approx. 10.1ha.
- Densely planted with sedges, herbs, low shrubs and scattered small trees.
- “Shrubland” classification.

*Sedges & Herbs*

- Planting density 10,000/ha (1m spacing)

- Recommended species:

| | |
|---|---|
| *Baumea articulata* | *Juncus kraussii* |
| *Baumea juncea* | *Juncus pallidus* |
| *Conostylis aculeata* | *Lepidosperma longitudinale* |
| *Dasypogon bromeliifolius* | *Lyginia imberbis* |
| *Gahnia trifida* | *Patersonia occidentalis* |
| *Hypolaena exsulca* | *Phlebocarya ciliata* |

*Shrubs (<2m)*

- Planting density 2,500/ha (2m spacing)
- Recommended species:

| | |
|---|---|
| *Acacia lasiocarpa* | *Phyllanthus calycinus* |
| *Hibbertia hypericoides* | *Regelia ciliata* |
| *Hypocalymma angustifolium* | *Xanthorrhoea preissii* |

*Tall Shrubs (>2m) and Trees*

- Planting density <50/ha (15m spacing).
- Recommended species:

| | |
|---|---|
| *Acacia saligna* | *Melaleuca rhaphiophylla* |
| *Casuarina obesa* | *Viminaria juncea* |
| *Melaleuca preissiana* | |

### 5.3 Effluent Irrigation Areas

- Planting area approx. 2.5ha (depending on workforce on individual lots).
- Planted with dense low shrubs, sedges &herbs.
- “Shrubland” classification.

*Sedges & Herbs*

- Planting density 10,000/ha (1m spacing).
- Recommended species:

| | |
|---|---|
| *Hypolaena exsulca* | *Lyginia imberbis* |
| *Juncus kraussii* | *Patersonia occidentalis* |
| *Lepidosperma longitudinale* | *Phlebocarya ciliata* |

*Low Shrubs (<2m)*

- Planting density 2,500/ha (2m spacing).
- Recommended species:

| | |
|---|---|
| *Acacia lasiocarpa* | *Phyllanthus calycinus* |
| *Hibbertia hypericoides* | *Regelia ciliata* |
| *Hypocalymma angustifolium* | *Xanthorrhoea preissii* |

## 5.4 Lot Landscaping

- Planting area approx. 8.4ha.
- Includes front & side boundary landscape buffers and other plantings to total 10% of lot area.
- Planted with sedges & herbs, low shrubs and scattered trees.
- "Shrubland" classification.

*Sedges & Herbs*

- Planting density 2,500/ha (2m spacing).
- Recommended species:

| | |
|---|---|
| *Hypolaena exsulca* | *Lyginia imberbis* |
| *Juncus kraussii* | *Patersonia occidentalis* |
| *Lepidosperma longitudinale* | *Phlebocarya ciliata* |

*Low Shrubs (<2m)*

- Planting density 2,500/ha (2m spacing).
- Recommended species:

| | |
|---|---|
| *Acacia lasiocarpa* | *Phyllanthus calycinus* |
| *Hibbertia hypericoides* | *Xanthorrhoea preissii* |
| *Hypocalymma angustifolium* | |

*Tall Shrubs (>2m) and Trees*

- Planting density <50/ha (15m spacing).
- Recommended species:

| | |
|---|---|
| *Allocasuarina fraseriana* | *M. teretifolia* |
| *Casuarina obesa* | *M. preissiana* |
| *Corymbia calophylla* | *M. rhaphiophylla* |
| *Eucalyptus rudis* | *Gastrolobium ebracteolatum* |
| *E. wandoo* | *Viminaria juncea* |
| *Melaleuca incana* | |

## 5.5 Drainage/Landscape Reserve

### 5.5.1 Reduced Fuel Zone

- Planting area approx. 5.9ha.
- Within 100m of lots.
- Planted with sedges, herbs, low shrubs (<2m) and scattered trees (<10% cover).
- "Shrubland" classification.

*Sedges & Herbs*
- Planting density 10,000/ha (1m spacing).
- Recommended species as for swales.

*Low Shrubs (<2m)*
- Planting density 2,500/ha (2m spacing).
- Recommended species as for swales.

*Tall Shrubs (>2m) and Trees*
- Planting density <50/ha (15m spacing).
- Recommended species as for swales.

### 5.5.2 Unrestricted Zone

- Planting area approx. 2.5ha.
- More than 100m from lots.
- Planted with sedges & herbs, shrubs and trees.
- "Woodland" classification.

*Sedges & Herbs*
- Planting density 10,000/ha (1m spacing).
- Recommended species as for swales.

*Shrubs*
- Planting density 400/ha (5m spacing).
- Recommended species:

| | |
|---|---|
| *Acacia lasiocarpa* | *Melaleuca incana* |
| *Acacia saligna* | *Melaleuca teretifolia* |
| *Hakea prostrata* | *Gastrolobium ebracteolatum* |
| *Hibbertia hypericoides* | *Pericalymma ellipticum* |
| *Hypocalymma angustifolium* | *Phyllanthus calycinus* |
| *Jacksonia furcellata* | *Regelia ciliata* |
| *J. sternbergiana* | *Viminaria juncea* |
| *Kunzea glabrescens* | *Xanthorrhoea preissii* |

*Trees*
- Planting density 50/ha (50m spacing).

- Recommended species:

| | |
|---|---|
| *Allocasuarina fraseriana* | *Eucalyptus rudis* |
| *Casuarina obesa* | *Melaleuca. preissiana* |
| *Corymbia calophylla* | *M. rhaphiophylla* |

### 5.6 Ellen Brook Foreshore

- Planting area approx. 1.6ha.
- Planted with sedges & herbs, shrubs and trees.
- Infill planting between existing native species.
- Weed control prior to planting.
- "Woodland" classification.

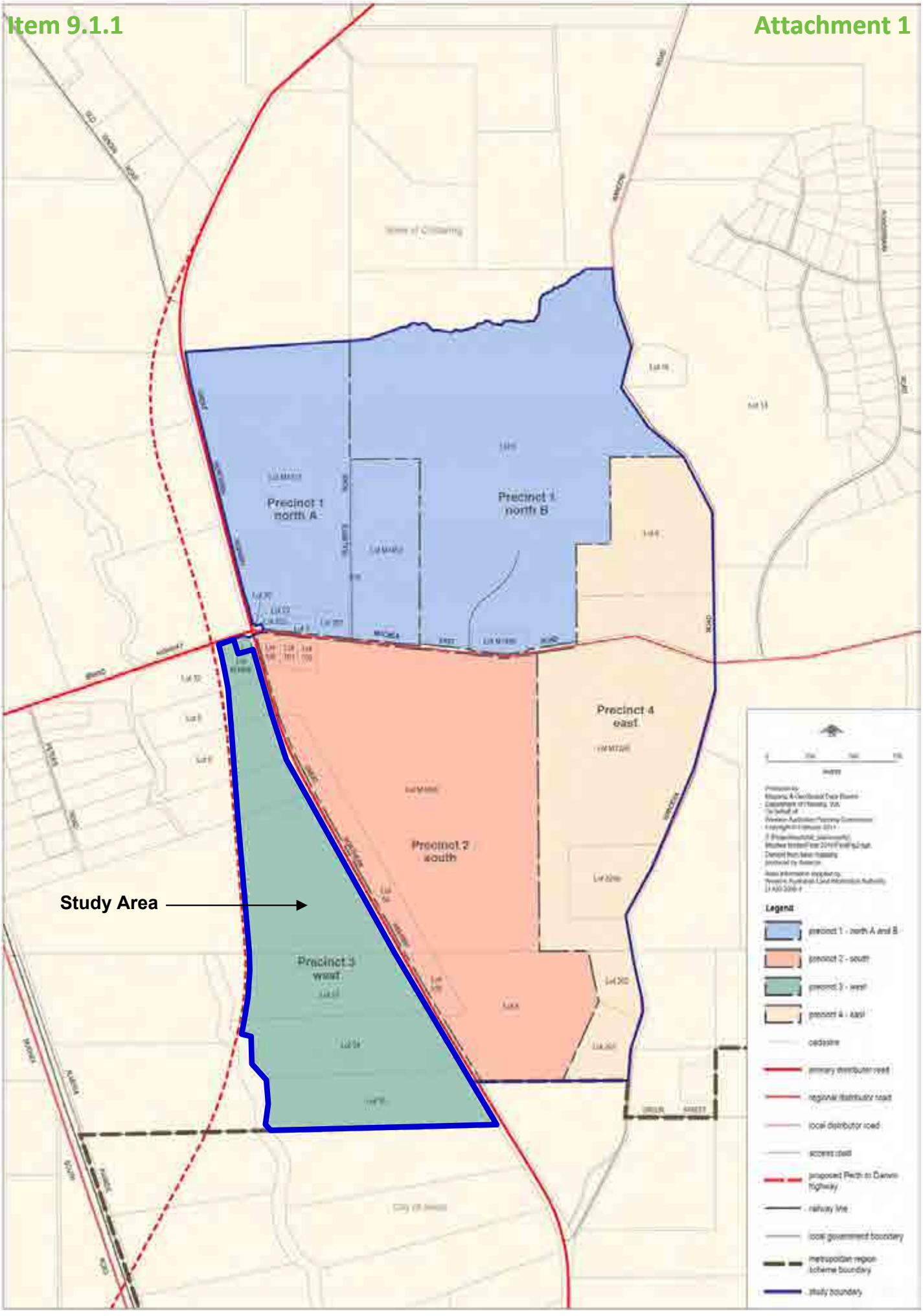
*Sedges & Herbs*

- Planting density up to 10,000/ha (1m spacing), in clumps.
- Recommended species:

| | |
|---|---|
| *Baumea articulata* | *Lepidosperma longitudinale* |
| *Baumea juncea* | *Lyginia imberbis* |
| *Hypolaena exsulca* | *Patersonia occidentalis* |
| *Juncus kraussii* | *Phlebocarya ciliata* |
| *Juncus pallidus* | |

–

# Figures




Source: WAPC, 2011

**Figure 1**

**MUCHEA EMPLOYMENT NODE STRUCTURE PLAN**

**Figure 2**

**THE PROJECT AREA AND SURROUNDINGS**

Image: Google Earth

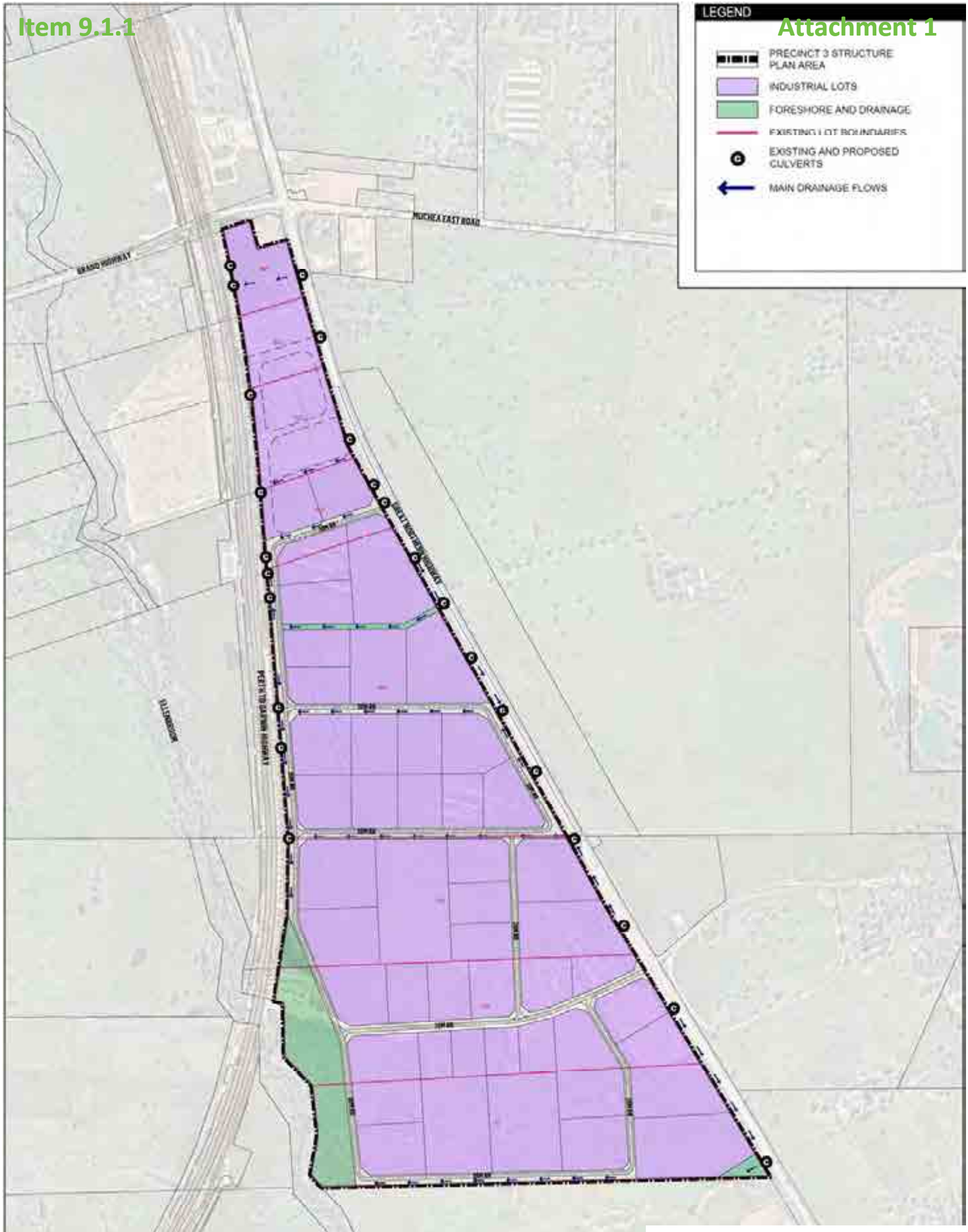



**Figure 3**

**SUBDIVISION CONCEPT**

URBIS

bayley environmental services

Lot 35 from Great Northern Highway

Lot 192 (RTA) from Great Northern Highway

Lot 800 (Inghams) from Great Northern Highway

Lot 803 (AMS) from Great Northern Highway

Lot 804 from Great Northern Highway

**Figure 4**

**VIEWS OF THE PROJECT AREA**

All images: Google

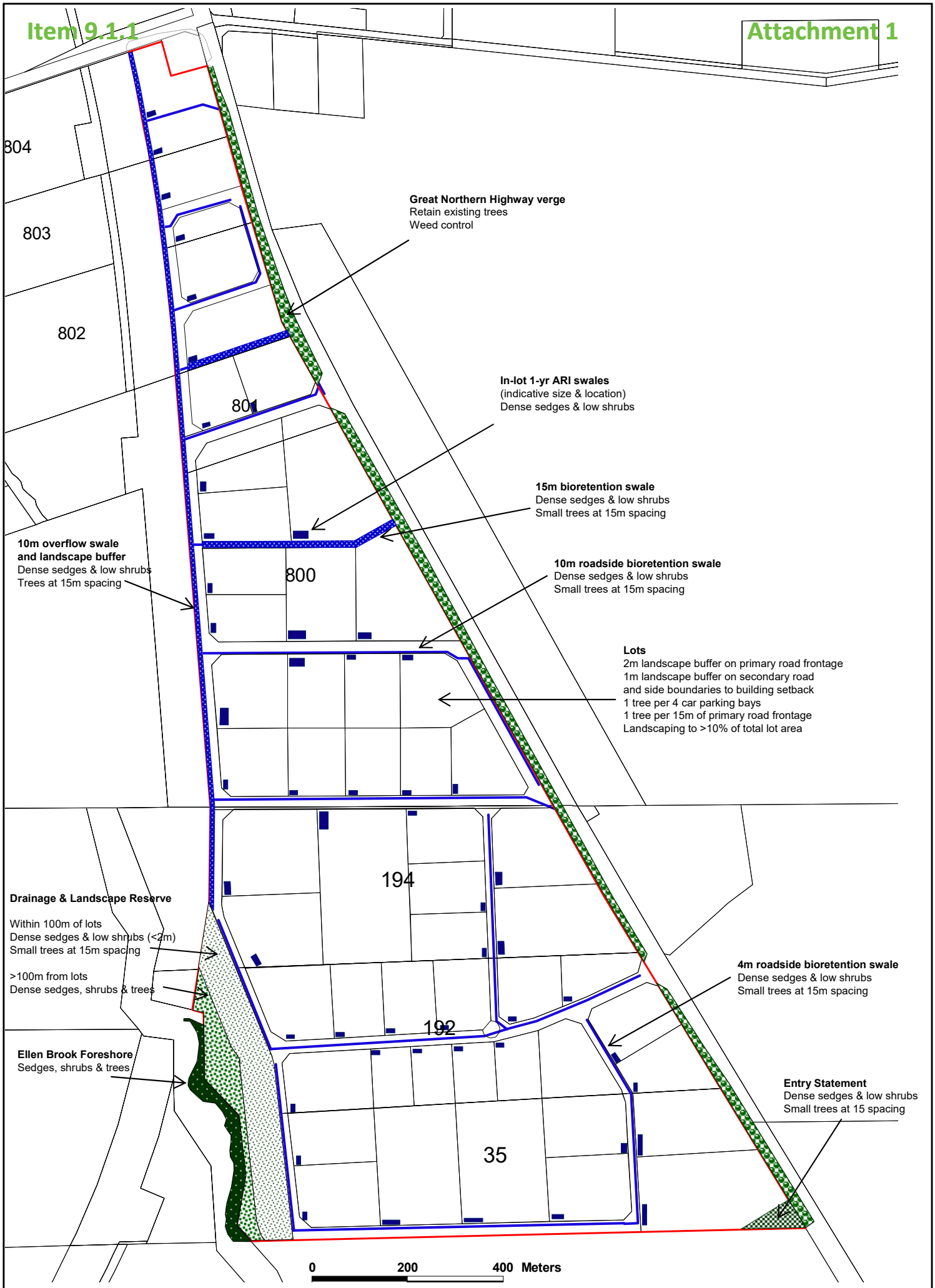



**Figure 5**

**LANDSCAPE MASTER PLAN**

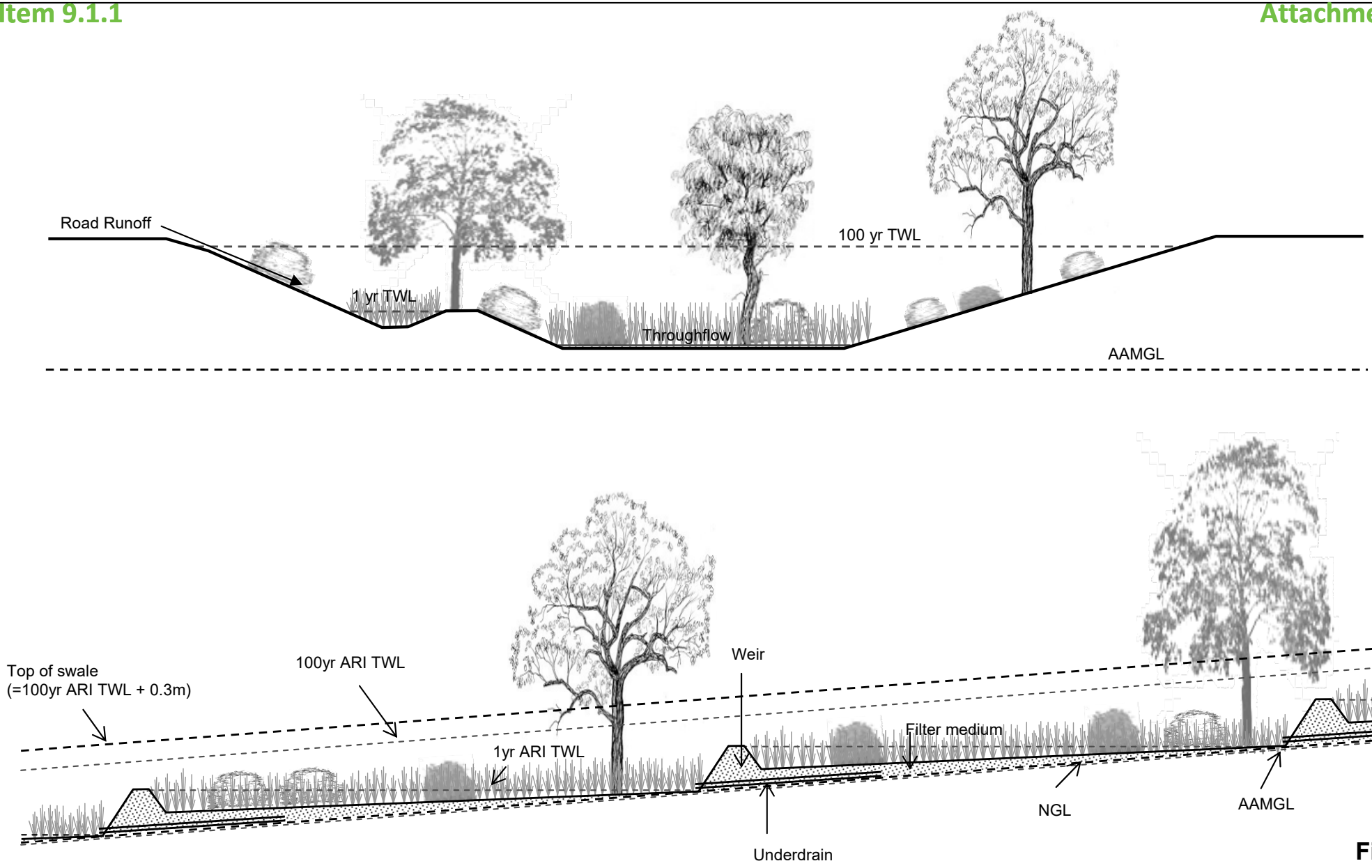



**Figure 6**

**BIORETENTION SWALES**

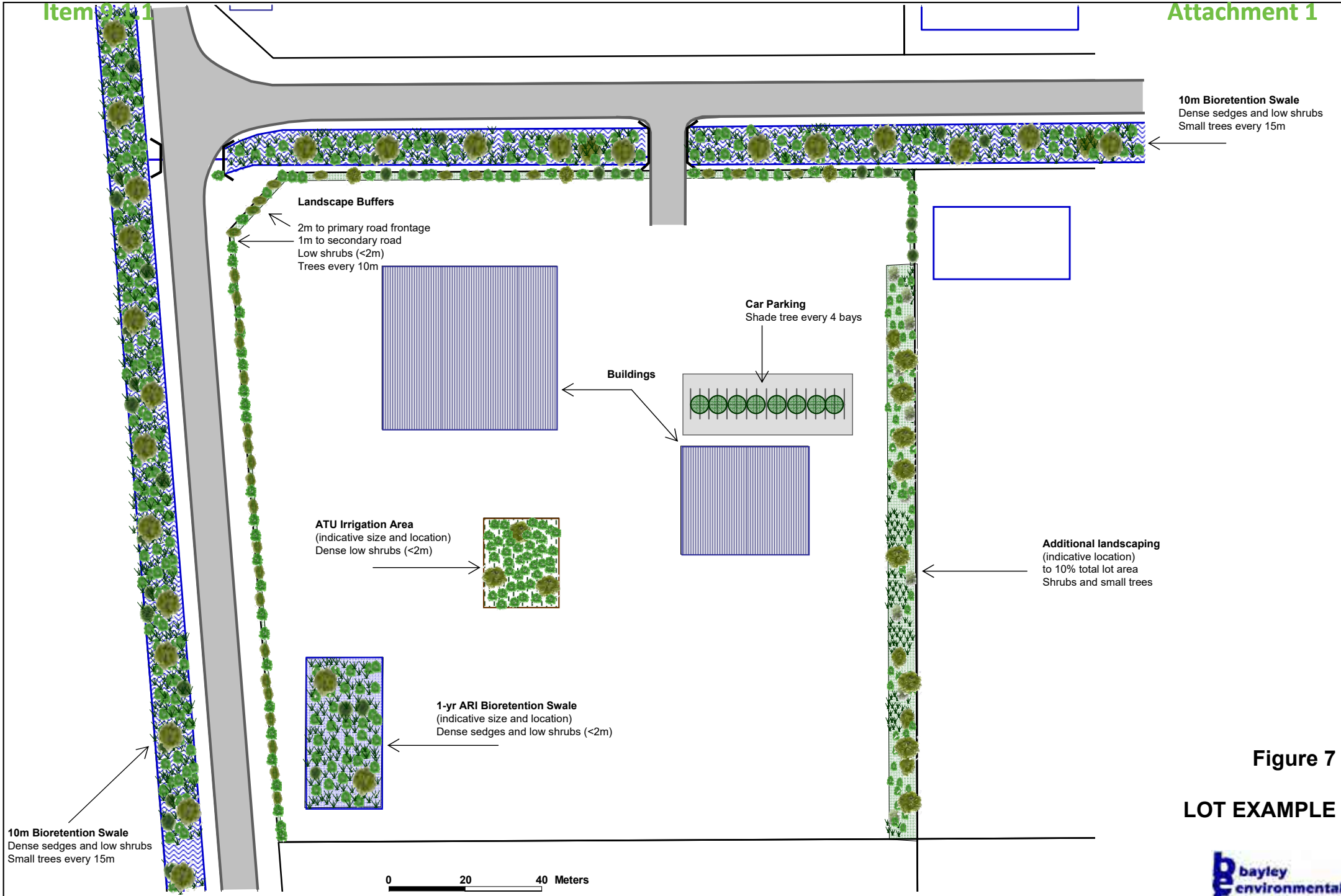



**Figure 7**

**LOT EXAMPLE**

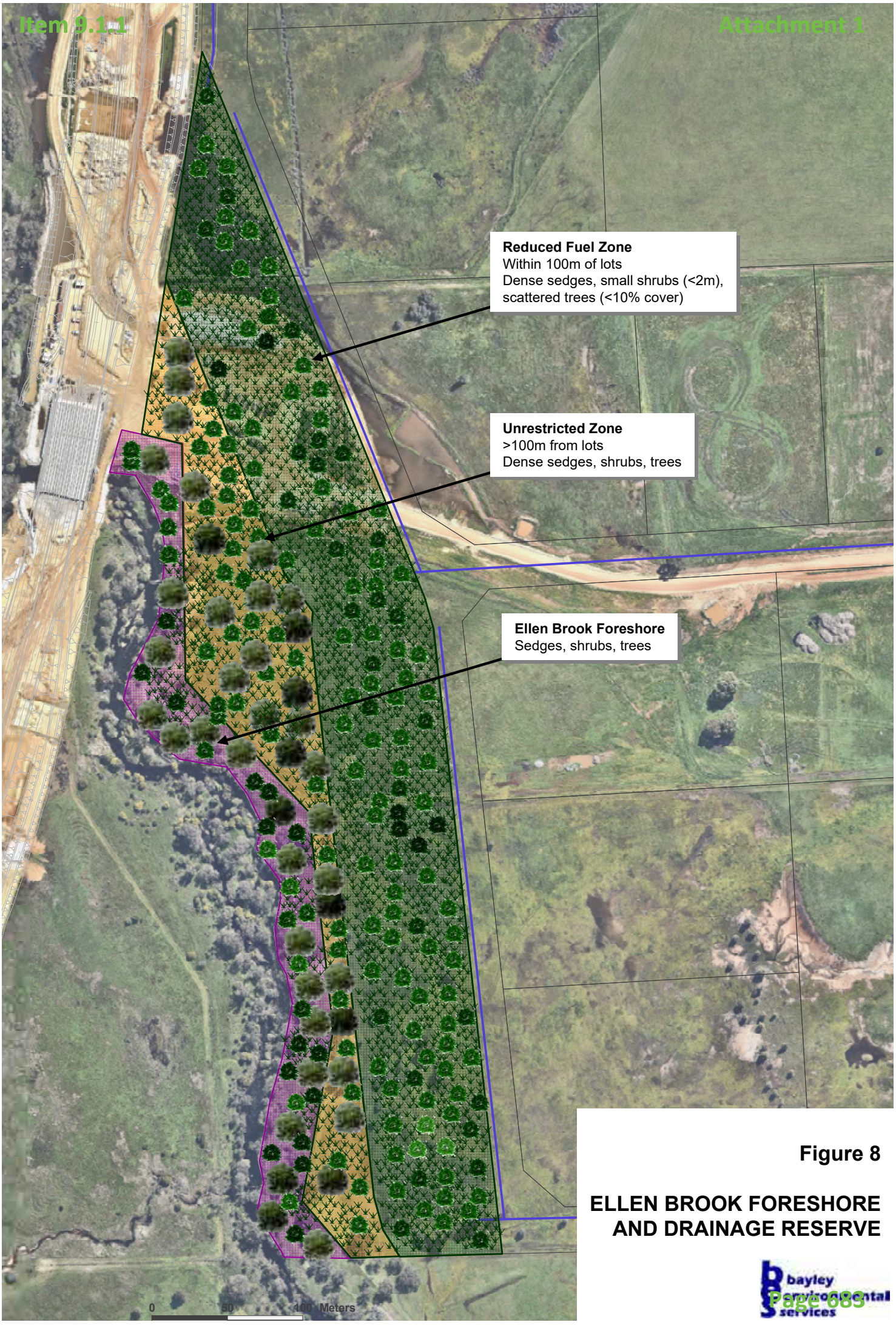



**Figure 8**

**ELLEN BROOK FORESHORE AND DRAINAGE RESERVE**

bayley environmental services

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# Planning and Development Act 2005

## RESOLUTION TO AMEND LOCAL PLANNING SCHEME

***Shire of Chittering Local Planning Scheme No.6***
***Amendment No.67***

**Resolved that the Local Government pursuant to section 75 of the *Planning and Development Act* 2005, amend the above Local Planning Scheme by:**

4. ***Rezoning Lots M1601, 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Industrial Development' zone.***

   ***And amending the Scheme Maps accordingly.***

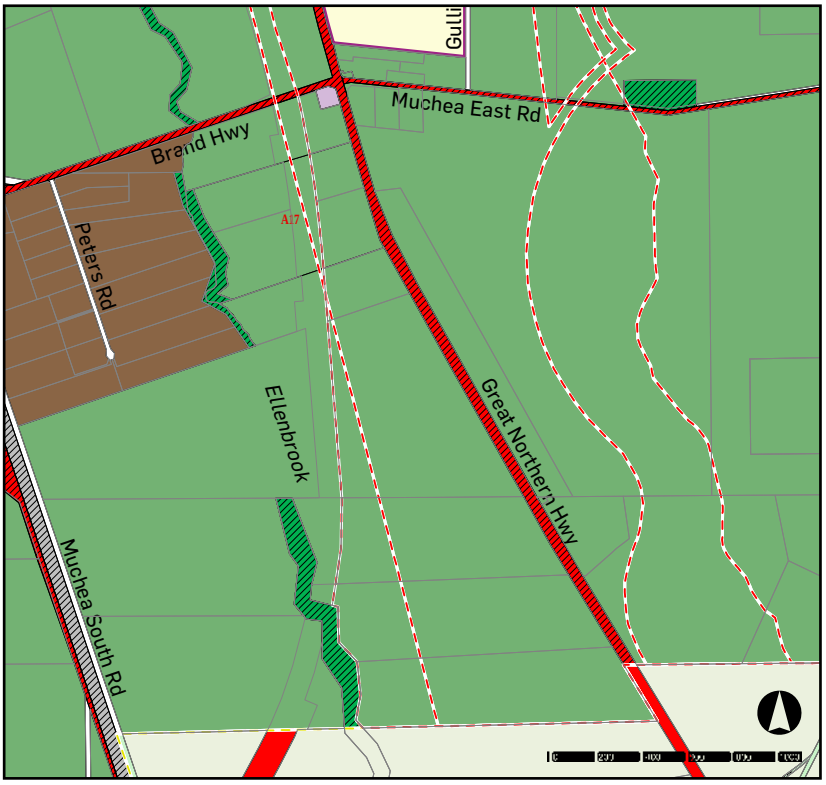
5. ***Amending clause 5.1.1 Operation of Special Control Areas to include 'Muchea Employment Node' as new dot point 6; and reflecting Precinct 3 of the Muchea Employment Node on the Scheme Maps accordingly.***

6. ***Amending Schedule 11 – Muchea Employment Node Special Control Area of Local Planning Scheme No.1 to add Precinct 3, by including provisions for Precinct 3 of the Muchea Industrial Precinct No.1 as follows:***

| NO. | DESCRIPTION OF LAND | CONDITIONS |
|---|---|---|
| 2. | Precinct 3 (P3) of the Muchea Employment Node | **1. Hierarchy of Plans**<br>Structure planning, subdivision and development shall be undertaken in accordance with the Scheme.<br>2. **Water Supply**<br>A reticulated water supply provided by a licensed operator shall be provided at the first stage of subdivision.<br>**3. Loop Road**<br>i. An internal loop road, constructed to accommodate RAV10 vehicles shall be constructed to the satisfaction of the Shire of Chittering and MRWA.<br>At the time of subdivision of each lot within P3 which contains portion of the Loop Road, provision shall be made for the construction and gazettal of that portion of road to RAV10 standard, within the lot boundaries. Construction and gazettal of that portion of Loop Road may occur on a staged basis within the subdivision area.<br>ii. Suitable arrangements for drainage shall be made to the satisfaction of the Shire of Chittering, where land is developed on a staged basis.<br>iii. The subdivision application shall demonstrate that a suitable sealed or unsealed temporary turning circle can be provided within the boundaries of that parent lot until such time as the entire loop road is constructed which will allow RAV10 vehicles to travel along its entire length.<br>At that time, the temporary turning circle shall be removed and the land suitably remediated. Such requirement shall be specified as a condition of subdivision approval.<br>iv. The Shire of Chittering shall not approve a development application over those lots containing portions of the Loop Road, unless the Loop Road has been constructed and ceded in accordance with the Structure Plan.<br>**4. Land Use Permissibility**<br>Land use permissibility within Precinct 3 shall be in accordance with the General Industrial Zone of LPS6 (as amended). |

| NO. | DESCRIPTION OF LAND | CONDITIONS |
|---|---|---|
| | | The following uses may also be considered within P3, in accordance with their applicable permissibility as outlined below:<br>Animal Establishment (D)<br>Concrete Batching Plant (D)*1<br>Fast Food Outlet (D)*2<br>Garden Centre (P)<br>Shop (I)<br>Transport Depot (P)*3.<br>1. Concrete Batching Plant means 'premises on which concrete is batched for concrete products manufactured on site for use at places other than the subject site, and includes storage of associated products and ancillary office use'<br>2. Only where the use is located abutting Great Northern Highway, and associated with a Convenience Store and/or Service Station<br>3. In the case of 'Transport Depot', accommodation for a site manager and drivers' accommodation will be allowed, in order to accommodate critical operational requirements of these businesses, ancillary to the Transport Depot use.<br>All other uses are 'X' (not permitted) |

# SHIRE OF CHITTERING
# LOCAL PLANNING SCHEME NO. 6
# AMENDMENT NO. 67

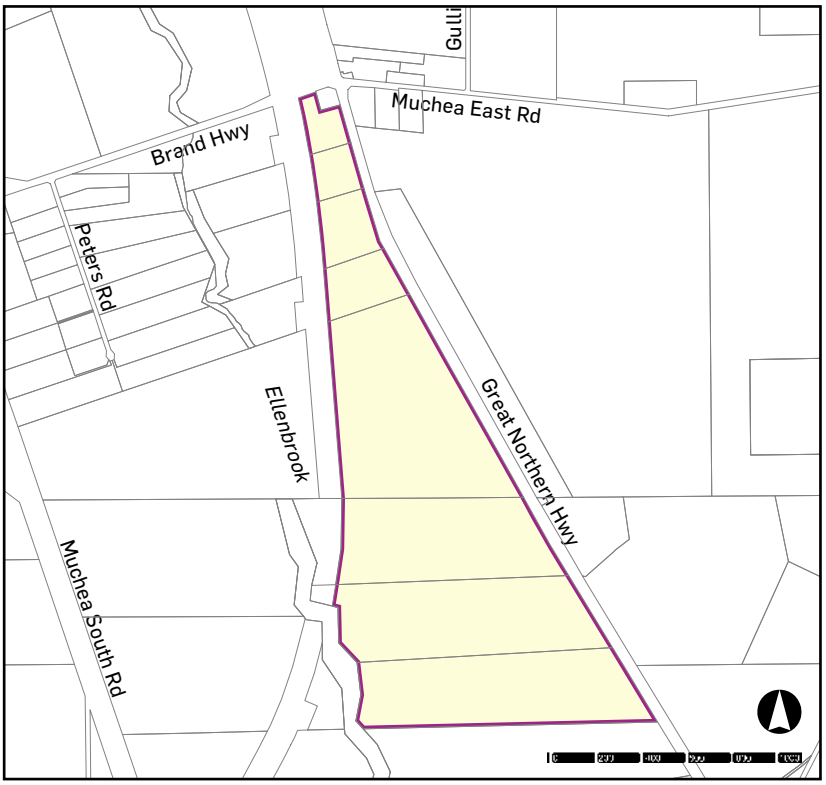



**LEGEND:**

LPS - ZONES AND RESERVES

- Special Control Area
- Agricultural Resource
- Highway
- Industrial Development
- Light Industrial
- Parks and Recreation
- Railway
- Rural Residential

**EXISTING SCHEME**




**LEGEND:**

LPS - ZONES AND RESERVES

- Special Control Area
- Agricultural Resource
- Highway
- Industrial Development
- Light Industrial
- Parks and Recreation
- Railway
- Rural Residential

**PROPOSED SCHEME**

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## LPS AMENDMENT
## MUCHEA EMPLOYMENT NODE

**DATE:** 21.01.2019
**JOB NO:** P02540
**DWG NO:** DWG-11
**REV:** B

**FORM 6A**

**COUNCIL ADOPTION**

**This Standard Amendment was adopted by resolution of the Council of the Shire of Chittering at the Ordinary Meeting of the Council held on the …….. day of ……., 20……**

**.....**

**SHIRE PRESIDENT**

**.....**

**CHIEF EXECUTIVE OFFICER**

**COUNCIL RESOLUTION TO ADVERTISE**

**by resolution of the Council of the Shire of Chittering at the Ordinary Meeting of the Council held on the ……. day of ……., 20..... proceed to advertise this Amendment.**

**.....**

**SHIRE PRESIDENT**

**.....**

**CHIEF EXECUTIVE OFFICER**

**COUNCIL RECOMMENDATION**

**This Amendment is recommended for support/not to be supported by resolution of the Shire of Chittering at the Ordinary Meeting of the Council held on the …… day of ……., 20…… and the Common Seal of the Shire of Chittering was hereunto affixed by the authority of a resolution of the Council in the presence of:**

**.....**

**SHIRE PRESIDENT**

**.....**

**CHIEF EXECUTIVE OFFICER**

**WAPC ENDORSEMENT (r.63)**

**.....**

**DELEGATED UNDER S.16 OF THE P&D ACT 2005**

**DATE.....**

**FORM 6A - CONTINUED**

**APPROVAL GRANTED**

**.....**

**MINISTER FOR PLANNING**

**DATE.....**

URBIS

LEVEL 14
1 WILLIAM STREET
PERTH WA 6000

URBIS.COM.AU
Urbis Pty Ltd
ABN 50 105 256 228

Tom Carmody
Director & Licensee
Tomahawk Property
PO Box 36
Cottesloe, WA 6911

Via email: tcarmody@tomahawkproperty.com.au

6 November 2019

Dear Tom,

# RE: MUCHEA EMPLOYMENT NODE – PRECINCT 3: RAV 10 LOOP ROAD LOCATION

Further to our previous liaison, we provide the following on the rationale for the location of the RAV 10 Loop Road for Precinct 3.

The proposed location of the RAV 10 Loop Road has been carefully considered in thorough consultation with the Shire of Chittering, Department of Planning Lands and Heritage and individual landowners. From a technical perspective, there are two primary drivers for the location of loop road, which are discussed in further detail below.

## HYDROLOGY AND TOPOGRAPHY

The land within Precinct 3 of the Muchea Employment Node generally grades from east to west in direction. The site also includes several major drainage alignments conveying water from east of Great Northern Highway in a westerly direction towards the Ellen brook. Wherever possible, we have sought to co-locate these east-west drainage functions with road alignments (including loop road alignments); an approach consistent with the Western Australia Planning Commission's Better Urban Water Management Guidelines.

The Perth to Darwin Highway (North Link) intersects these natural east-west drainage alignments and includes predetermined culvert locations. The highway essentially acts as a large bund which results in drainage needing to be located adjacent the highway to direct water towards these culverts. During the design consultation process the Shire of Chittering indicated that back of lot drainage reserves and easements (within lots) would not be supported adjacent the highway as convenient access to the drainage will required at all times. Again, consistent with the principles of Better Urban Water Management, together for the reason of access, a north-south parallel road is proposed adjacent the highway.

The narrow nature of the precinct impacts on the ability to have major centralized north-south road connection, in addition to the north-south connection running parallel with the North Link. The provision of an additional north-south road would also generate the need for controlled 4-way

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intersections; which are not considered necessary and have a significant implication on project feasibility.

## ACCESS POINTS

Another key driver in terms of loop road location is access to Great Northern Highway (GNH). The current design provides two access points to GNH. The southern access point is located in accordance with the existing access to lot 192, which already has been upgraded to Main Roads WA standards and therefore is a logical location for southern access. The most northern access point has been located to provide convenient access to the northern portion of the precinct and accommodate a main drainage alignment. The northern access point has been shared between two landowners (Karratha and Ingham) to provide for flexibility in terms of timing of subdivision.

Overall, the placement of the loop road was the subject of careful consideration of both technical and landowner requirements and intentions. Importantly, from a staging perspective, it will allow all landowners to proceed with at least some subdivision/development prior to the completion of the entire road.

Kind regards,

Kris Nolan
Director
08 9346 0508
knolan@urbis.com.au

Containment Area
Approximately 2 acres in area
KEY
Blue: Boundary of property, standard 1.2m Ring-Lock fencing
Yellow: PetSafe Dog Containment System (electric line which signals to collar)

# SHIRE OF CHITTERING

# TOWN PLANNING SCHEME NO. 6

## Local Planning Policy No. 10

# BASIC RAW MATERIALS and EXTRACTIVE INDUSTRIES

# SHIRE OF CHITTERING
# LOCAL PLANNING POLICY No. 10
# BASIC RAW MATERIALS and EXTRACTIVE INDUSTRIES

## 1. STATUTORY CONTEXT

The Shire of Chittering's Town Planning Scheme No. 6 (Scheme) controls basic raw materials through clauses 4.2.3, 5.16 and 6.4. The Shire makes this Local Planning Policy No 10 regarding Basic Raw Materials and Extractive Industries (Policy) under Part 2 of the Scheme.

If any provision of this Policy is inconsistent with the Scheme then the Scheme prevails. This Policy is not part of the Scheme and shall not bind the Shire in any respect of an application for Planning Approval. The Shire shall, however, have due regard to the provisions of this Policy and the objectives that this Policy is designed to achieve before making its decision.

This policy applies to all commercial extraction of basic raw materials on all land within the Shire's district and supersedes Local Planning Policy No. 10 - Basic Raw Materials and Extractive Industries adopted 20 December 2006.

## 2. DEFINITIONS

Unless the context otherwise requires, words and expressions used in this Policy have the same meaning as they have in the Scheme.

The following are definitions that relate directly to the application of this policy:

*"Basic Raw Materials"* means sand (including silica sand), clay, hard rock, limestone (including metallurgical limestone) and gravel and other construction and road building materials.

*"By-law"* means Shire of Chittering By-law Relating to Extractive Industries approved by the Governor 16 July 1996;

*"Council"* means the Council of the Shire of Chittering;

*"Extractive Industry"* means an industry which involves the extraction, quarrying or removal of sand, gravel, clay, hard rock, stone or similar material from the land and includes the treatment and storage of those materials, or the manufacture of products from those materials on, or adjacent to, the land from which the materials are extracted, but does not include industry-mining.

*"Lot"* has the same meaning as in the Planning and Development Act 2005, but does not include a strata or survey strata lot;

*"Scheme"* means Shire of Chittering Town Planning Scheme No. 6;

*"Shire"* means the Shire of Chittering;

## 3. BACKGROUND

The Shire of Chittering's mineral resources are limited to basic raw materials for construction – gravel for roads, sand for building and fill and clay for the manufacture of tiles and bricks. Unlike neighbouring Shires there are no identified large reserves of rock, stone or agriculturally useful additive materials such as lime sands. There have been traces of gold, platinum and palladium found in the northern part of the district and there are deposits of bauxite in the vicinity of Bindoon Hill, which are considered non-viable at present.

There is one mineral sands processing plant, Tiwest, at Muchea. Otherwise, all extractive industries are primary production with no secondary processing or value adding within the Shire at this time.

There is an abundance of sand throughout the western part of the Shire. Gravel, in large quantities and quality, is relatively scarce. The majority of excavations have been located for convenience. This particularly applies to sand and gravel pits where the end user is located nearby – hence the concentration in the southern part of the Shire, where there is the most building activity. Clay, on the other hand, is confined to the alignment of the Darling Fault line and is extracted in large commercial quantities in the southern part of the Shire. As clay resources along the fault line in the metropolitan area become exhausted, it is expected there will be increasing attention on the resources of the Shire, which extend in a line northwards, beyond Bindoon.

There has been and continues to be considerable community concern over various extractive industries within the Shire. This arises for two reasons – firstly, the growing number of permanent residents and tourists who come to the Shire for the natural and rural environments that it offers (lifestyle reasons) coming into conflict with extractive operations (noise, dust, truck movements, visual despoiling of landscape); secondly, poor control, management and leadership by the Shire in the past.

Of particular concern are damage of roads by truck movements, excavations into acid sulphate soils that have lowered surface water quality, excavations in dieback affected areas that spread the fungus and threaten the district's biodiversity and economically important viticultural industry and excavations that have left degraded land.

*State Planning Policy No. 10 Basic Raw Materials*, published by the Western Australian Planning Commission (WAPC) in 2000, identified the southern clay resources as "Priority Resource Location" on a resource protection map, along with two gravel extraction areas – one on the Bindoon-Dewars Pool Road and one on in the Chittering Valley, later removed.

The Shire's Town Planning Scheme No. 6 now permits extractive industries only within the Agricultural Resource Zone as an "A" use – with the approval of the Council, after advertising. Within the Scheme there are provisions to guide the control of basic raw materials, also a Special Control Area – Basic Raw Materials, which protects the resource and provides a buffer, refer Appendix 1. Supporting the Scheme is the Local Planning Strategy 2001 – 2015, which explains the role of basic raw materials in the context of future development, refer Appendix 2.

In addition to the Scheme, the Shire has a By-law Relating to Extractive Industries, refer Appendix 3.

This policy has been created to consolidate all requirements relating to basic raw materials and to provide guidance for Council, land owners and applicants in the administration of the Scheme and By-laws for the approval and management of extractive industries.

## 4. OBJECTIVES

The objectives of this policy are:

*To facilitate extraction of the Shire's basic raw materials using best available practice;*

*To provide guidance for the preparation of applications for extractive industry proposals and an indication of conditions likely to be applied to approved proposals;*

*To ensure that the use and development of land for the extraction of basic raw materials does not adversely affect the environment or amenity in the locality of the operation during or after extraction; and*

*To maintain the rural character of the Shire and minimize the loss of prime agricultural land.*

## 5. POLICY STATEMENT

5.1 General

a) For the commencement and continuance of an extractive industry, both a current planning approval and excavation licence are required.
b) For the purpose of the Applicant's long term planning Council is prepared to consider the granting of a planning approval for a period of up to ten (10) years.
c) For the purpose of managing day to day operations Council is prepared to consider the granting of an excavation licence for a period of up to five (5) years.
d) For ease of administration, the term of the planning approval will generally be a multiple of the term of the excavation licence, provided that Council may specify any term for the planning approval in accordance with the Scheme or for the excavation licence in accordance with the By-law.
e) Generally the planning approval will be issued to the land owner and runs with the land; the excavation licence will be issued to the operator and is not transferable, except with the written approval of the Council.

5.2 Application Requirements

Applications for an extractive industry shall:
a) be in accordance with:
   i) Part 9 of the Scheme;
   ii) By-law clause nos. 4 and 5; and
   iii) any licence or approval required by any statutory agency; and
b) comprise:
   i) Form of Application for Planning Approval as specified in Schedule 7 of the Scheme, plus the appropriate application fee;
   ii) Form of Application for Excavation Licence as specified in the First Schedule of the By-law, plus the appropriate application fee;
   iii) Certification by an accredited dieback interpreter that the land concerned is free from dieback; and
   iv) Excavation Management Plan, presented in the format specified in Appendix 4.

5.3 Advertising of Application

a) All applications for extractive industry are to be advertised for a minimum period of twenty-one (21) days in accordance with Section 9.4 of the Scheme and clause 6 of the By-law;
b) Council is to seek the views of relevant Government agencies, as appropriate;
c) Any application for a proposal abutting a highway reserve is to be referred to Main Roads Western Australia.

5.4 Preferred Development

a) Council prefers extractive industries that:
   i) are located south of the Bindoon Townsite;
   ii) do not involve prime agricultural land;
   iii) cater for basic raw material needs within the Shire of Chittering;
   iv) are situated within areas identified in the WAPC's *State Planning Policy No. 10 Basic Raw Materials;*
   v) are more than 1000m from the nearest house;
   vi) do not require the management of acid sulphate soils; and
   vii) have direct access to Brand or Great Northern Highway;

b) Subject to a) above, Council will not approve extractive industries that:
   i) are situated in a visually significant location, such as on a ridge or along an unscreened section of regional or tourist road;
   ii) involve major disturbance of high value remnant bushland or natural areas, following detailed environmental assessment;
   iii) remove material below the winter groundwater table;
   iv) are located on any lot where dieback is present;
   v) are situated within 500m of the nearest house; or
   vi) are located in the Chittering Valley or require access from Chittering, Chittering Valley, Julimar, Blue Plains or Maddern (North) Roads.

5.5 General Requirements

In granting a planning approval and an excavation licence, Council may in accordance with the Scheme and By-law attach conditions relating to any or all of the following:
a) the term of the approval/licence;
b) the period during which substantial commencement is to be undertaken;
c) the required buffer area, which may be the subject of a Scheme amendment;
d) maximum area and depth/height of excavations and stockpiles;
e) the location and minimum height of protective bunds;
f) the location and density of screen plantings;
g) minimum distances of works from public and private roads, lot boundaries, fences, buildings, waterways;
h) retaining walls, batters and wall slopes;
i) access, parking and layout of works, including financial contributions to the up-grading and/or maintenance of roads;
j) maximum number of truck movements in a specified period;
k) hours of operation;
l) staging of work;
m) acid sulphate soils;
n) dieback control;
o) fire management;
p) rehabilitation and maintenance;
q) methods by which mining and rehabilitation shall take place
r) drainage and disposal of waters;
s) treatment of wastes;

t) measures to protect existing vegetation, water quality;
u) additional landscape planting to be undertaken;
v) dust and noise suppression;
w) workplace and public safety;
x) public liability insurance;
y) soil and water monitoring and reporting;
z) any other matter permitted by the Scheme or By-laws ancillary to the above.

**5.6 Form of Approvals**

a) A typical planning approval under the Scheme is illustrated in Appendix 5.
b) A typical excavation licence under the By-law is illustrated in Appendix 6.

*Note: Conditions of planning approval and excavation licence may increase minimum requirements specified in the By-law eg. Setbacks from boundaries.*

## APPENDIX 1: TOWN PLANNING SCHEME NO. 6 – PARTS RELATED TO EXTRACTIVE INDUSTRY

4.2.3 Agricultural Resource Zone

4.2.3.1 Objectives:

To preserve productive land suitable for grazing, cropping and intensive horticulture and other compatible productive rural uses in a sustainable manner;

To protect the landform and landscape values of the district against despoliation and land degradation;

To encourage intensive agriculture and associated tourist facilities where appropriate;

To allow for the extraction of basic raw materials where it is environmentally and socially acceptable.

5.16 Basic Raw Materials

(a) Extraction of essential materials for roads and construction are to be permitted in areas where they will not adversely affect living environments, the landscape quality or contribute to land degradation problems during and after operations;

(b) Extraction of basic raw materials within the rural zones is to be managed in accordance with best industry practices including consideration of end use and rehabilitation at time of decommission;

(c) Appropriate buffer areas are to be applied to protect both the extractive operations as well as the living or agricultural environment in nearby areas;

(d) Council will not support development within those buffer areas, which may be detrimental to the efficiency of the industries. This is to protect the basic raw materials precincts from development that may compromise its operations.

6.4 Basic Raw Materials

6.4.1 Basic Raw Materials Areas are delineated on the Scheme Map.

6.4.2 Purpose

To secure known basic raw materials resources, and protect future resources.

6.4.3 Planning Requirements

Planning Approval is required to extend a dwelling or other building within the Buffer Area.

No new dwellings shall be approved within this buffer area.

6.4.4 Relevant Considerations

Whether development in the buffer area will affect future Extractive Industry operations.

PART 9 - APPLICATIONS FOR PLANNING APPROVAL

9.1 Form of Application

9.1.1 An application for approval for one or more of the following:

a use or commencement of development on a Local Reserve under clause 3.4;

commencement of a 'P' use, which does not comply with all the relevant development standards and requirements of the Scheme as referred to in clause 4.3.2;

commencement of a "D" use or an "A" use as referred to in clause 4.3.2;

commencement of a use not listed in the Zoning Table under clause 4.4.2 (b);

alteration or extension of a non-conforming use under clause 4.9;

a change of a non-conforming use under clause 4.9;

continuation of a non-conforming use under clause 4.12;

variation of a site or development requirement under clause 5.5;

commencement of development under clause 8.1;

continuation of development already commenced or carried out under clause 8.4;

a subsequent Planning Approval pursuant to an approval under clause 10.8.1; and

the erection, placement or display of an advertisement,

is, subject to clause 9.1.2, to be made in the form prescribed in Schedule Seven (7) and is to be signed by the owner, and accompanied by such plans and other information as is required under the Scheme.

9.1.2 An application for the erection, placement or display of an advertisement is to be accompanied by the additional information set out in the form in Schedule 9.

Note: An Application for Planning Approval in respect of land which is wholly within the management of the Swan River trust shall be referred by the Local Government for determination by the Minister responsible for the Swan River Trust Act 1988.

9.2 Accompanying Material

Unless Local Government waives any particular requirement (which the applicant shall be advised in writing), every application for Planning Approval shall be accompanied by-

(a) a plan or plans to a scale of not less than 1:1000 showing-

i. the location of the site including street names, lot numbers and tenure of the subject land and all adjoining parcels of land, north point and dimensions of site;

ii. the existing and proposed ground levels over the whole of the land the subject of the application and the location, height and type of all existing structures and vegetation proposed to be removed;

iii. the existing and proposed use of the site, including the proposed hours of operation, and buildings and structures to be erected on the site;

iv. the existing and proposed means of access for pedestrians and vehicles to and from the site;

v. the location, number, dimensions and layout of all car parking spaces intended to be provided;

vi. the location and dimensions of any area proposed to be provided for the loading and unloading of vehicles carrying goods or commodities to and from the site and the means of access to and from those areas;

vii. the location, dimensions and design of any open storage or trade display area and particulars of the manner in which it is proposed the develop the same;

viii. the nature and extent of any open space and landscaping proposed for the site.

ix. the location of any streamline or watercourse on the site; and

x. any remnant vegetation on the site.

(b) plans, elevations, and sections of any building proposed to be erected or altered and any building it is intended to retain;

(c) any specialist studies that Local Government may require the applicant to undertake in support of the application such as traffic, heritage, environmental, engineering or urban design studies; and

(d) any other plan or information that the Local Government may require to enable the application to be determined.

9.3 Additional Material for Heritage matters

Where an application relates to a place entered on the Heritage List or within a heritage area, the Local Government may require an applicant to provide one or more of the following to assist the Local Government in its determination of the application:

(a) street elevations drawn to a scale not smaller than 1:100 showing the proposed development and the whole of the existing development on each lot immediately adjoining the land the subject of the application, and drawn as one continuous elevation;

(b) a detailed schedule of all finishes, including materials and colours of the proposed development and, unless the Local Government exempts the applicant from the requirement or any part of it, the finishes of the existing developments on the subject lot immediately adjoining the subject lot.

9.4 Advertising of Applications

9.4.1 Where an application is made for Planning Approval to commence a use or commence or carry out development, which involves a use, which is-

(a) an "A" use as referred to in clause 4.3.2; or

(b) a use not listed in the Zoning,

the Local Government is not to grant approval to that application unless notice is first given in accordance with the provisions of sub-clause 9.4.3.

9.4.2 Despite clause 9.4.1, where application is made for a purpose other than a purpose referred to in that clause, the Local Government may require notice to be given in accordance with clause 9.4.3.

9.4.3 The Local Government may give notice or require the applicant to give notice or decide to give notice of an application for Planning Approval in one or more of the following ways-

(a) notice of the proposed use or development served on nearby owners and occupiers who, in the opinion of the Local Government, are likely to be affected by the granting of Planning Approval, stating that submissions may be made to the Local Government by a specified date not less than fourteen days from the day the notice is served;

(b) notice of the proposed use or development to be published in a newspaper circulating in the Scheme Area stating that submissions may be made to the Local Government by a specified day being not less than fourteen days from the day the notice is published;

(c) a sign or signs displaying notice of the proposed use or development to be erected in a conspicuous position on the land for a period of not less than 14 days from the day the notice is erected.

9.4.4 The notice referred to in clause 9.4.3 (a) and (b) is to be in the form prescribed in Schedule 8 with such modifications as are considered appropriate by the Local Government.

9.4.5 Any person may inspect the application for Planning Approval referred to in the notice and material accompanying that application at the offices of the Local Government.

9.4.6 After the expiration of the period specified from the serving of notice of the application for Planning Approval, the publication of the notice or the erection of a sign or signs, whichever is the later, the Local Government is to shall consider and determine the application.

SCHEDULE SEVEN

FORM OF APPLICATION FOR PLANNING APPROVAL

Application for Planning Approval

| Owner details: | | |
|---|---|---|
| Name: | | |
| Address:<br>Postcode: | | |
| Phone: | | FAX: |
| Home: | Work: | Email: |
| Mobile: | | |
| | | |
| Contact Person: | | |
| Signature: | | Date: |
| Signature: | | Date: |
| The signature of the owner(s) is required on all applications. This application will not proceed without that signature. | | |

| Applicant details: | | |
|---|---|---|
| Name: | | |
| Address:<br>Postcode: | | |
| Phone: | | FAX: |
| Home: | Work: | Email: |
| Mobile: | | |
| | | |
| Contact Person for Correspondence: | | |
| Signature: | | Date: |

Part 2

| Property details: | | |
|---|---|---|
| Lot No. | House/Street No: | Location No: |
| Diagram or Plan No: | Certificate of Title Vol. No: | Folio: |
| Diagram or Plan No: | Certificate of Title Vol. No: | Folio: |
| Title encumbrances (e.g. easements, restrictive covenants): | | |
| Street name: | Suburb: | |
| Nearest Street Intersection: | | |

| Existing building/land use: |
|---|
| Description of proposed development and/or use: |
| Nature of any existing buildings and/or use: |
| Approximate cost of proposed development: |
| Estimated time of completion: |

| Office Use Only |
|---|
| *Acceptance Officer's initials:* *Date Received:* |
| *Local Government Reference No:* |

## APPENDIX 2: LOCAL PLANNING STRATEGY 2001 – 2015 PARTS RELATED TO EXTRACTIVE INDUSTRY

### 8.9 PRIMARY BASIC RAW MATERIALS AREAS

#### 8.9.1 Description/Location

The main area for basic raw materials is the lower part of the Shire although there are numerous small pits for gravel and sand throughout the rest of the Shire.

Extraction of essential materials for roads and construction are to be permitted in areas where they will not adversely affect living environments, tourism, the landscape quality or contribute to land degradation problems during and after operations.

#### 8.9.2 Aims

*To manage the extraction of basic raw materials within the rural zones in accordance with best industry practices including consideration of end use and rehabilitation at time of decommission;*

*To ensure appropriate buffer areas are applied to protect the extractive operations as well as the living or agricultural environment in nearby areas.*

### 10.2 BASIC RAW MATERIALS EXTRACTION AREAS

There are several Basic Raw Material sites in the Shire. These are primarily between Bindoon-Dewars Pool Road (north) and the southern part of the Shire and are generally on the eastern side of Great Northern Highway.

The intent is: -

- To provide appropriate buffer areas in accordance with State Government and local policies and legislation to both protect the workings of extractive industry sites and protect any residences, agricultural development and tourism from adverse effects of noise and dust emissions;
- Not to support new development within any identified buffer areas which may be detrimental to the efficiency of the industries and the issues of basic raw material requirements at the local, regional and State levels;
- In relation to greenfields site applications for extractive industries, to protect existing residences and approved developments by ensuring that all buffer areas are designated so as not to encroach detrimentally on existing authorised developments.

## APPENDIX 3: BY-LAW RELATING TO EXTRACTIVE INDUSTRIES

**Local Government Act 1960**
*Municipality of the Shire of Chittering*
**By-law relating to extractive industries**

In pursuance of the powers conferred upon it by the above mentioned Act and of all other powers enabling it, the Council of the above mentioned municipality hereby records having resolved on 15 December, 1994 to make and submit for confirmation by the Governor the repeal of the By-law relating to Extractive Industries *gazetted* on 10 June, 1988 and to adopt the following By-law.

By law relating to Extractive Industries

1. Citation: This By-law may be cited as the By-law relating to Extractive Industries.

2. In this By-law unless the context otherwise requires –
"Act" means the Local Government Act 1960 (as amended).
"Carrying on an extractive industry" means quarrying and excavating for stone, gravel, sand and other material.
"Council" means the Council of the Municipality of the Shire of Chittering.
"Excavation licence" means a licence to carry on an extractive industry issued in accordance with this By-law.
"Excavation site" means a defined area of land upon which it is proposed to carry on an extractive industry or upon which an extractive industry is carried out.
"Licensee" means the holder of an excavation licence.
"Minister" means the Minister for Local Government.
"Municipal District" means the municipal district of the Shire of Chittering.
"Person" includes a body corporate.

Other words and expressions have the same meaning as they have in the Act.

3. A person shall not carry on an extractive industry on any land within the municipal district without first having an excavation licence to do so from the Council.

4. An application to the Council for an excavation licence or a renewal thereof shall be in the form of the First Schedule hereto and shall be accompanied by-
   4.1 four copies of an excavation site plan to a scale of between 1:500 and 1:2000 showing inter alia-
      4.1.1 existing and proposed land contours at one metre intervals based on Australia Height Datum;
      4.1.2 the maximum area and depth of the excavation site;
      4.1.3 distances from public and private streets, lot boundaries, fences, buildings,
      4.1.4 drains, water courses and land affected by registered grants of easement in the vicinity of the excavation site;
   4.2 four copies of an excavation programme containing, inter alia:
      4.2.1 a description of the existing excavation site environment and the likely effect upon this of the proposed excavation;
      4.2.2 the nature and estimated duration of the proposed excavation;
      4.2.3 a schedule of estimated stages of the excavation programme and of the time periods within which it is proposed operations will be carried out;
      4.2.4 a description of the methods by which existing vegetation is to be cleared and topsoil and overburden stockpiled;
      4.2.5 a description of the means of access to the excavation site and the types of roads to be constructed;
      4.2.6 a description of the methods by which the excavation site is to be drained;

4.2.7 maximum noise levels prescribed in the Environmental Protection Act are to be specified and a description of the measures to be taken to minimise noise and dust nuisance, erosion, water course siltation, adverse visual impact and dangers to the general public.

4.3 four copies of a rehabilitation programme indicating, inter alia-

4.3.1 the objectives of the programme, having due regard to the nature of the surrounding area and the proposed end use of the excavation site;

4.3.2 whether restoration and reinstatement of the excavation site is to be undertaken progressively or upon completion of excavation operations;

4.3.3 the method by which topsoil is to be replaced and seeded;

4.3.4 the numbers and types of trees to be planted and other landscaping features developed; and

4.4 a form of consent to the application in writing from the owner of the excavation site.

5. An applicant for an excavation licence shall provide the Council with such additional information concerning the proposed excavation as the Council may reasonably require.

6. On receipt of an application for an excavation licence, the Council-

6.1 shall forward a notice to the owners and occupiers of all land adjoining the land upon which it is proposed to excavate, or within an area determined by the Council as likely to be affected by the granting of a licence, advising of the application and specifying that they may, within 21 days from the date of service of the letter, object to or make representations in writing in respect of the issue of a licence by the Council;

6.2 shall publish in a newspaper circulating in the municipal district a notice advising of the application and specifying that any interested person may, within 21 days after the date of publication of the notice, object to or make representations in writing in respect of the issue of a licence by the Council;

6.3 may cause to be displayed in a prominent position on the excavation site a notice specifying particulars of the proposed excavation and inviting objections to and representation in respect thereof from members of the public, for a period of 21 days from the date of publication of the notice referred to in clause 6.2;

6.4 shall ensure that the application complies with the requirements of Town Planning Scheme number 5 as amended.

7. An excavation licence shall be substantially in the form of the Second Schedule hereto and shall be valid for such term not exceeding five years from the date of issue as the Council may at that date determine and may be renewed thereafter by the Council for a further term or terms.

8. Excavation licence and renewal fees shall be payable to the Council in the amounts set out in the third Schedule hereto.

9. A licence shall be valid for the period commencing on the date of its issue and expiring on the 30th day of June in the year specified therein as its year of expiration or on the sooner cancellation of the licence by the Council.

10. The licensee shall apply in writing for a renewal of the licence. The application shall be made not later than three months prior to the expiration of the licence and include certification from a licensed surveyor as to the area and volume of material excavated.

11. A licence issued under this By-law is not transferable unless the written approval of Council is obtained.

12. The Council may impose conditions upon an excavation licence in respect to the following matters-

12.1 the hours during which excavation work may be carried out;

12.2 the hours during which blasting operations may be carried out;

12.3 the depths below which a person shall not excavate;
12.4 distances from adjoining land or streets within which a person shall excavate;
12.5 the safety of persons employed at the excavation site;
12.6 the planting, care and maintenance of trees shrubs and other landscaping features during the time in which the extractive industry is carried out in order to effectively screen the area to be excavated;
12.7 the drainage of the excavation site and the disposal of water therein;
12.8 the restoration and reinstatement of the excavation site;
12.9 the provision of retaining walls to prevent subsidence of any portion of he excavation or of land abutting the excavation;
12.10 requiring the licensee to enter into any agreement with the Council in respect to any condition or conditions imposed;
12.11 otherwise regulating the carrying on of an extractive industry.

13. Upon the expiration of an excavation licence or the sooner cessation of any work, the licensee shall ensure that-
13.1 the excavation site is restored and reinstated in accordance with proposals approved by Council or in a such manner as the Council shall subsequently agree with the licensee in writing;
13.2 any face permitted to remain upon the excavation site is left safe with all loose materials removed there from, and the sides sloped to a batter or not more than 1.3,;
13.3 the agreed floor level of the excavation site is graded to an even surface or otherwise in accordance with excavation and rehabilitation programmes approved by the Council;
13.4 all dumps of stone, sand or other material are so left that no portion of that stone, and/or other material can escape onto land not owner or occupied by the licensee nor into any stream, water course or drain that is not wholly situated within the land owned or occupied by the licensee.

14. The Council-
14.1 may require as a condition of an excavation licence payment by the licensee into a fund established by the Council for the purpose of restoring and reinstating the excavation site, a sum calculated at a rate per hectare, or part thereof, of the excavation site proposed to be excavated annually, set out in the Third Schedule hereto;
14.2 may apply money in such a fund to or towards the restoration and reinstatement of the excavation site if the licensee does not carry out such restoration and reinstatement at his/her own cost upon completion of the excavation or the expiration of the licence, whichever the case may be;
14.3 shall refund to the licensee moneys paid by them into such a fund upon satisfactory restoration and reinstatement of the excavation site;
14.4 may require the licensee to carry out dust suppression measures at the excavation site but not limited to the sealing or water spraying section of the site.

15. As an alternative to payment into a fund in accordance with clause 14 hereof the Council-
15.1 may require an applicant for an excavation licence to give to the Council a bond, with or without sureties in a sum calculated as aforesaid to ensure that they will either carry out, or cause to be carried out, the restoration and reinstatement of the excavation site agreed between the applicant and the Council upon the granting of an excavation licence and in the case of default in carrying out or causing to be carried out such restoration and reinstatement, the bond is thereupon forfeited to the Council; and
15.2 may apply the amount of a bond forfeited as aforesaid, or so much of that amount as is required, towards the carrying out of such restoration and reinstatement work.

16. Subject always to any condition imposed by the Council in accordance with clause 12 of this By law a person shall not without the written approval of the Council-
16.1 excavate within 20 metres of the boundary of any land they do not own;
16.2 excavate within 20 metres of any land affected by a registered grant of easement or within 40 metres of any water course;

16.3 excavate within a distance of 40 metres of any road.

17. A licensee shall-
17.1 Not remove natural trees or scrub within 40 metres (or such lesser distance as may be allowed by the Council in accordance with clause 12 of this By-law) of the boundary of any road reserve on land in respect to which an excavation licence has been granted, except for the purpose of constructing access roads or erecting buildings for use in connection with the excavation and then only with the express approval of the Council and subject to any conditions which the Council may impose in accordance with clause 12 hereof;
17.2 Where the Council so requires, securely fence the excavation and keep the gateways locked when not actually in use in order that unauthorised persons will not enter the excavation;
17.3 Where the Council so requires, drain and keep the excavation site in such a manner as to prevent the accumulation of water therein;
17.4 Subject always to any condition imposed by Council in accordance with clause 12.2 hereof, refrain from carrying out blasting operations in or about an excavation site except between the hours of 8.00 am and 5.00 pm Mondays to Fridays (inclusive);
17.5 Take all reasonable steps to prevent the emission of dust, noise and other forms of nuisance from the excavation site;
17.6 Not excavate other than in accordance with the terms of application, and accompanying site plans and excavation and management programs approved by the Council;
17.7 Restore and reinstate the excavation site in accordance with the terms of the application and accompanying site plans and excavation and rehabilitation programmes approved by the Council;
17.8 Otherwise comply with conditions imposed by the Council in accordance with clause 12 hereof.

18. An officer of the Council shall inspect the licensed area annually and provide a written report to the Council as to the compliance by the licensee with this By-law and any conditions imposed by the licence.

19. If a licensee fails to comply with-
19.1 any of the conditions of an excavation licence;
19.2 any provision of this By-law; or
19.3 conditions of an Agreement with the Council made in accordance with clause 12.10 hereof,
and the default continues following the expiration of a period of 14 days from service upon the licensee of written notice from the Council of such default, the Council may cancel the excavation licence of the defaulting licensee.

20. Any person who contravenes the provision of this By-law commits an offence and it liable on conviction to –
20.1 a maximum penalty not exceeding $500.00; and
20.2 in the event of a continuing offence following conviction, a daily penalty not exceeding $50.00 for every day or part of a day during which such offence continues.

21. The provisions of this By-law shall apply to all land other than excluded by the provisions of section 235 of the Act within the municipal district and shall apply to every excavation whether commenced prior to or following the coming into operation of this By-law.

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## Local Government Act 1960

*Municipality of the Shire of Chittering*

*By-law Relating to Extractive Industries*

**First Schedule**

# APPLICATION FOR EXCAVATION LICENCE

**Name:**

**Address:**

**Address and locality of proposed excavation site:**

**Particular land description:**

**Lot no:** **Location no:**

**Plan or diagram no:**

**Certificate of Title Volume:** **Folio:**

**Owner of Land:**

**Address of Owner:**

**Material to be excavated:**

**Term of license sought:**

Submitted with this application are-
1. Application fee of $ (insert amount)
2. Site plans (four copies)
3. Excavation programme (four copies)
4. Rehabilitation programme (four copies)

**Signed:** _____

**Date:** _____

## Local Government Act 1960

*Municipality of the Shire of Chittering*

*By-law Relating to Extractive Industries*

**Second Schedule**

# EXCAVATION LICENCE

**Licence Holder:**

**Address:**

**Land Description:**

**Material to be excavated:**

**Term of Licence:**

**Permitted Hours of Operation:**

(Specify)

This licence is issued with the Shire of Chittering By-law relating to Extractive Industries upon and subject to the following conditions:

(Specify)

Dated the (insert) day of (insert) 20__

**Signed:** _____
**CHIEF EXECUTIVE OFFICER**

## Local Government Act 1960

*Municipality of the Shire of Chittering*

*By-law Relating to Extractive Industries*

**Third Schedule**

# LICENSE AND RENEWAL FEES

1. Initial license / service fee $400.00 payable on application (non-refundable).
2. Where the overall area of excavation is less than 5 ha: $300.00 per annum payable annually during the currency of the license.
3. Where the overall area of excavation is greater than 5 ha: $600.00 per annum payable annually during the currency of the license.

Calculation of the amount of guarantee (or other form of acceptable security) –

1. where it is proposed to excavate sand or similar fine grained material – the rehabilitation bond shall be calculated at a rate of $3000.00 per ha of area excavation to be excavated annually;
2. where it is proposed to excavate stone, gravel or other aggregate – the rehabilitation bond shall be calculated at a rate of $4000.00 per ha of area of excavation to be excavated annually.

Dated 16 May 1996

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The Common Seal of the Shire of Chittering was hereunto affixed by authority of a resolution of the Council in the presence of-

S M METCALF, President
R P HOOPER, Shire Clerk

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Recommended-

P Omodei Minister for Local Government

---

Approved by His Excellency the Governor in Executive Council the 16th day of July 1996.

M C Wauchope Clerk of the Council

## APPENDIX 4: FORMAT OF AN EXCAVATION MANAGEMENT PLAN

Title Page

Summary

Contents Page

| | | |
|---|---|---|
| 1.0 | Introduction - | brief general description of development proposal, the proponent, site location and title details, ownership and excavation agreements, description of the resource including size of deposit, purpose of plan (**Map 1**: Locality Plan eg. main roads, cadastral boundaries, mega contours); |
| 2.0 | Planning Issues - | district context (general land use of the site and surrounding area, including other excavations in the vicinity, distance to nearby residences), reference to any earlier excavation of the site, zoning, appropriate buffer area, proposed end use, responsible authorities and approvals, community consultation (**Map 2**: Ortho-photo, with anticipated excavation and possible further extension shown); |
| 3.0 | Existing Environment - | topography, geology, climate, soils (including any acid sulphate soils), hydrology (including depth to water table), flora (including any declared rare flora, noxious weeds, dieback affected areas), fauna, Aboriginal Sites (**Map 3**: Existing Site, with 0.5m contours, features) |
| 4.0 | Excavation Programme - | extent of topsoil removal, method, area and depth of excavation, method, staging and timing, anticipated quantity of resource to be removed annually,_hours of operation, machinery and equipment, access and transport, work force, water use, site drainage (**Map 4**: Staging) |
| 5.0 | Environmental Management - | aesthetics, noise, dust, soil erosion, pit water management, water quality, flora and fauna, safety, refuelling, dieback, acid sulphate soils, weeds, fire management, (**Map 5**: Site Management – proposed pits, stockpiles, drainage, dams, bunds, fire breaks, natural vegetation to be protected and landscaping, roads, fencing, buildings, structures, etc to be installed) |
| 6.0 | Rehabilitation Programme – | storage location for topsoil, method of topsoil replacement, plant species for rehabilitation, landform for end use, planting method, density and husbandry, maintenance (**Map 6**: Finished Site, with 0.5m final contours) |
| 7.0 | Monitoring and Reporting – | elements to be monitored, methods of soil and water testing, sampling frequency; reporting frequency |

Appendices

Reference material - relevant State Planning Policies, Protection Notes, Guidelines, etc

**APPENDIX 5: TYPICAL PLANNING APPROVAL**

*(Where relevant, the following conditions are to be included)*

"Council:

1. Grants planning approval to the landowner (*name)* of (*lot number, road, locality)* for the proposed extraction of (*material*), subject to the following conditions:

    1. This planning consent shall be for a period of (*number, being not more than 10*) years from the date of issue until the 30 June in the year specified as the year of expiration. The proponent may apply for an extension of the approval for a further period of up to (*number*) years. This application is to be made no later than three (3) months prior to the expiry of the current consent;
    2. The excavation licence shall be for a period of (*number, being not more than 5*) years from the date of issue until the 30 June in the year specified as the year of expiration. The proponent may apply for an extension of the licence for two further periods of up to (*number*) years each. Each of these applications is to be made no later than three (3) months prior to the expiry of the current licence;
    3. Prior to the issue of an excavation licence a guarantee/bond or other acceptable form of security shall be lodged with or paid to the Council in accordance with the amount stipulated in Schedule 3 of the By-law Relating to Extractive Industries;
    4. Prior to the issue of an excavation licence the Applicant shall request Council to initiate an amendment to Town Planning Scheme No. 6 to establish a buffer area of 1,000m from all proposed pits, crushing, stockpile and loading areas (*not required for sand pits)*;
    5. Prior to the issue of an excavation licence a Dieback Management Plan is to be prepared to the satisfaction of the Chief Executive Officer *(where relevant);*
    6. Prior to the issue of an excavation licence a Fire Management Plan is to be prepared to the satisfaction of the Chief Executive Officer in accordance with Local Planning Policy No. 21;
    7. Prior to the issue of an excavation licence a Refuelling Management Plan is to be prepared to the satisfaction of the Council, incorporating
        a. all on-site fuel storage and refuelling to take place within a lined and bunded area;
        b. any fuel leakages or spills to be cleaned up within 24 hours;
        c. as part of the close-out plan, contaminated soil to be disposed of to the satisfaction of the Chief Executive Officer;
    8. Prior to the issue of an excavation licence the Applicant shall submit to the Council evidence of currency of public liability insurance for the excavation works. The issue of the approval shall not, in any way, render the Shire of Chittering liable for damage or injury of any kind to any member of the public; such liability shall be the sole responsibility of the Applicant. The Applicant shall ensure that he/she and/or the excavating contractor and/or transportation contractor hold sufficient public liability insurance cover for any claim against them;
    9. Prior to the issue of an excavation licence:
        a. An assessment shall be conducted to determine whether acid sulphate soils are present on the land and, if present, their extent and severity;
        b. If the site is found to contain acid sulphate soils, an Acid Sulphate Soils Management Plan (ASSMP) shall be submitted and approved by the Council in consultation with the Department of Environment and Conservation; and
        c. Operations shall be carried out in accordance with the provisions of the approved management plan;
    10. Prior to the issue of an excavation licence the Applicant shall enter into an agreement with the Council for payment fees for road construction/maintenance;
    11. Prior to the commencement of work on each pit a Soil and Water Monitoring Program, including methodology, periodic sampling and analysis by an independent laboratory, shall be submitted and approved by the Council in consultation with the Department of Environment and Conservation, incorporating:

a. Monitoring of removed material, irrespective of whether the excavation area is within a location identified as 'high risk' of containing acid sulphate soil material or there is an approved ASSMP; and
b. Monitoring of water quality retained within on-site excavations;

12. Top soil from the excavated areas shall be stockpiled and used where applicable in the rehabilitation process;
13. Within nine (9) months of the date of this planning consent, screen landscaping belts of local species 10m wide shall be installed along the (*state which*) edges of all areas to be excavated, to the approval of the Council;
14. All stormwater shall be retained on site and no discharge of pit-water shall occur without prior approval from the Chief Executive Officer;
15. All areas containing rare or endangered species of flora and fauna shall be protected and no excavation shall be permitted in these areas;
16. Appropriate dust suppression measures shall be taken at all times where any operation on the site is likely to generate a dust nuisance to nearby residents, to the satisfaction of the Chief Executive Officer;
17. All vehicle loads leaving the site shall be covered to prevent the spread of material;
18. All vehicles leaving the site shall be washed down prior to departure, to the satisfaction of the Chief Executive Officer;
19. Internal access road shall be constructed to a standard that minimises dust emission from machinery and traffic, to the satisfaction of the Council;
20. The operations shall comply with the requirements of the Environmental Protection (Noise) Regulations 1997 in respect to noise but, not withstanding, the operations to have due regard to the health and amenity of any person in the vicinity;
21. The development shall comply with the provisions of Council's Town Planning Scheme No.6, By-law Relating to Extractive Industries, Health Act 1911, Building Code of Australia and any other relevant Acts, Regulations, Local Laws and Council Policies, except where varied by this approval;
22. Site access shall be to (*specify major road*), to the satisfaction and approval of Main Roads Western Australia;
23. The Applicant shall contribute to (*the up-grading and/or maintenance*) of (*name of road(s)*), to the extent of (*state quantum eg. 50c for each tonne of resource excavated*);
24. The hours of operation shall be limited to:

| | |
|---|---|
| Monday to Friday | 0600hrs to 1800hrs |
| Saturday | 0730hrs to 1700hrs |
| Sunday & Public Holidays | not permitted |

Any variation of these times requires written approval from Council;
25. Excavation for the extractive industry shall not occur in the following areas:
    a. Within 100 metres of a boundary of any land not owned by the proponent or Planning Consent holder;
    b. Within 20 metres of any land affected by a registered grant of easement;
    c. Within 40 metres of any designated water course; and
    d. Within 500 metres of any house;
    e. Below the level of the winter groundwater table;
26. The maximum area of pit being worked at any one time shall be (*specify number*) hectare(s);
27. A Rehabilitation or Land Management Plan (also referred to as a Close-out Plan) shall be submitted and approved by Council prior to the cessation of excavation works on each pit, incorporating:
    a. statement of end use
    b. final contouring plan, rehabilitation and land management;
    c. demarcation of surface water catchments; excavation pit hydrology and water balance;
    d. revegetation and landscaping; and
    e. ongoing monitoring requirements;
28. Upon decommissioning of each pit, rehabilitation shall take place in accordance with the approved plan using the stockpiled topsoil and replanting of appropriate local native species as recommended by the Chief Executive Officer;

29. Rehabilitation of each pit shall include surface water control measures on all pit faces to prevent gully erosion, and final batters to be graded to provide safe entry and exit slopes should access to any standing water within the pit be required or accidentally occur;
30. Materials imported for rehabilitation or other purposes shall be certified free of dieback or other plant diseases;
31. Any amendments or variations to the rehabilitation or land management plan associated with the excavation shall be approved in writing by the Chief Executive Officer;
32. The Applicant may be required to enter into an agreement with Council in relation to any condition/conditions;
33. An annual report shall be submitted to the Council that includes:
    a. the progress of excavation;
    b. depth to groundwater from each pit floor;
    c. monitoring program results and findings;
    d. progress of rehabilitation;
    e. contingency actions and outcomes; and
    f. community complaints and responses;
34. If the development, the subject of this approval, is not substantially commenced within a period of twelve months from the date of the approval, the approval shall lapse and be of no further effect. Where an approval has lapsed, no further development shall be carried out without the further approval of Council having first been sought and obtained.
35. Development shall generally occur in accordance with Excavation Management Plan submitted with the application for planning approval (Planning Application No. )
36. Breach of conditions may result in cancellation of this approval;

2. delegates authority to the Chief Executive Officer to issue an Excavation Licence for operations at (*lot number, road, locality*), in accordance with the planning consent specified in 1. above, on satisfaction of conditions 1.3 to 1.10 *(where relevant).*

Advice Notes:

1. This approval does not constitute an excavation licence.
2. Any buildings, fuel facilities or transportable buildings on site are to be the subject of a separate application for planning consent and, if required, a building licence.
3. The Department of Environment may require a Works Approval prior to commencement of work on site.
4. The Department of Environment may require a permit for the clearing of native vegetation prior to commencement of work on site.
5. Officers from Chittering Landcare Centre are available to assist the Applicant with respect to acid-sulphate soils, dieback control, catchment, drainage, plant selection, landscape and rehabilitation matters.
6. The Applicant is referred to the following publications:
    a. Water Quality Protection Note – Extractive Industries, Water and Rivers Commission, February 1999;
    b. Water Quality Protection Note – Temporary Above Ground Fuel Storage in Public Drinking Water Source Areas, Water and Rivers Commission, October 1998;
    c. Water Quality Protection Note – Contaminant Spills – Emergency Response, Department of Water, February 2006;
    d. Water Quality Protection Note – Extractive Industries within Public Drinking Water source Areas, Water and Rivers Commission, July 2000;
    e. Water Quality Protection Guidelines No.6, Mining and Mineral Processing - Minesite Stormwater, Water and Rivers Commission, 2000,
    f. Environmental Code of Practice – Extractive Industries, Department of Environmental Protection, 1990;
    g. Environmental Management of Quarries: Development, Operation and Rehabilitation, department of minerals and Energy, 1991;
    h. Local Planning Policy No. 21 – Fire management Plans, Shire of Chittering, November 2005, as amended;

7. Should an Applicant be aggrieved by a decision of Council, the State Administrative Tribunal can be requested to review the decision. Such a request should be lodged within twenty-eight (28) days of Council's decision.

## APPENDIX 6: TYPICAL EXCAVATION LICENCE

Council grants an Excavation Licence to (*name*) to excavate (*material*) from (*lot number, road, locality),* subject to the following conditions:

1. The Excavation Licence shall apply for a period of (*number, being not more than 5*) years from the date of issue until the 30th of June in the year specified as the year of expiration of the licence. The licensee may apply for an extension of the licence for a further period of up to (*number, being not more than 5*) years. This application is to be made not later than three (3) months prior to the expiry of the current licence;
2. All excavation/extraction shall be strictly in accordance with the Council's By-law Relating to Extractive Industries, conditions specified in the Planning Consent and conditions imposed by any other statutory authority;
3. The Excavation Licence shall only remain valid while there is the appropriate Planning Consent in place to support the extraction of materials;
4. The Excavation Licence is not transferable except with the written approval of Council and if required, the landowner;
5. The hours of operation shall be: -
   - Monday to Friday - 0600 - 1800 hours
   - Saturday - 0730 - 1700 hours
   - Sunday & Public Holidays - not permitted except with the written approval of Council;
6. The licensee is to be responsible for ensuring that the extractive operations are confined to those areas depicted in the plan accompanying the application to the Council and the approved Rehabilitation or Land Management Plan;
7. The licensee may not excavate in the following areas: -
   - Within 100 metres of a boundary of any land not owned by the proponent or Planning Consent holder;
   - Within 20 metres of any land affected by a registered grant of easement
   - Within 40 metres of any designated water course;
   - Within 500 metres of any house;

   except with the written approval of Council.
8. The licensee may not remove natural vegetation except with the written approval of Council and any other government department or agency controlling the clearing of land;
9. The licensee is required to provide appropriate drainage for the licensed area as designated by Council;
10. The licensee is to stockpile topsoil in the excavation area, to be used where applicable in the rehabilitation process;
11. The licensee is required to take all reasonable and appropriate steps to prevent soil and water erosion and the emission of dust, noise and other forms of nuisance from the excavation site;
12. The licensee is to retain a water tanker on site for dust suppression of overburden storage, stockpile material, pit floors and access tracks (*may not be required for sand pits)*;
13. Prior to transport of excavated material, the licensee is to ensure all loads are covered to eliminate dust generation during transit (*not required for transport of damp clay material*);
14. The licensee is to strictly comply with the Refuelling Management Plan applicable to the site;
15. The licensee is to maintain the currency of the public liability insurance cover for the site, excavation and transport of material;
16. The licensee is to strictly comply with the Fire Management Plan applicable to the site;
17. The licensee is to strictly comply with the Dieback Management Plan applicable to the site;
18. The licensee is to strictly comply with the Soil and Water Monitoring Programme applicable to the site;
19. The licensee is to strictly comply with the requirements of the Environmental Protection (Noise) Regulations 1997;
20. The licensee is required to progressively rehabilitate the area of excavation strictly in accordance with an approved Rehabilitation or Land Management Plan associated with the licence;

21. The licensee is to ensure that materials imported for rehabilitation or other purposes are certified free of dieback or other plant diseases;
22. The licensee is not to undertake any amendments or variations to any rehabilitation or land management plan associated with the excavation unless approved in writing by Council;
23. The licensee shall strictly comply with any/all buffer areas designated by any statutory authority;
24. The licensee is to protect all areas containing rare or endangered species of flora and fauna and no excavation shall be permitted in these areas;
25. The licensee is to be responsible for the repair of any undue damage to (*name of road*) caused by the extraction operations;
26. The licensee is to strictly comply with the Acid Sulphate Soil Management Plan applicable to the site *(where there is an ASSMP)*;
27. The licensee is to provide a (*frequency*) chemical analysis of:
    a. Soil samples from stockpiles and pit walls, for acidity (pH), salinity (electrical conductivity) and sulphate content;
    b. Water in pit/s to determine acidity, salinity and dissolved oxygen *(where there is no ASSMP)*;
28. The licensee is to undertake immediate remedial measures in the event of any significant levels of acidity (pH less than 4.5) and ensure that acid or highly saline waters are not released into either surface drainage lines or subsurface aquifers *(where there is no ASSMP)*;
29. The licensee is to submit an annual report to the Council, within 60 days of 30 June each year the licence is current, certified by an independent auditor, that includes:
    a. the progress of excavation, including volume and/or weight of resource removed;
    b. depth to groundwater from each pit floor;
    c. monitoring program results and findings;
    d. progress of rehabilitation;
    e. contingency actions and outcomes; and
    f. community complaints and responses;
30. The licensee is to pay to the Council within 30 days of submitting each annual report *(the royalty specified in the planning approval or, where no royalty is specified, 50c for each tonne of resource excavated)* for (*the up-grading and/or maintenance*) of (*name of road(s)*);
31. The licensee is to provide and maintain a safety barrier at the top of any excavated work face with a depth greater than 2m;
32. Breach of conditions may result in cancellation of this licence.

**ADOPTED FOR PRELIMINARY APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 16th day of May 2007.

**ADOPTED FOR FINAL APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 18th day of July 2007.

and the seal of the Municipality was pursuant to that resolution hereunto affixed in the presence of:

**PRESIDENT**.....

**CHIEF EXECUTIVE OFFICER**.....

**Date**:.....22/7/09.....

# TOWN PLANNING SCHEME NO 6

## Local Planning Policy No 21
## Fire Management Plans

# Local Planning Policy No 21 – Fire Management Plans

## 1. STATUTORY CONTEXT

This Local Planning Policy No. 21 – Fire Management Plans supersedes the current Policy adopted by Council on 19 December 2007.

## 2. OBJECTIVES

The objectives of this policy are:

- *To protect life and property.*
- *To maintain the rural character of the Shire.*

## 3. POLICY STATEMENT

### 3.1 General Requirements

Private property owners and occupiers have a responsibility for fire safety, as follows:

a) in accordance with FESA and Shire requirements under the *Bush Fires Act 1954* (see also Firebreak Notice to all Residents and Ratepayers of the Shire of Chittering). These requirements include clearing of individual firebreaks not less than 3metres wide completely surrounding and not more than 20metres from the perimeter of all buildings, haystacks and fuel storage areas within Rural Zones, unless otherwise approved;

b) in accordance with Town Planning Scheme No 6 (TPS 6) requirements for Development and Fire Management Plans, which are to be prepared for each proposed estate in Rural Residential, Rural Retreat, Rural Smallholdings and Rural Conservation zones and elsewhere as decided by Council; and

c) in accordance with *Planning for Bush Fire Protection Guidelines (Edition 2).*

### 3.2 Fire Service Access Routes

a) As part of Development and Fire Management Plans, Council will require the installation of Fire Service Access Routes in addition to individual fire breaks.

b) Council may accept maintenance responsibility for Fire Service Access Routes where:

(i) the Fire Service Access Route is in public ownership, as reserved land;

(ii) the cost to each property within the subdivision is shared;

(iii) the Council raises invoices for each lot owner with the rate notice each year for the maintenance of Fire Access Routes;

c) Fire Service Access Routes are to be:

(i) located around the perimeter of the estate, property or elsewhere as required;

(ii) may be in public ownership, designated as Local Reserves Public Purposes – Fire Fighting in scheme amendment documents and subdivision plans;

(iii) may be in private ownership protected by way of easement for the purposes of a Fire Service Access Route and is to maintain unimpeded continuous access along such easement;

(iv) a minimum of 6metres wide, of which the entire 6metres is to be trafficable constructed of 100mm compacted gravel above the natural ground level without being impeded by fences (see also *Local Planning Policy No 22*), gates or over-hanging trees;

(v) provide turn around areas/bays every 500metres sufficient for a 3.4 appliance to turn around safely;

(vi) have access to a public road network every 1,000metres;

(vii) comply with any other requirements deemed necessary under the "*Planning for Bush Fire Protection Guidelines – Edition 2*" as determined by Council;

d) Where a Fire Service Access Route meets a public open space, road or footway, there is to be a gate with a lock of approved design provided by the subdivider with signs installed on each gate in accordance with the attached "Fire & Emergency Signs" ; otherwise no fence or gate may be constructed across a Fire Service Access Route;

e) Where a Fire Service Access Route is located on private property, no fence or gate may be constructed across a Fire Service Access Route;

f) Where a Fire Service Access Route cross a natural drainage, the developer is to construct off sheet as appropriate to prevent scouring in accordance with Council's Engineering specification;

g) Emergency Access Ways are to be in accordance with section 3.2 c, d, e, and f above. Where gates are used as outlined in section (d) above, Emergency Access Ways gates must not be locked.

### 3.3 Individual Fire Breaks

Rural Residential and Shire Town sites with land less than 2.0ha do not require fire breaks but are required to follow General Fire Hazard reduction.

Individual fire breaks are to be constructed adjoining property boundaries as follows:

a) On any property with an area equal to and greater than 2.0ha;

b) Where required at the direction of the Shire or the Chief Bush Fire Control Officer;

c) 3m wide with a 4m vertical clearance, for four wheel drive access.

Land with an area of 120ha or more must have a firebreak in such a position which divides that land into areas not exceeding 120ha.

### 3.4 Water Supply

a) With land subdivisions, as part of Development and Fire Management Plans, water supply/storage, including tanks, dams and standpipes, shall be provided for community use, as follows:

(i) as may be required by Council;

(ii) land shall be in public ownership, ceded free of charge to the Council;

(iii) maintenance costs may be shared among benefiting property owners, at the discretion of the Council;

(iv) water tanks with a hydrant or standpipe are provided and meet the following requirements:

- Volume – 50,000 litres per tank
- Ratio of tanks to lots – 1 tank per 25 lots
- Tank location – tanks are located to achieve a 20 minute turn around time at legal road speeds from the tanks to the furthest dwelling site within the residential development
- Tank construction – above ground tanks are constructed of concrete or metal and the stands of raised tanks are constructed using non-combustible materials and heat shielding where appropriate
- Hardstand and turnaround area are suitable for a 3.4 appliances are provided within 3metres of each water tank

b) Fire Management Plans are to state that with development approval, water supply/storage shall be provided on-site, as follows:

(i) in the case of buildings intended for residential use, in accordance with TPS 6 requirements for 120,000litres capacity water supply, of which 10,000litres is to be held in reserve for fire fighting purposes, provided that where bore water is available with an independent power supply, this requirement may be reduced to 110,000litres with 10,000litres held in reserve. All water tanks intended to reserve 10,000litres for fire fighting purposes are to install a 50mm male Camlock fitting to the floor of the tank and the draw point for residential purposes is to be 10,000litres above the floor of the tank;

(ii) in the case of all other development, as required by the Council.

### 3.5 Fire Management Plans

a) Where required by Council, a Fire Management Plan is to be prepared with a format as specified in Schedule 1 for estates or Schedule 2 for individual properties, unless otherwise approved by the Council;

b) Every fire management plan shall be accompanied with a *Compliance Checklist for Performance Criteria and Acceptable Solutions* as per schedule 3;

c) The Fire Management Plan, which may include initial fire hazard reduction by the Developer, is to be approved prior to any construction being commenced on site;

d) The Fire Management Plan is approved when it bears the signatures of:

(i) Shire Planner;

(ii) Community Emergency Services Manager or nominee;

(iii) Chittering Fire Services Chief Bush Fire Control Officer;

e) The approved Fire Management Plan is to be retained at the Shire Offices and be available for public inspection.

### 3.6 Implementation of Development and Fire Management Plans

a) It is the responsibility of the Developer, on behalf of the owner, to supply to prospective purchasers of any newly created lots covered by approved Development and Fire Management Plans, copies of those plans, and subsequent owners to any further owners, to be enforced by a notification on title under s.70A of the *Transfer of Land Act 1893*;

b) The wording of the s.70A notification for Note 4 on Form N1, required on all newly created lots, is as follows:

> *"This Lot is subject to Development and Fire Management Plans approved by the Shire of Chittering. It is the responsibility of property owners to be familiar with and comply with such approved Plans. Failure to comply will result in further action being taken against noncompliant property owners".*

# Local Planning Policy No 21 – Fire Management Plan

## Schedule 1 – Format of an ESTATE FIRE MANAGEMENT PLAN

Shire of Chittering

Title Page

Contents Page

1.0 Introduction – purpose of plan, site location, district context (including fire service access route), zoning, lot number and area, general description of development proposal, any stages, relationship of Fire Management Plan to approval requirements, reference to any superseded plan(s) (**Map 1**: Location Plan e.g. cadastral boundaries, existing strategic fire breaks);

2.0 Site Details – topography, rock outcrops, soils, existing vegetation, water resources, existing land use and improvements (**Map 2**: Site Details eg. contours, site features, existing improvements, access roads);

3.0 Statutory Requirements – quote condition of approval that is to be satisfied by preparation of the Fire Management Plan:

4.0 Fire Risk – fuel loadings, risk factors, climate, effect of Fire Management Plan on overall risk (**optional map** of relative fire hazards: low-medium-high-extreme);

5.0 Fire Management Plan – list components e.g. initial fire hazard reduction by Developer, main access roads, sealed subdivisional roads, strategic firebreaks, selective firebreaks on properties, location of access gates if required, established water sources/storage, building envelopes (**Map 3**: Fire Management Plan e.g. contours, roads, remnant vegetation, building envelopes, fire breaks, water sources/storage, gates, buffer zones, fire stations, etc);

6.0 Estate Layout and Road Pattern – structure of estate in terms of access, circulation, fire breaks, emergency escape routes;

7.0 Fire Service Access Route System – purpose, width, surface, location, ownership, access, care and control, fencing, gates, keys, Developer/Owner/Shire responsibilities;

8.0 Shire Fire Protection Plan and Standard Firebreaks – purpose of Shire Plan, emergency contact personnel, responsibilities of property owners to attend an induction course and to satisfy general Shire requirements, individual firebreaks, chemical firebreaks;

9.0 Dwelling Construction – building design and construction requirements, fuel reduction zone;

10.0 Fire Fighting Facilities –

10.1 Community Water Supplies – *refer clause 3.4(a) of policy*

10.2 Domestic Water Supplies – *refer clause 3.4(b) of policy*

11.0 Summary –

11.1 Overall Fire Threat

11.2 Fire Management Plan

11.3 Owner's Responsibility

11.4 Developer's Responsibility

11.5 Shire's Responsibility

Appendices – as required, e.g. field gate details, chemical firebreaks.

Endorsement page – signatories as described in Clause 3.5, date *(see Schedule 4).*

# Local Planning Policy No 21 – Fire Management Plans

## Schedule 2 – Format of a Property Fire Management Plan

Title Page

Contents Page

1.0 Introduction – purpose of plan, site location, district context (including fire service access route), zoning, lot number and area, brief general description of development proposal, any stages, relationship of Fire Management Plan to approval requirements, reference to any superseded plan(s) (**Map 1**: Location Plan e.g. main roads, cadastral boundaries, existing strategic fire breaks);

2.0 Site Details – topography, rock outcrops, soils, existing vegetation, water resources, existing land use and improvements

3.0 Proposed Development – intended land use and buildings, specifying materials (**Map 2**: Development Plan e.g. contours, site features, existing and proposed buildings, access roads);

4.0 Fire Risk – fuel loadings, risk factors, climate, effect of Fire Management Plan on overall risk (**optional map** of relative fire hazards: low-medium-high-extreme);

5.0 Property Layout and Circulation Pattern – structure of property in terms of emergency access/egress, circulation, fire breaks, emergency escape routes, assembly area(s);

6.0 Fire Management Plan – list and discuss components e.g. communications, hydrants, water sources/storage, fire fighting equipment/vehicles, building protection zones, storage of hazardous materials, internal gates/keys, back up generation, personnel/chain of command, hazard elimination, precautions for special events, e.g. refuelling (**Map 3**: Fire Management Plan e.g. roads, buildings, protection zones, fire breaks, water sources/storage, gates, location of equipment, hydrants, communications, key personnel, etc).

7.0 Shire Fire Protection Plan – purpose of Shire Plan, emergency contact personnel, responsibilities of property owners to attend an induction course and to satisfy general Shire requirements for locked gates, individual firebreaks, chemical firebreaks.

8.0 Emergency Procedures – in event of fire, evacuation plan, first aid, traffic management.

9.0 Maintenance – equipment maintenance, fire drills, training of key personnel, frequency of hazard reduction.

10.0 Summary
- 10.1 Overall Fire Threat
- 10.2 Fire Management Plan
- 10.3 Owner's Responsibility
- 10.4 Shire's Responsibility

Appendices – as required, e.g. field gate details, chemical firebreaks, hydrant markings.

Endorsement page – signatories as described in Clause 3.5, date *(see Schedule 4)*.

# Local Planning Policy No 21 – Fire Management Plans

## Schedule 3 – Format of a compliance checklist for performance criteria and acceptable solutions

**ELEMENT 1 – LOCATION**

*Does this proposal comply with the performance criteria by applying acceptable solution A1.1?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P1 for this area of non-compliance, and attach this explanation to the rear of this checklist.

**ELEMENT 2 – VEHICULAR ACCESS**

*Does the proposal comply with the performance criteria by applying acceptable solution A2.1?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.2?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.3?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.4?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.5?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.6?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.7?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.8?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.9?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A2.10?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P2 for this area of non-compliance, and attach this explanation to the rear of this checklist.

# Local Planning Policy No 21 – Fire Management Plans

## Schedule 3 – Format of a compliance checklist for performance criteria and acceptable solutions

### ELEMENT 3 – WATER

*Does the proposal comply with the performance criteria by applying acceptable solution A3.1?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P3 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A3.2?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P3 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A3.3?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P3 for this area of non-compliance, and attach this explanation to the rear of this checklist.

### ELEMENT 4 – SITING OF DEVELOPMENT

*Does the proposal comply with the performance criteria by applying acceptable solution A4.1?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P4 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A4.2?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P4 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A4.3?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P4 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Note: Please indicate the extent of the building protection zone on the plan submitted.*

*Does the proposal comply with the performance criteria by applying acceptable solution A4.4?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P4 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Note: Please indicate the extent of the hazard separation zone on the plans.*

*Does the proposal comply with the performance criteria by applying acceptable solution A4.5?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P4 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Note: Please provide details of the proposed shielding to be implemented as part of the development.*

# Local Planning Policy No 21 – Fire Management Plans

## Schedule 3 – Format of a compliance checklist for performance criteria and acceptable solutions

**ELEMENT 5 – DESIGN OF DEVELOPMENT**

*Does the proposal comply with the performance criteria by applying acceptable solution A5.1?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P5 for this area of non-compliance, and attach this explanation to the rear of this checklist.

*Does the proposal comply with the performance criteria by applying acceptable solution A5.2?*

Yes ☐ No ☐

If "No", please explain in writing how the proposal satisfactorily complies with performance criterion P5 for this area of non-compliance, and attach this explanation to the rear of this checklist.

**Applicant Declaration**

I declare that the information provided is true and correct to the best of my knowledge.

FULL NAME .....

APPLICANT SIGNATURE .....

DATE .....

# Local Planning Policy No 21 – Fire Management Plans

## Schedule 3 – Format of a compliance checklist for performance criteria and acceptable solutions

Application property details:

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# Local Planning Policy No 21 – Fire Management Plan

## Schedule 4 – Format of an endorsement page

Fire Management Plan
*(insert here name of estate or property)*
*(insert here date of plan document)*

Endorsement

| | | |
|---|---|---|
| Shire Planner | ..... Name | ..... Signature |
| Community Emergency Services Manager or Delegate | ..... Name | ..... Signature |
| Chittering Fire Services Chief Bush Fire Control Officer | ..... Name | ..... Signature |

Dated this ..... day of ..... 20.....

# Local Planning Policy No 21 – Fire Management Plan

## Schedule 4 – Format of an endorsement page

**ADOPTED FOR PRELIMINARY APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 19th day of September 2007

**ADOPTED FOR FINAL APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 19th day of December 2007

**ADOPTED FOR PRELIMINARY APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 18th day of July 2012

**ADOPTED FOR FINAL APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 20th day of February 2013

and the seal of the Municipality ]
was pursuant to that resolution ]
hereunto affixed in the presence ]
of: ]

SHIRE OF CHITTERING Common Seal ABN 48 445 751 800

**PRESIDENT** .....

**CHIEF EXECUTIVE OFFICER** .....

**Date** 27/2/13

# SHIRE OF CHITTERING

# TOWN PLANNING SCHEME NO. 6

## Local Planning Policy No. 26

## WASTE MANAGEMENT

# SHIRE OF CHITTERING
# LOCAL PLANNING POLICY No. 26
# WASTE MANAGEMENT

## 1. STATUTORY CONTEXT

The Shire of Chittering, as enabled under Part 2 of Town Planning Scheme (TPS) No. 6, hereby makes this Local Planning Policy (LPP)_regarding Waste Management throughout the Shire of Chittering.
Any Local Planning Policy prepared under this Part shall be consistent with the Scheme and if any inconsistency arises the Scheme shall prevail.
A Local Planning Policy is not part of the Scheme and shall not bind the Local Government in any respect of an application for Planning Approval but the Local Government shall have due regard to the provisions of any Policy and the objectives that the Policy is designed to achieve before making its decision.
This policy applies to all land within the Shire of Chittering. It supersedes LPP No. 26 – Waste Management adopted by Council 19 December 2007.

## 2. DEFINITIONS

*"Council"* means the elected Council of the Shire of Chittering;

*"Local Waste"* means waste products generated within the Shire of Chittering;

*"Shire"* means the Shire of Chittering;

*"Waste Management"* means the generation, collection, transport, processing and disposal of waste products.

*"Waste Products"* means all wastes, including medical, biosolids, household, industrial, agricultural, nuclear, construction and demolition wastes.

## 3. BACKGROUND

Because of its relatively small population and low densities of settlement the Shire has difficulty collecting and disposing of household waste.
In recent years there have been attempts to concentrate wastes produced outside the Shire within the Shire for disposal. This has been perceived as being in conflict with tourism objectives for the Shire.

Schedule 1 of TPS No. 6 defines Landfill/Refuse Centre as meaning "premises used for the disposal, storage and recycling of waste material". Schedule 2 the Zoning Table specifies Land Refuse Centre as an A use in the Light Industrial and Agricultural Resource Zones and an X use in the Townsite and Rural Residential Zones. An A use is one permitted at the discretion of the Council following advertising; an X use is prohibited.

Within the Scheme there is a Local Reserve for "Public Purposes – Land Refuse", which covers the Shire's landfill sites. There is a "Special Control Area – Land Refuse" buffer of 500m from the centre of the land refuse sites.

This policy has been prepared to provide householders with an indication of what waste collection and disposal options they might expect within the foreseeable future and to

provide developers/contractors with Council's view on regional waste processing and disposal and associated rezoning.

## 4. OBJECTIVES

The objectives of this policy are:

*To reduce waste generation, in line with Government policies;*

*To adopt a safe and convenient local waste collection, transport and disposal methods;*

*To minimise the social, environmental and economic costs of waste management to Shire residents;*

*To exclude the Shire as a processing and dumping ground for wastes generated outside the Shire.*

## 5. POLICY STATEMENT

**Local waste generation, collection and disposal**

5.1 It is Council's intention within the foreseeable future that:
there shall be no kerbside waste collection within Agricultural Resource, Light Industrial and Special Use Zones;
there may be kerbside waste collection within Townsite and Rural Residential Zones.

5.2 There shall be public landfills available for local waste disposal, with access to Shire residents on presentation of a tip pass.

5.3 Local waste products shall be disposed of within the Shire only at public landfills or on-site, to the satisfaction of Council's Environmental Health Officer.

5.4 Recycling facilities shall be provided at public landfills to assist in minimising waste generation.

**Processing and disposal within the Shire of wastes produced outside the Shire**

5.5 There shall be no processing and/or disposal within the Shire of waste products generated outside the Shire or any rezoning in TPS No. 6 to permit such activity, provided that nothing shall prevent the Council working with adjoining Local Governments to jointly address waste management issues.

**ADOPTED FOR PRELIMINARY APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 19th day of September 2007.

**ADOPTED FOR FINAL APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 19th day of December 2007

and the seal of the Municipality was pursuant to that resolution hereunto affixed in the presence of:

**PRESIDENT**.....

**CHIEF EXECUTIVE OFFICER**.....

**Date:**.....

# SHIRE OF CHITTERING

# TOWN PLANNING SCHEME NO. 6

## Local Planning Policy No. 28

## PUBLIC OPEN SPACE DEDICATION ON REZONING

# SHIRE OF CHITTERING
# LOCAL PLANNING POLICY No. 28
# PUBLIC OPEN SPACE DEDICATION ON REZONING

## STATUTORY CONTEXT

The Shire of Chittering, as enabled under Part 2 of Town Planning Scheme (TPS) No. 6, hereby makes this Local Planning Policy regarding Public Open Space (POS) Dedication on Rezoning throughout the Shire of Chittering.

Any Local Planning Policy prepared under this Part shall be consistent with the Scheme and if any inconsistency arises the Scheme shall prevail.

A Local Planning Policy is not part of the Scheme and shall not bind the Local Government in any respect of an application for Planning Approval but the Local Government shall have due regard to the provisions of any Policy and the objectives that the Policy is designed to achieve before making its decision.

This policy applies to all land being rezoned for increased residential density within the Shire of Chittering.

## DEFINITIONS

Unless inconsistent with the context, words and expressions used in this policy have the same meaning as they have in the *Planning and Development Act 2005* and TPS No. 6.

## BACKGROUND

The Council of the Shire of Chittering is concerned that land has been rezoned in TPS No. 6 for higher residential density without adequate provision being made for POS for future generations. Deficiencies are unlikely to become apparent until many years into the future, when the land concerned is further subdivided and it is more difficult to acquire suitable POS at reasonable cost. Consequently, the Council desires to obtain POS at the earliest opportunity, when land is first rezoned from rural use.

TPS No. 6 refers to POS and related matters in the following provisions:

*1.5 Purposes of the Scheme*

The purposes of the Scheme are to: -
*(b) Set aside land as reserves for public purposes;*

*1.6 The Aims of the Scheme*

The Aims of the Scheme are: -
*a. To provide environmental protection and enhancement of biodiversity and the natural resources including land, air and water quality;*
*g. To protect and improve areas of remnant vegetation and, waterways from further degradation;*
*h. To facilitate vegetated wildlife corridors and greenways, particularly along the primary water courses throughout the Shire by means of reserves and partnerships with government agencies and private landholders;*
*i. To protect the landscape values of any designated landscape precinct/area/zone;*

*5.8.1. Requirement for a Development Plan*

*Subdivision shall be generally in accordance with a Development Plan or any subsequent variation approved by the Council.*

*An application for subdivision of land in these zones is to be accompanied by a Development Plan which indicates and addresses the following but is not limited to:*

*(b) areas to be set aside for public open space, pedestrian accessways, horse trails, community facilities, etc, as may be considered appropriate;*

**OBJECTIVES**

The objectives of this policy are:

*To maintain the rural character of the Shire;*

*To ensure adequate areas of POS are available for future residents.*

**POLICY STATEMENT**

5.1 Where land is rezoned in TPS No. 6 to permit higher residential density 10 percent of the gross subdivisible area of the land shall be shown as a local scheme reserve for "Parks and Recreation" in rezoning documents and given up free of cost by the owner to the Council;

5.2 Such land for POS shall comprise one or more fee simple lots and be transferred to the Council in return for the granting of final approval of the scheme amendment, in accordance with a legal agreement between the Council and the landowner;

5.3 In determining the gross subdivisible area the Council deducts any land for schools, major regional roads, public utility sites, municipal use sites, and, at its discretion, any other non residential use site.

5.4 Land provided for POS shall where practicable be located to consolidate with adjoining POS and exclude areas for drainage, water-courses and the margins of wetlands;

5.5 Where land is rezoned and developed in stages, the Council may require that the POS for the whole of the area be met entirely from the initial rezoning, or from any succeeding stage, if it considers this desirable;

5.6 Where the land area is such that a 10 percent POS contribution would be too small to be of practical use a cash payment can be made by the subdivider in lieu of providing land for POS;

5.7 All cash in lieu money received by the Council is required by the *Local Government Act 1995* to be paid into a separate account, where the *Local Government Financial Management Regulations 1996* clearly sets out the purposes for which the money is held, the landholding from which it was obtained and the date on which it was paid to the local government;

5.8 Cash in lieu money may be applied:

a) for the purchase of land by the Council for parks, recreation grounds or open spaces generally, in the locality in which the land is situated;

b) in repaying any loans raised by the Council for the purchase of any such land; or

c) for the improvement or development as parks, recreation grounds or open spaces generally or any land in the said locality vested in or administered by the Council for any of these purposes.

**ADOPTED FOR PRELIMINARY APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 14th day of December 2005.

**ADOPTED FOR FINAL APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 15th day of November 2006.

and the seal of the Municipality was pursuant to that resolution hereunto affixed in the presence of:

**PRESIDENT**.....

**CHIEF EXECUTIVE OFFICER**.....

**Date:**.....18/12/06.....

# SHIRE OF CHITTERING

# TOWN PLANNING SCHEME NO. 6

## Local Planning Policy No. 30

## REGISTERED ROAD VERGES

# SHIRE OF CHITTERING
# LOCAL PLANNING POLICY No. 30
# REGISTERED ROAD VERGES

## 1. STATUTORY CONTEXT

The Shire makes this Local Planning Policy No 30 regarding Registered Road Verges (Policy) under Part 2 of the Scheme.

If any provision of this Policy is inconsistent with the Scheme then the Scheme prevails.

This Policy is not part of the Scheme and shall not bind the Shire in any respect of an application for Planning Approval. The Shire shall, however, have due regard to the provisions of this Policy and the objectives that this Policy is designed to achieve before making its decision.

This policy applies to all road reserves within the Shire's district not controlled by Main Roads Western Australia.

## 2. DEFINITIONS

Unless the context otherwise requires, words and expressions used in this Policy have the same meaning as they have in the Scheme.

The following are definitions that relate directly to the application of this policy:

*"Council"* means the Council of the Shire of Chittering;

*"Road Reserve"* means a road reserve as delineated on the Scheme Map;

*"Scheme"* means Shire of Chittering Town Planning Scheme No. 6;

*"Shire"* means the Shire of Chittering;

## 3. BACKGROUND

Registered road verges have a long history and their function varies from one Local Government area to another. In the metropolitan area they have variously been used to protect planted lawns and prevent vehicle parking. Within the Shire of Chittering registered road verges have been mainly associated with preserving natural vegetation and prohibitions on weed spraying, to protect nearby sensitive crops.

With the growing importance of organic certification, contamination of produce by weed spray may take years to recover and have significant economic consequences.

TPS No. 6 makes the following references to reserves, which include road reserves:

*PART 3 - RESERVES*

*3.1 Reserves*

*Certain lands within the Scheme Area are classified as Local Reserves.*

*3.2 Regional Reserves*

*There are no Regional Reserves in the Scheme Area.*

*3.3 Local Reserves*

*"Local Reserves" are delineated and depicted on the Scheme Map according to the legend on the Scheme Map.*

*3.4 Use and Development of Local Reserves*

*3.4.1 A person must not-*

*(a) use a Local Reserve; or*
*(b) commence or carry out any development on a Local Reserve,*

*without first having obtained planning approval under Part 9 of the Scheme.*

*3.4.2 In determining an application for Planning Approval the Local Government is to have regard to:*

*(a) the matters set out in Clause 10.2; and*
*(b) the ultimate purpose intended for the Reserve.*

*3.4.3 In the case of land reserved for the purposes of a public authority, the Local Government is to consult with that authority before determining an application for Planning Approval.*

*10.2 Matters to be considered by Local Government*

*The Local Government in considering an application for Planning Approval, is to have due regard to such of the following matters as are in the opinion of the Local Government relevant to the use or development the subject of the application-*

*(a) the aims and provisions of the Scheme;*
*(b) the requirements of orderly and proper planning including any relevant proposed new district planning scheme or amendment, which has been granted consent for public submissions to be sought;*
*(c) any approved Statement of Planning Policy of the Commission;*
*(d) any approved environmental protection policy under the Environmental Protection Act 1986;*
*(e) any relevant policy or strategy of the Commission and any relevant policy adopted by the Government of the State;*
*(f) any Local Planning Policy adopted by the Local Government under clause 2.4, any heritage policy statement for a designated heritage area adopted under clause 7.2.2, and any other plan or guideline adopted by the Local Government under the Scheme;*
*(g) the aims and objectives of Catchment Management Plans and Principles for the Scheme Area;*
*(h) in the case of land reserved under the Scheme, the ultimate purpose intended for the reserve;*
*(i) the conservation of any place that has been registered in the Register of Places within the meaning of the Heritage Act of Western Australia 1990, or which is included in the Heritage List under clause 7.1, and the effect of the proposal on the character or appearance of a heritage area;*
*(j) the compatibility of a use or development within its setting taking into consideration any Special Control Area;*
*(k) any social issues that have an effect on the amenity of the locality;*
*(l) the cultural significance of any place or area affected by the development;*

(m) *the likely effect of the proposal on the natural environment and any means that are proposed to protect or to mitigate impacts on the natural environment;*
(n) *wether the land to which the application relates is unsuitable for the proposal by reason of it being, or being likely to be, subject to flooding, tidal inundation, subsidence, landslip, bush fire or any other risk;*
(o) *the preservation of the amenity of the locality;*
(p) *the relationship of the proposal to development on adjoining land or on other land in the locality including but not limited to, the likely effect of the height, bulk, scale, orientation and appearance of the proposal;*
(q) *whether the proposed means of access to and egress from the site are adequate and whether adequate provision has been made for the loading, unloading, manoeuvring and parking of vehicles;*
(r) *the amount of traffic likely to be generated by the proposal, particularly in relation to the capacity of the road system in the locality and the probable effect on traffic flow and safety;*
(s) *whether public transport services are necessary and, if so, whether they are available and adequate for the proposal;*
(t) *whether the public utility services are available and adequate for the proposal. This includes existing facilities and those planned for construction to meet the needs of the proposal and future servicing requirements of the Scheme Area;*
(u) *whether adequate provision has been made for access for pedestrians and cyclists (including end of trip storage, toilet and shower facilities);*
(v) *whether adequate provisions have been made for access by disabled persons;*
(w) *whether adequate provision has been made for the landscaping of the land to which the application relates and whether any trees or other vegetation on the land should be preserved;*
(x) *whether the proposal is likely to cause soil erosion or land degradation;*
(y) *the potential loss of any community service or benefit resulting from the Planning Approval;*
(z) *any relevant submissions received on the application;*
(aa) *the comments or submissions received from any authority consulted under clause 10.1.1;*
(bb) *any other planning consideration the Local Government considers relevant.*

This policy has been created to provide guidance for Council and land owners in the creation, administration and on-going maintenance of Registered Road Reserves.

## 4. OBJECTIVES

The objectives of this policy are:

*To specify the functions of registered road reserves;*

*To delineate the responsibilities of adjoining landowners and Council;*

*To maintain the rural character of the Shire.*

## 5. POLICY STATEMENT

### 5.1 General

a) A Registered Road Reserve may be created on part of any public road not controlled by Main Roads Western Australia (Brand and Great Northern Highways and the Bindoon-Moora Road) by an adjoining landowner lodging an application for planning approval and paying the appropriate fee.
b) The application shall state:
   (i) the function of the Registered Road Reserve, which may be one or more of the following:
      - to prevent the application of biocides, for organic certification or health reasons;
      - to protect exotic or natural vegetation, including declared rare flora;
   (ii) the extent of the Registered Road Reserve, which is defined as part or whole of the verge(s) fronting the adjoining landowner's property, or in the case of an unmade road, the area of land to the centreline of the road reserve.
c) Applications for the creation of a Registered Road Reserve may be dealt with by the Chief Executive Officer under delegation issued by Council in accordance with Section 5.46 of the Local Government Act.
d) Any person may petition the Council for cancellation of a Registered Road Reserve, provided that the adjoining landowner concerned shall be consulted prior to cancellation.
e) The creation of a Registered Road Reserve shall not in any way hinder the operation of a service agency from fulfilling its obligations.

### 5.2 Responsibilities of Council

On creation of a Registered Road Reserve the Council shall:

a) enter that part of the road reserve in its database;
b) henceforth refrain from spraying biocides in that part of the road reserve;
c) arrange for the manufacture and placement of one or more appropriate signs on the road verge of the land concerned;
d) continue to be responsible for road and drainage maintenance; and
e) use its best endevours to ensure the road verge is used in a manner consistent with the stated function of the Registered Road Reserve, given the common right of carriageway on the public road.

### 5.3 Responsibilities of Landowner

On creation of a Registered Road Reserve the adjoining landowner shall:

(a) maintain the road verge free of litter, weeds and fire hazards; and
(b) not otherwise alter the status quo of the road verge with respect to level or vegetation, whether natural or created, without planning approval of the Council.

**ADOPTED FOR PRELIMINARY APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the 5th day of April 2006.

**ADOPTED FOR FINAL APPROVAL** by resolution of the **Shire of Chittering** at the Ordinary Meeting of the Council held on the15th day of November 2006.

and the seal of the Municipality was pursuant to that resolution hereunto affixed in the presence of:

**PRESIDENT**.....

**CHIEF EXECUTIVE OFFICER**.....

**Date:**....18/12/06.....

Shire of Chittering

# Local Planning Policy 7
# OUTBUILDINGS

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# 1. Statutory Context

The Shire of Chittering, as enabled under, Schedule 2, Part 2, Division 2 – 'Local Planning Polices' of the deemed provisions, hereby amends this Local Planning Policy (LPP) regarding outbuildings and sheds.

Any LPP prepared under this part shall be consistent with the Scheme and if any inconsistency arises the Scheme shall prevail.

A LPP is not part of the Scheme and shall not bind the Local Government in any respect of any application for development approval, but the local government shall have due regard to the provisions of any policy, and the objectives which the policy is designed to achieve before making its decision in accordance with the deemed provisions.

This LPP applies to all land zoned within the Scheme area and supersedes the previous version of Local Planning Policy No.7 (adopted 19 October 2016).

## 2. Definitions

The following are definitions that relate directly to the application of this policy:

***"Attached"*** means that a structure is joined and structurally connected to another structure.

***"Building Envelope"*** means the area of land within a lot marked on a plan approved by the responsible authority within which all buildings and effluent disposal facilities on the lot must be contained.

***"Carport"*** means a roofed structure designed to accommodate one or more motor vehicles unenclosed except to the extent that it abuts a dwelling or a property boundary on one side, and being without a door unless that door is visually permeable.

***"Council"*** means the elected members of the Shire.

***"Deemed provisions"*** means the provisions of Schedule 2 of the Planning and Development (Local Planning Schemes) Regulations 2015.

***"Detached"*** means that no part of a structure is joined or connected to any part of another structure.

***"Development"*** means the development or use of any land, including –

a. any demolition, erection, construction, alteration of or addition to any building or structure on the land;
b. the carrying out on the land of any excavations or other works;
c. in the case of a place to which a protection order made under the Heritage Act 2018 Part 4 Division 1 applies, any act or thing that –
    i. is likely to change the character of that place or the external appearance of any building; or
    ii. Would constitute an irreversible alteration of the fabric of any building.

***"Development site"*** means a lot on which development occurs, or is proposed.

***"Enclosed"*** means an area bound on three or more sides by a permanent wall and covered in a water impermeable material.

***"Garage"*** means any enclosed roofed structure, other than a carport, designed to accommodate one or more motor vehicles and are attached to a dwelling.

***"LPS6"*** means Shire of Chittering Local Planning Scheme No. 6

***"Natural ground level"*** means the levels on a site which precede the proposed development, excluding any site works unless approved by the decision-maker or established as part of subdivision of the land preceding development.

***"Non-habitable building"*** means a Class 10 building as defined under the National Construction Code Series.

***"Outbuilding"*** means an enclosed non-habitable structure that is detached from any dwelling and used for purposes incidental to a dwelling. For the purpose of this policy, animal feed bins, dongas, sea containers and water tanks do not constitute an outbuilding. An outbuilding not associated with a dwelling, is regarded as a 'shed'.

***"Patio"*** means an unenclosed structure covered in a water impermeable material which may or may not be attached to a dwelling.

***"Residential Design Codes"*** means State Planning Policy 7.3 - Residential Design Codes.

***"Ridge Height"*** means the vertical distance between the natural ground level immediately below the ridge of a roof, and the highest point of a roof.

***"Rural Living Zone"*** means Rural Retreat zone, Rural Smallholdings zone and Rural Conservation zone as defined by LPS6.

***"Scheme"*** means the Shire of Chittering Local Planning Scheme in affect at the time.

***"Shed"*** means an enclosed non-habitable structure not associated with a dwelling.

***"Shire"*** means Shire of Chittering.

***"Substantially commenced"*** means the complete laying of the entire slab of the whole ground floor of a building.

***"Unenclosed"*** means an area bounded on no more than two sides by a permanent wall and covered in a water impermeable material.

***"Wall height"*** means the maximum vertical distance between the finished natural ground level at the base of the wall and the top of the wall where the wall intersects the roof.

## 3. Policy Statement & Objectives

This policy applies to outbuildings and sheds and any attached lean-tos within the Shire. The provisions of this Policy are intended to guide the design and positioning of outbuildings and sheds to ensure a balance between legitimate forms of storage and hobby requirements of landowners, and potential amenity and landscape impacts.

The objectives of this policy are:

- To allow for appropriate outbuildings that do not have adverse impacts on the streetscape, character, amenity or environmental attributes of the surrounding area.
- To protect the natural vegetation and landscape amenity of the Shire.
- To vary Part 5.4.3, C3 deemed-to-comply provisions of the Residential Design Codes.
- To provide guidance on the Development Approval requirements for outbuildings and sheds.

# 4. Statutory Exemptions from Development Approval

This Section of the Policy provides guidance on the existing statutory development approval exemptions that apply to the construction of sheds and outbuildings. This section of the Policy has no implementation purpose, but merely highlights the exemptions of other planning instruments.

4.1 Development approval shall be obtained for the construction of an outbuilding or shed on land within the Scheme area unless:

a. The development is of a type that is exempt from development approval pursuant to Schedule A – 'Supplemental Provisions' of LPS6; or

**Note:** Schedule A – 'Supplemental Provisions' of the Scheme provides an exemption from development approval for the construction of outbuildings on all lots that have constructed (or substantially commenced) a 'single house', where that 'single house' is listed as permissible ('P') under Schedule 2 – Zoning Table of the Scheme, if the outbuilding:

- Complies with the LPS6 setback requirements for that zone or is within the designated building envelope as illustrated on an approved Structure Plan (development plan);
- Complies with the provisions of an approved Structure Plan (development plan);
- Is not within a Special Control Area as defined by the Scheme; and
- Complies with all development standards of the Scheme.

b. The development is of a type that is exempt from approval pursuant to the Deemed Provisions; or

**Note:** The Deemed Provisions exempt outbuildings from development approval when the R-Codes apply, and all the applicable 'deemed-to-comply' provisions of the R-Codes are met.

c. The development is of a type that is exempt from approval pursuant to Section 5 of this Policy.

# 5. Policy Exemptions from Development Approval

This section of the Policy provides exemptions for the requirement for development approval pursuant to Sch. 2, Pt. 7, Cl. 61(i) of the deemed provisions.

5.1 The following are exempt from the requirement for development approval:

a. The construction of a shed or outbuilding on land zoned 'Agricultural Resource' outside of any Special Control Area and compliant with the following setback requirements:

- Highway – 100m
- Major Road – 50m
- Other Road – 30m
- Rear – 30m
- Side – 30m

b. The construction of an outbuilding that complies with the maximum development standards of Section 6.1.1 of this Policy.

# 6. Maximum Development Requirements in Townsite Zone

6.1 The following Table 1 prescribes the maximum aggregate outbuilding size within the Townsite zone:

| R-Coded Areas | Gross total area ($m^2$) | Wall Height (m) | Ridge Height (m) |
|---|---|---|---|
| R2.5 and below | 120 | 3.5 | 4.5 |
| R10/30 | 70 | 3 | 4.5 |
| No R-Code | 200 | 3.5 | 4.5 |

***Note:*** *Pursuant to the Supplemental Provisions of LPS6, outbuildings in the Townsite zone where no R-code applies is exempt from Development Approval - except within a Special Control Area (which is all of Muchea Townsite).*

6.2 Where development approval is required, outbuildings shall be located in cleared areas, behind the main residential building line as illustrated by Schedule 1.

6.3 The gross total area is cumulative and includes any lean-tos, carports or patio structures attached to the outbuilding(s).

6.4 The construction of an outbuilding or shed in the Townsite zone shall be on the same lot as an existing dwelling, or a dwelling that has been substantially commenced.

# 7. Development Requirements in Rural Residential and other Rural Living Zones

7.1 The erection of a shed on a Rural Residential and other Rural Living zoned property prior to the construction of a dwelling requires Development Approval as per the Deemed Provisions. Any shed approved by the Shire in these instances, cannot be used for any 'storage' purpose (including storing personal or household items) until such time that a 'single house' is constructed on the property, or has been substantially commenced.

7.2 Setbacks shall be in accordance with Clause 4.8.2 of the Scheme. Where building envelopes do not apply, development shall be located a minimum of 30 metres from any natural water body and 1.8 metres from any effluent disposal system and their irrigation areas.

7.3 Outbuildings are encouraged to be located in cleared areas, behind the main residential building line as illustrated in Schedule 1. Where an outbuilding/shed is proposed prior to construction of a dwelling, provision should be made for a dwelling to be constructed in-line or on-front of the outbuilding.

7.4 Outbuildings and sheds shall be constructed only of non-reflective material in accordance with Clause 4.8.3 of the Scheme.

## 8. Use of Outbuildings and Sheds

8.1 Outbuildings shall only be used for incidental activities associated with a dwelling (e.g. storage of personal and/or household type items and vehicles). Any commercial use of an outbuilding, including storage of work/commercial related items for the purpose of commercial activities, requires Development Approval from the Shire.

8.2 Sheds shall only be used for purposes incidental to the primary activity on the land (e.g. a farm shed can only be used for storage of farm related items, or for uses associated with the farm).

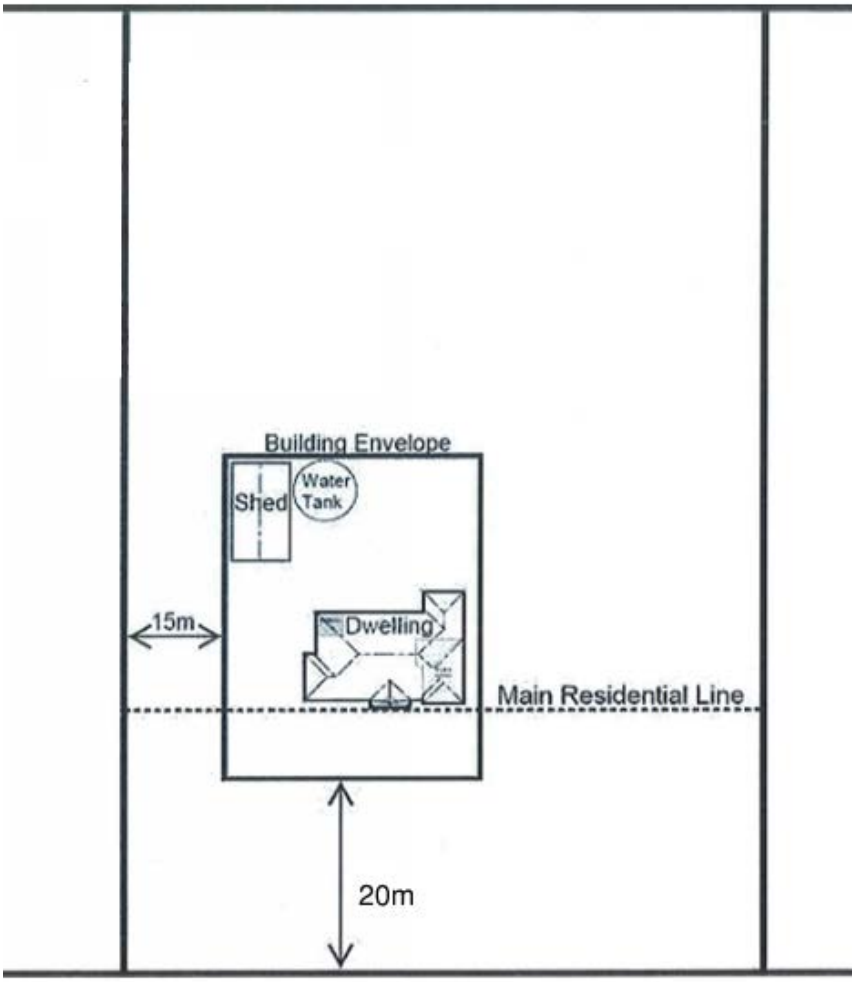
## 9. Additional Information

9.1 If Development Approval is required for a proposed outbuilding or shed, an Application for Development Approval form shall be submitted to the Shire with suitable plans and the relevant application fee.

9.2 A development application to vary the acceptable standards of this Policy and/or LPS6 may be referred to affected surrounding landowners for comment through the development application process. Where a submission is received objecting to a proposal, the application may be referred to Council for consideration, if a condition of approval cannot address the objection raised.

9.3 Any development application lodged with the Shire for a variation to a standard within this Policy, should be accompanied by suitable justification for such variation.

## 10. Schedule 1



**SCHEDULE OF SUBMISSIONS – LOCAL PLANNING POLICY NO.7 - OUTBUILDINGS**

| PUBLIC SUBMISSIONS | | |
|---|---|---|
| **Submitter** | **Comment** | **Proponent Response** |
| | 1. There appears to be an inconsistency in the proposal in relation to the outbuilding size restrictions based on zoning of the land as follows:<br>A) Outbuilding floor sizes to 200m$^2$ in Townsite areas for lots with no R-Code (2-4ha) whereas rural residential zoned (lots) there is no outbuilding size limit.<br>B) Lot sizes in Rural Residential zones are often of a similar size to the Townsite lots (particularly in the Lower Chittering area).<br><br>2. We do not believe that size limitations should be removed for Rural Residential zones.<br><br>3. At the very least the same restrictions should apply for lots of similar size.<br><br>4. We are concerned that by relinquishing all controls on outbuilding size the Shire is putting the objectives of allowing appropriately outbuildings that no do not have adverse impacts on the streetscape, character, amenity, or environmental attributes of the surrounding area at risk.<br><br>5. How does the Shire ensure "appropriate" outbuildings are constructed?<br><br>6. Will there be any restrictions on the number of outbuildings permitted on any one lot?<br><br>7. Will we be able to build four monster sheds on a 2ha lot? | 1. Administration acknowledges that Townsite lots with no R-Code specification are of a comparable size to existing rural residential zoned lots. However, Townsite zoned lots are located within the Bindoon and Muchea townsites and are generally closer to higher residential densities. It is considered appropriate to restrict outbuilding size limits closer to higher density sized lots given the proximity to higher density lots.<br><br>2. Noted.<br><br>3. As discussed at Note 1, it is considered appropriate to restrict outbuilding size limits closer to higher density sized lots given the proximity to higher density lots.<br><br>4 & 5. Administration must give due consideration to any endorsed Local Planning Policy and as such by removing the size specification it will not relinquish all planning controls (refer 1. Statutory Context of the policy). The Shire must also give due consideration to any endorsed local structure plan, neighbours comments and other relevant clauses of the Scheme to enable an appropriate development outcome.<br><br>6. The number of outbuildings permitted is not restricted by the current local planning policy or proposed amendments to the policy. It is considered that the aggregate size and use of outbuildings can have a more profound impact to surrounding neighbours.<br><br>7. Development Applications for an outbuilding(s) are considered on a case-by-case basis, depending on the location proposed and the Shire of Chittering Local Planning Scheme No. 6 requirements. |

**SCHEDULE OF SUBMISSIONS – A11722, P089/19 – PROPOSED DWELLING; LOT 107 CHITTERING ROAD, CHITTERING**

| Submitter | Submission | Proponent Response | Shire Officer Response |
|---|---|---|---|
| PUBLIC 1 - OPPOSE | 1. This proposed dwelling location, in our opinion, will inhibit any future plans we may have to develop that particular corner of our property, in particular due to loss of privacy. Loss of visual privacy and separation for noise. | 1. We understand the neighbour's objection but we feel that they may not understand the reasoning behind the setback reduction. We cannot comment on any future development on the adjacent property as we do not know what the neighbour has in mind, although we do note that there is already one residence on the site already. However we feel that the current position, size and shape of the proposed building is the most beneficial to the neighbour on the eastern boundary. Please see below reasons:<br><br>As detailed in the variation to setbacks submission letter, relocating the house to the west of the Brockman River or the drainage easement is not possible due to the low lying nature of the property and its susceptibility to inundation. Whether it is this proposal or another, any future proposed residence will and must be on this corner of the property. | 1. The submitter has not submitted plans to the Shire for any development proposal on that portion of their property, and their future development plans are not relevant to this proposal. |
| | 2. We do not agree for current setback set by Shire to be amended in any way for this proposal. We recommend the proposed dwelling (using your site map, its current proposed location being on right hand side of Brockman river) to consider relocation to the left hand side of Brockman river. | 2. Given the above, one reason for the reduced setback of the proposed residence is to protect the visual amenity of the existing neighbours. Increasing the setback would make the proposed residence more visible to the neighbour in opposition. The google map provided does not take into account the terrain of the area and its ability to reduce the visual impact of the proposed dwelling to the neighbour who is in opposition to its current proposed position. In the proposed position, the dwelling is blocked by a granite outcrop, hill and trees. The owners also want to reduce the overlooking of the new dwelling as well, and have chosen the proposed site with this strongly in mind.<br><br>My client wishes to place the building in the most appropriate position for all parties including neighbours, the environment and the community and I am not sure that the neighbour understands that by increasing the setbacks to the neighbours property and or redesigning the house to fit the current planning framework would not be the best option for all parties. In particular the points that they have raised in regard to their existing residence.<br><br>We hope that the above information gives you and the neighbour a better understanding of the reasons why we have chosen to reduce the setback and why we feel it is in the interests of the neighbour who has opposed it. | 2. The objector's submission in relation to the proposed dwelling being visible from their dwelling does not relate to the variation to required setbacks. |
| PUBLIC 2 - OPPOSE | 1. The proposed location for the building seriously, unnecessarily and inconsiderately affects the privacy of my property.<br><br>2. The location critically impacts the 30m setback from the boundaries. The surveyed area shows 10m to the boundary and in our case 15.3m from the edge of the proposed building to our common boundary. | 1. See above.<br><br>2. This is correct. Except that it is 15.7m not 15.3m (please see attached site plan). We are seeking a reduced setback. However given that there is no house or infrastructure on the neighbour's property and we are unsure how a reduction of 30m to 15.7m would affect the neighbour's privacy in a rural area. Due to the position of the boundaries and the hill behind, pushing the building back actually decreases the amount of the neighbours land visible to our client. Happy to discuss further. | 1. Refer to #1 above.<br><br>2. |

| | | | |
|---|---|---|---|
| | 3. There is no attempt to cut and fill the land; instead there is a sand pad which will be raised to a considerable height. | 3. There is a small cut and fill proposed. The sand pad is indicative subject to Building approval and Geotechnical report at building approval stage. Height is shown as maximum only for planning consideration and height calculation and if possible will be reduced. The height is not a priority of the client. Not sure how this relates to building setback. | 3. Noted. Not considered to significantly impact neighbouring amenity and is consistent with the objectives of the Agricultural Resource zone. |
| | 4. On wet days, I have noticed the rain come down the mandatory firebreaks and on to the proposed location of the building. There is evidence of rivulets down the firebreaks and onto the surveyed area. The sand may well be affected by the rain and be washed down into the Brockman River area, thereby causing some flooding which may flow back on to my own property. I would therefore query the environmental impact of such movement of sand. | 4. Firebreaks are reduced to mineral earth for fire protection. The fact that the land is reduced mineral earth makes them prone to erosion (by water and wind). This does not apply to the surrounded area as grass and other vegetation stabilises the soil. During construction precautions and proper practice are taken as they are with all other construction in similar situations to ensure no runoff or erosion as this would hinder the construction and increase cost. Post construction the landscaping will void any risk of this in future. Not sure how this relates to building setback. | 4. Flooding and environmental impact |
| | 5. For our neighbour to argue that this area is the only place on his land where he can erect a building is incorrect as his own site plan shows.<br>There is ample room and elevation for a building to be erected along Chittering Road (on the site plan this road is erroneously named as Valley View Road). This would be a better area to locate the proposed building and will considerably reduce site costs, access etc. | 5. The area the neighbour refers to would require a reduction to the setbacks to Chittering Rd. It would also place the building right on Chittering Rd, an existing tourist drive. This is not in keeping with the Chittering Valley Landscape Protection Area. This is further detailed in our setback variation letter under "Planning Considerations" (see attached). In addition, the house would be just as visible to both neighbours in opposition, arguably more visible without the hill to the back. | 5. Noted. The Shire assesses the application as submitted. |
| | 6. There is no fencing between our properties. In February 2019 I contacted our neighbour to come to an agreement over the fencing. I accepted this as necessary, but he then advised me that he did not have enough funds for the fencing. As there is now no fencing between us and our neighbour, this will impact not only on our privacy but also on our security. Builders, contractors and building rubbish will have direct access to our property without hindrance. This is completely unacceptable.<br><br>7. In conclusion I oppose this application for privacy, impact, engineering, safety and environmental reasons. Any application by the neighbour will need to include surveying and erection of fencing between our 2 properties. | 6. I am sure the client would be happy to erect a fence prior to construction of the house. This can even be a condition of planning approval. Not sure how this relates to building setback. | 6. Fencing and trespassing is a civil issue between neighbours and is not considered to be relevant in considering this Development Application. |