Appendix A

Environmental Assessment Report

Table of Contents

1. Introduction 1
   - 1.1 Overview 1
   - 1.2 Purpose and scope of this document 1
   - 1.3 Stakeholder consultation 2
     - 1.3.1 Environmental Protection Authority 2
2. Legislation, policies and guidelines 4
   - 2.1 Federal legislation 4
     - *2.1.1 Environment Protection and Biodiversity Conservation Act 1999* 4
   - 2.2 State legislation 5
     - 2.2.1 Biodiversity Conservation Act 2016 5
     - 2.2.2 Environmental Protection Act 1986 5
     - 2.2.3 State Planning Policies 5
   - 2.3 Environmental Protection Authority (EPA) guidance 6
   - 2.4 Local government policies, strategies and guidance 6
3. Overview of existing environment 8
   - 3.1 Land use 8
     - 3.1.1 Current land use zones 8
     - 3.1.2 Previous land use 9
     - 3.1.3 Surrounding land use 9
   - 3.2 Topography 9
   - 3.3 Landscape and geology 10
   - 3.4 Hydrology 10
     - 3.4.1 Groundwater 10
     - 3.4.2 Public drinking water source area 11
     - 3.4.3 Surface water 11
     - 3.4.4 Geomorphic wetlands 12
   - 3.5 Acid sulfate soils 12
   - 3.6 Vegetation and flora 17
     - 3.6.1 Desktop assessment 17
     - 3.6.2 Site surveys 24
   - 3.7 Fauna and habitat 32
     - 3.7.1 Desktop assessment 32
     - 3.7.2 Field surveys 37
   - 3.8 Conservation areas 42
     - 3.8.1 Bush Forever 42
     - 3.8.2 DBCA managed lands 42

3.8.3 Local Natural Areas 42
3.9 Ecological linkages 43
3.10 Contamination 45
3.11 Bushfire risk 47
3.12 Heritage 48
3.12.1 Indigenous heritage 48
3.12.2 European heritage 48
4. Potential impacts, management and approvals 51
4.1 Surrounding land use 51
4.1.1 Major roads 51
4.1.2 Market gardens 52
4.1.3 Alcoa operations 53
4.1.4 Conservation areas 53
4.2 Geology and soils 54
4.3 Hydrology 54
4.3.1 Groundwater 54
4.3.2 Surface water 55
4.3.3 Geomorphic wetlands 55
4.4 Vegetation and flora 56
4.5 Fauna and habitat 57
4.6 Conservation areas and ecological linkages 58
4.7 Contamination 58
4.8 Bushfire risk 59
4.9 Acid sulfate soils 59
4.10 Heritage 60
5. Assessment against the EPA Principles, Factors and Objectives 62
6. Conclusion 63
7. Limitations 64
8. References 65

List of Tables

Table 2.1: Existing EPBC Act Approvals within the Subject Area 4
Table 3.1: Wetland management categories and management objectives 12
Table 3.2: Geomorphic wetlands within the Subject Area 12
Table 3.3: Threatened and Priority flora potentially occurring within the Subject Area and Sandwich Lots 18
Table 3.7: Previous flora and vegetation surveys conducted 24

Table 3.8: Vegetation Types recorded within the Subject Area 25
Table 3.9: Vegetation Types recorded within the Sandwich Lots.....26
Table 3.10: Vegetation condition scale (Keighery 1994) 26
Table 3.11: Vegetation condition recorded within the Subject Area 27
Table 3.12: Vegetation condition recorded within the Sandwich Lots.....27
Table 3.13: Threatened and Priority fauna potentially occurring within the Subject Area and Sandwich Lots 33
Table 3.14: Previous fauna habitat surveys conducted within the Subject Area 37
Table 3.16: Black Cockatoo foraging species recorded within the Sandwich lots.....39
Table 3.17: Listing categories of European cultural heritage places 48
Table 3.18: European heritage sites mapped within the Subject Area 49
Table 4.1: Noise targets for noise-sensitive land uses as defined in SPP 5.4. 51
Table 4.2: Measured average noise levels – Kwinana Freeway.....51
Table 4.3: Measured average noise levels – Anketell Road.....52
Table 4.4: Soil and land use compatibility (Gozzard 1983).....54

List of Figures

Figure 1.1: Site location 3
Figure 3.1: Topographic and groundwater contours.....13
Figure 3.2: Geology 14
Figure 3.3: Surface water features.....15
Figure 3.4: Acid sulfate soil risk.....16
Figure 3.5: Pre-European vegetation mapping.....23
Figure 3.6: Vegetation Types 29
Figure 3.7: Vegetation condition 30
Figure 3.8: TECs / PECs.....31
Figure 3.9: Black cockatoo habitat.....41
Figure 3.10: Conservation areas and ecological linkages 44
Figure 3.11: Contaminated sites 46
Figure 3.12: Indigenous and European heritage.....50
Figure 4.1: Summary of Environmental, Heritage and Bushfire spatial considerations.....61

Appendices

Appendix A NatureMap and PMST database searches
Appendix B Flora, Vegetation and Black Cockatoo Habitat Assessment
Appendix C Basic Summary of Records (Alcoa landholding)
Appendix D APZ standards

1. Introduction

1.1 Overview

The Department of Planning, Lands and Heritage (DPLH) is preparing the Mandogalup Improvement Scheme (IS) to guide land use planning and future development of approximately 331 ha located south of Rowley Road, north of Anketell Road and west of the Kwinana Freeway (the Subject Area; Figure 1.1). The Subject Area is located approximately 26 km south of Perth CBD within the City of Kwinana (the City).

In addition to the Subject Area, the City also requested that DPLH consider seven additional lots (19.6 ha; herein referred to as ''Sandwich Lots'') for potential inclusion in the IS (Figure 1.1).

The Subject Area is zoned predominantly Rural under the City's Local Planning Scheme (LPS) No. 2 (LPS) and Metropolitan Region Scheme (MRS). A variety of land uses currently occur within the Subject Area including:

- Rural residential properties
- Market gardening
- Sand extraction
- Conservation (Bush Forever Site 393)
- Mandogalup Pioneer Reserve
- Mandogalup fire station.

The Sandwich Lots are zoned Rural under the City's LPS No. 2 and MRS. Current land use of the Sandwich Lots includes rural residential, horticulture and commercial vehicle parking.

Land uses surrounding the Subject Area and Sandwich Lots include:

- The Kwinana Freeway, Rural land uses (including market gardening) and residential development to the east
- Anketell Road and The Spectacles wetland to the south
- Bush Forever Sites 268 and 267 and Rural land uses to the west
- City of Kwinana LPS No. 2 Policy Area 11 (Postans East) associated with Alcoa tailings ponds (part of the Alcoa Residue Disposal Area [RDA]) to the west and south-west
- Hope Valley - Wattleup Redevelopment Area to the north-west
- Rural land uses (including market gardening), Urban (residential) land uses, the proposed Rowley Road extension and Frankland Park to the north.

The above land uses have been considered in determining the IS, and where relevant, have been discussed throughout this report.

1.2 Purpose and scope of this document

This Environmental Assessment Report (EAR) has been prepared to support the preparation of the IS and includes identification of:

- applicable legislation, policy and guidance
- the environmental, bushfire and heritage characteristics of the Subject Area
- potential impacts to the above characteristics associated with the proposed Scheme

- relevant environmental approvals, including current approvals over the site and anticipated approvals that may be required and;
- the likely spatial and management responses of future development to ensure that any identified potential impacts can be mitigated or managed.

1.3 Stakeholder consultation

The DPLH has developed a stakeholder engagement strategy. The IS will be developed in consultation with State and Local Government agencies, industry groups, environmental groups and the local community.

Key State environmental agencies to be consulted include:

- Environmental Protection Authority (EPA)
- Department of Water and Environmental Regulation
- Department of Biodiversity, Conservation and Attractions.

1.3.1 Environmental Protection Authority

1.3.1.1 Air Quality

In June 2016, the Minister for Environment requested the EPA provide advice on the size of a land use planning buffer relating to health and amenity impacts of dust, now and into the future, in respect of potential urban development in the Mandogalup area.

In 2017, the EPA published advice pursuant to section 16(e) of the Environmental Protection Act 1986. The key findings in the EPA's advice include:

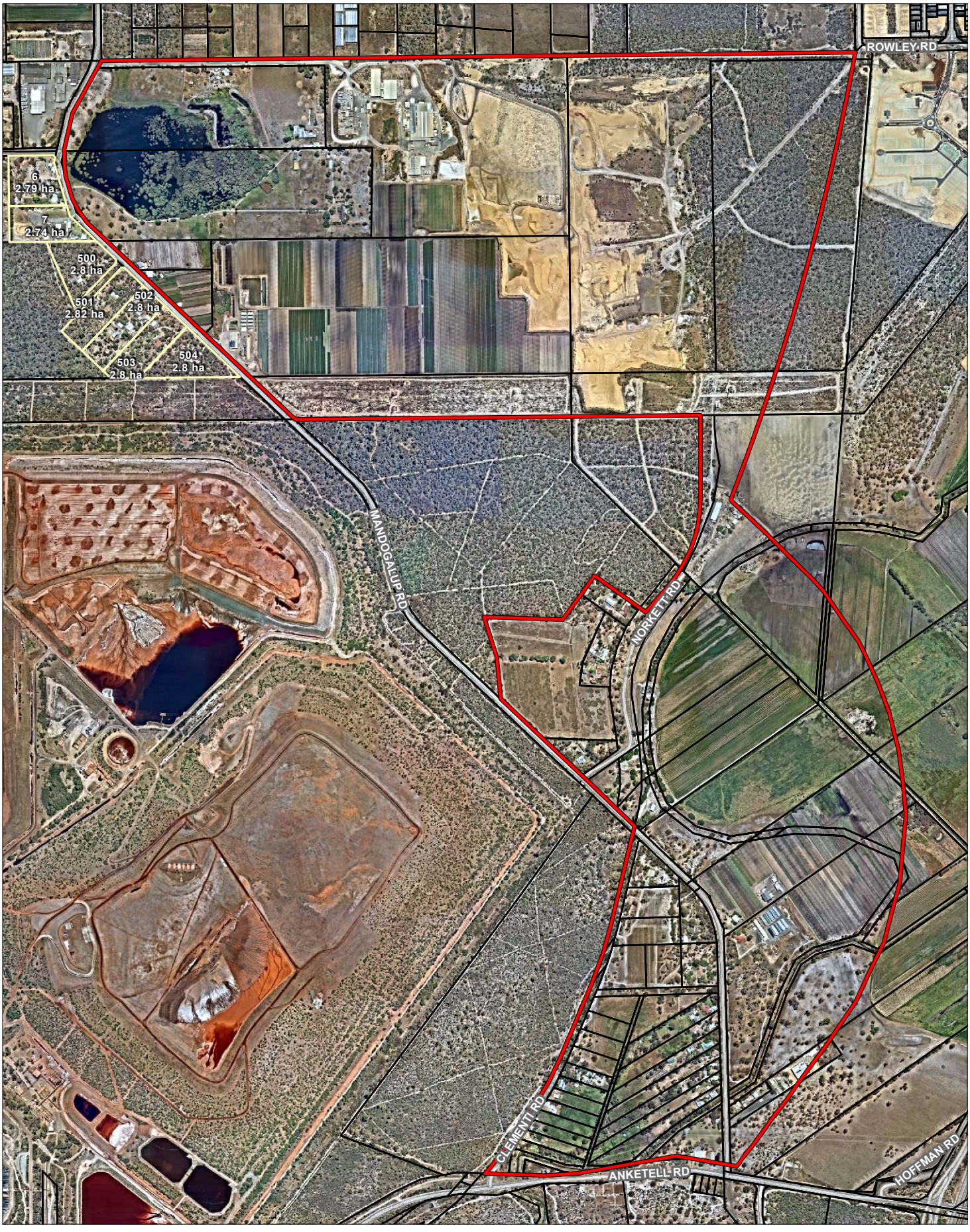
- The eastern area of Mandogalup is located sufficiently far away from the RDA, and outside the predominant wind field that generates dust from the RDA, that there is negligible health risk and low likelihood of unreasonable amenity impacts in this area; and
- Air quality in the north and north-east Mandogalup area does not appear to meet recently revised national air quality goals for particulates. This is likely due to a combination of dust from Alcoa's RDA, and sand and limestone quarrying in the area.

It is understood that air quality considerations are being addressed separately to this EAR by another consultant, and therefore Strategen-JBS&G has not provided any assessment or discussion in relation to this air quality buffer.

1.3.1.2 Part IV *Environmental Protection Act 1986*

In accordance with Section 122B of the *Planning and Development Act 2005* (PD Act) Improvement Schemes are required to be referred to EPA for assessment against its Environmental Principles, Factors and Objectives (pursuant to Section 48 of the *Environmental Protection Act 1986* [EP Act]). It is therefore anticipated that the IS will be referred to the EPA for their assessment under the provisions of the *Environmental Protection Act 1986*.

Section 5 includes a high-level assessment of the proposed rezoning against the EPA's Environmental Principles, Factors and Objectives.



Legend:

- MIP 47 boundary (331.2 ha)
- Cadastral boundary
- Sandwich lots (19.56 ha)
- Roads (MRWA)

strategen JBS&G

0 300 metres

Mandogalup, WA

SITE LOCATION

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: hsullivan	Checked By: CT	Version: A	Date: 16-Dec-2019	**FIGURE: 1.1**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01 Rev A\57020_01_1_SiteLocation.mxd

Image Reference: www.nearmap.com© - Imagery Date: 21 October 2019.

2. Legislation, policies and guidelines

Key statutory and policy documents are listed below, and where specifically relevant to the proposed rezoning, are described in detail in the following sections.

2.1 Federal legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Department of the Environment and Energy (DEE). The EPBC Act aims to protect and manage nine Matters of National Environmental Significance (MNES) throughout Australia including:

- World Heritage Properties
- National Heritage Places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species and ecological communities
- migratory species protected under international agreements
- Commonwealth Marine Areas
- Great Barrier Reef Marine Park
- nuclear actions (including uranium mines)
- a water resource, in relation to coal seam gas development and large coal mining development.

A number of EPBC Act referrals and approvals intersect the Subject Area, which are summarised in Table 2.1. It is anticipated that vegetation currently existing within the boundaries of EPBC approval areas will be cleared over time. Within the Subject Area, a large portion of black cockatoo habitat and 'Banksia woodlands of the Swan Coastal Plain Threatened Ecological Community (TEC)'contained within Lots 2 and 10 is planned for removal to facilitate sand extraction and is currently being assessed under the Commonwealth EPBC Act (EPBC 2018/8182), and under Section 38 of the Western Australian EP Act. This is discussed further in Section 4.

Table 2.1: Existing EPBC Act Approvals within the Subject Area

EPBC reference	Status	Referral/ Approval area	Expiry date
EPBC 2014/7126	Approved	Lot 9002 on Plan 417428	31 July 2024
EPBC 2018/8182	Under assessment	Lot 2 on Plan 11392 and Part Lot 10 on Plan 69890	N/A
EPBC 2018/8186	Not a controlled action (approved)	Lot 52 on Plan 9780	N/A
EPBC 2018/8264	Not a controlled action (approved)	Part Lots 9006 on Plan 70124, 9002 on Plan 69132, Lot 11 on Plan 79538 and Lot 9000 on Plan 31293	N/A

Remaining areas of the Subject Area contain habitat suitable for Threatened black cockatoo species, as well as potential ''Banksia woodlands of the Swan Coastal Plain TEC'' and ''Tuart woodlands and forests of the Swan Coastal Plain TEC'', which are MNES under the EPBC Act. The potential impacts to MNES and associated EPBC Act referral/ approval requirements are discussed in Section 4.4 and Section 4.5 of this report.

2.2 State legislation

The environmental assessment has been conducted with reference to the following State legislation which provides for the environmental and heritage values, and bushfire risk addressed within this report:

- *Biodiversity Conservation Act 2016* (BC Act)
- EP Act
- *Biosecurity and Agriculture Management Act 2007* (BAM Act)
- *Rights in Water and Irrigation Act 1914* (RIWI Act)
- *Aboriginal Heritage Act 1972 (WA)* (AH Act)
- *Contaminated sites Act 2003* (CS Act)
- *Planning and Development Act 2005.*

2.2.1 Biodiversity Conservation Act 2016

The *Biodiversity Conservation Act 2016* has now replaced the *Wildlife Conservation Act 1950* (WC Act). On 3 December 2016, several parts of the new Act were enacted by the State Governor. The remaining parts of the Act and the associated Regulations came into effect on 1 January 2019.

In addition to providing for the protection of flora and fauna, the *Biodiversity Conservation Act 2016* includes provisions for threatened ecological communities, threatening processes, critical habitats and environmental pests.

The potential for State listed threatened and priority species and communities to occur within the Subject Area is discussed in Sections 3.6 and 3.7.

2.2.2 Environmental Protection Act 1986

The EP Act is administered by the EPA. The EP Act provides for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing.

Part IV of the EP Act makes provisions for the EPA to undertake environmental impact assessment of significant proposals, strategic proposals and land use planning schemes. The EPA uses environmental principles, factors and associated objectives as the basis for assessing whether a proposal or land use planning scheme's impact on the environment is acceptable.

As outlined in Section 1.3.1, the IS will be referred to the EP Act under Section 38 and/ or 81 of the *Planning and Development Act 2005* during the future rezoning process, and may choose to formally assess the proposal under Section 48 of the EP Act, where significant impacts to the EPA factors are possible. An assessment against the EPA factors has been provided in Section 5.

2.2.3 State Planning Policies

The Western Australian Planning Commission (WAPC) prepares and adopts state planning policies under statutory procedures set out in part 3 of the *Planning and Development Act 2005.* State planning policies relevant to the IS, Sandwich Lots and/ or this EAR are listed below:

- State Planning Policy 2.1: *Peel-Harvey Coastal Plain Catchment Policy* (SPP 2.1)
- State Planning Policy 2.4: *Basic Raw Materials* (SPP 2.4)

- State Planning Policy 2.5: *Rural Planning* (SPP 2.5)
- State Planning Policy 2.8: *Bushland Policy for the Perth Metropolitan Areas* (SPP 2.8)
- State Planning Policy 2.9: *Water Resources* (SPP 2.9)
- State Planning Policy 3.1: *Residential Design Codes* (SPP 3.1)
- State Planning Policy 3.5: *Historic Heritage Conservation* (SPP 3.5)
- State Planning Policy 3.7: *Planning in Bushfire Prone Areas* (SPP 3.7)
- State Planning Policy 4.1: *State Industrial Buffer Policy* (SPP 4.1)
- State Planning Policy 5.4: *Road and Rail Transport Noise and Freight Considerations in Land Use Planning – Section 5.3 Noise Criteria* (SPP 5.4)
- State Planning Policy 7.0: *Design of the Built Environment and Apartment Design Guide* (SPP 7.0)

Where relevant, the above SPPs have been discussed throughout this EAR.

2.3 Environmental Protection Authority (EPA) guidance

The EAR has given consideration to the recommendations of key EPA policy and guidance as listed below:

- *Environmental Factor Guideline - Social Surroundings*
- *Environmental Factor Guideline - Human Health*
- *Environmental Factor Guideline - Inland Waters*
- *Environmental Factor Guideline - Terrestrial Fauna*
- *Environmental Factor Guideline - Terrestrial Environmental Quality*
- *Environmental Factor Guideline – Landforms*
- *Environmental Factor Guideline - Flora and Vegetation*
- *Environmental Protection Peel Inlet - Harvey Estuary Policy 1992*
- *WA Environmental Offsets Policy 2011 and guidelines*
- *EPA Guidance Statement No. 33 Environmental Guidance for Planning and Development (EPA 2008)*
- *Environmental Protection Bulletin No. 20 Protection of naturally vegetated areas through planning and development.*

Given that air quality is outside of the scope of Strategen-JBS&G, this EAR has not considered the EPA's Environmental Factor Guideline for air quality nor has it considered the *Environmental Protection (Kwinana) (Atmospheric Wastes) Policy 1999 and Environmental Protection (Kwinana) (Atmospheric Wastes) Regulations 1992.*

2.4 Local government policies, strategies and guidance

The City has developed numerous polices, strategies and guidelines relevant to planning and the environment, as listed below. Reference to these documents has been made throughout the report where applicable to a specific environmental factor.

- Conservation of Remnant Vegetation
- Cultural Policy and Plan

- Design Guidelines for Medium Density Development
- Development within Special Rural zones
- Planning for Bushfire Protection Guidelines
- Landscape Feature and Tree Retention
- Site Requirements and Standards for Development within the Industrial Zones
- Public Open Space
- Residential Subdivision and Development
- Street trees and verge treatments
- Local Biodiversity Study.

3. Overview of existing environment

3.1 Land use

3.1.1 Current land use zones

The Subject Area is zoned predominantly Rural under the City's Local Planning Scheme (LPS) No. 2 (LPS) and Metropolitan Region Scheme (MRS). In addition to Rural uses, the following additional uses are currently permissible under the City's LPS (Plate 1):

- Public Purposes (Lot 76 Mandogalup Road, north of Anketell Road)
- Park recreation and drainage (Peel Main Drain and Sub Drain).

Under the MRS, Norkett Road (also referred to as Hammond Road extension) is mapped as an 'Other Regional Road', extending north through the centre of the Subject Area, however this road extension is not currently constructed. Additionally two planning control areas (PCAs) exist at the northern and southern site boundaries, associated with Rowley Road PCA 112 and Anketell Road PCA 111, respectively.

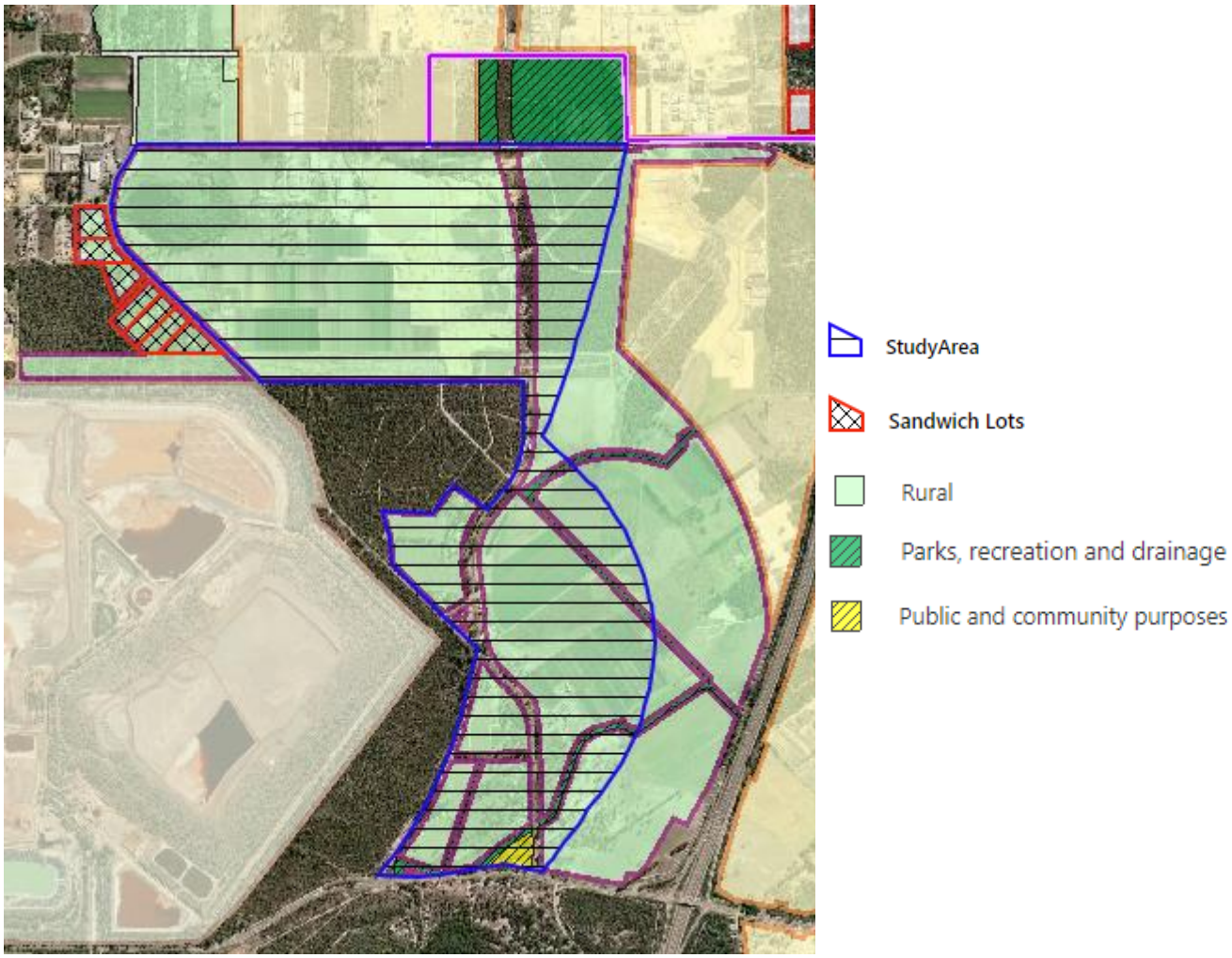


Plate 1: City of Kwinana LPS No. 2 land use zoning

A variety of land uses currently occur within the Subject Area including:

- rural residential properties
- market gardening

- sand extraction
- conservation (Bush Forever Site 393)
- Mandogalup Pioneer Reserve
- Mandogalup fire station.

The Sandwich Lots are zoned Rural under the City's LPS No. 2 and MRS. Current land use of the Sandwich Lots includes rural residential and commercial uses.

3.1.2 Previous land use

Based on a review of historical aerial imagery, the Subject Area and Sandwich Lots have been previously used for general rural/ agricultural uses (market gardening, horse agistment) as well as sand extraction. Land uses within two of the Sandwich Lots appear to include horticultural commercial vehicle uses.

Potential contamination sources associated with historic use of the Subject Area and Sandwich Lots are discussed further in Section 3.10.

3.1.3 Surrounding land use

Land uses surrounding the Subject Area and Sandwich Lots include:

- The Kwinana Freeway, Rural land uses (including market gardening) and residential development to the east
- Anketell Road and The Spectacles wetland to the south
- Bush Forever Sites 268 and 267 and Rural land uses to the west
- City of Kwinana LPS No. 2 Policy Area 11 (Postans East) associated with Alcoa tailings ponds (part of the Alcoa Residue Disposal Area [RDA]) to the west and south-west
- Hope Valley - Wattleup Redevelopment Area to the north-west
- Rural land uses (including market gardening), Urban (residential) land uses, the proposed Rowley Road extension and Frankland Park to the north.

The compatibility of surrounding land uses with future development within the Subject Area, is further discussed in Section 4.1.

3.2 Topography

Topography across the Study Area is generally varied and influenced by current land use. The topographic contours have been taken from LiDAR (2008) and are shown in Figure 3.1.

The northern section of the Study Area shows topography generally sloping east to west from 35 and 40 mAHD to 10 mAHD at the north-western corner of the Study Area. Contours shown in in Figure 3.1 around the sand quarry are likely not representative of current elevations.

For example, the mound suggested in the northern area near Rowley Road appears to represent stock-pilling of sand on the land in 2008. No such mound is evident in the recent aerial photograph in Figure 3.1.

In the southern section of the Study Area, there are three topographic mounds at 20 to 23 mAHD which generally slope towards Peel Main Drain (12 to 13 mAHD). The Main Drain is shown as a more incised channel near the southern end of the Study Area and shallower amongst the market garden areas of Mandogalup Swamp (13 mAHD).

Consideration of topography and determination of appropriate levels and grades for development will be undertaken by the project engineer.

3.3 Landscape and geology

Regional landscape mapping (DAFWA 2012) identifies the following eight landscape units within the Subject Area and Sandwich Lots (Figure 3.2):

- 211SpW_SWAMP:Swamp.
- 211Sp__S1b:Dune ridges with deep siliceous yellow brown sands or pale sands with yellow-brown subsoil and slopes up to 15%.
- 211Sp__S2a:Lower slopes (1-5%) of dune ridge with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop.
- 211Sp__S4a:Flat to gently undulating sandplain with deep, pale and sometimes bleached, sands with yellow-brown subsoils.
- 211Va__V9:Areas of former swamps which have been artificially drained, with uniform loamy or peaty sands.
- 212Bs__B1:Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak ironorganic hardpan at depths generally greater than 2 m; banksia dominant.
- 212Bs__B2:Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
- 212Bs__B4:Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.

Regional geological mapping (Gozzard 1983) identifies three geological units within the Subject Area and Sandwich Lots:

- SANDY SILT (Ms_5)- dark brownish grey silt, with disseminated fine-grained quarts sand, firm, variable clay content, of lacustrine origin.
- SAND (S_7)- pale yellowish brown, medium to course-grained sub-angular quartz, trace of feldspar, moderately sorted, of residual origin.
- SAND (S_8)- very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of aeolian origin.)

The Ms_5 geological unit is limited to wetland areas (described in Section 3.4.4). The S_7 unit occurs predominantly in the western portions of the Subject Area and Sandwich Lots, while S_8 occurs predominantly in the eastern portion.

The compatibility of development with the broadly mapped soil types within the Subject Area and Sandwich Lots is discussed in Section 4.2.

3.4 Hydrology

3.4.1 Groundwater

The Subject Area is located within the following groundwater catchment areas and sub-areas:

- Cockburn groundwater catchment area
    - Thompsons sub-area
    - Cockburn confined sub-area
    - Valley sub-area

- Jandakot groundwater catchment area
    - Mandogalup sub -area
    - Jandakot confined sub-area.

The Subject Area is situated upon three groundwater aquifers, which are (in order of proximity to ground level):

- Perth Superficial Swan
- Perth Leederville
- Perth Yarragadee North.

Regional historical maximum groundwater contour mapping (DWER 2004) indicates that the water table is situated at approximately 12 m AHD in the north-western portion of the Subject Area, increasing to approximately 20 m AHD in the north-eastern corner of the Subject Area (see Figure 3.1).

Based on a review of groundwater contour data (DWER 2004), regional topographic contours and expressions of surface water (based on aerial imagery and site walkover), groundwater is above natural surface level in the north-western corner of the Subject Area. Depth to groundwater in the north-eastern portion of the Subject Area is expected to be up to 20 m below ground level, while groundwater in the southern portions of the Subject Area is anticipated to range from ''at surface'' to over 15 m below ground level.

Depth to groundwater in the location of the Sandwich Lots is expected to range from two metres in the north, up to 20 m in the south (see Figure 3.1).

A number of groundwater bores and associated abstraction licences currently exist across the Subject Area and Sandwich Lots. This is further discussed in Section 4.3.1.

3.4.2 Public drinking water source area

The *Metropolitan Water Supply, Sewerage and Drainage Act 1909* (MWSSD Act) and the *Country Areas Water Supply Act 1947* (CAWS Act) identify and categorise public drinking water source areas (PDWSA) as catchment areas, water reserves, or underground water pollution control areas.

There are no mapped PDWSAs within or adjacent to the Subject Area or Sandwich Lots. The nearest PDWSA is located approximately 1 km east of the Subject Area.

3.4.3 Surface water

The Subject Area is located within the following surface water catchment areas and sub-areas:

- Cockburn/ Kwinana Coastal surface water area
    - Cockburn/ Kwinana Coastal subarea
- Serpentine River Catchment surface water area
    - Lower Serpentine subarea.

The Peel Main Drain and sub-drain occur within the central and southern portions of the Subject Area. The Peel main drain is a rural drain that forms a regional drainage network, running through many wetlands and other low-lying areas (DoW 2009; Figure 3.3).

Water flows from Banjup Swamp to the north-east, through Mandogalup Swamp (North and South) within the Subject Area, to the Spectacles Wetlands south of the Subject Area (Figure 3.3). The Peel main drain contributes approximately 48 per cent of the water entering the Spectacles (the

remainder is from groundwater) and therefore plays an important ecological function to the local wetland network (DoW 2009).

3.4.4 Geomorphic wetlands

The nature of the protection and management of Swan Coastal Plain wetlands should be afforded is guided by the appropriate management category they have been assigned. These management categories are listed below:

Table 3.1: Wetland management categories and management objectives

Category	Objective
Conservation (C category) Wetlands	To preserve wetland (natural) attributes and functions
Resource Enhancement (R category) wetlands	To restore wetlands through maintenance and enhancement of wetland functions and attributes
Multiple Use (M category) wetlands	To use, develop and manage wetlands in the context of water, town and environmental planning

Mapping of the geomorphic wetlands of the Swan Coastal Plain (DBCA 2019a) identifies four wetlands within the Subject Area (see Figure 3.3). These are listed in Table 3.2.

Table 3.2: Geomorphic wetlands within the Subject Area

UFI	Wetland type	Wetland management category
6610 (Wattleup Lake)	Basin/ lake	Resource Enhancement
6531	Basin/ dampland	Multiple Use
6530 (Mandogalup Swamp North)	Basin/ dampland	Multiple Use
6538 (Mandogalup Swamp South)	Basin/ dampland	Multiple Use

Management considerations regarding the presence of a Resource Enhancement Wetland within the Subject Area are further discussed in Section 3.4.3. It should also be noted that this Resource Enhancement Wetland forms part of Bush Forever Site 393.

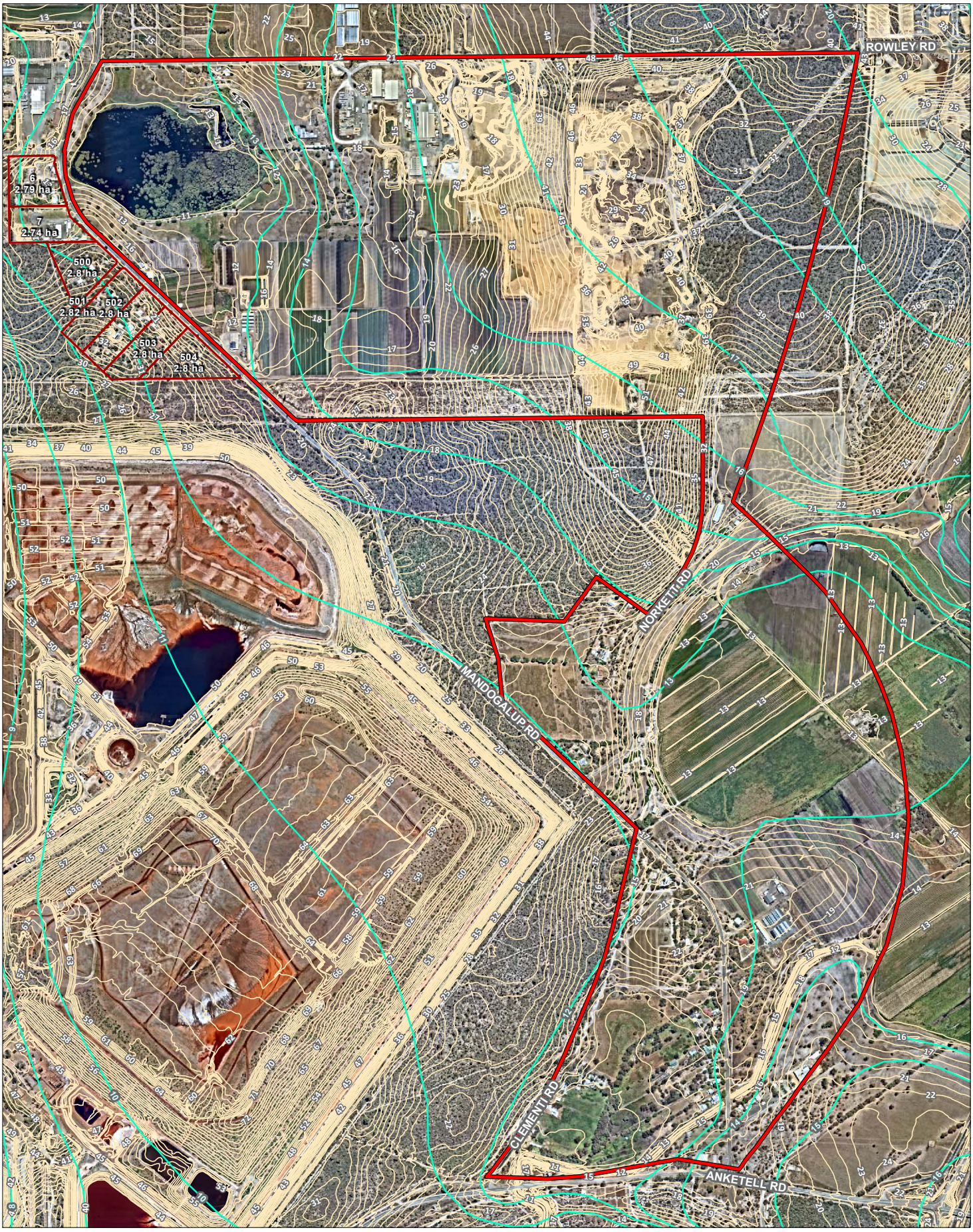
There are no mapped wetlands within the Sandwich Lots.

3.5 Acid sulfate soils

Acid sulfate soils (ASS) are naturally occurring, iron-sulfide rich soils, sediments or organic substrates, formed under waterlogged conditions. If exposed to air, these sulfides can oxidise and release sulfuric acid and heavy metals. This process can occur due to drainage, dewatering or excavation.

The eastern portions of the Subject Area are mapped as having a ''moderate to low'' risk of ASS occurring within 3 m of the natural surface. Low lying areas in the north-western, central and south western portions of the Subject Area are mapped as having a ''high to moderate'' risk of ASS occurring within 3 m of the natural surface. A significant portion of the north of the Subject Area, the central west and the Sandwich Lots do not have a known risk of ASS.

ASS risk mapping is present in Figure 3.4, and ASS management requirements are discussed in Section 4.9.



Legend:

- MIP 47 boundary (331.2 ha)
- Sandwich lots (19.56 ha)
- Topographic contours (1m)
- Groundwater contours (historic maximum)

strategen JBS&G

0 300 metres

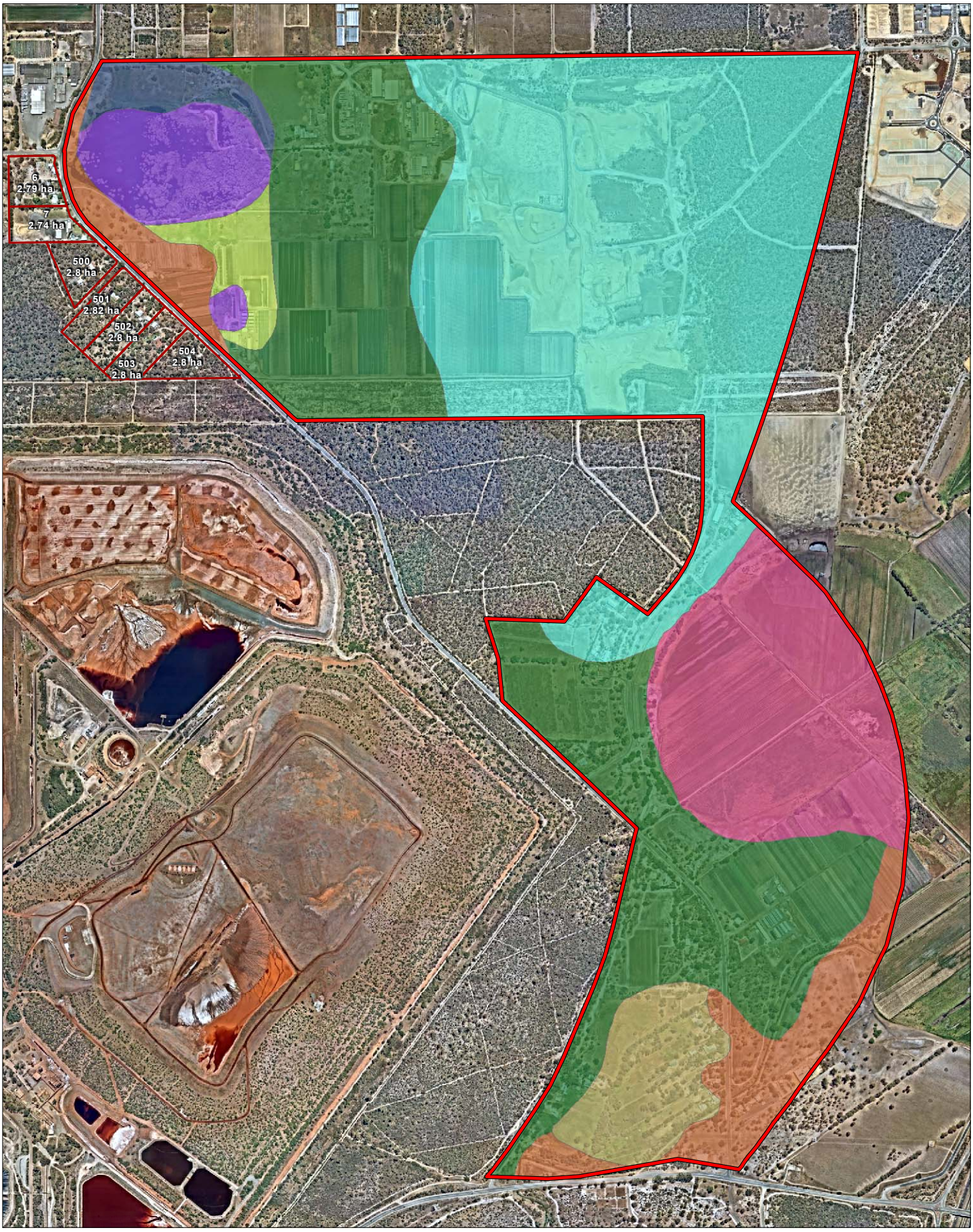
Mandogalup, WA

TOPOGRAPHIC AND GROUNDWATER CONTOURS

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: CoB	Version: A	Date: 24-Mar-2020	**FIGURE: 3.1**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01 Rev A\57020_03_1_Topo_GW.mxd

Image Reference: www.nearmap.com© - Imagery Date: 21 October 2019.



Legend:

- MIP 47 boundary (331.2 ha)
- Sandwich lots (19.56 ha)

Soil landscape mapping (DPIRD-027)

- 211SpW_SWAMP:Swamp.
- 211Sp__S1b:Dune ridges with deep siliceous yellow brown sands or pale sands with yellow-brown subsoil and slopes up to 15%.
- 211Sp__S2a:Lower slopes (1-5%) of dune ridge with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop.
- 211Sp__S4a:Flat to gently undulating sandplain with deep, pale and sometimes bleached, sands with yellow-brown subsoils.
- 211Va__V9:Areas of former swamps which have been artificially drained, with uniform loamy or peaty sands.
- 212Bs__B1:Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant.
- 212Bs__B2:Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.
- 212Bs__B4:Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.

strategen JBS&G

0 300 metres

Job No: 57020 | Scale 1:14,000 at A4

Client: Taylor Burrell Barnett | Coord. Sys. GDA 1994 MGA Zone 50

Drawn By: hsullivan | Checked By: CT | Version: A | Date: 16-Dec-2019

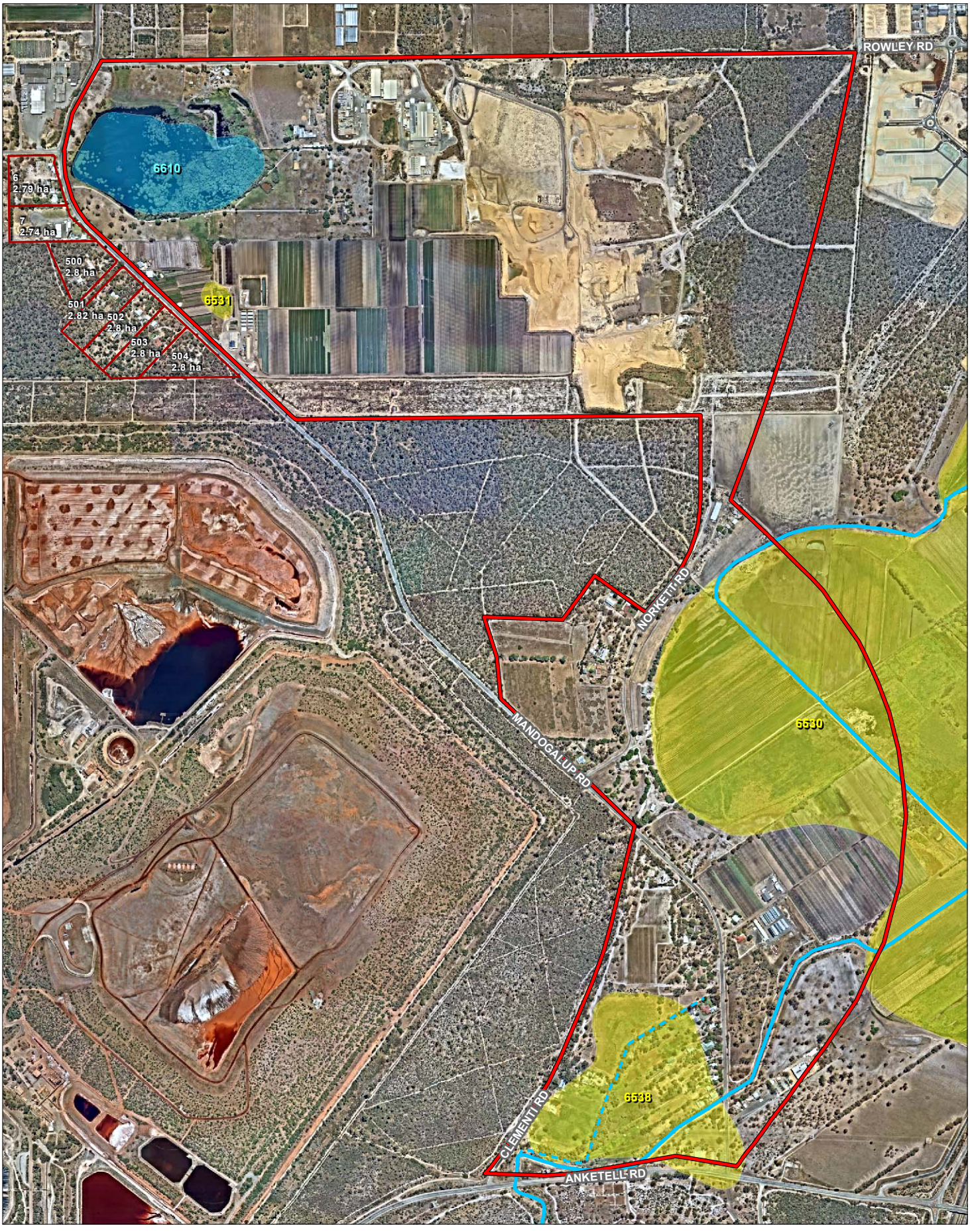
Mandogalup, WA

GEOLOGY

FIGURE: 3.2

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01 Rev A\57020_03_2_Geology.mxd

Image Reference: www.nearmap.com© - Imagery Date: 21 October 2019.



Legend:

- MIP 47 boundary (331.2 ha)
- Sandwich lots (19.56 ha)
- Resource Enhancement
- Multiple Use

Drainage channels

- Peel main drain
- Peel sub-drain

strategen JBS&G

0 300 metres

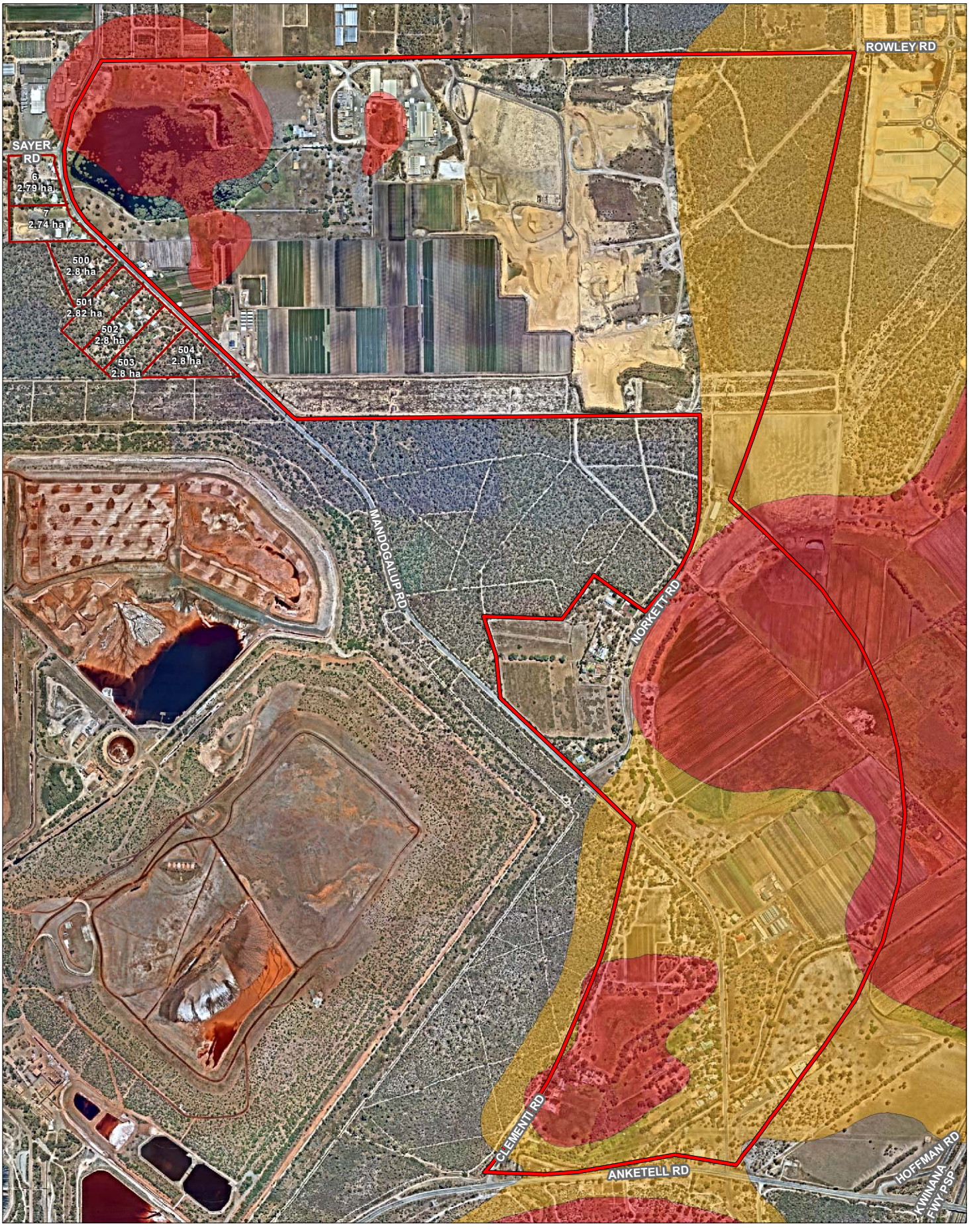
Mandogalup, WA

SURFACE WATER FEATURES

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: hsullivan	Checked By: CoB	Version: A	Date: 16-Dec-2019	**FIGURE: 3.3**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01 Rev A\57020_03_3_SurfaceWater.mxd

Image Reference: www.nearmap.com© - Imagery Date: 21 October 2019.



Legend:

- MIP 47 boundary (331.2 ha)
- Sandwich lots (19.56 ha)

Acid sulfate soil risk mapping (DWER)

- High to moderate risk
- Moderate to low risk

strategen JBS&G

0 300 metres

Mandogalup, WA

ACID SULFATE SOIL RISK

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: hsullivan	Checked By: CoB	Version: A	Date: 16-Dec-2019	**FIGURE: 3.3**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01 Rev A\57020_03_4_ASS.mxd

Image Reference: www.nearmap.com© - Imagery Date: 21 October 2019.

3.6 Vegetation and flora

3.6.1 Desktop assessment

3.6.1.1 Flora

The Commonwealth EPBC Act and State BC Act provide for the listing and protection of threatened flora. Additionally, at a State level, DBCA list ''priority'' species which are possibly threatened species that do not meet survey criteria, or are otherwise data deficient.

Desktop searches were conducted using a 5km buffer of the centre-point of the Subject Area, in *NatureMap* (DBCA 2019b) and the EPBC *Protected Matters Search Tool* (PMST). The objective of these searches was to identify flora species of conservation significance potentially occurring within the Subject Area and Sandwich Lots.

The searches identified a total of eight threatened and five priority flora species as having been previously recorded, or with potentially suitable habitat occurring within 5 km of the centre-point of the Subject Area (Appendix A). The species returned by the desktop searches are listed below:

- *Andersonia gracilis* (Slender Andersonia) – Threatened (EPBC Act; BC Act)
- *Caladenia huegelii* (Grand Spider Orchid)- Threatened (EPBC Act; BC Act)
- *Diuris micrantha* (Dwarf Bee-orchid)- Threatened (EPBC Act; BC Act)
- *Diuris purdiei* (Purdie's Donkey-orchid) – Threatened (EPBC Act; BC Act)
- *Drakaea elastica* (Glossy-leaved Hammer Orchid) – Threatened (EPBC Act; BC Act)
- *Drakaea micrantha* (Dwarf Hammer-orchid) – Threatened (EPBC Act; BC Act)
- *Eleocharis keigheryi* (Keighery's Eleocharis) – Threatened (EPBC Act; BC Act)
- *Lepidosperma rostratum* (Beaked Lepidosperma) – Threatened (EPBC Act; BC Act)
- *Cyathochaeta teretifolia* – Priority 3 (DBCA listed)
- *Pimelea calcicola*– Priority 3 (DBCA listed)
- *Pithocarpa corymbulosa* (Corymbose Pithocarpa)– Priority 3 (DBCA listed)
- *Stylidium paludicola* – Priority 3 (DBCA listed)
- *Dodonaea hackettiana* (Hackett's Hopbush)– Priority 4 (DBCA listed).

Of the species listed above, based on general habitat requirements (Table 3.6), three Threatened and one Priority flora species were considered to have the potential to occur within the Subject Area and Sandwich Lots, as follows:

- *Caladenia huegelii* (Threatened – Endangered [EPBC Act]; Threatened [BC Act])
- *Dodonaea hackettiana* (P4)
- *Drakaea elastica* (Threatened – Endangered [EPBC Act]; Threatened [BC Act])
- *Drakaea micrantha* (Threatened – Vulnerable [EPBC Act]; Threatened [BC Act])

The potential for these species to occur within the Subject Area is discussed further in Section 3.6.2.1.

Table 3.3: Threatened and Priority flora potentially occurring within the Subject Area and Sandwich Lots

Species	Conservation status		Description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
Andersonia gracilis	Threatened – Endangered	Threatened	A slender, erect or open straggly shrub, 10 to 100 cm high. Flowers are white to pink to purple from September to November. Habitat for this species occurs in white/grey sand, sandy clay, gravelly loam within winter-wet areas and near swamps (Western Australian Herbarium 1998-). The species occurs in damp black, sandy clay flats near swamps in open low heath with Calothamnus hirsutus (hairy clawflower), Verticordia densiflora (compact featherflower), Kunzea recurva (recurved kunzea) and Banksia telmatiaea over sedges (Western Australian Herbarium 1998-, DEE 2019a).	**Unlikely** due to absence of preferred habitat. While wetlands are present within the Subject Area, these are heavily degraded, with understorey species largely displaced by weeds and ornamental species. None of the associated species were recorded within the Subject Area or Sandwich Lots.
Caladenia huegelii	Threatened – Endangered	Threatened	A slender orchid from 30 to 50 cm tall. One or two striking flowers characterised by a greenish-cream lower petal with a maroon tip. Other petals are cream with red or pink suffusions. Habitat for this species occurs within well-drained, deep sandy soils in low mixed *Banksia*, *Allocasuarina* and Jarrah woodlands (Western Australian Herbarium 1998-, DEE 2019a).	**Possible.** Potential habitat is present within VT6, VT7 and VT10. Habitat is also present within VT12; however, two seasons of survey for this species were conducted over two consecutive years, and no individuals were recorded.
Cyathochaeta teretifolia	-	P3	A rhizomatous, clumped, robust perennial, grass-like or herb (sedge), to 2 m high and to 1.0 m wide. Flowers are brown. Habitat for this species includes grey sand or sandy clay within swamps or creek edges (Western Australian Herbarium 1998-).	**Unlikely** due to absence of preferred habitat. While wetlands are present within the Subject Area, these are heavily degraded, with understorey species largely displaced by weeds and ornamental species.
Diuris micrantha	Threatened – Vulnerable	Threatened	A slender orchid to 60 cm tall. Yellow flowers with reddish-brown markings measuring 1.3 cm across. Habitat for this species occurs within clay-loam substrates in winter-wet depressions or swamps.	**Unlikely** due to absence of preferred habitat. While wetlands / winter-wet depressions are present within the Subject Area, these are heavily degraded, with understorey species largely displaced by weeds and ornamental species.
Diuris purdiei	Threatened – Endangered	Threatened	A slender orchid to 0.35 m tall. Flowers are yellow and visible from September to October. Habitat for this species is grey-black sand substrates in winter-wet swamps which have high moisture (Western Australian Herbarium 1998-). Diuris purdiei occurs from Perth south to near the Whicher Range, within the Swan (Western Australia) Natural Resource Management Region. It grows on sand to sandy clay soils, in areas subject to winter inundation, and amongst native sedges and	**Unlikely** due to absence of preferred habitat. No areas comprising an intact understorey of dense heath or sedges with key emergent species were recorded within the Subject Area.

			dense heath with scattered emergent *Melaleuca preissiana*, *Corymbia calophylla*, *E. marginata* and *Nuytsia floribunda* (DEE 2019a).	
Dodonaea hackettiana	-	P4	An erect shrub or tree, 100 to 500 cm tall. Flowers are yellow to green/red and occur mainly from July to October. Habitat for this species occurs in sand and outcropping limestone (Western Australian Herbarium 1998-).	**Present.** Species was recorded within VT7, in remnant vegetation alongside Norkett Road.
Drakaea elastica	Threatened – Endangered	Threatened	A slender orchid to 30 cm tall with a prostrate, round to heart shaped leaf. Singular, bright green, glossy flower. The species grows on bare patches of sand within otherwise dense vegetation in low-lying areas alongside winter-wet swamps, typically in banksia (*Banksia menziesii*, *B. attenuata* and *B. ilicifolia*) woodland or spearwood (*Kunzea glabrescens*) thicket vegetation. *D. elastica* often occurs with other orchid species (DEE 2019a).	**Possible** due to presence of preferred habitat in VT7, i.e. banksia woodland alongside swamps. VT15 potentially contained suitable habitat; however, this area may have been cleared since surveys were undertaken of the area in 2005. Suitable habitat may formerly have been present within VT9; however, heavy disturbance has resulted in the displacement of most native understorey with grassy weeds. Marginal habitat is also present within VT12; however, two seasons of survey for this species were conducted over two consecutive years, and no individuals were recorded.
Drakaea micrantha	Threatened – Vulnerable	Threatened	A tuberous, terrestrial herb which has a diminutive red and yellow flower, 1.2–2.5 cm long, on a stem that grows to 30 cm. Flowering occurs form September to October. Its heart-shaped leaf, about 1.5 cm long, is silvery grey with prominent green veins. Habitat for this species occurs within cleared firebreaks or open sandy patches that have been disturbed, where competition from other plants has been removed (Western Australian Herbarium 1998-, DEE 2019a).	**Possible** due to presence of preferred habitat. Potential habitat is located within firebreaks near tracts of remnant bushland, e.g. around Sandwich Lots and lots adjacent to Bush Forever sites.
Eleocharis keigheryi	Threatened – Vulnerable	Threatened	A rhizomatous, tufted/clumped perennial herb, reaching a maximum diameter of 40 cm. It has erect, smooth, green stems that are 20–40 cm tall and hollow, supporting cross bars that are 2 mm in diameter. This species grows in small clumps in a substrate of clay or sandy loam. This species is emergent in freshwater creeks, and transient waterbodies such as drainage lines and claypans in water to approximately 15 cm deep. Fringing woodland species and associated species include Swamp Sheoak (*Casuarina obesa*), Flooded Gum (*Eucalyptus rudis*), Red Robin Bush (*Melaleuca lateritia*), Swamp	**Unlikely** due to absence of preferred habitat. While VT4 contained vegetation within and adjacent to standing water associated with a drainage channel, this water was deeper than 15 cm.

			Paperbark (*M. rhaphiophylla*), Common Spike-sedge (*Eleocharis acuta*), *Aponogeton hexatepalus*, Veined Swamp Wallaby Grass (*Amphibromus nervosus*) and herbs such as *Wurmbea*, *Tribonanthes* and *Leptocarpus* spp. (Western Australian Herbarium 1998-, DEE 2019a).	
Lepidosperma rostratum	Threatened – Endangered	-	A rhizomatous sedge to 30 cm in diameter. Stems are circular in cross section and flowers are spike-like and up to 4 cm long. Habitat for this species occurs in sandy soils among low heath comprised of *Banksia telmatiaea* and *Calothamnus hirsutus* in winter-wet swamps (Western Australian Herbarium 1998-, DEE 2017a).	**Unlikely** due to absence of preferred habitat and associated species.
Pimelea calcicola	-	P3	An erect to spreading shrub to 1 m tall. Flowers are pink and visible between September to November. Habitat for this species occurs in sand on coastal limestone ridges (Western Australian Herbarium 1998-).	**Unlikely** due to absence of preferred habitat.
Pithocarpa corymbulosa	-	P3	An erect to scrambling perennial herb 50 to 100 cm tall. Flowers are white and are present from January to April. Habitat for this species occurs within gravelly or sandy loam amongst granite outcrops (Western Australian Herbarium 1998-, DEE 2019a).	**Unlikely** due to absence of preferred habitat.
Stylidium paludicola	-	P3	Reed-like perennial, herb, 35 to 100 cm tall. Leaves are tufted, linear or subulate or narrowly oblanceolate. Flowers are pink and occur in October to December. Habitat for this species occurs in peaty sand over clay and winter wet areas, often in Marri and Melaleuca woodland or Melaleuca shrubland (Western Australian Herbarium 1998-).	**Unlikely** due to absence of preferred habitat. While winter-wet areas are present within the Subject Area, the majority of these have been severely disturbed and understorey replaced with no-native species, or completely cleared for market gardens.

3.6.1.2 Regional vegetation

Vegetation occurring within the region was initially mapped at a broad scale (1: 1 000 000) by Beard during the 1970s. This dataset formed the basis of several regional mapping systems, including the biogeographical region dataset (Interim Biogeographic Regionalisation for Australia) for Western Australia (DEE 2017b), physiographic regions defined by Beard (1981), and System 6 Vegetation Complex mapping undertaken by Heddle *et al.* (1980).

The Subject Area and Sandwich Lots comprises two Beard (1981) vegetation associations. The percentage remaining of each vegetation association within the Swan Coastal Plain (Perth) IBRA sub-region, is provided in Table 3.4 (GoWA 2019a).

Table 3.4: Vegetation associations within the Subject Area and Sandwich Lots

Vegetation association code	Description	Percentage remaining (%)	% Current Extent Protected (IUCN I - IV) for Conservation (proportion of Pre-European Extent)
6	medium woodland; tuart & jarrah	23.72	3.3
1001	medium very sparse woodland; jarrah, with low woodland; banksia & casuarina	22.05	2.8

System 6 mapping refers to vegetation mapping undertaken at a Vegetation Complex scale by Heddle *et al.* (1980). This is the primary source of information used to calculate potential impacts of proposals to clear native vegetation on the Swan Coastal Plain. The Subject Area and Sandwich Lots occurs within the following broad vegetation complexes described by GoWA (2019b) in Table 3.5. The percentage remaining of each vegetation complex within the Swan Coastal Plain (Perth) IBRA region, is also provided in Table 3.5 (GoWA 2019b).

Table 3.5: Vegetation complexes within the Subject Area and Sandwich Lots

Complex name	Description	Percentage remaining (%)	Current percentage remaining within lands Protected (IUCN I-IV) for Conservation (%)
Karrakatta Complex- Central and South	Predominantly open forest of *Eucalyptus gomphocephala* (Tuart) - *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) and woodland of *Eucalyptus marginata* (Jarrah) - Banksia species. *Agonis flexuosa* (Peppermint) is co-dominant south of the Capel River.	23.49	3.87
Bassendean Complex Central and South	Vegetation ranges from woodland of *Eucalyptus marginata* (Jarrah) - *Allocasuarina fraseriana* (Sheoak) - Banksia species to low woodland of Melaleuca species, and sedgelands on the moister sites. This area includes the transition of *Eucalyptus marginata* (Jarrah) to *Eucalyptus todtiana* (Pricklybark) in the vicinity of Perth.	26.87	1.86
Herdsman Complex	Sedgelands and fringing woodland of Eucalyptus rudis (Flooded Gum) - Melaleuca species.	32.11	10.83

The *National Objectives and Targets for Biodiversity Conservation 2001–2005* (Commonwealth of Australia 2001) recognise that the retention of 30 per cent or more of the pre-clearing extent of each ecological community is necessary if Australia's biological diversity is to be protected. This is the threshold level, below which species loss appears to accelerate exponentially and loss below this level should not be permitted (DER 2014a). In recognition of past land use planning decisions, constrained areas have been identified on the Swan Coastal Plain within which, retention objectives may be varied to "at least 10%". Given that the Subject Area is located within the Perth Metropolitan

Region and has been identified for potential future development, the retention objective of 10% is likely considered appropriate.

The percentage of the pre-European extent remaining within the Swan Coastal Plain (Perth) IBRA region, of the vegetation associations and complexes listed above, is above the 10 percent threshold for constrained areas, and potential clearing of vegetation within the Subject Area will not reduce the remaining extent of these associations and complexes to 10 percent or less.

3.6.1.3 Threatened and Priority Ecological Communities

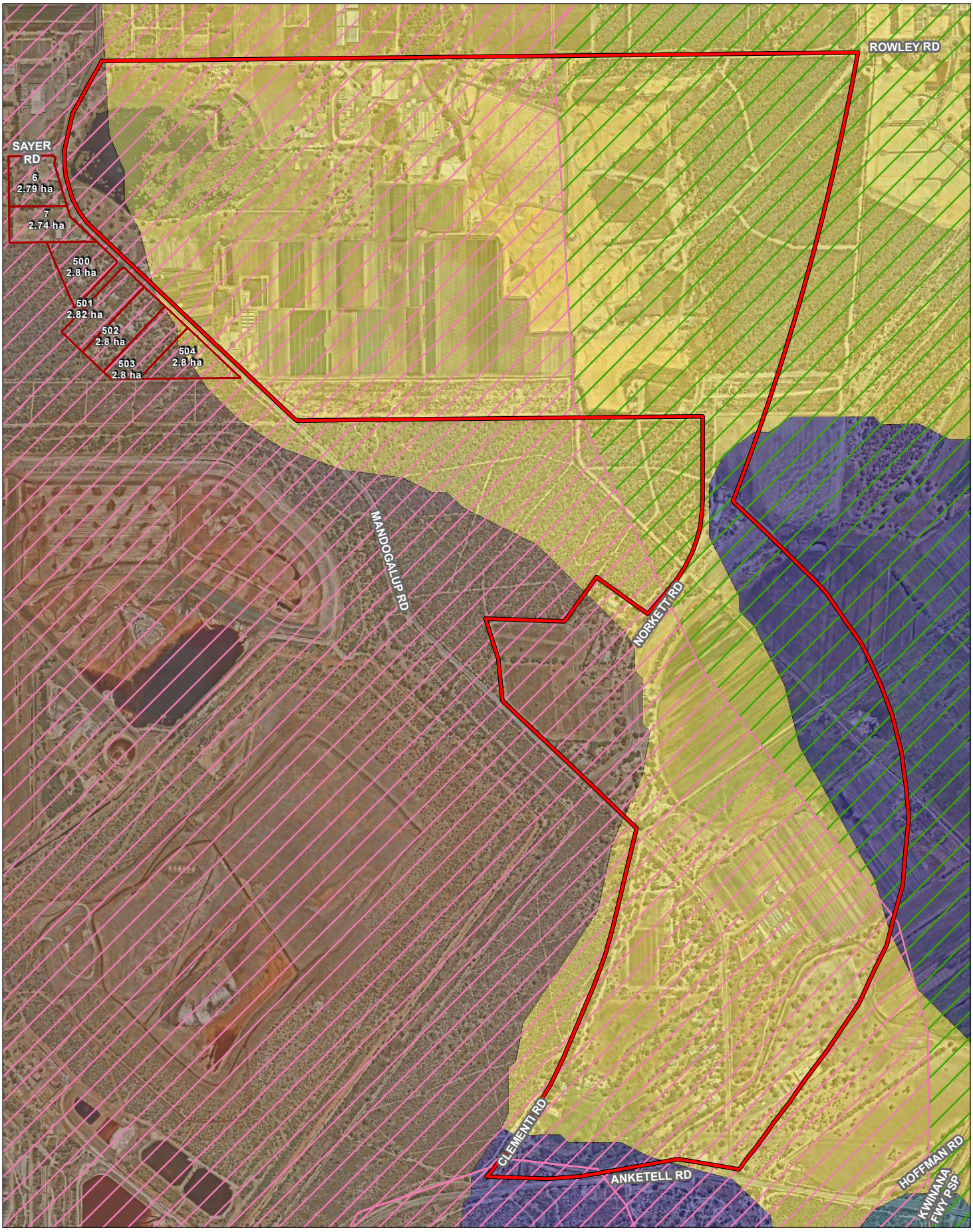
The Commonwealth EPBC Act and State BC Act provide for the listing and protection of threatened ecological communities (TECs). Additionally, at a State level, DBCA list ''priority'' ecological communities (PECs) which are possibly threatened but that do not meet survey criteria, or are otherwise data deficient.

One TEC listed under the BC Act, one TEC listed under the EPBC Act, and three PECs listed by DBCA have been identified as having the potential to occur in the broader area, based on a desktop assessment (Strategen 2018). These ecological communities are listed in Table 3.6.

Table 3.6: TECs and PECs identified in proximity to the Subject Area

Community identifier	Community name	Listing under BC Act	Listing under EPBC Act
Various floristic community types (FCTs)	Banksia woodlands of the Swan Coastal Plain	Various listings; encompasses multiple state-listed TECs and PECs	Endangered
Limestone ridges (SCP 26a)	*Melaleuca huegelii - Melaleuca systena* shrublands on limestone ridges	Endangered	NA
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	Priority 3	Endangered
SCP22	*Banksia ilicifolia woodlands,* southern Swan Coastal Plain	Priority 3	Endangered
SCP24	Northern Spearwood shrublands and woodlands	Priority 3	Endangered

The potential for the TECs and PECs to occur within the Subject Area, is discussed in Section 3.6.2.4.



Legend:

- MIP 47 boundary (331.2 ha)
- Sandwich lots (19.56 ha)

Vegetation system (Beard)

- Bassendean
- Spearwood

Vegetation complex (Heddle)

- Bassendean Complex-Central and South
- Cottesloe Complex-Central and South
- Herdsman Complex
- Karrakatta Complex-Central and South

strategen JBS&G

0 300 metres

Mandogalup, WA

PRE-EUROPEAN VEGETATION MAPPING

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: hsullivan	Checked By: CoB	Version: A	Date: 16-Dec-2019	**FIGURE: 3.5**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01 Rev A\57020_03_5_PreEurVegMapping.mxd

Image Reference: www.nearmap.com© - Imagery Date: 21 October 2019.

3.6.2 Site surveys

A number of publicly available flora and vegetation surveys have been previously conducted across portions of the Subject Area, as outlined in Table 3.7.

Table 3.7: Previous flora and vegetation surveys conducted

Landholdings	Survey	Date of survey	Reference
The survey included the following titles within the Subject Area: • Lot 10 on Plan 069890 • Lot 2 on Plan 011392 • Lot 53 on Plan 009780 • Lot 4 on Plan 011392 • Lot 664 on Plan 202790 • Part Lot 791 on Plan 202790 • Lot 663 on Plan 202790 • Lot 665 on Plan 202618 • Lot 666 on Plan 202618 • Lot 667 on Plan 202618 • Lot 668 on Plan 202618 • Lot 2 on Diagram 039567 • Lot 669 on Plan 202618 • Lot 670 on Plan 202618 • Lot 671 on Plan 202618 • Lot 9002 on Plan 069132 • Lot 9006 on Plan 70124 • Lot 9002 on Plan 417428	Flora, Vegetation, Fauna and Wetland Assessment	6th and 7th September 2005	Cardno 2005
	Targeted Priority And Threatened Flora Search	23rd and 24th October 2012	Plantecology Consulting 2012
The survey included the following titles within the Subject Area: • Lot 9006 on Plan 070124 • Lot 9002 on Plan 069132	Level 2 Detailed Flora and Vegetation Survey	• September and late November 2004 • November 2006 • March 2007 • September and October 2004 (targeted searches)	RPS 2010
	Targeted Declared Rare Flora Survey	• 23rd and 24th October 2012	Woodman Environmental Consulting 2014
	Level 1 flora and vegetation survey	• 19 January 2017	Strategen Environmental 2018
The survey included the following titles within the Subject Area: • Lot 10 on Plan 069890 • Lot 2 on Plan 011392	Detailed Flora and Vegetation Survey	• 18th July 2017 • 10th and 11th October 2017	Strategen Environmental 2017

Subsequent to the above studies, Strategen-JBS&G Senior Botanists conducted two field surveys across the Subject Area and Sandwich Lots on 24 October and 14 November 2019, and 30 September and 1 October 2020. The field surveys were conducted according to standards set out in the *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). It is noted that access permission was not granted for Lot 503 (on Diagram 61498) and Lot 3 (on Diagram 050536), as such these lots have not been subject to assessment.

The Strategen-JBS&G flora and vegetation survey report is provided in Appendix B.

3.6.2.1 Flora

As outlined in Table 3.7, targeted surveys have been conducted across a number of lots within the Subject Area. During the surveys listed in Table 2.1, no threatened flora listed under the EBPC Act or

BC Act, or DBCA listed Priority flora have been recorded within lots which have been subject to a targeted flora survey.

During the 2019 survey undertaken by Strategen-JBS&G (Appendix B), one Priority flora species, *Dodonaea hackettiana* (P4) was recorded in intact remnant native vegetation within the road verge on the western side of Norkett Road.

While the majority of vegetation is heavily degraded and infested with weeds, VT7 (refer to Table 3.8) has the potential to contain *Drakaea elastica* and *Caladenia huegelii*; however, only a small area (0.08 ha) occurs within the Subject Area. *Drakaea micrantha* also has the potential to occur within firebreaks adjacent to areas of intact remnant native vegetation, i.e. Sandwich Lots, lots adjacent to remnant vegetation in Bush Forever sites (i.e., Lot 51 and 23 Mandogalup Rd). These areas have not been subject to a targeted flora survey.

3.6.2.2 Vegetation types

Nine native vegetation types (VTs) have been identified within the portions of the Subject Area and Sandwich Lots . The vegetation types are described in Table 3.8 and Table 3.9

Table 3.8: Vegetation Types recorded within the Subject Area

Vegetation Type	Description	Area (ha)	Percentage of area within Subject Area (%)
Within Scheme site boundary			
3	Open woodland of *Eucalyptus rudis*, *Melaleuca rhaphiophylla* and *Eucalyptus marginata* over introduced species.	0.925	0.279
4	Woodland of *Eucalyptus rudis*, *Melaleuca rhaphiophylla*, *Agonis flexuosa* over mixed in.	12.330	3.723
5	Open woodland of *Eucalyptus gomphocephala*, *Eucalyptus rudis* and occasionally ^*Corymbia maculata*, *Allocasuarina fraseriana* and *Banksia menziesii* over isolated shrubs of *Xanthorrhoea preissii* and other native species over introduced grasses.	5.048	1.524
6	Woodland of *Eucalyptus gomphocephala*, *Banksia menziesii*, *Melaleuca rhaphiophylla*, and *Melaleuca preissiana* over shrubland of *Acacia pulchella*, *Macrozamia riedlei*, *Hibbertia hypericoides* and mixed introduced species.	1.229	0.371
7	Woodland of *Eucalyptus gomphocephala*, *Allocasuarina fraseriana* and *Banksia attenuata* over shrubland of *Xanthorrhoea preissii* and *Macrozamia riedlei* over mixed native and introduced herbs and shrubs	0.546	0.165
8	Woodland of *Eucalyptus marginata*, *Banksia attenuata* and *Allocasuarina fraseriana* over isolated shrubs to open shrubland of *Jacksonia sternbergiana*, *Acacia saligna*, and *Xanthorrhoea preissii* over mixed introduced species .	0.285	0.086
9	Open woodland of *Eucalyptus marginata*, *Allocasuarina fraseriana, Banksia attenuata* and *Banksia menziesii* over shrubland of *Hibbertia hypericoides*, *Acacia pulchella*, *Macrozamia riedlei* over herbland of *Burchardia* sp., *Tetraria octandra* and mixed introduced species.	31.404	9.482
Revegetation/ regrowth	Mixed shrubland within powerline corridor.	10.949	3.306
Planted - Pines	Plant *Pinus* sp.	2.443	0.738
Parkland Cleared	Open woodland of native tree species over non-native understorey	8.272	2.498
Cleared	Cleared - varies between completely cleared for hardstand, housing or infrastructure, paddocks comprising introduced grass and herb species, and residential gardens planted with ornamental species. (Not considered to be native vegetation)	257.771	77.829
Total native vegetation	Excludes “Cleared” areas and “Planted-pines”	**70.988**	21.269

Table 3.9: Vegetation Types recorded within the Sandwich Lots

Vegetation Type	Description	Area (ha)	Percentage of area within Sandwich Lots (%)
Within Sandwich Lots			
1	Woodland of *Corymbia calophylla, Allocasuarina fraseriana* and *Banksia attenuata* over open heath of *Xanthorrhoea preissii*, *Hibbertia hypericoides* and *Macrozamia riedlei* mixed native and introduced species .	0.975	50.212
2	Open woodland of *Eucalyptus marginata* and *Allocasuarina fraseriana* and occasionally *Banksia grandis* over open heath of *Xanthorrhoea preissii, Macrozamia riedlei* over introduced species .	0.748	0.455
4	Open woodland of *Eucalyptus rudis, Melaleuca rhaphiophylla* and *Eucalyptus marginata* over introduced species .	0.216	6.982
7	Woodland of *Eucalyptus rudis, Melaleuca rhaphiophylla*, *Agonis flexuosa* over mixed inr **Leptospermum laevigatum, *Ricinus communis, *Ficus* sp., *Typha orientalis* and **Poaceae* spp. in standing water .	0.890	5.356
8	Open woodland of *Eucalyptus gomphocephala*, *Eucalyptus rudis* and occasionally ^*Corymbia maculata, Allocasuarina fraseriana* and *Banksia menziesii* over isolated shrubs of *Xanthorrhoea preissii* and other native species over introduced grasses.	2.432	1.549
9	Woodland of *Eucalyptus gomphocephala*, *Banksia menziesii, Melaleuca rhaphiophylla,* and *Melaleuca preissiana* over shrubland of *Acacia pulchella, Macrozamia riedlei, Hibbertia hypericoides* and mixed introduced species.	1.626	6.376
Parkland cleared	Open woodland of native tree species over non-native understorey	7.009	17.419
Cleared	Cleared - varies between completely cleared for hardstand, housing or infrastructure, paddocks comprising introduced grass and herb species, and residential gardens planted with ornamental species. (Not considered to be native vegetation)	0.064	11.650
Total native vegetation	Excludes “Cleared” areas	13.896	88.349

3.6.2.3 Vegetation condition

Vegetation condition within the areas surveyed, has been described using the vegetation condition scale for the South West Botanical Province outlined in Table 3.10 (Keighery 1994). A breakdown of vegetation condition within the Subject Area and Sandwich lots is provided in Table 3.11 and Table 3.12 respectively.

Table 3.10: Vegetation condition scale (Keighery 1994)

Condition rating	Description
Pristine	Pristine or nearly so, no obvious sign of disturbance.
Excellent (2)	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback, grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.

Condition rating	Description
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Table 3.11: Vegetation condition recorded within the Subject Area

Vegetation Condition	Area (ha)	Percentage of the Subject Area
Very good	40.50	12.22
Good	3.01	0.91
Degraded - good	0.40	0.12
Degraded	14.86	4.48
Completely degraded	272.41	82.25

Table 3.12: Vegetation condition recorded within the Sandwich Lots

Vegetation Condition	Area (ha)	Percentage of the Sandwich Lots
Very Good	1.54	11.05
Good – very good	0.71	5.12
Good	2.15	15.42
Degraded - good	1.63	11.65
Degraded	0.63	4.55
Completely degraded	7.29	52.22

3.6.2.4 Threatened ecological communities

The following TECs are present within the Subject Area and/ or the Sandwich Lots (based on vegetation surveys conducted):

- Banksia woodlands of the Swan Coastal Plain (TEC under EPBC Act; Priority 3 PEC listed by DBCA)
- Tuart woodlands and forests of the Swan Coastal Plain (TEC under EPBC Act; Priority 3 PEC listed by DBCA).

Banksia woodlands of the Swan Coastal Plain EPBC Act listed TEC

Four patches across both the Subject Area and Sandwich Lots are considered to form the Banksia Woodlands of the Swan Coastal Plain EPBC Act listed TEC. They cover 37.04 ha in total. The most substantial patches of this TEC are located within the Sandwich lots and within the north-eastern portion of the Subject Area. One patch is located along the south-western boundary of the Subject Area (Figure 3.8). Further details of assessment under the key diagnostic criteria for the TEC and the distribution of this community can be found in the Flora, Vegetation and Black Cockatoo Habitat Assessment (Appendix B).

Banksia woodlands of the Swan Coastal Plain State listed PEC

The description, area and condition thresholds that apply to the EPBC Act listed Banksia woodlands of the Swan Coastal Plain TEC, also apply to this Priority ecological community. Given this, the occurrences of the Banksia woodlands of the Swan Coastal Plain EPBC Act listed TEC are considered to also represent the Banksia woodlands of the Swan Coastal Plain State listed PEC.

Tuart woodlands and forests of the Swan Coastal Plain TEC

Vegetation within the south-eastern potion of the Subject Area has been assessed as forming a 10.06 ha patch of the Tuart Woodlands and forests of the Swan Coastal Plain EPBC Act listed TEC

(Figure 3.8). It is noted that, in accordance with the conservation advice for the TEC, the 10.06 ha area of the assessed "patch" includes bare ground with little/ no vegetation value. This reflects the requirement to include a 30 m buffer from the outer canopy of Tuarts in the mapping of TEC.

Further details of assessment under the key diagnostic criteria for the TEC and the distribution of this community can be found in the Flora, Vegetation and Black Cockatoo Habitat Assessment (Appendix B).

Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain PEC

The description, area and condition thresholds that apply to the EPBC Act listed TEC, also apply to the State listed Priority ecological community. Given this, the occurrences of the Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain TEC are considered to also represent the Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain PEC.

Legend:

- Subject area
- Sandwich lots
- Roads (MRWA)

Vegetation type

- Cleared
- Parkland cleared
- Planted - Pines
- Revegetation
- VT1
- VT2
- VT3
- VT4
- VT5
- VT6
- VT7
- VT8
- VT9

strategen JBS&G

0 300 metres

Mandogalup, WA

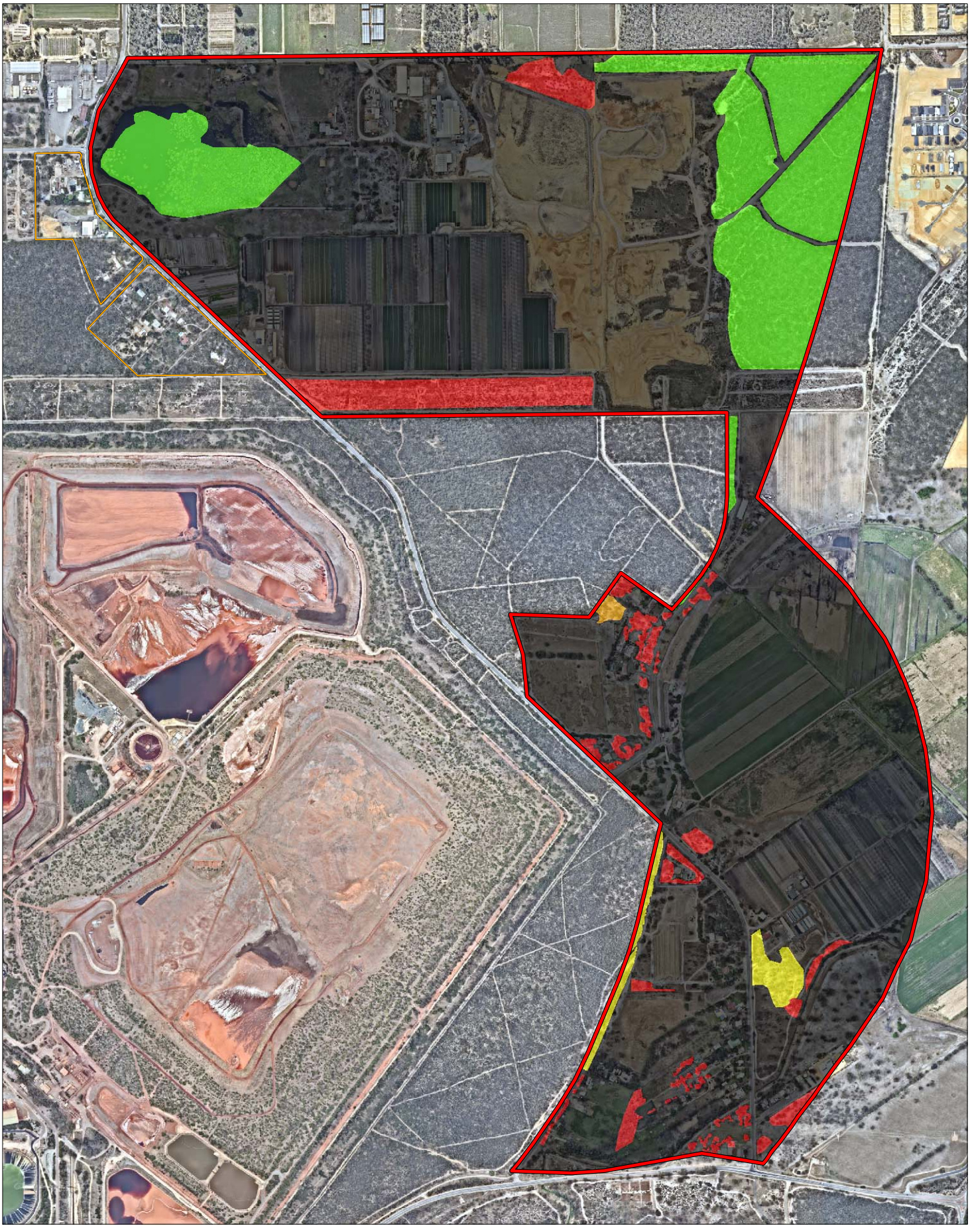
VEGETATION TYPES

Job No: 57020		Scale 1:14,000 at A4	
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: cthatcher	Checked By: CC	Version: A	Date: 17-Dec-2020

FIGURE: 3.6

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_1\57020_03_6_VegTypes.mxd

Image Reference: www.nearmap.com© - Imagery Date: 11 November 2020



Legend:

Subject area
Sandwich lots

Vegetation condition
- Very good
- Good
- Degraded - good
- Degraded
- Completely degraded

strategen JBS&G

0 300 metres

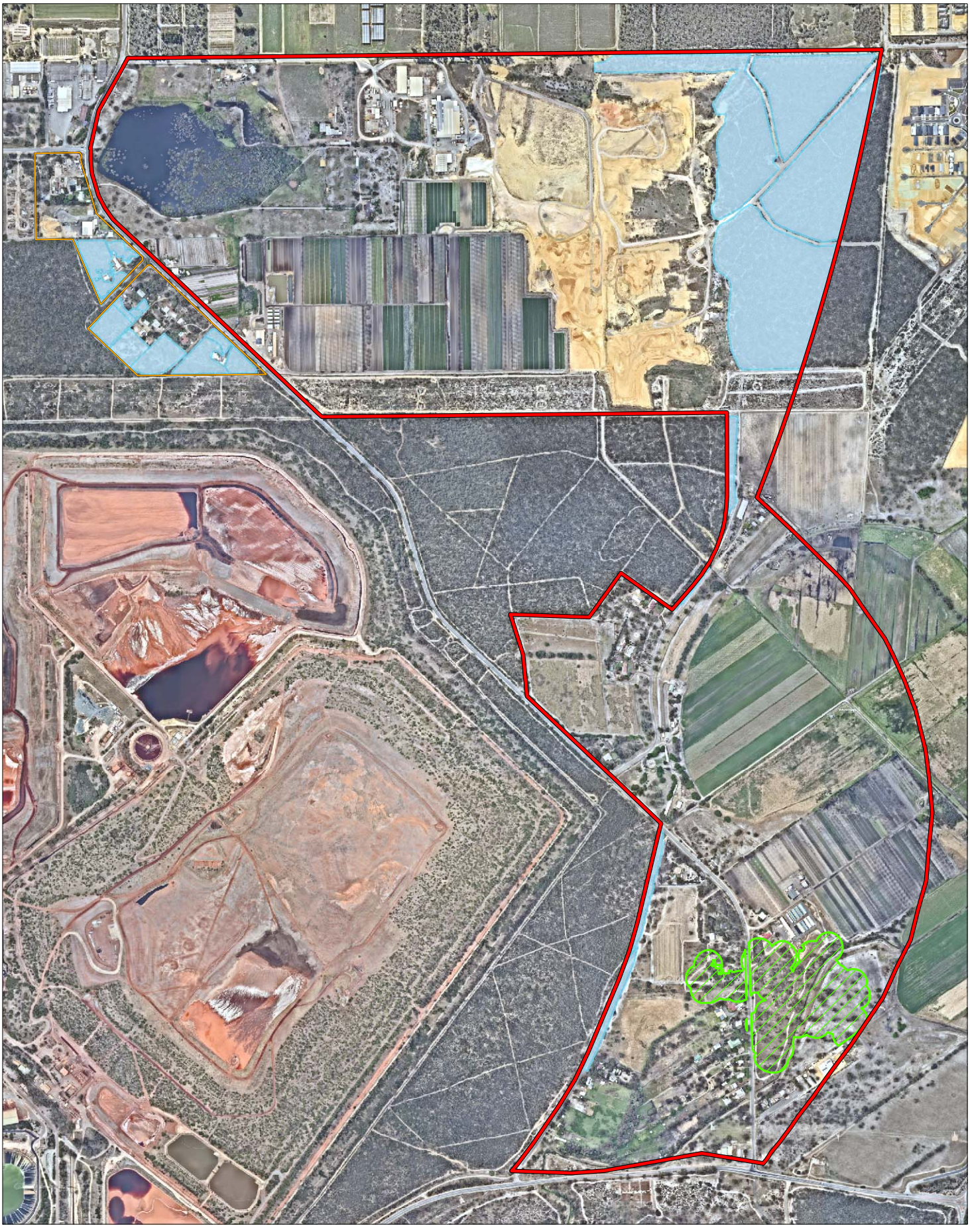
Mandogalup, WA

VEGETATION CONDITION

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: CT	Version: A	Date: 17-Dec-2020	**FIGURE: 3.7**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_1\57020_03_7_VegCond.mxd

Image Reference: www.nearmap.com© - Imagery Date: 19 November 2020



Legend:

- Subject area
- Sandwich lots
- Banksia woodlands of the SCP
- Tuart woodlands and forests of the SCP

strategen JBS&G

0 300 metres

Mandogalup, WA

TECS / PECS

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: TS	Version: A	Date: 17-Dec-2020	**FIGURE: 3.8**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_1\57020_03_8_TEC_PEC.mxd

Image Reference: www.nearmap.com© - Imagery Date: 19 November 2020

3.7 Fauna and habitat

3.7.1 Desktop assessment

The Commonwealth EPBC Act and State BC Act provide for the listing and protection of threatened fauna. Additionally, at a State level, DBCA list ''priority'' species which are possibly threatened species that do not meet survey criteria, or are otherwise data deficient.

Desktop searches were conducted using a 5km buffer of the centre-point of the Subject Area, in *NatureMap* (DBCA 2019b) and the EPBC *Protected Matters Search Tool* (PMST). The objective of these searches was to identify fauna species of conservation significance potentially occurring within the Subject Area and Sandwich Lots.

The searches identified a total of 14 threatened, eight priority and one specially protected fauna species as having been previously recorded, or with potentially suitable habitat occurring within 5 km of the centre-point of the Subject Area (Appendix A). The threatened and priority species returned by the desktop searches are listed in Table 3.13, along with their conservation status, habitat preference and likelihood of occurrence.

Of the threatened, priority and specially protected species identified by the desktop searches, the following are considered to possibly or likely occur, or are known to occur within the Subject Area and/ or Sandwich Lots:

- *Calyptorhynchus banksii naso* (Forest Red-tailed Black-Cockatoo; FRTBC)- Threatened (EPBC Act/ BC Act)
- *Calyptorhynchus latirostris* (Carnaby's Cockatoo; CC)
- *Falco peregrinus* (Peregrine Falcon)
- *Isoodon fusciventer* (Quenda)
- *Lerista lineata* (Perth Slider)
- *Neelaps calonotos* (Black-striped Snake)
- *Synemon gratiosa* (Graceful Sunmoth).

Additionally, one migratory terrestrial species and 17 migratory wetland species were identified by the desktop searches. The migratory terrestrial species (*Motacilla cinerea;* Grey Wagtail) has not been recorded from the Perth Metropolitan area and is highly unlikely to utilise the sight (Atlas of Living Australia and Birdlife 2015).

The migratory wetland species may utilise the REW in the north-western portion of the Subject Area, however are likely to favour the larger wetlands located north and south of the Subject Area; Thomsons Lake and The Spectacles (respectively).

Table 3.13: Threatened and Priority fauna potentially occurring within the Subject Area and Sandwich Lots

Species	Conservation status		Habitat description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
Botaurus poiciloptilus Australasian Bittern	Threatened – Endangered	Threatened	The Australasian Bittern's preferred habitat is comprised of wetlands with tall dense vegetation, where it forages in still, shallow water up to 0.3 m deep, often at the edges of pools or waterways, or from platforms or mats of vegetation over deep water. It favours permanent and seasonal freshwater habitats, particularly those dominated by sedges, rushes and reeds (e.g. Phragmites, Cyperus, Eleocharis, Juncus, Typha, Baumea, Bolboschoenus) or cutting grass (Gahnia) growing over a muddy or peaty substrate (Marchant and Higgins 1990).	**Unlikely** due to a lack of suitable habitat within the project area.
Calidris canutus Red Knot	Threatened – Endangered	Threatened	The Red Knot predominantly inhabits intertidal mudflats, sandflats and sandy beaches along sheltered coasts and are occasionally seen on terrestrial saline wetlands near the coast, but rarely use inland lakes or swamps.	**Unlikely** due to a lack of suitable habitat within the project area.
Calidris ferruginea Curlew Sandpiper	Threatened – Critically Endangered	Threatened	The Curlew Sandpiper occurs on intertidal mudflats of sheltered coastal areas such as estuaries, bays, inlets and lagoons, in shallow waters. They also occur in non-tidal swamps, lakes and lagoons. They occur less often in inland areas such as ephemeral and permanent lakes, dams, waterholes and bore drains.	**Unlikely** due to a lack of suitable habitat within the project area.
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo	Threatened – Vulnerable	Threatened	The Forest Red-tailed Black-Cockatoo occurs predominantly in dense eucalypt forests of jarrah, marri and karri, and occasionally in more open woodland habitats. They forage on marri, jarrah and other native and non-native vegetation species. They breed and nest in woodland or forest in live or dead eucalypt trees. Roosting occurs in tall eucalypt trees within or on the edges of forests and woodlands.	**Likely to occur** due to presence of suitable habitat.
Calyptorhynchus baudinii Baudin's Cockatoo	Threatened – Endangered	Threatened	Baudin's Cockatoo occurs predominantly in jarrah, marri and karri eucalypt forests, and less frequently in woodlands and cleared urban areas. During breeding season they forage on banksia, hakea, and dryandra species. During non-breeding season they forage in marri forests. Breeding occurs predominantly in woodland or forest habitats, nesting in hollows of live or dead trees of karri, marri, wandoo and tuart (DSEWPaC 2012). They roost typically in eucalypt trees near permanent water sources.	**Unlikely** to occur based on distribution range (ERIN 2019c).
Calyptorhynchus latirostris Carnaby's Cockatoo	Threatened - Endangered	Threatened	Carnaby's Cockatoo occurs in uncleared or remnant native eucalypt woodland, and heathlands containing hakea, dryandra,	**Likely to occur** due to presence of suitable habitat.

Species	Conservation status		Habitat description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
			banksia and grevillia species. They forage on a range of native and non-native vegetation. They breed in eucalypt woodlands, mainly within the wheatbelt region, in large hollows of live or dead eucalypt trees. Roosting occurs near water sources in large trees such as marri and pine trees.	
Dasyurus geoffroii Chuditch	Threatened – Vulnerable	Threatened	The Chuditch occurs in jarrah forests and woodlands, and mallee heath and shrublands.	**Unlikely** due to a lack of suitable habitat within the project area.
Falco peregrinus Peregrine Falcon	Not listed	Other specially protected fauna	The Peregrine Falcon is not restricted to a specific habitat, and can occur across woodlands, grasslands and coastal cliffs.	**Possibly** occurs within the project area due to presence of suitable habitat.
Falsistrellus mackenziei Western False Pipistrelle	Not listed	Priority 4	The Western False Pipistrelle predominantly inhabit wet sclerophyll forests of Karri, Jarrah and Tuart eucalypts, roosting in branches, stumps and hollows of old trees (Australian Museum 2019).	**Unlikely** due to a lack of suitable habitat within the project area.
Hydromys chrysogaster Water rat	Not listed	Priority 4	The Water-rat is associated with a range of permanent aquatic habitats. This species favours most types of freshwater habitats, and can also occur in mangrove and estuarine areas (Burbidge 2016).	**Unlikely** due to a lack of suitable habitat within the project area.
Isoodon fusciventer Quenda	Not listed	Priority 4	The Quenda occurs across a broad range of habitats such as forests and dense scrub vegetation, to open croplands or pastures that contain or are adjacent to dense native vegetation. They are also associated with wetlands on the Swan Coastal Plain (DEC 2012).	**Known to occur** within the project area and has been directly (dead specimen) and indirectly (diggings) recorded.
Leipoa ocellata Malleefowl	Threatened – Vulnerable	Threatened	The Malleefowl occurs in shrublands and low woodlands dominated by mallee and acacia species. They favour environments with dense vegetation and require an abundance of leaf litter and a sandy substrate for breeding.	**Unlikely** due to a lack of suitable habitat within the project area.
Lerista lineata Perth Slider	Not listed	Priority 3	The Perth Slider is found in sandy coastal heath and low scrubland, banksia woodland, tuart open woodland over deep sands, and coastal dunes immediately adjacent to the beach. They are believed to favour white to grey sandy substrates and sandy areas with limestone outcrops (Gaikhorst *et al.* 2017).	**Possibly** occurs within the project area due to nearby records (the Spectacles) (Cardno 2005).
Myrmecobius fasciatus Numbat	Threatened - Endangered	Threatened	The Numbat has historically occupied a range of habitats, including eucalypt forest and woodland, Acacia woodland and Triodia grassland, however they now only occur in a small portion of their former range. They are reliant upon adequate ground cover for protection from predation and eucalypt species that provide logs and hollows (DPaW 2017).	**Unlikely** due to a lack of suitable habitat within the project area.

Species	Conservation status		Habitat description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
Neelaps calonotos Black-striped Snake	Not listed	Priority 3	The Black-striped Snake inhabits Banksia woodland and sandy areas in the Perth Region (ALA 2019).	**Likely** due to the presence of good quality Banksia woodland within and surrounding the project area (Cardno 2005).
Notamacropus eugenii subsp. derbianus Tammar Wallaby	Not listed	Priority 4	The Tammar Wallaby inhabits dense, low vegetation including coastal scrub, heath, dry sclerophyll forest and thickets in mallee and woodland, and feeds in open grassy areas. This species is nocturnal.	**Unlikely** due to a lack of suitable habitat within the project area.
Numenius madagascariensis Eastern Curlew	Threatened – Critically Endangered	Threatened	The Eastern Curlew occurs on mudflats or sandflats associated with sheltered coastal areas, such as estuaries, bays, harbours, inlets and lagoons. They are also often recorded within mangroves and saltmarshes. The Eastern Curlew does not breed in Australia. In southern Western Australia, eastern curlews are recorded from Eyre, and there are scattered records from Stokes Inlet to Peel Inlet. The species is a scarce visitor to Houtman Abrolhos and the adjacent mainland, and is also recorded around Shark Bay. It is also recorded on Norfolk Island and Lord Howe Island (Marchant & Higgins 1993).	**Unlikely** due to a lack of suitable habitat within the project area.
Oxyura australis Blue-billed Duck	Not listed	Priority 4	The Blue-billed Duck is almost wholly aquatic, and is seldom seen on land. Non-breeding flocks, often with several hundred individuals, congregate on large, deep open freshwater dams and lakes in autumn. The Blue-billed duck occurs in freshwater to saline terrestrial wetlands (Birdlife International 2016).	**Unlikely** due to a lack of suitable habitat within the project area.
Pseudocheirus occidentalis Western Ringtail Possum	Threatened – Critically Endangered	Threatened	The current distribution of the Western Ringtail Possum is patchy and largely restricted to the moister south-western corner of Western Australia (de Tores 2008), especially near coastal areas of peppermint (Agonis flexuosa) woodland and peppermint/tuart associations from the Australind/Eaton area to the Waychinicup National Park. The species occurs within the Esperance Plains, Jarrah Forest, and Warren IBRA Bioregions, as well as the South West and South Coast Natural Resource Management Regions.	**Unlikely** due to a lack of suitable habitat within the project area.
Rostratula australis Australian Painted Snipe	Threatened – Endangered	Threatened	The Australian Painted Snipe occurs in shallow terrestrial wetlands, permanent and temporary lakes, swamps and claypans. They favour environments hosting tussocks of grass, sedges, rushes/reeds and samphire. They breed and nest in shallow wetlands with areas of bare wet mud and canopy cover nearby.	**Unlikely** due to a lack of suitable habitat within the project area.
Sternula nereis nereis Australian Fairy Tern	Threatened – Vulnerable	Threatened	The Australian Fairy Tern nests on sheltered sandy beaches, spits and banks above the high tide line and below vegetation. This	**Unlikely** due to a lack of suitable habitat within the project area.

Species	Conservation status		Habitat description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
			species has also been found in embayments of a variety of habitats including offshore, estuarine or lake islands, wetlands and mainland coastlines.	
Synemon gratiosa Graceful Sunmoth	Not listed	Priority 4	The Graceful Sunmoth is associated with two habitat types, namely the coastal heathland on Quindalup dunes where the preferred host plant (Lomandra maritima) is abundant, and Banksia woodland on Spearwood and Bassendean dunes where the second known host plant (L. hermaphrodita) is widespread.	**Possibly** occurs within the project area due to presence of suitable habitat.
Westralunio carteri Carter's Freshwater Mussel	Threatened - Vulnerable	Threatened	The Carter's Freshwater Mussel occurs in freshwater lakes, rivers and streams in sandy or muddy sediments. Greatest densities associated with exposed submerged tree roots (*Eucalyptus rudis*, Melaleuca spp. and others), woody debris and overhanging riparian vegetation near stream banks and edges of lakes/dams.	**Possibly** occurs within the project area due to presence of suitable habitat at north-western REW. However, based on *Naturemap* (DBCA 2019) search results, this species has not been recorded within 5km of the Subject Area.

3.7.1.1 Black cockatoo habitat

Habitat distribution mapping for CC and FRTBC identify the Subject Area within the non-breeding range of CC and within the potential breeding range of FRTBC (ERIN 2016a and b).

Broadly mapped potential feeding areas for Carnaby's Cockatoo (DBCA *et. al* 2011) identify large intact areas of potential CC foraging habitat within the north-eastern portion of the Subject Area and within the Sandwich Lots. Several smaller pockets of potential CC foraging habitat occur adjacent to the REW in the north-western potion of the Subject Area, adjacent to Bush Forever site 268 and in the southern portion of the Subject Area.

Known and potential breeding sites have been mapped by DBCA *et. al* (2011). This mapping does not identify any known or potential breeding sites for CC within or adjacent to the Subject Area and Sandwich Lots. As outlined above, the Subject Area and Sandwich Lots are not within the known breeding range of CC or BC. The nearest confirmed breeding site for CC is located approximately 10.5 km to the north east of the Subject Area.

A search of the Great Cocky Count data set prepared by Birdlife WA (2018) identified one known roosting site within 2 km of the Subject Area and Sandwich Lots (site code: KWIWANR002). The roosting site is located to the east of the Subject Area. Five CC were recorded at the roosting site between 2010 and 2018, and no FRTBC were recorded from this roosting site.

No roosting sites were identified within the proposal area Birdlife WA (2018).

3.7.2 Field surveys

A number of publicly available fauna habitat surveys have been previously conducted across portions of the Subject Area, as outlined in Table 3.14.

Table 3.14: Previous fauna habitat surveys conducted within the Subject Area

Landholdings	Survey	Date of survey	Reference
The survey included the following titles within the Subject Area: • Lot 10 on Plan 069890 • Lot 2 on Plan 011392 • Lot 53 on Plan 009780 • Lot 4 on Plan 011392 • Lot 664 on Plan 202790 • Part Lot 791 on Plan 202790 • Lot 663 on Plan 202790 • Lot 665 on Plan 202618 • Lot 666 on Plan 202618 • Lot 667 on Plan 202618 • Lot 668 on Plan 202618 • Lot 2 on Diagram 039567 • Lot 669 on Plan 202618 • Lot 670 on Plan 202618 • Lot 671 on Plan 202618 • Lot 9002 on Plan 069132 • Lot 9006 on Plan 70124 Lot 9002 on Plan 417428	Flora, vegetation, fauna and wetland assessment	6th and 7th September 2005	Cardno 2005

Landholdings	Survey	Date of survey	Reference
The survey included the following titles within the Subject Area: • Lot 9002 on Plan 417428 • Lot 668 on Plan 202618 • Lot 669 on Plan 202618 • Lot 791 on Plan 202790 • Lot 663 on Plan 202790 • Lot 664 on Plan 202790	Level 1 fauna survey and habitat assessment	• 10th December 2010 (detailed habitat assessment) • 14th December 2010 and 17th January 2011 (reconnaissance fauna survey)	Emerge 2011
The survey included the following titles within the Subject Area: • Lot 9006 on Plan 070124 • Lot 9002 on Plan 069132	Black cockatoo habitat assessment	• 28th June 2013 • 2nd and 4th July 2013	Strategen Environmental 2013
The survey included the following titles within the Subject Area: • Lot 10 on Plan 069890 • Lot 2 on Plan 011392	Black cockatoo habitat assessment	10th and 11th October 2017	Strategen Environmental 2017

Surveys undertaken by Strategen Environmental (2017) and Emerge (2011) within portions of the Subject Area, identified potential nesting habitat trees, some with potentially suitable nesting hollows (>10 cm diameter). Subsequent to the above studies, a Strategen-JBS&G Senior Ecologist conducted two field surveys within vegetated lots on 24th October and 14th of November 2019, as well as 30 September and 1 October 2020. It is noted that access permission was not granted for Lot 503 (on Diagram 61498) and Lot 3 (on Diagram 050536), as such these lots have not been subject to a significant tree survey.

A total of 362 potential nesting habitat trees and 35 potentially suitable hollows (of at least 10 cm diameter) were identified within the Subject Area (Figure 3.9). The potential nesting habitat trees include the following species; *Eucalyptus marginata, Eucalyptus gomphocephala, and Eucalyptus rudis*.

A total of 48 potential nesting habitat trees and 8 potentially suitable hollows were identified within the Sandwich Lots, including the following species; *Corymbia calophylla, Eucalyptus marginata* (Figure 3.11).

An assessment of black cockatoo foraging habitat for each vegetation type recorded within the Subject Area and Sandwich Lots is presented in Table 3.15 and Table 3.16 respectively.

Table 3.15: Black cockatoo foraging species recorded within the Subject Area

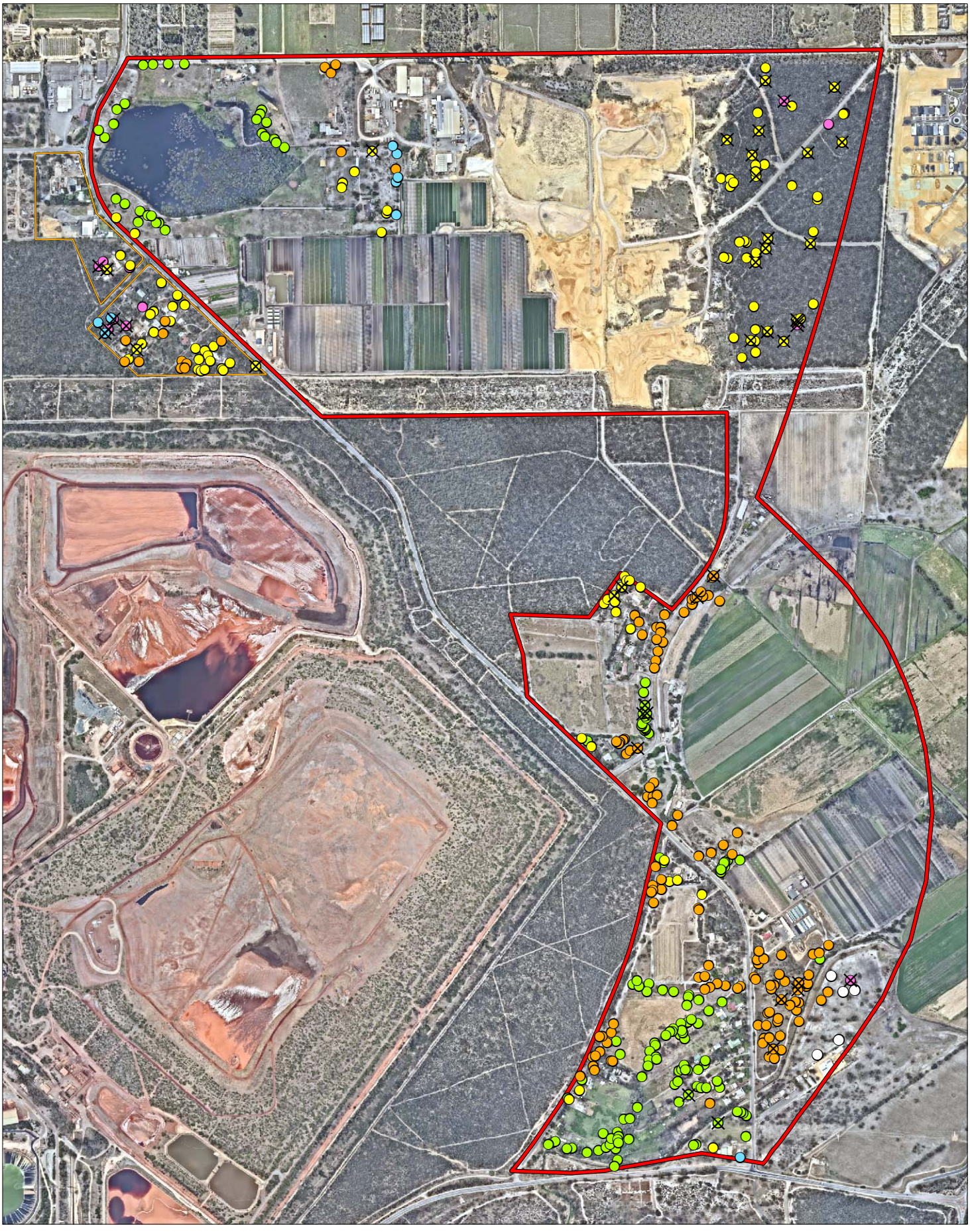
Vegetation type	Black cockatoo foraging species	Area of potential CC foraging habitat (ha)	Area of potential FRTBC foraging habitat (ha)
3	CC - *Eucalyptus rudis, Eucalyptus marginata* FRTBC - *Eucalyptus marginata* (Strategen 2019)	0.9	0.9
4	CC - *Eucalyptus rudis, Agonis flexuosa, Ficus* sp. FRTBC - None (Strategen 2019)	12.3	0
5	CC – *Eucalyptus gomphocephala, Eucalyptus rudis, Allocasuarina fraseriana, Banksia menziesii, Xanthorrhoea preissii* FRTBC – *Allocasuarina fraseriana* (Strategen 2019).	4.9	4.9
6	CC – *Eucalyptus gomphocephala, Banksia menziesii* FRTBC – None (Strategen 2019).	1.2	0

Vegetation type	Black cockatoo foraging species	Area of potential CC foraging habitat (ha)	Area of potential FRTBC foraging habitat (ha)
7	CC - *Eucalyptus gomphocephala, Allocasuarina fraseriana, Banksia attenuata, Xanthorrhoea preissii,* FRTBC - *Allocasuarina fraseriana* (Strategen 2019).	0.5	0.5
8	CC – *Eucalyptus marginata, Banksia attenuate, Allocasuarina fraseriana, Acacia saligna, Xanthorrhoea preissii* FRTBC - *Eucalyptus marginata, Allocasuarina fraseriana* (Strategen 2019)	0.2	0.2
9	CBC – *Eucalyptus marginata, Banksia menziesii, Xanthorrhoea preissii, *Corymbia maculata, Jacksonia furcellata, Hakea prostrata* FRTBC - *Eucalyptus marginata*	31.3	31.3
Revegetation	Mixed shrubland regrowth within powerline corridor. Unlikely to provide foraging habitat for CC or FRTBC.	10.9	10.9
Planted - Pines	Moderate (CBC and FRTBC)	2.4	2.4
Parkland Cleared	Open woodland of native tree species over non-native understorey. Poor (CBC) FRTBC - none.	8.27	8.27
Cleared	Cleared – varies between completely cleared for hardstand, housing or infrastructure, paddocks comprising introduced grass and herb species, and residential gardens planted with ornamental species. (Not considered to be native species). Unlikely to provide foraging habitat for CC or FRTBC.	257.4	257.4
Total area of VTs containing potential CC and FRTBC foraging habitat within the Subject Area (excludes "Cleared" areas)		72.87	51.1

Table 3.16: Black Cockatoo foraging species recorded within the Sandwich lots

Vegetation type	Black Cockatoo foraging species	Area of potential CC foraging habitat (ha)	Area of potential FRTBC foraging habitat (ha)
1	CC – *Corymbia calophylla, Allocasuarina fraseriana, Banksia attenuate, Xanthorrhoea preissii* FRTBC - *Corymbia calophylla, Allocasuarina fraseriana* (Strategen 2019).	0.9	0.9
2	CC – *Eucalyptus marginata, Allocasuarina fraseriana, Banksia grandis, Xanthorrhoea preissii* FRTBC - *Eucalyptus marginata, Allocasuarina fraseriana* (Strategen 2019).	0.7	0.7
4	CC - *Eucalyptus rudis, Agonis flexuosa, Ficus* sp. FRTBC – None (Strategen 2019).	0.2	0
7	CC - *Eucalyptus gomphocephala, Allocasuarina fraseriana, Banksia attenuata, Xanthorrhoea preissii,* FRTBC - *Allocasuarina fraseriana* (Strategen 2019).	0.8	0.8

Vegetation type	Black Cockatoo foraging species	Area of potential CC foraging habitat (ha)	Area of potential FRTBC foraging habitat (ha)
8	CC – *Eucalyptus marginata, Banksia attenuate, Allocasuarina fraseriana, Acacia saligna, Xanthorrhoea preissii* FRTBC - *Eucalyptus marginata, Allocasuarina fraseriana* (Strategen 2019).	2.4	2.4
9	CBC – *Eucalyptus marginata, Banksia menziesii, Xanthorrhoea preissii, *Corymbia maculata, Jacksonia furcellata, Hakea prostrata* FRTBC - *Eucalyptus marginate.*	1.6	1.6
Parkland Cleared	Open woodland of native tree species over non-native understorey. Poor (CBC and FRTBC) habitat.	0.06	0.06
Cleared	Cleared – varies between completely cleared for hardstand, housing or infrastructure, paddocks comprising introduced grass and herb species, and residential gardens planted with ornamental species. (Not considered to be native species). Unlikely to provide foraging habitat for CC or FRTBC.	7.0	7.0
Total area of VTs containing potential CC and FRTBC foraging habitat within the Sandwich Lots (excludes “Cleared” areas)		6.66	6.46



Legend:

- Subject area
- Sandwich lots
- Hollow present - potentially suitable

Significant Black Cockatoo habitat trees

- *Corymbia calophylla*
- *Eucalyptus gomphocephala*
- *Eucalyptus marginata*
- *Eucalyptus rudis*
- *Eucalyptus* sp.
- N/A

strategen JBS&G

0 300 metres

Mandogalup, WA

BLACK COCKATOO HABITAT

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: CC	Version: A	Date: 17-Dec-2020	**FIGURE: 3.9**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_1\57020_03_9_BCHabitat.mxd

Image Reference: www.nearmap.com© - Imagery Date: 19 November 2020

3.8 Conservation areas

State Planning Policy 2.8: Bushland Policy for the Perth Metropolitan Region (SPP 2.8) aims to provide a policy and implementation framework that ensures bushland protection and management issues throughout the Perth Metropolitan Region are adequately addressed and integrated with broader land use planning and decision-making (WAPC 2010). The policy predominantly deals with two distinct subjects, Bush Forever areas and local bushland areas.

In accordance with SPP 2.8, proposals must recognise regionally significant bushland and outline methods by which it will avoid, minimise and offset any likely adverse impacts it will have on regionally significant bushland.

3.8.1 Bush Forever

Bush Forever site 393 is located within the north-western corner of the Subject Area (associated with Wattleup Lake). A small portion of Bush Forever site 268 is mapped within the Subject Area, within the Norkett Road reserve and Lot 3 on Diagram 050536 (Figure 3.10).

Additionally, the central and south-western portions of the Subject Area directly abut the large Bush Forever site (268), and the Sandwich Lots directly abut Bush Forever site 267. The northern-western portion of the Subject Area shares a common boundary with Bush Forever site 393.

The management of Bush Forever areas both within the Subject Area, and the interfaces with Bush forever areas abutting the Subject Area require consideration during planning of the IS. This is discussed further in Section 4.6.

3.8.2 DBCA managed lands

There are no areas managed by DBCA within the Subject Area or Sandwich Lots. Nearby areas including parts of The Spectacles located approximately 40 m to the south, and Harry Waring Marsupial Reserve located approximately 800 m to the north, are conservation areas managed by DBCA.

3.8.3 Local Natural Areas

Local Natural Areas (LNAs) are natural areas that exist outside of Bush Forever Sites (Swan Coastal Plain), the CALM Managed Estate and Regional Parks. In the past these areas have been referred to as Local Biodiversity Areas. LNAs may be recognised by local government as priority areas for consideration in land use planning.

Local natural areas are mapped (WALGA 2019) within the north-eastern portion of the Subject Area, as well as in isolated patches in the southern parts of the Subject Area (Plate 2). The Sandwich Lots are also predominantly mapped as local natural areas.

It is noted that the largest and most intact LNA mapped within the Subject Area (Lots 2 and 10) is proposed to be cleared under a separate proposal, unrelated to the IS. This proposal is currently being assessed under the EPBC Act (EPBC 2018/8182) and under s. 38 of the EPA Act (EPA 2197). EPBC 2018/8182 and EPA 2197 depict an area of 4.1 ha which will be retained, including no less than 3.74 ha of vegetation.

Where possible, the IS will retain vegetation associated with mapped LNAs, as discussed in Section 4.6.

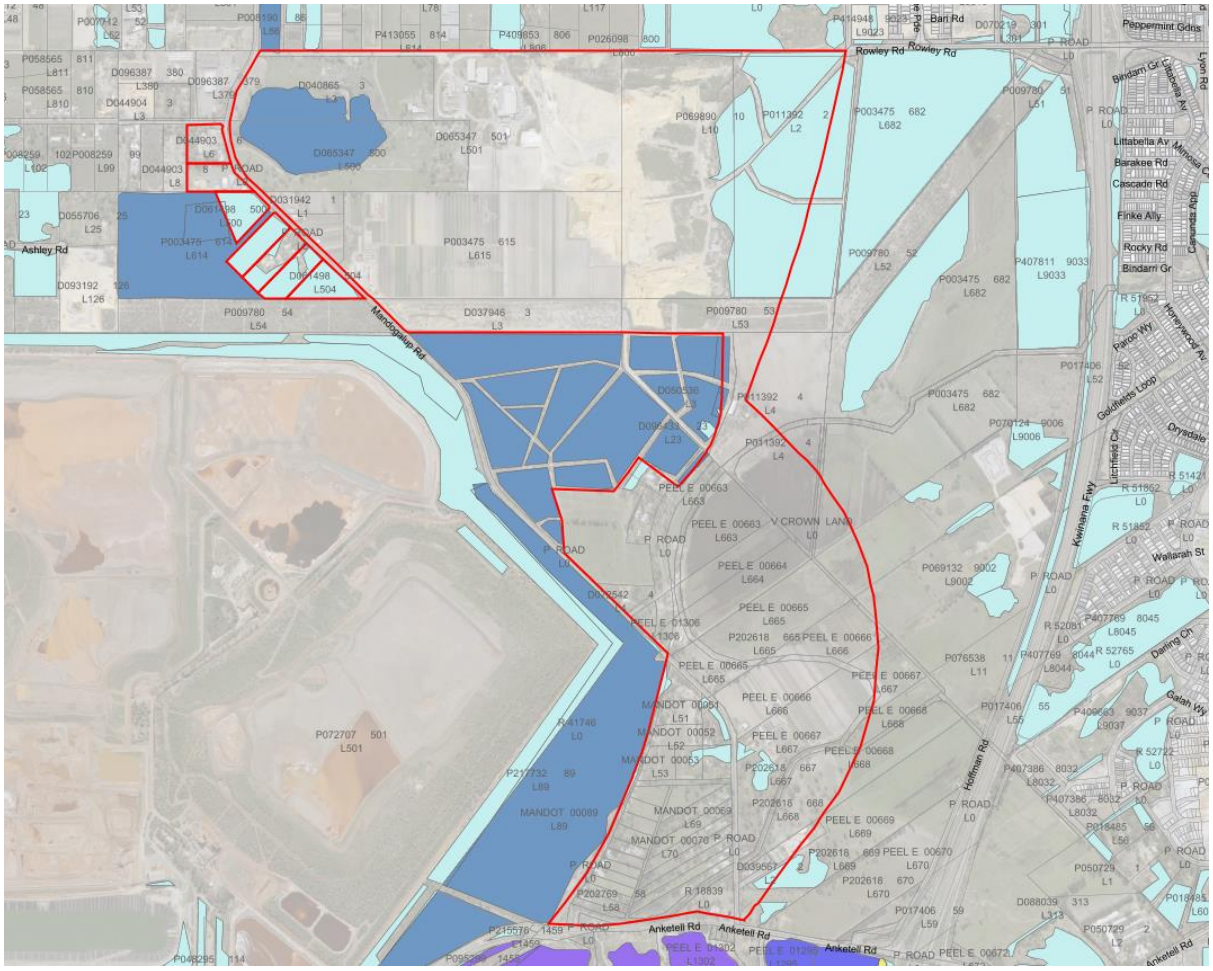


Plate 2: LNAs as indicated in pale blue (darker blue depicts Bush Forever; WALGA 2019)

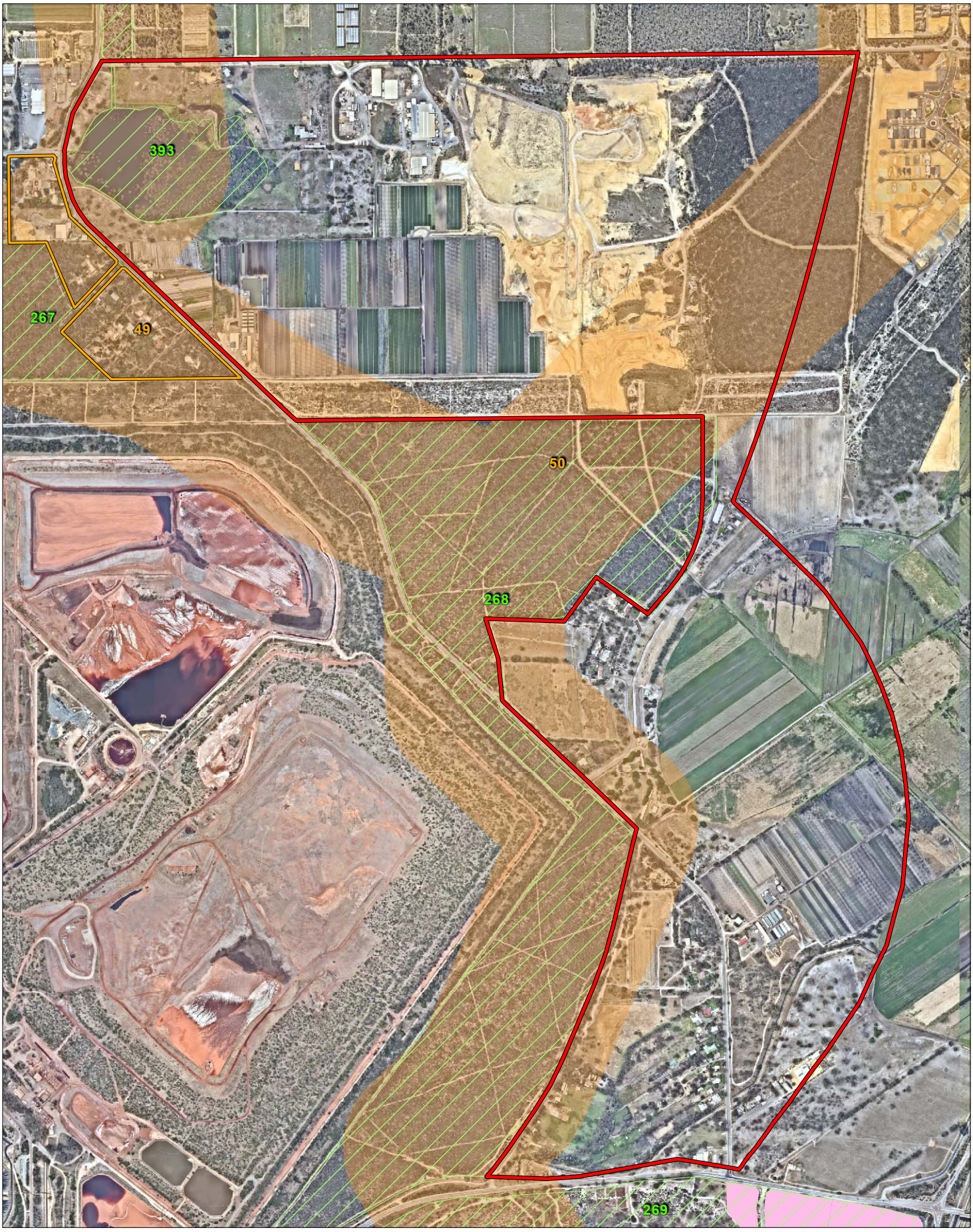
3.9 Ecological linkages

Regional Ecological Linkages link protected Regionally Significant Natural Areas by retaining the best condition conservation areas and local natural areas available between them that can act as stepping stones for flora and fauna (WALGA 2019).

Regional ecological linkages for the Perth Metropolitan Region were identified and mapped by the Perth Biodiversity Project in 2003. Spatial data maintained by WALGA (2003) identifies two regional ecological linkages mapped within the Subject Area (Linkage 49 and Linkage 50; Figure 3.10). Of these two linkages, Linkage 49 also occurs within the Sandwich Lots.

The mapped ecological linkages are largely associated with the conservation areas identified in Section 3.8, particularly Bush Forever sites.

Opportunities to retain and enhance conservation areas and ecological linkages are discussed in Section 4.6.



Legend:

- Subject area
- Sandwich lots
- Bush Forever site (DOP)
- Regional Ecological Linkages

Legislated Lands and Waters (DBCA)

- Crown Freehold - Dept Managed

strategen JBS&G

0 300 metres

Mandogalup, WA

CONSERVATION AREAS AND ECOLOGICAL LINKAGES

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: CoB	Version: A	Date: 17-Dec-2020	**FIGURE: 3.10**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_1\57020_03_10_ConsEcoLinks.mxd

Image Reference: www.nearmap.com© - Imagery Date: 19 November 2020

3.10 Contamination

The *Contaminated Sites Act 2003* (CS Act) defines contamination as having a substance present in land or water above background concentrations that presents a risk of harm to human health or the environment. The Act also provides for the identification, recording, management and remediation of contaminated sites. Contamination commonly occurs through accidental leakage and spillage, or poor site management practices.

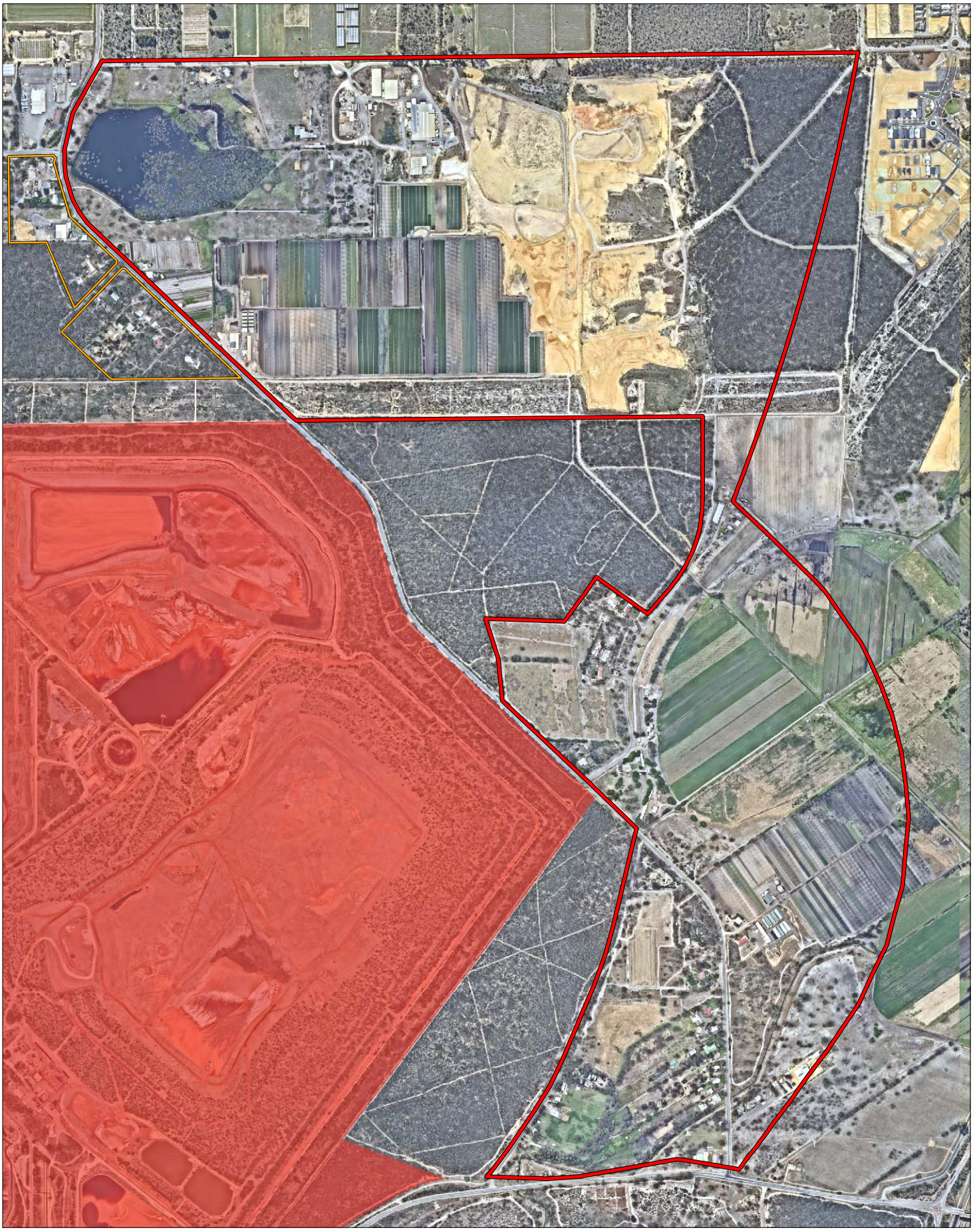
The *Contaminated Sites Database* (DWER 2019b) does not identify any registered contaminated sites within the Subject Area or Sandwich Lots. A registered contaminated site (status: remediation required) is located west of the Subject Area, associated with Alcoa's tailing ponds. The Basic Summary of Records (BSR) (Appendix C) identifies the nature of contamination as ''alkali groundwater plumes are present beneath the Source Site''.

The BSR makes reference to migration of contaminated water to another ''affected site'' to the east of Alcoa's landholding, and states that the affected site has been separately classified. However, it is noted that the *Contaminated Sites Database* (DWER 2019b) does not identify any registered contaminated sites, east of the Alcoa landholding, in the local vicinity. As such, it is possible that there are landholdings within or immediately adjacent to the Subject Area and Sandwich Lots that are classified as potentially contaminated (as a result of contaminated groundwater migration) and investigations required. Further investigation and/ or liaison with DWER and Alcoa will likely be required to determine the extent of any contamination affecting the Subject Area and Sandwich Lots, from Alcoa land uses.

It is noted that a number of market garden operations currently occur, or have previously operated within the Subject Area. The *Contaminated Sites Guidelines* (DER 2014b) identify market gardens as a potentially contaminating land use as a result of the potential for contaminants (such as metals, acids, paint residue, alkalis, solvents, salts, hydrocarbons or cyanide) to be discharged to the environment.

Additionally, a number of buildings (residences, sheds, workshops) occur across the Subject Area and Sandwich Lots that potentially contain asbestos or other hazardous materials.

A preliminary site investigation should be undertaken prior to development, to determine the potential nature of contamination (if any) across the Subject Area and Sandwich Lots, and to develop and implement a sampling and analysis plan where further investigations are warranted.



Legend:

- Subject area
- Sandwich lots

Contaminated sites (DWER-059)

- Contaminated - remediation required

strategen JBS&G

0 300 metres

Mandogalup, WA

CONTAMINATED SITES

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: CoB	Version: A	Date: 17-Dec-2020	**FIGURE: 3.11**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_1\57020_03_11_ContamSites.mxd

Image Reference: www.nearmap.com© - Imagery Date: 19 November 2020

3.11 Bushfire risk

Portions of the Subject Area and Sandwich Lots are identified as bushfire prone areas (OBRM 2019), as shown in Plate 3.

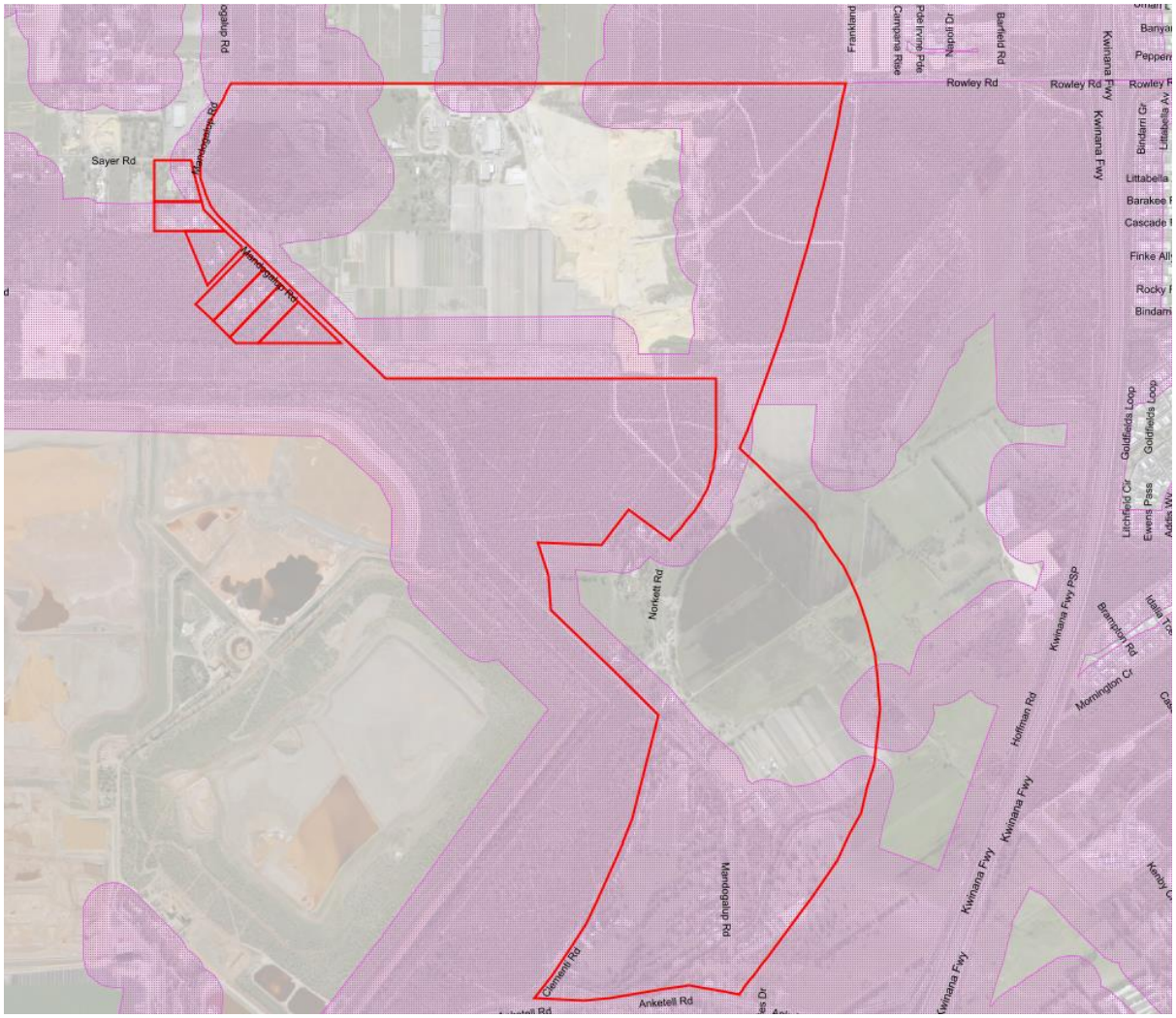


Plate 3: Map of Bushfire Prone Areas (OBRM 2019)

As a result of the bushfire prone status of the Subject Area, a Bushfire Management Plan (BMP) is required to accompany the IS strategic planning proposal, to address the following requirements of *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7), namely Policy Measure 6.3:

- a bushfire hazard level (BHL) assessment or where lot layout is known, a Bushfire Attack Level (BAL) contour assessment to determine the indicative acceptable BAL ratings across the Subject Area
- identification of any bushfire hazard issues arising from the above assessment
- assessment against the bushfire protection criteria requirements contained within the Guidelines demonstrating compliance can be achieved in subsequent planning stages.

A BMP is being prepared in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (the Guidelines; WAPC 2017), as discussed further in Section 4.8.

It is understood that residential development is occurring to the north-east of the Subject Area, and the majority of the vegetation in the north-eastern portion of the Subject Area (Lots 2 and 10) is

proposed to be cleared. As such, it is anticipated the predominant and permanent bushfire hazards will be associated with the Bush Forever sites located to the south, west and north of the Subject Area. Where the development interfaces with intact vegetation, appropriate separation to development (habitable buildings) to achieve a bushfire attack level (BAL) rating of BAL-29 or lower will be required.

Additionally, the development will be required to ensure adequate water supply for firefighting purposes, and appropriate vehicular access and egress provisions for residents and emergency services in accordance with the Guidelines. This is discussed further in Section 4.8.

3.12 Heritage

3.12.1 Indigenous heritage

The *Aboriginal Heritage Act 1972* (AHA Act) aims to protect Aboriginal heritage by registering Aboriginal sites (places and/or objects) that are of cultural importance to Aboriginal people. Any proposal to use or alter an area of land, for purposes such as research or development, must first determine if Aboriginal sites occur within the proposed area. If an Aboriginal site is found to occur, permission must be sought from the Minister for Aboriginal Affairs before that land can be used or altered in any way.

A search of the Department of Planning, Lands and Heritage – Aboriginal Heritage Places mapping tool (DPLH 2017) found no registered Aboriginal heritage sites within the Subject Area or Sandwich Lots.

Two ''Other Heritage Places'', Mandogalup Swamp Spectacles (Place ID: 3427, Type: Mythological, Hunting Place, Water Source) and Norkett Road (Place ID: 4360, Type: Artefacts/Scatter) intersect with the Subject Area but have a status of "Stored Data/Not a Site" and therefore do not meet the criteria to be considered a registered site.

3.12.2 European heritage

European cultural heritage places are recorded in a variety of different heritage listings. Some of these listings give statutory protection to heritage places, through requirements for heritage-related approvals or referrals. These are listed below:

Table 3.17: Listing categories of European cultural heritage places

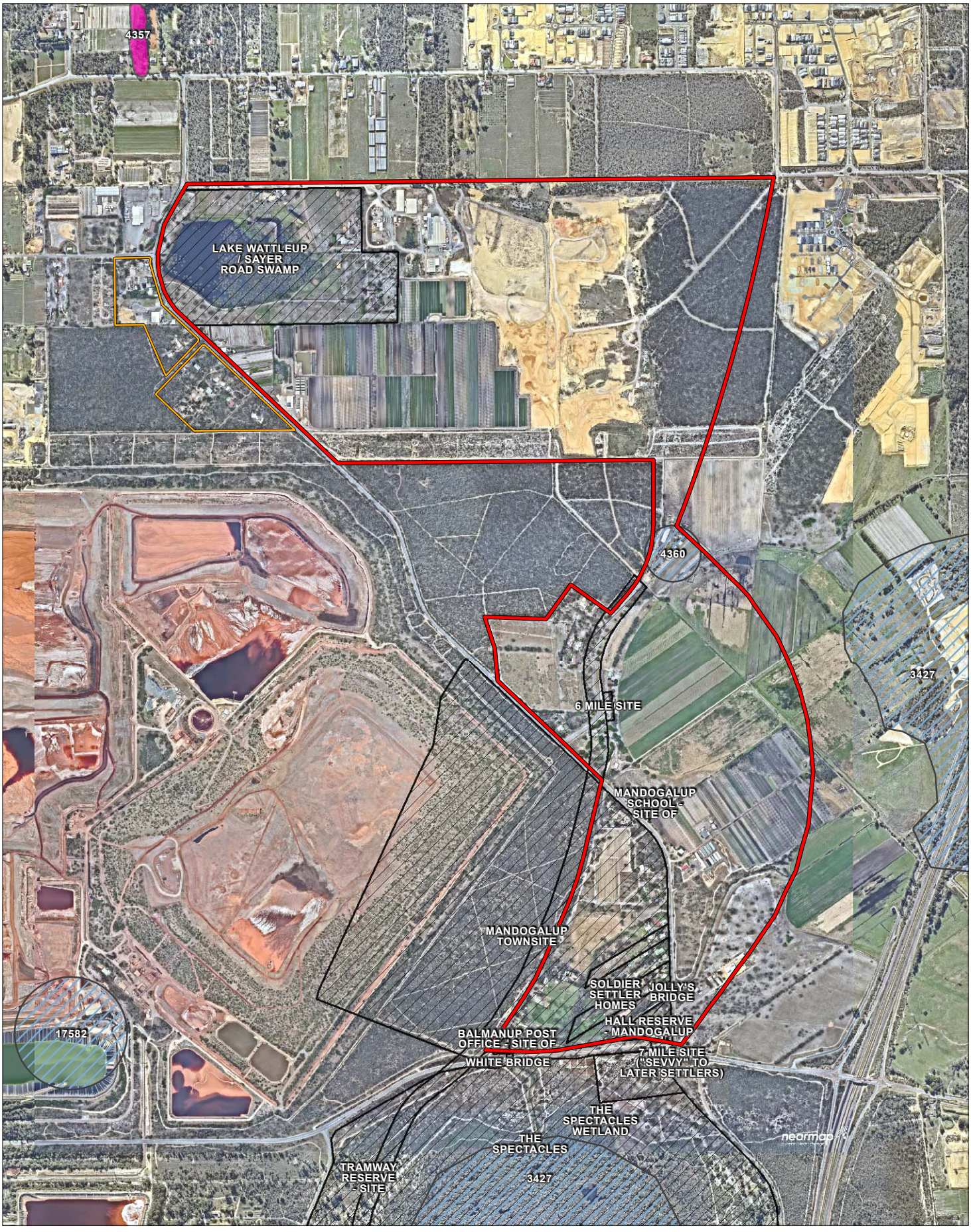
Type	Organisation	Legislation	What is listed
State register	Heritage Council (assisted by the Department of Planning, Lands and Heritage [DPLH])	*Heritage Act 2018* and *Heritage Regulations 2019*	Places of State significance included in the State Register of Heritage Places
Conservation Order	Heritage Council (assisted by DPLH)	*Heritage Act 2018* and *Heritage Regulations 2019*	Places of State significance or potential State significance (special cases)
Heritage Agreement	Heritage Council (assisted by DPLH)	*Heritage Act 2018* and *Heritage Regulations 2019*	Places protected by long-term agreement between the parties
Heritage List	Local Governments	*Planning and Development Act 2005*	Places of local heritage significance
National Heritage List	Australian Heritage Council	*Environment Protection and Biodiversity Conservation Act 1999*	Places of national significance

A search of the *inHerit* database identified 10 heritage places as listed below in Table 2.1, 9 of which are on the City's Municipal Inventory. None are listed as State Registered Places or Places of National Significance.

Table 3.18: European heritage sites mapped within the Subject Area

Place Number	Place Name	Statutory Listings	Other listings
12087	Mandogalup Post Office (fmr)	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12100	Hall Reserve - Mandogalup	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12123	Mandogalup School Cottage - site	N/A	N/A
12130	7 Mile Site ("Sevvy" to later settlers)	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12106	Lake Wattleup / Sayer Road Swamp	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12111	Mandogalup School - Site of	Heritage List Adopted 20 Nov 1992 (City of Kwinana)	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12125	Mandogalup Townsite	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12114	Jolly's Bridge	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12129	6 Mile Site	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)
12092	Soldier Settler Homes, Mandogalup	N/A	Municipal Inventory Adopted 13 May 1998 (City of Kwinana)

Sites listed by local governments on their municipal inventories are generally considered significant to their local community.



Legend:

- Subject area
- Sandwich lots
- Municipal Inventory (SHO-005)

Aboriginal Heritage Places (DAA-001)

- Other Heritage Place
- Registered Site

strategen JBS&G

0 300 metres

Mandogalup, WA

INDIGENOUS AND EUROPEAN HERITAGE

Job No: 57020		Scale 1:18,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: CoB	Version: A	Date: 17-Dec-2020	**FIGURE: 3.12**

Document Path: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_1\57020_03_12_Heritage.mxd

Image Reference: www.nearmap.com© - Imagery Date: 19 November 2020

4. Potential impacts, management and approvals

The potential impacts, management and approval requirements associated with the attributes identified in Section 3, are discussed in this section.

The environmental, bushfire and heritage considerations discussed in this section that require a spatial response are depicted in Figure 4.1. It is noted that noise contours are not mapped on this figure, and are displayed in the report produced by Lloyd George Acoustics (2020).

4.1 Surrounding land use

4.1.1 Major roads

The proximity of major roads; Kwinana Freeway, Anketell Road and Rowley Road (potential future extension along northern Subject Area boundary) to the Subject Area is an important consideration in determining appropriate placement of sensitive land uses, as a result of potential noise implications.

State Planning Policy 5.4 Road and Rail Noise (SPP 5.4) has been prepared for the purpose of minimising the impact of road and rail noise on noise-sensitive land use and development within specified trigger distances of strategic freight and major traffic routes and other significant freight and traffic routes. This policy applies where there is proposed noise-sensitive land use within the policy's trigger distance of a transport corridor, as specified in Table 1 of SPP 5.4. Through its objectives, SPP 5.4 seeks to:

- protect the community from unreasonable levels of transport noise
- protect strategic and other significant freight transport corridors from incompatible urban encroachment
- ensure transport infrastructure and land-use can mutually exist within urban corridors
- ensure that noise impacts are addressed as early as possible in the planning process
- encourage best practice noise mitigation design and construction standards.

A set of noise targets for noise-sensitive land use is outlined in Table 4.1, which are to be achieved by proposals under which SPP 5.4 applies.

Table 4.1: Noise targets for noise-sensitive land uses as defined in SPP 5.4.

Outdoor noise target		Indoor noise target	
55 dB $L_{Aeq(Day)}$	50 dB $L_{Aeq(Night)}$	40 dB $L_{Aeq(Day)}$ (Living and work areas)	35 dB $L_{Aeq(Night)}$ (Bedrooms)

Given that development is proposed within the specified trigger distance to strategic freight and major traffic routes, namely Kwinana Freeway to the east and Anketell Road to the south, a Transportation Noise Assessment has been undertaken by Lloyd George Acoustics (Lloyd George Acoustics 2019) for the Subject Area to determine the level of exposure to traffic and freight noise.

Two noise receivers were placed along Kwinana Freeway and Anketell Road to measure the average noise levels from each of these traffic routes, which are presented in Table 4.2 and Table 4.3 below.

Table 4.2: Measured average noise levels – Kwinana Freeway

Date	Average Weekday Noise Level (dB)			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Monday 21 October 2019	73.4	69.9	71.0	66.1
Tuesday 22 October 2019	72.8	69.5	70.8	64.2
Wednesday 23 October 2019	74.0	71.1	72.0	68.5
Thursday 24 October 2019	74.0	71.0	71.9	68.2
Friday 25 October 2019	74.0	70.9	71.8	68.1
Weekday average	**73.6**	**70.5**	**71.5**	**67.0**

Table 4.3: Measured average noise levels – Anketell Road

Date	Average Weekday Noise Level (dB)			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Friday 15 November 2019	65.1	65.0	63.9	66.6
Monday 18 November 2019	64.5	62.1	62.3	61.8
Tuesday 19 November 2019	62.5	60.0	60.2	59.4
Wednesday 20 November 2019	66.8	66.2	65.6	67.3
Thursday 21 November 2019	64.8	66.3	66.1	66.8
Weekday average	**64.8**	**63.9**	**63.6**	**64.4**

Based on the measured average noise levels for Kwinana Freeway and Anketell Road, Lloyd George Acoustics (2020) have recommended that future premises with a noise-sensitive nature be located away from these traffic routes, and that premises not considered to be noise-sensitive be located nearer to these routes to provide potential noise barrier effects to sensitive land uses behind them. Where future noise sensitive premises are located in areas above the outdoor noise targets, Lloyd George Acoustics (2020) have recommended treatments including noise walls and quiet house design packages.

It is noted that the noise assessment has not considered the potential extension of Rowley Road (and associated Westport development) or Hammond Road. Additional studies are to be undertaken to understand the potential implications of these roads.

4.1.2 Market gardens

A number of market gardens exist, both within and surrounding the Subject Area. Market gardens are potentially contaminating land uses (DER 2014b) and are known to generate gaseous, dust, noise and odour emissions. As a result of these potential emissions, the EPA recommend a separation buffer between market gardens and sensitive land uses (such as residential land uses) ranging from 300 m to 500 m depending on the size of the operation (EPA 2005). It is noted that a reduced separation distance may be supported where technical studies demonstrate that risks associated with potential emissions are mitigated.

Research has shown a single row of trees is effective in capturing up to 80 per cent of pesticide spray drift from an application upwind (Harden cited in DNR, 1997) and that a 20m vegetated buffer (with 10 m cleared either side, total 40 m) containing a mix of species and foliage types will reduce spray drift to less than 1 per cent at the sensitive receptor (Centre of Pesticide Application and Safety, University of Queensland cited in DNR, 1997). The Department of Health provides the following requirements for vegetative buffers to be effective barriers to spray drift:

- be located as close as practicable to the point of release of the spray
- be a minimum total width of 40 m made up of 10 m cleared fire break area either side of a 20 m wide planted area
- contain random plantings of a variety of tree and shrub species of differing growth habitats, at spacings of 4 to 5 m
- include species with long, thin (needle-like) and rough (furry/hairy) foliage which facilitates the more efficient capture of spray droplets and which are fast growing and hardy
- foliage should be from the base to the crown; mixed plantings of trees may be required to ensure there are no gaps in the lower canopy
- provide a permeable barrier which allows air to pass through the buffer – a porosity of 0.5 is acceptable (that is, approximately 50 per cent of the screen should be air space)
- have a mature tree height twice the height of the spray release height

- have mature height and width dimensions which do not detrimentally impact upon adjacent crop land.

Consideration of appropriate setbacks and interface treatments between sensitive land uses and market gardens will be required for both market gardens external to the Subject Area, and market gardens within the Subject Area (including during land use transition).

4.1.3 Alcoa operations

As outlined in Section 3.1.3, air quality considerations associated with Alcoa's operations are not discussed in this report.

In addition to air quality considerations, Alcoa's operations have resulted in classification of Lot 501 (on Plan 72707) as a contaminated site under *the Contaminated Sites Act 2003*. Implications associated with contaminated sites status of these land holdings is discussed further in Section 4.7.

4.1.4 Conservation areas

The Subject Area and Sandwich Lots abut a number of conservation areas (Figure 3.10), including:

- Bush Forever site 268
- Bush Forever site 267
- Bush Forever site 393.

Additionally, the Spectacles is located approximately 40 m to the south.

The above conservation areas require consideration in relation to interface treatments to protect these conservation areas from future development, as well as consideration in relation to providing appropriate separation to protect future development from associated bushfire hazards.

Policy measures for the protection of Bush Forever sites are outlined in SPP2.8. SPP 2.8 applies to any proposal or decision-making that is likely to have an adverse impact on regionally significant bushland within a Bush Forever area. SPP 2.8 defines an adverse impact as *''a significant indirect impact on a Bush Forever area through development directly abutting regionally significant bushland that is likely to result in, but not limited to, significant hydrological impacts, the spread of dieback, direct drainage into regionally significant bushland, significant access and weed infestation issues, fire management issues and other significant management implications or threatening processes arising from development*.''.

To avoid potential adverse impacts to Bush Forever, appropriate interface treatments should be applied. These measures should be determined in consultation with Department of Biodiversity, Conservation and Attractions, the City and land owners/ managers of Bush Forever sites, and may include:

- Conservation fencing and signage to restrict pedestrian/ vehicular access
- Appropriate batter grades, as determined in consultation with the DBCA/Bush Forever site manager, so that vegetation within the Bush forever sites is not adversely impacted by development
- Appropriate management of stormwater onsite (i.e. no direct drainage into Bush Forever)
- Development and implementation of weed and Dieback hygiene controls during construction.

It is noted that bushfire risk and management is discussed in Section 4.8.

4.2 Geology and soils

Regional geological mapping (Gozzard 1983) identifies three geological units within the Subject Area and Sandwich Lots; SANDY SILT (Ms_5), SAND (S_7) and SAND (S_8).

The Ms_5 geological unit is limited to wetland areas. The S_7 unit occurs predominantly in the western portions of the Subject Area and Sandwich Lots, while S_8 occurs predominantly in the eastern portion.

Table outlines the compatibility of each of these soil types with waste disposal, road construction, urbanisation and excavation.

Table 4.4: Soil and land use compatibility (Gozzard 1983)

Soil type	Suitability for specified use						Notes
	Solid waste disposal	Liquid waste disposal	Septic tanks	Road construction	Urbanisation	Excavation (mining and quarrying)	
SANDY SILT (Ms5)	Activity undesirable for the environment	Activity undesirable for the environment	Activity undesirable for the environment	Possible problems for activity	Activity undesirable for the environment	Possible problems for environment	High water table, prone to flooding, differential settlement may occur.
SAND (S7)	Possible problems for environment	Possible problems for environment	Possible problems for environment	Activity compatible	Activity compatible	Activity compatible	Few limitations, some settlement under foundations can be expected, some ability to attenuate pollutants due to small clay content, usually considerable depth to water table due to topography.
SAND (S8)	Possible problems for environment	Activity undesirable for the environment	Possible problems for environment	Activity compatible	Activity compatible	Activity compatible	Well drained, when vegetation free it could be remobilised (subject to erosion, drainage disposal is only a problem in areas of high water table.

Development should avoid areas of SANDY SILT associated with the REW in the north-western portion of the Subject Area. Where development is proposed in SANDY SILT across other parts of the Subject Area, the importation of fill (or cut-fill) will likely be required to achieve appropriate separation to groundwater.

Areas of SAND are expected to be compatible with urbanisation and the construction of roads.

Based on land use compatibility described by Gozzard (1983), development should be connected to sewer to avoid potential environmental impacts. Where this cannot be achieved, a land capability assessment for onsite effluent disposal would be required, and compliance with the *Government Sewerage Policy* 2019 would need to be demonstrated.

The onsite geological environment, and land use suitability should be determined by geotechnical investigations and recommendations prior to development occurring.

4.3 Hydrology

4.3.1 Groundwater

As outlined in Section 3.4.1, groundwater is expected to be above natural surface level in the north-western corner of the Subject Area and groundwater in the southern portions of the Subject Area is anticipated to range from ‘’at surface’’ to over 15 m below ground level.

Appropriate separation (1.2 m) between building floor level and the maximum expected groundwater table is required, in accordance with Better Urban Water Management (DoW 2008). Prior to development, groundwater monitoring should be undertaken to confirm maximum groundwater levels.

A number of groundwater bores and associated abstraction licences currently exist across the Subject Area and Sandwich Lots. Groundwater abstraction licences are able to be transferred to new landowners and therefore these bores could be utilised for groundwater abstraction where required, such as for construction purposes or irrigation of public open space.

The suitability of groundwater for abstraction may need to be confirmed through water quality sampling, particularly noting the potential for contamination of groundwater migrating from Alcoa's operations (discussed in Section 4.7).

Separately, development of the Subject Area and Sandwich Lots will be required to demonstrate how groundwater will be managed to ensure pre-development groundwater conditions are maintained in accordance with *Better Urban Water Management* (DoW 2008) guidelines and will be addressed through the standard water management requirements of the planning process, including:

- A District Water Management Plan to support future rezoning
- A Local Water Management Plan to support future Structure Plans
- An Urban Water Management Plan to support future Subdivision applications.

A hydrological report is being prepared by JDA Consultant Hydrologists to support the Improvement Scheme.

4.3.2 Surface water

As outlined in Section 3.4.3, the Peel main drain traverses the IS area and plays an important ecological function to the local wetland network.

Pre-development surface water conditions will be maintained within future development areas in accordance through development of District, Local and Urban Water Management Plans, where required.

A hydrological report is being prepared by JDA Consultant Hydrologists to support the Improvement Scheme.

4.3.3 Geomorphic wetlands

As outlined in Section 3.4.4, a Resource Enhancement Wetland occurs within the north-western portion of the Subject Area. The management objective for REWs is to restore these wetlands through maintenance and enhancement of wetland functions and attributes. The REW will be retained and an appropriate buffer applied from any development.

While there is no formal policy for wetlands and associated buffers, guidance is provided in the EPA (2008) *Environmental Guidance for Planning and Development* (Guidance Statement (GS) 33) and the DPLH (2005) *Draft guideline for the determination of wetland buffer requirements*. As outlined in GS 33, there are many land uses that can result in an adverse impact to wetlands if not appropriately managed. These include, but are not limited to:

- clearing of vegetation
- draining water into or out of a wetland
- filling with soil or other material
- direct discharge or disposal of stormwater and/or effluent into the wetland or its buffer

- use, storage or disposal of nutrients or chemicals
- waste disposal or processing
- dewatering
- use of fertilisers, sprays (for example, sprays for midge and mosquito control) and watering (irrigation)
- recreational activities, which may contribute to compaction of ground, damage to vegetation, introduction of weeds, rubbish
- disturbance of acid sulfate soils (see Section 4.9)
- any other works or development in the wetland or its buffer.

The buffer adjoining a wetland helps to maintain the ecological processes and functions associated with the wetland, and aims to protect the wetland from potential adverse impacts (EPA 2005). The EPA (2005) outlines that wetlands that are to be protected require a minimum 50 metre buffer distance, or alternatively a site-specific buffer requirement may be determined. A separation buffer of 30 m is generally accepted by regulatory agencies, between the mapped boundary of the REW and development. Where the 30 m buffer area is degraded, occasionally a reduced buffer can be accepted where there is an improved environmental outcome. For example, a 20 m buffer could potentially be accepted, if the 20 m area is revegetated, and land uses adjacent to the buffer are passive and compatible with the objectives for REWs.

It is noted however, that the REW occurs within BF and that additional separation to development may be warranted. There is a possibility that due to the presence of standing water and native vegetation surrounding the wetland, the REW may be viewed with greater conservation significance and a 50 m buffer recommended by DBCA.

As the wetland is an REW, and is located within a Bush Forever site, development within the wetland itself would not be permissible. Any land uses proposed within the wetland buffer would need to be commensurate with the objectives for REWs, being, maintenance and enhancement of wetland functions and attributes, as well as the objectives of SP2.8. As such, uses within the buffer may include vegetation protection, rehabilitation, and potentially passive land uses in degraded areas, where agreed to by WAPC in consultation with DBCA and the land owner/ manager.

4.4 Vegetation and flora

As a result of historic land uses within the Subject Area and Sandwich Lots (such as market gardening), intact vegetation is limited. Of the areas subject to a flora and vegetation survey within the Subject Area, approximately 72% of these areas are mapped as ‘’cleared’’. Of the areas subject to a flora and vegetation survey within the Sandwich Lots, approximately 48% of these areas are mapped as ‘’cleared’’.

As outlined in Section 3.6 the following TECs and PECs are present within the Subject Area and Sandwich Lots:

- Banksia woodlands of the Swan Coastal Plain (TEC under EPBC Act; Priority 3 PEC listed by DBCA)
- Tuart woodlands and forests of the Swan Coastal Plain (TEC under EPBC Act; Priority 3 PEC listed by DBCA).

Given the limited vegetation within the Subject Area, development should be concentrated in areas which are mapped as ‘’completely degraded’’ and ‘’degraded’’. Areas of vegetation which are of “good” quality or better, should be prioritised for retention, where possible.

Based on the flora and vegetation surveys undertaken to date, no Threatened and one Priority flora species, *Dodonaea hackettiana* (P4) has been recorded (in intact remnant native vegetation within the road verge on the western side of Norkett Road). Priority 4 species are species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons. Priority 4 species are not formally protected but are considered during the planning and approvals process and where possible, development should avoid clearing of this species.

Any vegetation, trees and flora proposed to be retained as part of future development can be protected through construction management practices including:

- Demarcation with flagging tape
- Identification of root protection zones
- Dieback hygiene management
- Weed hygiene management
- Dust controls.

4.5 Fauna and habitat

The following conservation significant fauna species are considered to possibly or likely occur, or are known to occur within the Subject Area and/ or Sandwich Lots:

- *Calyptorhynchus banksii naso* (Forest Red-tailed Black-Cockatoo; FRTBC)- Threatened (EPBC Act/ BC Act)
- *Calyptorhynchus latirostris* (Carnaby's Cockatoo; CC)
- *Falco peregrinus* (Peregrine Falcon)
- *Isoodon fusciventer* (Quenda)
- *Lerista lineata* (Perth Slider)
- *Neelaps calonotos* (Black-striped Snake)
- *Synemon gratiosa* (Graceful Sunmoth).

Additionally, 17 conservation significant migratory wetland species may utilise the REW in the north-western portion of the Subject Area. These species however, are likely to favour the larger wetlands located north and south of the Subject Area; Thomsons Lake and The Spectacles (respectively).

A total of 82.87 ha of CC foraging habitat and 51.1 ha of FRTBC foraging habitat has been identified within the Subject Area, excluding cleared areas which may provide additional habitat. A total of 6.66 ha of CC foraging habitat and 6.46 ha of FRTBC habitat has been identified within the Sandwich Lots, excluding cleared areas. A portion of the black cockatoo habitat mapped within the Subject Area is contained within Lots 2 and 10 and is proposed to be cleared to facilitate sand extraction for a separate proposal, which is currently subject to assessment under the Commonwealth EPBC Act and State EP Act (EPBC 2018/8182 and EPA 2197). Pending the outcome of these assessments and any areas negotiated for retention, the amount of black cockatoo habitat remaining within the Subject Area or Sandwich Lots, at the time of development may be reduced.

A total of 362 potential nesting habitat trees and 35 potentially suitable hollows have been identified within the Subject Area (Figure 3.9; species including *Eucalyptus marginata, Eucalyptus gomphocephala, Eucalyptus rudis, Corymbia calophylla*).

A total of 48 potential nesting habitat trees and 8 potentially suitable hollows have been identified within the Sandwich Lots (Figure 3.9; species including *Corymbia calophylla, Eucalyptus marginata*).

Where possible, future development should avoid impacts to black cockatoo habitat including significant trees, particularly those with potentially suitable nesting hollows. Any rehabilitation proposed (such as of the REW or ecological linkages) or landscaping, should consider use of black cockatoo foraging, roosting and breeding species, to create habitat for these threatened species. Additionally, consideration should be given to the creation of habitat for other avian and ground dwelling fauna (such as within public open space, Bush Forever site 268 or ecological linkages) where development constraints permit.

Fauna habitat to be retained should be protected through construction management measures, such as demarcation of retention areas prior to clearing taking place. Additionally, fauna relocation and pre-clearing hollow inspections can be undertaken in accordance with any conditions of future subdivision approvals, development approvals or clearing approvals.

Where significant residual impacts are anticipated to State listed species, the EPA may choose to assess the scheme amendment.

Where significant residual impacts are anticipated to Commonwealth listed MNES, an EPBC Act referral will be warranted.

4.6 Conservation areas and ecological linkages

A number of conservation areas are located within and adjacent to the Subject Area and Sandwich Lots, as outlined in Section 3.8 and displayed in Figure 3.10. These conservation areas are "connected'' via mapped regional ecological linkages.

The IS provides opportunities to retain and enhance conservation areas and ecological linkages through retention of vegetation and trees, as well as the creation of ecological linkages or ''green links'', where development constraints permit.

Ecological linkages are intended to serve as stepping stones of habitat which facilitate the maintenance of ecological processes and the movement of organisms within, and across, a landscape (WALGA and DEC 2009). To serve this function, ecological linkages are preferred to be >500 m in width, and not less than 100 m in width (Davis 2008, Saunders *et al.* 1991, Mason *et al.* 2006, Major *et al.* 1999).

The most obvious opportunity to enhance the existing mapped regional ecological linkage is within and surrounding Bush Forever site 393, including the REW and associated buffer, where rehabilitation would result in an improved environmental outcome. Vegetation within the Sandwich Lots also currently contributes to the north-western ecological linkage.

It is understood however that development constraints (such as bushfire risk) may make formal ecological linkages difficult to achieve. As an alternative, ''green links'' could be proposed. Where any local or public open space is proposed, landscaping with native vegetation can be utilised for the purpose of habitat creation, whilst ensuring that bushfire hazards are appropriately managed. Native vegetation planting and tree retention could also be accommodated within road reserves to achieve green linkages. Additionally, any Asset Protection Zones (APZs) required (as outlined in Section 4.8) can retain up to 15% canopy cover and may contain ground cover in a managed state (as per Appendix D).

4.7 Contamination

A number of potential contamination sources have been identified as part of the desktop assessment of this EAR, both within and adjacent to the Subject Area. These include:

- Potential contamination of groundwater associated with Alcoa's operations

- Potential contamination associated with historic market gardening land uses
- Potential presence of asbestos and other hazardous materials associated with dated buildings and rural land uses.

A preliminary site investigation should be undertaken prior to development, to determine the potential nature of contamination (if any) across the Subject Area and Sandwich Lots, and to develop and implement a sampling and analysis plan where further investigations are warranted.

Where these investigations identify that remediation or restriction of land uses are warranted, future development will be required to take this into consideration.

4.8 Bushfire risk

As a result of the bushfire prone status of the Subject Area, a Bushfire Management Plan (BMP) is required to accompany the IS strategic planning proposal, to address the following requirements of *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7), namely Policy Measure 6.3:

- a bushfire hazard level (BHL) assessment or where lot layout is known, a Bushfire Attack Level (BAL) contour assessment to determine the indicative acceptable BAL ratings across the Subject Area
- identification of any bushfire hazard issues arising from the above assessment
- assessment against the bushfire protection criteria requirements contained within the Guidelines demonstrating compliance can be achieved in subsequent planning stages.

A BMP has been prepared in accordance with the *Guidelines for Planning in Bushfire Prone Areas* (the Guidelines; WAPC 2017) which details the bushfire hazard and management considerations for the Subject Area and Sandwich Lots.

It is anticipated the predominant post-development bushfire hazards will be associated with the Bush Forever sites located to the south, west and north of the Subject Area. Where the development interfaces with intact vegetation, appropriate separation to development (habitable buildings) to achieve a bushfire attack level (BAL) rating of BAL-29 or lower will be required.

Additionally, the development will be required to ensure adequate water supply for firefighting purposes, and appropriate vehicular access and egress provisions for residents and emergency services in accordance with the Guidelines.

4.9 Acid sulfate soils

As outlined in Section 3.5, the eastern portions of the Subject Area are mapped as having a ''moderate to low'' risk of ASS occurring within 3 m of the natural surface. Low lying areas in the north-western, central and south western portions of the Subject Area are mapped as having a ''high to moderate'' risk of ASS occurring within 3 m of the natural surface (Figure 3.4).

The disturbance of ASS occurs when these soils are drained or excavated, releasing elements such as metals and nutrients from the soil profile which can then be mobilised/transported to waterways, wetlands and groundwater systems, often with deleterious environmental and economic impacts. (DER 2015).

In accordance with DER 2015, ASS investigations should be undertaken where any of the following activities are proposed:

- soil or sediment disturbance of 100 m^3 or more in areas mapped as 'high to moderate risk of ASS occurring within 3m of natural soil surface'

- soil or sediment disturbance of 100 m^3 or more with excavation from below the natural watertable in areas mapped as 'moderate to low risk of ASS occurring within 3m of natural soil surface'
- lowering of the watertable, whether temporary or in areas mapped as 'high to moderate risk' of AASS or PASS occurrence' or 'moderate to low risk of AASS or PASS occurrence within 3m of natural soil surface'
- extractive industry works (e.g. mineral sand mining) in areas where ASS are generally found (refer to Table 1 of DER 2015)
- flood mitigation works, including construction of levees and flood gates, in areas where ASS are generally found (refer to Table 1 of DER 2015).

Where ASS investigations are required and ASS is detected, and ASS Management Plan will be required to be prepared and implemented. ASS are generally considerable manageable and not a constraint to development.

4.10 Heritage

All Aboriginal Heritage Sites are protected under the *Aboriginal Heritage Act 1972*, whether or not they have been previously identified or registered, provided that the Subject Area meets the criteria under Section 5 of that Act. As such, development of the Subject Area and Sandwich Lots should be undertaken in accordance with the DPLH and Department of Premier and Cabinet *Aboriginal Heritage Due Diligence Guidelines 2013*.

As outlined in the guidelines, due diligence may involve one or all of the following actions:

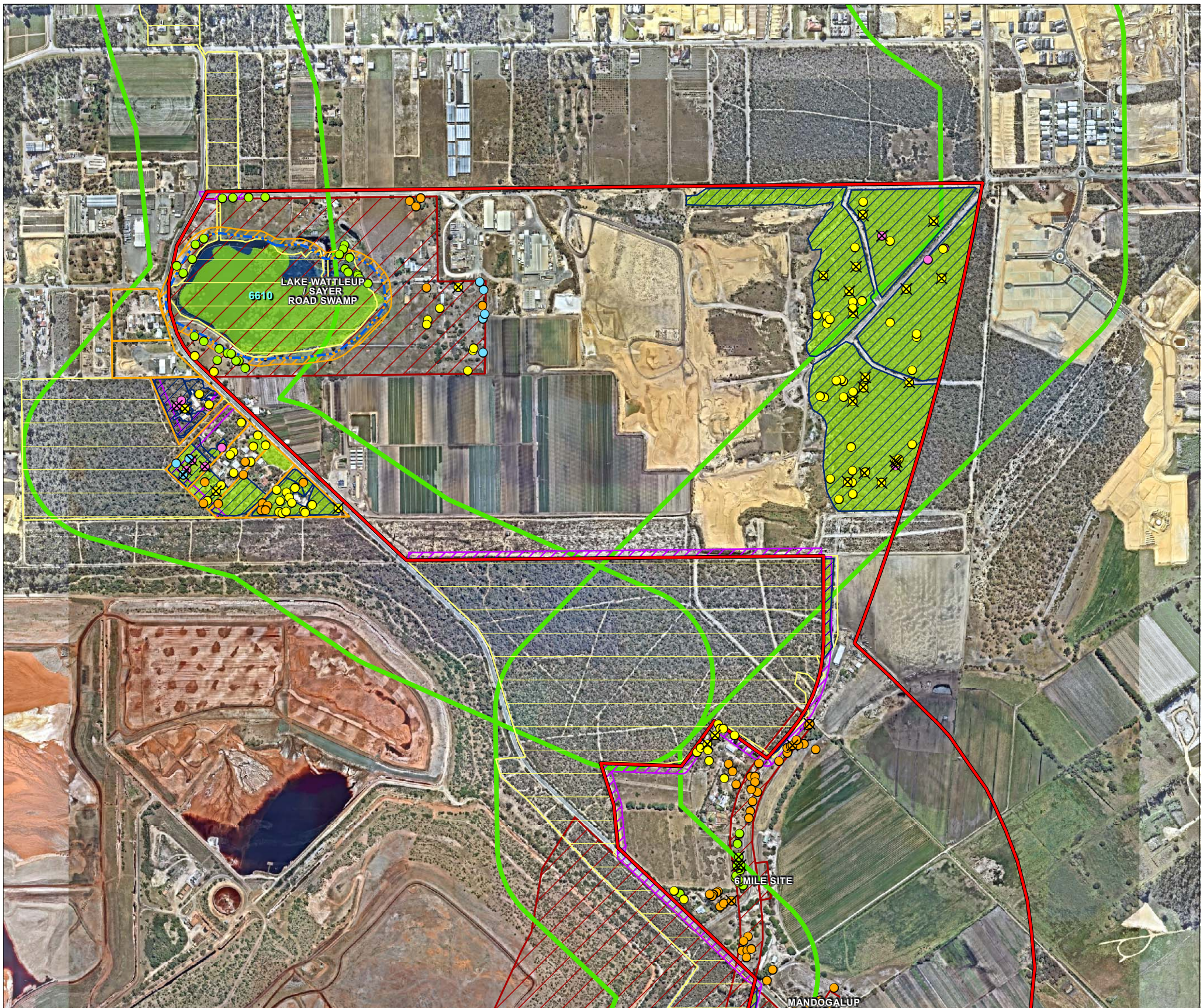
- assessing the landscape where an activity is to take place
- assessing the proposed activity and the potential impact on the landscape
- searching the Register of Aboriginal Sites and the Aboriginal Heritage Inquiry System
- consulting with the relevant Aboriginal people
- agreeing to an Aboriginal heritage survey
- other heritage management strategies.

A desktop assessment did not identify any registered Aboriginal heritage sites within the Subject Area or Sandwich Lots. Liaison with DPLH is required to determine if an Aboriginal heritage survey or consultation with relevant Aboriginal people is warranted.

Alternatively, future development should ensure that all site contractors are appropriately inducted on Aboriginal heritage due diligence, and are instructed to stop works in the event that any artefacts are uncovered, until these have been assessed by a suitably qualified person and relevant authorities to determine if an Aboriginal heritage site is present (under Section 5 of the Act).

Where the presence of an Aboriginal heritage site is confirmed, a Section 18 application and consent will be required under the Act prior to any works disturbing the Subject Area.

A number of European heritage sites are mapped within the Subject Area. Prior to development in the location of European heritage sites, the City should be consulted to determine the compatibility of any land uses proposed, and to identify any development restrictions or opportunities.



Legend

- MIP 47 boundary (331.2 ha)
- Sandwich lots
- European Heritage Sites
- Regional Ecological Linkages
- Bush Forever site (DOP)
- Resource Enhancement Wetland (REW)
- 30m buffer of REW
- Vegetation in good or better condition
- Tuart woodlands and forests of the SCP
- Banksia woodlands of the SCP

Indicative APZs

- 17m wide APZ
- 21m wide APZ

Significant Black Cockatoo habitat trees

- *Corymbia calophylla*
- *Eucalyptus gomphocephala*
- *Eucalyptus marginata*
- *Eucalyptus rudis*
- *Eucalyptus* sp.
- N/A
- Hollow present - potentially suitable

strategen JBS&G

0 350 metres

Mandogalup, WA

SUMMARY OF ENVIRONMENTAL, HERITAGE AND BUSHFIRE SPATIAL CONSIDERATIONS

Job No: 57020		Scale 1:12,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: hsullivan	Checked By: CT	Version: A	Date: 10-Dec-2020	**FIGURE: 4.1**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R01_Rev_A\57020_04_1_SummaryConsiderations_RevB.mxd

Image Reference: www.nearmap.com© - Imagery Date: 21 October 2019.

5. Assessment against the EPA Principles, Factors and Objectives

To be completed following development of land use plan.

6. Conclusion

To be completed following development of land use plan.

7. Limitations

This report has been prepared for use by the client who has commissioned the works in accordance with the project brief only, and has been based in part on information obtained from the client and other parties.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

Strategen-JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by Strategen-JBS&G, and should not be relied upon by other parties, who should make their own enquires.

This report does not provide a complete assessment of the environmental status of the Subject Area, and it is limited to the scope defined herein. Should information become available regarding conditions at the Subject Area including previously unknown sources of contamination, Strategen-JBS&G reserves the right to review the report in the context of the additional information.

8. References

Atlas of Living Australia and Birdlife WA. 2015, *Grey Wagtail (Motacilla cinerea)* distribution map, Australian Government, Canberra. Available via: http://www.environment.gov.au/system/files/resources/c05f5b87-0a99-4998-897e-7072c236cf83/files/migratory-birds-map-grey-wagtail.pdf

Beard JS 1981, *Swan, 1:1000000 vegetation series: explanatory notes to sheet 7: the vegetation of the Swan area,* University of Western Australia Press, Nedlands, Western Australia.

Beard JS 1990. *Plant life of Western Australia*. Kangaroo Press, Kenthurst, New South Wales

Birdlife WA. 2018. *Great Cocky Count Dataset*. Available online via the Environmental Planning Tool.

Cardno 2005, *Flora, Vegetation, Fauna and Wetland Assessment Mandogalup,* unpublished report.

Commonwealth of Australia 2001*, National Objectives and Targets for Biodiversity Conservation 2001–2005*, Australian Government, Canberra.

Davis R A 2008, *Ecological Linkages for birds- management guidelines*. Discussion paper. Unpublished.

Department of Agriculture and Food Western Australia (DAFWA) 2001, 2m Elevation Contours (spatial dataset). Accessed via WA Local Government Association Environmental Planning Tool 25/10/2019.

Department of Agriculture and Food, Western Australia (DAFWA) 2012*, Soil-landscape mapping systems,* Government of Western Australia, Perth.

Department of Biodiversity, Conservation and Attractions (DBCA), BirdLife Australia and the WA Museum 2011 - present, *Carnaby's Cockatoos Habitat* spatial dataset. Accessed via WA Local Government Association Environmental Planning Tool 18/12/2019.

Department of Biodiversity, Conservation and Attractions (DBCA) 2019a, Geomorphic Wetlands, Swan Coastal Plain spatial dataset. Government of Western Australia, Kensington. Accessed via WA Local Government Association Environmental Planning Tool 05/11/2019.

Department of Biodiversity, Conservation and Attractions (DBCA) 2019b, *Naturemap* database, Government of Western Australian, Kensington. Available via: https://naturemap.dbca.wa.gov.au/

Department of Environment and Energy (DEE) 2017a, *Interim Biogeographic Regionalisation for Australia, Version 7,* [Online], Australian Government, Available from: http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra

Department of the Environment and Energy (DEE) 2017b, *Species Profiles and Threats Database*, [Online], Australian Government, available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Environment Regulation [DER] 2014a, *A guide to the assessment of applications to clear native vegetation,* Government of Western Australia, Perth.

Department of Environment Regulation [DER] 2014b, *Contaminated Sites Guidelines*, Government of Western Australia, Perth.

Department of Environment Regulation (DER) 2014b, *Assessment and management of contaminated sites; Contaminated sites guidelines,* Government of Western Australia, Perth.

Department of Natural Resources (DNR) Queensland 1997, *Planning Guidelines: Separating Agricultural and Residentials Land Uses,* Queensland Government.

Department of Planning, Lands and Heritage (DPLH) 2005, *Draft guideline for the determination of wetland buffer requirements*, Government of Western Australia, Perth.

Department of Environment Regulation (DER) 2015*, Identification and investigation of acid sulfate soils and acidic landscapes,* Government of Western Australia, Perth.

Department of Water (DoW) 2008, *Better Urban Water Management*, Government of Western Australia, Perth.

Department of Water (DoW) 2009, *Jandakot Drainage and Water Management Plan,* Government of Western Australia, Perth. Accessed via: https://www.water.wa.gov.au/__data/assets/pdf_file/0018/1746/91068.pdf

Department of Water and Environment Regulation (DWER) 2004, *Historical maximum groundwater contour* spatial data*,* Government of Western Australia, Perth. Accessed via WA Local Government Association Environmental Planning Tool 05/11/2019.

Department of Water and Environment Regulation (DWER) 2019a, *The Water Register,* Government of Western Australia, Perth. Accessed via: https://maps.water.wa.gov.au/#/webmap/register

Department of Water and Environment Regulation (DWER) 2019b, *Contaminated Sites Database*, Government of Western Australia, Perth. Available via: https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47

Environmental Protection Authority (EPA) 2005, *Separation Distances between Industrial and Sensitive Land Uses (GS 3)*, Government of Western Australia, Perth.

Environmental Protection Authority (EPA) 2008, *Environmental Guidance for Planning and Development* (Guidance Statement 33), Government of Western Australia, Perth.

Environmental Protection Authority (EPA) 2016, *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment,* Government of Western Australia, Perth.

Environmental Resources Information Network (ERIN) 2016a, *Map 4: Modelled distribution for Forest Red-tailed Black-Cockatoo (Calyptorhynchus banksii naso),* Australian Government, Canberra. Available via: https://www.environment.gov.au/epbc/comment/draft-revised-referral-guideline-black-cockatoo

Environmental Resources Information Network (ERIN) 2016b*, Map 3: Modelled distribution for Carnaby's Cockatoo (Calyptorhynchus latirostris)*, Australian Government, Canberra. Available via: https://www.environment.gov.au/epbc/comment/draft-revised-referral-guideline-black-cockatoo

Environmental Resources Information Network (ERIN) 2016c, *Map 2: Modelled distribution for Baudin's Cockatoo (Calyptorhynchus baudinii),* Australian Government, Canberra. Available via: https://www.environment.gov.au/epbc/comment/draft-revised-referral-guideline-black-cockatoo

Government of Western Australia (GoWA) 2019a, *2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report)*. Current as of March 2019, WA Department of Biodiversity, Conservation and Attractions, Perth.

Government of Western Australia (GoWA) 2019b, *2018 South West Vegetation Complex Statistics*. Current as of March 2019, WA Department of Biodiversity, Conservation and Attractions, Perth.

Gozzard, J. R., 1983, *Fremantle Part Sheets 2033 I & 2033 IV, Perth Metropolitan Region, Environmental Geology Series*, Geological Survey of Western Australia.

Heddle EM, Loneragan OW & Havel JJ, 1980, *Darling System, Vegetation Complexes*, Forest Department, Perth.

Keighery B 1994, *Bushland Plant Survey: A Guide to Plant Community Survey for the Community*, Wildflower Society, Floreat.

Lloyd George Acoustics 2020, *Transportation Noise Assessment: Mandogalup Improvement Scheme*, unpublished report prepared for Strategen Environmental (on behalf of DPLH).

Major R E, Christie F J, Gowing G and Ivison T J 1999, Elevated rates of predation on artificial nests in linear strips of habitat. *Journal of Field Ornithology*. 70, 351-64.

Mason J, Moorman C, Hess G and Sinclair K 2006, *Designing suburban greenways to provide habitat for forest-breeding birds. Landscape and Urban Planning*. 80, 153-64.

Office of Bushfire Risk Mitigation (OBRM) 2019, *Map of Bush Fire Prone Areas*, [Online], Government of Western Australia, available from: https://maps.slip.wa.gov.au/landgate/bushfireprone/ , [18/12/2019].

Plantecology Consulting 2012, *Targeted Priority and Threatened Flora Search – Mandogalup,* unpublished report.

RPS 2010, *Vegetation and Flora Report- Proposed Urban Development Area, Wandi/ Mandogalup*. Unpublished report.

Saunders D A and de Rebeira C P 1991, Values of corridors to avian populations in a fragmented landscape. Pp 221-244 in *Nature Conservation 2: The Role of Corridors*. Saunders and Hobbs eds. Surrey Beatty and Sons. Chipping Norton, NSW.

Strategen Environmental 2017, *Flora, Vegetation and Black Cockatoo Habitat Assessment - Lots 2 and 10 Rowley Road, Mandogalup,* unpublished report.

Strategen 2018, *Lot 2 and 10 Rowley Road, Mandogalup Flora, vegetation and black cockatoo habitat survey,* report prepared for Frankland Sand Supplies.

WALGA and DEC 2009, *South West Regional Ecological Linkages Technical Report*, Government of Western Australia, Perth.

Western Australian Herbarium 1998-, *FloraBase – the Western Australian Flora, [Online],* Government of Western Australia, Available from: http://florabase.dpaw.wa.gov.au/

Western Australian Local Government Association (WALGA) 2003, *Regional Ecological Linkages for the Perth Metropolitan Region.* Accessed via WA Local Government Association Environmental Planning Tool 18/12/2019.

Western Australian Planning Commission (WAPC) 2010, *State Planning Policy 2.8: Bushland Policy for the Perth Metropolitan Region* (SPP 2.8), Western Australian Planning Commission, Perth.

Western Australian Planning Commission (WAPC) 2017, *Guidelines for Planning in Bushfire Prone Areas*, Version 1.3 August 2017, Western Australian Planning Commission, Perth.

Woodman Environmental Consulting 2014, *Targeted Declared Rare Flora Survey of Proposed Mandogalup Development Site,* unpublished report.

Appendix A NatureMap and PMST database searches

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 10/10/2019

Kingdom	Plantae
Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115° 50' 32" E,32° 11' 37" S
Buffer	5km
Group By	Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	452	1913
Priority 3	4	6
Priority 4	1	9
Rare or likely to become extinct	3	20
TOTAL	**460**	**1948**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	1596	*Caladenia huegelii (Grand Spider Orchid)*		T	
2.	12938	*Diuris micrantha*		T	
3.	1639	*Drakaea elastica (Glossy-leaved Hammer Orchid)*		T	
Priority 3					
4.	16245	*Cyathochaeta teretifolia*		P3	
5.	5237	*Pimelea calcicola*		P3	
6.	8163	*Pithocarpa corymbulosa (Corymbose Pithocarpa)*		P3	
7.	25800	*Stylidium paludicola*		P3	
Priority 4					
8.	4763	*Dodonaea hackettiana (Hackett's Hopbush)*		P4	
Non-conservation taxon					
9.		*?Anigozanthos humilis*			
10.		*?Arnocrinum preissii*			
11.		*?Austrostipa compressa*			
12.		*?Austrostipa semibarbata*			Y
13.		*?Burchardia congesta*			
14.		*?Hovea pungens*			Y
15.		*?Hovea trisperma var. trisperma*			
16.		*?Hybanthus calycinus*			Y
17.		*?Kunzea glabrescens*			
18.		*?Lepidosperma squamatum s.l.*			
19.		*?Lomandra caespitosa*			
20.		*?Lotus subbiflorus*			
21.		*?Lysimachia arvensis*			
22.		*?Mesomelaena pseudostygia*			Y
23.		*?Microlaena stipoides*			
24.		*?Phlebocarya ciliata*			
25.		*?Phyllanthus calycinus*			Y
26.		*?Pterostylis sanguinea*			
27.		*?Rytidosperma occidentalis*			
28.		*?Sowerbaea laxiflora*			
29.		*?Vicia sativa*			Y
30.	3262	*Acacia cochlearis (Rigid Wattle)*			
31.	3282	*Acacia cyclops (Coastal Wattle)*			
32.	3374	*Acacia huegelii*			
33.	3502	*Acacia pulchella (Prickly Moses)*			
34.	30032	*Acacia saligna subsp. saligna*			
35.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
36.	3602	*Acacia willdenowiana (Grass Wattle)*			
37.	6203	*Actinotus glomeratus*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
38.	1775	*Adenanthos cygnorum (Common Woollybush)*			
39.	11837	*Adenanthos cygnorum subsp. cygnorum (Common Woollybush)*			
40.	1791	*Adenanthos obovatus (Basket Flower)*			
41.	17202	*Agonis flexuosa var. flexuosa*			
42.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
43.		*Aira caryophyllea/cupaniana group*			
44.	185	*Aira cupaniana (Silvery Hairgrass)*	Y		
45.	187	*Aira praecox (Early Hairgrass)*	Y		
46.	1728	*Allocasuarina fraseriana (Sheoak, Kondil)*			
47.	1732	*Allocasuarina humilis (Dwarf Sheoak)*			
48.	198	*Amphipogon laguroides*			
49.	20184	*Amphipogon laguroides subsp. laguroides*			
50.	200	*Amphipogon turbinatus*			
51.	7833	*Angianthus preissianus*			
52.	11434	*Anigozanthos humilis subsp. humilis*			
53.	1411	*Anigozanthos manglesii (Mangles Kangaroo Paw, Kurulbrang)*			
54.	11261	*Anigozanthos manglesii subsp. manglesii*			
55.	3688	*Aotus gracillima*			
56.	3692	*Aotus procumbens*			
57.	1264	*Arnocrinum preissii*			
58.	8779	*Asparagus asparagoides (Bridal Creeper)*	Y		
59.	20283	*Astartea scoparia (Common Astartea)*			
60.		*Asterella drummondii*			
61.	6334	*Astroloma pallidum (Kick Bush)*			
62.		*Austrostipa ?semibarbata*			Y
63.	17234	*Austrostipa compressa*			
64.	17240	*Austrostipa flavescens*			
65.	17245	*Austrostipa mollis*			
66.	17253	*Austrostipa semibarbata*			
67.		*Austrostipa sp.*			
68.	37421	*Austrostipa sp. Marchagee (B.R. Maslin 1407)*			
69.	233	*Avena barbata (Bearded Oat)*	Y		
70.	36441	*Babingtonia camphorosmae (Camphor Myrtle)*			
71.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
72.	32580	*Banksia dallanneyi subsp. dallanneyi var. dallanneyi*			
73.	1822	*Banksia ilicifolia (Holly-leaved Banksia)*			
74.	1830	*Banksia littoralis (Swamp Banksia, Pungura)*			
75.	1834	*Banksia menziesii (Firewood Banksia)*			
76.	32077	*Banksia sessilis var. cygnorum*			
77.	1852	*Banksia telmatiaea (Swamp Fox Banksia)*			
78.	741	*Baumea articulata (Jointed Rush)*			
79.	743	*Baumea juncea (Bare Twigrush)*			
80.	5382	*Beaufortia elegans (Elegant Beaufortia)*			
81.	48868	*Bellardia viscosa*	Y		
82.	749	*Bolboschoenus caldwellii (Marsh Club-rush)*			
83.	4413	*Boronia crenulata (Aniseed Boronia)*			
84.	11503	*Boronia crenulata subsp. crenulata var. crenulata*			
85.	16636	*Boronia crenulata subsp. viminea*			
86.	4417	*Boronia dichotoma*			
87.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
88.	6341	*Brachyloma preissii (Globe Heath)*			
89.	8661	*Brachypodium distachyon (False Brome)*	Y		
90.	3000	*Brassica tournefortii (Mediterranean Turnip)*	Y		
91.	244	*Briza maxima (Blowfly Grass)*	Y		
92.	245	*Briza minor (Shivery Grass)*	Y		
93.		*Briza sp.*			
94.	249	*Bromus diandrus (Great Brome)*	Y		
95.	12770	*Burchardia congesta*			
96.	1276	*Caesia micrantha (Pale Grass Lily)*			
97.	1277	*Caesia occidentalis*			
98.		*Caladenia ?flava*			
99.	1586	*Caladenia discoidea (Dancing Orchid)*			
100.	1592	*Caladenia flava (Cowslip Orchid)*			
101.	1599	*Caladenia latifolia (Pink Fairy Orchid)*			
102.	15361	*Caladenia longicauda subsp. calcigena*			
103.	17760	*Caladenia nobilis*			
104.		*Caladenia sp.*			
105.	2848	*Calandrinia corrigioloides (Strap Purslane)*			
106.	19309	*Calectasia narragara*			
107.	34942	*Callitriche brutia subsp. brutia*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
108.	36600	*Callitris pyramidalis (Swamp Cypress)*			
109.	5411	*Calothamnus hirsutus*			
110.	5415	*Calothamnus lateralis*			
111.	5439	*Calytrix angulata (Yellow Starflower)*			
112.	5458	*Calytrix flavescens (Summer Starflower)*			
113.	5460	*Calytrix fraseri (Pink Summer Calytrix)*			
114.	5476	*Calytrix sapphirina*			
115.	2795	*Carpobrotus edulis (Hottentot Fig)*	Y		
116.	1162	*Cartonema philydroides*			
117.	2951	*Cassytha flava (Dodder Laurel)*			
118.	2957	*Cassytha racemosa (Dodder Laurel)*			
119.	11799	*Cassytha racemosa forma racemosa*			
120.	41568	*Cenchrus setaceus (Fountain Grass)*	Y		
121.	6542	*Centaurium tenuiflorum*	Y		
122.	1125	*Centrolepis drummondiana*			
123.	1134	*Centrolepis polygyna (Wiry Centrolepis)*			
124.	2889	*Cerastium glomeratum (Mouse Ear Chickweed)*	Y		
125.	18156	*Chamaecytisus palmensis (Tagasaste)*	Y		
126.	1280	*Chamaescilla corymbosa (Blue Squill)*			
127.	11299	*Chamaescilla corymbosa var. corymbosa*			
128.	7937	*Cirsium vulgare (Spear Thistle, Scotch Thistle)*	Y		
129.	4550	*Comesperma calymega (Blue-spike Milkwort)*			
130.	4555	*Comesperma integerrimum*			
131.	15611	*Conospermum stoechadis subsp. stoechadis (Common Smokebush)*			
132.	6348	*Conostephium pendulum (Pearl Flower)*			
133.	6349	*Conostephium preissii*			
134.	1418	*Conostylis aculeata (Prickly Conostylis)*			
135.	11826	*Conostylis aculeata subsp. aculeata*			
136.	1436	*Conostylis juncea*			
137.	1454	*Conostylis setigera (Bristly Cottonhead)*			
138.	11597	*Conostylis setigera subsp. setigera*			
139.		*Conyza ?bonariensis*			
140.	7939	*Conyza bonariensis (Flaxleaf Fleabane)*	Y		
141.		*Conyza sp.*			
142.	20074	*Conyza sumatrensis*	Y		
143.	48259	*Cortaderia selloana subsp. selloana*	Y		
144.	1285	*Corynotheca micrantha (Sand Lily)*			
145.	7945	*Cotula coronopifolia (Waterbuttons)*	Y		
146.	3137	*Crassula colorata (Dense Stonecrop)*			
147.	11563	*Crassula colorata var. colorata*			
148.	19625	*Cymbalaria muralis subsp. muralis*	Y		
149.	806	*Cyperus polystachyos (Bunchy Sedge)*			
150.	816	*Cyperus tenuiflorus (Scaly Sedge)*	Y		
151.	7454	*Dampiera linearis (Common Dampiera)*			
152.	35618	*Darwinia sp. Karonie (K. Newbey 8503)*			
153.	1218	*Dasypogon bromeliifolius (Pineapple Bush)*			
154.	3807	*Daviesia divaricata (Marno)*			
155.	3832	*Daviesia physodes*			
156.	3845	*Daviesia triflora*			
157.	16595	*Desmocladus flexuosus*			
158.	299	*Deyeuxia quadriseta (Reed Bentgrass)*			
159.	1259	*Dianella revoluta (Blueberry Lily)*			
160.	11636	*Dianella revoluta var. divaricata*			
161.	17838	*Dielsia stenostachya*			
162.	9027	*Diplolaena drummondii*			
163.	19649	*Disa bracteata*	Y		
164.	7054	*Dischisma arenarium*	Y		
165.		*Diuris corymbosa/magnifica*			
166.	1634	*Diuris laxiflora (Bee Orchid)*			
167.	12939	*Diuris magnifica*			
168.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
169.	3106	*Drosera macrantha (Bridal Rainbow)*			
170.	3109	*Drosera menziesii (Pink Rainbow)*			
171.	48710	*Drosera micrantha*			
172.	3118	*Drosera pallida (Pale Rainbow)*			
173.	29178	*Drosera porrecta*			
174.		*Drosera sp. "climbing"*			
175.	3135	*Drosera zonaria (Painted Sundew)*			
176.		*Ehrharta ?longiflora*			Y
177.	347	*Ehrharta calycina (Perennial Veldt Grass)*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
178.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
179.		*Ehrharta sp.*			
180.	1645	*Epiblema grandiflorum (Babe-in-a-cradle)*			
181.	6133	*Epilobium hirtigerum (Hairy Willow Herb)*			
182.	13949	*Eremaea asterocarpa*			
183.	13950	*Eremaea asterocarpa subsp. asterocarpa*			
184.	5541	*Eremaea pauciflora*			
185.	14104	*Eremaea pauciflora var. pauciflora*			
186.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
187.	5615	*Eucalyptus decipiens (Limestone Marlock, Moit)*			
188.	5708	*Eucalyptus marginata (Jarrah, Djara)*			
189.	13547	*Eucalyptus marginata subsp. marginata (Jarrah)*			
190.	5763	*Eucalyptus rudis (Flooded Gum, Kulurda)*			
191.	13511	*Eucalyptus rudis subsp. rudis*			
192.	5790	*Eucalyptus todtiana (Coastal Blackbutt)*			
193.	3872	*Euchilopsis linearis (Swamp Pea)*			
194.	20014	*Euphorbia hyssopifolia*	Y		
195.	4648	*Euphorbia terracina (Geraldton Carnation Weed)*	Y		
196.	3880	*Eutaxia virgata*			
197.	1747	*Ficus carica (Common Fig)*	Y		
198.	2969	*Fumaria capreolata (Whiteflower Fumitory)*	Y		
199.		*Fumaria sp.*			
200.	907	*Gahnia trifida (Coast Saw-sedge)*			
201.	20247	*Gamochaeta calviceps*	Y		
202.	20475	*Gastrolobium capitatum*			
203.	20473	*Gastrolobium ebracteolatum*			
204.	20483	*Gastrolobium linearifolium*			
205.	1520	*Gladiolus caryophyllaceus (Wild Gladiolus)*	Y		
206.	6587	*Gomphocarpus fruticosus (Narrowleaf Cottonbush)*	Y		
207.	3957	*Gompholobium tomentosum (Hairy Yellow Pea)*			
208.	6161	*Gonocarpus pithyoides*			
209.	7538	*Goodenia pulchella*			
210.	14282	*Gratiola pubescens*			
211.	12824	*Grevillea vestita subsp. vestita*			
212.		*Haemodorum sp.*			
213.	1475	*Haemodorum spicatum (Mardja)*			
214.	2197	*Hakea prostrata (Harsh Hakea)*			
215.	2214	*Hakea trifurcata (Two-leaf Hakea)*			
216.	2216	*Hakea varia (Variable-leaved Hakea)*			
217.	3961	*Hardenbergia comptoniana (Native Wisteria)*			
218.	6839	*Hemiandra pungens (Snakebush)*			
219.	38320	*Hemiandra sp. Jurien (B.J. Conn & M.E. Tozer BJC 3885)*			
220.	1293	*Hensmania turbinata*			
221.	5134	*Hibbertia huegelii*			
222.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
223.	45534	*Hibbertia hypericoides subsp. hypericoides*			
224.	5162	*Hibbertia racemosa (Stalked Guinea Flower)*			
225.	48381	*Hibbertia striata*			
226.	5173	*Hibbertia subvaginata*			
227.	5176	*Hibbertia vaginata*			
228.	444	*Holcus lanatus (Yorkshire Fog)*	Y		
229.	6222	*Homalosciadium homalocarpum*			
230.	3966	*Hovea pungens (Devil's Pins, Puyenak)*			
231.	3968	*Hovea trisperma (Common Hovea)*			
232.	12859	*Hovea trisperma var. trisperma*			
233.	12741	*Hyalosperma cotula*			
234.	5216	*Hybanthus calycinus (Wild Violet)*			
235.	6224	*Hydrocotyle blepharocarpa*			
236.	6240	*Hydrocotyle scutellifera*			
237.	5817	*Hypocalymma angustifolium (White Myrtle, Kudjid)*			
238.	35070	*Hypocalymma angustifolium subsp. Swan Coastal Plain (G.J. Keighery 16777)*			
239.	5825	*Hypocalymma robustum (Swan River Myrtle)*			
240.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
241.	9352	*Hypochaeris radicata (Flat Weed, Cats-ear)*	Y		
242.	1070	*Hypolaena exsulca*			
243.	17841	*Hypolaena pubescens*			
244.		*Iridaceae sp.*			Y
245.	20200	*Isolepis cernua var. setiformis*			
246.	917	*Isolepis marginata (Coarse Club-rush)*			
247.	19700	*Isotropis cuneifolia subsp. cuneifolia*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
248.	4012	*Jacksonia furcellata (Grey Stinkwood)*			
249.	4029	*Jacksonia sternbergiana (Stinkwood, Kapur)*			
250.	1178	*Juncus bufonius (Toad Rush)*	Y		
251.	1186	*Juncus microcephalus*	Y		
252.	1188	*Juncus pallidus (Pale Rush)*			
253.	1190	*Juncus planifolius (Broadleaf Rush)*			
254.	4044	*Kennedia prostrata (Scarlet Runner)*			
255.	5832	*Kunzea ericifolia (Spearwood, Pondil)*			
256.	15498	*Kunzea glabrescens (Spearwood)*			
257.	20019	*Lachnagrostis filiformis*			
258.	8096	*Lactuca serriola (Prickly Lettuce)*	Y		
259.	18585	*Lagenophora huegelii*			
260.	467	*Lagurus ovatus (Hare's Tail Grass)*	Y		
261.	4052	*Latrobea tenella*			
262.	1307	*Laxmannia ramosa (Branching Lily)*			
263.	11911	*Laxmannia ramosa subsp. ramosa*			
264.	1309	*Laxmannia squarrosa*			
265.	7572	*Lechenaultia expansa*			
266.	7574	*Lechenaultia floribunda (Free-flowering Leschenaultia)*			
267.	44490	*Leontodon rhagadioloides*	Y		
268.		*Lepidosperma ?aff. costale*			Y
269.	925	*Lepidosperma angustatum*			
270.	937	*Lepidosperma longitudinale (Pithy Sword-sedge)*			
271.	940	*Lepidosperma pubisquameum*			
272.	944	*Lepidosperma scabrum*			
273.		*Lepidosperma scabrum (inland form)*			Y
274.		*Lepidosperma sp.*			
275.		*Lepidosperma sp. Brixton Street broad inflorescence*			
276.		*Lepidosperma sp. Brixton Street broadish inflorescence*			Y
277.		*Lepidosperma sp. Brixton Street narrow inflorescence*			
278.	945	*Lepidosperma squamatum*			
279.		*Lepidosperma squamatum s.l.*			
280.	946	*Lepidosperma striatum*			
281.	1653	*Leporella fimbriata (Hare Orchid)*			
282.	1077	*Leptocarpus canus (Hoary Twine-rush)*			
283.	1080	*Leptocarpus scariosus*			
284.	2342	*Leptomeria cunninghamii*			
285.	2344	*Leptomeria empetriformis*			
286.	2350	*Leptomeria pauciflora (Sparse-flowered Currant Bush)*			
287.	5850	*Leptospermum laevigatum (Coast Teatree)*	Y		
288.	6360	*Leucopogon australis (Spiked Beard-heath)*			
289.	6374	*Leucopogon conostephioides*			
290.	6436	*Leucopogon propinquus*			
291.	7676	*Levenhookia pusilla (Midget Stylewort)*			
292.		*Levenhookia pusilla/stipitata*			
293.	7677	*Levenhookia stipitata (Common Stylewort)*			
294.	9289	*Lobelia anceps (Angled Lobelia)*			
295.	7408	*Lobelia tenuior (Slender Lobelia)*			
296.	6515	*Logania vaginalis (White Spray)*			
297.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
298.		*Lolium sp. (annual)*			
299.		*Lomandra ?caespitosa*			
300.		*Lomandra ?preissii*			
301.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
302.	1228	*Lomandra hermaphrodita*			
303.	14542	*Lomandra micrantha subsp. micrantha*			
304.	1234	*Lomandra nigricans*			
305.	1239	*Lomandra preissii*			
306.	1246	*Lomandra suaveolens*			
307.	8564	*Lotus subbiflorus*	Y		
308.	1198	*Luzula meridionalis (Field Woodrush)*			
309.	1097	*Lyginia barbata*			
310.	18049	*Lyginia imberbis*			
311.	1656	*Lyperanthus serratus (Rattle Beak Orchid)*			
312.	36375	*Lysimachia arvensis (Pimpernel)*	Y		
313.	6456	*Lysinema ciliatum (Curry Flower)*			
314.	5281	*Lythrum hyssopifolia (Lesser Loosestrife)*	Y		
315.	2839	*Macarthuria australis*			
316.	18119	*Macrozamia fraseri*			
317.	85	*Macrozamia riedlei (Zamia, Djiridji)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
318.	4079	*Medicago polymorpha (Burr Medic)*	Y		
319.	5900	*Melaleuca cuticularis (Saltwater Paperbark)*			
320.	13271	*Melaleuca huegelii subsp. huegelii*			
321.	13273	*Melaleuca incana subsp. incana*			
322.	5926	*Melaleuca lateritia (Robin Redbreast Bush)*			
323.	5946	*Melaleuca pauciflora*			
324.	5952	*Melaleuca preissiana (Moonah)*			
325.	5959	*Melaleuca rhaphiophylla (Swamp Paperbark)*			
326.	5964	*Melaleuca seriata*			
327.	18598	*Melaleuca systena*			
328.	5978	*Melaleuca teretifolia (Banbar)*			
329.	5980	*Melaleuca thymoides*			
330.	4085	*Melilotus indicus*	Y		
331.	955	*Mesomelaena pseudostygia*			
332.	957	*Mesomelaena tetragona (Semaphore Sedge)*			
333.	485	*Microlaena stipoides (Weeping Grass)*			
334.	1658	*Microtis atrata (Swamp Mignonette Orchid)*			
335.	15419	*Microtis media subsp. media*			
336.	6189	*Myriophyllum crispatum*			
337.	6199	*Myriophyllum tillaeoides*			
338.	492	*Neurachne alopecuroidea (Foxtail Mulga Grass)*			
339.	6974	*Nicotiana glauca (Tree Tobacco)*	Y		
340.	12782	*Ophioglossum gramineum*			
341.	36177	*Ornduffia albiflora*			
342.	4113	*Ornithopus compressus (Yellow Serradella)*	Y		
343.	4358	*Oxalis purpurea (Largeflower Wood Sorrel)*	Y		
344.	527	*Paspalum dilatatum*	Y		
345.	1550	*Patersonia occidentalis (Purple Flag, Koma)*			
346.	30471	*Patersonia occidentalis var. angustifolia*			
347.	30472	*Patersonia occidentalis var. occidentalis*			
348.	4343	*Pelargonium capitatum (Rose Pelargonium)*	Y		
349.	40423	*Pentameris airoides (False Hairgrass)*	Y		
350.	6006	*Pericalymma ellipticum (Swamp Teatree)*			
351.	16477	*Pericalymma ellipticum var. ellipticum*			
352.	2273	*Persoonia saccata (Snottygobble)*			
353.	2299	*Petrophile linearis (Pixie Mops)*			
354.	2301	*Petrophile macrostachya*			
355.	2312	*Petrophile striata*			
356.	19825	*Petrorhagia dubia*	Y		
357.	552	*Phalaris paradoxa (Paradoxa Grass)*	Y		
358.	1478	*Phlebocarya ciliata*			
359.	16177	*Phyllangium paradoxum*			
360.	4675	*Phyllanthus calycinus (False Boronia)*			
361.	2793	*Phytolacca octandra (Red Ink Plant)*	Y		
362.	18117	*Pimelea rosea subsp. rosea*			
363.	6249	*Platysace compressa (Tapeworm Plant)*			
364.	6253	*Platysace filiformis*			
365.	4524	*Platytheca galioides*			
366.		*Poaceae sp.*			
367.	8175	*Podolepis gracilis (Slender Podolepis)*			
368.	8182	*Podotheca angustifolia (Sticky Longheads)*			
369.	8183	*Podotheca chrysantha (Yellow Podotheca)*			
370.	8184	*Podotheca gnaphalioides (Golden Long-heads)*			
371.	582	*Polypogon monspeliensis (Annual Beardgrass)*	Y		
372.	4691	*Poranthera microphylla (Small Poranthera)*			
373.		*Poranthera microphylla/moorokatta*			
374.	1670	*Prasophyllum drummondii (Swamp Leek Orchid)*			
375.	10853	*Prasophyllum plumiforme*			
376.	8189	*Pseudognaphalium luteoalbum (Jersey Cudweed)*			
377.	15426	*Pterostylis aspera*			
378.	44723	*Pterostylis glebosa*			
379.	1693	*Pterostylis recurva (Jug Orchid)*			
380.	12217	*Pterostylis sanguinea*			
381.		*Pterostylis sp.*			
382.	2718	*Ptilotus drummondii (Narrowleaf Mulla Mulla)*			
383.	11260	*Ptilotus drummondii var. drummondii (Pussytail)*			
384.	4181	*Pultenaea reticulata*			
385.	16367	*Pyrorchis nigricans (Red beaks, Elephants ears)*			
386.	8195	*Quinetia urvillei*			
387.	6012	*Regelia ciliata*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
388.	3085	*Reseda luteola (Wild Mingnonette)*	Y		
389.	13300	*Rhodanthe citrina*			
390.	14485	*Romulea flava var. minor*	Y		
391.	1556	*Romulea rosea (Guildford Grass)*	Y		
392.	14924	*Romulea rosea var. communis*	Y		
393.	40426	*Rytidosperma occidentale*			
394.	6483	*Samolus junceus*			
395.	11647	*Samolus repens var. repens*			
396.	7603	*Scaevola canescens (Grey Scaevola)*			
397.	978	*Schoenus brevisetis*			
398.	982	*Schoenus clandestinus*			
399.	984	*Schoenus curvifolius*			
400.	986	*Schoenus efoliatus*			
401.	992	*Schoenus grandiflorus (Large Flowered Bogrush)*			
402.	6033	*Scholtzia involucrata (Spiked Scholtzia)*			
403.	2909	*Silene gallica (French Catchfly)*	Y		
404.	15972	*Silene gallica var. gallica*	Y		
405.	8225	*Siloxerus humifusus (Procumbent Siloxerus)*			
406.	7020	*Solanum linnaeanum (Apple of Sodom)*	Y		
407.	7022	*Solanum nigrum (Black Berry Nightshade)*	Y		
408.	9367	*Sonchus hydrophilus (Native Sowthistle)*			
409.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
410.	1312	*Sowerbaea laxiflora (Purple Tassels)*			
411.	4211	*Sphaerolobium vimineum (Leafless Globe Pea)*			
412.	2316	*Stirlingia latifolia (Blueboy)*			
413.	7693	*Stylidium brunonianum (Pink Fountain Triggerplant)*			
414.	7774	*Stylidium piliferum (Common Butterfly Triggerplant)*			
415.	7785	*Stylidium repens (Matted Triggerplant)*			
416.	25806	*Stylidium scariosum*			
417.	7798	*Stylidium schoenoides (Cow Kicks)*			
418.	1260	*Stypandra glauca (Blind Grass)*			
419.	2329	*Synaphea spinulosa*			
420.	15532	*Synaphea spinulosa subsp. spinulosa*			
421.	11143	*Thelymitra graminea*			
422.	20731	*Thelymitra vulgaris*			
423.	20728	*Thelymitra xanthotricha*			
424.		*Thysanotus ?thyrsoideus*			
425.	1318	*Thysanotus arbuscula*			
426.	1319	*Thysanotus arenarius*			
427.	1338	*Thysanotus manglesianus (Fringed Lily)*			
428.		*Thysanotus manglesianus/patersonii complex*			
429.	1339	*Thysanotus multiflorus (Many-flowered Fringe Lily)*			
430.	1343	*Thysanotus patersonii*			
431.		*Thysanotus sp.*			
432.	1351	*Thysanotus sparteus*			
433.	1357	*Thysanotus thyrsoideus*			
434.	1358	*Thysanotus triandrus*			
435.	6280	*Trachymene pilosa (Native Parsnip)*			
436.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
437.	1363	*Tricoryne tenella*			
438.	1038	*Tricostularia neesii*			
439.	17145	*Trifolium angustifolium var. angustifolium*	Y		
440.		*Trifolium campestre/dubium*			
441.	14738	*Trifolium resupinatum var. resupinatum*	Y		
442.	4360	*Tropaeolum majus (Garden Nasturtium)*	Y		
443.	8254	*Urospermum picroides (False Hawkbit)*	Y		
444.	8255	*Ursinia anthemoides (Ursinia)*	Y		
445.	38388	*Ursinia anthemoides subsp. anthemoides*	Y		
446.	15725	*Verbesina encelioides*	Y		
447.	15432	*Verticordia densiflora var. densiflora*			
448.	4320	*Vicia hirsuta (Hairy Vetch)*	Y		
449.	11474	*Vicia sativa subsp. nigra*	Y		
450.	722	*Vulpia bromoides (Squirrel Tail Fescue)*	Y		
451.		*Vulpia sp.*			
452.	7384	*Wahlenbergia capensis (Cape Bluebell)*	Y		
453.	7389	*Wahlenbergia preissii*			
454.	8282	*Waitzia suaveolens (Fragrant Waitzia)*			
455.	12072	*Wurmbea dioica subsp. alba*			
456.	1256	*Xanthorrhoea preissii (Grass tree, Palga)*			
457.		*Xanthorrhoea sp.*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
458.	6289	*Xanthosia huegelii*			
459.	2331	*Xylomelum occidentale (Woody Pear, Djandin)*			
460.	1049	*Zantedeschia aethiopica (Arum Lily)*	Y		

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

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

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 10/10/2019

Kingdom	Animalia
Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115° 50' 32" E,32° 11' 37" S
Buffer	5km
Group By	Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	213	4380
Other specially protected fauna	1	2
Priority 3	2	147
Priority 4	6	90
Protected under international agreement	9	45
Rare or likely to become extinct	7	257
TOTAL	**238**	**4921**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	24784	*Calidris ferruginea (Curlew Sandpiper)*		T	
2.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black Cockatoo)*		T	
3.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo, White-tailed Long-billed Black Cockatoo)*		T	
4.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo, White-tailed Short-billed Black Cockatoo)*		T	
5.	48400	*Calyptorhynchus sp. (white-tailed black cockatoo)*		T	
6.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
7.	24146	*Myrmecobius fasciatus (Numbat, Walpurti)*		T	
Protected under international agreement					
8.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*		IA	
9.	24786	*Calidris melanotos (Pectoral Sandpiper)*		IA	
10.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
11.	24789	*Calidris subminuta (Long-toed Stint)*		IA	
12.	25741	*Limosa limosa (Black-tailed Godwit)*		IA	
13.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
14.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
15.	24808	*Tringa nebularia (Common Greenshank, greenshank)*		IA	
16.	41351	*Xenus cinereus (Terek Sandpiper)*		IA	
Other specially protected fauna					
17.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
Priority 3					
18.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
19.	25249	*Neelaps calonotos (Black-striped Snake, black-striped burrowing snake)*		P3	
Priority 4					
20.	24189	*Falsistrellus mackenziei (Western False Pipistrelle, Western Falsistrelle)*		P4	
21.	24215	*Hydromys chrysogaster (Water-rat, Rakali)*		P4	
22.	48588	*Isoodon fusciventer (Quenda, southwestern brown bandicoot)*		P4	
23.	48024	*Notamacropus eugenii subsp. derbianus (Tammar Wallaby, Tammar)*		P4	
24.	24328	*Oxyura australis (Blue-billed Duck)*		P4	
25.	33992	*Synemon gratiosa (Graceful Sunmoth)*		P4	
Non-conservation taxon					
26.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
27.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
28.	24262	*Acanthiza inornata (Western Thornbill)*			
29.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
30.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
31.	25536	*Accipiter fasciatus (Brown Goshawk)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
32.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
33.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
34.		*Aname mainae*			
35.	24312	*Anas gracilis (Grey Teal)*			
36.	24315	*Anas rhynchotis (Australasian Shoveler)*			
37.	24316	*Anas superciliosa (Pacific Black Duck)*			
38.	47414	*Anhinga novaehollandiae (Australasian Darter)*			
39.	24561	*Anthochaera carunculata (Red Wattlebird)*			
40.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
41.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			
42.	24285	*Aquila audax (Wedge-tailed Eagle)*			
43.		*Arachnura higginsi*			
44.		*Araneus cyphoxis*			
45.		*Araneus senicaudatus*			
46.	41324	*Ardea modesta (great egret, white egret)*			
47.	24340	*Ardea novaehollandiae (White-faced Heron)*			
48.	24341	*Ardea pacifica (White-necked Heron)*			
49.		*Argiope protensa*			
50.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
51.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
52.		*Artoria flavimana*			
53.		*Artoria linnaei*			
54.		*Artoriopsis expolita*			
55.		*Austracantha minax*			
56.	24318	*Aythya australis (Hardhead)*			
57.		*Backobourkia brounii*			
58.		*Barnardius zonarius*			
59.	24319	*Biziura lobata (Musk Duck)*			
60.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
61.	25716	*Cacatua sanguinea (Little Corella)*			
62.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
63.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
64.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
65.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
66.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
67.	24187	*Chalinolobus morio (Chocolate Wattled Bat)*			
68.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
69.	43380	*Chelodina colliei (South-western Snake-necked Turtle)*			
70.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
71.	33939	*Cherax cainii (Marron)*			
72.		*Cherax destructor*			
73.		*Cherax quinquecarinatus*			
74.		*Cherax sp.*			
75.	24980	*Christinus marmoratus (Marbled Gecko)*			
76.		*Chroicocephalus novaehollandiae*			
77.	24288	*Circus approximans (Swamp Harrier)*			
78.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
79.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
80.	24399	*Columba livia (Domestic Pigeon)*	Y		
81.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
82.		*Cormocephalus novaehollandiae*			
83.	25592	*Corvus coronoides (Australian Raven)*			
84.	24671	*Coturnix pectoralis (Stubble Quail)*			
85.	25701	*Coturnix ypsilophora (Brown Quail)*			
86.	25595	*Cracticus tibicen (Australian Magpie)*			
87.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
88.	25596	*Cracticus torquatus (Grey Butcherbird)*			
89.	25399	*Crinia glauerti (Clicking Frog)*			
90.	25400	*Crinia insignifera (Squelching Froglet)*			
91.		*Crustulina bicruciata*			
92.	30893	*Cryptoblepharus buchananii*			
93.	30899	*Ctenophorus adelaidensis (Southern Heath Dragon, Western Heath Dragon)*			
94.	25027	*Ctenotus australis*			
95.	25039	*Ctenotus fallens*			
96.		*Cyclosa trilobata*			
97.	24322	*Cygnus atratus (Black Swan)*			
98.		*Cyrtophora parnasia*			
99.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
100.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
101.	25766	*Delma fraseri (Fraser's Legless Lizard)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
102.	25296	*Demansia psammophis subsp. reticulata (Yellow-faced Whipsnake)*			
103.	25100	*Egernia napoleonis*			
104.		*Egretta novaehollandiae*			
105.		*Elanus axillaris*			
106.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
107.		*Eolophus roseicapillus*			
108.	24567	*Epthianura albifrons (White-fronted Chat)*			
109.		*Eriophora biapicata*			
110.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
111.	25621	*Falco berigora (Brown Falcon)*			
112.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
113.	25623	*Falco longipennis (Australian Hobby)*			
114.	24041	*Felis catus (Cat)*	Y		
115.	25727	*Fulica atra (Eurasian Coot)*			
116.	24761	*Fulica atra subsp. australis (Eurasian Coot)*			
117.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
118.	24763	*Gallinula tenebrosa subsp. tenebrosa (Dusky Moorhen)*			
119.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
120.	25530	*Gerygone fusca (Western Gerygone)*			
121.	24443	*Grallina cyanoleuca (Magpie-lark)*			
122.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			
123.	24295	*Haliastur sphenurus (Whistling Kite)*			
124.	25410	*Heleioporus eyrei (Moaning Frog)*			
125.	25119	*Hemiergis quadrilineata*			
126.		*Heurodes turritus*			
127.	47965	*Hieraaetus morphnoides (Little Eagle)*			
128.	25734	*Himantopus himantopus (Black-winged Stilt)*			
129.	24491	*Hirundo neoxena (Welcome Swallow)*			
130.		*Holoplatys dejongi*			
131.		*Idiommata blackwalli*			
132.		*Isopeda leishmanni*			
133.		*Lampona cylindrata*			
134.	24511	*Larus novaehollandiae subsp. novaehollandiae (Silver Gull)*			
135.		*Latrodectus hasseltii*			
136.	25133	*Lerista elegans*			
137.	25005	*Lialis burtonis*			
138.	25661	*Lichmera indistincta (Brown Honeyeater)*			
139.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
140.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
141.	25388	*Litoria moorei (Motorbike Frog)*			
142.		*Lycosa ariadnae*			
143.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
144.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
145.	25654	*Malurus splendens (Splendid Fairy-wren)*			
146.		*Maratus pavonis*			
147.	25758	*Megalurus gramineus (Little Grassbird)*			
148.	25184	*Menetia greyii*			
149.	24598	*Merops ornatus (Rainbow Bee-eater)*			
150.		*Microcarbo melanoleucos*			
151.	25693	*Microeca fascinans (Jacky Winter)*			
152.	25191	*Morethia lineoocellata*			
153.	25192	*Morethia obscura*			
154.	24223	*Mus musculus (House Mouse)*	Y		
155.	25420	*Myobatrachus gouldii (Turtle Frog)*			
156.		*Nanometa gentilis*			
157.	25248	*Neelaps bimaculatus (Black-naped Snake)*			
158.	24738	*Neophema elegans (Elegant Parrot)*			
159.		*Nephila edulis*			
160.	25252	*Notechis scutatus (Tiger Snake)*			
161.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
162.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
163.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
164.		*Ommatoiulus moreletii*			
165.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
166.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
167.	25253	*Parasuta gouldii*			
168.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
169.	25682	*Pardalotus striatus (Striated Pardalote)*			
170.	24642	*Passer montanus (Eurasian Tree Sparrow)*	Y		
171.	24648	*Pelecanus conspicillatus (Australian Pelican)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
172.	48061	*Petrochelidon nigricans (Tree Martin)*			
173.	48066	*Petroica boodang (Scarlet Robin)*			
174.	24659	*Petroica goodenovii (Red-capped Robin)*			
175.	25697	*Phalacrocorax carbo (Great Cormorant)*			
176.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
177.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
178.	25699	*Phalacrocorax varius (Pied Cormorant)*			
179.	24409	*Phaps chalcoptera (Common Bronzewing)*			
180.	48071	*Phylidonyris niger (White-cheeked Honeyeater)*			
181.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
182.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
183.	24842	*Platalea regia (Royal Spoonbill)*			
184.	25720	*Platycercus icterotis (Western Rosella)*			
185.	25509	*Pletholax gracilis (Keeled Legless Lizard)*			
186.	25007	*Pletholax gracilis subsp. gracilis (Keeled Legless Lizard)*			
187.	25703	*Podargus strigoides (Tawny Frogmouth)*			
188.	25704	*Podiceps cristatus (Great Crested Grebe)*			
189.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
190.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
191.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
192.	25722	*Polytelis anthopeplus (Regent Parrot)*			
193.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
194.	24767	*Porphyrio porphyrio subsp. bellus (Purple Swamphen)*			
195.	24769	*Porzana fluminea (Australian Spotted Crake)*			
196.	25732	*Porzana pusilla (Baillon's Crake)*			
197.	24771	*Porzana tabuensis (Spotless Crake)*			
198.	25511	*Pseudonaja affinis (Dugite)*			
199.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
200.		*Purpureicephalus spurius*			
201.	25008	*Pygopus lepidopodus (Common Scaly Foot)*			
202.	24243	*Rattus fuscipes (Western Bush Rat)*			
203.	24245	*Rattus rattus (Black Rat)*	Y		
204.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
205.	48096	*Rhipidura albiscapa (Grey Fantail)*			
206.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
207.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
208.		*Servaea melaina*			
209.		*Servaea spinibarbis*			
210.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
211.	30948	*Smicrornis brevirostris (Weebill)*			
212.		*Steatoda grossa*			
213.	24329	*Stictonetta naevosa (Freckled Duck)*			
214.	25597	*Strepera versicolor (Grey Currawong)*			
215.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
216.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
217.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
218.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
219.	24207	*Tachyglossus aculeatus (Short-beaked Echidna)*			
220.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
221.		*Tamopsis perthensis*			
222.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
223.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
224.	25519	*Tiliqua rugosa*			
225.	25204	*Tiliqua rugosa subsp. aspera*			
226.	25207	*Tiliqua rugosa subsp. rugosa*			
227.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
228.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
229.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
230.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
231.		*Urodacus novaehollandiae*			
232.	24386	*Vanellus tricolor (Banded Lapwing)*			
233.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
234.		*Venator immansueta*			
235.		*Venatrix pullastra*			
236.	24206	*Vespadelus regulus (Southern Forest Bat)*			
237.	24040	*Vulpes vulpes (Red Fox)*	Y		
238.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area

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

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

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

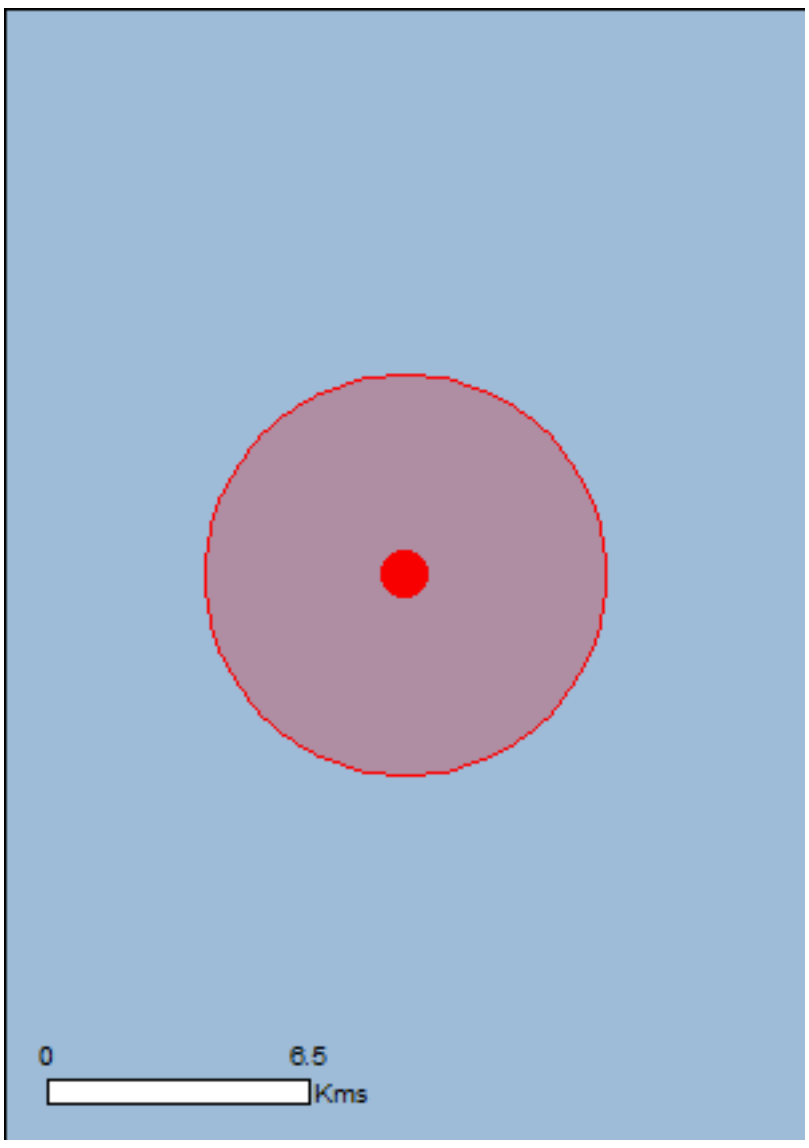
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

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

Report created: 10/10/19 20:42:06

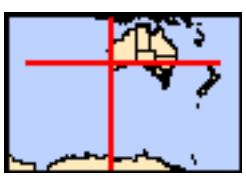
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	21
Listed Migratory Species:	19

Other Matters Protected by the EPBC Act

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

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

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

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	28
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	40
Nationally Important Wetlands:	3
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Forrestdale and thomsons lakes	Within Ramsar site
Peel-yalgorup system	30 - 40km upstream

Listed Threatened Ecological Communities [Resource Information]

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

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii		
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis		
Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat likely to occur within area
Other		
Westralunio carteri		
Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Andersonia gracilis		
Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Caladenia huegelii		
King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
Diuris micrantha		
Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei		
Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica		
Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat known to occur within area
Drakaea micrantha		
Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eleocharis keigheryi		
Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Lepidosperma rostratum		
Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Sterna dougallii		
Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Harry Waring Marsupial Reserve	WA
Thomsons Lake	WA
Unnamed WA48291	WA
Unnamed WA49561	WA
Wandi	WA

Invasive Species	[Resource Information]

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

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla		
Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Gibbs Road Swamp System	WA
Spectacles Swamp	WA
Thomsons Lake	WA

Caveat

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

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

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

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

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-32.19018 115.84266

Acknowledgements

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

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

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

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

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix B Flora, Vegetation and Black Cockatoo Habitat Assessment

Table of Contents

1. Introduction 1
   - 1.1 Background 1
   - 1.2 Scope 1
2. Context 3
   - 2.1 Legislative context 3
     - 2.1.1 EPBC Act 3
     - 2.1.2 BC Act 3
     - 2.1.3 BAM Act 3
   - 2.2 Environmental setting 4
     - 2.2.1 Geomorphology 4
     - 2.2.2 Climate 4
     - 2.2.3 Regional vegetation 5
     - 2.2.4 Black cockatoo habitat 6
3. Methods 8
   - 3.1 Desktop assessment 8
   - 3.2 Field assessment 8
     - 3.2.1 Flora and vegetation 8
     - 3.2.2 Black cockatoo habitat assessment 9
   - 3.3 Survey limitations and constraints 10
4. Results 12
   - 4.1 Desktop assessment results 12
     - 4.1.1 Threatened and Priority flora 12
     - 4.1.2 Threatened and Priority Ecological Communities 17
     - 4.1.3 Wetlands 19
     - 4.1.4 Bush Forever 19
   - 4.2 Field survey results 21
     - 4.2.1 Native flora 21
     - 4.2.2 Threatened and Priority flora 21
     - 4.2.3 Introduced (exotic) taxa 21
     - 4.2.4 Vegetation types 22
     - 4.2.5 Threatened and Priority Ecological Communities 24
     - 4.2.6 Vegetation Condition 28
     - 4.2.7 Black cockatoo habitat 30
5. Discussion and Conclusion 33
   - 5.1 Flora and vegetation 33
   - 5.2 Black cockatoo habitat 34

6. Limitations 35

7. References 36

List of Tables

Table 2.1: Vegetation associations within Survey Area 5

Table 2.2: Vegetation complexes within the Survey Area 5

Table 3.1: Personnel involved in survey 8

Table 3.2: Vegetation condition scale for South West and Interzone Botanical Provinces (EPA 2016) 8

Table 3.3: Black cockatoo potential breeding and roosting tree species (Groom 2011, DSEWPaC 2012) 10

Table 3.4: Flora and vegetation survey potential limitations and constraints 10

Table 4.1: Threatened and Priority flora potentially occurring within the Survey Area 13

Table 4.2: Mapped TECs identified within 5 km of the Survey Area 17

Table 4.3: Wetland management categories and management objectives 19

Table 4.4: Vegetation types recorded within the Survey Area 22

Table 4.9: Area (ha) covered by each vegetation condition category within the Survey Area 28

Table 4.10: Definitions of black cockatoo foraging habitat quality 30

Table 4.11: Black cockatoo foraging species (by VT) recorded within the Survey Area 30

List of Figures

Figure 1.1: Survey Area 2

Figure 2.1: Mean monthly climatic data (temperature and rainfall) for Medina Research Centre 4

Figure 2.2: Regional vegetation mapping 7

Figure 4.1: Location of Threatened and Priority Flora and Ecological Communities within 5 km of the Survey Area 18

Figure 4.2: Wetlands and Bush Forever sites within 5 km of the Survey Area 20

Figure 4.3: Vegetation Types (VTs) mapped within the Survey Area 23

Figure 4.4: Conservation Significant Vegetation Communities within the Survey Area 27

Figure 4.5: Vegetation condition within the Survey Area 29

Figure 4.6: Black cockatoo habitat 32

Appendices

Appendix A Conservation significant flora and ecological community definitions

Appendix B Desktop assessment results (DBCA 2019; DoEE 2019)

Appendix C Native plant taxa recorded within the Survey Area

1. Introduction

1.1 Background

Improvement Plan 47: Mandogalup was gazetted on 12 April 2019, for the purpose of enabling the Western Australian Planning Commission (WAPC) to advance the planning of and development of the plan area (including authorising the preparation of an improvement scheme). The Improvement Plan affects approximately 330 ha of land in the Mandogalup locality in the City of Kwinana, and is bound by Rowley Road to the north and Anketell Road to the south, with Kwinana Freeway to the east and the Alcoa residue storage area to the west (Figure 1.1). The Department of Planning, Lands and Heritage (DPLH) is now preparing a draft Improvement Scheme (IS), for the same area (the subject area).

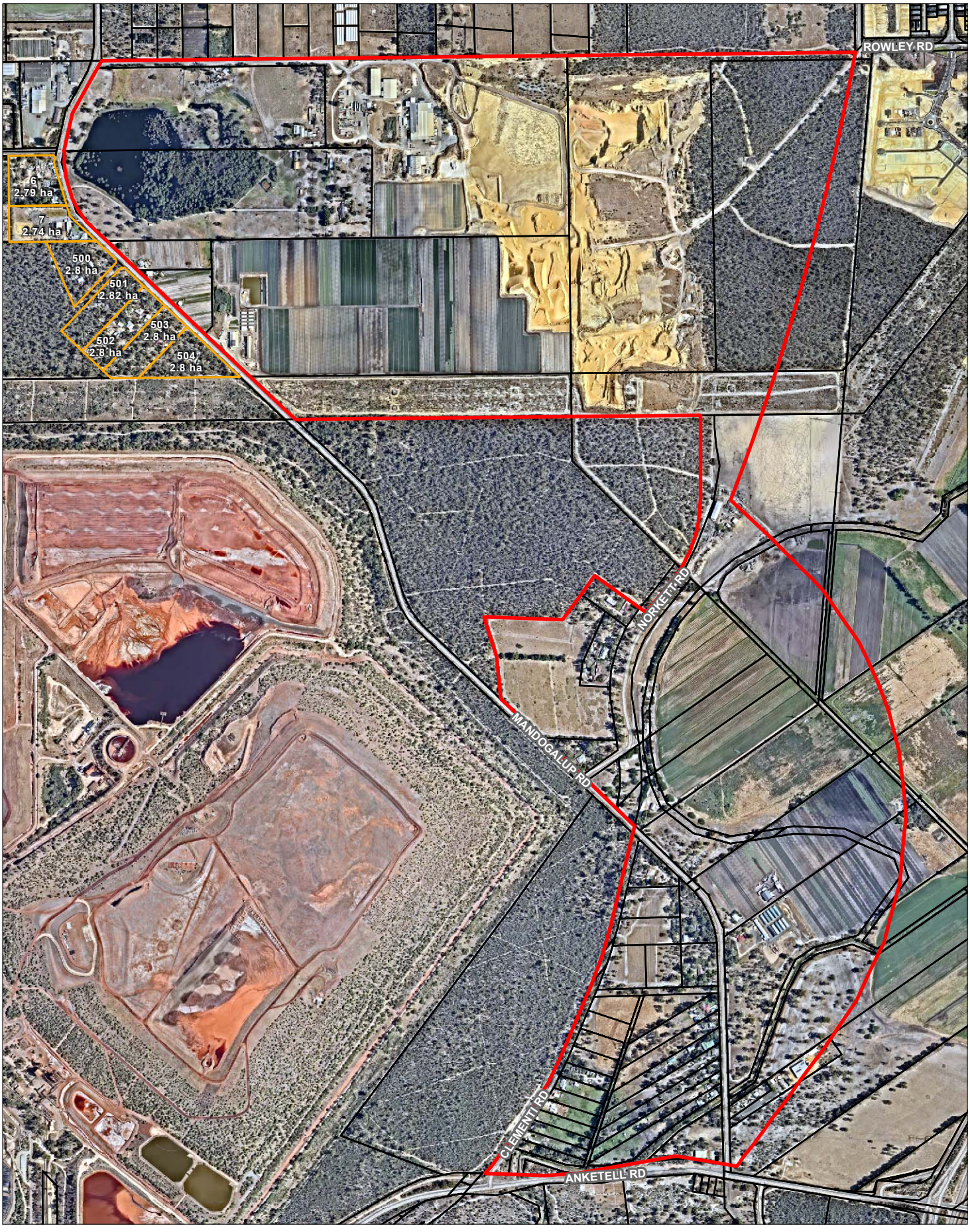
In support of the Improvement Scheme DPLH commissioned Strategen-JBS&G to undertake a flora, vegetation and black cockatoo habitat assessment for those parts of the subject area that have not been studied within the previous 10 years (the Survey Area; Figure 1.1). The Survey Area encompasses a total area of 19.6 ha.

1.2 Scope

The scope of this flora, vegetation and black cockatoo habitat survey was to undertake a desktop assessment and field assessment within the Survey Area consistent with the requirements of *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) and *EPBC Act referral guidelines for three threatened black cockatoo species* (DSEWPaC 2012).

The objectives were to:

- Conduct a desktop survey for Threatened and Priority flora which have been identified as being present in or around the Survey Area
- Collect and identify the vascular plant species present within the Survey Area
- Search areas of suitable habitat for Threatened and/or Priority flora
- Define and map the native vegetation communities present within the Survey Area
- Map vegetation condition within the Survey Area
- Provide recommendations on the local and regional significance of the vegetation communities
- Determine whether vegetation communities within the Survey Area are suitable as black cockatoo habitat, and describe and map the quality of each area of habitat
- Search for any potential nesting habitat trees for any of the threatened black cockatoo species (Eucalypts with a diameter at breast height [DBH]>500 mm)
- Record and map locations of potential nesting habitat trees
- Prepare a report summarising the findings.



Legend:

- Mandogalup IS boundary (331.2 ha)
- Sandwich lots (19.56 ha)
- Cadastral boundary
- Roads (MRWA)

strategen JBS&G

0 300 metres

Mandogalup, WA

MANDOGALUP IS SURVEY AREA

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: CT	Version: A	Date: 18-Dec-2020	**FIGURE: 1.1**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03_Rev_A\57020_01_1_SiteLocation.mxd

Image Reference: www.nearmap.com© - Imagery Date: 9 December 2019.

2. Context

2.1 Legislative context

Flora and fauna in Western Australia (WA) is protected formally and informally by various legislative and non-legislative measures, which are as follows:

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) – Australian Government
- *Biodiversity Conservation Act 2016* (BC Act) – State
- *Biosecurity and Agriculture Management Act 2007* (BAM Act) – State.

Non-legislative measures:

- WA Department of Biodiversity, Conservation and Attractions (DBCA) Priority lists for flora, ecological communities and fauna
- Weeds of National Significance
- Recognition of locally significant populations by the DBCA.

A short description of each legislative measure is given below. Other definitions, including species conservation categories, are provided in Appendix A.

2.1.1 EPBC Act

The EPBC Act aims to protect matters of national environmental significance, which are detailed in Appendix A. Under the EPBC Act, the Commonwealth Department of the Environment and Energy (DEE) lists protected species and Threatened Ecological Communities (TECs) by criteria set out in the Act. Species are conservation significant if they are listed as Threatened (i.e. Critically Endangered, Endangered and Vulnerable) or Migratory.

Bird species protected as Migratory under the EPBC Act include those listed under international migratory bird agreements relating to the protection of birds which migrate between Australia and other countries, for which Australia has agreed. This includes the Japan-Australia Migratory Bird Agreement (JAMBA), the China-Australia Migratory Bird Agreement (CAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Some marine fauna or terrestrial fauna that use marine habitats are listed as Marine under the EPBC Act. These species are only considered conservation significant when a proposed development occurs in a Commonwealth marine area (i.e. any Commonwealth Waters or Commonwealth Marine Protected Area). Outside of such areas, the EPBC Act does not consider these species to be matters of national environmental significance so are not protected under the Act.

2.1.2 BC Act

DBCA lists taxa (flora and fauna) under the provisions of the BC Act as protected and classifies these taxa according to their need for protection (see Appendix A). The BC Act makes it an offence to 'take' Threatened species without an appropriate licence. There are financial penalties for contravening the BC Act.

2.1.3 BAM Act

The BAM Act provides for management and control of listed organisms, including introduced flora species (weeds). Species listed as declared pests under the BAM Act are classified under three categories:

- C1 Exclusion: Pests assigned under this category are not established in Western Australia, and control measures are to be taken to prevent them entering and establishing in the State

- C2 Eradication: Pests assigned under this category are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility
- C3 Management: Pests assigned under this category are established in Western Australia, but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area that is currently free of that pest.

Under the BAM Act, land managers are required to manage populations of declared pests as outlined under the relevant category.

2.2 Environmental setting

2.2.1 Geomorphology

The survey area is located within the Swan Coastal Plain 2 (SWA2 – Swan Coastal Plain subregion) of Western Australia (Mitchell *et al.* 2002). The Swan Coastal Plain comprises five major geomorphologic systems that lie parallel to the coast, namely (from west to east) the Quindalup Dunes, Spearwood Dunes, Bassendean Dunes, Pinjarra Plain and Ridge Hill Shelf (Churchward & McArthur 1980; Gibson *et al*. 1994). The Survey Area is located within the Bassendean Dune system (Churchward & McArthur 1980).

2.2.2 Climate

The Mandogalup locality experiences a Mediterranean climate characterised by mild, wet winters and warm to hot, dry summers. The nearest Bureau of Meteorology (BoM) weather station at Medina Research Centre (Station No. 009194; now closed) provides average monthly climate statistics for the Mandogalup locality (Figure 2.1). Average annual rainfall recorded at Medina Research Centre since 1983 is 746 mm (BoM 2019). Rainfall may occur at any time of year; however, most occurs in winter in association with cold fronts from the southwest. Highest temperatures occur between January and February, with average monthly maximums ranging from 18.3°C in July to 31.5°C in February (BoM 2019). Lowest temperatures occur in July and August, with average monthly minimums ranging from 8.2°C in July and August to 17.6°C in February (BoM 2019).

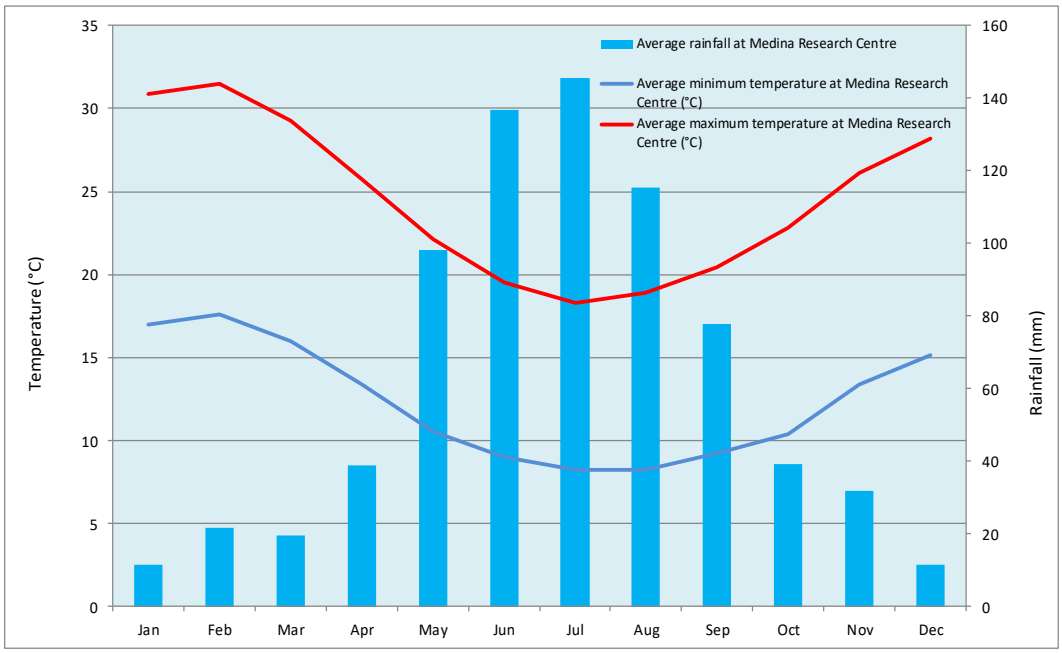


Figure 2.1: Mean monthly climatic data (temperature and rainfall) for Medina Research Centre

2.2.3 Regional vegetation

Vegetation occurring within the region was initially mapped at a broad scale (1:1 000 000) by Beard during the 1970s. This dataset has formed the basis of several regional mapping systems, including physiographic regions defined by Beard (1981) which led to the delineation of botanical districts as described in Beard (1990); the biogeographical region dataset (Interim Biogeographic Regionalisation for Australia, IBRA) for Western Australia (DoEE 2017a) and System 6 Vegetation Complex mapping undertaken by Heddle *et al.* (1980).

2.2.3.1 Beard (1990) Botanical Subdistrict

The Survey Area occurs within the Drummond Botanical Subdistrict which is characterised by low *Banksia* woodlands on leached sands; *Melaleuca* swamps on poorly-drained depressions; and *Eucalyptus gomphocephala* (Tuart), *Eucalyptus marginata* (Jarrah) and *Corymbia calophylla* (Marri) woodlands on less leached soils (Beard 1990).

2.2.3.2 IBRA subregion

IBRA describes a system of 85 'biogeographic regions' (bioregions) and 403 subregions covering the entirety of the Australian continent (Thackway & Cresswell 1995). Bioregions are defined on the basis of climate, geology, landforms, vegetation and fauna.

The Survey Area occurs within the Swan Coastal Plain 2 IBRA subregion which is dominated by *Banksia* or Tuart on sandy soils, *Casuarina obesa* on outwash plains and paperbark (*Melaleuca*) in swampy areas (Mitchell *et al.* 2002).

2.2.3.3 Vegetation association and System 6 mapping

Vegetation associations (Beard 1990) that fall within the Survey Area are outlined in Table 2.1 and shown in Figure 2.2.

Table 2.1: Vegetation associations within Survey Area

Identifier	Description	Percent of pre-European extent remaining (%) (as at 2019)	% Current Extent Protected (IUCN I - IV) for Conservation (proportion of Pre-European Extent)
6	medium woodland; tuart & jarrah	23.72	3.3
1001	medium very sparse woodland; jarrah, with low woodland; banksia & casuarina	22.05	2.8

System 6 mapping refers to vegetation mapping undertaken at a Vegetation Complex scale by Heddle *et al.* (1980). This is the primary source of information used to calculate potential impacts of proposals to clear native vegetation on the Swan Coastal Plain. The Survey Area occurs within the following vegetation complexes, which are outlined in Table 2.2 and illustrated in Figure 2.2.

Table 2.2: Vegetation complexes within the Survey Area

Complex name	Description	Percentage remaining (%)	Current percentage remaining within lands Protected (IUCN I-IV) for Conservation (%)
Karrakatta Complex-Central and South	Predominantly open forest of *Eucalyptus gomphocephala* (Tuart) - *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) and woodland of *Eucalyptus marginata* (Jarrah) - Banksia species. *Agonis flexuosa* (Peppermint) is co-dominant south of the Capel River.	23.49	3.87
Bassendean Complex Central and South	Vegetation ranges from woodland of *Eucalyptus marginata* (Jarrah) - *Allocasuarina fraseriana* (Sheoak) - Banksia species to low woodland of Melaleuca species, and sedgelands on the moister sites. This area includes the transition of	26.87	1.86

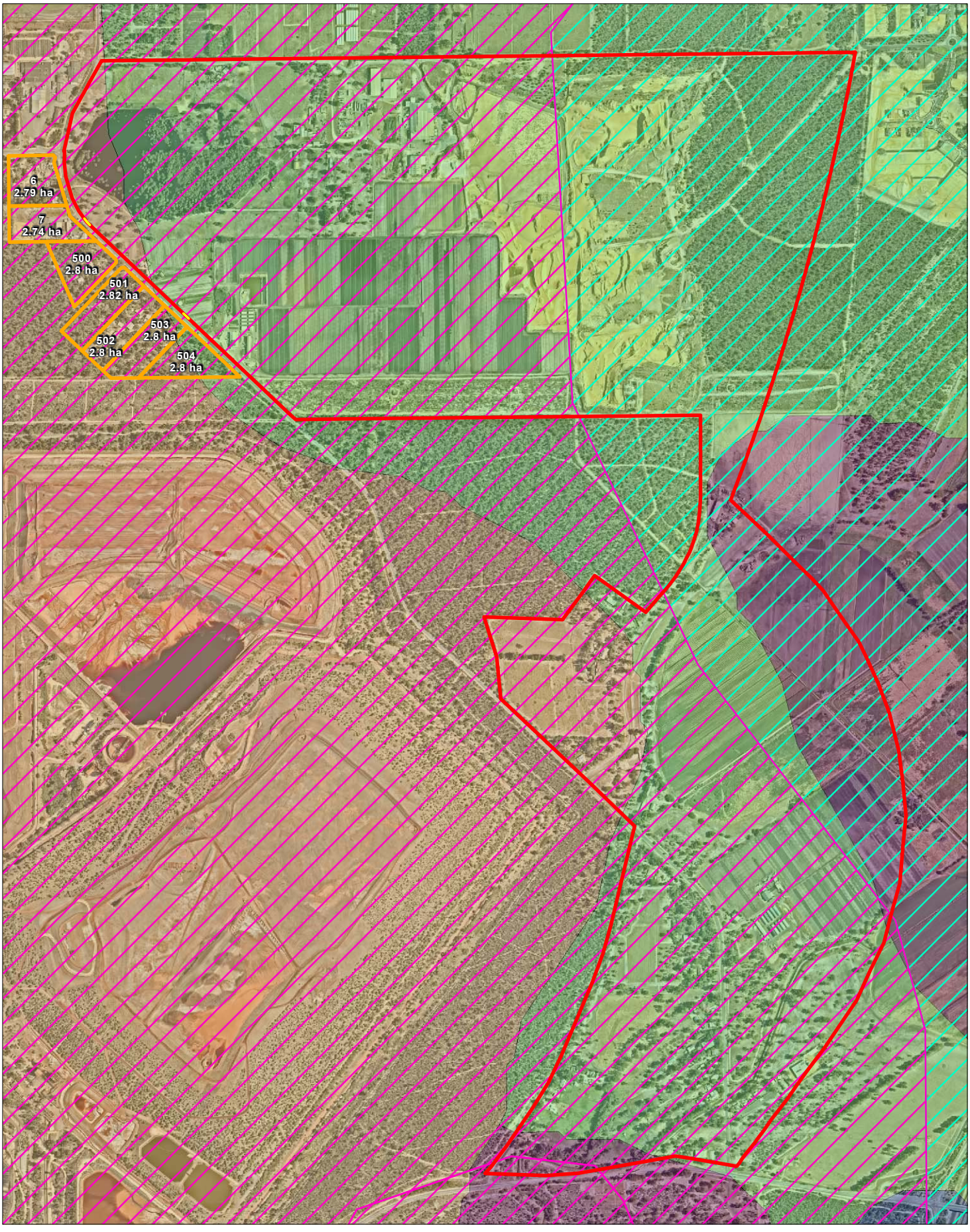
Complex name	Description	Percentage remaining (%)	Current percentage remaining within lands Protected (IUCN I-IV) for Conservation (%)
	Eucalyptus marginata (Jarrah) to *Eucalyptus todtiana* (Pricklybark) in the vicinity of Perth.		
Herdsman Complex	Sedgelands and fringing woodland of Eucalyptus rudis (Flooded Gum) - Melaleuca species.	32.11	10.83

2.2.4 Black cockatoo habitat

Calyptorhynchus latirostris (Carnaby's Black-Cockatoos; CBC), listed as Endangered under the EPBC Act, feed on the seeds, nuts and flowers, of a variety of native and introduced plant species and insect larvae (DSEWPaC 2012). Food plants generally occur within proteaceous genera such as *Banksia, Hakea* and *Grevillea*, though are known to forage on eucalypt species in woodland areas. CBC have also adapted to feeding on exotic species such as pines and cape lilac and weeds such as wild radish and wild geranium (DSEWPaC 2012). CBC usually breed between July and December in the hollows of live or dead eucalypts; primarily in Salmon Gum and Wandoo, but also within Jarrah, Marri and other eucalypt species (Johnstone 2010). Hollows are usually at least 2 m above ground, sometimes over 10 m and the depth of the hollow varies from 0.25 m to 6 m (DSEWPaC 2012). Mapping of Carnaby's Black Cockatoo distribution (Johnstone and Kirkby undated) identifies the Survey Area as occurring within the range of the species.

Calyptorhynchus banksii naso (Forest Red-tailed Black-Cockatoos; FRTBC), listed as Vulnerable under the EPBC Act, depend primarily on Marri and Jarrah trees for both foraging and nesting. The seeds of both eucalypts are the favoured food source of the birds and hollows within live or dead individual trees are utilised for nesting purposes (Johnstone 2010b). Breeding varies between years and occurs at times of Jarrah and Marri fruiting. These black cockatoos breed in woodland, forest or artificial nest boxes, but may also breed in former woodland or forest that has been reduced to isolated trees (DSEWPaC 2012). Mapping of the FRTBC distribution (Johnstone and Kirkby undated) identifies the species as likely to occur within the Survey Area.

Baudin's Black-Cockatoos primarily occur in eucalypt forests and forage at all strata levels within the forests with a tendency to favour areas containing Marri (Johnstone and Kirkby 2008, DSEWPaC 2012). Breeding generally occurs in the Jarrah, Marri and Karri forests of the southwest of Western Australia in areas averaging more than 750 mm of rainfall annually (DSEWPaC 2012). As with the other two species of Threatened black cockatoos in Western Australia, breeding habitat also occurs in former woodland or forest that has been reduced to isolated trees (DSEWPaC 2012). Mapping of the Baudin's Black-Cockatoos distribution (Johnstone and Kirkby undated; DoEE 2017) identifies the species as unlikely to occur in the Survey Area and are therefore not discussed further.



Legend:

- Mandogalup IS boundary (331.2 ha)
- Sandwich lots (19.56 ha)

Vegetation system (Beard) - DPIRD
- Bassendean
- Spearwood

Vegetation complex (Heddle) - DBCA
- Bassendean Complex-Central and South
- Cottesloe Complex-Central and South
- Herdsman Complex
- Karrakatta Complex-Central and South

strategen JBS&G

0 300 metres

Mandogalup, WA

REGIONAL VEGETATION MAPPING

Job No: 57020		Scale 1:14,000 at A4	
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: hsullivan	Checked By: CT	Version: A	Date: 31-Jan-2020

FIGURE: 2.2

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03 Rev A\57020_02_2_RegVegMapping.mxd

Image Reference: www.nearmap.com© - Imagery Date: 9 December 2019.

3. Methods

3.1 Desktop assessment

A desktop assessment was conducted using DBCA and Department of the Environment and Energy (DoEE) databases to identify the possible occurrence of TECs, PECs and Threatened and Priority flora potentially occurring within the Survey Area. These databases included NatureMap (DBCA 2019) and the Commonwealth Protected Matters Search Tool (DoEE 2019) as well as requesting data from the Threatened Species and Communities branches of DBCA.

Reports that document regional flora, vegetation and fauna within the surrounds of the Survey Area were also reviewed prior to the field assessment.

3.2 Field assessment

3.2.1 Flora and vegetation

The field survey was conducted according to standards set out in *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). The assessment of flora and vegetation within the Survey Area was undertaken by three ecologists from Strategen-JBS&G on 24 October and 14 November 2019, and 30 September and 1 October 2020. Table 3.1 identifies the staff involved in the assessment, their role and qualifications.

Table 3.1: Personnel involved in survey

Name	Role	Flora collection permit
Tristan Sleigh Strategen-JBS&G (Senior Ecologist)	Survey planning, fieldwork, plant identification, data interpretation and report preparation.	FB62000128
Robyn Chesney Strategen-JBS&G (Senior Ecologist)	Survey planning, fieldwork, plant identification, data interpretation and report preparation.	FB62000123
Jenna Hyatt Strategen-JBS&G (Environmental Scientist)	Survey planning, fieldwork	n/a

The Survey Area was traversed on foot and relevés were placed where native vegetation was encountered. Flora and vegetation was described and sampled systematically at each quadrat and additional opportunistic collecting was undertaken wherever previously unrecorded plants were observed. At each site the following floristic and environmental parameters were noted:

- GPS location
- Topography
- Soil type and colour
- Outcropping rocks and their type
- Percentage cover and average height of each vegetation stratum
- Vegetation condition

For each vascular plant species, the average height and percent cover were recorded. Vegetation condition was rated according to the scale of Keighery (1994) (Table 3.2).

Table 3.2: Vegetation condition scale for South West and Interzone Botanical Provinces (EPA 2016)

Condition rating	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.

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

All plant specimens collected during the field surveys were identified using appropriate reference material or through comparisons with pressed specimens housed at the Western Australian Herbarium where necessary. Nomenclature of the species recorded is in accordance with Western Australian Herbarium (1998-).

3.2.1.1 Data analysis and vegetation mapping

Vegetation types (VT) were delineated using a combination of results, site observations and cluster analysis. Aerial photography interpretation and field notes taken during the survey were then used to develop VT mapping polygon boundaries over the Survey Area. These polygon boundaries were then digitised using the Geographic Information System (GIS) software.

VT descriptions (through floristic in origin) have been adapted from the National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0 (ESCAVI 2003), a system of describing structural vegetation units (based on dominant taxa). This model follows nationally-agreed guidelines to describe and represent VTs, so that comparable and consistent data is produced nation-wide. For the purposes of this report, a VT is considered equivalent to a NVIS sub-association as described in ESCAVI (2003).

3.2.2 Black cockatoo habitat assessment

The Survey Area was inspected on 24 October and 14 November 2019 by Strategen-JBS&G personnel with relevant experience as specified by the *EPBC Act Referral guidelines for three threatened black cockatoo species* (DSEWPaC 2012). The inspection included:

- A vegetation assessment to identify vegetation communities and potential black cockatoo foraging species
- A significant tree assessment to identify any trees with the potential to be utilised by black cockatoos for breeding.

3.2.2.1 Vegetation and foraging assessment

The Survey Area was traversed on foot to record any flora species with the potential to provide a food source for black cockatoos. Following the assessment, vegetation units defined as part of the flora and vegetation survey were assigned a foraging value based on the presence and quantity of potential food species and any evidence of foraging by black cockatoos.

3.2.2.2 Significant tree assessment

Significant trees are defined as trees of suitable species with a diameter at breast height (DBH) greater than 500 mm (> 300 mm for salmon gum and wandoo) (DSEWPaC 2012). Tree species which are considered to be potential breeding or roosting trees are outlined in Table 3.3. Trees with a DBH greater than 500 mm (or >300 mm for salmon gum and wandoo) are large enough to potentially contain hollows suitable for nesting black cockatoos, or have the potential to develop suitable

hollows over the next 50 years. Trees of this size may also be large enough to provide roosting habitat (i.e. trees which provide a roost or rest area for the birds). The locations of such trees within the Survey Area were recorded using a GPS. In addition to the location and DBH, the species of each tree was also recorded. The survey of significant trees was not able to be completed within 297 Mandogalup Road, due to access constraints. All other properties within the survey area were surveyed.

Table 3.3: Black cockatoo potential breeding and roosting tree species (Groom 2011, DSEWPaC 2012)

Scientific name	Common name	Breeding	Roosting
Corymbia calophylla	Marri	Yes	Yes
Corymbia maculate	Spotted Gun		Yes
Eucalyptus accedens	Powderbark	Yes	
Eucalyptus camaldulensis	River Red Gum		Yes
Eucalyptus citriodora	Lemon Scented Gum		Yes
Eucalyptus diversicolor	Karri	Yes	
Eucalyptus globulus	Tasmania Blue Gum		Yes
Eucalyptus gomphocephala	Tuart	Yes	Yes
Eucalyptus grandis	Flooded Gum, Rose Gum		Yes
Eucalyptus longicornis	Red Morrell	Yes	
Eucalyptus loxophleba	York Gum	Yes	Yes
Eucalyptus marginata	Jarrah	Yes	Yes
Eucalyptus megacarpa	Bullich	Yes	Yes
Eucalyptus occidentalis	Swamp Yate	Yes	
Eucalyptus patens	Blackbutt	Yes	Yes
Eucalyptus robusta	Swamp Mahogany		Yes
Eucalyptus rudis	Flooded Gum	Yes	Yes
Eucalyptus salmonophloia	Salmon Gum	Yes	
Eucalyptus salubris	Gimlet	Yes	
Eucalyptus wandoo	Wandoo	Yes	Yes
Pinus pinaster	Pinaster, Maritime Pine		Yes
Pinus radiata	Monterey, Radiata Pine		Yes

3.3 Survey limitations and constraints

Table 3.4 displays the evaluation of the flora and vegetation assessment against a range of potential limitations that may have an effect on that assessment. Based on this evaluation, the assessment has not been subject to limitations or constraints that have affected the thoroughness of the assessment and the conclusions reached.

Table 3.4: Flora and vegetation survey potential limitations and constraints

Potential limitation	Impact on assessment	Comment
Sources of information and availability of contextual information (i.e. pre-existing background versus new material).	**Not a constraint.**	The survey has been undertaken in the Drummond Botanical Subdistrict on the Swan Coastal Plain which has been well studied and documented with ample literature available (Beard 1990).
Scope (i.e. what life forms, etc., were sampled).	**Not a constraint.**	Number of species recorded, number of sites sampled and timing of the survey (i.e. spring) were adequate for this level of survey.
Proportion of flora/fauna collected and identified (based on sampling, timing and intensity).	**Not a constraint.**	The proportion of flora surveyed was adequate. All areas of remnant vegetation within the survey area were traversed and flora species were recorded systematically.
Completeness and further work which might be needed (i.e. was the relevant Survey Area fully surveyed).	**Not a constraint.**	The information collected during the survey was sufficient to assess the vegetation that was present during the time of the survey.
Mapping reliability.	**Not a constraint.**	Aerial photography of a suitable scale was used to map the project area. Sites were chosen from these aerials to reflect changes in community structure. Vegetation types were assigned to each site based on topography,

		soil type and presence/absence and percent foliage cover of vegetation.
Timing, weather, season, cycle.	**Not a constraint.**	Flora and vegetation surveys are normally conducted following winter rainfall in the South-West Province, ideally during spring (EPA 2016). The field assessment was conducted in October and November (i.e. spring) in fine weather conditions and therefore these factors are not deemed to be constraints for the spring survey.
Disturbances (fire flood, accidental human intervention, etc.).	**Not a constraint.**	The project area and regional surrounds have been subject to disturbance over a significant period of time. Given the wide range of this disturbance, this is not considered to be a limitation within the project area.
Intensity (in retrospect, was the intensity adequate).	**Not a constraint.**	The project area was traversed on foot and all differences in vegetation structure were recorded appropriately.
Resources (i.e. were there adequate resources to complete the survey to the required standard).	**Not a constraint.**	The available resources were adequate to complete the survey.
Access problems (i.e. ability to access Survey Area).	**Not a constraint.**	The project area was easily traversed on foot enabling adequate access to survey the vegetation within the project area.
Experience levels (e.g. degree of expertise in species identification to taxon level).	**Not a constraint.**	All survey personnel have the appropriate training in sampling and identifying the flora of the region.

4. Results

4.1 Desktop assessment results

4.1.1 Threatened and Priority flora

The desktop assessment identified a total of eight threatened and five priority flora species as having been previously recorded, or with potentially suitable habitat occurring within 5 km of the centre-point of the Survey Area (Appendix B). Of these species, based on general habitat requirements (Table 4.1), three Threatened and one Priority flora species were considered to have the potential to occur within the subject area and sandwich lots, as follows:

- *Caladenia huegelii* (Threatened – Endangered [EPBC Act]; Threatened [BC Act])
- *Drakaea elastica* (Threatened – Endangered [EPBC Act]; Threatened [BC Act])
- *Drakaea micrantha* (Threatened – Vulnerable [EPBC Act]; Threatened [BC Act])

The potential for these species to occur within the Survey Area is discussed further in Table 4.1. The Likelihood of each species is based on the following criteria:

- Recorded: Recorded during the field survey or site reconnaissance
- Likely: Suitable habitat is present in the Survey area and the Survey area is in the species' known distribution
- Possible: Limited or no suitable habitat is present in Survey area, but is nearby. The species has good dispersal abilities and is known from the general area
- Unlikely: No suitable habitat is present in Survey area but is nearby, the species has poor dispersal abilities, but is known from the general area; or suitable habitat is present, however the Survey area is outside of the species' known distribution; or suitable habitat is present, however these species was not recorded during targeted surveys.

Table 4.1: Threatened and Priority flora potentially occurring within the Survey Area

Species	Conservation status		Description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
Andersonia gracilis	Threatened – Endangered	Threatened	A slender, erect or open straggly shrub, 10 to 100 cm high. Flowers are white to pink to purple from September to November. Habitat for this species occurs in white/grey sand, sandy clay, gravelly loam within winter-wet areas and near swamps (Western Australian Herbarium 1998-). The species occurs in damp black, sandy clay flats near swamps in open low heath with *Calothamnus hirsutus* (hairy clawflower), *Verticordia densiflora* (compact featherflower), *Kunzea recurva* (recurved kunzea) and *Banksia telmatiaea* over sedges (Western Australian Herbarium 1998-, DEE 2019a).	**Unlikely** due to absence of preferred habitat. While wetlands are present within the Survey Area, these are heavily degraded, with understorey species largely displaced by weeds and ornamental species. None of the associated species were recorded within the Survey Area.
Caladenia huegelii	Threatened – Endangered	Threatened	A slender orchid from 30 to 50 cm tall. One or two striking flowers characterised by a greenish-cream lower petal with a maroon tip. Other petals are cream with red or pink suffusions. Habitat for this species occurs within well-drained, deep sandy soils in low mixed *Banksia*, *Allocasuarina* and Jarrah woodlands (Western Australian Herbarium 1998-, DEE 2019a).	**Possible.** Potential habitat is present within VT6, VT7, and VT9.
Cyathochaeta teretifolia	-	P3	A rhizomatous, clumped, robust perennial, grass-like or herb (sedge), to 2 m high and to 1.0 m wide. Flowers are brown. Habitat for this species includes grey sand or sandy clay within swamps or creek edges (Western Australian Herbarium 1998-).	**Unlikely** due to absence of preferred habitat. While wetlands are present within the Survey Area, these are heavily degraded, with understorey species largely displaced by weeds and ornamental species.
Diuris micrantha	Threatened – Vulnerable	Threatened	A slender orchid to 60 cm tall. Yellow flowers with reddish-brown markings measuring 1.3 cm across. Habitat for this species occurs within clay-loam substrates in winter-wet depressions or swamps.	**Unlikely** due to absence of preferred habitat. While wetlands / winter-wet depressions are present within the Survey Area, these are heavily degraded, with understorey species largely displaced by weeds and ornamental species.
Diuris purdiei	Threatened – Endangered	Threatened	A slender orchid to 0.35 m tall. Flowers are yellow and visible from September to October. Habitat for this species is grey-black sand substrates in winter-wet swamps which have high moisture (Western Australian Herbarium 1998-). Diuris purdiei occurs from Perth south to near the Whicher Range, within the Swan (Western Australia) Natural Resource Management Region. It grows on sand to sandy clay soils, in areas subject to winter inundation, and amongst native sedges and dense heath with scattered emergent *Melaleuca preissiana*, *Corymbia calophylla*, *E. marginata* and *Nuytsia floribunda* (DEE 2019a).	**Unlikely** due to absence of preferred habitat. No areas comprising an intact understorey of dense heath or sedges with key emergent species were recorded within the Survey Area.

Species	Conservation status		Description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
Dodonaea hackettiana	-	P4	An erect shrub or tree, 100 to 500 cm tall. Flowers are yellow to green/red and occur mainly from July to October. Habitat for this species occurs in sand and outcropping limestone (Western Australian Herbarium 1998-).	**Present.** Species was recorded within VT7, in remnant vegetation alongside Norkett Road.
Drakaea elastica	Threatened – Endangered	Threatened	A slender orchid to 30 cm tall with a prostrate, round to heart shaped leaf. Singular, bright green, glossy flower. The species grows on bare patches of sand within otherwise dense vegetation in low-lying areas alongside winter-wet swamps, typically in banksia (*Banksia menziesii*, *B. attenuata* and *B. ilicifolia*) woodland or spearwood (*Kunzea glabrescens*) thicket vegetation. *D. elastica* often occurs with other orchid species (DEE 2019a).	**Possible** due to presence of preferred habitat in VT1 and VT7, i.e. banksia woodland alongside swamps.
Drakaea micrantha	Threatened – Vulnerable	Threatened	A tuberous, terrestrial herb which has a diminutive red and yellow flower, 1.2–2.5 cm long, on a stem that grows to 30 cm. Flowering occurs form September to October. Its heart-shaped leaf, about 1.5 cm long, is silvery grey with prominent green veins. Habitat for this species occurs within cleared firebreaks or open sandy patches that have been disturbed, where competition from other plants has been removed (Western Australian Herbarium 1998-, DEE 2019a).	**Possible** due to presence of preferred habitat. Potential habitat is located within firebreaks near tracts of remnant bushland, e.g. around sandwich lots and lots adjacent to Bush Forever sites.
Eleocharis keigheryi	Threatened – Vulnerable	Threatened	A rhizomatous, tufted/clumped perennial herb, reaching a maximum diameter of 40 cm. It has erect, smooth, green stems that are 20–40 cm tall and hollow, supporting cross bars that are 2 mm in diameter. This species grows in small clumps in a substrate of clay or sandy loam. This species is emergent in freshwater creeks, and transient waterbodies such as drainage lines and claypans in water to approximately 15 cm deep. Fringing woodland species and associated species include Swamp Sheoak (*Casuarina obesa*), Flooded Gum (*Eucalyptus rudis*), Red Robin Bush (*Melaleuca lateritia*), Swamp Paperbark (*M. rhaphiophylla*), Common Spike-sedge (*Eleocharis acuta*), *Aponogeton hexatepalus*, Veined Swamp Wallaby Grass (*Amphibromus nervosus*) and herbs such as *Wurmbea*, *Tribonanthes* and *Leptocarpus* spp. (Western Australian Herbarium 1998-, DEE 2019a).	**Unlikely** due to absence of preferred habitat. While VT4 contained vegetation within and adjacent to standing water associated with a drainage channel, this water was deeper than 15 cm.
Lepidosperma rostratum	Threatened – Endangered	-	A rhizomatous sedge to 30 cm in diameter. Stems are circular in cross section and flowers are spike-like and up to 4 cm long. Habitat for this species occurs in sandy soils among low heath comprised of *Banksia telmatiaea* and *Calothamnus hirsutus* in winter-wet swamps (Western Australian Herbarium 1998-, DEE 2017a).	**Unlikely** due to absence of preferred habitat and associated species.

Species	Conservation status		Description	Potential to occur
	EPBC Act	BC Act/ DBCA listing		
Pimelea calcicola	-	P3	An erect to spreading shrub to 1 m tall. Flowers are pink and visible between September to November. Habitat for this species occurs in sand on coastal limestone ridges (Western Australian Herbarium 1998-).	**Unlikely** due to absence of preferred habitat.
Pithocarpa corymbulosa	-	P3	An erect to scrambling perennial herb 50 to 100 cm tall. Flowers are white and are present from January to April. Habitat for this species occurs within gravelly or sandy loam amongst granite outcrops (Western Australian Herbarium 1998-, DEE 2019a).	**Unlikely** due to absence of preferred habitat.
Stylidium paludicola	-	P3	Reed-like perennial, herb, 35 to 100 cm tall. Leaves are tufted, linear or subulate or narrowly oblanceolate. Flowers are pink and occur in October to December. Habitat for this species occurs in peaty sand over clay and winter wet areas, often in Marri and Melaleuca woodland or Melaleuca shrubland (Western Australian Herbarium 1998-).	**Unlikely** due to absence of preferred habitat. While winter-wet areas are present within the Survey Area, the majority of these have been severely disturbed and understorey replaced with no-native species, or completely cleared for market gardens.

4.1.2 Threatened and Priority Ecological Communities

A TEC is defined under the EP Act as an ecological community listed, designated or declared under a written law or a law of the Australian Government as Threatened, Endangered or Vulnerable. There are four State categories of TECs (DEC 2010)

- presumed totally destroyed (PD)
- critically endangered (CR)
- endangered (EN)
- vulnerable (VU)

A description of each of these TECs is presented in Appendix A. TECs are gazetted as such by DBCA (2019) and some Western Australian TECs listed by DBCA are also listed as Threatened under the EPBC Act.

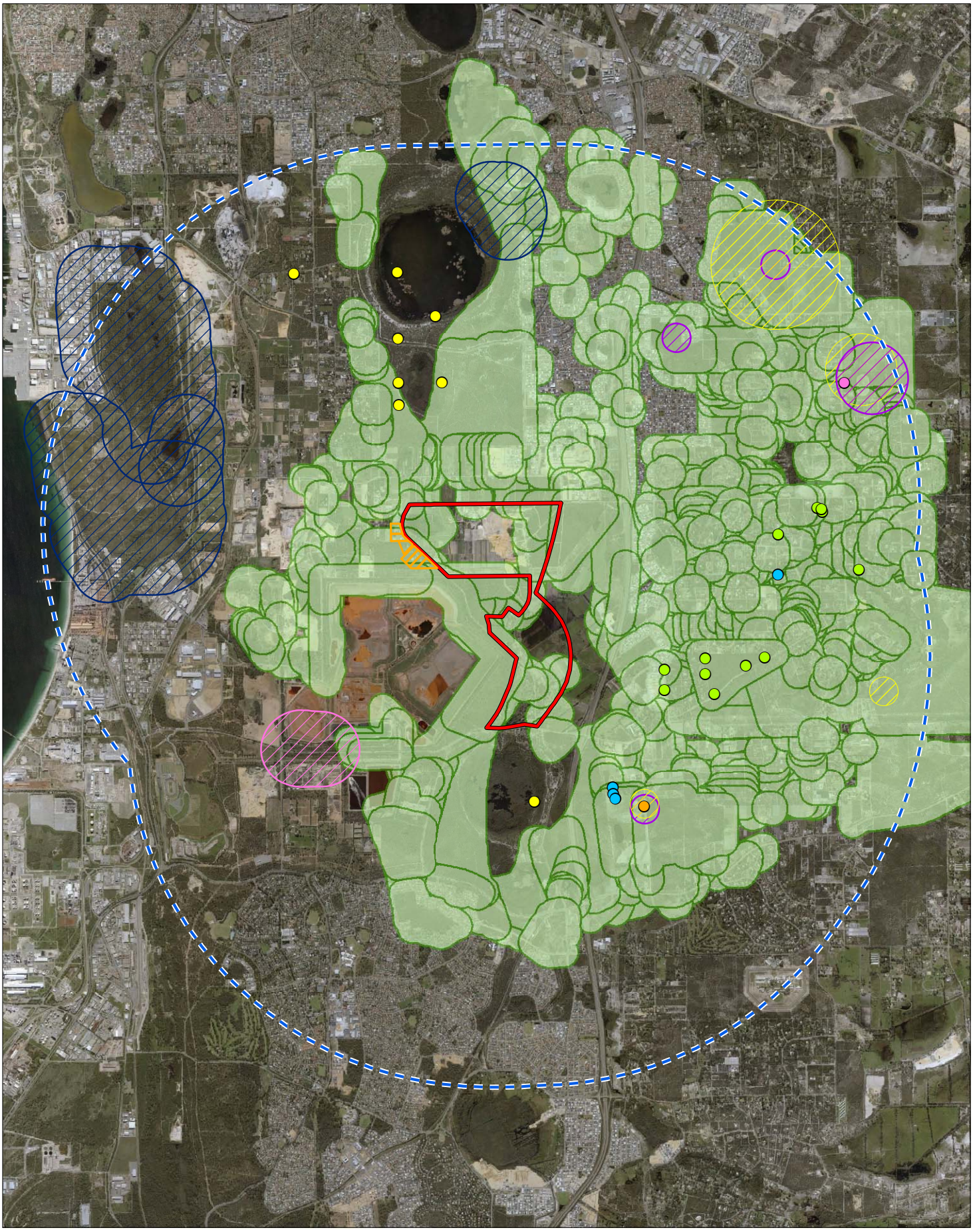
Under the EPBC Act, a person must not undertake an action that has or will have a significant impact on a listed TEC without approval from the Australian Government Minister for the Environment, unless those actions are not prohibited under the EPBC Act. A description of each of these categories of TECs is presented in Appendix A. The current EPBC Act list of TECs can be located on the DoEE (2019) website.

Ecological communities identified as Threatened, but not listed as TECs, are classified as Priority Ecological Communities (PECs). These communities are under threat, but there is insufficient information available concerning their distribution to make a proper evaluation of their conservation status. DBCA categorises PECs according to their conservation priority, using five categories; P1 (highest conservation significance) to P5 (lowest conservation significance), to denote the conservation priority status of such ecological communities. Appendix A defines PECs (DEC 2010). DBCA (2019) contains a list of current PECs.

One TEC listed under the BC Act, three PECs listed by DBCA and one TEC listed under the EPBC Act were identified within 5 km of the Survey Area (Figure 4.1); however, it is worth noting that these mapped boundaries do not necessarily represent the actual extent of their respective communities and are rather a broad scale indication of where the communities have been previously mapped plus an additional buffer.

Table 4.2: Mapped TECs identified within 5 km of the Survey Area

Community identifier	Community name	Listing under the BC Act	Listing under the EPBC Act
Various floristic community types (FCTs)	Banksia woodlands of the Swan Coastal Plain	Various listings; encompasses multiple state-listed TECs and PECs	Endangered
Limestone ridges (SCP 26a)	*Melaleuca huegelii* - *Melaleuca systena* shrublands on limestone ridges	Endangered	NA
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	Priority 3	Endangered
SCP22	*Banksia ilicifolia woodlands,* southern Swan Coastal Plain	Priority 3	Endangered
SCP24	Northern Spearwood shrublands and woodlands	Priority 3	Endangered



Legend

- Mandogalup IS boundary (331.2 ha)
- 5km buffer
- Sandwich lots (19.56 ha)

TECs/PECs

- Banksia Woodlands of the Swan Coastal Plain
- SCP21c
- SCP22
- SCP24
- Limestone ridges (SCP 26a)

Threatened and Priority Flora species

- *Caladenia huegelii* (T)
- *Cyathochaeta teretifolia* (P3)
- *Dodonaea hackettiana* (P4)
- *Drakaea elastica* (T)
- *Verticordia lindleyi* subsp. *lindleyi* (P4)

strategen JBS&G

0 1,000 metres

Mandogalup, WA

LOCATION OF THREATENED AND PRIORITY FLORA AND ECOLOGICAL COMMUNITIES WITHIN 5KM OF THE SURVEY AREA

Job No: 57020		Scale 1:70,000 at A4	
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: hsullivan	Checked By: CT	Version: A	Date: 31-Jan-2020

FIGURE: 4.1

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03 Rev A\57020_04_1_TPFL_TEC.mxd

Image Reference: www.nearmap.com© - Imagery Date: 9 December 2019.

4.1.3 Wetlands

The nature of the protection and management that Swan Coastal Plain wetlands should be afforded is guided by the appropriate management category they have been assigned. These management categories are listed below in Table 4.3.

Table 4.3: Wetland management categories and management objectives

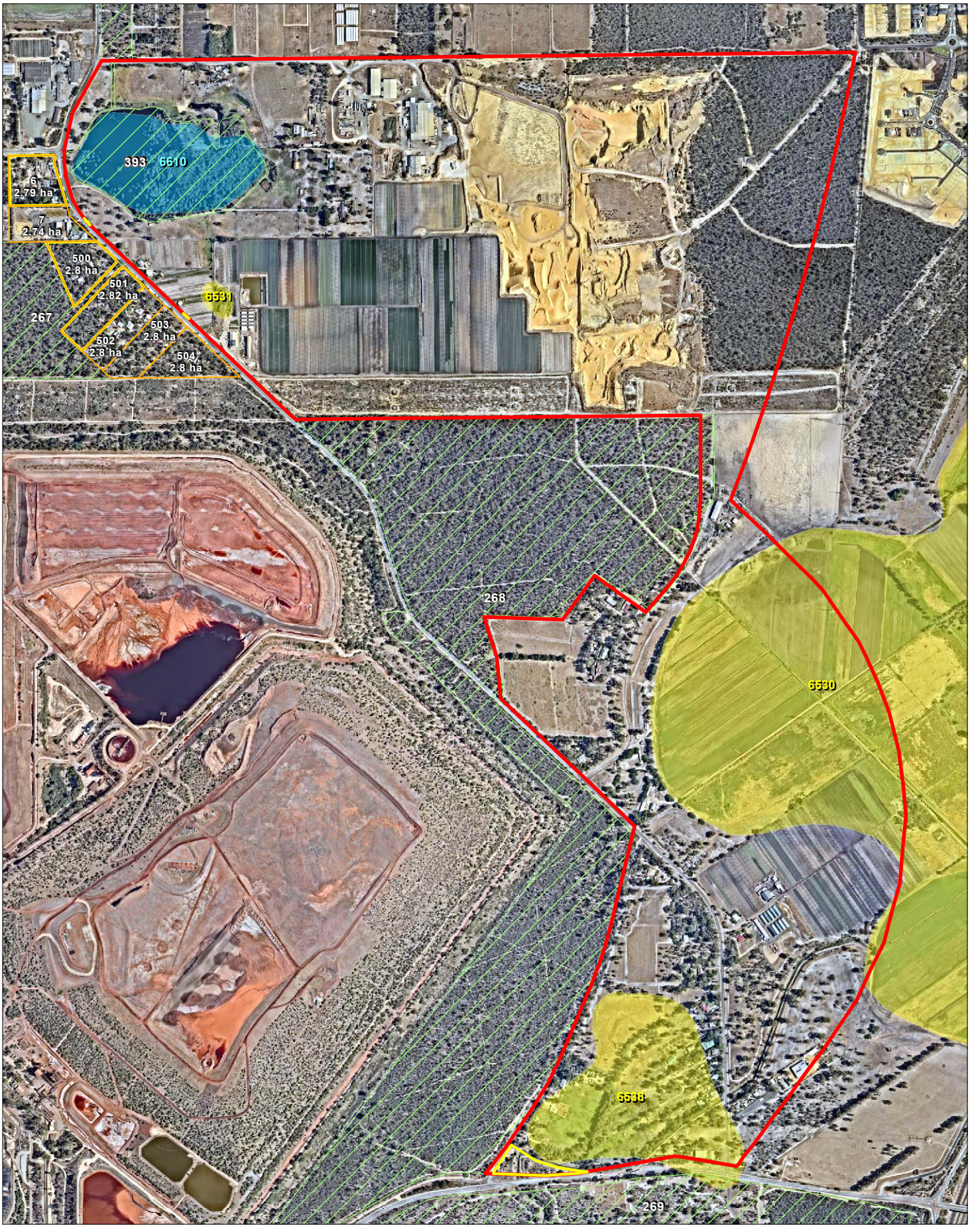
Category	Objective
Conservation Category Wetlands (CCW)	To preserve wetland (natural) attributes and functions
Resource Enhancement Wetlands (REW)	To restore wetlands through maintenance and enhancement of wetland functions and attributes
Multiple Use Wetlands (MUW)	To use, develop and manage wetlands in the context of water, town and environmental planning

No CCWs are present within the Survey Area, or within the wider Improvement Plan area (Figure 4.2). One REW is located within the north west of the wider Improvement Plan area (UFI: 6610) in association with Wattleup Lake. This wetland covers a total area of approximately 15.27 ha (Figure 4.2). One MUW is located within the Survey Area: a portion of UFI 6538 (28.15ha). Two other MUW's are mapped within the wider Improvement Plan area (UFI 6530 and UFI 6531) covering areas of 301.66 ha and 0.94 ha respectively.

4.1.4 Bush Forever

State Planning Policy 2.8: Bushland Policy for the Perth Metropolitan Region (SPP 2.8) aims to provide a policy and implementation framework that ensures bushland protection and management issues throughout the Perth Metropolitan Region are adequately addressed and integrated with broader land use planning and decision-making (WAPC 2010).

No Bush Forever sites are located within the Survey Area. Three Bush Forever Sites (393, 267 and 268) are located directly adjacent to the Survey Area.



Legend:

- Mandogalup IS boundary (331.2 ha)
- Sandwich lots (19.56 ha)
- Bush Forever site (DOP)
- Geomorphic Wetlands (DBCA)
  - Resource Enhancement
  - Multiple Use

strategen JBS&G

0 300 metres

Mandogalup, WA

WETLANDS AND BUSH FOREVER SITES WITHIN 5KM OF THE SURVEY AREA

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: hsullivan	Checked By: CT	Version: A	Date: 31-Jan-2020	**FIGURE: 4.2**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03 Rev A\57020_04_2_Wetlands_BF.mxd

Image Reference: www.nearmap.com© - Imagery Date: 9 December 2019.

4.2 Field survey results

4.2.1 Native flora

A total of 50 native vascular plant taxa from 21 families and 39 genera were recorded within the Survey Area (Appendix C).

4.2.2 Threatened and Priority flora

No Threatened flora species as listed under section 178 of the EPBC Act or section 19(1) of the BC Act were recorded within the Survey Area. One Priority flora species, *Dodonaea hackettiana* (P4), was recorded within roadside vegetation mapped as VT7, at the northern end of Norkett Road.

The survey was conducted during the main flowering season for flora of the southwest botanical region (i.e. spring), including the Threatened and Priority species with potential to occur within the Survey Area. As such, this is the optimal time to detect the majority of species present.

4.2.3 Introduced (exotic) taxa

A total of 33 introduced (exotic) taxa were recorded within the Survey Area, as follows:

- **Arctotheca calendula*
- **Asparagus asparagoides*
- **Avena barbata*
- **Brassica sp.*
- **Briza maxima*
- **Bromus diandrus*
- **Carpobrotus edulis*
- **Cenchrus clandestinus*
- **Disa bracteata*
- **Ehrharta calycina*
- **Eragrostis curvula*
- **Eucalyptus grandis*
- **Euphorbia peplus*
- **Ficus carica*
- **Fumaria capreolata*
- **Gladiolus caryophyllaceus*
- **Gladiolus undulatus*
- **Hypochaeris glabra*
- **Lagurus ovatus*
- **Leptospermum laevigatum*
- **Lolium perenne*
- **Lupinus cosentinii*
- **Lysimachia arvensis*
- **Opuntia stricta*
- **Pelargonium capitatum*
- **Ricinus communis*
- **Schinus terebinthifolia*
- **Solanum nigrum*
- **Sonchus oleraceus*
- **Trifolium arvense var. arvense*
- **Ursinia anthemoides*
- **Wahlenbergia capensis*
- **Zantedeschia aethiopica.*

It should be noted that introduced species were only recorded in areas where native vegetation occurred, i.e., within quadrats or where notes were taken on the suite of species present in an area. Introduced species were not recorded in areas that were fully cleared such as paddocks or road verges. As such, this list should not be considered a full inventory of introduced species within the Survey Area.

Three declared pest plant species pursuant to section 22 of the *Biosecurity and Agriculture Management Act 2007* (BAM ACT) were recorded in the Survey Area; namely, **Asparagus asparagoides* (Bridal Creeper), **Opuntia stricta* (Prickly pear) and **Zantedeschia aethiopica* (Arum Lily).

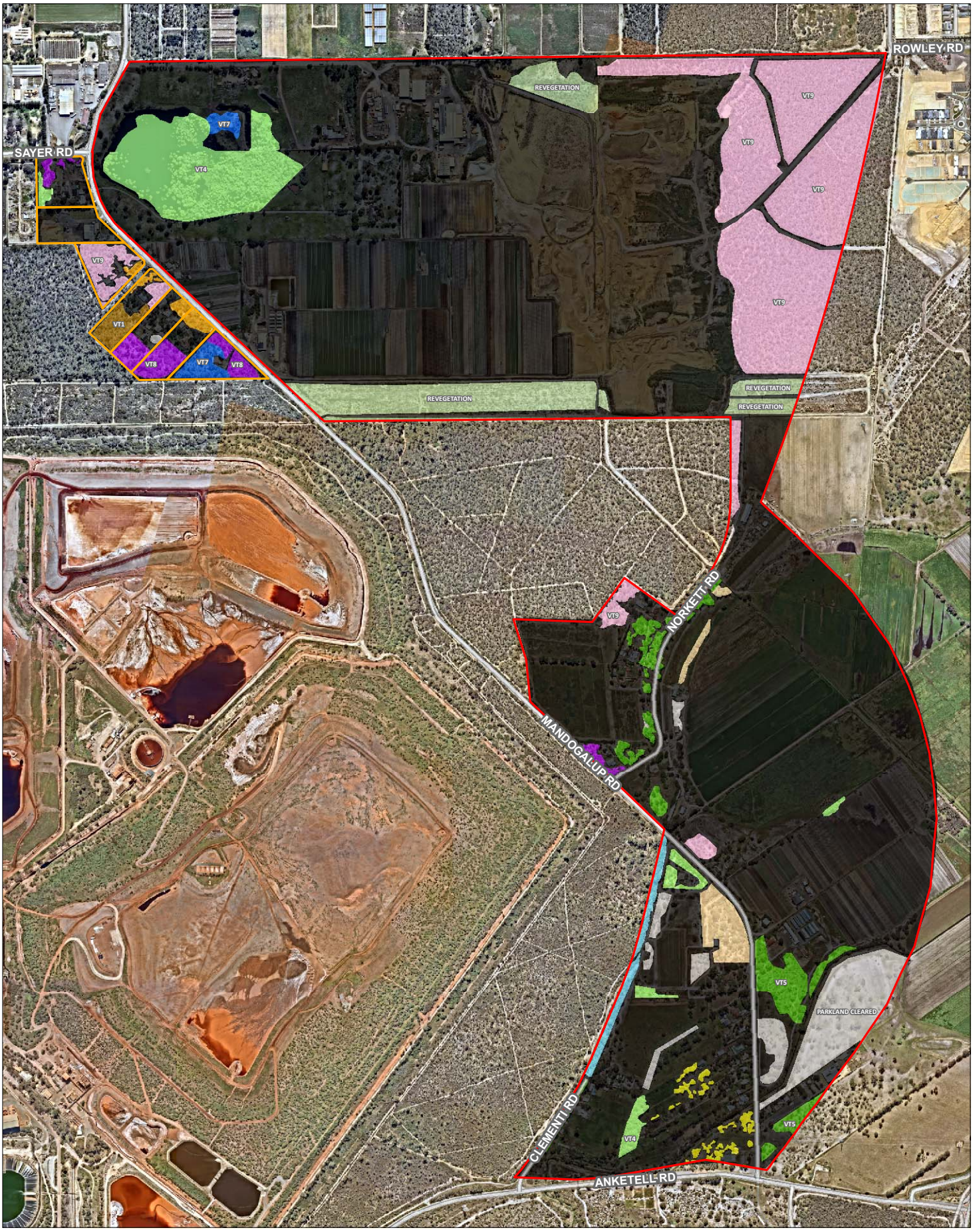
4.2.4 Vegetation types

Nine vegetation types (VTs) were defined and mapped within the Survey Area (Figure 4.3). Areas containing vegetation in parkland cleared or highly degraded states have not been counted as unique native VTs but have been included in Table 4.4 for area calculation purposes. Total areas within the Survey Area by each of the identified VTs are set out in Table 4.4.

The total area mapped within the Survey Area was 345.48 ha which includes completely degraded areas.

Table 4.4: Vegetation types recorded within the Survey Area

Vegetation type	Description	Area (ha)	Percentage of the Survey Area
1	Woodland of *Corymbia calophylla*, *Allocasuarina fraseriana* and *Banksia attenuata* over open heath of *Xanthorrhoea preissii*, *Hibbertia hypericoides* and *Macrozamia riedlei* mixed native and introduced species.	0.97	0.28
2	Open woodland of *Eucalyptus marginata* and *Allocasuarina fraseriana* and occasionally *Banksia grandis* over open heath of *Xanthorrhoea preissii*, *Macrozamia riedlei* over introduced species.	0.75	0.22
3	Open woodland of *Eucalyptus rudis*, *Melaleuca rhaphiophylla* and *Eucalyptus marginata* over introduced species .	0.92	0.27
4	Woodland of *Eucalyptus rudis*, *Melaleuca rhaphiophylla*, *Agonis flexuosa* over mixed in.	12.55	3.63
5	Open woodland of *Eucalyptus gomphocephala*, *Eucalyptus rudis* and occasionally ^*Corymbia maculata*, *Allocasuarina fraseriana* and *Banksia menziesii* over isolated shrubs of *Xanthorrhoea preissii* and other native species over introduced grasses.	4.99	1.44
6	Woodland of *Eucalyptus gomphocephala*, *Banksia menziesii*, *Melaleuca rhaphiophylla*, and *Melaleuca preissiana* over shrubland of *Acacia pulchella*, *Macrozamia riedlei*, *Hibbertia hypericoides* and mixed introduced species.	1.23	0.36
7	Woodland of *Eucalyptus gomphocephala*, *Allocasuarina fraseriana* and *Banksia attenuata* over shrubland of *Xanthorrhoea preissii* and *Macrozamia riedlei* over mixed native and introduced herbs and shrubs .	1.44	0.42
8	Woodland of *Eucalyptus marginata*, *Banksia attenuata* and *Allocasuarina fraseriana* over isolated shrubs to open shrubland of *Jacksonia sternbergiana*, *Acacia saligna*, and *Xanthorrhoea preissii* over mixed introduced species .	2.72	0.79
9	Open woodland of *Eucalyptus marginata*, *Allocasuarina fraseriana, Banksia attenuata* and *Banksia menziesii* over shrubland of *Hibbertia hypericoides*, *Acacia pulchella*, *Macrozamia riedlei* over herbland of *Burchardia* sp., *Tetraria octandra* and mixed introduced species .	33.11	9.58
Revegetation	Mixed shrubland regrowth within powerline corridor.	10.95	3.17
Planted - pines	Plant *Pinus* sp.	2.44	0.71
Parkland Cleared	Open woodland of native tree species over non-native understorey	8.34	2.41
C	Cleared - varies between completely cleared for hardstand, housing or infrastructure, paddocks comprising introduced grass and herb species, and residential gardens planted with ornamental species. (Not considered to be native vegetation)	265.07	76.73
Total		**345.48**	**100**



Legend:

- Mandogalup IS boundary (331.2ha)
- Sandwich lots (19.56ha)
- Roads (MRWA)

Vegetation type

- Cleared
- Parkland cleared
- Planted - Pines
- Revegetation
- VT1
- VT2
- VT3
- VT4
- VT5
- VT6
- VT7
- VT8
- VT9

strategen JBS&G

0 300 metres

Job No: 57020		Scale 1:14,000 at A4	
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50	
Drawn By: cthatcher	Checked By: TS	Version: A	Date: 02-Dec-2020

Mandogalup, WA

VEGETATION TYPES (VTS) MAPPED WITHIN THE SURVEY AREA

FIGURE: 4.3

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03_Rev_A\57020_04_3_VTs.mxd

Image Reference: www.nearmap.com© - Imagery Date: 23 September 2020

4.2.5 Threatened and Priority Ecological Communities

The following TECs are present or possibly occur within the Survey Area (based on vegetation surveys conducted):

- *Banksia* woodlands of the Swan Coastal Plain (TEC under EPBC Act; Priority 3 PEC listed by DBCA)
- Tuart woodlands and forests of the Swan Coastal Plain (TEC under EPBC Act; Priority 3 PEC listed by DBCA).

4.2.5.1 Banksia woodlands of the Swan Coastal Plain TEC

An analysis of the relevé data was undertaken to determine the extent of the Banksia Woodlands of the Swan Coastal Plain TEC. The determination of patches was made using the key diagnostic criteria as per the *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community* (TSSC 2016). Four patches were considered for assessment. All four patches met the diagnostic criteria and are therefore considered to form the Banksia Woodlands of the Swan Coastal Plain TEC (Table 4.5). The distribution of this community is shown in Figure 4.4.

Banksia woodlands of the Swan Coastal Plain PEC

The description, area and condition thresholds that apply to the EPBC-listed TEC of the same name, also apply to this Priority ecological community. Given this, the occurrences of the Banksia woodlands of the Swan Coastal Plain TEC are considered to also represent the Banksia woodlands of the Swan Coastal Plain PEC.

Table 4.5: Assessment of vegetation against key diagnostic criteria for *Banksia* Woodlands of the Swan Coastal Plain TEC

Key diagnostic criteria (TSSC 2019)	Patch 1	Patch 2	Patch 3	Patch 4
Location: Occurs in the Swan Coastal Plain or Jarrah Forest IBRA bioregions.	**Yes.** Patch within the Survey Area occurs on the Swan Coastal Plain.	**Yes.** Patch within the Survey Area occurs on the Swan Coastal Plain.	**Yes.** Patch within the Survey Area occurs on the Swan Coastal Plain.	**Yes.** Patch within the Survey Area occurs on the Swan Coastal Plain.
Soils and landform: Occurs on: well drained, low nutrient soils on sandplain landforms, particularly deep Bassendean and Spearwood sands and occasionally on Quindalup sands, sandy colluviums and aeolian sands of the Ridge Hill Shelf, Whicher Scarp and Dandaragan Plateau transitional substrates and sandflats.	**Yes.** Patch within the Survey Area occur on Bassendean sands.	**Yes.** Patch within the Survey Area occur on Bassendean sands.	**Yes.** Patch within the Survey Area occur on Bassendean sands.	**Yes.** Patch within the Survey Area occur on Bassendean sands.
Structure: Low woodland to forest with: a distinctive upper sclerophyllous layer of low trees (occasionally large shrubs more than 2 m tall), typically dominated or co-dominated by one or more of the *Banksia* species identified below emergent trees of medium or tall (>10 m) height. *Eucalyptus* or *Allocasuarina* species may sometimes be present above the *Banksia* canopy an often highly species-rich understorey.	**Yes.** Patch occurs within VTs 1,7,8 and 9 which occur as low woodlands with wither Banksia attenuata or Banksia menziesii within the upper layer.	**Yes.** Patch occurs within VT9 which is described as an Open woodland of *Eucalyptus marginata, Allocasuarina fraseriana, Banksia attenuata* and *Banksia menziesii*	**Yes.** Patch occurs within VT9 which is described as an Open woodland of *Eucalyptus marginata, Allocasuarina fraseriana, Banksia attenuata* and *Banksia menziesii*	**Yes.** Patch occurs within VT6 which is described as a Woodland of *Eucalyptus gomphocephala*, *Banksia menziesii*, *Melaleuca rhaphiophylla*, and *Melaleuca preissiana.*
Composition: Contains at least one of the following species: *Banksia attenuata* *Banksia menziesii* *Banksia prionotes* *Banksia ilicifolia*.	**Yes.** Patch within the Survey Area contains *Banksia attenuata* and *Banksia menziesii*.	**Yes.** Patch within the Survey Area contains *Banksia attenuata* and *Banksia menziesii*.	**Yes.** Patch within the Survey Area contains *Banksia menziesii*.	**Yes.** Patch within the Survey Area contains *Banksia menziesii*.
Condition (Keighery 1994): 'Pristine': no minimum patch size 'Excellent': 0.5 ha 'Very Good': 1 ha 'Good': 2 ha.	**Yes.** Patch of 'Good - Very Good' covers an area of 5.38 ha within the Survey Area. This patch extends outside the survey area to a total area of approximately 20 ha.	**Yes.** Patch of 'Good to Very Good' covers an area of 29.8 ha. This patch extends outside the survey area to a total area of approximately 36 ha.	**Yes.** Patch of 'Very Good' covers an area of 0.63 ha. This patch extends outside the survey area to a total area of approximately 60 ha.	**Yes.** Patch of 'Good - Very Good' covers an area of 1.23 ha. This patch extends outside the survey area to a total area of approximately 36 ha.
Result	TEC present	TEC present	TEC present	TEC present

4.2.5.2 Tuart woodlands and forests of the Swan Coastal Plain TEC

Given the location of the Survey Area, the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC, listed under the EPBC Act on 4 July 2019, was considered to have the potential to occur. Given this, vegetation within the Survey Area was assessed against the diagnostic criteria in the Approved Conservation Advice (incorporating listing advice) for the Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain ecological community (TSSC 2019, Table 4.6; Table 4.7). Tuart woodlands are present within the Survey Area, occurring across one patch (Figure 4.4 Table 4.7).

Table 4.6: Assessment of vegetation within the Survey Area against key diagnostic criteria for Tuart Woodlands of the Swan Coastal Plain TEC

Key diagnostic criteria (TSSC 2019)	Assessment of vegetation within the Survey Area
Location: Occurs in the Swan Coastal Plain Bioregion, Western Australia (IBRA v7. Department of the Environment 2012).	**Yes.** The Survey Area is located within the Swan Coastal Plain Bioregion.
Soils and landform: Primarily occurs on the Spearwood and Quindalup dune systems, but can also occur on the Bassendean dunes and Pinjarra Plain. It can occur on the banks of rivers and wetlands.	**Yes.** The Survey Area occurs on Spearwood and Quindalup dune systems.
Structure and composition: Defining features include: the presence of at least two living established *Eucalyptus gomphocephala* (Tuart) trees in the uppermost canopy layer, although they may co-occur with trees of other species. a gap of no more than 60 m between the outer edges of the canopies of adjacent Tuart trees. These trees may occur either as single stemmed trees or as a mallee growth form. woodland structure, or other structural forms such as forest, open forest, woodland, open woodland, and various mallee forms an understorey of native plants which may include grasses, herbs and shrubs; though this is typically present, it is often modified by disturbance other tree species may be present in the canopy or sub-canopy, commonly including: *Agonis flexuosa* (Peppermint) and *Banksia grandis* (Bull Banksia) (both in the southern part of the range), *Banksia attenuata* (Candlestick Banksia), *Eucalyptus marginata* (Jarrah); and less commonly, *Corymbia calophylla* (Marri), *Banksia menziesii* (Firewood Banksia) and *Banksia prionotes* (Acorn Banksia).	**Yes**. Vegetation within this patch occurs as a woodland to open woodland with *Eucalyptus gomphocephala*.

Table 4.7: Assessment of Tuart Woodlands patches against condition thresholds

Criteria	Patch
	1
Area (ha)	10.62 ha
Native Species Richness per 0.01ha	<4
Proportion of native understorey cover per 0.01 ha	<50%
Density of very large trees per 0.5ha	4.8
Condition (TSSC 2019)*	Moderate
Mean Vegetation Condition (EPA 2016)	Degraded
Result	**TEC present**. Patch >5 ha.

* Condition is based on criteria set out in Table 2 of Approved Conservation Advice (incorporating listing advice) for the Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain ecological community (TSSC 2019)

Tuart (Eucalyptus gomphocephala) woodlands of the Swan Coastal Plain PEC

The description, area and condition thresholds that apply to the EPBC-listed TEC of the same name, also apply to this Priority ecological community. Given this, the occurrences of the Tuart (Eucalyptus gomphocephala) woodlands of the Swan Coastal Plain TEC are considered to also represent the Tuart (Eucalyptus gomphocephala) woodlands of the Swan Coastal Plain PEC.

Legend:

- MIP 47 boundary
- Sandwich lots

Possible TEC/PECs

- Banksia woodlands of the SCP
- Tuart woodlands and forests of the SCP

strategen JBS&G

0 300 metres

Mandogalup, WA

FCTS, PECS AND TECS MAPPED WITHIN THE SURVEY AREA

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: TS	Version: A	Date: 18-Dec-2020	**FIGURE: 4.4**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03_Rev_A\57020_04_4_FCT_PEC_TEC.mxd

Image Reference: www.nearmap.com© - Imagery Date: 23 September 2020

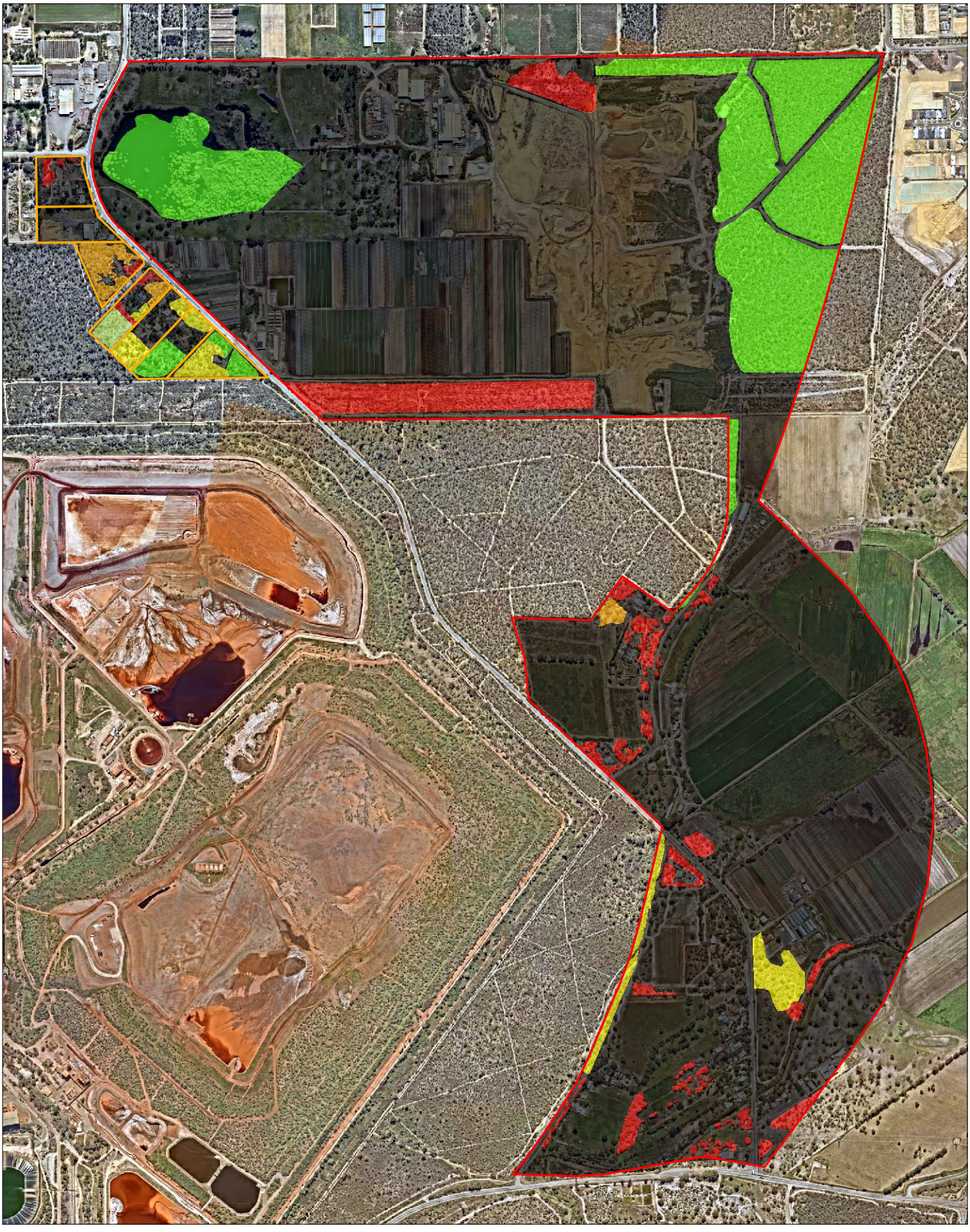
4.2.6 Vegetation Condition

Vegetation condition within the areas surveyed, has been described in Table 3.2. A breakdown of vegetation condition within the areas surveyed is provided in Table 4.8.

A large portion of the unsurveyed areas are cleared and occupied by market gardening land uses. These areas are anticipated to be Completely Degraded in native vegetation condition. However, some unsurveyed areas contain vegetation and should be surveyed prior to any clearing or development.

Table 4.8: Area (ha) covered by each vegetation condition category within the Survey Area

Vegetation Condition	Area (ha)	Percentage of the site (%)
Very Good	42.05	12.17
Good – Very Good	0.72	0.21
Good	5.17	1.50
Degraded - Good	2.03	0.59
Degraded	15.43	4.47
Completely Degraded	280.00	81.07
Total	**345.48**	**100**



Legend:

- Mandogalup IS boundary
- Sandwich lots

Vegetation condition

- Very good
- Good - very good
- Good
- Degraded - good
- Degraded
- Completely degraded

strategen JBS&G

0 300 metres

Mandogalup, WA

VEGETATION CONDITION WITHIN THE SURVEY AREA

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: TS	Version: A	Date: 02-Dec-2020	**FIGURE: 4.5**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03_Rev_A\57020_04_5_VegCond.mxd

Image Reference: www.nearmap.com© - Imagery Date: 23 September 2020

4.2.7 Black cockatoo habitat

A review of the modelled distribution of FRTBC and CBC (DoEE 2017) identifies the Survey Area to be within the non-breeding range of CBC and within the potential breeding range of FRTBC.

Broadly mapped potential feeding areas for CBC (DBCA *et. al* 2011) identify large intact areas of potential CBC foraging habitat within the north-eastern portion of the subject area and within the sandwich lots. Several smaller pockets of potential CBC foraging habitat occur adjacent to the REW in the north-western potion of the subject area, adjacent to Bush Forever site 268 and in the southern portion of the subject area.

Known and potential breeding sites have been mapped by DBCA *et. al* (2011). This mapping does not identify any known or potential breeding sites for CBC within or adjacent to the subject area and sandwich lots. As outlined above, the subject area and sandwich lots are not within the known breeding range of CBC or BC. The nearest confirmed breeding site for CBC is located approximately 10.5 km to the north east of the subject area.

A search of the Great Cocky Count data set prepared by Birdlife WA (2018) identified one known roosting site within 2 km of the subject area and sandwich lots (site code: KWIWANR002). The roosting site is located to the east of the subject area. Five CBC were recorded at the roosting site between 2010 and 2018, and no FRTBC were recorded from this roosting site.

No roosting sites were identified within the proposal area Birdlife WA (2018).

4.2.7.1 Site survey

A total of 410 potential nesting trees were identified within the Survey area (Figure 4.6; species including *Eucalyptus marginata, Eucalyptus gomphocephala, Eucalyptus rudis, Corymbia calophylla*). Of these, 43 trees contained visible hollows of at least 10 cm diameter.

Habitat foraging quality of each vegetation type is shown in Table 4.10 and was determined using the scale described in Table 4.9.

Each vegetation type recorded during the surveys identified in Table 4.4 was assessed for suitability for CBC and FRTBC as outlined in Table 4.10.

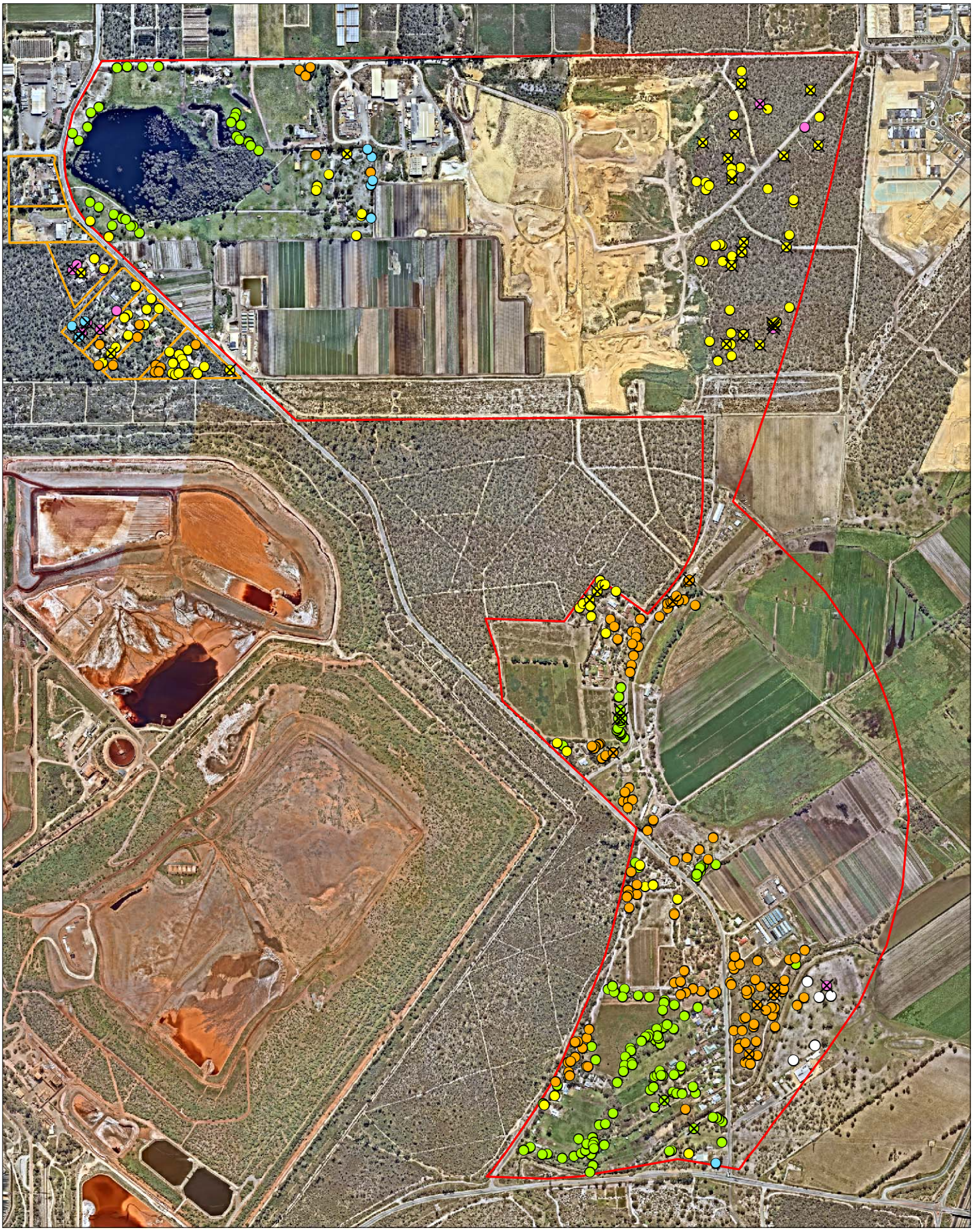
Table 4.9: Definitions of black cockatoo foraging habitat quality

Foraging quality	Justification
Excellent	High density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species >60%) and presence of food sources at several strata (i.e. canopy, midstorey and understorey).
Good	High density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species >60%) but food sources only present at one or two strata (i.e. canopy and midstorey).
Moderate	Moderate foraging value density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species 20-40%) and food sources only present at one or two strata (i.e. canopy and midstorey).
Poor	Low density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species 10-20%) and presence of food sources at only one stratum (i.e. canopy).
Very poor	Very low density of species suitable for foraging by black cockatoos (i.e. foliage cover of suitable species <10%) and presence of food sources at only one stratum (i.e. canopy).
Nil	Cleared areas - no suitable vegetation present.

Table 4.10: Black cockatoo foraging species (by VT) recorded within the Survey Area

Vegetation type	Black cockatoo foraging species	Foraging quality	Area (ha)
Within Scheme (IS 47) site boundary			
3	CBC - *Eucalyptus rudis, Eucalyptus marginata, Corymbia calophylla* FRTBC - *Eucalyptus marginata, Corymbia calophylla*	• Moderate (CBC) • Very poor (FRTBC)	0.92

Vegetation type	Black cockatoo foraging species	Foraging quality	Area (ha)
4	CC - *Eucalyptus rudis, Agonis flexuosa* FRTBC - Nil	• Moderate (CBC) • Nil (FRTBC)	12.55
5	CBC – *Eucalyptus gomphocephala, Eucalyptus rudis, Allocasuarina fraseriana, Banksia menziesii, Xanthorrhoea preissii, *Corymbia maculata* FRTBC – Nil	• Poor – Moderate (CBC) • Nil (FRTBC)	4.99
6	CBC – Banksia attenuata, Xanthorrhoea preissii, Allocasuarina fraseriana, *Banksia menziesii* FRTBC – *Allocasuarina fraseriana*	• Moderate (CBC) • Very poor (FRTBC)	1.23
7	CBC - *Eucalyptus gomphocephala, Allocasuarina fraseriana, Banksia attenuata, Xanthorrhoea preissii* FRTBC - Nil	• Good (CBC) • Nil (FRTBC)	1.44
8	CBC – *Eucalyptus marginata, Xanthorrhoea preissii, *Corymbia maculata, Banksia attenuata, Allocasuarina fraseriana, *Pinus sp.* FRTBC - *Eucalyptus marginata, Allocasuarina fraseriana*	• Poor (CBC) • Very poor (FRTBC)	2.72
9	CBC – *Eucalyptus marginata, Banksia menziesii, Xanthorrhoea preissii, *Corymbia maculata, Jacksonia furcellata, Hakea prostrata* FRTBC - *Eucalyptus marginata*	• Moderate (CBC) • Poor (FRTBC)	33.11
Planted - Pines		• Moderate (CBC)	2.44
Parkland Cleared		• Poor (CBC and FRTBC)	8.34
Cleared		• nil	-



Legend:

- Sandwich lots
- Mandogalup IS boundary
- Hollow present - potentially suitable

Significant Black Cockatoo habitat trees

- *Corymbia calophylla*
- *Eucalyptus gomphocephala*
- *Eucalyptus marginata*
- *Eucalyptus rudis*
- *Eucalyptus* sp.
- N/A

strategen JBS&G

0 300 metres

Mandogalup, WA

BLACK COCKATOO HABITAT

Job No: 57020		Scale 1:14,000 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: cthatcher	Checked By: TS	Version: A	Date: 19-Oct-2020	**FIGURE: 4.6**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R03_Rev_A\57020_04_6_BCHabitat.mxd

Image Reference: www.nearmap.com© - Imagery Date: 23 September 2020

5. Discussion and Conclusion

5.1 Flora and vegetation

The flora and vegetation assessment of the Survey Area was conducted during October and November 2019, which was prime flowering time for a majority of species within the region. A total of 42 native vascular plant taxa from 18 families were recorded within the Survey Area (Appendix C).

A desktop assessment based on general habitat requirements and distribution indicated three Threatened and one Priority flora species were considered to have potential to occur within the Survey Area; as follows:

- *Caladenia huegelii* (Threatened – Endangered [EPBC Act]; Threatened [BC Act])
- *Drakaea elastica* (Threatened – Endangered [EPBC Act]; Threatened [BC Act])
- *Drakaea micrantha* (Threatened – Vulnerable [EPBC Act]; Threatened [BC Act]).

No Threatened species were recorded within the Survey Area. One Priority flora species, *Dodonaea hackettiana* (P4), was recorded within the Survey Area in remnant vegetation alongside Norkett Rd.

During the vegetation assessment, marginal habitat for *D. elastica* was identified within VT1, VT7 and VT9. Further targeted surveys are required during June, July and early August which is the optimal survey timing to determine presence.

Possible habitat for *C. huegelii* was also identified within VT6, VT7 and VT9; however, VT7 contained heavy grass weed infestations which may result in small herbaceous species being outcompeted.. Further targeted surveys of these VTs in spring would be required to assess the presence of this species.

D. micrantha has the potential to occur in areas where competition by other species has been removed including firebreaks. Cleared areas including firebreaks near tracts of remnant native vegetation (e.g. firebreaks in sandwich lots and near Bush Forever sites) should be subject to targeted surveys in spring to further assess whether this species is present.

A total of 33 introduced (exotic) taxa were recorded within the Survey Area. Three declared pest plant species pursuant to section 22 of the *Biosecurity and Agriculture Management Act 2007* (BAM ACT) were recorded in the Survey Area; namely, **Asparagus asparagoides* and **Zantedeschia aethiopica*.

Nine vegetation types (VTs) were defined and mapped within the Survey Area.

Vegetation within the Survey Area was assessed against the key diagnostic criteria as per the Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (TSSC 2016). Four patches of vegetation within the Survey Area met the diagnostic criteria required to form part of this TEC (Figure 4.4). As detailed above, the details of any planned development are required to determine the ecological significance of these patches of Banksia Woodland TEC. Additionally, this vegetation forms part of the *Banksia* woodlands of the Swan Coastal Plain PEC.

Vegetation within the Survey Area was also assessed against diagnostic criteria for Tuart Woodlands and Forests of the Swan Coastal Plain, an ecological community which has recently been listed as a TEC under the EPBC Act. One patch of vegetation within the Survey Area contained tuarts; with an assessment of the patch against detailed diagnostic criteria (TSSC 2019) indicated that it formed part of the TEC (Figure 4.4). Additionally, this vegetation forms part of the Tuart Woodlands and Forests of the Swan Coastal Plain PEC.

5.2 Black cockatoo habitat

A total of 410 significant trees were recorded within the Survey Area (species including *Eucalyptus marginata, Eucalyptus gomphocephala, Eucalyptus rudis, Corymbia calophylla*). Of these, 43 trees contained visible hollows of at least 10 cm diameter. A detailed inspection of these hollows is likely to be required should clearing of these trees be required.

A total of 67.74 ha of potential foraging habitat for both species of Black Cockatoo was recorded within the Survey Area.

Based on density of suitable species present and presence of foraging species within each stratum, foraging habitat quality was rated from Very Poor to Moderate. The remainder of the Survey Area was rated as poor foraging habitat and nil foraging habitat based on the presence and density of suitable species. The foraging habitat present within the Survey Area is considered to be consistent with other local examples of remnant woodland vegetation.

6. Limitations

Scope of services

This report ("the report") has been prepared by Strategen-JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen-JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen-JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen-JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen-JBS&G has also not attempted to determine whether any material matter has been omitted from the data. Strategen-JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen-JBS&G. The making of any assumption does not imply that Strategen-JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen-JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

Strategen-JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by Strategen-JBS&G, and should not be relied upon by other parties, who should make their own enquiries.

7. References

Beard JS 1981, Swan, *1:1000000 vegetation series: explanatory notes to sheet 7: the vegetation of the Swan area,* University of Western Australia Press, Nedlands, Western Australia.

Beard JS 1990, *Plant Life of Western Australia.* Kangaroo Press, Kenthurst, New South Wales.

Bureau of Meteorology (BoM), 2019, *Climatic Statistics for Australian Locations*: *Monthly climate statistics for Gingin Aero,* [Online], Australian Government, Available from: http://www.bom.gov.au/climate/averages/tables/cw_009194.shtml

Churchward HM & McArthur WM, 1980, 'Landforms and Soils of the Darling System', in *Atlas of Natural Resources, Darling System, Western Australia,* eds Department of Conservation and Environment, Perth, pp. 25-33.

Department of Biodiversity, Conservation and Attractions (DBCA), 2018, *Wildlife Conservation (Threatened Flora) Notice 2016* [Online]. Government of Western Australia.

Department of Biodiversity, Conservation and Attractions (DBCA), 2019, List of threatened Ecological Communities, [Online], Government of Western Australia. Available from: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Priority%20ecological%20communities%20list%20_Jan%202019.pdf

Department of Conservation and Land Management (CALM), 2005, *Forrestdale Lake Nature Reserve Management Plan*, Government of Western Australia, Available from: https://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/forrestdale_lake.pdf

Department of Environment and Conservation (DEC), 2010, *Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*, [Online], Government of Western Australia, Available from: http://www.dpaw.wa.gov.au/images/documents/plants-animals/threatenedspecies/tecs/tec-definitions-dec2010.pdf.

Department of the Environment and Energy (DoEE), 2017a, *Interim Biogeographic Regionalisation for Australia, Version 7,* [Online], Australian Government, Available from: http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-anddata/australias-bioregions-ibra

Department of the Environment and Energy (DoEE), 2019, *Species Profiles and Threats Database*, [Online], Australian Government, Available from: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), 2012, *EPBC Act referral guidelines for three threatened black cockatoo species*. Australian Government, Canberra.

Environmental Protection Authority (EPA), 2016, *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment.* Government of Western Australia, Perth.

Executive Steering Committee for Australian Vegetation Information (ESCAVI), 2003, *National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0*, Department of the Environment and Heritage, Australian Government, Available from: https://www.environment.gov.au/land/publications/australian-vegetation-attribute-manual-v6 [29 January 2020].

Gibson N, Keighery B, Keighery G, Burbidge A & Lyons M, 1994, *A Floristic survey of the southern Swan Coastal Plain*, report prepared for the Australian Heritage Commission.

Heddle EM, Loneragan OW & Havel JJ, 1980, *Darling System, Vegetation Complexes*, Forest Department, Perth.

Johnstone RE, 2010, *Information Sheet Carnaby's Cockatoo Calyptorhynchus latirostris*, Department of Terrestrial Vertebrates, Western Australian Museum.

Johnstone RE, 2010b, *Information Sheet Red-tailed Black Cockatoo Calyptorhynchus banksii naso*, Department of Terrestrial Vertebrates, Western Australian Museum.

Johnstone RE & Kirkby T, 2008, *Distribution, status, social organisation, movements and conservation of Baudin's Cockatoo (Calyptorhynchus baudinii) in South-west Western Australia*. *Rec. West. Aust. Mus*. 25(4): 107–118.

Johnstone RE & Kirkby T, (undated), *Black Cockatoos on the Swan Coastal Plain*, report prepared for the Department of Planning, Western Australia.

Mitchell D, Williams K & Desmond A, 2002, 'Swan Coastal Plain 2 (SWA2 – Swan Coastal Plain subregion)', in *A biodiversity audit of Western Australia's 53 Biogeographical Subregions in 2002,* eds Department of Conservation and Land Management, Perth, pp. 606-623.

Thackway & Cresswell, 1995, *An Interim Biogeographic Regionalisation for Australia: A framework for setting priorities in the National Reserves System Cooperative Program Version 4,* Australian Nature Conservation Agency, Canberra.

Threatened Species Scientific Committee (TSSC), 2016, *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community*, [Online], Australian Government, Available from: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/131-conservation-advice.pdf [28 January 2020].

Threatened Species Scientific Committee (TSSC), 2019, *Approved Conservation Advice (incorporating listing advice) for the Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain ecological community*, [Online], Australian Government, Available from: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/131-conservation-advice.pdf [28 January 2020].

Western Australian Herbarium (WAH), 1998-, *Florabase – the Western Australian Flora,* [Online], Government of Western Australia, Available from: https://florabase.dpaw.wa.gov.au/ [January 2020].

Appendix A Conservation significant flora and ecological community definitions

CONSERVATION CODES

For Western Australian Flora and Fauna

Threatened, Extinct and Specially Protected fauna or flora[1] are species[2] which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such.

The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016.*

Categories of Threatened, Extinct and Specially Protected fauna and flora are:

T **Threatened species**

Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act).

Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for Threatened Fauna.

Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the *Wildlife Conservation (Rare Flora) Notice 2018* for Threatened Flora.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

CR **Critically endangered species**

Threatened species considered to be "*facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines*".

Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for critically endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for critically endangered flora.

EN **Endangered species**

Threatened species considered to be "*facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines*".

Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for endangered flora.

VU **Vulnerable species**

Threatened species considered to be "*facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines*".

Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for vulnerable fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for vulnerable flora.

Extinct species

Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.

EX Extinct species

Species where "*there is no reasonable doubt that the last member of the species has died*", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).

Published as presumed extinct under schedule 4 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for extinct fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for extinct flora.

EW Extinct in the wild species

Species that *"is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form*", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).

Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.

Specially protected species

Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.

Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.

MI Migratory species

Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).

Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the *Convention on the Conservation of Migratory Species of Wild Animals* (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species.

Published as migratory birds protected under an international agreement under schedule 5 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

CD Species of special conservation interest (conservation dependent fauna)

Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act).

Published as conservation dependent fauna under schedule 6 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

OS Other specially protected species

Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).

Published as other specially protected fauna under schedule 7 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

P Priority species

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

1 Priority 1: Poorly-known species

Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

2 Priority 2: Poorly-known species

Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

3 Priority 3: Poorly-known species

Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

4 Priority 4: Rare, Near Threatened and other species in need of monitoring

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands.
(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent.
(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

[1] The definition of flora includes algae, fungi and lichens
[2] Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Definition of Threatened Ecological Communities -EPBC Act

Critically endangered

An ecological community is facing an extremely high risk of extinction in the wild in the immediate future (indicative timeframe being the next 10 years).

Endangered

An ecological community is not critically endangered but is facing a very high risk of extinction in the wild in the near future (indicative timeframe being the next 20 years).

Vulnerable

An ecological community is not critically endangered or endangered, but is facing a high risk of extinction in the wild in the medium–term future (indicative timeframe being the next 50 years).

Appendix B Desktop assessment results (DBCA 2019; DoEE 2019)

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 10/10/2019

Kingdom	Plantae
Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	115° 50' 32" E,32° 11' 37" S
Buffer	5km
Group By	Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	452	1913
Priority 3	4	6
Priority 4	1	9
Rare or likely to become extinct	3	20
TOTAL	**460**	**1948**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	1596	*Caladenia huegelii (Grand Spider Orchid)*		T	
2.	12938	*Diuris micrantha*		T	
3.	1639	*Drakaea elastica (Glossy-leaved Hammer Orchid)*		T	
Priority 3					
4.	16245	*Cyathochaeta teretifolia*		P3	
5.	5237	*Pimelea calcicola*		P3	
6.	8163	*Pithocarpa corymbulosa (Corymbose Pithocarpa)*		P3	
7.	25800	*Stylidium paludicola*		P3	
Priority 4					
8.	4763	*Dodonaea hackettiana (Hackett's Hopbush)*		P4	
Non-conservation taxon					
9.		*?Anigozanthos humilis*			
10.		*?Arnocrinum preissii*			
11.		*?Austrostipa compressa*			
12.		*?Austrostipa semibarbata*			Y
13.		*?Burchardia congesta*			
14.		*?Hovea pungens*			Y
15.		*?Hovea trisperma var. trisperma*			
16.		*?Hybanthus calycinus*			Y
17.		*?Kunzea glabrescens*			
18.		*?Lepidosperma squamatum s.l.*			
19.		*?Lomandra caespitosa*			
20.		*?Lotus subbiflorus*			
21.		*?Lysimachia arvensis*			
22.		*?Mesomelaena pseudostygia*			Y
23.		*?Microlaena stipoides*			
24.		*?Phlebocarya ciliata*			
25.		*?Phyllanthus calycinus*			Y
26.		*?Pterostylis sanguinea*			
27.		*?Rytidosperma occidentalis*			
28.		*?Sowerbaea laxiflora*			
29.		*?Vicia sativa*			Y
30.	3262	*Acacia cochlearis (Rigid Wattle)*			
31.	3282	*Acacia cyclops (Coastal Wattle)*			
32.	3374	*Acacia huegelii*			
33.	3502	*Acacia pulchella (Prickly Moses)*			
34.	30032	*Acacia saligna subsp. saligna*			
35.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
36.	3602	*Acacia willdenowiana (Grass Wattle)*			
37.	6203	*Actinotus glomeratus*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
38.	1775	*Adenanthos cygnorum (Common Woollybush)*			
39.	11837	*Adenanthos cygnorum subsp. cygnorum (Common Woollybush)*			
40.	1791	*Adenanthos obovatus (Basket Flower)*			
41.	17202	*Agonis flexuosa var. flexuosa*			
42.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
43.		*Aira caryophyllea/cupaniana group*			
44.	185	*Aira cupaniana (Silvery Hairgrass)*	Y		
45.	187	*Aira praecox (Early Hairgrass)*	Y		
46.	1728	*Allocasuarina fraseriana (Sheoak, Kondil)*			
47.	1732	*Allocasuarina humilis (Dwarf Sheoak)*			
48.	198	*Amphipogon laguroides*			
49.	20184	*Amphipogon laguroides subsp. laguroides*			
50.	200	*Amphipogon turbinatus*			
51.	7833	*Angianthus preissianus*			
52.	11434	*Anigozanthos humilis subsp. humilis*			
53.	1411	*Anigozanthos manglesii (Mangles Kangaroo Paw, Kurulbrang)*			
54.	11261	*Anigozanthos manglesii subsp. manglesii*			
55.	3688	*Aotus gracillima*			
56.	3692	*Aotus procumbens*			
57.	1264	*Arnocrinum preissii*			
58.	8779	*Asparagus asparagoides (Bridal Creeper)*	Y		
59.	20283	*Astartea scoparia (Common Astartea)*			
60.		*Asterella drummondii*			
61.	6334	*Astroloma pallidum (Kick Bush)*			
62.		*Austrostipa ?semibarbata*			Y
63.	17234	*Austrostipa compressa*			
64.	17240	*Austrostipa flavescens*			
65.	17245	*Austrostipa mollis*			
66.	17253	*Austrostipa semibarbata*			
67.		*Austrostipa sp.*			
68.	37421	*Austrostipa sp. Marchagee (B.R. Maslin 1407)*			
69.	233	*Avena barbata (Bearded Oat)*	Y		
70.	36441	*Babingtonia camphorosmae (Camphor Myrtle)*			
71.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
72.	32580	*Banksia dallanneyi subsp. dallanneyi var. dallanneyi*			
73.	1822	*Banksia ilicifolia (Holly-leaved Banksia)*			
74.	1830	*Banksia littoralis (Swamp Banksia, Pungura)*			
75.	1834	*Banksia menziesii (Firewood Banksia)*			
76.	32077	*Banksia sessilis var. cygnorum*			
77.	1852	*Banksia telmatiaea (Swamp Fox Banksia)*			
78.	741	*Baumea articulata (Jointed Rush)*			
79.	743	*Baumea juncea (Bare Twigrush)*			
80.	5382	*Beaufortia elegans (Elegant Beaufortia)*			
81.	48868	*Bellardia viscosa*	Y		
82.	749	*Bolboschoenus caldwellii (Marsh Club-rush)*			
83.	4413	*Boronia crenulata (Aniseed Boronia)*			
84.	11503	*Boronia crenulata subsp. crenulata var. crenulata*			
85.	16636	*Boronia crenulata subsp. viminea*			
86.	4417	*Boronia dichotoma*			
87.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
88.	6341	*Brachyloma preissii (Globe Heath)*			
89.	8661	*Brachypodium distachyon (False Brome)*	Y		
90.	3000	*Brassica tournefortii (Mediterranean Turnip)*	Y		
91.	244	*Briza maxima (Blowfly Grass)*	Y		
92.	245	*Briza minor (Shivery Grass)*	Y		
93.		*Briza sp.*			
94.	249	*Bromus diandrus (Great Brome)*	Y		
95.	12770	*Burchardia congesta*			
96.	1276	*Caesia micrantha (Pale Grass Lily)*			
97.	1277	*Caesia occidentalis*			
98.		*Caladenia ?flava*			
99.	1586	*Caladenia discoidea (Dancing Orchid)*			
100.	1592	*Caladenia flava (Cowslip Orchid)*			
101.	1599	*Caladenia latifolia (Pink Fairy Orchid)*			
102.	15361	*Caladenia longicauda subsp. calcigena*			
103.	17760	*Caladenia nobilis*			
104.		*Caladenia sp.*			
105.	2848	*Calandrinia corrigioloides (Strap Purslane)*			
106.	19309	*Calectasia narragara*			
107.	34942	*Callitriche brutia subsp. brutia*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
108.	36600	*Callitris pyramidalis (Swamp Cypress)*			
109.	5411	*Calothamnus hirsutus*			
110.	5415	*Calothamnus lateralis*			
111.	5439	*Calytrix angulata (Yellow Starflower)*			
112.	5458	*Calytrix flavescens (Summer Starflower)*			
113.	5460	*Calytrix fraseri (Pink Summer Calytrix)*			
114.	5476	*Calytrix sapphirina*			
115.	2795	*Carpobrotus edulis (Hottentot Fig)*	Y		
116.	1162	*Cartonema philydroides*			
117.	2951	*Cassytha flava (Dodder Laurel)*			
118.	2957	*Cassytha racemosa (Dodder Laurel)*			
119.	11799	*Cassytha racemosa forma racemosa*			
120.	41568	*Cenchrus setaceus (Fountain Grass)*	Y		
121.	6542	*Centaurium tenuiflorum*	Y		
122.	1125	*Centrolepis drummondiana*			
123.	1134	*Centrolepis polygyna (Wiry Centrolepis)*			
124.	2889	*Cerastium glomeratum (Mouse Ear Chickweed)*	Y		
125.	18156	*Chamaecytisus palmensis (Tagasaste)*	Y		
126.	1280	*Chamaescilla corymbosa (Blue Squill)*			
127.	11299	*Chamaescilla corymbosa var. corymbosa*			
128.	7937	*Cirsium vulgare (Spear Thistle, Scotch Thistle)*	Y		
129.	4550	*Comesperma calymega (Blue-spike Milkwort)*			
130.	4555	*Comesperma integerrimum*			
131.	15611	*Conospermum stoechadis subsp. stoechadis (Common Smokebush)*			
132.	6348	*Conostephium pendulum (Pearl Flower)*			
133.	6349	*Conostephium preissii*			
134.	1418	*Conostylis aculeata (Prickly Conostylis)*			
135.	11826	*Conostylis aculeata subsp. aculeata*			
136.	1436	*Conostylis juncea*			
137.	1454	*Conostylis setigera (Bristly Cottonhead)*			
138.	11597	*Conostylis setigera subsp. setigera*			
139.		*Conyza ?bonariensis*			
140.	7939	*Conyza bonariensis (Flaxleaf Fleabane)*	Y		
141.		*Conyza sp.*			
142.	20074	*Conyza sumatrensis*	Y		
143.	48259	*Cortaderia selloana subsp. selloana*	Y		
144.	1285	*Corynotheca micrantha (Sand Lily)*			
145.	7945	*Cotula coronopifolia (Waterbuttons)*	Y		
146.	3137	*Crassula colorata (Dense Stonecrop)*			
147.	11563	*Crassula colorata var. colorata*			
148.	19625	*Cymbalaria muralis subsp. muralis*	Y		
149.	806	*Cyperus polystachyos (Bunchy Sedge)*			
150.	816	*Cyperus tenuiflorus (Scaly Sedge)*	Y		
151.	7454	*Dampiera linearis (Common Dampiera)*			
152.	35618	*Darwinia sp. Karonie (K. Newbey 8503)*			
153.	1218	*Dasypogon bromeliifolius (Pineapple Bush)*			
154.	3807	*Daviesia divaricata (Marno)*			
155.	3832	*Daviesia physodes*			
156.	3845	*Daviesia triflora*			
157.	16595	*Desmocladus flexuosus*			
158.	299	*Deyeuxia quadriseta (Reed Bentgrass)*			
159.	1259	*Dianella revoluta (Blueberry Lily)*			
160.	11636	*Dianella revoluta var. divaricata*			
161.	17838	*Dielsia stenostachya*			
162.	9027	*Diplolaena drummondii*			
163.	19649	*Disa bracteata*	Y		
164.	7054	*Dischisma arenarium*	Y		
165.		*Diuris corymbosa/magnifica*			
166.	1634	*Diuris laxiflora (Bee Orchid)*			
167.	12939	*Diuris magnifica*			
168.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
169.	3106	*Drosera macrantha (Bridal Rainbow)*			
170.	3109	*Drosera menziesii (Pink Rainbow)*			
171.	48710	*Drosera micrantha*			
172.	3118	*Drosera pallida (Pale Rainbow)*			
173.	29178	*Drosera porrecta*			
174.		*Drosera sp. "climbing"*			
175.	3135	*Drosera zonaria (Painted Sundew)*			
176.		*Ehrharta ?longiflora*			Y
177.	347	*Ehrharta calycina (Perennial Veldt Grass)*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
178.	349	*Ehrharta longiflora (Annual Veldt Grass)*	Y		
179.		*Ehrharta sp.*			
180.	1645	*Epiblema grandiflorum (Babe-in-a-cradle)*			
181.	6133	*Epilobium hirtigerum (Hairy Willow Herb)*			
182.	13949	*Eremaea asterocarpa*			
183.	13950	*Eremaea asterocarpa subsp. asterocarpa*			
184.	5541	*Eremaea pauciflora*			
185.	14104	*Eremaea pauciflora var. pauciflora*			
186.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
187.	5615	*Eucalyptus decipiens (Limestone Marlock, Moit)*			
188.	5708	*Eucalyptus marginata (Jarrah, Djara)*			
189.	13547	*Eucalyptus marginata subsp. marginata (Jarrah)*			
190.	5763	*Eucalyptus rudis (Flooded Gum, Kulurda)*			
191.	13511	*Eucalyptus rudis subsp. rudis*			
192.	5790	*Eucalyptus todtiana (Coastal Blackbutt)*			
193.	3872	*Euchilopsis linearis (Swamp Pea)*			
194.	20014	*Euphorbia hyssopifolia*	Y		
195.	4648	*Euphorbia terracina (Geraldton Carnation Weed)*	Y		
196.	3880	*Eutaxia virgata*			
197.	1747	*Ficus carica (Common Fig)*	Y		
198.	2969	*Fumaria capreolata (Whiteflower Fumitory)*	Y		
199.		*Fumaria sp.*			
200.	907	*Gahnia trifida (Coast Saw-sedge)*			
201.	20247	*Gamochaeta calviceps*	Y		
202.	20475	*Gastrolobium capitatum*			
203.	20473	*Gastrolobium ebracteolatum*			
204.	20483	*Gastrolobium linearifolium*			
205.	1520	*Gladiolus caryophyllaceus (Wild Gladiolus)*	Y		
206.	6587	*Gomphocarpus fruticosus (Narrowleaf Cottonbush)*	Y		
207.	3957	*Gompholobium tomentosum (Hairy Yellow Pea)*			
208.	6161	*Gonocarpus pithyoides*			
209.	7538	*Goodenia pulchella*			
210.	14282	*Gratiola pubescens*			
211.	12824	*Grevillea vestita subsp. vestita*			
212.		*Haemodorum sp.*			
213.	1475	*Haemodorum spicatum (Mardja)*			
214.	2197	*Hakea prostrata (Harsh Hakea)*			
215.	2214	*Hakea trifurcata (Two-leaf Hakea)*			
216.	2216	*Hakea varia (Variable-leaved Hakea)*			
217.	3961	*Hardenbergia comptoniana (Native Wisteria)*			
218.	6839	*Hemiandra pungens (Snakebush)*			
219.	38320	*Hemiandra sp. Jurien (B.J. Conn & M.E. Tozer BJC 3885)*			
220.	1293	*Hensmania turbinata*			
221.	5134	*Hibbertia huegelii*			
222.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
223.	45534	*Hibbertia hypericoides subsp. hypericoides*			
224.	5162	*Hibbertia racemosa (Stalked Guinea Flower)*			
225.	48381	*Hibbertia striata*			
226.	5173	*Hibbertia subvaginata*			
227.	5176	*Hibbertia vaginata*			
228.	444	*Holcus lanatus (Yorkshire Fog)*	Y		
229.	6222	*Homalosciadium homalocarpum*			
230.	3966	*Hovea pungens (Devil's Pins, Puyenak)*			
231.	3968	*Hovea trisperma (Common Hovea)*			
232.	12859	*Hovea trisperma var. trisperma*			
233.	12741	*Hyalosperma cotula*			
234.	5216	*Hybanthus calycinus (Wild Violet)*			
235.	6224	*Hydrocotyle blepharocarpa*			
236.	6240	*Hydrocotyle scutellifera*			
237.	5817	*Hypocalymma angustifolium (White Myrtle, Kudjid)*			
238.	35070	*Hypocalymma angustifolium subsp. Swan Coastal Plain (G.J. Keighery 16777)*			
239.	5825	*Hypocalymma robustum (Swan River Myrtle)*			
240.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
241.	9352	*Hypochaeris radicata (Flat Weed, Cats-ear)*	Y		
242.	1070	*Hypolaena exsulca*			
243.	17841	*Hypolaena pubescens*			
244.		*Iridaceae sp.*			Y
245.	20200	*Isolepis cernua var. setiformis*			
246.	917	*Isolepis marginata (Coarse Club-rush)*			
247.	19700	*Isotropis cuneifolia subsp. cuneifolia*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
248.	4012	*Jacksonia furcellata (Grey Stinkwood)*			
249.	4029	*Jacksonia sternbergiana (Stinkwood, Kapur)*			
250.	1178	*Juncus bufonius (Toad Rush)*	Y		
251.	1186	*Juncus microcephalus*	Y		
252.	1188	*Juncus pallidus (Pale Rush)*			
253.	1190	*Juncus planifolius (Broadleaf Rush)*			
254.	4044	*Kennedia prostrata (Scarlet Runner)*			
255.	5832	*Kunzea ericifolia (Spearwood, Pondil)*			
256.	15498	*Kunzea glabrescens (Spearwood)*			
257.	20019	*Lachnagrostis filiformis*			
258.	8096	*Lactuca serriola (Prickly Lettuce)*	Y		
259.	18585	*Lagenophora huegelii*			
260.	467	*Lagurus ovatus (Hare's Tail Grass)*	Y		
261.	4052	*Latrobea tenella*			
262.	1307	*Laxmannia ramosa (Branching Lily)*			
263.	11911	*Laxmannia ramosa subsp. ramosa*			
264.	1309	*Laxmannia squarrosa*			
265.	7572	*Lechenaultia expansa*			
266.	7574	*Lechenaultia floribunda (Free-flowering Leschenaultia)*			
267.	44490	*Leontodon rhagadioloides*	Y		
268.		*Lepidosperma ?aff. costale*			Y
269.	925	*Lepidosperma angustatum*			
270.	937	*Lepidosperma longitudinale (Pithy Sword-sedge)*			
271.	940	*Lepidosperma pubisquameum*			
272.	944	*Lepidosperma scabrum*			
273.		*Lepidosperma scabrum (inland form)*			Y
274.		*Lepidosperma sp.*			
275.		*Lepidosperma sp. Brixton Street broad inflorescence*			
276.		*Lepidosperma sp. Brixton Street broadish inflorescence*			Y
277.		*Lepidosperma sp. Brixton Street narrow inflorescence*			
278.	945	*Lepidosperma squamatum*			
279.		*Lepidosperma squamatum s.l.*			
280.	946	*Lepidosperma striatum*			
281.	1653	*Leporella fimbriata (Hare Orchid)*			
282.	1077	*Leptocarpus canus (Hoary Twine-rush)*			
283.	1080	*Leptocarpus scariosus*			
284.	2342	*Leptomeria cunninghamii*			
285.	2344	*Leptomeria empetriformis*			
286.	2350	*Leptomeria pauciflora (Sparse-flowered Currant Bush)*			
287.	5850	*Leptospermum laevigatum (Coast Teatree)*	Y		
288.	6360	*Leucopogon australis (Spiked Beard-heath)*			
289.	6374	*Leucopogon conostephioides*			
290.	6436	*Leucopogon propinquus*			
291.	7676	*Levenhookia pusilla (Midget Stylewort)*			
292.		*Levenhookia pusilla/stipitata*			
293.	7677	*Levenhookia stipitata (Common Stylewort)*			
294.	9289	*Lobelia anceps (Angled Lobelia)*			
295.	7408	*Lobelia tenuior (Slender Lobelia)*			
296.	6515	*Logania vaginalis (White Spray)*			
297.	478	*Lolium rigidum (Wimmera Ryegrass)*	Y		
298.		*Lolium sp. (annual)*			
299.		*Lomandra ?caespitosa*			
300.		*Lomandra ?preissii*			
301.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
302.	1228	*Lomandra hermaphrodita*			
303.	14542	*Lomandra micrantha subsp. micrantha*			
304.	1234	*Lomandra nigricans*			
305.	1239	*Lomandra preissii*			
306.	1246	*Lomandra suaveolens*			
307.	8564	*Lotus subbiflorus*	Y		
308.	1198	*Luzula meridionalis (Field Woodrush)*			
309.	1097	*Lyginia barbata*			
310.	18049	*Lyginia imberbis*			
311.	1656	*Lyperanthus serratus (Rattle Beak Orchid)*			
312.	36375	*Lysimachia arvensis (Pimpernel)*	Y		
313.	6456	*Lysinema ciliatum (Curry Flower)*			
314.	5281	*Lythrum hyssopifolia (Lesser Loosestrife)*	Y		
315.	2839	*Macarthuria australis*			
316.	18119	*Macrozamia fraseri*			
317.	85	*Macrozamia riedlei (Zamia, Djiridji)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
318.	4079	*Medicago polymorpha (Burr Medic)*	Y		
319.	5900	*Melaleuca cuticularis (Saltwater Paperbark)*			
320.	13271	*Melaleuca huegelii subsp. huegelii*			
321.	13273	*Melaleuca incana subsp. incana*			
322.	5926	*Melaleuca lateritia (Robin Redbreast Bush)*			
323.	5946	*Melaleuca pauciflora*			
324.	5952	*Melaleuca preissiana (Moonah)*			
325.	5959	*Melaleuca rhaphiophylla (Swamp Paperbark)*			
326.	5964	*Melaleuca seriata*			
327.	18598	*Melaleuca systena*			
328.	5978	*Melaleuca teretifolia (Banbar)*			
329.	5980	*Melaleuca thymoides*			
330.	4085	*Melilotus indicus*	Y		
331.	955	*Mesomelaena pseudostygia*			
332.	957	*Mesomelaena tetragona (Semaphore Sedge)*			
333.	485	*Microlaena stipoides (Weeping Grass)*			
334.	1658	*Microtis atrata (Swamp Mignonette Orchid)*			
335.	15419	*Microtis media subsp. media*			
336.	6189	*Myriophyllum crispatum*			
337.	6199	*Myriophyllum tillaeoides*			
338.	492	*Neurachne alopecuroidea (Foxtail Mulga Grass)*			
339.	6974	*Nicotiana glauca (Tree Tobacco)*	Y		
340.	12782	*Ophioglossum gramineum*			
341.	36177	*Ornduffia albiflora*			
342.	4113	*Ornithopus compressus (Yellow Serradella)*	Y		
343.	4358	*Oxalis purpurea (Largeflower Wood Sorrel)*	Y		
344.	527	*Paspalum dilatatum*	Y		
345.	1550	*Patersonia occidentalis (Purple Flag, Koma)*			
346.	30471	*Patersonia occidentalis var. angustifolia*			
347.	30472	*Patersonia occidentalis var. occidentalis*			
348.	4343	*Pelargonium capitatum (Rose Pelargonium)*	Y		
349.	40423	*Pentameris airoides (False Hairgrass)*	Y		
350.	6006	*Pericalymma ellipticum (Swamp Teatree)*			
351.	16477	*Pericalymma ellipticum var. ellipticum*			
352.	2273	*Persoonia saccata (Snottygobble)*			
353.	2299	*Petrophile linearis (Pixie Mops)*			
354.	2301	*Petrophile macrostachya*			
355.	2312	*Petrophile striata*			
356.	19825	*Petrorhagia dubia*	Y		
357.	552	*Phalaris paradoxa (Paradoxa Grass)*	Y		
358.	1478	*Phlebocarya ciliata*			
359.	16177	*Phyllangium paradoxum*			
360.	4675	*Phyllanthus calycinus (False Boronia)*			
361.	2793	*Phytolacca octandra (Red Ink Plant)*	Y		
362.	18117	*Pimelea rosea subsp. rosea*			
363.	6249	*Platysace compressa (Tapeworm Plant)*			
364.	6253	*Platysace filiformis*			
365.	4524	*Platytheca galioides*			
366.		*Poaceae sp.*			
367.	8175	*Podolepis gracilis (Slender Podolepis)*			
368.	8182	*Podotheca angustifolia (Sticky Longheads)*			
369.	8183	*Podotheca chrysantha (Yellow Podotheca)*			
370.	8184	*Podotheca gnaphalioides (Golden Long-heads)*			
371.	582	*Polypogon monspeliensis (Annual Beardgrass)*	Y		
372.	4691	*Poranthera microphylla (Small Poranthera)*			
373.		*Poranthera microphylla/moorokatta*			
374.	1670	*Prasophyllum drummondii (Swamp Leek Orchid)*			
375.	10853	*Prasophyllum plumiforme*			
376.	8189	*Pseudognaphalium luteoalbum (Jersey Cudweed)*			
377.	15426	*Pterostylis aspera*			
378.	44723	*Pterostylis glebosa*			
379.	1693	*Pterostylis recurva (Jug Orchid)*			
380.	12217	*Pterostylis sanguinea*			
381.		*Pterostylis sp.*			
382.	2718	*Ptilotus drummondii (Narrowleaf Mulla Mulla)*			
383.	11260	*Ptilotus drummondii var. drummondii (Pussytail)*			
384.	4181	*Pultenaea reticulata*			
385.	16367	*Pyrorchis nigricans (Red beaks, Elephants ears)*			
386.	8195	*Quinetia urvillei*			
387.	6012	*Regelia ciliata*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
388.	3085	*Reseda luteola (Wild Mingnonette)*	Y		
389.	13300	*Rhodanthe citrina*			
390.	14485	*Romulea flava var. minor*	Y		
391.	1556	*Romulea rosea (Guildford Grass)*	Y		
392.	14924	*Romulea rosea var. communis*	Y		
393.	40426	*Rytidosperma occidentale*			
394.	6483	*Samolus junceus*			
395.	11647	*Samolus repens var. repens*			
396.	7603	*Scaevola canescens (Grey Scaevola)*			
397.	978	*Schoenus brevisetis*			
398.	982	*Schoenus clandestinus*			
399.	984	*Schoenus curvifolius*			
400.	986	*Schoenus efoliatus*			
401.	992	*Schoenus grandiflorus (Large Flowered Bogrush)*			
402.	6033	*Scholtzia involucrata (Spiked Scholtzia)*			
403.	2909	*Silene gallica (French Catchfly)*	Y		
404.	15972	*Silene gallica var. gallica*	Y		
405.	8225	*Siloxerus humifusus (Procumbent Siloxerus)*			
406.	7020	*Solanum linnaeanum (Apple of Sodom)*	Y		
407.	7022	*Solanum nigrum (Black Berry Nightshade)*	Y		
408.	9367	*Sonchus hydrophilus (Native Sowthistle)*			
409.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
410.	1312	*Sowerbaea laxiflora (Purple Tassels)*			
411.	4211	*Sphaerolobium vimineum (Leafless Globe Pea)*			
412.	2316	*Stirlingia latifolia (Blueboy)*			
413.	7693	*Stylidium brunonianum (Pink Fountain Triggerplant)*			
414.	7774	*Stylidium piliferum (Common Butterfly Triggerplant)*			
415.	7785	*Stylidium repens (Matted Triggerplant)*			
416.	25806	*Stylidium scariosum*			
417.	7798	*Stylidium schoenoides (Cow Kicks)*			
418.	1260	*Stypandra glauca (Blind Grass)*			
419.	2329	*Synaphea spinulosa*			
420.	15532	*Synaphea spinulosa subsp. spinulosa*			
421.	11143	*Thelymitra graminea*			
422.	20731	*Thelymitra vulgaris*			
423.	20728	*Thelymitra xanthotricha*			
424.		*Thysanotus ?thyrsoideus*			
425.	1318	*Thysanotus arbuscula*			
426.	1319	*Thysanotus arenarius*			
427.	1338	*Thysanotus manglesianus (Fringed Lily)*			
428.		*Thysanotus manglesianus/patersonii complex*			
429.	1339	*Thysanotus multiflorus (Many-flowered Fringe Lily)*			
430.	1343	*Thysanotus patersonii*			
431.		*Thysanotus sp.*			
432.	1351	*Thysanotus sparteus*			
433.	1357	*Thysanotus thyrsoideus*			
434.	1358	*Thysanotus triandrus*			
435.	6280	*Trachymene pilosa (Native Parsnip)*			
436.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
437.	1363	*Tricoryne tenella*			
438.	1038	*Tricostularia neesii*			
439.	17145	*Trifolium angustifolium var. angustifolium*	Y		
440.		*Trifolium campestre/dubium*			
441.	14738	*Trifolium resupinatum var. resupinatum*	Y		
442.	4360	*Tropaeolum majus (Garden Nasturtium)*	Y		
443.	8254	*Urospermum picroides (False Hawkbit)*	Y		
444.	8255	*Ursinia anthemoides (Ursinia)*	Y		
445.	38388	*Ursinia anthemoides subsp. anthemoides*	Y		
446.	15725	*Verbesina encelioides*	Y		
447.	15432	*Verticordia densiflora var. densiflora*			
448.	4320	*Vicia hirsuta (Hairy Vetch)*	Y		
449.	11474	*Vicia sativa subsp. nigra*	Y		
450.	722	*Vulpia bromoides (Squirrel Tail Fescue)*	Y		
451.		*Vulpia sp.*			
452.	7384	*Wahlenbergia capensis (Cape Bluebell)*	Y		
453.	7389	*Wahlenbergia preissii*			
454.	8282	*Waitzia suaveolens (Fragrant Waitzia)*			
455.	12072	*Wurmbea dioica subsp. alba*			
456.	1256	*Xanthorrhoea preissii (Grass tree, Palga)*			
457.		*Xanthorrhoea sp.*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
458.	6289	*Xanthosia huegelii*			
459.	2331	*Xylomelum occidentale (Woody Pear, Djandin)*			
460.	1049	*Zantedeschia aethiopica (Arum Lily)*	Y		

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

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

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

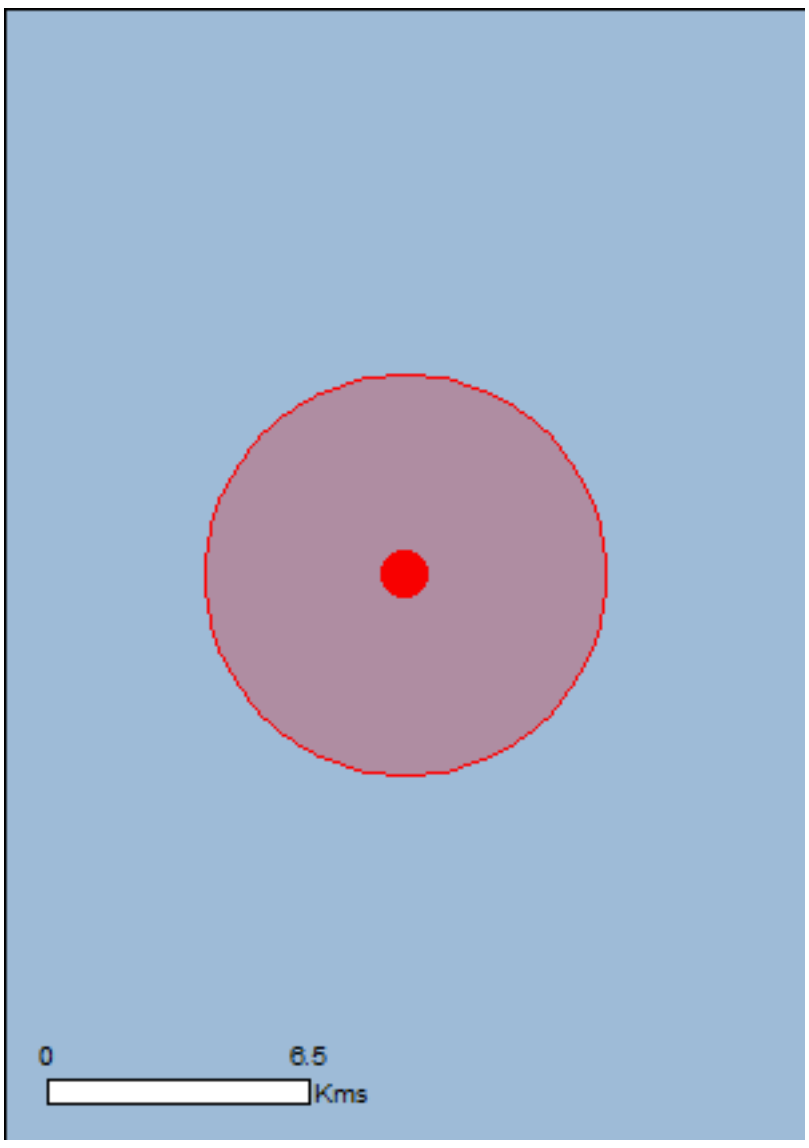
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

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

Report created: 10/10/19 20:42:06

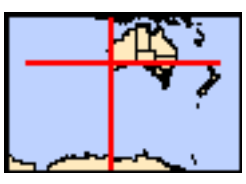
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	21
Listed Migratory Species:	19

Other Matters Protected by the EPBC Act

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

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

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

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	28
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

State and Territory Reserves:	5
Regional Forest Agreements:	None
Invasive Species:	40
Nationally Important Wetlands:	3
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Forrestdale and thomsons lakes	Within Ramsar site
Peel-yalgorup system	30 - 40km upstream

Listed Threatened Ecological Communities [Resource Information]

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

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Tuart (Eucalyptus gomphocephala) Woodlands and Forests of the Swan Coastal Plain ecological community	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area

Name	Status	Type of Presence
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Species or species habitat may occur within area
Mammals		
Dasyurus geoffroii		
Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis		
Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat likely to occur within area
Other		
Westralunio carteri		
Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Andersonia gracilis		
Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Caladenia huegelii		
King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat known to occur within area
Diuris micrantha		
Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei		
Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica		
Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat known to occur within area
Drakaea micrantha		
Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eleocharis keigheryi		
Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Lepidosperma rostratum		
Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Sterna dougallii		
Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat likely to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Species or species habitat known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat known to occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Harry Waring Marsupial Reserve	WA
Thomsons Lake	WA
Unnamed WA48291	WA
Unnamed WA49561	WA
Wandi	WA

Invasive Species	[Resource Information]

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

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla		
Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area

Nationally Important Wetlands	[Resource Information]
Name	State
Gibbs Road Swamp System	WA
Spectacles Swamp	WA
Thomsons Lake	WA

Caveat

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

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

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

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

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-32.19018 115.84266

Acknowledgements

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

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

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

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

© Commonwealth of Australia
Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix C Native plant taxa recorded within the Survey Area

Table C-1: Native plant taxa recorded within the Survey Area

Family	Taxa
Asparagaceae	*Sowerbaea laxiflora*
Casuarinaceae	*Allocasuarina fraseriana*
	Allocasuarina humilis
	Casuarina ?obesa
Colchicaceae	*Burchardia congesta*
Cyperaceae	*Leucopogon propinquus*
	Mesomelaena pseudostygia
	Tetraria octandra
Dennstaedtiaceae	*Pteridium esculentum*
Dilleniaceae	*Hibbertia hypericoides*
Ericaceae	*Astroloma macrocalyx*
Fabaceae	*Acacia pulchella*
	Acacia rostellifera
	Acacia saligna
	Acacia willdenowiana
	Gompholobium tomentosum
	Hardenbergia comptoniana
	Kennedia prostrata
Goodeniaceae	*Scaevola repens*
Haemodoraceae	*Conostylis aculeata*
Hemerocallidaceae	*Corynotheca micrantha*
	Dianella revoluta
Myrtaceae	*Agonis flexuosa*
	Chamelaucium uncinatum
	Corymbia calophylla
	Eucalyptus gomphocephala
	Eucalyptus marginata
	Eucalyptus rudis
	Hypocalymma angustifolium
	Kunzea recurva
	Melaleuca preissiana
	Melaleuca rhaphiophylla
	Taxandria linearifolia
Phyllanthaceae	*Phyllanthus calycinus*
Poaceae	*Jacksonia furcellata*
	Jacksonia sternbergiana
	Poaceae sp.
Proteaceae	*Banksia attenuata*
	Banksia grandis
	Banksia ilicifolia
	Banksia menziesii
	Hakea prostrata
	Petrophile linearis
	Stirlingia latifolia
Ranunculaceae	*Clematis pubescens*
Restionaceae	*Desmocladus flexuosus*
Sapindaceae	*Dodonaea hackettiana* (P4)
Typhaceae	*Typha orientalis*
Xanthorrhoeaceae	*Xanthorrhoea preissii*
Zamiaceae	*Macrozamia riedlei*

© JBS&G Australia Pty Ltd T/A Strategen-JBS&G

This document is and shall remain the property of Strategen-JBS&G. The document may only be used for the purposes for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Document Distribution

Rev No.	Copies	Recipient	Date
A	Electronic	Taylor Burrell Barnett	31/01/2020
0	Electronic	Taylor Burrell Barnett	23/03/2020
1	Electronic	Taylor Burrell Barnett	18/12/2020

Document Status

Rev No.	Author	Reviewer	Approved for Issue		
		Name	Name	Signature	Date
A	A Hortle / R Chesney / W Oversby	T Sleigh / C Obrien	D Newsome		31/01/2020
0	C O'Brien	D Newsome	D Newsome		23/03/2020
1	T Sleigh	D Newsome	D Newsome		18/12/2020

www.jbsg.com.au

Appendix C Basic Summary of Records (Alcoa landholding)

Contaminated Sites Act 2003
Basic Summary of Records Search Response

Report generated at 02:58:29PM, 18/12/2019

Receipt No:	
ID No:	*74385*

Search Results

This response relates to a search request received for:

Lot 501 On Plan 72707
Hope Valley, WA, 6165

This parcel belongs to a site that contains 1 parcel(s).

According to Department of Water and Environmental Regulation records, this land has been reported as a known or suspected contaminated site.

Address	Lot 501 On Plan 72707 Hope Valley, WA, 6165
Lot on Plan Address	Lot 501 On Plan 72707
Parcel Status	**Classification:** 06/03/2009 - *Contaminated - remediation required* **Nature and Extent of Contamination:** Alkali groundwater plumes are present beneath the Source Site. **Restrictions on Use:** Abstraction of groundwater at the Source Site is restricted to remediation of contamination and industrial refinery purposes. The land use of the Source Site is restricted to non-sensitive commercial/industrial use. **Reason for Classification:** This Site was reported to the Department of Environment and Conservation (DEC) prior to the commencement of the 'Contaminated Sites Act 2003'. The Site classification is based on information submitted to DEC by 31 May 2007. The Site operates as part of an alumina refining operation. The Site infrastructure includes alumina refinery residue storage and disposal areas, cooling ponds, pipelines and a network of groundwater recovery and monitoring bores. These are land uses that have the potential to cause contamination, as specified in the guideline 'Potentially Contaminating Activities, Industries and Land uses' (Department of Environment, 2004). This Site comprises a source of alkali groundwater contamination that has migrated to affect a parcel of land to the east. The Affected Site has been classified separately. The Source Site is Lot 100 Anketell Road, Hope Valley. The Affected Site is Lot 89 Mandogalup Road, Mandogalup. Periodic groundwater investigations are undertaken at the Source Site as a condition of the licence for the Source Site under the Environmental Protection Act 1986. Groundwater investigations

Disclaimer
This Summary of Records has been prepared by Department of Water and Environmental Regulation (DWER) as a requirement of the Contaminated Sites Act 2003. DWER makes every effort to ensure the accuracy, currency and reliability of this information at the time it was prepared, however advises that due to the ability of contamination to potentially change in nature and extent over time, circumstances may have changed since the information was originally provided. Users must exercise their own skill and care when interpreting the information contained within this Summary of Records and, where applicable, obtain independent professional advice appropriate to their circumstances. In no event will DWER, its agents or employees be held responsible for any loss or damage arising from any use of or reliance on this information. Additionally, the Summary of Records must not be reproduced or supplied to third parties except in full and unabridged form.

Contaminated Sites Act 2003
Basic Summary of Records Search Response

Report generated at 02:58:29PM, 18/12/2019

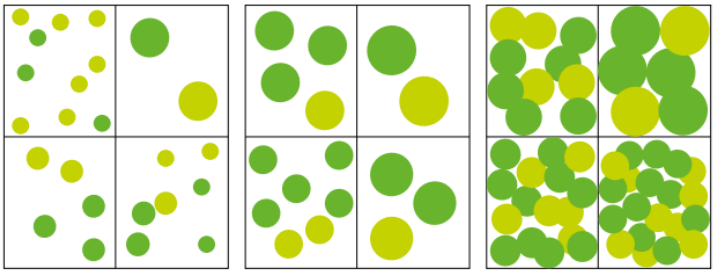
	conducted in 2006 identified the presence of elevated pH, alkalinity, electrical conductivity and salinity. The investigations found that this poor groundwater quality was caused by leaking of sodium carbonate and sodium hydroxide from refinery residue storage ponds. The groundwater investigations were limited in nature and did not meet the standards set out in DEC's "Contaminated Sites Management Series" of guidelines and the extent of the groundwater contamination beneath the Source Site has not been accurately delineated. Groundwater contamination plumes at the Source Site are being actively managed by means of recovery bores, natural attenuation and periodic monitoring. The Source Site has only been partially investigated and reported to Contaminated Sites Branch of DEC; as such a comment cannot be made on the suitability of the Source Site as a whole for a land use. As remedial works are in progress but not yet completed, the Source Site is classified as 'contaminated - remediation required'. As the alumina refinery residue area site is a Source Site, future reports on investigation, assessment, monitoring or remediation of the Source and Affected Sites which are submitted to DEC will need to be accompanied by a Mandatory Auditor's Report, in accordance with regulation 31(1)(b) of the Contaminated Sites Regulations 2006. DEC, in consultation with Department of Health, has classified this Source Site based on the information available to DEC at the time of classification. It is acknowledged that the contamination status of the Source Site may have changed since the information was collated and/or submitted to DEC, and as such, the usefulness of this information may be limited.
Certificate of Title Memorial	Under the Contaminated Sites Act 2003, this Site has been classified as "Contaminated - remediation required". An instrument affecting land which comprises all, or part of, this Site will not be registered or accepted for registration, unless the CEO of the Department of Environment & Conservation consents to the registration in writing. For further information on the contamination status of this Site, or this restriction, please contact the Contaminated Sites section of the Department of Environment & Conservation.
Current Regulatory Notice Issued	**Type of Regulatory Notice:** *Nil* **Date Issued:** *Nil*
General	No other information relating to this parcel.

Disclaimer
This Summary of Records has been prepared by Department of Water and Environmental Regulation (DWER) as a requirement of the Contaminated Sites Act 2003. DWER makes every effort to ensure the accuracy, currency and reliability of this information at the time it was prepared, however advises that due to the ability of contamination to potentially change in nature and extent over time, circumstances may have changed since the information was originally provided. Users must exercise their own skill and care when interpreting the information contained within this Summary of Records and, where applicable, obtain independent professional advice appropriate to their circumstances. In no event will DWER, its agents or employees be held responsible for any loss or damage arising from any use of or reliance on this information. Additionally, the Summary of Records must not be reproduced or supplied to third parties except in full and unabridged form.

Appendix D APZ standards

Schedule 1: Standards for Asset Protection Zones

- **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.



15% 30% 70%

- **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.

© JBS&G Australia Pty Ltd T/A Strategen-JBS&G

This document is and shall remain the property of Strategen-JBS&G. The document may only be used for the purposes for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Document Distribution

Rev No.	Copies	Recipient	Date
2	Electronic	DPLH	10/11/2021

Document Status

Rev No.	Author	Reviewer	Approved for Issue		
		Name	Name	Signature	Date
A	C. OBrien	D. Newsome	D. Newsome		20/12/2019
B	C. OBrien	D. Newsome	D. Newsome		21/01/2020
C	C. OBrien	D. Newsome	D. Newsome		06/02/2020
0	C. OBrien	D. Newsome	D. Newsome		24/03/2020
1	C. OBrien	D. Newsome	D. Newsome		18/12/2020
2	G. Ogston, J. Culverwell	J. Blitz	J. Blitz		10/11/2021

Appendix B

District Water Management Strategy

Department of Planning, Lands and Heritage

Mandogalup Improvement Scheme

District Water Management Strategy (DWMS)

August 2023

Report ref. J6778e

JDA Consultant Hydrologists

DISCLAIMER

This document is published in accordance with and subject to an agreement between JDA Consultant Hydrologists ("JDA") and the client for whom it has been prepared ("Client"), and is restricted to those issues that have been raised by the Client in its engagement of JDA. It has been prepared using the skill and care ordinarily exercised by Consultant Hydrologists in the preparation of such documents.

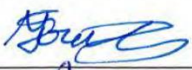
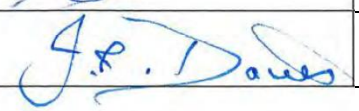
Any person or organisation that relies on or uses the document for purposes or reasons other than those agreed by JDA and the Client without first obtaining a prior written consent of JDA, does so entirely at their own risk and JDA denies all liability in tort, contract or otherwise for any loss, damage or injury of any kind whatsoever (whether in negligence or otherwise) that may be suffered as a consequence of relying on this document for any purpose other than that agreed with the Client.

JDA does not take responsibility for checking any landscape and engineering plans attached to this report for accuracy or consistency with this report.

QUALITY ASSURANCE

The JDA quality control system has been in place since 1997 and meets the requirements of AS/NZS ISO 9001:2008. JDA is committed to maintaining and improving the quality management system.

Document Version No.	Issue Date
J6778a (DRAFT)	29 November 2019
J6778b	4 February 2020
J6778c	25 March 2020
J6778d	10 November 2021
J6778e	21 August 2023

	Name	Signature	Date
Author	Michael Ioannidis		21 August 2023
Checked by	Alex Rogers		21 August 2023
Approved by	Jim Davies		21 August 2023

CONTENTS

1. INTRODUCTION **1**

1.1 PRINCIPLES AND OBJECTIVES 1

1.2 LOCAL PLANNING AND MASTER PLAN CONCEPT 1

2. PRE-DEVELOPMENT ENVIRONMENT **2**

2.1 EXISTING LAND USE 2

2.2 TOPOGRAPHY 2

2.3 CLIMATE 2

2.4 SOILS AND SURFACE GEOLOGY 3

2.5 ACID SULPHATE SOILS 3

2.6 WETLANDS AND SIGNIFICANT VEGETATION 4

2.7 SURFACE HYDROLOGY 4

2.7.1 Existing Surface Drainage *4*

2.7.2 Drainage Catchments *5*

2.7.3 Peel Main Drain Nutrient Loading to the Peel-Harvey Estuary *5*

2.8 GROUNDWATER HYDROLOGY 5

2.8.1 Hydrogeology *5*

2.8.2 Groundwater Levels *6*

2.8.3 Groundwater Availability *7*

2.9 CONTAMINATED SITES 7

2.10 ABORIGINAL HERITAGE 8

2.11 SITE CONSTRAINTS AND OPPORTUNITIES 8

3. SURFACE WATER MANAGEMENT STRATEGY **11**

3.1 KEY DESIGN CRITERIA 11

3.1.1 Surface Water Quantity *11*

3.1.2 Surface Water Quality *11*

3.2 PEEL MAIN DRAIN 12

3.3 PEEL MAIN DRAIN ONLINE STORAGE IN MANDOGALUP SWAMP 12

3.4 DRAINAGE CATCHMENTS AND PEAK FLOW ESTIMATES 13

4. GROUNDWATER MANAGEMENT STRATEGY **15**

4.1 KEY OBJECTIVES 15

4.2 GROUNDWATER LEVELS 15

4.3 GROUNDWATER QUALITY 15

4.4 PRE-DEVELOPMENT MONITORING 16

5. WATER SOURCE PLANNING AND CONSERVATION **17**

5.1 KEY OBJECTIVES 17

5.1 WATER SUPPLY 17

5.1.1 Potable Water *17*

5.1.2 Non-Potable Water *17*

5.2 WASTEWATER MANAGEMENT 19
5.3 WATER CONSERVATION OBJECTIVES 19
6. IMPLEMENTATION FRAMEWORK 21
6.1 LOCAL STRUCTURE PLANNING 21
6.2 WATER MANAGEMENT STRATEGY SUMMARY 21
7. REFERENCES 23

LIST OF TABLES

1. Geomorphic Wetlands within Subject Area
2. DWER Bore Details
3. DWER Groundwater Resource Allocation Limits & Availability (November, 2019)
4. Pre- and Post-Development Levels and Volume of Mandogalup Swamp (DoW, 2009)
5. Peak Allowable Outflows and Detention Storages Required
6. Summary of Design Objectives

LIST OF FIGURES

1. Location Plan
2. Jandakot Structure Plan (WAPC, 2007)
3. Aerial Photography
4. Topography
5. Rainfall and Evaporation
6. Surface Geology, Soils and Acid Sulphate Soils Mapping
7. Wetland, Bush Forever and Aboriginal Heritage Mapping
8. Surface Water Mapping and Drainage Catchments
9. Groundwater Contours
10. Long-Term Groundwater Levels, DWER Bores T95(O), T140(O), JM41 and JE12A
11. Groundwater Management Areas and Current Groundwater Licences
12. Mandogalup Swamp Development Scenarios
13. Concept Land Use Plan and Indicative Storage Requirements

APPENDICES

A. Mandogalup Local Planning Scheme (TBB, 2023a)
B. Concept Land Use Plan (TBB, 2023b)
C. Extracts from Jandakot DWMP (DoW, 2009)
D. Extracts from Rockwater (2019)

1. INTRODUCTION

This District Water Management Strategy (DWMS) has been prepared by JDA Consultant Hydrologists on behalf of the Department of Planning, Lands and Heritage [DPLH] for 344 ha of land in the Mandogalup locality in the City of Kwinana. This includes a 331 ha parcel of land gazetted under Improvement Plan 47 (IP47): *Mandogalup* and an additional 14 ha sub-section of lots in the north-west corner of the Subject Area, west of Mandogalup Road, Figure 1.

1.1 Principles and Objectives

In addition to Better Urban Water Management (WAPC, 2008) this DWMS uses the following documents to define its key principles and objectives:

- Jandakot Structure Plan (WAPC, 2007);
- Jandakot Drainage and Water Management Plan (DoW, 2009a);
- Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorus Management (EPA, 2008) which is an implementation of the State Planning Policy 2.1: Peel-Harvey coastal plan catchment (1992);
- Decision Process for Stormwater Management in Western Australia (DWER, 2017);
- Stormwater Management Manual for WA (DWER, 2022); and
- Peel-Harvey Coastal Catchment: Water Sensitive Urban Design Technical Guidelines (PDC, 2006).

This DWMS Area has a 116 ha crossover with the DWMS prepared for the eastern side of the Mandogalup locality (JDA, 2018), Figure 1. The water management strategy proposed in this DWMS is consistent with JDA (2018).

1.2 Local Planning and Master Plan Concept

The Subject Area is generally zoned *Rural* and *Urban* under the Metropolitan Region Scheme and *Rural A* under the City of Kwinana Local Planning Scheme No. 2. The north-east corner is included within Area of Landscape Protection Poly Area 4 and portions of the Subject Area are including the Drainage Catchment Management area.

The proposed Local Planning Scheme map for IP47 is included in Appendix A. Once IP47 is gazetted, the Metropolitan Region Scheme and City of Kwinana Local Planning Scheme No. 2 will cease to apply.

A Master Plan Concept has been prepared for the Subject Area and is attached as Appendix B. The majority of the Subject Area (343 ha) is proposed General/Light Industrial (174 ha). In addition, Composite lots (24 ha) are proposed in the south-west; Residential lots within the north-east (18 ha) and Service Commercial lots (8 ha) adjacent to the proposed Hammond Road Extension through the Subject Area.

2. PRE-DEVELOPMENT ENVIRONMENT

2.1 Existing Land Use

The 344 ha Subject Area is bound by Rowley Road to north, partially Mandogalup Road to the west and Anketell Road to the south, Figure 1.

The Subject Area forms part of the Mandogalup cell of the Jandakot Structure Plan Area, Figure 2 and is designated as “long-term urban” (WAPC, 2007). The land is currently zoned Rural and Urban under the Metropolitan Region Scheme.

Land use is predominantly market gardens and medium-scale agriculture with some rural residential, Figure 3. A sand quarry is located in the north with a pocket of native vegetation in the north-east corner of the site. A High Voltage (HV) transmission corridor traverses the site from east to west in the north and to smaller extents in south and central-east of the Subject Area, see Figure 1.

2.2 Topography

Figure 4 shows topography across the Subject Area and is generally varied and influenced by current land use. The topographic contours have been taken from LiDAR (2008) with Figure 4 showing an aerial image from 26 May 2008, similar to the LiDAR capture date.

The northern section of the Subject Area shows topography generally sloping east to west from 35 and 40 mAHD to 10 mAHD at the north-western corner of the Subject Area. Contours shown in Figure 4 around the sand quarry are likely not representative of current elevations. For example, the mound suggested in the northern area near Rowley Road appears to represent stock-pilling of sand on the land in 2008, as evidenced in the 26 May 2008 aerial photograph. No such mound is evident in the aerial photograph April 2023 in Figure 3.

In the southern section of the Subject Area, there are three topographic mounds at 20 to 23 mAHD shown on Figure 4 which generally slope towards Peel Main Drain (12 to 13 mAHD). The Main Drain is shown as a more incised channel near the southern end of the Subject Area and shallower amongst the market garden areas of Mandogalup Swamp (13 mAHD).

2.3 Climate

The Mandogalup area is characterised by a Mediterranean climate with warm dry summers and cool wet winters.

Rainfall data is provided by the nearby Bureau of Meteorology *Anketell* rain gauge (Site ID. 009258), 3.8 km south-east of the Subject Area, and the *Medina Research Centre* gauge (Site ID. 009194), 4.4 km south-west, Figure 5. The Medina Research Station gauge was closed in 2018 and formed part of a larger weather station operated by the Department of Primary Industries and Regional Development [DPIRD]. This weather station was relocated in 2018 to Harry Waring Marsupial Reserve in Wattleup, 2 km north of the Subject Area and 6.9 km north-east of the previous location.

The average annual rainfall, 1984 to 2017, for Medina Research Station was 746 mm and for Anketell, 2002 to 2022, was 796 mm. The annual rainfall totals recorded at Anketell gauge were generally 50 to

100 mm higher than at the Medina Research Station. The 10-year average annual rainfall for Anketell, 2013 to 2022, is 799 mm, similar to the total station average. There is a general decreasing rainfall trend across south-west Western Australian since the 1970s (DoW, 2015), however, the nearest rain gauges to the Subject Area predate this general shift. Monthly average totals show no significant trends. Across south-west Western Australia, there has also generally been a shift in rainfall distribution with reduction in winter rainfall but reductions or increases in rainfall in the drier summer months.

Average annual pan evaporation for the Subject Area is estimated at 1,670 mm from monthly pan evaporation data at DPIRD's Wattleup weather station (2018-2022). This is similar to estimated average annual pan evaporation of 1,700 mm in Luke et al. (1987).

2.4 Soils and Surface Geology

Surface geology mapping by Gozzard (1983) is shown on Figure 6 and indicates the Subject Area is generally calcareous coastal sands from the Spearwood Sand System (S7 & S8) with areas of silt associated with low lying wetland-swamp areas (Ms5) and a small outcrop of peaty clay (Cps) in the north.

Description of the key geological units in the Subject Area are:

Sand (S7):	Pale yellowish brown, medium to coarse-grained sub-angular quartz, trace of feldspar, moderately sorted, or residual origin.
Sand (S8):	Very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin.
Sandy Silt (Ms5):	Dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content, of lacustrine origin.
Peaty Clay (Cps):	Dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin.

2.5 Acid Sulphate Soils

Regional acid sulphate soil mapping (Figure 6) published by the DER (2014) generally aligns to surface geology mapping by Gozzard (1983).

Surface Geology mapped as S8 *Sand* is classified as Class 2, having a moderate to low risk of Acid Sulphate Soils (A.S.S) occurring less than 3 m from surface.

Ms5 *Sandy Silt* and Cps *Peaty Clay* areas are classified as Class 1, having a high to moderate risk of A.S.S less than 3 m from surface.

2.6 Wetlands and Significant Vegetation

The Geomorphic Wetlands Mapping of the Swan Coastal Plain (DPaW, 2016) is shown in Figure 7.

Details of wetlands within the Subject Area are given in Table 1 below.

TABLE 1: GEOMORPHIC WETLANDS WITHIN SUBJECT AREA

Wetland Category	General Description	UFI Indicator
Conservation	Wetlands which support a high level of attributes and functions	N/A
Resource Enhancement	Wetlands which may have been partially modified but still support substantial ecological attributed and functions	6610
Multiple Use	Wetlands with few remaining important attributes and functions	6530, 6538

A Resource Enhancement [RE] Wetland (UFI 6610), Wattleup Lake, is located in the north-west corner of the Subject Area with vegetation within and surrounding the RE wetland classified as Bush Forever. Generally a 50 m buffer is required around the RE Wetland as shown on Figure 7.

A 100 ha Bush Forever site is located adjacent to the Subject Area's western boundary, with a 1 ha portion of this within the Subject Area (Figure 7). The Spectacles Wetlands are located just south of Anketell Road with surrounding vegetation classified as Bush Forever.

Ministerial statement no. 688: Jandakot Mound Groundwater Resources sets water level criteria for 10 wetland sites, 9 terrestrial phreatophytic vegetation sites, and 4 rare flora sites across the Jandakot, Perth and Cockburn groundwater areas. Lake Banganup, 1.3 km north, is the closest of these listed sites to the Subject Area.

2.7 Surface Hydrology

2.7.1 Existing Surface Drainage

The Peel Main Drain generally flows north-east to south-west through the southern extent of the Subject Area (Figure 8), and across Anketell Road and into the northern Spectacles Wetland. Long-sections of the existing Peel Main Drain through the Subject Area from the Jandakot DWMP (DoW, 2009) are attached in Appendix C.

A Water Corporation open channel is located in the south-west corner of the Subject Area and connects to the Main Drain near Anketell Road.

In the north-western section of the Subject Area, any surface water runoff will flow towards Wattleup Lake. In the north-east section, surface water flow is to a topographic low-point within the Banksia Woodlands. This area is included as part of the InfoWorks Peel Main Drain model in the DWMP, however, it is denoted as "soakage", that is, an internally draining catchment, and is not shown as contributing flow to the Main Drain. This is confirmed by review of topography of this area (Figure 4).

2.7.2 Drainage Catchments

The Subject Area falls within part of 6 subcatchments identified in the DWMP: CAT16A, CAT17, CAT17B, CT17B, CAT18 and CAT18A; shown on Figure 8.

The north-western section of the Subject Area drains westwards and is not part of the Peel Main Drain catchment.

2.7.3 Peel Main Drain Nutrient Loading to the Peel-Harvey Estuary

Peel Main Drain is a tributary of the Serpentine River. The statutory Environmental Protection Policy (EPP) (EPA, 1992) target for annual median load of phosphorus flowing into the Peel-Harvey Estuary from the Serpentine River is 21 tonnes. The catchment area of the Serpentine River is 1018 km^2. Assuming 70% (717 km^2) development of the catchment, the target phosphorus loading rate from the Serpentine catchment to the Estuary is 0.29 kg/ha/yr.

Estimated nitrogen and phosphorus loads (1997 to 2007) from the Peel Main Drain catchment of 120 km^2 with 79% potential developed area and 11.2 GL annual flow, are 25.8 TN and 4.5 tonnes TP, respectively (Kelsey *et al.*, 2011). This equates to a phosphorus loading rate of 0.47 kg/ha/yr. To reach the EPP target of 21 tonnes/yr TP from the Serpentine catchment, the target load from the Peel Main Drain catchment is a maximum of 2.8 tonnes/yr.

Based on this nutrient loading target, the EPA (2008) Total Phosphorus target is for a long-term 0.1 mg/L median winter concentration, or 0.2 mg/L in the shorter term.

There are no target loadings or concentration for Nitrogen to the Peel-Harvey Estuary, either in EPA (1992) nor EPA (2008).

UNDO water quality modelling will be required at the LSP/LWMS stage to assess proposed development impacts on outflow water quality.

2.8 Groundwater Hydrology

2.8.1 Hydrogeology

The hydrogeological formations under the Subject Area are grouped into three distinct aquifers, each being assigned the name of the major geological unit contributing to it. In descending order of depth from natural surface they are: Superficial Aquifer (unconfined), Leederville Aquifer (confined) and Yarragadee Aquifer (confined).

The superficial aquifer is directly recharged from direct rainfall percolation, and within the Subject Area has a saturated thickness of approximately 30 to 40 m. The base of the superficial aquifer is estimated to be approximately at -20 mAHD (Department of Environment, 2004).

The superficial formations are comprised of Tamala Limestone with generally fresh to slightly brackish groundwater (500 to 1000 mg/L Total Dissolved Solids) and slightly acidic to neutral pH (Davidson, 1995).

The Leederville Formation underlies the Superficial Formation (Davidson, 1995). Beneath the Subject Area, it has a thickness of about 300 m. It consists of generally fine to medium-grained quartz sandstone and inter-bedded grey shale, which form a multi-layed, confined aquifer.

The Yarragadee Formation underlies the Leederville Formation beneath the Subject Area. It consists predominantly of medium to coarse grained sandstone in the lower part of the Formation and inter-bedded sands and shales in the upper part.

2.8.2 Groundwater Levels

The Perth Groundwater Atlas First Edition (WRC, 1997) provides estimated maximum groundwater contours and shows groundwater flowing from north-east to south-west across the Subject Area. In Figure 9 these maximum groundwater levels range from 18 mAHD in the north-east corner to 10 to 11 mAHD in the respective north-west and south-west corners of the Subject Area. Figure 9 also shows the Controlled Groundwater Level (CGL) contours as presented in the Jandakot DWMP (DoW, 2009).

West of the Subject Area, the difference between CGL (DoW, 2009) and Estimated Maximum Groundwater Levels (WRC, 1997) is 2 to 3 m, Figure 9. For the Subject Area itself, the CGL is generally 0.5 to 1 m lower than Estimated Maximum Groundwater Levels (MGLs).

Bore details of shallow long-term DWER groundwater bores within or near the Subject Area are summarised in Table 2 and their locations shown in Figure 9. Long-Term groundwater levels from these DWER Bores are shown in Figure 10.

TABLE 2: DWER BORE DETAILS

Bore	GDA 94 Coordinates		Top of casing [mAHD]	Natural Surface [mAHD]	Maximum Level and Year	Maximum Level (2004 – 2022) and Year	Interp. Max Level from WRC (1997)
	Easting	Northing					
T95(O)	388387	6439234	22.71	22.28	2.42 (1984)	1.52 (2021)	3.4
JM41	390745	6437277	20.23	19.65	13.72 (1975)	12.88 (2022)	13.5
T140(O)	390984	6435915	16.68	16.13	12.62 (1974)	12.23 (2018)	14.1
JE12C	391646	6438958	37.07	36.72	21.14 (2021)	21.14 (2021)	20.8

Note: All Levels in mAHD

Groundwater levels in T95(O) and T140(O) have been relatively stable across the long-term at 0.5 to 1.5 mAHD and 10.5 to 12 mAHD, respectively. MGLs in both bores are 1 to 1.5 m below estimated maximum, Table 2.

Groundwater Levels in JM41 and JE12C show a downward trend from the 1970s and 1980s till around 2010 when groundwater levels have progressively risen to the present. For JM41, the 2022 peak was still 0.8 m below maximum recorded levels and 0.6 m below WRC (1997) contours, Table 2. For JE12C, the 2021 peak was the maximum recorded groundwater level at the bore, 0.34 m above the estimated maximum interpolated from WRC (1997) groundwater contours.

Groundwater contours from WRC (1997) provide initial guidance on groundwater variations across the Subject Area. These should be refined with pre-development monitoring across the Subject Area.

2.8.3 Groundwater Availability

The Department of Water and Environmental Regulation (DWER) manages the groundwater of the State under the Rights in Water and Irrigation Act 1914 (RIWI Act). The Subject Area intersects both the Cockburn (west) and Jandakot (east) Groundwater Areas, Figure 11.

The *Cockburn Groundwater Allocation Plan* (DWER, 2021) replaces the previous 2007 Allocation Plan. The western side of the Subject Area is covered by the Valley and Thompsons subareas. There is no allocation plan for the Jandakot Groundwater Area.

DWER groundwater allocation limits and remaining available abstractions from relevant aquifers are shown in Table 3 as at July/August 2023. All aquifers are over-allocated with no allocations available.

TABLE 3: DWER GROUNDWATER RESOURCE ALLOCATION LIMITS & AVAILABILITY (JULY/AUGUST 2023)

GW Area	GW Sub-Area	Aquifer Category	Allocation Limit Licensable component, (kL/yr)	Allocated & committed (kL/yr)	% Allocated & committed	Balance Available (kL/yr)
Cockburn	Thompsons	Superficial Swan	4,280,000	4,894,188	114	0
	Valley	Superficial Swan	5,500,000	6,938,450	126	0
	Cockburn Confined	Leederville	1,350,000	1,500,000	111	0
		Yaragadee North	5,150,000	5,155,689	100	0
Jandakot	Mandogalup	Superficial Swan	1,990,000	1,826,270	92	0
	Jandakot Confined	Yaragadee North	0	0	0	0

Current groundwater licences and their allocations across the Subject Area are shown on Figure 11.

Total current allocation across the Subject Area is approximately 2,250,000 kL/yr; 70% of which is under a single licence (1,550,000 kL/yr). All licences are for the Superficial Aquifer.

A licenced allocation of 75,000 kL/yr is held by QUBE for Aspley Estate, part of which intersects the Subject Area.

2.9 Contaminated Sites

A search of DWER's publicly available Contaminated Sites Database (accessed 16 August 2023) indicated no contaminated sites within the Subject Area. JDA notes the publicly available database only identifies 3 of the 7 contaminated sites classifications: *Contaminated – restricted use*; *Contaminated – remediation required*; and *Remediated for restricted use*. The remaining classifications are *Report not substantiated*; *Possibly contaminated – investigation required*, *Not contaminated – unrestricted use*; and *Decontaminated*.

The Alcoa Residue Storage Area, Figure 1, is down-gradient of the Subject Area and is classified as a *Contaminated – remediation required* contaminated site. In response to a Form 2 request in 2019 for a summary of records, DWER has provided JDA with the following documents:

- *Alcoa Kwinana Refinery Borehole Performance and Aquifer Review 2006*, March 2007 (Parsons Brinckerhoff [PB], 2007); and

- *Review of Borefield Performance and Groundwater Quality Report for Alcoa of Australia Limited*, April 2019 (Rockwater, 2019)

Extracts from Rockwater (2019) are attached as Appendix D to this report.

Figure 2 in Appendix D shows the layout of the Aloca Kwinana site including Residue Storage Areas A, B, C, F, H, J, K, L and N, with Area F the largest and eastern-most. Areas A, B, C and F were the earliest constructed ponds and defects thereafter developed in the underlying clay liner of these storage areas (except for Area B).

Investigations of the Alcoa Kwinana site in 2006 identified high pH, alkalinity, electrical conductivity and salinity from sodium carbonate and hydroxide leakage from residue storage ponds (DEC, 2019). The initial listing of the Residue Storage Area suggested that a source of alkali groundwater contamination had migrated eastward to affect Lot 89 Mandogalup Road; located west of Mandogalup Road and within the Subject Area. Lot 89 is listed as a contaminated site but is not shown on the publicly available Contaminated Sites Database.

Rockwater (2019) suggests there is an area of elevated alkali contamination in the north-east corner of Area F. This plume was estimated to extend 100 m outside of the eastern Aloca property. The buffer between the western lots of the Subject Area and Alcoa Residue Storage Area is approximately 200 m.

Bore F-154S/D, shown on Figure 2 in Appendix D, is the upgradient bore monitored six monthly for pH and electrical conductivity (EC) as part of Alcoa's Kwinana Groundwater Monitoring and Management Plan. Monitoring of F-154S/D in 2016, 2017 and 2018 showed a rise in EC across both years from 1,295 µS/cm (2016) to 1,656 µS/cm (2018). EC results for the period however were in the range of the last 7 years of 1,200 µS/cm (2014) to 1,800 µS/cm (2012). Rockwater (2019) suggested the rises between 2016 and 2018 in F-154S/D were in the range of the natural variations of the bore over the last 7 years and not associated with any alkaline groundwater plume.

A PSI assessment and groundwater quality monitoring of lots west of Mandogalup Road will be required at the LSP/LWMS stage to further ascertain any potential migration of the alkaline plume into the Subject Area.

2.10 Aboriginal Heritage

Wattleup Road Swamp, 400 m north of the Subject Area, is a registered Aboriginal Heritage Site (Figure 7). However, there are no registered sites within the Subject Area.

2.11 Site Constraints and Opportunities

The above described characteristics of the pre-development environment in the Subject Area provide a number of key constraints and opportunities for the application of Water Sensitive Urban Design with land use change:

- Acid Sulphate Soil risk mapping for the Subject Area indicates high to moderate risk of A.S.S. occurring within 3 m of the existing surface for silty soil areas of the Subject Area, in particular around Mandogalup Swamp. An A.S.S Investigation and Management Plan will be required prior to development.

- Geomorphic Wetland mapping identifies multiple wetlands in the Subject Area, including Resource Enhancement and Multiple Use categories. A detailed assessment of all wetlands will be required at the Local Structure Planning stage to assess the condition, value and any development constraints around each wetland.
- Estimated Maximum Groundwater Contours (WRC, 1997) provides initial guidance of likely depth to groundwater across the Subject Area. Approximately one third of the site has Estimated Maximum Groundwater (WRC, 1997) within 1.5 m of the existing natural surface, in particular near the Peel Main Drain, Mandogalup Swamp and Wattleup Lake. Subsoil drainage will likely be required in the southern areas (Peel Main Drain and Mandogalup Swamp) for management and control of any water level rise in the post-development environment – these are part of the Peel Main Drain catchment and subsoil will discharge to the Drain. In the northern area, much of the western sections are cleared for quarrying or market gardens (Figure 3) – these will currently have relatively high rainfall recharge rates to groundwater, and the impact of urbanisation on groundwater level change will be smaller than for the southern area, even with infiltration of stormwater runoff. Groundwater change on the eastern boundary will be limited due to the planned implementation of subsoil drainage in the adjacent subdivisions.
- The northern section of the Subject Area has sandy soils and a greater depth to groundwater (>4 to 5 m) than the rest of the Subject Area. On-site retention of all stormwater is possible in these areas, however, an overflow to Wattleup Lake may be required.
- Sandy soils over most of the site will aid the infiltration of frequently occurring storm events (i.e. first 15mm rainfall event) at source where possible via soakwells or other small-scale infiltration devices.
- The DWMP (DoW, 2009) identifies Mandogalup Swamp as an important regional flood storage and modelling was used to assess four potential scenarios for post development land use for partial or complete filling of the swamp on the flood storage capacity of the drain. The preferred scenario keeps the powerline and pipeline corridors within Mandogalup Swamp undeveloped (see Figure 12). The alignment and associated storage volumes and flood levels of Mandogalup Swamp should be refined with detailed modelling at the LSP/LWMS stage of development.
- Multiple landholders within the Subject Area have superficial groundwater licences and should be sufficient to meet the irrigation requirements of POS proposed within the Subject Area.
- Historical rural land use over most of the Subject Area will have, to varying degrees, affected groundwater quality and there are currently no water quality controls. Change in land use provides an opportunity to improve groundwater quality through application of sustainability principles, WSUD, and establishment of water quality targets, monitoring and compliance reporting.
- A High Voltage (HV) transmission corridor traverses the site from east to west in the centre of the Subject Area and north to south along the south-east boundary. These are development constraints in these areas.
- The north-eastern section of the Subject Area includes a sand quarry operated by WA Limestone. The main constraint with both the existing quarry is the uncertainty over the final landform.

- The Alcoa Residue Storage Area, down-gradient and west of the Subject Area and classified as a Contaminated Site in 2006, was a source of alkali groundwater contamination which had migrated eastward to affect Lot 89 Mandogalup Road. A Preliminary Site Investigation (PSI) and water quality monitoring on the western boundary should be conducted at the LSP/LWMS stage to assess potential migration of the contamination further eastward into the Subject Area.

These constraints and opportunities are to be used to assist in the development of a suitable LWMS for the Subject Area.

3. SURFACE WATER MANAGEMENT STRATEGY

3.1 Key Design Criteria

The key objectives for surface water management for the Subject Area are consistent with those identified in the DWMP (DoW, 2009) for the protection of:

- Wetlands and waterways from the impacts of urban runoff;
- Infrastructure and assets from flooding and inundation; and
- Human life and property within floodplains.

3.1.1 Surface Water Quantity

Key design criteria to meet the surface water management objectives are:

- Retention and infiltration of the first 15 mm of rainfall at source, i.e. the "small" event.

  Details of suitable storage devices are included in Chapter 9 of DWER (2022) including consideration of the most appropriate type of retention system for the underlying soil types of the Subject Area.

- For catchments draining to the Peel Main Drain, Figure 8, post-development critical 10% AEP (10 year ARI) and 1% AEP (100 year ARI) peak flows shall be attenuated to pre-development flows as outlined in DoW (2009).
- Pre-development flows entering and leaving the Subject Area are to be maintained to preserve the existing hydrological regime to the Spectacles.
- Public Open Space (POS) and retention basins should operate as dry basins, with a typical clearance of at least 0.5 m between the basin invert and the controlled groundwater level.

  Detention Storages within the Peel Main Drain catchments shall provide minimum detention storages as outlined in DoW (2009) for post-development subcatchments.

- Water quality treatment systems and water sensitive urban design structures must be designed in accordance with DWER (2022) Chapter 9 *Structural Controls*.

3.1.2 Surface Water Quality

Targets to be achieved through adopting a treatment train approach include:

- Non-structural measures to reduce applied nutrient loads, as described in Chapter 7 of DWER (2022);
- TP concentration target of less than 0.2 mg/L as per EPA (2008);
- On-site retention of the first 15 mm of rainfall, effectively equivalent to 1 EY 1 hour event for Perth; and
- Sizing of bio-retention structures/systems to approximately 2% of connected impervious areas, as described in Chapter 9 of DWER (2022).

3.2 Peel Main Drain

The Peel Main Drain was modelled in the DWMP (DoW, 2009).

The DWMP proposed retention of the existing drainage routes through the Peel Main Drain Catchment and in general, the alignment of the existing Drain. The DWMP does however allow for channel realignments and profile modifications provided that it is demonstrated that the pre-development hydraulic capacity of the drain has been preserved. Possible main drain alignments would necessitate changes to the drainage corridors and public open space provisions as outlined within the District Structure Plan (WAPC, 2007; Figure 2).

The Peel Main Drain through Mandogalup Swamp, as shown in catchments CAT17 and CAT18A in Figure 8, is to be preserved as detailed in Section 3.3.

There is potential for realignment of the Main Drain through catchments CAT17 and CAT16A (Figure 8). Any proposed realignments or modifications are to be discussed with the City of Kwinana, DWER and the Department of Planning at the LSP/LWMS stage. Proposed realignments and/or modifications will take the form of a living stream as is the requirement of both Water Corporation and DWER. Living streams will need to maintain the hydraulic capacity of the existing drain and integrate into the proposed Structure Plan for the area.

Non-structural measures and bio-retention structures will be utilised to reduce nutrient loading to the Peel Main Drain. UNDO Modelling will be required at the LWMS stage to quantify the post-development nutrient inputs into the Main Drain.

3.3 Peel Main Drain Online Storage in Mandogalup Swamp

The Subject Area includes approximately half of Mandogalup Swamp, a significantly modified wetland which is currently used for market gardens. Surface water modelling in the Jandakot DWMP (DoW, 2009) identified the swamp as an important regional flood storage.

The DWMP assessed four scenarios for post-development land use to quantify the impact of partial or full filling of the swamp on the hydraulic capacity of the Peel Main Drain and flood protection within the area. Based on the magnitude of impact of the filling of the swamp, the then Department of Water and Town of Kwinana identified Scenario 3 – *Mandogalup Swamp north partially retained – only power line and pipeline corridors undeveloped*, shown on Figure 12, as the preferred scenario in the Jandakot DWMP (DoW, 2009) due to minimal and manageable effect on the Spectacles Wetlands. Adoption of this scenario allows for an increase in discharge from pre-development flows.

The water level and volume in Mandogalup Swamp North for the 1% AEP storm event with pre- and post-development land use is summarised in Table 4. Ultimate Development modelled in the DWMP assumed adoption of Scenario 3. The alignment of the Mandogalup Swamp online storage should be confirmed at the LWMS/LSP stage of development and remodelled based on LiDAR (DoW, 2008) elevation data to determine post-development storage volumes and peak discharge rates.

TABLE 4: PRE- AND POST-DEVELOPMENT LEVELS AND VOLUME OF MANDOGALUP SWAMP (DOW, 2009)

	Water Level (mAHD)		Storage Volume, Mandogalup Swamp (m^3)	Peak Discharge, Mandogalup Road (m^3/s)
	Mandogalup North	Spectacles North		
Pre-Development	13.5	9.4	85,900	1.5
Ultimate Development Scenario 3 (Swamp partially retained; power line and pipeline corridors only)	13.7	9.6	68,700	2.0

3.4 Drainage Catchments and Peak Flow Estimates

The east of the Subject Area is within surface water subcatchments CAT16A, CAT17, CAT17A, CAT17B, CAT18 and CAT18A in the DWMP.

Development within the Peel Main Drain Catchment must attenuate post-development flow to the Main Drain to pre-development flow rates. Detention storage and peak outflows have accordingly been calculated pro-rata from DWMP catchment areas for the Subject Area and are presented in Table 5.

TABLE 5: PEAK ALLOWABLE OUTFLOWS AND DETENTION STORAGES REQUIRED

Catchment	DWMP Catchment Area (ha)	Area within DWMS (ha)	Required Detention Storage (m^3)	Peak Discharge Outflow (m^3/s)	Pro-rata DWMS Storage (m^3)	Pro-rata DWMS Outflow (m^3/s)
CAT16A	53.4	42.4	32,700	0.05	25,965	0.040
CAT17	50.0	11.1	10,700	0.16	2,375	0.036
CAT17A	85.2	0.8	18,200	0.16	170	0.002
CAT17B	36.2	13.8	68,500	0.09	26,110	0.034
CAT18	50.5	26.6	-	-	-	-
CAT18A	81.6	57.7	24,300	0.30	17,180	0.212
Total	356.9	152.4	154,400	0.76	71,800	0.324

Indicative storage areas, volumes and peak flow rates are shown on Figure 13. For Peel Main Drain catchments, these are based on Table 5 and the DWMP. Water storages for the northern areas including the 'Soak' Peel Main Drain catchment have been estimated for the 1% AEP based on the requirement for 1 m^3 per 20 m^2 of contributing impervious areas. The runoff coefficient used for industrial/commercial areas was 90% and for residential areas was 80%. Storage areas were calculated assuming a water depth of 1.0 m.

For the LWMS, drainage catchments and storages areas will be reviewed and amended as necessary. Modelling to refine the surface water management strategy within the Subject Area will utilise the outflow and tailwater criteria of the final DWMP shown at the Subject Area boundary with consideration for refined catchment boundaries and flows from upstream developments.

4. GROUNDWATER MANAGEMENT STRATEGY

4.1 Key Objectives

Key objectives for groundwater management for the Subject Area are consistent with that identified in the DWMP (DoW, 2009) as follows:

- Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels;
- Protection of groundwater-dependent ecosystems from the impacts of urban runoff; and
- Minimising and managing changes in groundwater levels and quality following the development.

4.2 Groundwater Levels

Key design criteria for groundwater management are:

- Where the maximum groundwater level is at or near natural surface, the importation of clean fill and/or provision of subsoil drainage will be required to ensure that adequate separation of building floor slabs and groundwater is achieved. In such instances, the subsoil drainage will need to be placed at or above the approved control groundwater level (CGL).
- Bio-retention system inverts to be set a minimum of 0.5 m above CGL or AAMGL, although existing inverts below CGL may remain.
- Sub-surface drainage is to be installed at or above CGL with free-draining outlets.

4.3 Groundwater Quality

Key factors to maintain or improving existing groundwater quality are:

- Groundwater discharge from subsoils (where required) should be conveyed into a water quality treatment area where sufficient hydraulic grade permits.
- Stormwater runoff to be treated via bio-retention areas prior to infiltration to groundwater.
- Bio-retention areas to have a minimum of 0.5 m separation to CGL or AAMGL. Bio-retention areas are to be offline to large event storage areas.
- Use of a combination of soil amendments and landscape design (native vegetation, minimising turf areas etc) to limit fertiliser and pesticide application in public open space areas.
- The water quality of dewatering water discharge during construction should meet DWER requirements (DER, 2015).

Specific details on the local scale of application, and responsibilities for individual best management practices will be appropriately addressed during later planning stages in accordance with Better Urban Water Management (WAPC, 2008) requirements.

4.4 Pre-Development Monitoring

A detailed groundwater monitoring program has not been completed specifically for the Subject Area. Pre-development monitoring of groundwater quality is recommended to be undertaken at the local Subject Area scale to establish baseline water quality to assess the hydrological impacts of (proposed) development, support the planning and engineering design, and assist in establishing targets and a contingency action plan with associated trigger values for specified parameters.

Post development monitoring, including the scope and extent of monitoring, will be determined based on the type, form, and staging of development ultimately proposed in the Local Structure Plan. Monitoring will be undertaken in accordance with DWER requirements. Specific details of proposed post-development monitoring program are to be included in the LWMS. All water quality testing must be conducted by a National Association of Testing Authorities (NATA) accredited laboratory.

Pre-development monitoring is required for at least 2 winters (18 months) prior to development as outlined in WAPC (2008) *Better Urban Water Management*.

5. WATER SOURCE PLANNING AND CONSERVATION

5.1 Key Objectives

The key objectives for water source planning and conservation for the Subject Area are consistent with that identified in the DWMP (DoW, 2009) as follows:

- Ensure the efficient use of all water resources in the newly developing urban form and aim to achieve highest value use of fit for purpose water; and
- Maintain opportunities for future generations by using water more efficiently. This is best achieved by combining several approaches such as raising community awareness, regulation, market mechanisms to facilitate recognition of the true value of water and financial incentives/assistance to facilitate change.

5.1 Water Supply

5.1.1 Potable Water

Water supply to households will likely be via extension of the scheme water system.

Further details will be presented in the LWMS.

5.1.2 Non-Potable Water

Non-potable water supply options that can be investigated further to meet POS irrigation demand and ex-house use are briefly described below.

Groundwater Supply

The current water allocation attached to properties within the Subject Area amounts to approximately 2.25 GL (2,250,000 kL). Full development of the site would likely require 200,000 to 300,000 kL for irrigation in the establishment of POS, road verges and medians and water for dust suppression and construction works. Actual water requirement is to be determined at a later date after finalisation of a Structure Plan for the Subject Area, however an irrigation demand of 6,750 kL/ha should be adopted for calculation of the water allocation required for the establishment and ongoing irrigation of vegetated areas.

Whilst the superficial aquifer is fully allocated, there is sufficient allocations attached to properties within the Subject Area to facilitate development.

Land developers will need to negotiate and obtain allocations from existing licensees within the Subject Area.

Rainwater Tanks

Collection and storage of rainwater runoff from roof and other impervious surfaces have generally been considered of minimal value to supply or supplement irrigation demand in Perth at the development scale. This is due to the vast majority of annual rainfall occurring in the space of a few months when water

consumption is at its lowest. It also requires the need for sufficient storage capacity to allow water to be utilised over the course of the year.

Limitations to use of rainwater tanks include reliability of rainfall, infrastructure required to store water either above or below ground, water quality considerations and cost.

Whilst use of rainwater tanks can be beneficial for supplementing non-potable water demand, it is more suitable at the household scale rather than at the development scale for irrigation of POS.

Greywater Recycling

Greywater is water collected from showers, bathrooms and laundry and is potentially available for reuse. Treated greywater is suitable for garden irrigation in accordance with the Code of Practice for the Reuse of Greywater in Western Australia. Where greywater is applied to gardens for irrigation, sandy soils need improved organic matter and soil texture to ensure excessive nutrients do not leach to the watertable.

It is generally considered that greywater can only be stored for up to 24 hours at a time without significant impacts on water quality and subsequent risks to public health. Therefore greywater generated during each day would need to be discharged, either for reuse or for disposal to the sewer network every 24 hours. A water balance would need to be performed to assess volume of water generated against supply required.

Construction of a separate pipe system within the development is required to collect and reuse greywater. A specific area will also be required to be set aside for the greywater treatment system and provision of other supporting infrastructure such as power. Responsibility for ownership and ongoing operation and maintenance of the system also need to be established upfront.

While greywater recycling could be used for development scale water supply for irrigation of POS, it may be cost prohibitive due to additional pipe infrastructure required. It is more suitable at the household scale rather than at the development scale.

Wastewater Recycling

Wastewater is all water generated in a household and includes the combination of greywater (water from showers, bathrooms and laundry) and blackwater (toilet). The collection, treatment and reuse of household wastewater can only be performed at development scale and requires construction of a purpose built on-site wastewater treatment system, commonly referred to as a decentralised wastewater recycling system.

The planning and construction of such a system requires many regulatory clearances, approvals and management plans with various government agencies including but not limited to the City of Kwinana, Department of Water & Environmental Regulation, Water Corporation, Department of Health and Department of Biodiversity, Conservation and Attractions.

Planning also needs to consider location with respect to environmental impacts and required buffers for adjacent land uses. Initial construction costs can be high in comparison to other non-potable water source options. It does not require construction of additional collection pipes as the standard residential sewer

network should be sufficient, however responsibility for ownership and ongoing maintenance need to be determined.

A third party licenced Water Service Provider is required to provide this wastewater recycling service. The use of such a system can provide an almost guaranteed water supply with predictable volumes. This is particularly beneficial for irrigation purposes where water demand can be forecast in the POS areas. The wastewater will need to be treated to acceptable levels specified by the relative agencies.

5.2 Wastewater Management

The proposed Wastewater Management Strategy will consist of extension of the existing Water Corporation reticulated sewer pipe system.

Further details will be presented in the LWMS.

5.3 Water Conservation Objectives

The objective for water conservation is to minimise use of water and maximise water use efficiency where possible. This objective can be achieved at both the development and household scale and has been identified by the State Government as part of the State Water Plan (Government of Western Australia, 2007) as a priority item for potable water. It has set a target for household water use of 100 kL/person/year, with a consumption target for scheme water of 40-60 kL/person/year.

Consistent with the State Water Plan, the main objectives for the development are:

- Avoid use of potable water for irrigation in POS areas.
- Household water use to be less than 100 kL/person/year.
- Minimise use of potable water where drinking water quality is not essential, particularly ex-house.
- Household consumption targets for in-house potable water use of 40-60 kL/person/yr.
- Improvements in water conservation and efficiency to meet these objectives at both the development and lot scale through various mechanisms and measures are described further below.

Development Scale

Development scale water conservation measures appropriate for the site include:

- Strategic planning (orientation, shape, elevation etc.) of irrigation areas such as pocket parks, active and passive public open space areas, and road reserves to minimise long-term irrigation demand.
- Where possible co-locate facilities with significant irrigation demand.
- Within irrigation areas, the use of waterwise landscaping practices including hydrozoning, mulching, soil amendments, water retention products and installation of appropriate water efficient irrigation fixtures.
- POS and turfed areas should be irrigated using groundwater from the existing groundwater allocation. Water conservation could also be achieved by using alternative non-potable water to meet roadside swale and public area irrigation requirements.

- Retain and where appropriate rehabilitate native bush areas.

Lot Scale

Lot scale water conservation measures appropriate for the site include:

- Buildings constructed to current National Construction Code (NCC) guidelines and the State Government 6-star Star Plus Scheme. These include using AAA rated appliances such as toilets, washing machines, dishwashers, water saving showerheads, taps and toilets and subsurface irrigation. The Water Corporation's Waterwise Rebate Program will also assist in encouraging the purchase of waterwise AAA rated appliances.
- Initiatives to encourage waterwise landscaping of residential lots including hydrozoning, mulching, soil amendments, water retention products and installation of appropriate irrigation fixtures.
- All buildings should be encouraged and supported to implement these waterwise practices and measures within this development.

6. IMPLEMENTATION FRAMEWORK

6.1 Local Structure Planning

The water management planning requirements for the various stages of land use planning are set out in Better Urban Water Management (WAPC, 2008) and include a Local Water Management Strategy (LWMS) in support of the Local Structure Plan and an Urban Water Management Plan (UWMP) as a condition of subdivision approval. The design objectives outlined in this DWMS form the basis for design criteria to be developed and reported in the LWMS. The design criteria of the LWMS are implemented through the final design concept presented in the UWMP.

Specific issues raised in the DWMS that need to be further investigated as part of the LWMS include:

- Hydrological management of the wetlands and protection of environmental assets;
- Retention of existing flow paths and natural drainage systems located throughout the Subject Area;
- Irrigation supply and water efficiency measures for irrigation of POS;
- Refine catchment and sub-catchment areas to maintain pre-development flows entering and leaving the site;
- Refine storage areas based on the outcomes of the geotechnical investigation and detailed stormwater modelling.
- Refinement of the Peel Main Drain online storage in Mandogalup Swamp through detailed stormwatermodelling.
- Geotechnical investigation;
- Earthwork and fill strategy; and
- An ASS Investigation and Management Plan will be undertaken at the appropriate development phase to identify the exact extent and depth and whether it will impact future proposed development.

6.2 Water Management Strategy Summary

Key elements of the Mandogalup District Water Management Strategy (DWMS) have been identified to provide guidance on local water management issues in the Mandogalup catchment area. Preparation of a Local Water Management Strategy (LWMS) for the Mandogalup development will be the responsibility of the Developer of the land and should address key design objectives as identified in this DWMS (Table 7).

TABLE 6: SUMMARY OF DESIGN OBJECTIVES

DWMS Principles	LWMS Objectives
Design and Management Objectives • Design objectives for potable water use, stormwater quality and quantity (including flood management), groundwater quality and quantity, wastewater and water re-use.	• Implement sustainable best practice in urban water management by integration of water and land use planning. • Minimise the use of potable water where drinking water is not essential by considering all potential water sources and water demand requirements in water supply and land use planning. • Identify site constraints and opportunities by performing environmental assessments. • Retain natural drainage systems and protect ecosystem health by creating living streams and ephemeral storage areas. • Provide protection from flooding by provision of suitable drainage areas and flow paths. • Maintain surface water and groundwater hydrological regimes where possible through appropriate design practice. • Maintain and/or improve surface water and groundwater quality by implementing water sensitive urban design techniques to meet WQIP targets. • Flood management and discharge objectives consistent with the DWMP (DoW, 2009) and the Stormwater Management Manual (DWER, 2022).
Fit-for-Purpose Water Source Planning • Allocation of water • Required infrastructure	• Landscaped and POS areas minimised where possible during land use planning, and a minimum 50% of plants to be native vegetation. • Waterwise landscape packages provided to each lot purchaser. • Buildings are to comply with water efficiency standards introduced into the building code. • The superficial aquifer is fully allocated. Water for establishment and ongoing irrigation of POS will need to be negotiated and obtained from existing licensees within the DWMS area. • Required infrastructure for abstracting superficial groundwater will be via production bores proposed to be constructed within POS areas.
Water Management Strategy • Drinking water conservation and efficiency of water use • Surface water management strategy • Groundwater management strategy • Wastewater management strategy	• Water Efficiency initiatives includes waterwise landscaping packages, public POS areas to be at least 50% native vegetation. • Buildings are to comply with water efficiency standards introduced into the building code. • The surface water management strategy to be guided by the DWMP, Stormwater Management Manual and follows Water Sensitive Urban Design principles. • Drainage areas required for flood management to be determined based stormwater modelling for the 1% AEP. These areas will be allocated in the local structure plan. • Channel realignments and profile modifications to the Peel Main Drain may occur if pre-development cross-sectional area is maintained, consistent with the DWMP. • The first 15 mm of rainfall will be infiltrated at source (via soakwells, road pits) where possible, consistent with DWMP design criteria. • Stormwater modelling for surface water/flood management for the Mandogalup development performed with discharge criteria consistent with the DWMP. • Groundwater management at the district level is covered in detailed in the DWMP. It specifies a CGL which will be achieved by installation of subsoil drainage with areas requiring CGL determined by refined groundwater mapping presented in the LWMS.
Implementation Framework • Consideration and requirements for local planning • Monitoring	• The water management strategy will be refined at further planning levels (LWMS, UWMP) consistent with Better Urban Water Management, the DWMP, Stormwater Management Manual, and developed in consultation with the City of Kwinana and other relevant agencies. • The funding and ongoing maintenance responsibilities will be negotiated with City of Kwinana and reported in the LWMS. • The developer is committed to and responsible for post-development monitoring, details to be outlined in the LWMS at Local Structure Planning Stage.

7. REFERENCES

BoM (2023) *Climate Data Online, Medina Research Centre (009194) and Anketell (009258) Rainfall Data*. Accessed July 2023.

Davidson, W.A. (1995) *Hydrology and Groundwater Resources of the Perth Region Western Australia.*

Davidson, W.A. and Yu, X. (2008) *Perth Regional Aquifer Modelling System (PRAMS) model development: Hydrogeology and groundwater modelling*. DoW Hydrogeological Record Series HG 20.

Department of the Environment (2004) *Perth Groundwater Atlas, Second Edition*.

Department of Environment Regulation (2014) *Acid Sulphate Soil Risk Map*.

Department of Parks and Wildlife [DPaW] (2016) *Geomorphic Wetlands - Swan Coastal Plain Dataset*.

Department of Planning (2013) *Bush Forever Site*.

Department of Primary Industries and Regional Development [DPIRD] (2023) *Pan Evaporation data from Wattleup weather station*. Accessed July 2023.

Department of Water [DoW] (2009) *Jandakot Drainage and Water Management Plan*.

DoW (2015) *Selection of future climate projections for Western Australia*. Water Science Technical Series, Report no. WST 72.

Department of Water Regulation [DER] (2015) *Treatment and Management of Soils and Water in Acid Sulphate Soil Landscapes. Acid* Sulphate Soils Guideline Series.

Department of Water and Environmental Regulation [DWER] (2017) *Decision process for stormwater management in Western Australia*. November 2017.

DWER (2019) Contaminated Sites Act 2003, *Basic Summary of Records Search Response*, Report ID: 743385, Accessed 12 November 2019.

DWER (2021) *Cockburn Groundwater Allocation Plan*. Water Resource Allocation and Planning Report Series, Report no. 60, January 2021.

DWER (2022) *Stormwater Management Manual for Western Australia*. First published 2004-2007, updated May 2022.

Environmental Protection Authority [EPA] (1992) *Environmental Protection (Peel Inlet-Harvey Estuary) Policy Approval Order* 1992

EPA (2008) *Water Quality Improvement Plan for the Rivers and Estuary of the Peel-Harvey System – Phosphorus Management*. Environmental Protection Authority, Perth.

EPA (2017) *Consideration of potential health and amenity impacts of dust in determining the size of a buffer for urban development in the Mandogalup area, Advice of the Environmental Protection Authority to the Minister for Environment under section 16(e) of the Environmental Protection Act 1986*. June 2017. EPA, Western Australia.

Government of Western Australia (2007) *State Water Plan 2007*.

Gozzard J.R. (1983) *Fremantle part Sheets 2033 I and 2033 IV, Perth Metropolitan Region*, Environmental Geology Series, GSWA.

Institute of Public Works Engineering Australia (2017) *Local Government Guidelines for Subdivisional Development Edition 2.3*, 2017.

JDA (2018) *Mandogalup DWMS*. Report for QUBE Property Group and Satterley Property Group, ref J6575b 2/8/18.

Kelsey, P., Hall, J., Kretschmer, P., Quinton, B. and Shakya, D. (2011) *Hydrological and nutrient modelling of the Peel-Harvey catchment*. Water Science technical series, Report no. WST 33, February 2011.

Luke, G.L, Burke, K.L. & O'Brien, T.M. (1987) *Evaporation data for Western Australia – Resource Management Technical Report No. 65*. Perth: W.A. Department of Agriculture, division of Resource Management. October 1987.

Parsons Brinckerhoff [PB] (2007) *Review of Borefield Performance and Groundwater Quality Report for Aloca of Australia Ltd*, April 2019.

Peel Development Commission (2006) *Peel-Harvey Coastal Catchment Water Sensitive Urban Design Technical Guidelines*.

Rockwater (2019) *Review of Borefield Performance and Groundwater Quality Report for Alcoa of Australia Limited*, April 2019.

Western Australian Planning Commission [WAPC] (2004) *Statement of Planning Policy 2.9: Water Resources*.

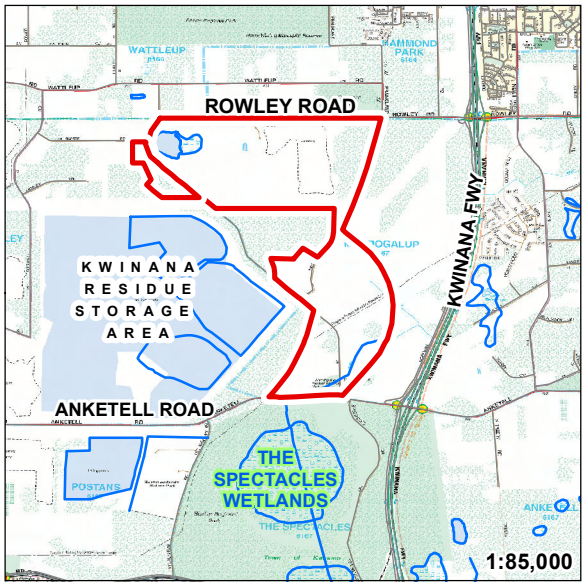
WAPC (2007) *Jandakot Structure Plan. Final Report*, August 2007.

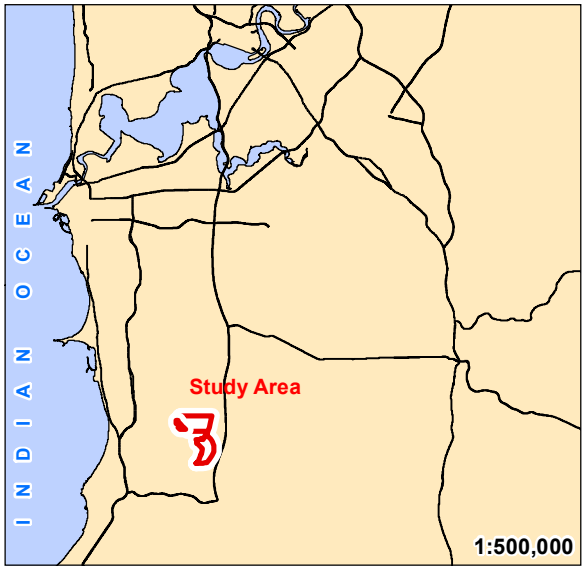
WAPC (2008), Better Urban Water Management.

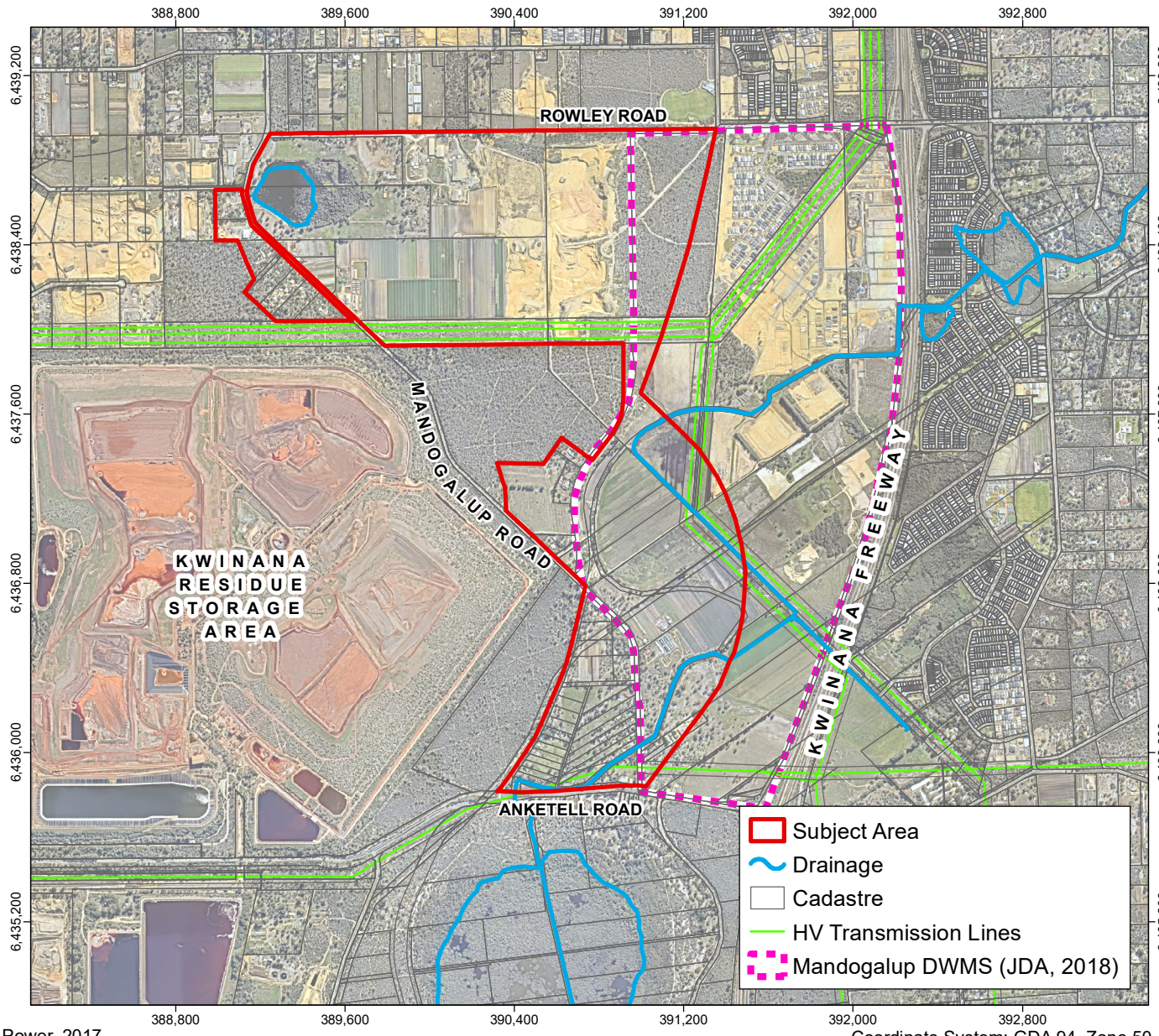
WAPC (2017) *State Planning Policy 2.3 Jandakot Groundwater Protection*. Prepared under Part Three of the Planning and Development Act 2005 by the Western Australian Planning Commission, January 2017.

Waters and Rivers Commission [WRC] (1997) *Perth Groundwater Atlas*.

FIGURES







Data Source: Nearmap Digital Imagery (29 April 2023); Western Power, 2017

Coordinate System: GDA 94, Zone 50

JDA Consultant Hydrologists

Job No. J6778

Scale: 1:30,000 @A4

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

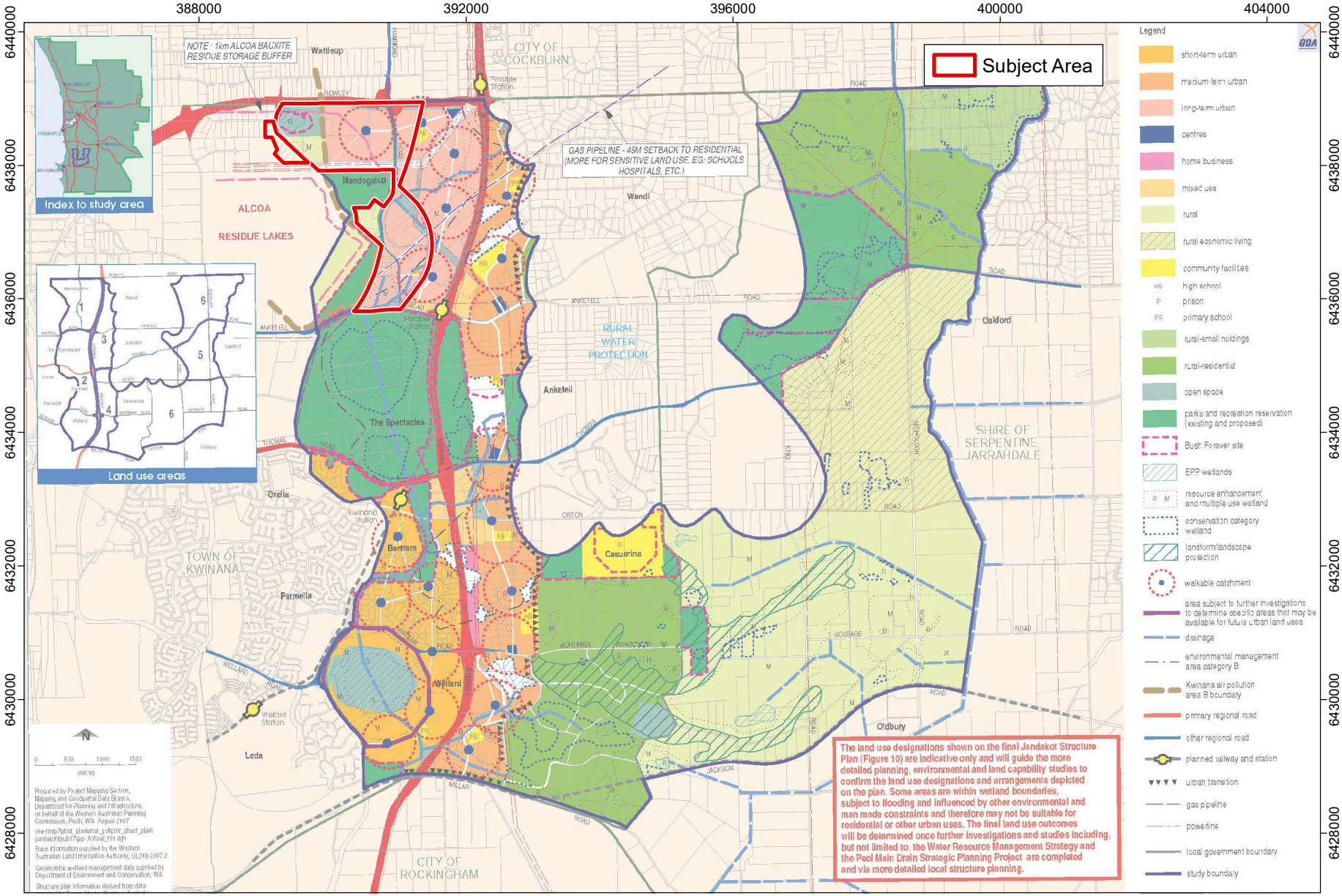
N

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

Department of Planning, Lands and Heritage

Mandogalup Improvement Scheme: DWMS

Figure 1: Location Plan



Data Source: WAPC 2007, *Jandakot Structure Plan*

Coordinate System: GDA 94, Zone 50

JDA Consultant Hydrologists

Job No. J6778

Scale: 1:83,000 @A4

0 1 2 3 4 Kilometers

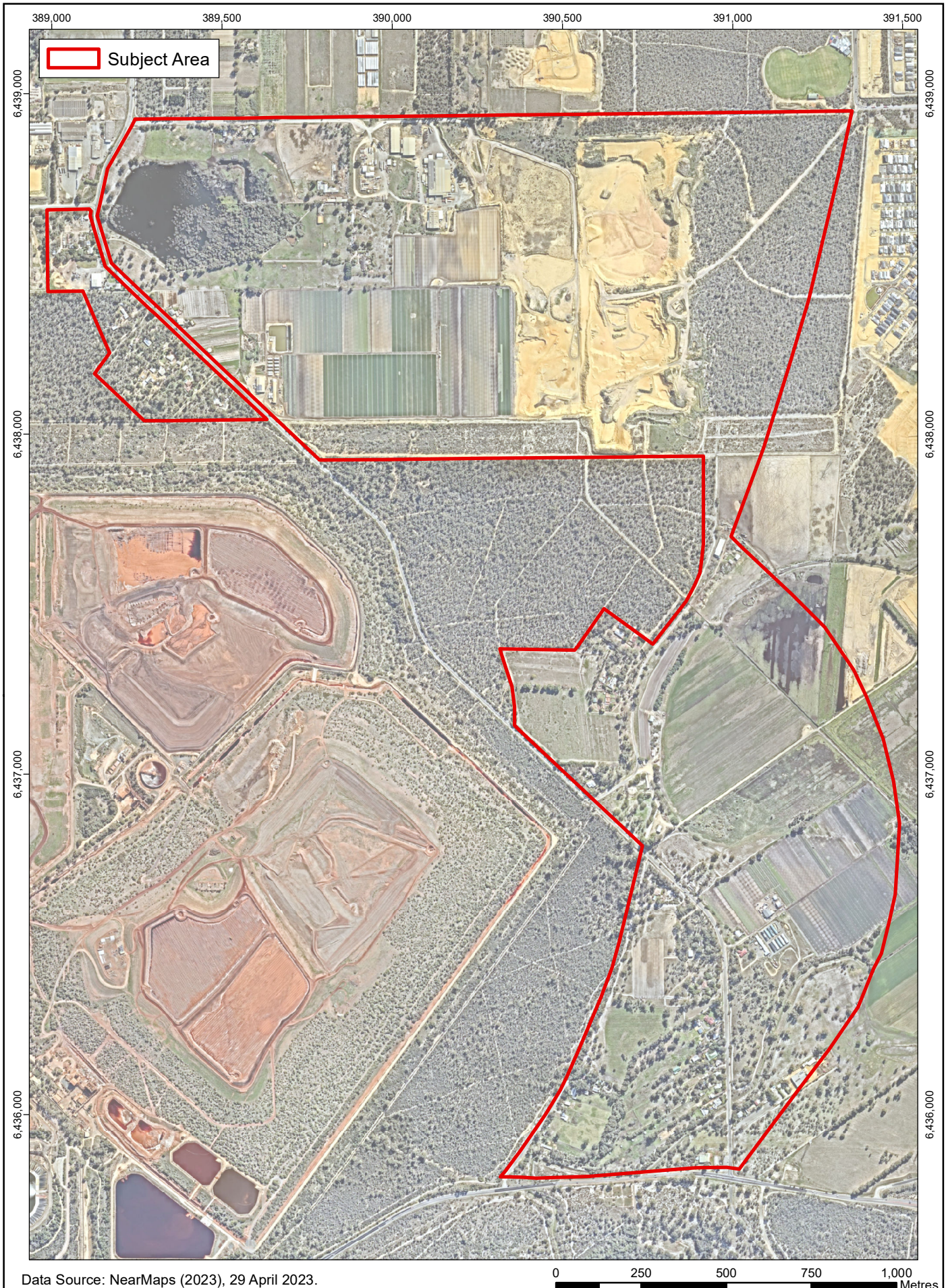
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

N

Department of Planning, Lands and Heritage

Mandogalup Improvement Scheme: DWMS

Figure 2: Jandakot Structure Plan (WAPC, 2007)



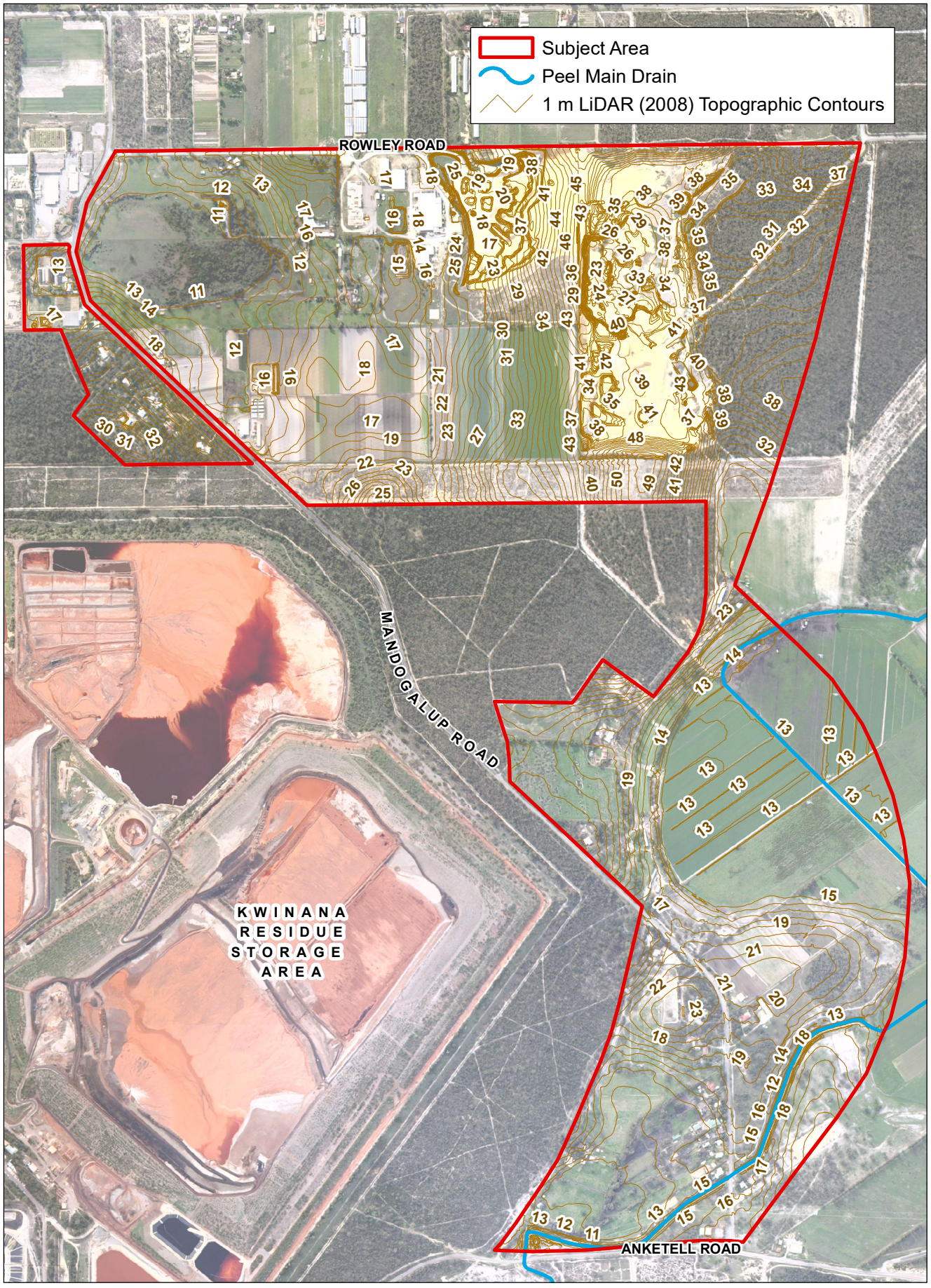
Data Source: NearMaps (2023), 29 April 2023.

JDA Consultant Hydrologists

Job No. J6778
Scale 1:15,000 @A4
Coordinate System: GDA 94, Zone 50
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 3: Aerial Photography



Data Source: NearMaps (2019), 26 May 2008; DoW (2008).

0 250 500 750 1,000 Metres

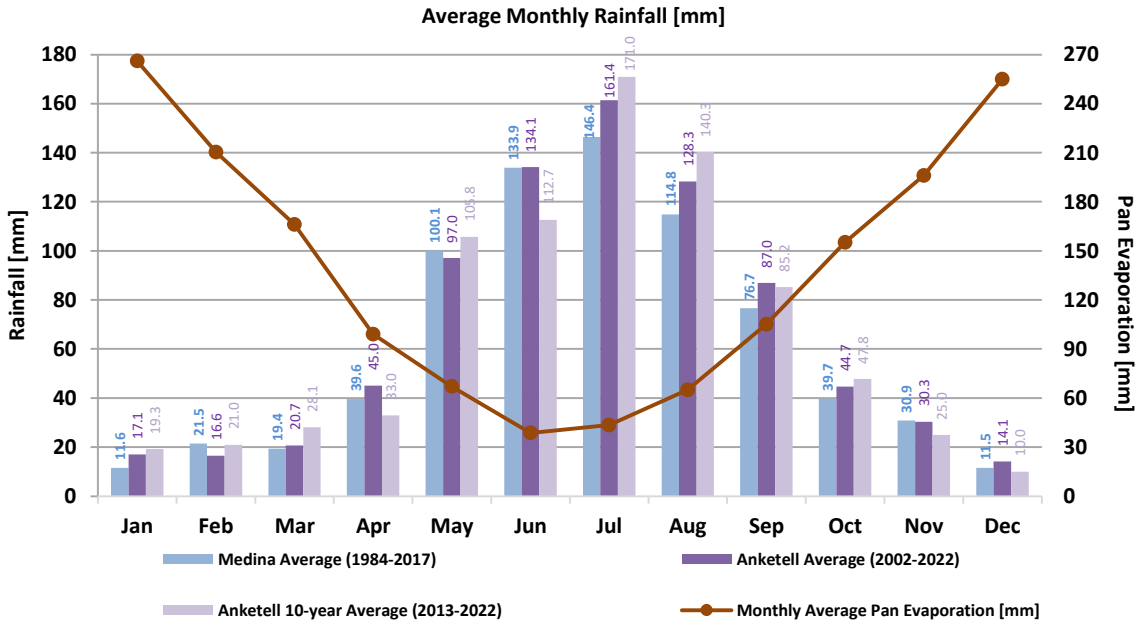
JDA Consultant Hydrologists

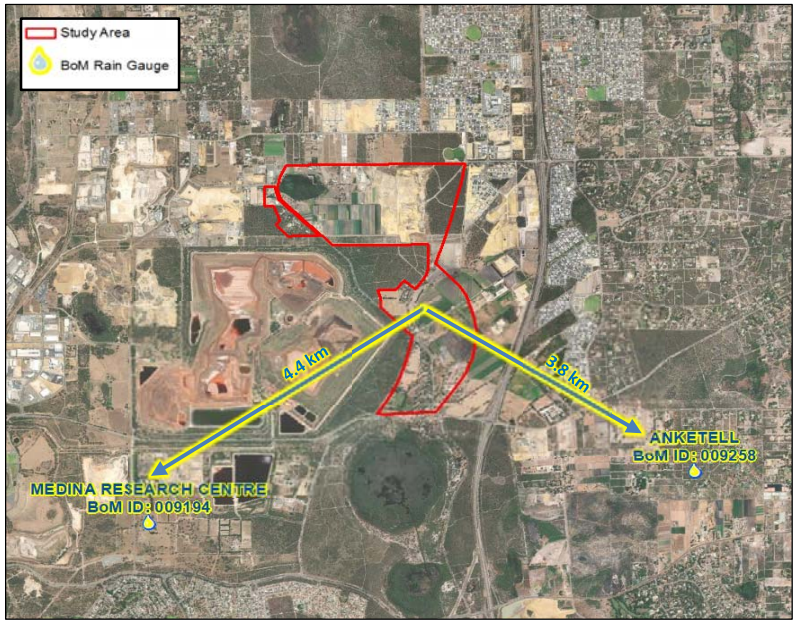
Job No. J6778
Scale 1:15,000 @A4
Coordinate System: GDA 94, Zone 50
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

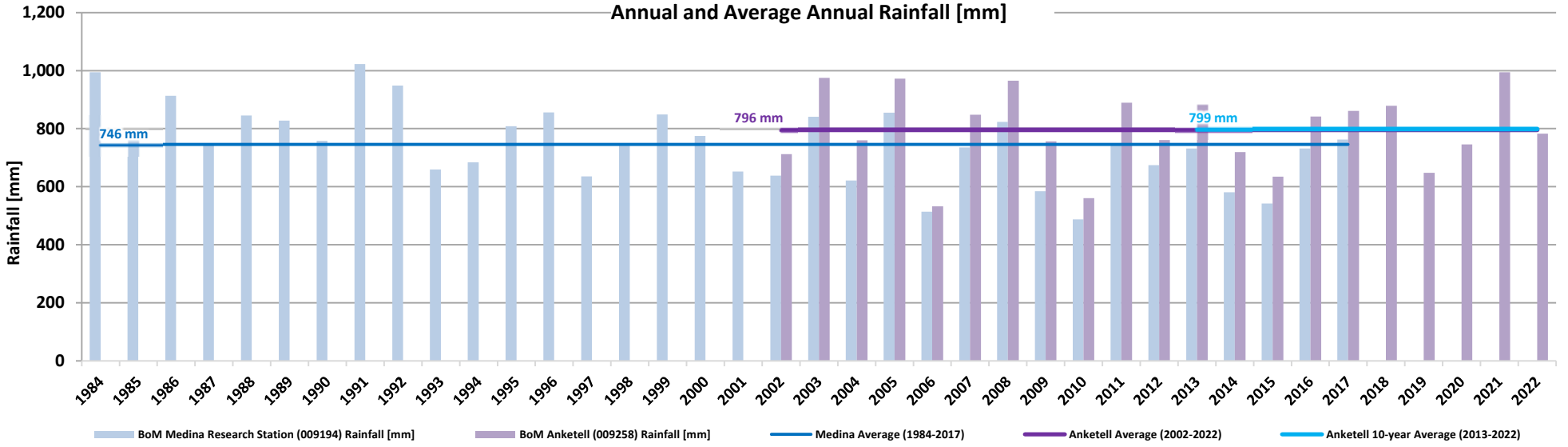
N

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 4: Topography







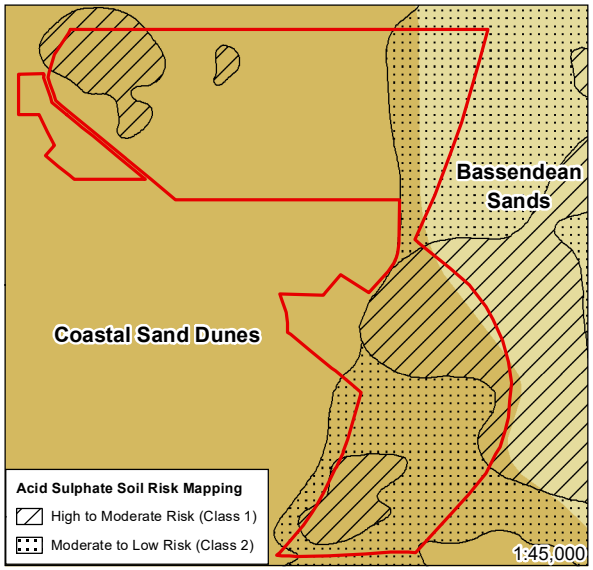
Data Source: Bureau of Meteorology (2023) *Medina Research Station (009194) and Anketell Rainfall Gauging Stations (009258)* ; DPIRD (2023) Wattleup Weather Station Pan Evaporation (2018-2022)

Job No. J6778

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 5: Rainfall and Evapoation



Lithological Classification

S7 - sand, pale and olive yellow, medium to coarse-grained, sub-angular to sub-rounded quartz, trace of feldspar, moderately sorted, of residual origin.

S8 - sand, very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted of eolian origin.

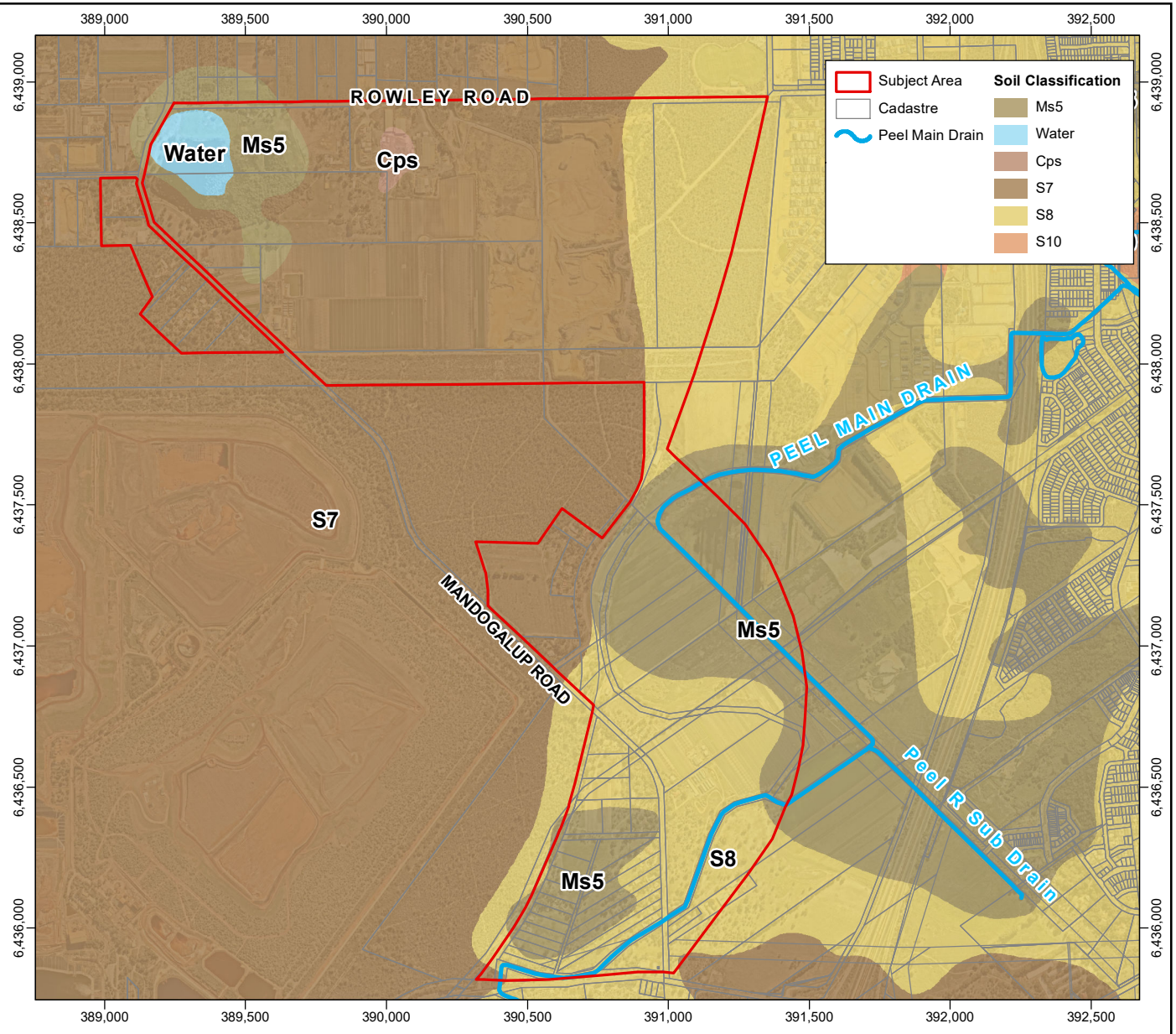
Ms5 - dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content, of lacustrine origin

Cps - peaty clay, dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin

Surface Geology

Bassendean Sands - Aeolian and coastal sediment. Basal conglomerates overlain by dune quartz sand with heavy mineral concentrations.

Coastal Sand Dunes - calcareous sand with quartz sand and minor fine-grained, black, heavy mineral concentration.



Data Source: Environmental Geology Series (Gozzard, 1983); Nearmap Digital Imagery (29 April 2023); DER (2014) *Acid Sulphate Soil Risk Map, Swan Coastal Plain*

Job No. J6778
Scale: 1:22,500 @A4
0 250 500 750 1,000 Metres

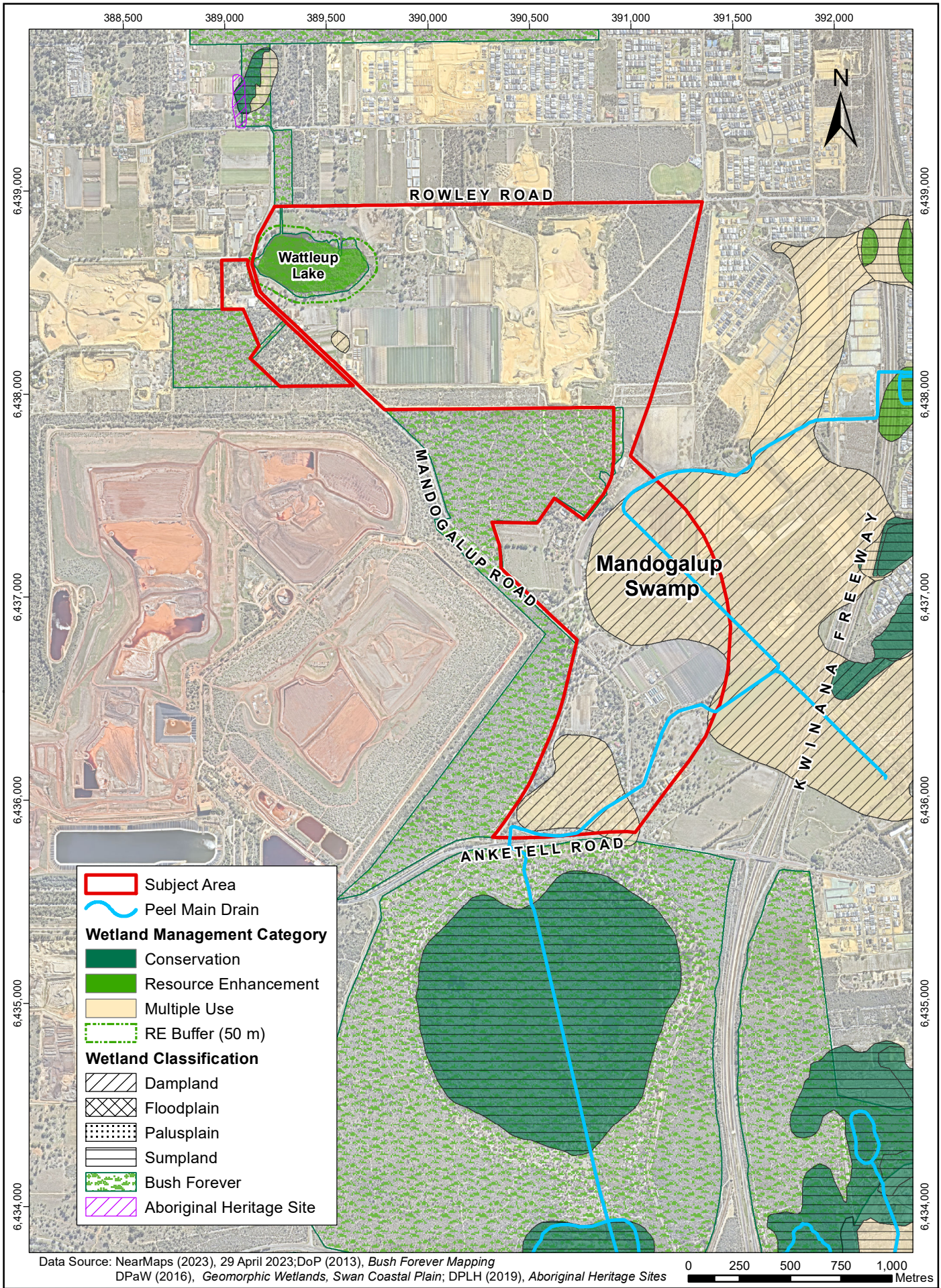
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

N

Coordinate System: GDA 94, Zone 50

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 6: Surface Geology, Soils and Acid Sulphate Soils Mapping



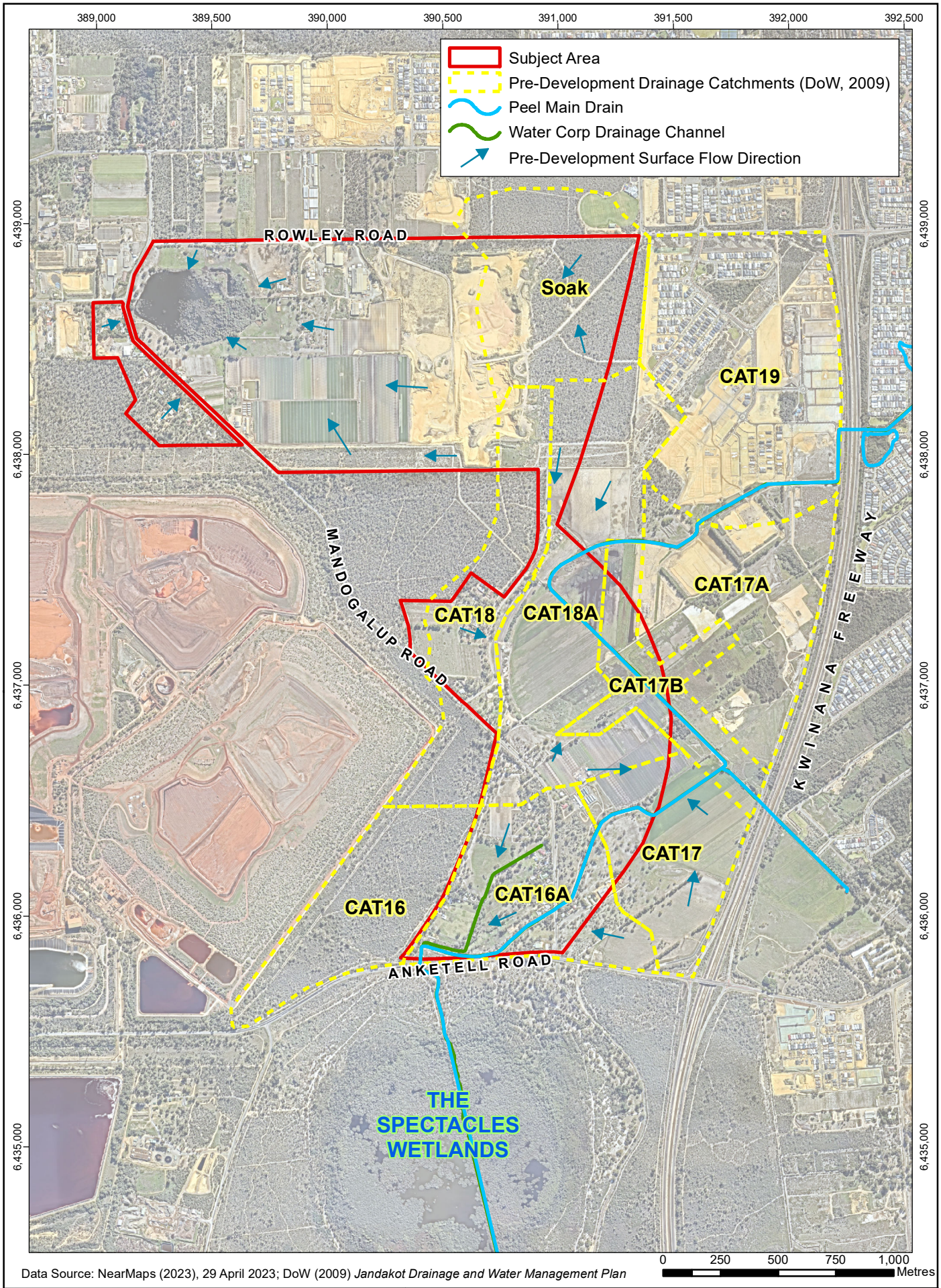
Data Source: NearMaps (2023), 29 April 2023;DoP (2013), *Bush Forever Mapping*
DPaW (2016), *Geomorphic Wetlands, Swan Coastal Plain*; DPLH (2019), *Aboriginal Heritage Sites*

JDA Consultant Hydrologists

Job No. J6778
Scale 1:25,000 @A4
Coordinate System: GDA 94, Zone 50
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 7: Wetland, Bush Forever and Aboriginal Heritage Mapping



Data Source: NearMaps (2023), 29 April 2023; DoW (2009) *Jandakot Drainage and Water Management Plan*

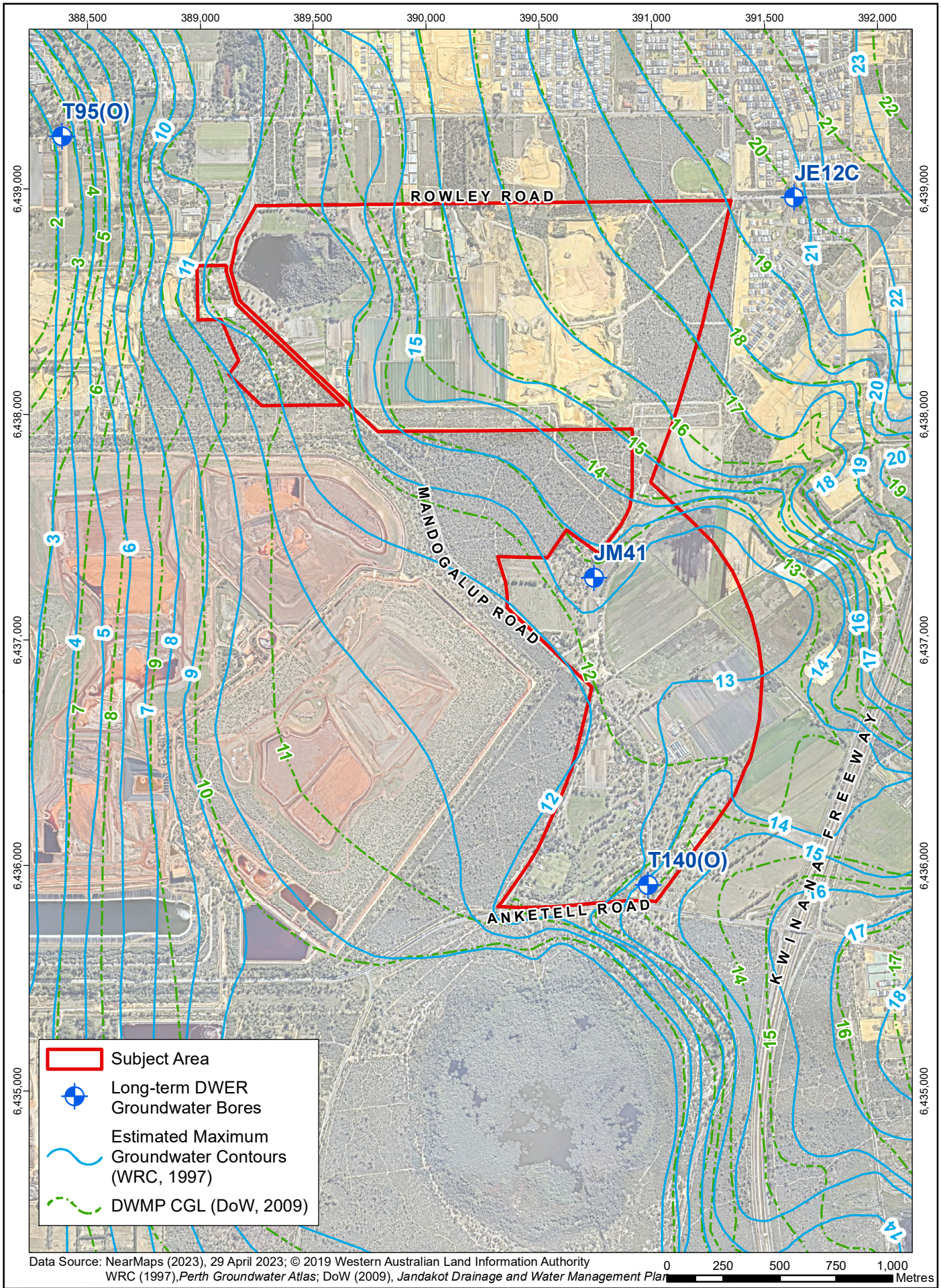
JDA Consultant Hydrologists

Job No. J6778
Scale 1:22,000 @A4
Coordinate System: GDA 94, Zone 50
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

N

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 8: Surface Water Mapping and Drainage Catchments



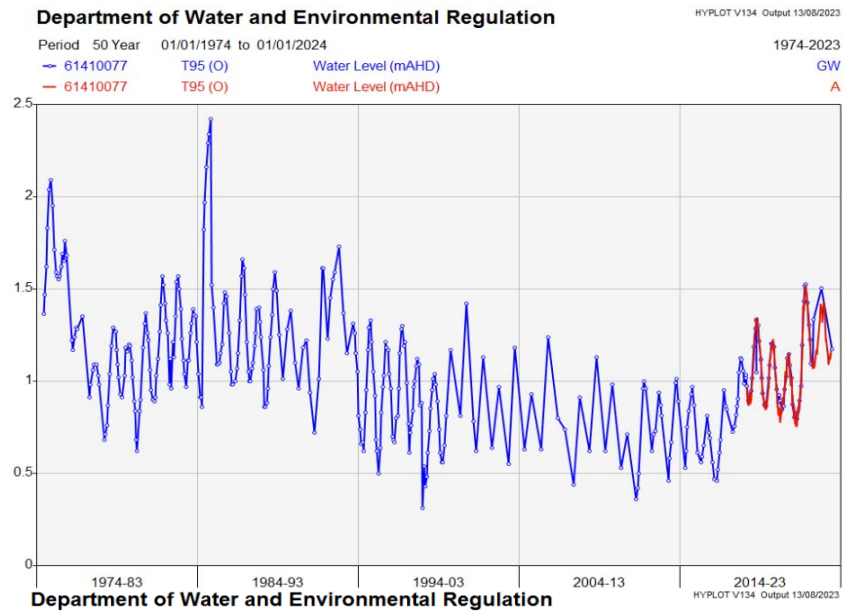
JDA Consultant Hydrologists

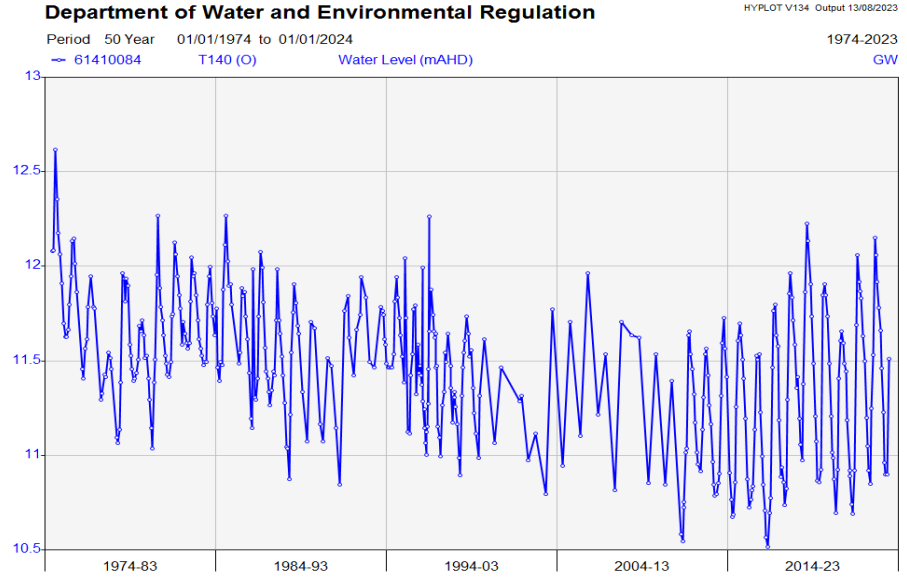
Job No. J6778
Scale 1:22,500 @A4
Coordinate System: GDA 94, Zone 50
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

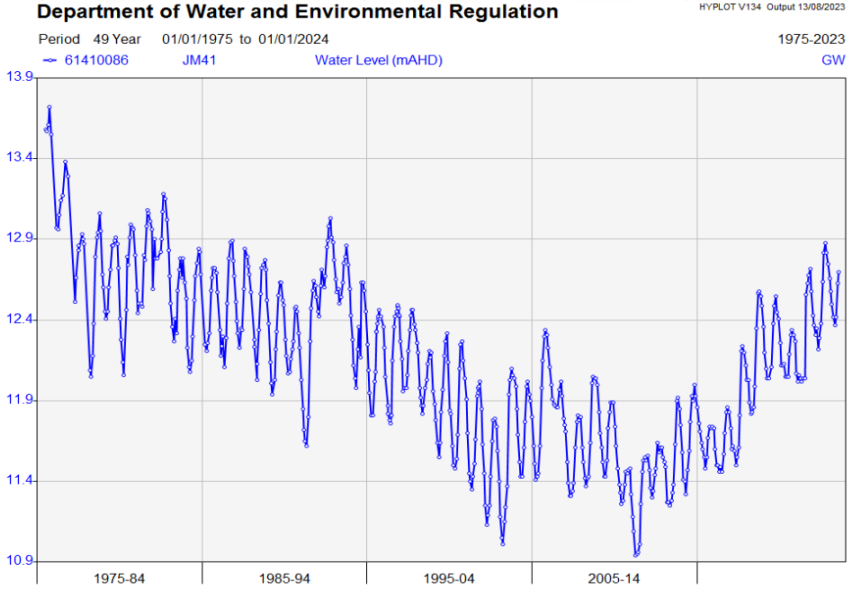
N

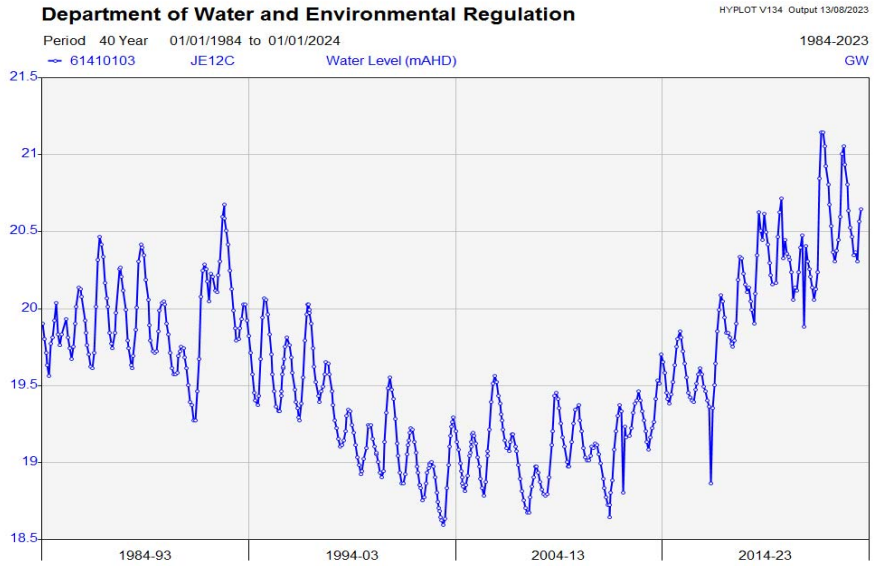
Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 9: Groundwater Contours









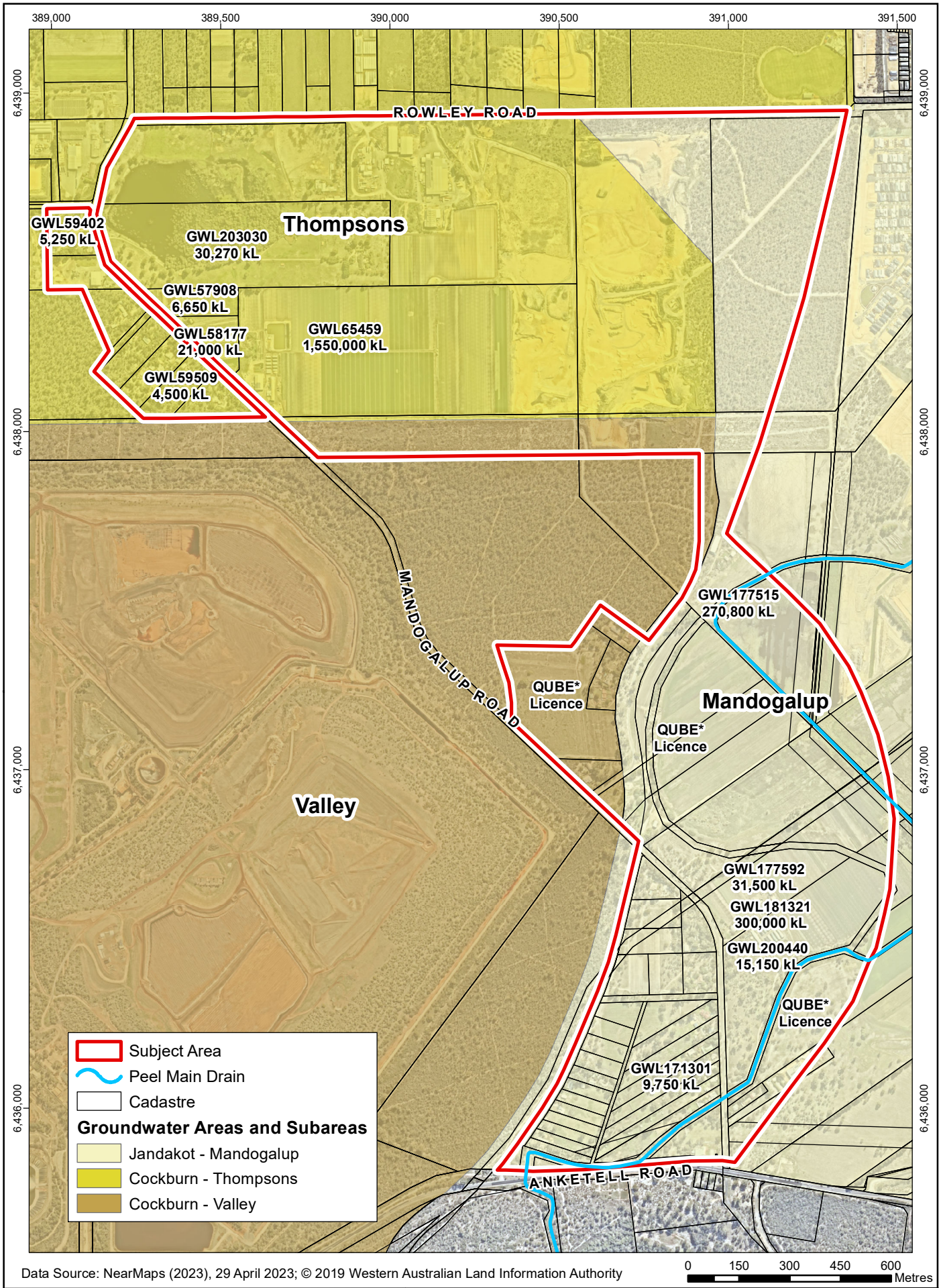
Data Source: *DWER (2023) Water Information Reporting,* Accessed August 2023

Job No. J6778

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 10: Long-Term Groundwater Levels, DWER Bores T95(O), T140(O), JM41 and JE12C



Data Source: NearMaps (2023), 29 April 2023; © 2019 Western Australian Land Information Authority

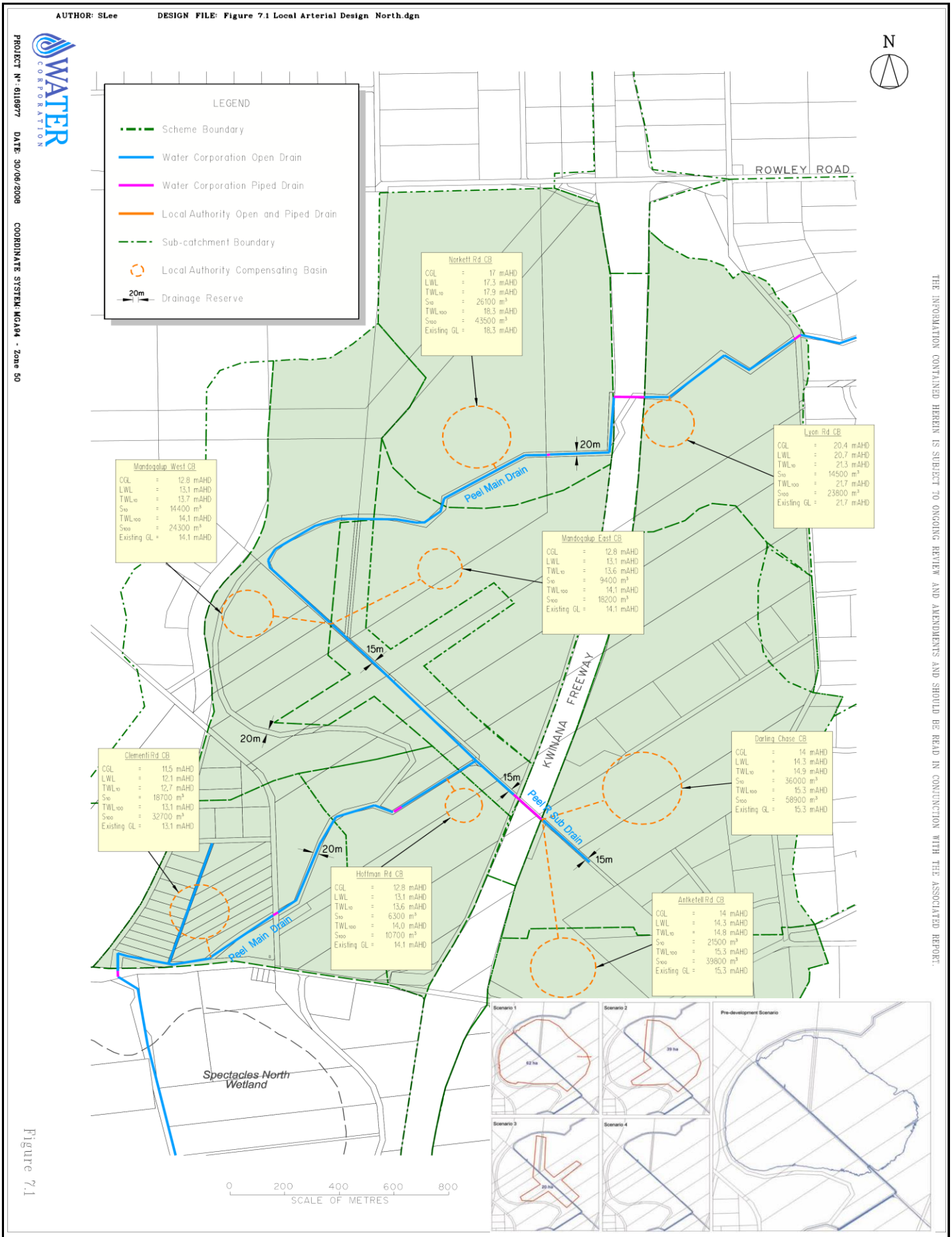
JDA Consultant Hydrologists

Job No. J6778
Scale 1:15,000 @A4
Coordinate System: GDA 94, Zone 50
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

N

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 11: Groundwater Management Areas and Current Groundwater Licences



Data Source: DoW (2009) *Jandakot Drainage and Water Management Plan*

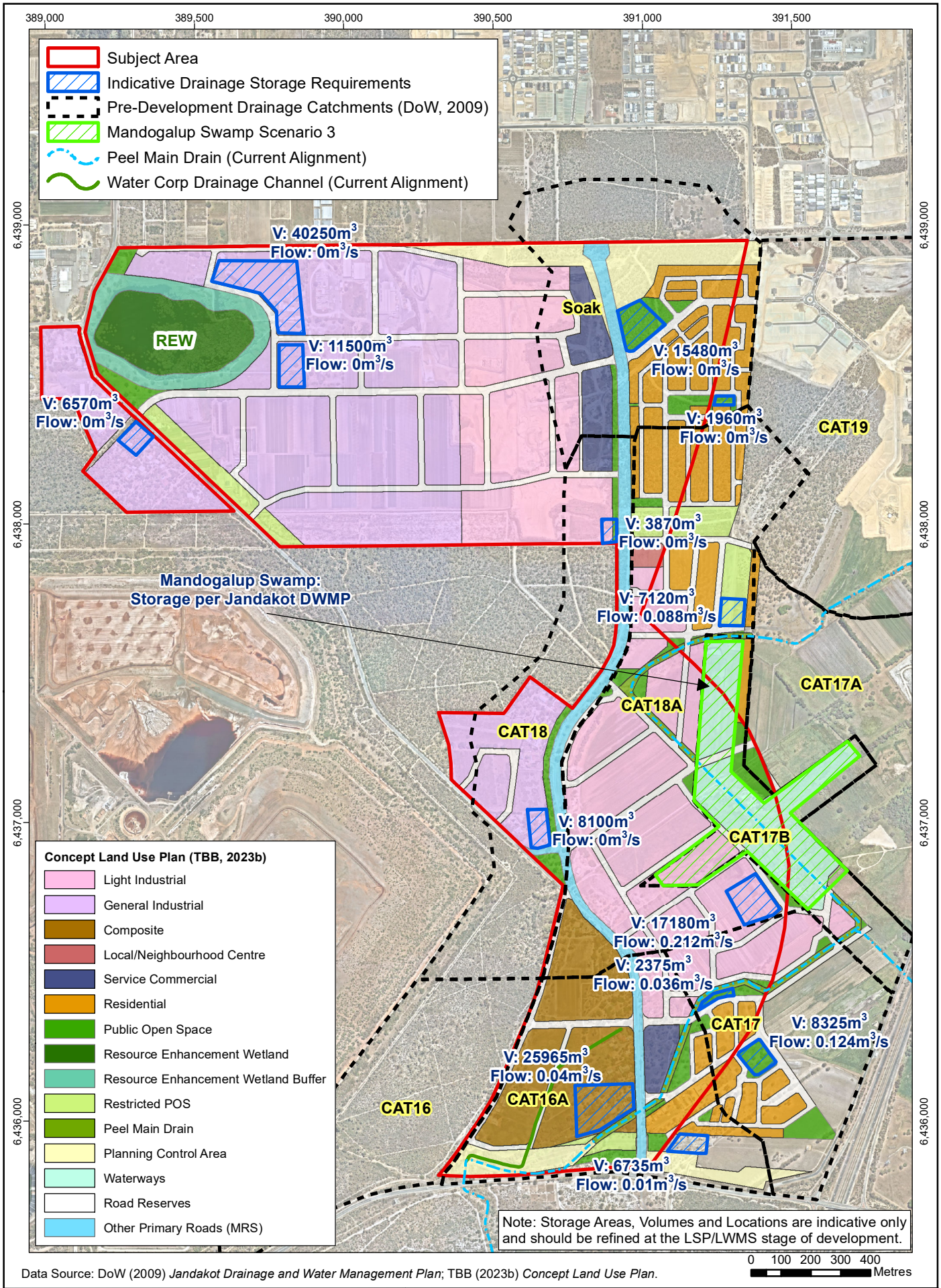
JDA Consultant Hydrologists

Job No. J6778

© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 12: Mandogalup Swamp Development Scenarios



Data Source: DoW (2009) *Jandakot Drainage and Water Management Plan*; TBB (2023b) *Concept Land Use Plan*.

JDA Consultant Hydrologists

Job No. J6778
Scale 1:17,000 @A4
Coordinate System: GDA 94, Zone 50
© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2023

N

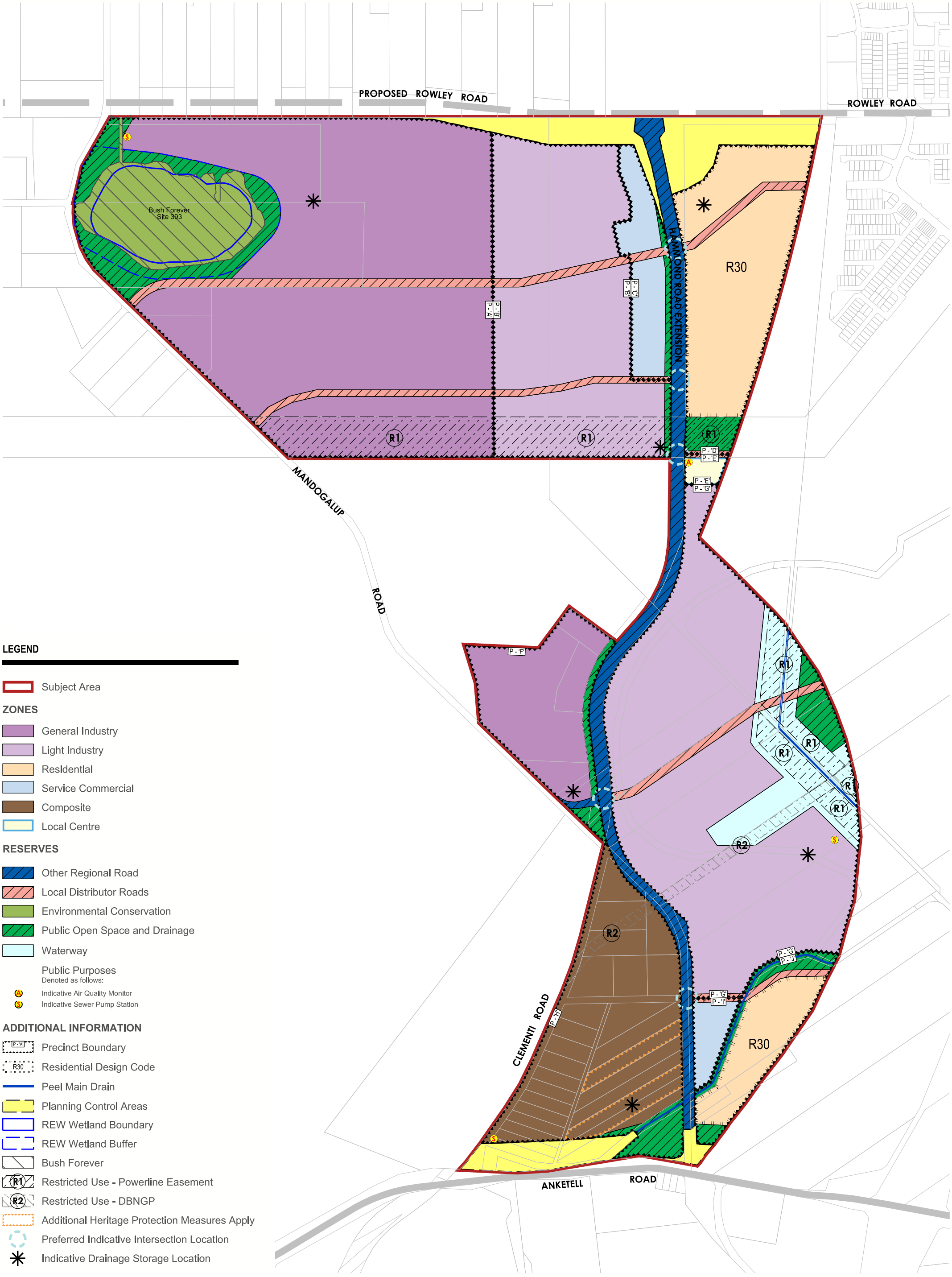
Department of Planning, Lands and Heritage
Mandogalup Improvement Scheme: DWMS

Figure 13: Concept Land Use Plan and Indicative Storage Requirements

APPENDICES

APPENDIX A

Mandogalup Local Planning Scheme (TBB, 2023a)



LEGEND

- Subject Area

ZONES

- General Industry
- Light Industry
- Residential
- Service Commercial
- Composite
- Local Centre

RESERVES

- Other Regional Road
- Local Distributor Roads
- Environmental Conservation
- Public Open Space and Drainage
- Waterway
- Public Purposes
  Denoted as follows:
  - Indicative Air Quality Monitor
  - Indicative Sewer Pump Station

ADDITIONAL INFORMATION

- Precinct Boundary
- Residential Design Code
- Peel Main Drain
- Planning Control Areas
- REW Wetland Boundary
- REW Wetland Buffer
- Bush Forever
- Restricted Use - Powerline Easement
- Restricted Use - DBNGP
- Additional Heritage Protection Measures Apply
- Preferred Indicative Intersection Location
- Indicative Drainage Storage Location

Improvement Scheme No. 1

MANDOGALUP

Prepared for Department of Planning, Lands and Heritage

DRAFT

plan: 19/055/033C
date: 31/07/2023
designed: MT
scale: 1:10,000@A3 | 1:5000@A1
grid: PCG 94
checked: MT
0 100 200m
aerial: n/a
drawn: BR

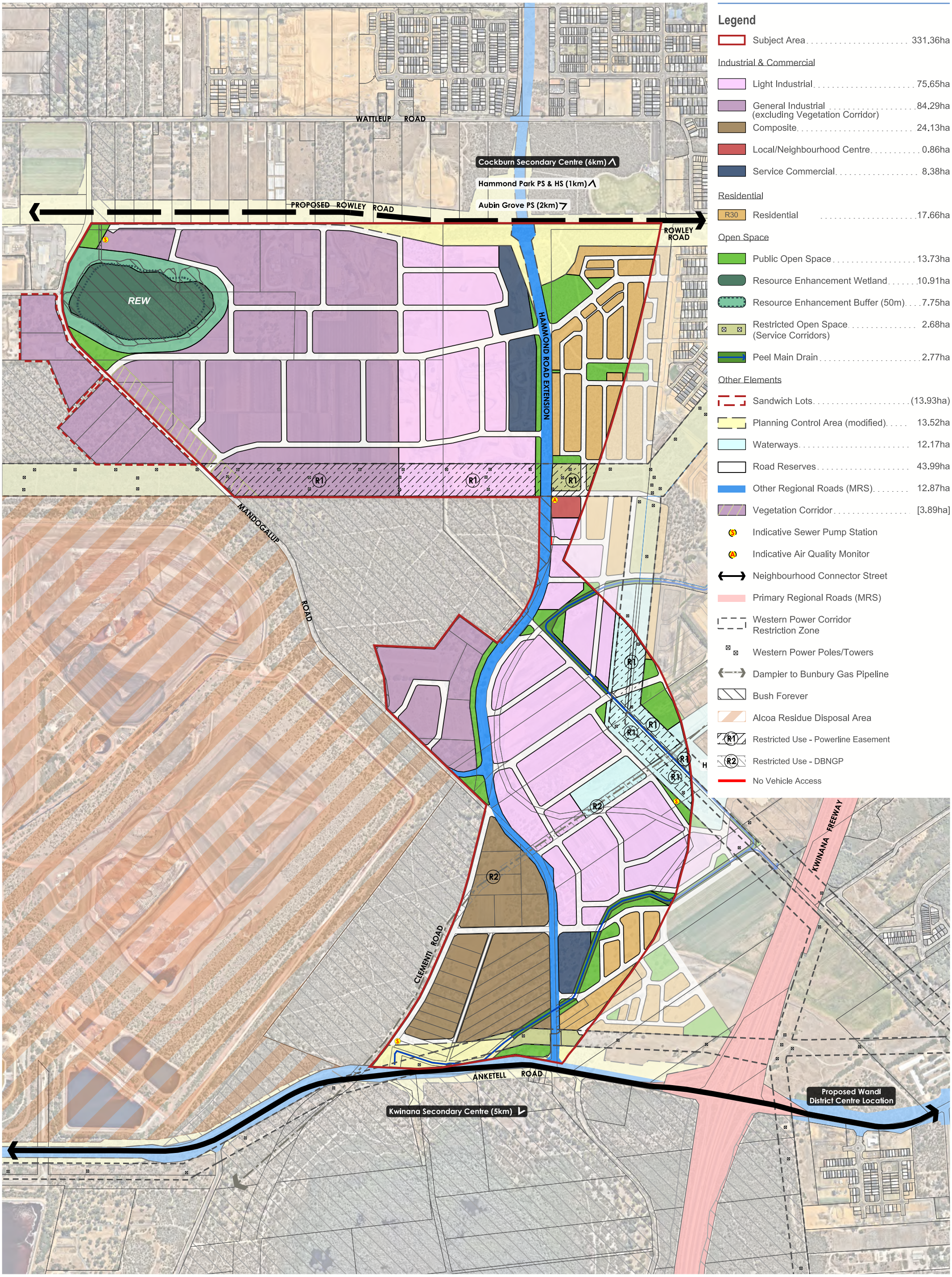
Taylor Burrell Barnett Town Planning & Design
Level 7, 160 St Georges Terrace, Perth WA 6000
e: admin@tbbplanning.com.au
p: (08) 9226 4276

© COPYRIGHT TAYLOR BURRELL BARNETT. ALL RIGHTS RESERVED.
ALL AREAS AND DIMENSIONS DISPLAYED ARE SUBJECT TO DETAIL SURVEY.

Taylor Burrell Barnett

APPENDIX B

Concept Land Use Plan (TBB, 2023b)



Concept Lan Use Plan

MANDOGALUP IMPROVEMENT SCHEME No. 1

PREPARED FOR DEPARTMENT OF PLANNING LANDS AND HERITAGE

DRAFT

scale: 1:12,500@A3 / NTS@A1

0 50 100 150 200m

plan: 19/055/032H

date: 01/08/2023

aerial: Feb 2023

Taylor Burrell Barnett Town Planning & Design
Level 7, 160 St Georges Terrace, Perth WA 6000
e: admin@tbbplanning.com.au
p: (08) 9226 4276

© COPYRIGHT TAYLOR BURRELL BARNETT: ALL RIGHTS RESERVED.
ALL AREAS AND DIMENSIONS DISPLAYED ARE SUBJECT TO DETAIL SURVEY.

Taylor Burrell Barnett

APPENDIX C

Extracts from Jandakot DWMP (DoW, 2009)

AUTHOR: SLee DESIGN FILE: Figure_ES1_UltimateDrainageSystem.dgn

PROJECT N°: 6116977 DATE: 30/06/2008 COORDINATE SYSTEM: MGA94 - Zone 50

WATER CORPORATION

N

LEGEND

- Catchment Boundary
- Water Corporation Open Drain
- Water Corporation Piped Drain
- Local Authority Open and Piped Drains
- Drains to be transferred to Local Auth.
- ① Flow Station locations in Table 5.1
- Gauging Station

GIBBS ROAD
LYON RD
ROWLEY ROAD
Peel Main Drain
Banjup Swamp
CGL = 23.9 mAHD
TWL10 = 24.3 mAHD
S10 = 900 m³
TWL100 = 24.5 mAHD
S100 = 2,700 m³
Mandogalup Swamp North
CGL = 12.8 mAHD
TWL10 = 13.5 mAHD
S10 = 31,700 m³
TWL100 = 13.7 mAHD
S100 = 68,500 m³
Mandogalup Swamp North
Mandogalup Swamp South
CGL = 12.7 mAHD
TWL10 = 13.4 mAHD
S10 = 1,500 m³
TWL100 = 13.7 mAHD
S100 = 2,000 m³
Incorporate drainage requirements into ERIC DSP
Peel Sub Q Drain
Peel Sub R Drain
ANKETELL ROAD
Spectacles Wetland North
CGL = 9.3 mAHD
TWL10 = 9.4 mAHD
S10 = 368,000 m³
TWL100 = 9.6 mAHD
S100 = 502,800 m³
Spectacles Wetland North
Treeby Rd Lake
CGL = 15.5 mAHD
TWL10 = 15.8 mAHD
S10 = 23,600 m³
TWL100 = 16.0 mAHD
S100 = 31,500 m³
KWINANA
Treeby Rd Lake
Sandy Lake
CGL = 14.5 mAHD
TWL10 = 14.6 mAHD
S10 = 3,000 m³
TWL100 = 14.6 mAHD
S100 = 5,500 m³
Spectacles Wetland South
Sandy Lake
THOMAS ROAD
Spectacles Wetland South
CGL = 9.3 mAHD
TWL10 = 9.3 mAHD
S10 = 98,900 m³
TWL100 = 9.5 mAHD
S100 = 153,400 m³
Peel Sub P Drain
Peel Sub P1 Drain
Transfer Sub Drains to Town of Kwinana
ORTON ROAD
Peel Sub P1A Drain
FREEWAY
Johnson Road Wetland
CGL = 11 mAHD
TWL10 = 11 mAHD
S10 = 3,700 m³
TWL100 = 11 mAHD
S100 = 4,100 m³
Develop Operating Regimes for Wetlands with Environmental Regulators
Peel Sub O Drain
Peel Sub N2 Drain
MORTIMER ROAD
Mortimer Rd Wetland
Bollard Bulrush Swamp
CGL = 5.5 mAHD
TWL10 = 4.8 mAHD
S10 = 705,900 m³
TWL100 = 5.6 mAHD
S100 = 1,826,800 m³
Bollard Bulrush
Peel Main Drain
Mortimer Road Wetland
CGL = 10 mAHD
TWL10 = 10 mAHD
S10 = 31,100 m³
TWL100 = 10.1 mAHD
S100 = 34,900 m³
Peel Sub N Drain
Peel Sub N1 Drain
KING ROAD
JACKSON ROAD
MILLAR ROAD

0 500 1000 1500 2000
SCALE OF METRES

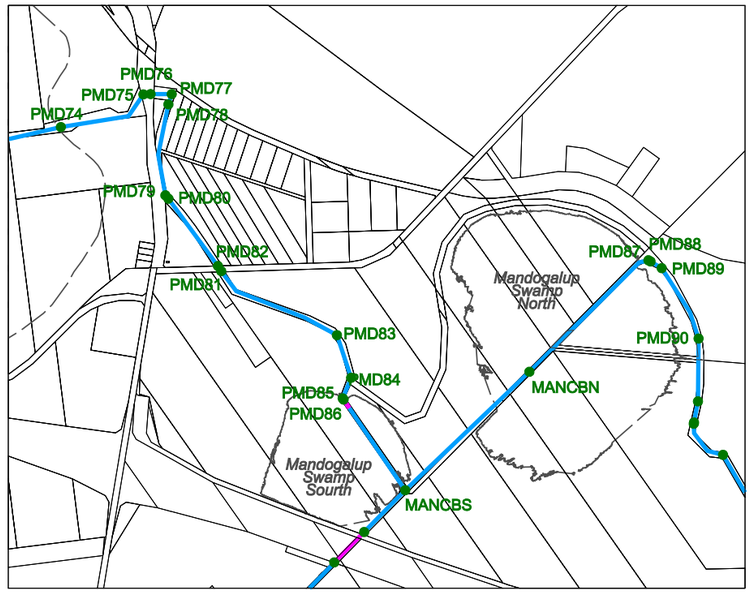
Figure ES1

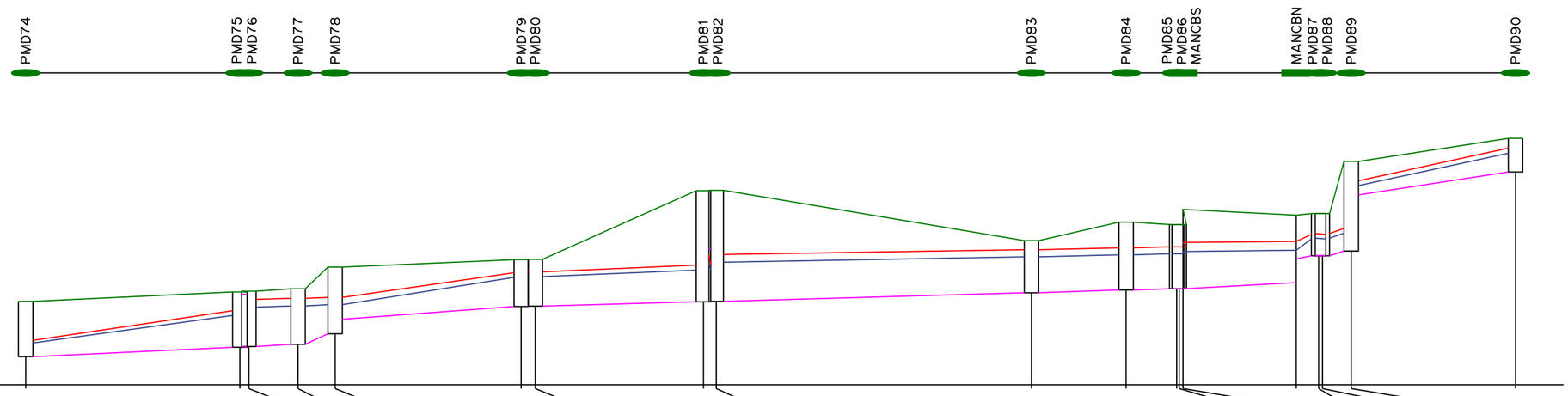
ULTIMATE DRAINAGE SYSTEM

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

N

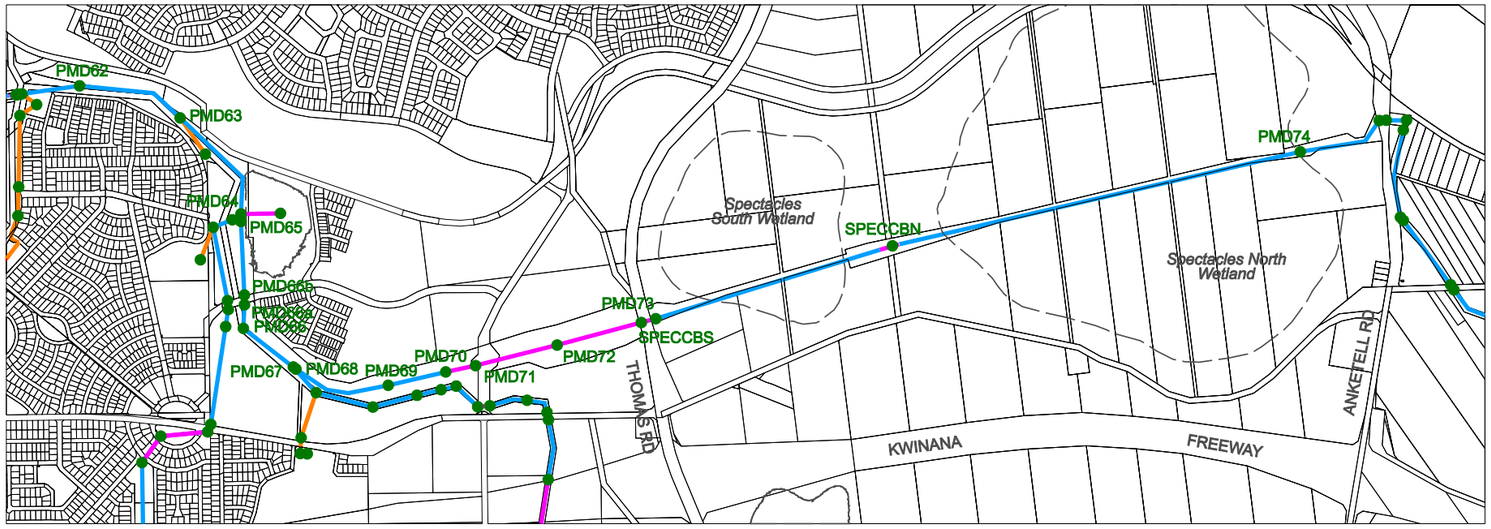


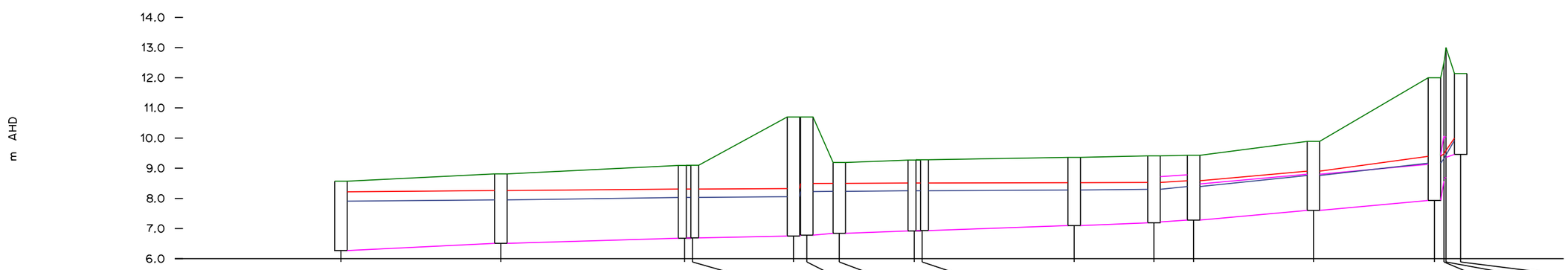


| | | |

THE INFORMATION CONTAINED HEREIN IS SUBJECT TO ONGOING REVIEW AND AMENDMENTS AND SHOULD BE READ IN CONJUNCTION WITH THE ASSOCIATED REPORT.

N



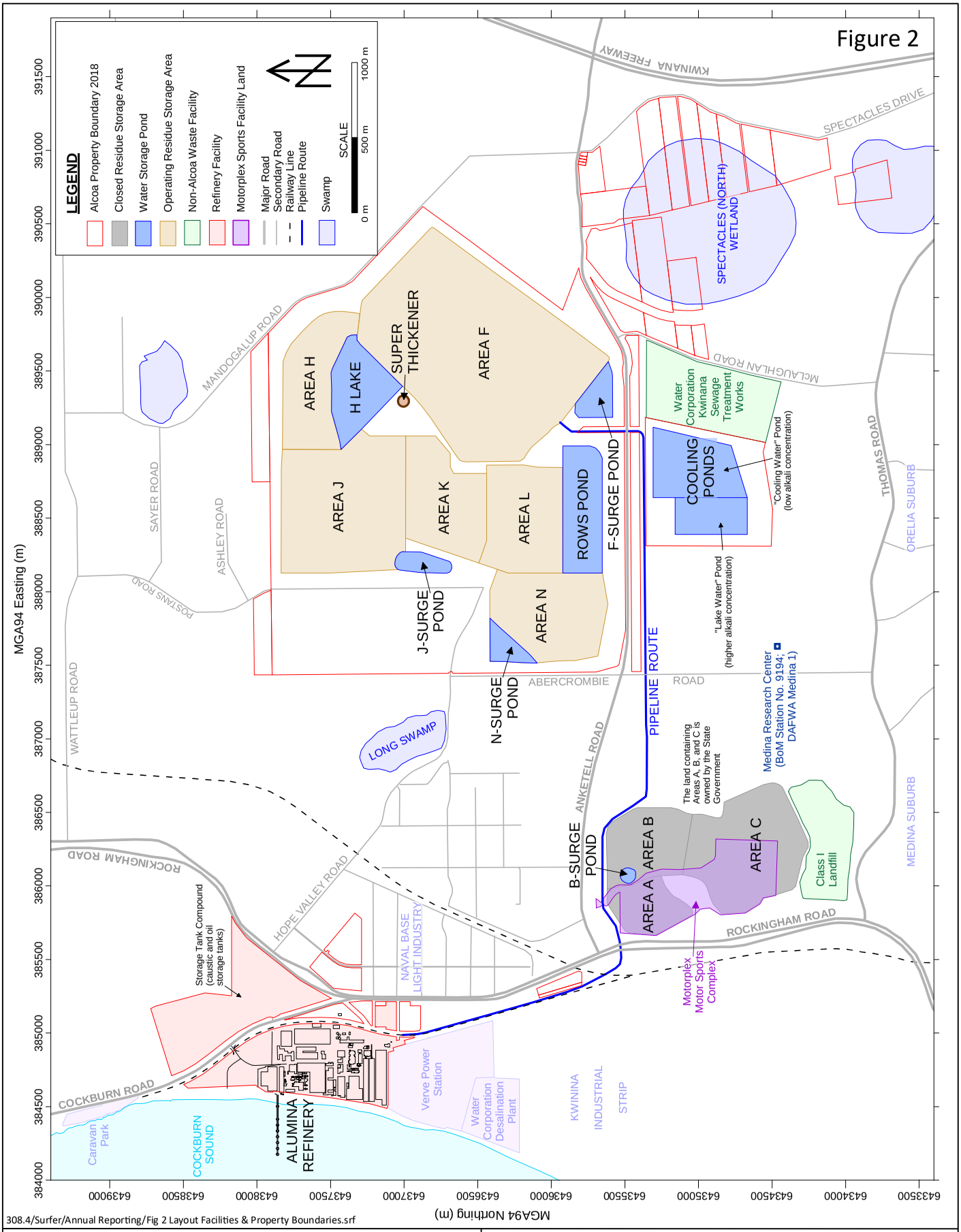


| | | |

APPENDIX D

Extracts from Rockwater (2019)

Figure 2



308.4/Surfer/Annual Reporting/Fig 2 Layout Facilities & Property Boundaries.srf

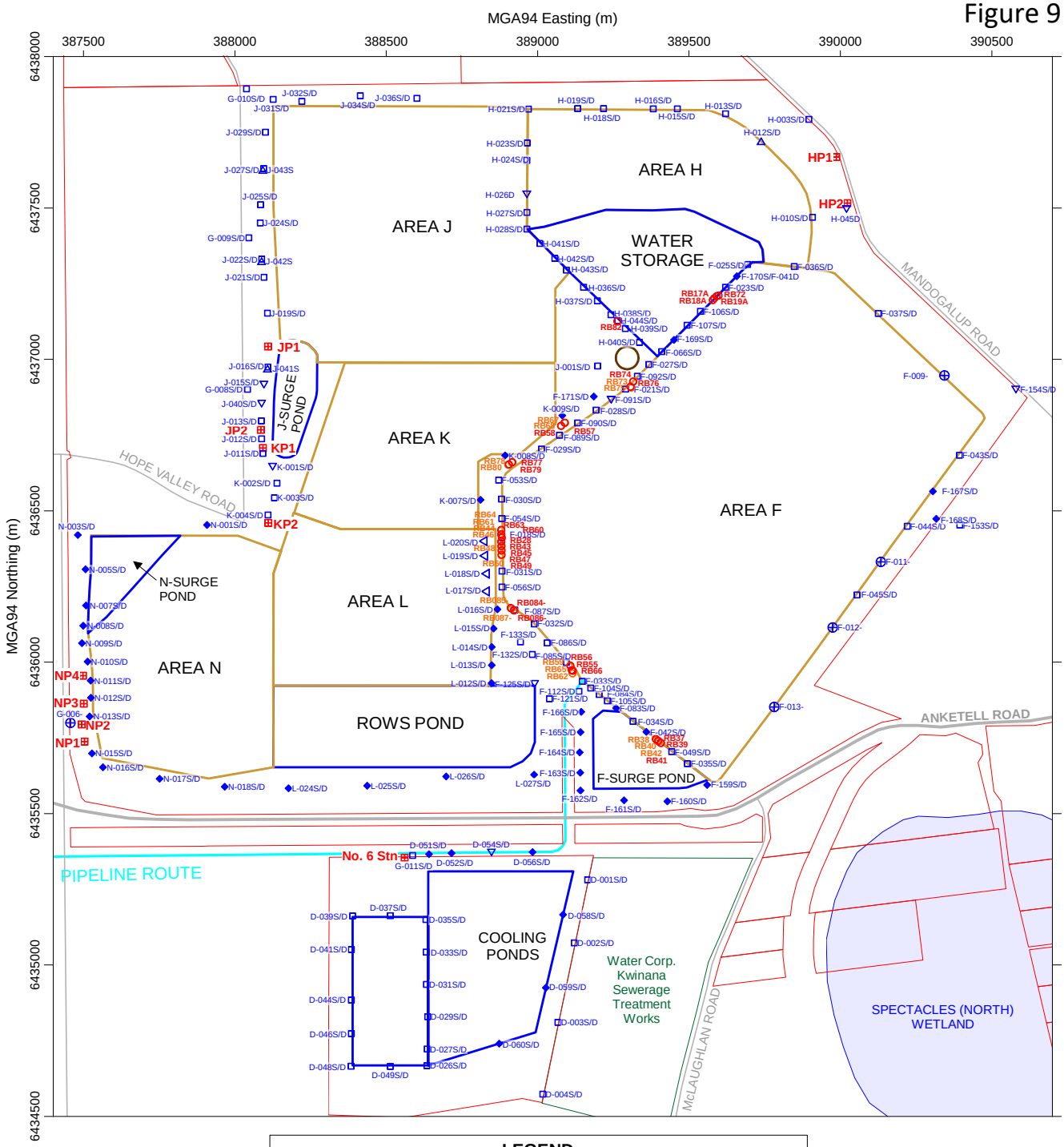
CLIENT:	Alcoa of Australia Limited
PROJECT:	Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018
DATE:	March 2019
Dwg. No:	308.4/19/1-02

LAYOUT OF ALCOA KWINANA FACILITIES AND PROPERTY BOUNDARIES 2018

Alcoa

Rockwater PROPRIETARY LIMITED

Figure 9



LEGEND

- Single Monitor Bore over full aquifer
- Paired Monitor Bore in a single hole
- Pair of Monitor Bores in separate holes
- Shallow Monitor Bore Tube only
- Deep Monitor Bore Tube only
- Pair of Inclined Monitor Bores
- Blocked Monitor Bore
- Shallow Recovery Bore
- Deep Recovery Bore
- Production Bore for Water Supply

SCALE 0m 250m 500m

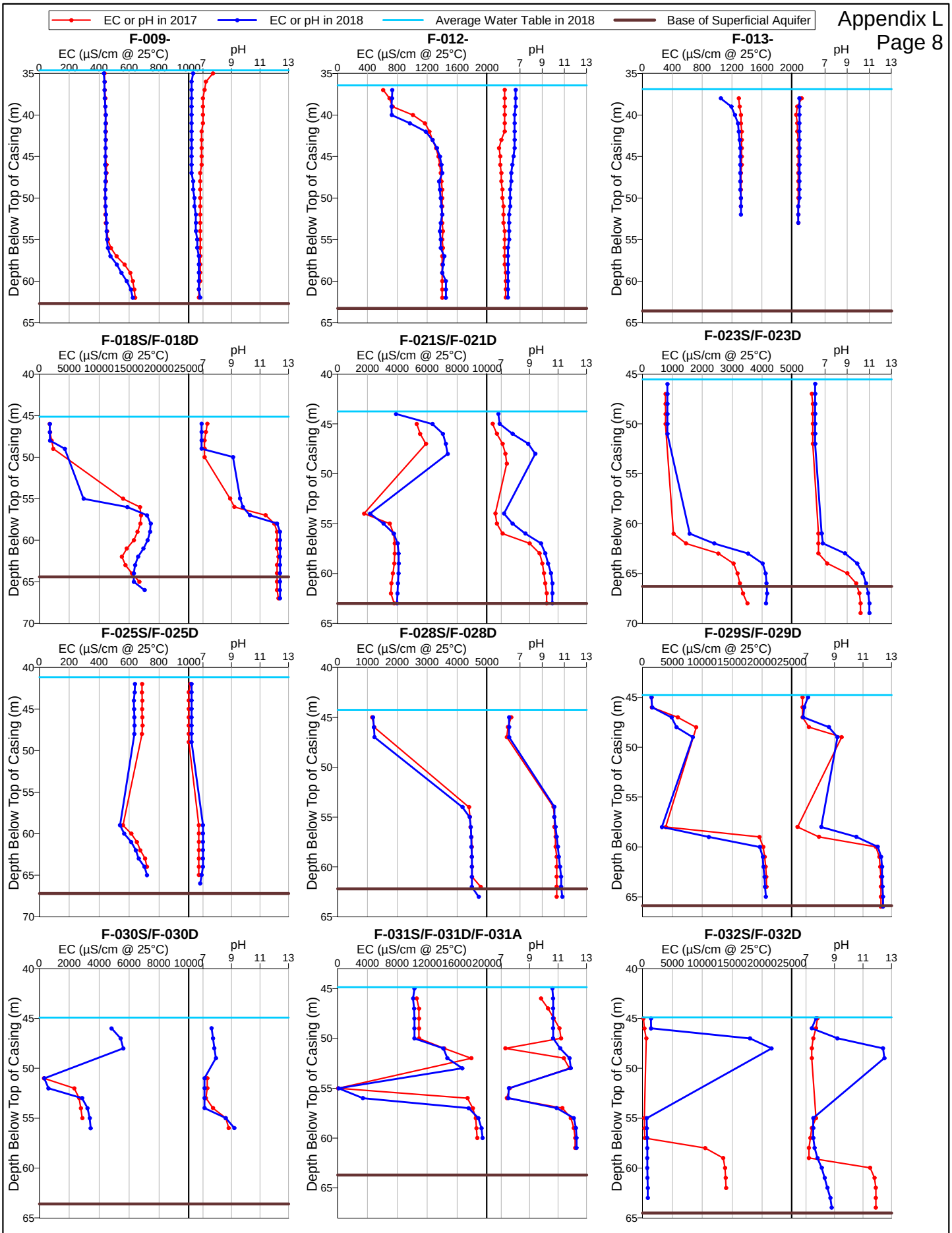
308.4/Surfer/Annual Reporting/Fig 9 Active RSA Bores.srf

CLIENT:	Alcoa of Australia Limited
PROJECT:	Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018
DATE:	March 2019
Dwg. No:	308.4/19/1-09

OPERATING RESIDUE FACILITIES BORES LOCATIONS

Alcoa

Rockwater PROPRIETARY LIMITED



308.4/Grapher/Annual Reporting/Appendix L/Page 8.grf

Client: Alcoa of Australia Limited

Project : Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

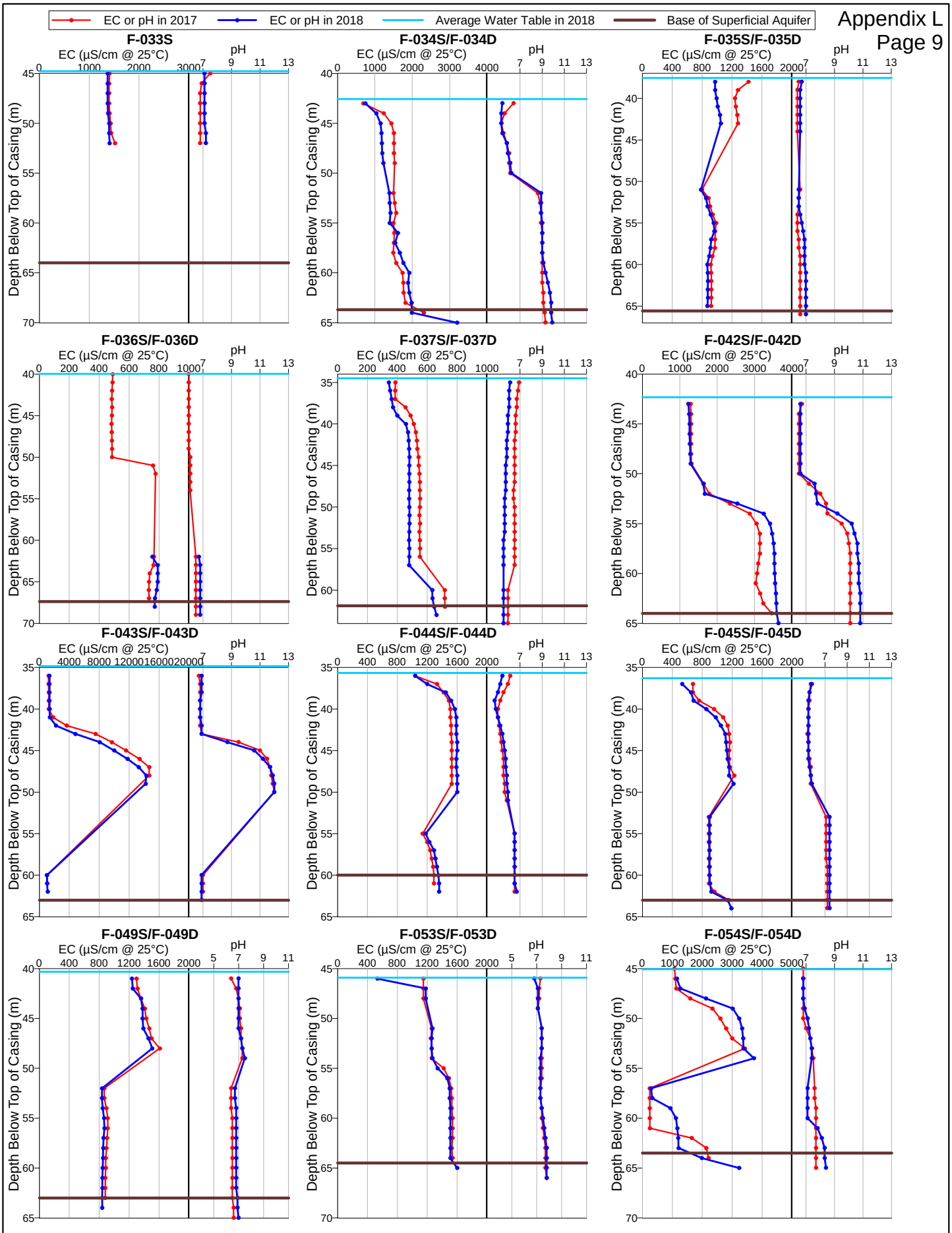
Date : March 2019

Dwg. No: 308-4/19/Appendix L-Page 8

DOWN-HOLE EC-pH LOGS FOR 2017 AND 2018

Alcoa

Rockwater PROPRIETARY LIMITED



308.4/Grapher/Annual Reporting/Appendix L/Page 9.grf

Client: Alcoa of Australia Limited

Project : Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

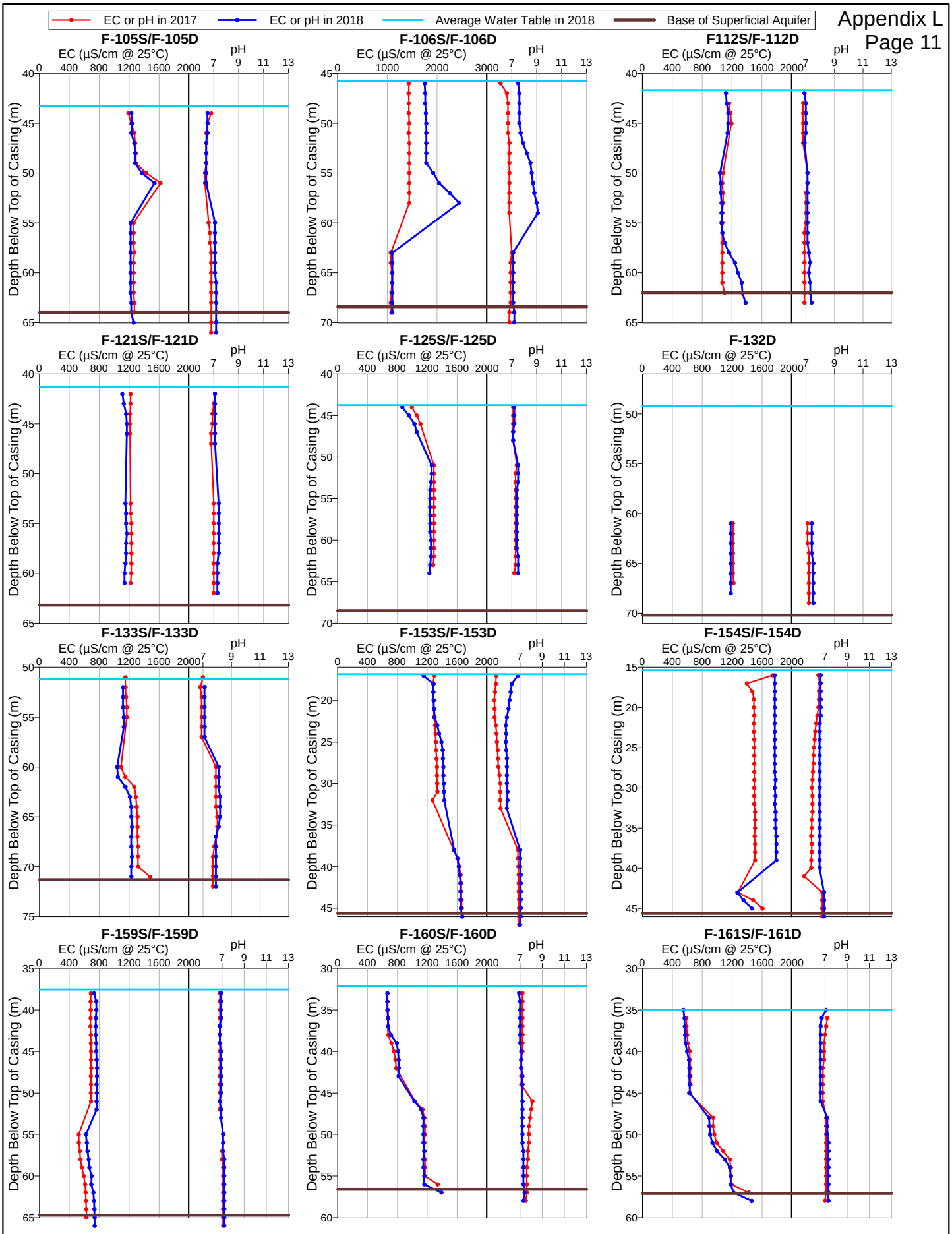
Date : March 2019

Dwg. No: 308-4/19/Appendix L-Page 9

DOWN-HOLE EC-pH LOGS FOR 2017 AND 2018

Alcoa

Rockwater PROPRIETARY LIMITED



308.4/Grapher/Annual Reporting/Appendix L/Page 11.grf

Client: Alcoa of Australia Limited

Project : Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

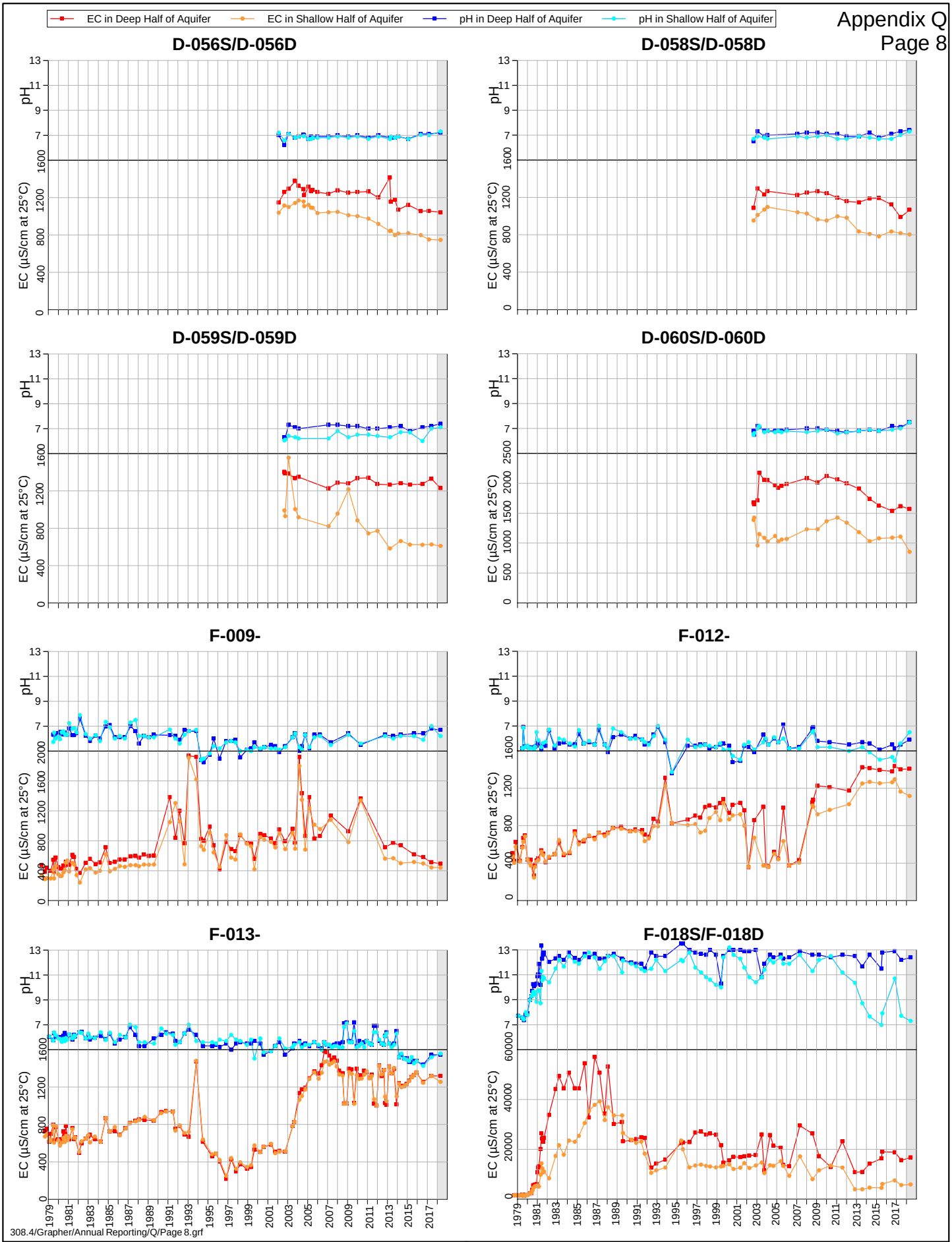
Date : March 2019

Dwg. No: 308-4/19/Appendix L-Page 11

DOWN-HOLE EC-pH LOGS
FOR 2017 AND 2018

Alcoa

Rockwater PROPRIETARY LIMITED

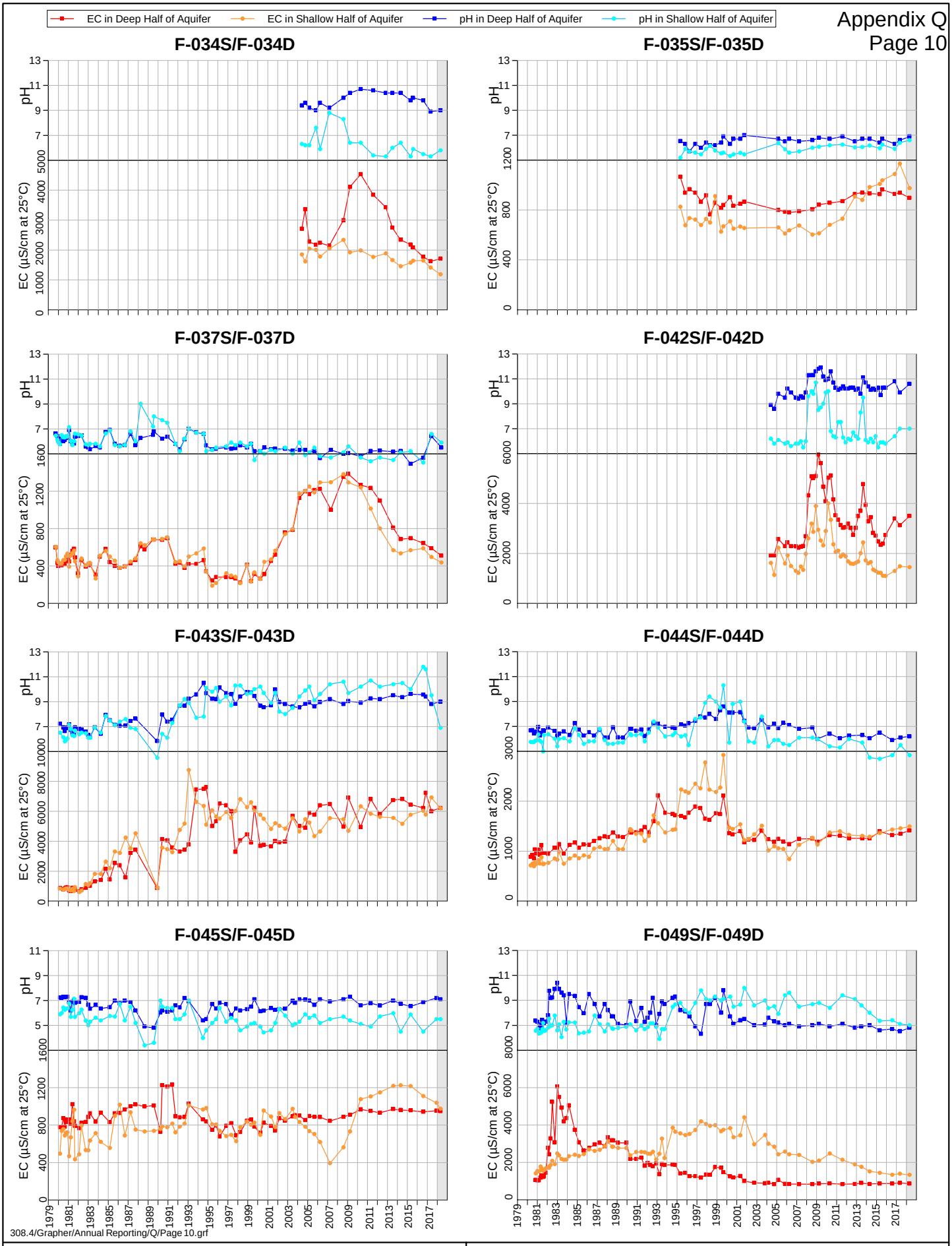


Client:	Alcoa of Australia Limited
Project :	Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018
Date :	March 2019
Dwg. No:	308-4/19/1-Appendix Q-Page 8

HISTORY OF DEPTH-AVERAGED EC & pH FOR SITES MONITORED IN 2018

Alcoa

Rockwater PROPRIETARY LIMITED



Client: Alcoa of Australia Limited

Project : Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

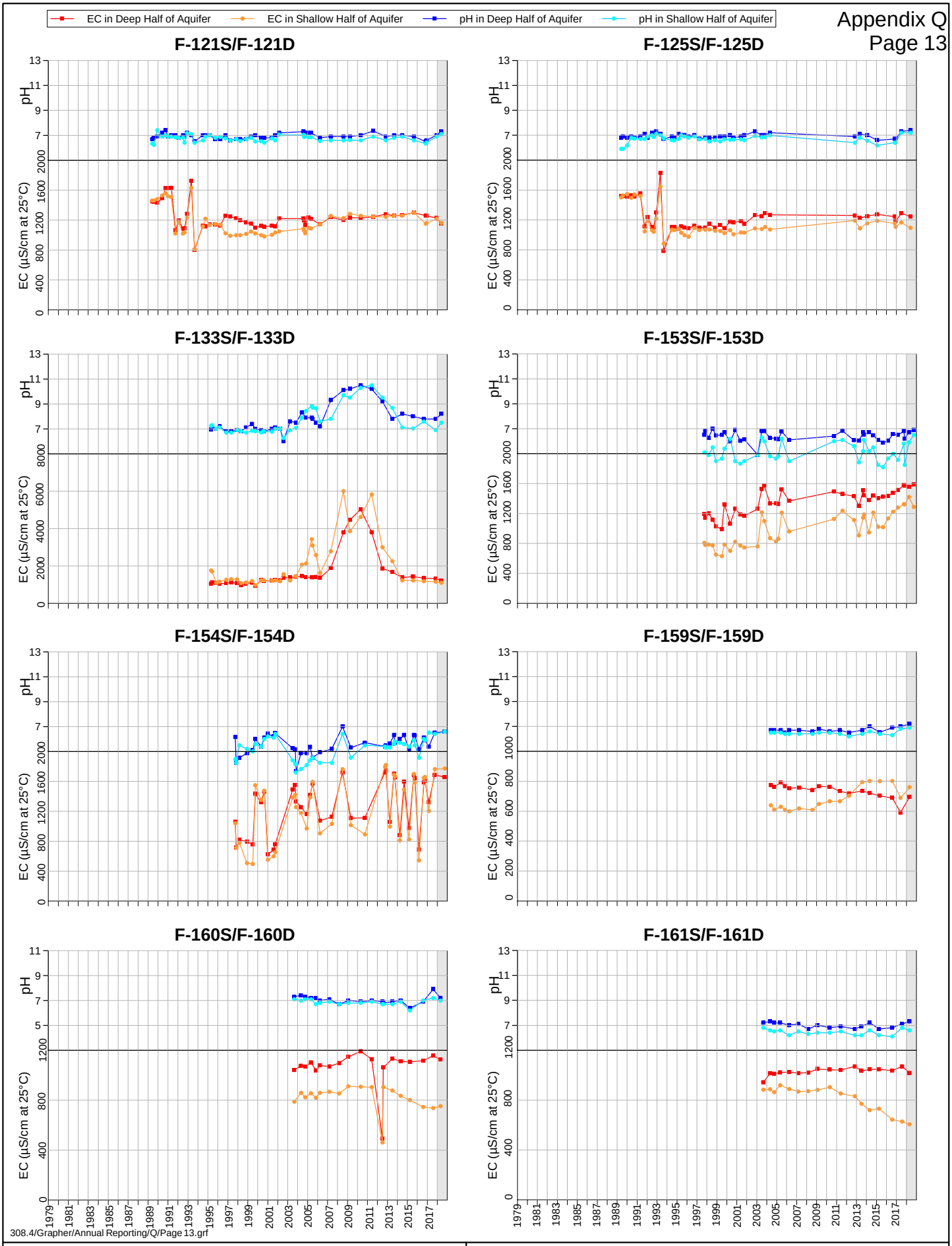
Date : March 2019

Dwg. No: 308-4/19/1-Appendix Q-Page 10

HISTORY OF DEPTH-AVERAGED EC & pH FOR SITES MONITORED IN 2018

Alcoa

Rockwater PROPRIETARY LIMITED



Client: Alcoa of Australia Limited

Project : Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

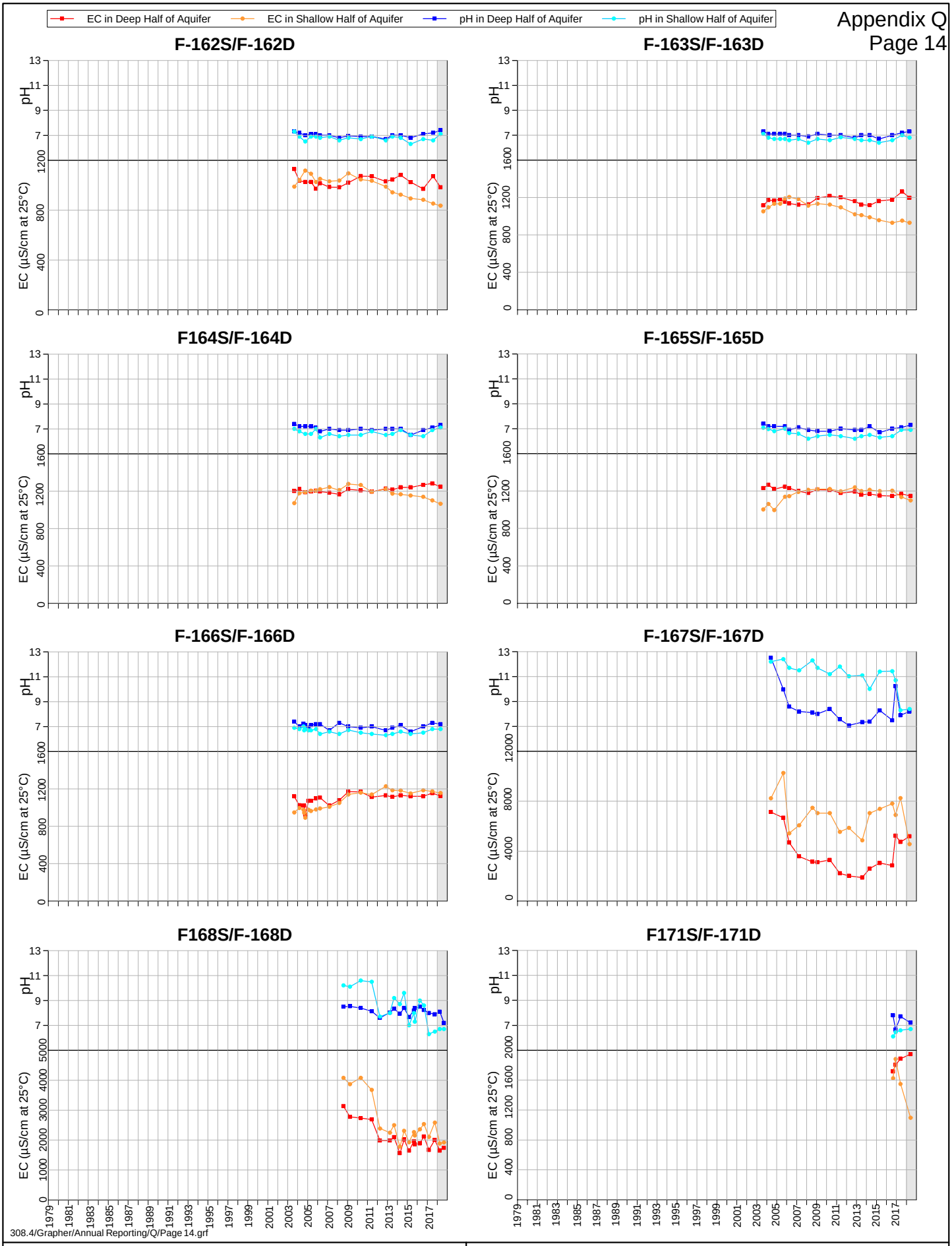
Date : March 2019

Dwg. No: 308-4/19/1-Appendix Q-Page 13

HISTORY OF DEPTH-AVERAGED EC & pH FOR SITES MONITORED IN 2018

Alcoa

Rockwater PROPRIETARY LIMITED



Client: Alcoa of Australia Limited

Project : Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

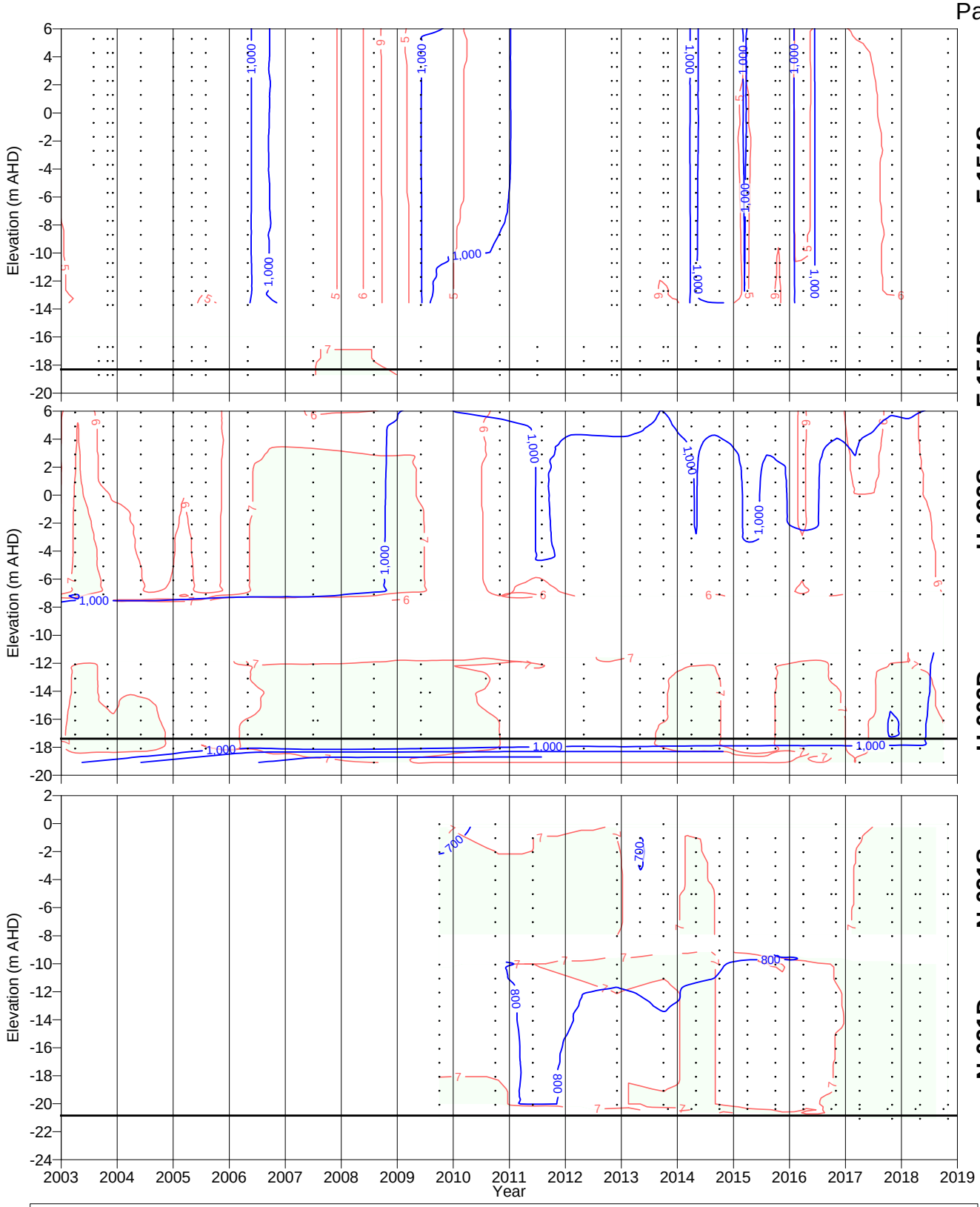
Date : March 2019

Dwg. No: 308-4/19/1-Appendix Q-Page 14

HISTORY OF DEPTH-AVERAGED EC & pH FOR SITES MONITORED IN 2018

Alcoa

Rockwater PROPRIETARY LIMITED



308.4/Surfer/Annual Reporting/Appendix M/Page 7 GMMP F&H Up 1.srf

CLIENT: Alcoa of Australia Limited

PROJECT: Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

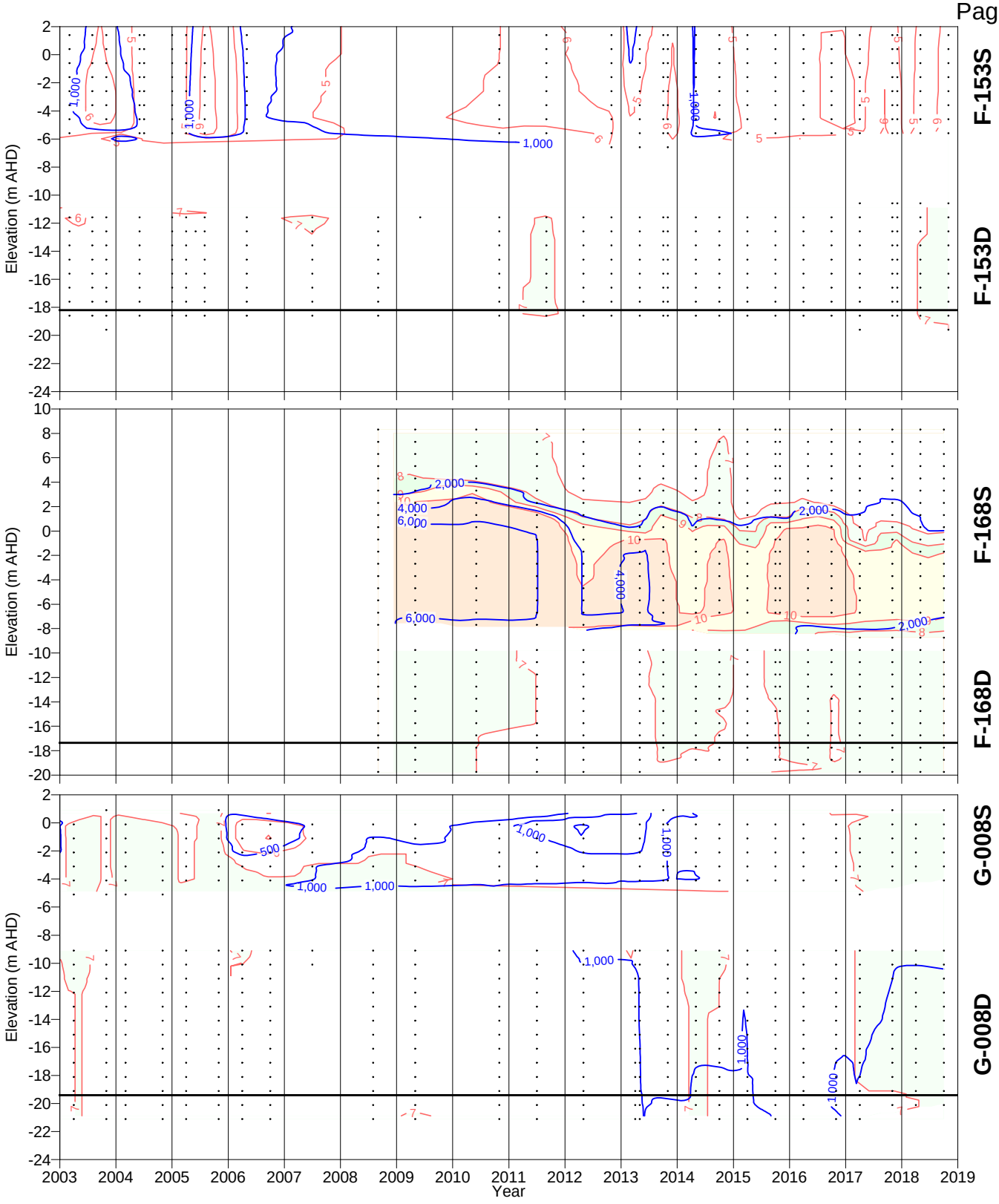
DATE: March 2019

Dwg. No: 308.4/19/Appendix M-Page 7

GMMP EC & pH PROFILES OVER TIME
UPGRADIENT OF AREAS F & H

Alcoa

Rockwater PROPRIETARY LIMITED



CLIENT: Alcoa of Australia Limited

PROJECT: Kwinana Refinery & RSA - Review of Borefield Performance & Groundwater Quality 2018

DATE: March 2019

Dwg. No: 308.4/19/Appendix M-Page 8

GMMP EC & pH PROFILES OVER TIME DOWNGRADIENT OF AREAS F & H

Alcoa

Rockwater PROPRIETARY LIMITED

Suite 1, 27 York St, Subiaco WA 6008
PO Box 117, Subiaco WA 6904
Ph: +61 8 9388 2436

www.jdahydro.com.au

info@jdahydro.com.au

Appendix C

Bushfire Management Plan

Table of Contents

1. Proposal Details 1
   - 1.1 Background 1
   - 1.2 Purpose 1
   - 1.3 Other plans / reports 2
2. Environmental considerations 4
   - 2.1 Native vegetation – modification and clearing 4
   - 2.2 Revegetation / Landscape Plans 5
3. Bushfire hazard level assessment 7
   - 3.1 Assessment inputs 7
     - 3.1.1 Vegetation classification 7
     - 3.1.2 Effective slope 7
     - 3.1.3 Pre-development inputs 7
     - 3.1.4 Post development inputs 9
   - 3.2 Assessment outputs 12
4. Identification of bushfire hazard issues 15
   - 4.1 Bushfire context 15
   - 4.2 Bushfire hazard issues 15
5. Assessment against the bushfire protection criteria 17
6. Responsibilities for implementation and management of the bushfire measures 19
7. References 21
8. Limitations 22

List of Tables

Table 1.1: Reports of relevance to this BMP 2

Table 3.1: Pre-development vegetation classifications/exclusions and effective slope 8

Table 5.1: Compliance with the bushfire protection criteria (acceptable solutions) of the Guidelines 17

List of Figures

Figure 1.1: Site overview 3

Figure 3.1: Pre-development vegetation classification and topography 10

Figure 3.2: Post-development vegetation classification and topography (to be provided following provision of land use plan) 11

Figure 3.3: Pre-development BHL assessment 13

Figure 3.4: Post-development BHL (to be provided following land use plan) 14

Appendices

Appendix A Landscape concept plan
Appendix B Vegetation classification and photographs
Appendix C APZ standards (Schedule 1; the Guidelines, WAPC 2017)
Appendix D City of Kwinana Fire Notice
Appendix E Vehicular access technical standards

1. Proposal Details

1.1 Background

The Department of Planning, Lands and Heritage (DPLH) is preparing the Mandogalup Improvement Scheme (IS) to guide land use planning and future development of approximately 331 ha located south of Rowley Road, north of Anketell Road and west of the Kwinana Freeway.

The Scheme affects approximately 330 ha of land in the Mandogalup locality in the City of Kwinana, and is bound by Rowley Road to the north and Anketell Road to the south, with Kwinana Freeway to the east and the Alcoa residue storage area to the west (the Subject Area; Figure 1.1). The Subject Area is currently zoned Rural and Urban Deferred under the Metropolitan Region Scheme (MRS).

Additionally, the City requested that DPLH consider seven additional lots (19.6 ha; referred to as ''sandwich lots'') for potential inclusion in the Scheme (Figure 1.1).

The majority of the Subject Area and sandwich lots are designated as bushfire prone on the *Map of Bushfire Prone Areas* (DFES 2019; see Plate 1).

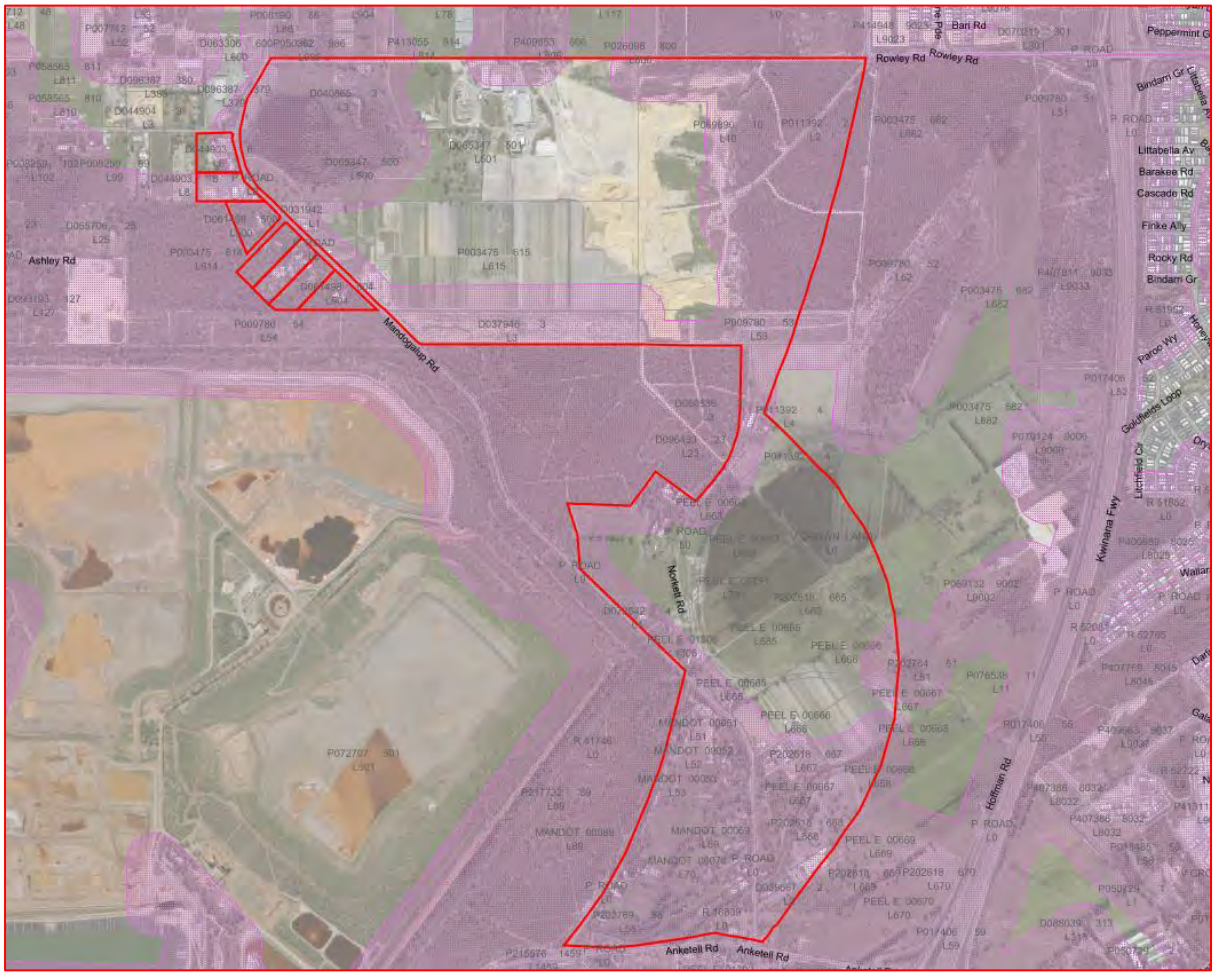


Plate 1: Bushfire Prone Areas mapped within project area and sandwich lots (indicated in pink)

1.2 Purpose

This Bushfire Management Plan (BMP) has been prepared to address requirements under *Policy Measure 6.3* of *State Planning Policy 3.7 Planning in Bushfire-Prone Areas* (SPP 3.7; WAPC 2015) and *Guidelines for Planning in Bushfire Prone Areas* (the Guidelines; WAPC 2017).

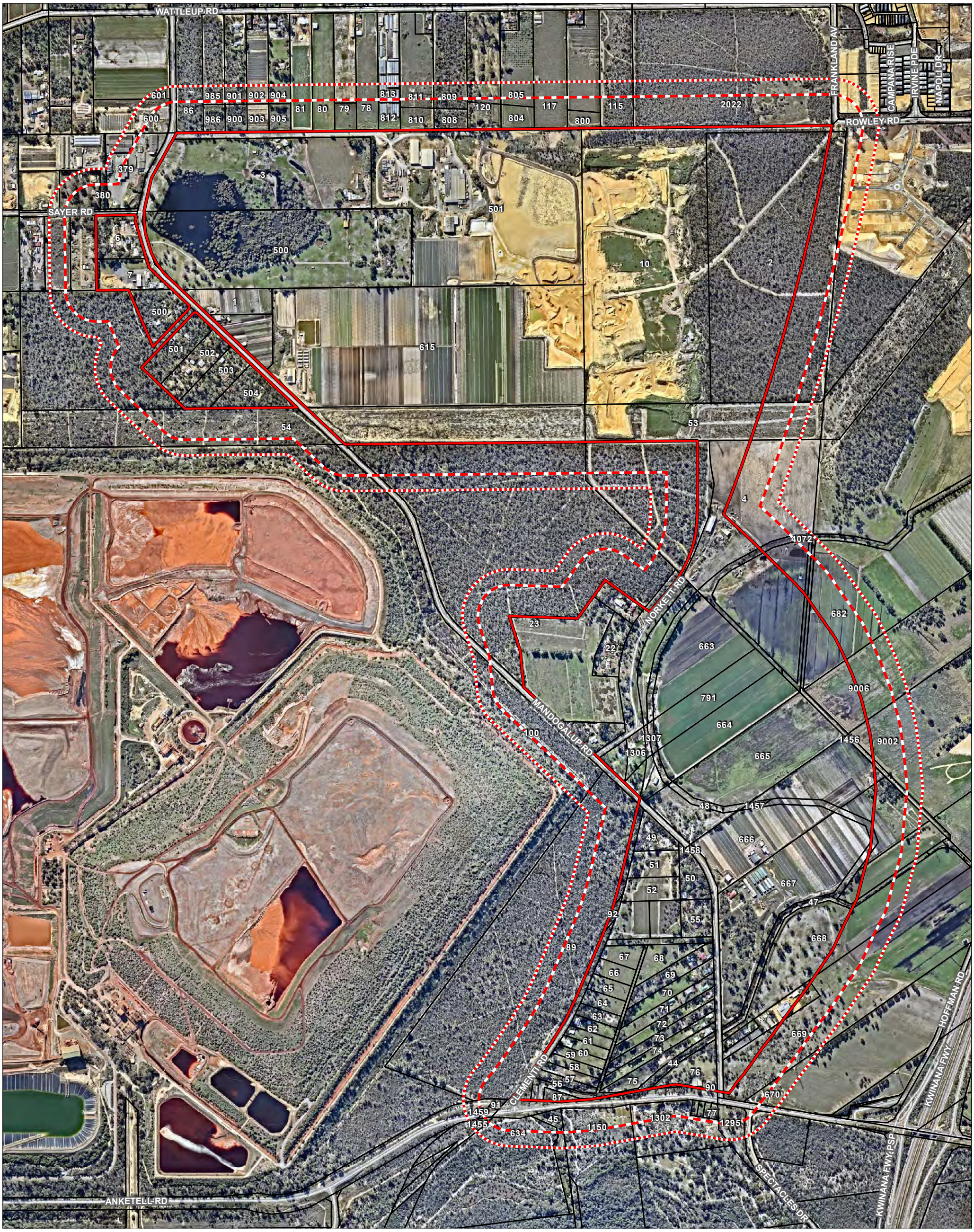
The IP47 area will be subject to an Improvement Scheme (IS). This BMP has been prepared to support the IS.

1.3 Other plans / reports

Other reports of relevance that have been prepared for the Subject Area and sandwich lots as part of the Scheme are presented below in Table 1.1.

Table 1.1: Reports of relevance to this BMP

Report Title	Author/ date
Mandogalup Improvement Scheme Planning Report	Taylor Burrell Barnett 2020
Environmental Assessment Report	Strategen-JBS&G 2020
District Water Management Strategy	JDA Hydrological Consultants
Landscape Masterplan	EPCAD Landscape Architects
Transport Report	Flyt 2020
Infrastructure & Engineering Services Assessment	Wood & Grieve Engineers
Dampier to Bunbury Gas Pipeline Risk Assessment	Advisian



Legend:

- Improvement plan area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries
- Roads (MRWA)

strategen JBS&G

0 200 400 metres

Mandogalup

SITE OVERVIEW

Job No: 57020		Scale 1:11,500 at A4		
Client: Taylor Burrell Barnett		Coord. Sys. GDA 1994 MGA Zone 50		
Drawn By: hsullivan	Checked By: COB	Version: A	Date: 31-Jan-2020	**FIGURE: 1.1**

Document Path: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_01_1_SiteOverview.mxd

Image Reference: www.nearmap.com© - Imagery Date: 29 October 2015

2. Environmental considerations

2.1 Native vegetation – modification and clearing

Table 2.1 below summarise the key conservation significant environmental values both within and adjacent to the Subject Area and sandwich lots.

Table 2.1: Summary of environmental values

Environmental value	Not applicable	Mapped within or adjacent to the Subject Area		Description
		Within	Adjacent	
Environmentally Sensitive Area		✓		An ESA occurs in the north-western portion of the Subject Area, associated with Bush Forever site 393.
Swan Bioplan Regionally Significant Natural Area	✓			Not applicable.
Ecological linkages		✓	✓	Two Regional Ecological Linkages are mapped within the Subject Area, one of which occurs within the sandwich lots. These linkages run within/ adjacent to the western project area boundary (including sandwich lots), and across the north-eastern portion of the Subject Area.
Wetlands		✓		Mapping of the geomorphic wetlands of the Swan Coastal Plain identifies four wetlands within the Subject Area, including three multiple use wetlands (UFI 6531, 6530 and 6538) and one resource enhancement wetland (UFI 6610). There are no mapped wetlands within the sandwich lots. No additional wetlands are mapped within 150 m of the Subject Area or sandwich lots.
Waterways		✓	✓	The Peel Main Drain and sub-drain occur within the central and southern portions of the Subject Area, and adjacent to the southern and eastern project boundaries. The Peel main drain is a rural drain that forms a regional drainage network, running through many wetlands and other low-lying areas.
Threatened Ecological Communities listed under the EPBC Act		✓ (unconfirmed)	✓ (unconfirmed)	It is likely that the Subject Area and sandwich lots (as well as surrounding areas) comprise Banksia woodlands of the Swan Coastal Plain Threatened Ecological Community (TEC) and Tuarts woodlands and forests of the Swan Coastal Plain TEC. Further assessment of vegetation within the Subject Area and sandwich lots will be undertaken to determine if referral under the *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act) is required.
Threatened or priority flora	✓ (unconfirmed)			No threatened flora listed under the EBPC Act or BC Act, or DBCA listed Priority flora have been recorded within lots which have been subject to a targeted flora survey. However, a number of landholdings within the Subject Area and sandwich lots have not yet been subject to a flora and vegetation survey. These areas will be surveyed prior to any development on these landholdings.
Threatened and priority fauna		✓	✓	The Subject Area and sandwich lots provide potential foraging, roosting and breeding habitat for the

Environmental value	Not applicable	Mapped within or adjacent to the Subject Area		Description
		Within	Adjacent	
				threatened forest red-tailed black cockatoo (FRTBC) and Carnaby's Cockatoo (CC). A total of 166 potential nesting habitat trees and 16 potentially suitable hollows have been identified within the Subject Area. An additional 19 hollows were identified within a previous survey of Lots 2 and 20 Rowley Road, for which no hollow suitability (spatial) data was provided. Some of these hollows may also be potentially suitable. A total of 14 potential nesting habitat trees and 6 potentially suitable hollows have been identified within the sandwich lots. Following development design, an assessment of impacts to black cockatoo habitat will be required to determine if referral under the EPBC Act is required. The Subject Area and sandwich lots also potentially provide habitat for the following State listed conservation significant species: • *Falco peregrinus* (Peregrine Falcon; specially protected) • *Isoodon fusciventer* (Quenda; Priority 4) • *Lerista lineata* (Perth Slider; Priority 3) • *Neelaps calonotos* (Black-striped Snake; Priority 3) • *Synemon gratiosa* (Graceful Sunmoth; Priority 4).
Bush Forever Site		✓	✓	Bush Forever site 393 occurs in the north-western portion of the Subject Area. Additionally, the central and south-western portions of the site directly abut the large Bush Forever site (268), and the sandwich lots directly abut Bush Forever site 267. The north-western portion of the site shares a common boundary with Bush Forever site 393.
DBCA managed lands and waters			✓	There are no DBCA legislated lands or waters within the Subject Area or sandwich lots. The nearest DBCA legislated lands or waters are located immediately south of Anketell Road, associated with The Spectacles.

Environmental values will be considered during the design of development within the Subject Area and sandwich lots. It is anticipated that much of the Subject Area and sandwich lots will be cleared/ modified to a low-threat condition. Development design will respond to any retained, unmanaged vegetation that poses a bushfire risk through provision of appropriate separation, water supply and access/ egress arrangements (to be detailed in future BMPs).

Environmental impacts resulting from implementation of the proposal will need to be addressed under the State planning and development process. Additionally, where significant impacts to Matters of National Environmental Significance (MNES) are expected, referral under the EPBC Act will be warranted. Impacts to MNES may include clearing of black cockatoo habitat, or listed TECs.

2.2 Revegetation / Landscape Plans

A broad draft landscape concept plan has been prepared by EPCAD Landscape Architects (Appendix A).

Detail to be added following provision of landscape plan, particularly around low threat versus classified landscaped areas.

No revegetation is currently proposed.

Details to be added if revegetation is proposed (potentially around REW, or within mapped ecological linkage).

3. Bushfire hazard level assessment

3.1 Assessment inputs

3.1.1 Vegetation classification

Vegetated areas within and surrounding the Subject Area and sandwich lots can be broadly described as the following Heddle *et al.* (1980) vegetation complexes:

- Karrakatta Complex- Central and South; open forest of *Eucalyptus gomphocephala* (Tuart) - *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) and woodland of *Eucalyptus marginata* (Jarrah) - Banksia species, and
- Bassendean Complex Central and South; woodland of *Eucalyptus marginata* (Jarrah) - *Allocasuarina fraseriana* (Sheoak) - Banksia species to low woodland of Melaleuca species, and sedgelands on the moister sites. This area includes the transition of *Eucalyptus marginata* (Jarrah) to *Eucalyptus todtiana* (Pricklybark)
- Herdsman Complex; Sedgelands and fringing woodland of *Eucalyptus rudis* (Flooded Gum) - Melaleuca species.

Areas of intact vegetation assessed within and surrounding the Subject Area and sandwich lots was relatively consistent with the broad vegetation complexes listed above and comprise a combination of Class A forest, Class B woodland and Class D scrub.

As a result of rural land uses and historical disturbance, many areas within and surrounding the Subject Area and sandwich lots were cleared, comprising of Class G grassland and market gardens (both managed and unmanaged).

Strategen-JBS&G assessed classified vegetation and exclusions within 150 m of the Subject Area through on-ground verification on 24 October 2019 in accordance with *AS 3959—2018 Construction of Buildings in Bushfire-Prone Areas* (AS 3959; SA 2018) and the *Visual Guide for Bushfire Risk Assessment in Western Australia* (DoP 2016). Georeferenced site photos and a description of the vegetation classifications and exclusions are contained in Appendix B and depicted in Figure 3.1.

3.1.2 Effective slope

Strategen-JBS&G assessed effective slope under classified vegetation through on-ground verification on 24 October 2019 in accordance with AS 3959. Results were cross-referenced with 2008 LIDAR data (Figure 3.1).

For the purpose of the bushfire hazard level assessment, effective slope for each vegetation plot has been classified as either ≤10 degrees, or >10 degrees (see Table 3.1). This is based on the BHL methodology outlined in Appendix Two of the Guidelines.

3.1.3 Pre-development inputs

A summary of the assessed pre-development classified vegetation, exclusions and effective slope within the assessment area and adjacent 150 m are listed in Table 3.1 and illustrated in Figure 3.1.

It is noted that some areas of vegetation within 150 m of the Subject Area and sandwich lots were not able to be accessed during the site inspection, and vegetation classification has been inferred based on strategic level vegetation mapping (both regional mapping and previous vegetation surveys), as well as recent aerial imagery, which is deemed commensurate with the strategic planning stage of the IS. Detailed vegetation classifications can be confirmed at future planning stages within the BMPs required for both structure planning and subdivision.

Table 3.1: Pre-development vegetation classifications/exclusions and effective slope

Vegetation plot	Vegetation classification	Effective slope
1	Class A Forest	>10°
2	Class A Forest	>10°
3	Class A Forest	≤10°
4	Class A Forest	≤10°
5	Class A Forest	≤10°
6	Class A Forest	≤10°
7	Class A Forest	≤10°
8	Class A Forest	≤10°
9	Class A Forest	≤10°
10	Class A Forest	≤10°
11	Class A Forest	≤10°
12	Class A Forest	≤10°
13	Class B Woodland	≤10°
14	Class B Woodland	≤10°
15	Class B Woodland	≤10°
16	Class B Woodland	≤10°
17	Class B Woodland	≤10°
18	Class B Woodland	≤10°
19	Class B Woodland	≤10°
20	Class B Woodland	≤10°
21	Class B Woodland	≤10°
22	Class B Woodland	≤10°
23	Class B Woodland	≤10°
24	Class B Woodland	≤10°
25	Class B Woodland	≤10°
26	Class B Woodland	≤10°
27	Class B Woodland	≤10°
28	Class B Woodland	≤10°
29	Class B Woodland	≤10°
30	Class B Woodland	≤10°
31	Class B Woodland	≤10°
32	Class B Woodland	≤10°
33	Class B Woodland	≤10°
34	Class B Woodland	≤10°
35	Class D Scrub	≤10°
36	Class D Scrub	≤10°
37	Class D Scrub	≤10°
38	Class D Scrub	≤10°
39	Class G Grassland	≤10°
40	Class G Grassland	≤10°
41	Class G Grassland	≤10°
42	Class G Grassland	≤10°
43	Class G Grassland	≤10°
44	Class G Grassland	≤10°
45	Class G Grassland	≤10°
46	Class G Grassland	≤10°
47	Class G Grassland	≤10°
48	Class G Grassland	≤10°
49	Class G Grassland	≤10°
50	Class G Grassland	≤10°
51	Class G Grassland	≤10°
52	Class G Grassland	≤10°
53	Class G Grassland	≤10°
54	Class G Grassland	≤10°
55	Class G Grassland	≤10°
56	Class G Grassland	≤10°
57	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])	N/A

3.1.4 Post development inputs

To be completed once land use plan has been developed.

WATTLEUP RD

SAYER RD

MANDOGALUP RD

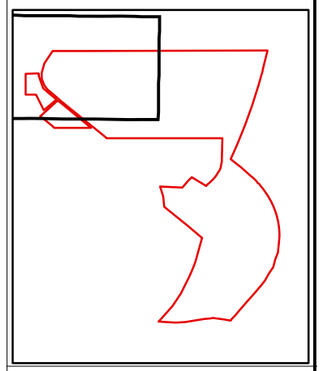
PLOT 3 PLOT 13 PLOT 40 PLOT 57 PLOT 4 PLOT 41 PLOT 16 PLOT 39 PLOT 14 PLOT 14 PLOT 57 PLOT 15 PLOT 45 PLOT 41 PLOT 41 PLOT 19 PLOT 57 PLOT 36 PLOT 57 PLOT 45 PLOT 20 PLOT 45 PLOT 18 PLOT 43 PLOT 35 PLOT 19 PLOT 15 PLOT 45 PLOT 35 PLOT 56 PLOT 57 PLOT 21 PLOT 57 PLOT 57 PLOT 6 PLOT 57 PLOT 57 PLOT 57 PLOT 45

Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries

Vegetation classification

- Class A Forest
- Class B Woodland
- Class D Scrub
- Class G Grassland
- Excluded under Clauses 2.2.3.2 (e) & (f)
- Topographic contours (1m)
- Photo point and direction
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 24-Mar-2020
Drawn By: cthatcher	Checked By: JH
Scale 1:4,250	

0 50 100
metres

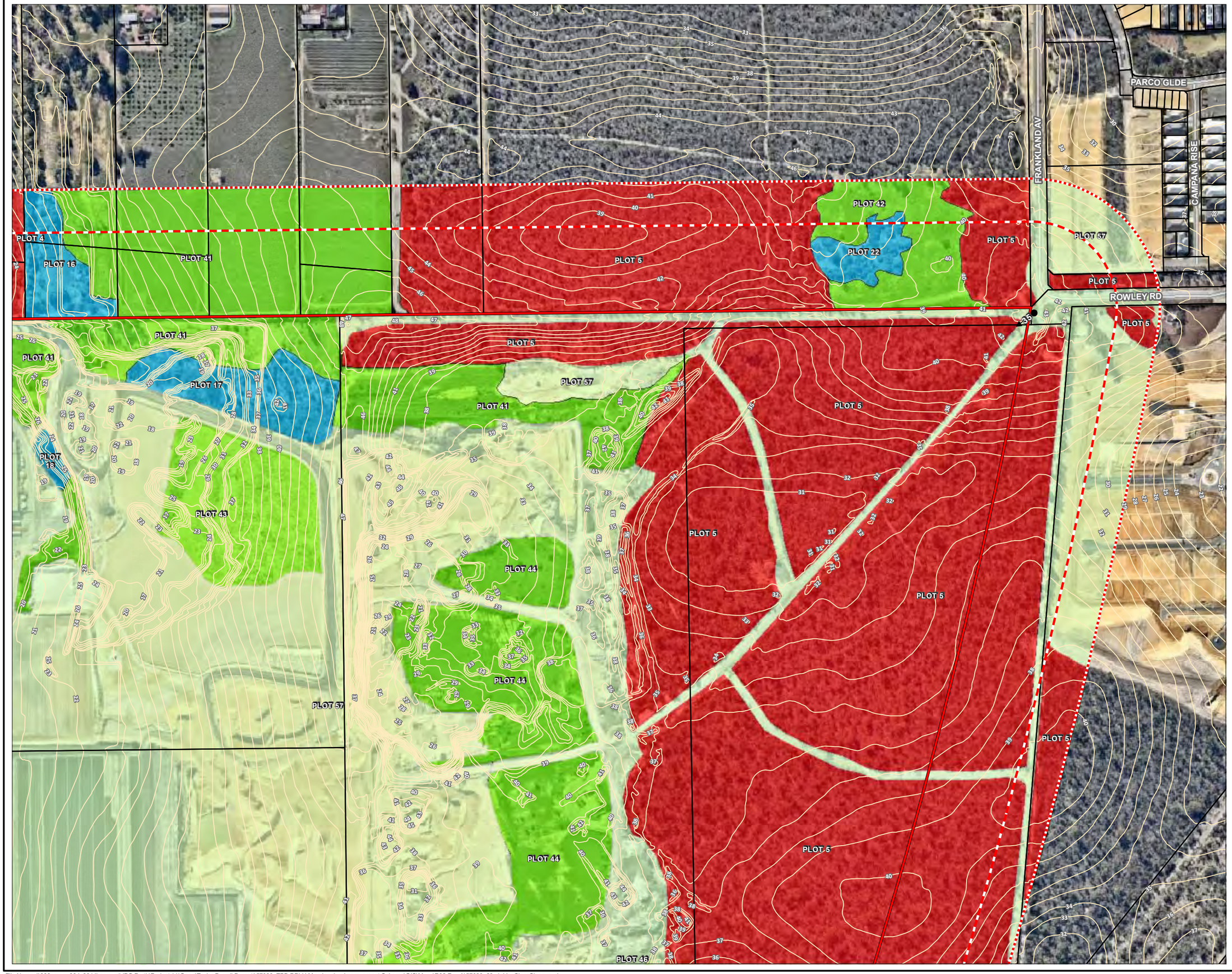
Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE PAGE 1

FIGURE 3.1

File Name: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1}Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_1_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019



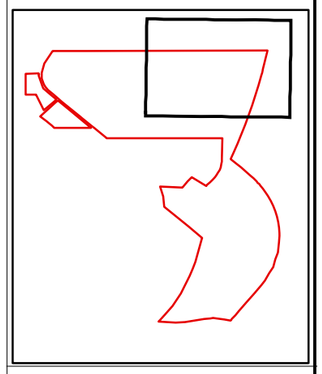
Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries

Vegetation classification

- Class A Forest
- Class B Woodland
- Class G Grassland
- Excluded under Clauses 2.2.3.2 (e) & (f)

- Topographic contours (1m)
- Photo point and direction
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 24-Mar-2020
Drawn By: cthatcher	Checked By: JH
Scale 1:4,000	

0 50 100
metres

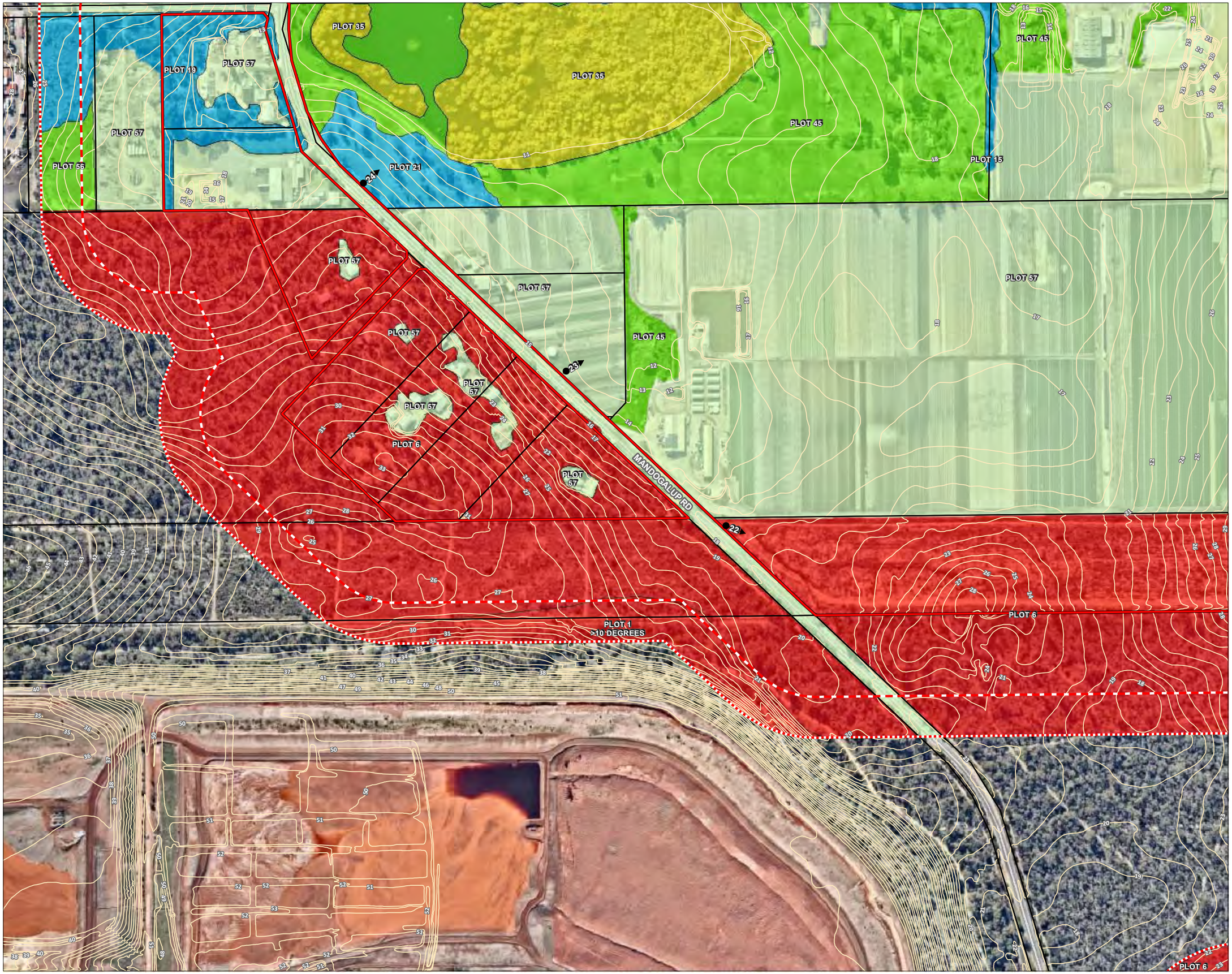
Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE PAGE 2

FIGURE 3.1

File Name: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_1_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

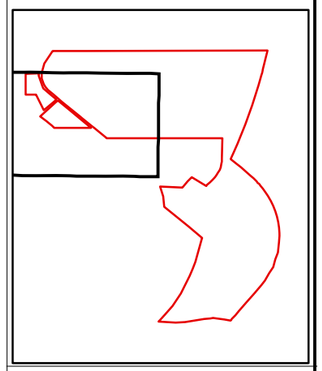


Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries

Vegetation classification

- Class A Forest
- Class B Woodland
- Class D Scrub
- Class G Grassland
- Excluded under Clauses 2.2.3.2 (e) & (f)
- Topographic contours (1m)
- Photo point and direction
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 24-Mar-2020
Drawn By: cthatcher	Checked By: JH
Scale 1:4,250	

0 50 100
metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE PAGE 3

FIGURE 3.1

File Name: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_1_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

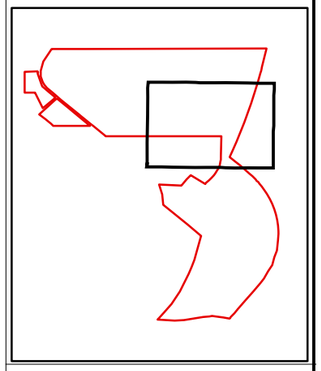
PLOT 44
PLOT 5
PLOT 5
PLOT 5
PLOT 57
PLOT 44
PLOT 5
PLOT 46
PLOT 6
PLOT 57
PLOT 6
PLOT 46
PLOT 57

Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries

Vegetation classification

- Class A Forest
- Class G Grassland
- Excluded under Clauses 2.2.3.2 (e) & (f)
- Topographic contours (1m)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 24-Mar-2020
Drawn By: cthatcher	Checked By: JH

Scale 1:3,500

0 50 100
metres

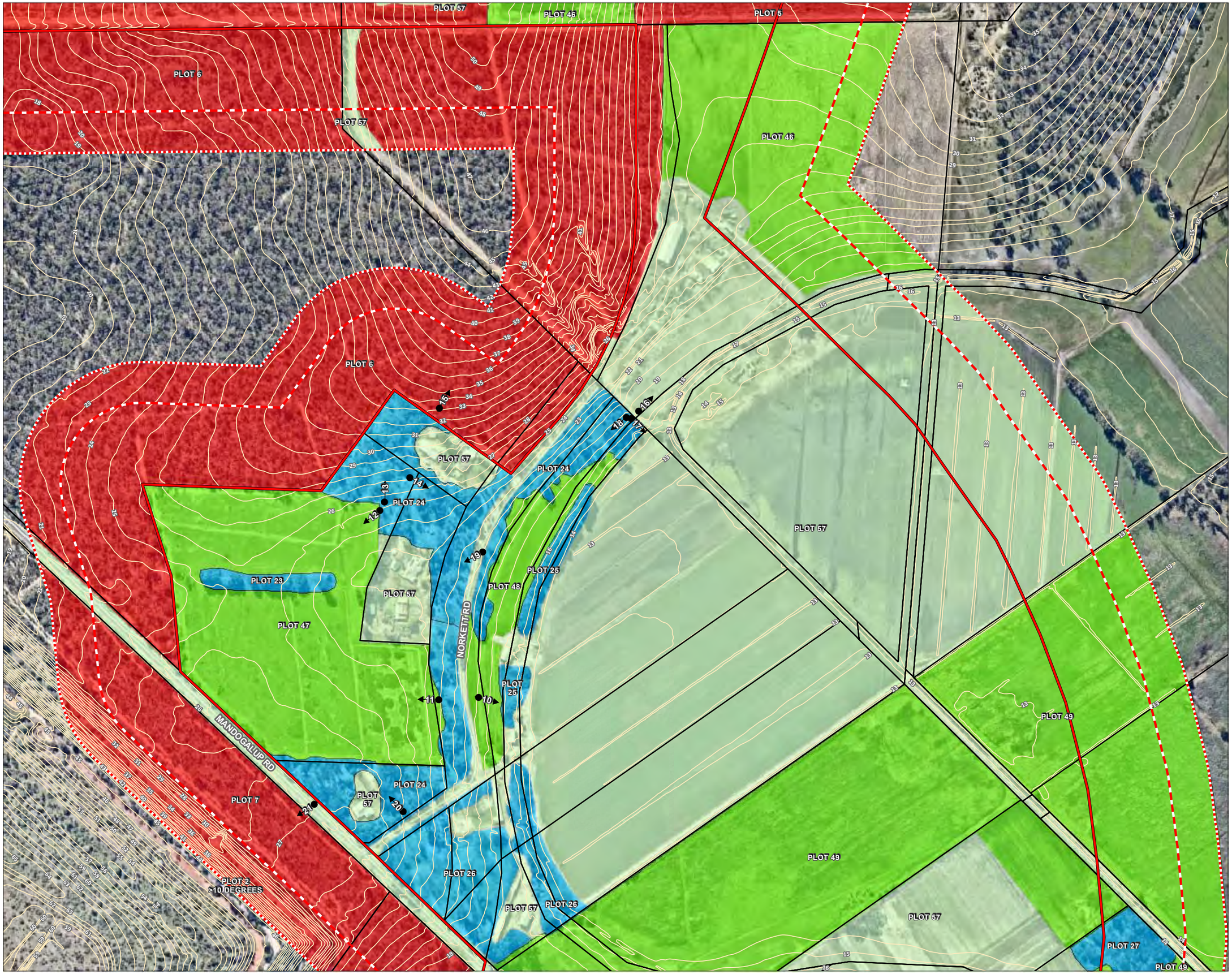
Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE PAGE 4

FIGURE 3.1

File Name: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_1_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

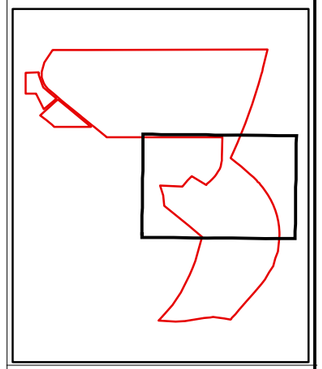


Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries

Vegetation classification

- Class A Forest
- Class B Woodland
- Class G Grassland
- Excluded under Clauses 2.2.3.2 (e) & (f)
- Topographic contours (1m)
- Photo point and direction
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 24-Mar-2020
Drawn By: cthatcher	Checked By: JH
Scale 1:4,250	

0 50 100
metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE PAGE 5

FIGURE 3.1

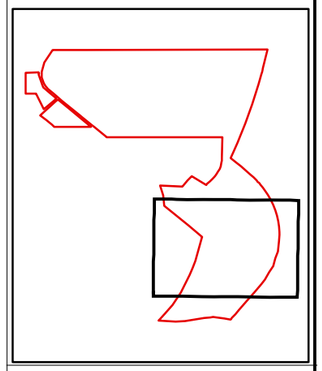
File Name: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_1_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries

Vegetation classification

- Class A Forest
- Class B Woodland
- Class D Scrub
- Class G Grassland
- Excluded under Clauses 2.2.3.2 (e) & (f)
- Topographic contours (1m)
- Photo point and direction
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 24-Mar-2020
Drawn By: cthatcher	Checked By: JH
Scale 1:4,000	

0 50 100
metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE PAGE 6

FIGURE 3.1

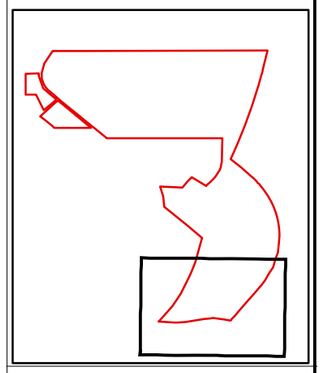
File Name: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_1_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area
- Cadastral boundaries

Vegetation classification

- Class A Forest
- Class B Woodland
- Class D Scrub
- Class G Grassland
- Excluded under Clauses 2.2.3.2 (e) & (f)
- Topographic contours (1m)
- Photo point and direction
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 24-Mar-2020
Drawn By: cthatcher	Checked By: JH
Scale 1:4,000	

0 50 100
metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE PAGE 7

FIGURE 3.1

File Name: \\008pmpmr004v001.jbsg.aust\JBS Perth\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_1_VegClassSlope.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

Figure 3.2: Post-development vegetation classification and topography (to be provided following provision of land use plan)

3.2 Assessment outputs

Pre and post-development vegetation extents have been assigned a bushfire hazard level in accordance with Table 3.2, which is based on the methodology detailed in Appendix Two of the Guidelines and has been adapted to reflect the vegetation classifications as described in the current version of AS3959:2018.

Table 3.2: Bushfire hazard levels and characteristics

Bushfire hazard level	Characteristics*
Extreme	• Class A Forest • Class B Woodland (05) • Class D Scrub • Any classified vegetation with a greater than 10° slope.
Moderate	• Class B Low woodland (07) • Class C Shrubland • Class E Mallee/Mulga • Class G Grassland, including sown pasture and crops • Class G Grassland: Open woodland (06), Low open woodland (08), Open shrubland (09) • Vegetation that has a low hazard level but is within 100 metres of vegetation classified as a moderate or extreme hazard, is to adopt a moderate hazard level.
Low	• Low threat vegetation may include areas of maintained lawns, golf courses, public recreation reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks • Managed grassland in a minimal fuel condition (insufficient fuel is available to significantly increase the severity of the bushfire attack). For example, short-cropped grass to a nominal height of 100 millimetre • Non-vegetated areas including waterways, roads, footpaths, buildings and rock outcrops.
*Vegetation classifications from AS 3959-2018 Table 2.3.	

3.2.1.1 Pre-development

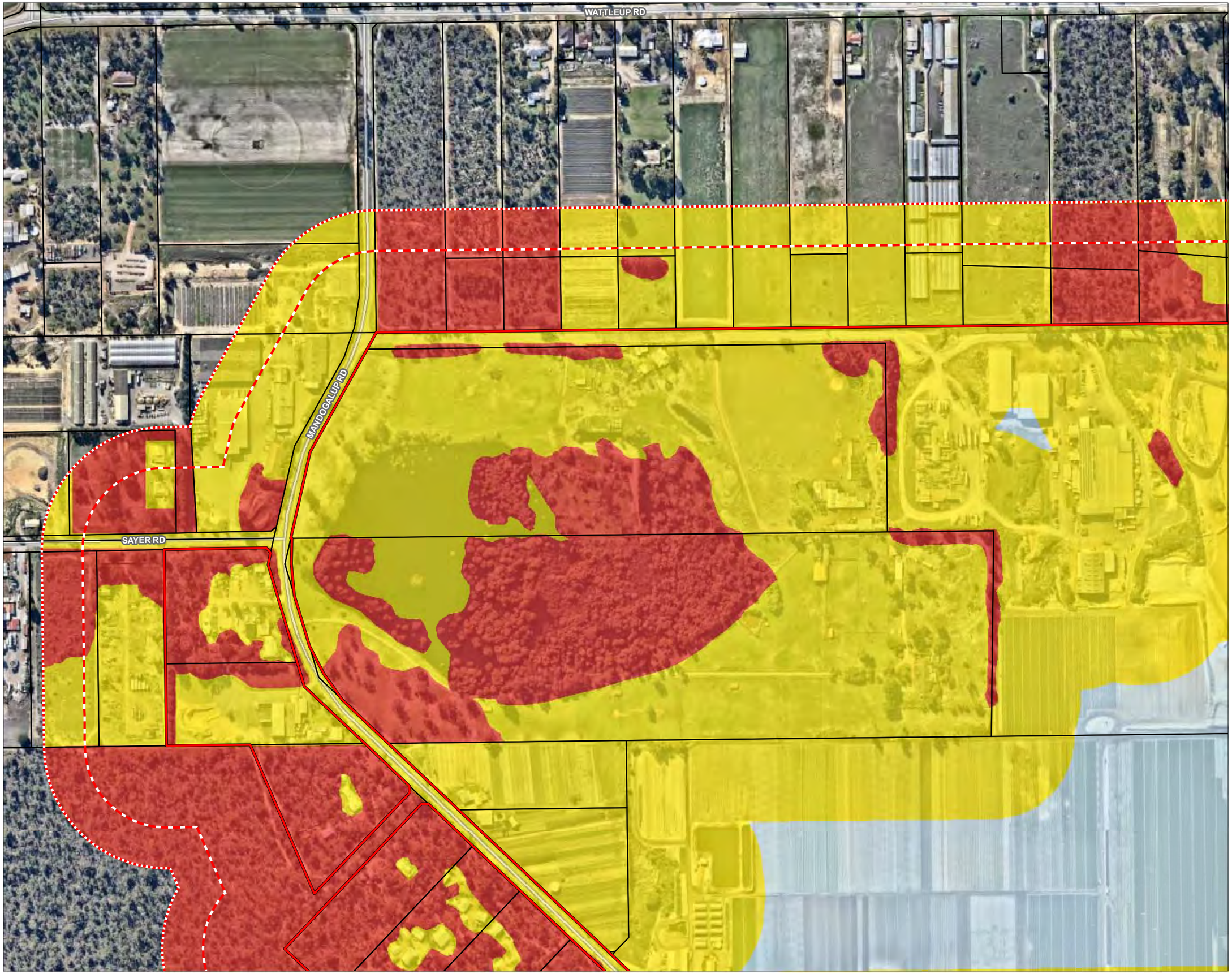
Strategen-JBS&G has mapped the pre-development bushfire hazard levels within the Subject Area and adjacent 150 m wide assessment area. The bushfire hazard levels have been assessed on the basis of the vegetation discussed in Section 3.1.1 (i.e. the current pre-development extent of vegetation within and surrounding the Subject Area).

The pre-development BHL assessment (refer to Figure 3.3) shows that based on the existing vegetation, the Subject Area and sandwich lots contain land with:

- Low bushfire hazard levels associated with areas of managed market gardening within the Subject Area, greater than 100 m from Moderate or Extreme bushfire hazards.
- Moderate bushfire hazard levels associated with areas of unmanaged grassland/ unmanaged market gardens (Class G grassland), or areas within 100 m of Moderate or Extreme bushfire hazards, both within and adjacent to the Subject Area and sandwich lots.
- Extreme bushfire hazard levels associated with areas of Class A forest, Class B woodland and Class D scrub, and areas with an effective slope greater than 10 degrees, both within and adjacent to the Subject Area and sandwich lots. It is noted that the only areas with a slope greater than 10 degrees occur on the batters to the Alcoa tailings ponds, however the Subject Area is located downslope of these.

3.2.1.2 Post-development

To be completed following preparation of land use plan.

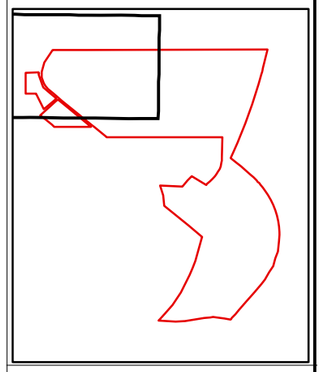


Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area

Bushfire Hazard Level

- Extreme
- Moderate
- Low
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 31-Jan-2020
Drawn By: hsullivan	Checked By: JH

Scale 1:4,250

0 50 100
metres

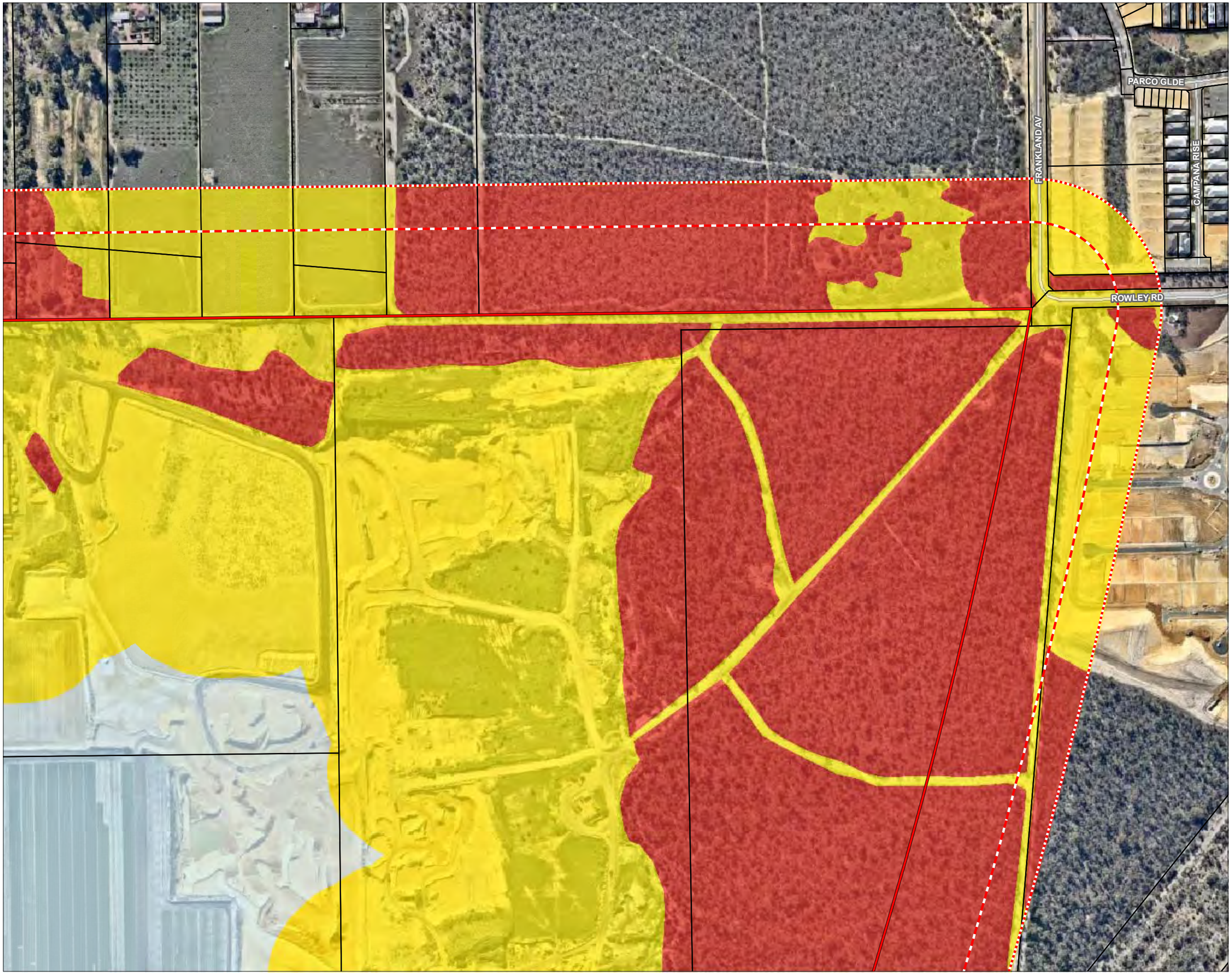
Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

BUSHFIRE HAZARD LEVEL MAP
PAGE 1

FIGURE 3-3

File Name: W:\Projects\1)Open\Taylor Burrell Barnett\57020_TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_BHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

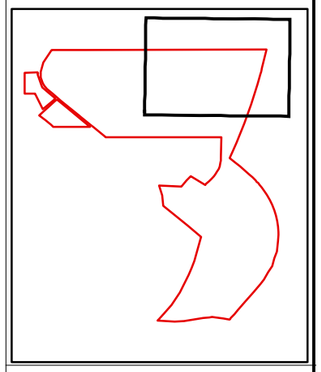


Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area

Bushfire Hazard Level

- Extreme
- Moderate
- Low
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 31-Jan-2020
Drawn By: hsullivan	Checked By: JH

Scale 1:4,000

0 50 100
metres

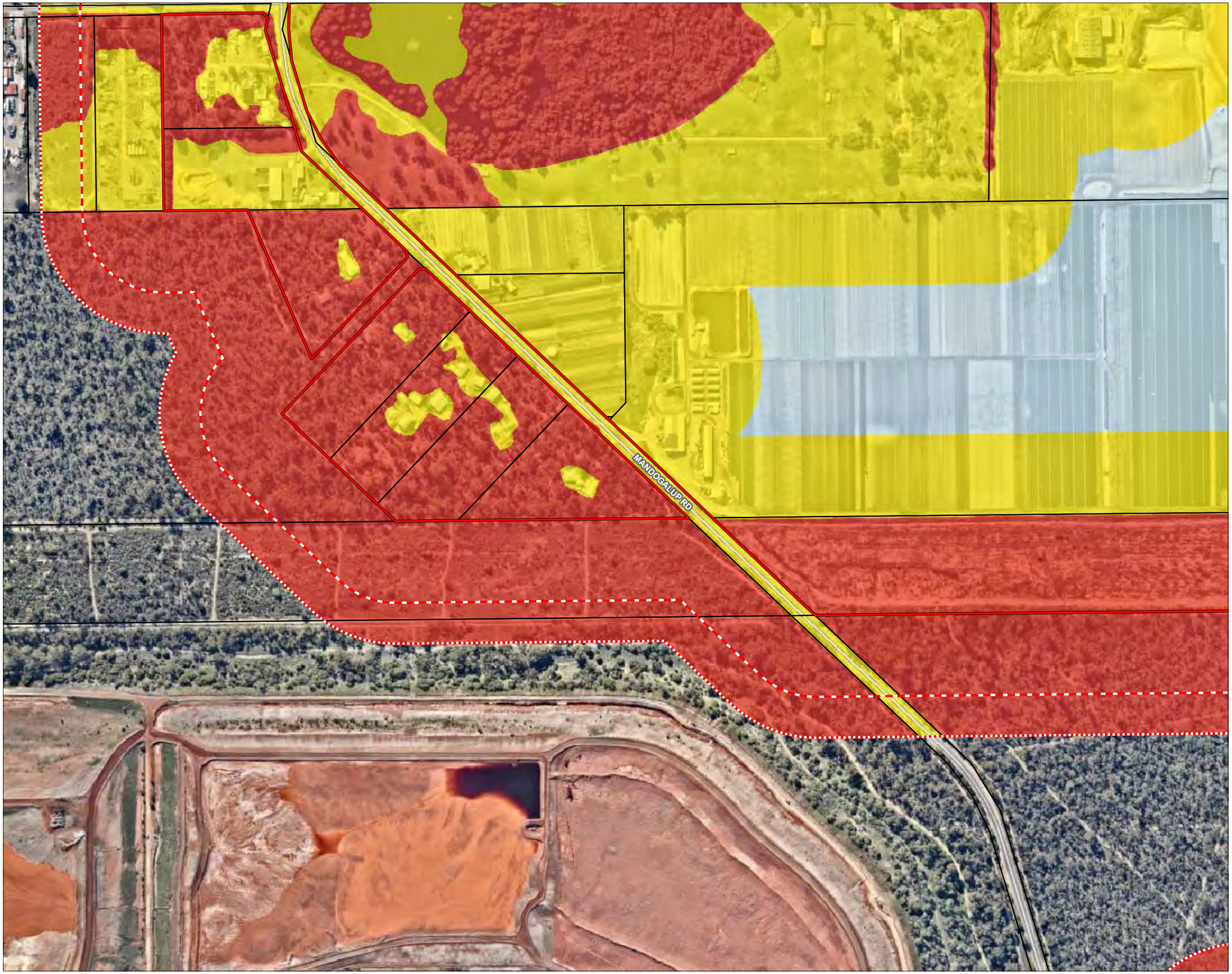
Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

BUSHFIRE HAZARD LEVEL MAP
PAGE 2

FIGURE 3-3

File Name: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_BHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

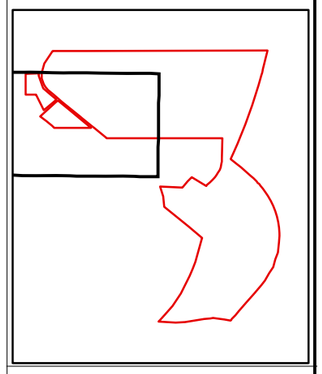


Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area

Bushfire Hazard Level

- Extreme
- Moderate
- Low
- Roads (MRWA)



strategen JBS&G

Job No: 57020

Client: Taylor Burrell Barnett

Version: A	Date: 31-Jan-2020
Drawn By: hsullivan	Checked By: JH

Scale 1:4,250

0 50 100
metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

BUSHFIRE HAZARD LEVEL MAP PAGE 3

FIGURE 3-3

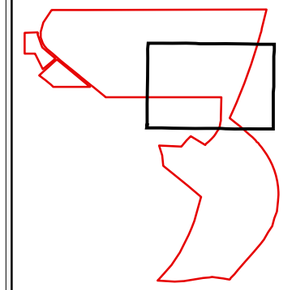
File Name: W:\Projects\1)Open\Taylor Burrell Barnett\57020 TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_BHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area

Bushfire Hazard Level

- Extreme
- Moderate
- Low



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 31-Jan-2020
Drawn By: hsullivan	Checked By: JH
Scale 1:3,500	

0 50 100
metres

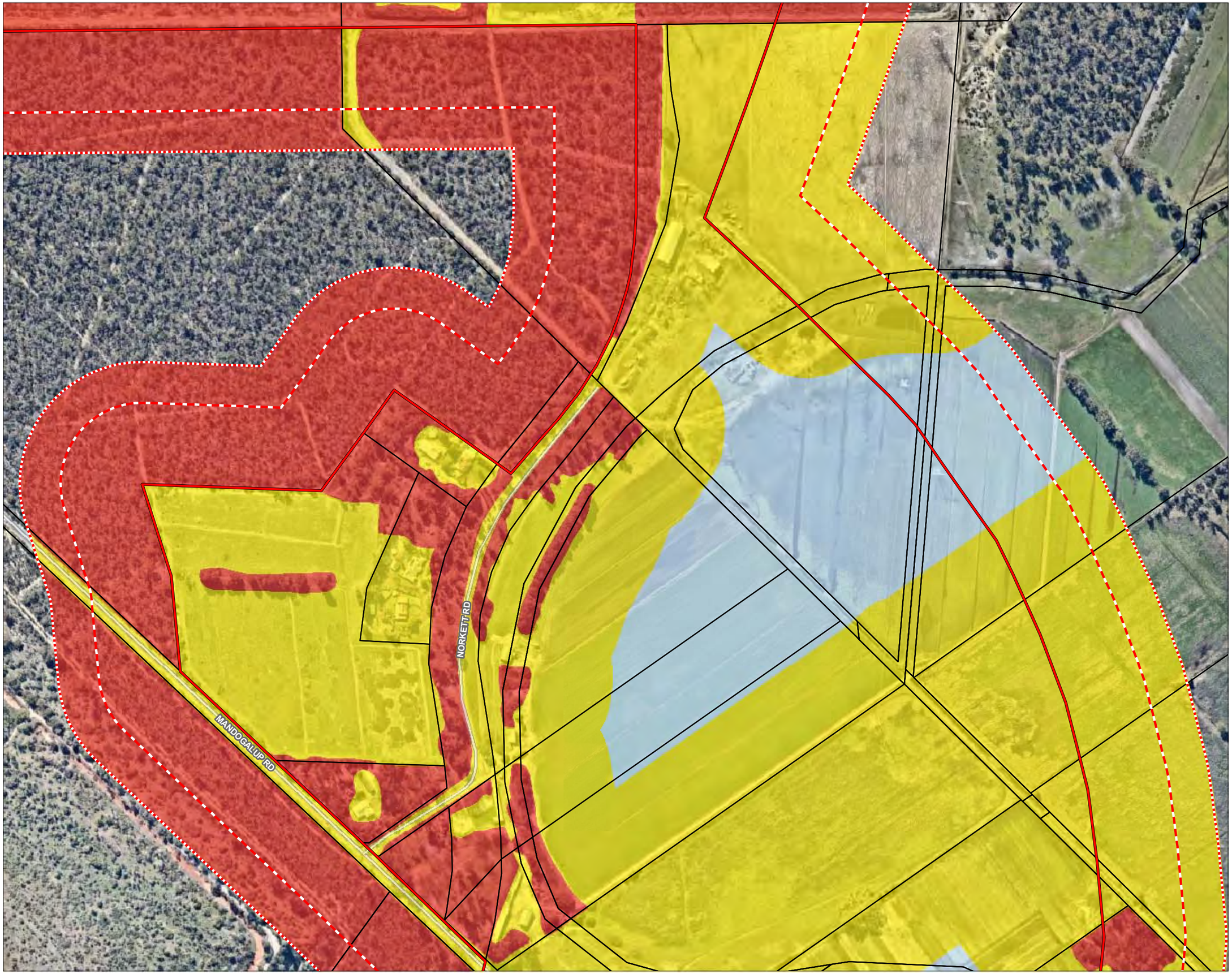
Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

BUSHFIRE HAZARD LEVEL MAP
PAGE 4

FIGURE 3-3

File Name: W:\Projects\1)Open\Taylor Burrell Barnett\57020_TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_BHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

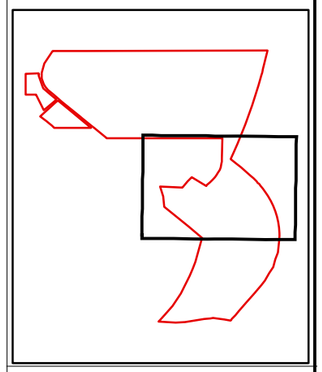


Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area

Bushfire Hazard Level

- Extreme
- Moderate
- Low
- Roads (MRWA)



strategen JBS&G

Job No: 57020

Client: Taylor Burrell Barnett

Version: A	Date: 31-Jan-2020
Drawn By: hsullivan	Checked By: JH

Scale 1:4,250

0 50 100
metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

BUSHFIRE HAZARD LEVEL MAP
PAGE 5

FIGURE 3-3

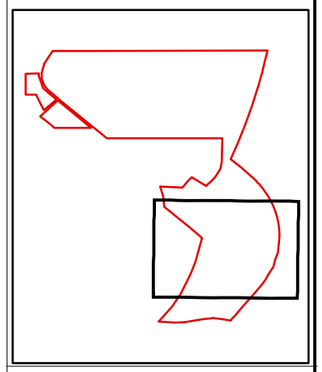
File Name: W:\Projects\1)Open\Taylor Burrell Barnett\57020_TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_BHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area

Bushfire Hazard Level

- Extreme
- Moderate
- Low
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 31-Jan-2020
Drawn By: hsullivan	Checked By: JH

Scale 1:4,000

0 50 1

metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

BUSHFIRE HAZARD LEVEL MAP
PAGE 6

FIGURE 3-3

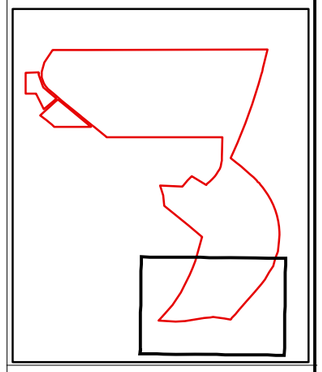
File Name: W:\Projects\1)Open\Taylor Burrell Barnett\57020_TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_BHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

Legend:

- Improvement plan 47 area
- 100m assessment area
- 150m assessment area

Bushfire Hazard Level

- Extreme
- Moderate
- Low
- Roads (MRWA)



strategen JBS&G

Job No: 57020	
Client: Taylor Burrell Barnett	
Version: A	Date: 31-Jan-2020
Drawn By: hsullivan	Checked By: JH

Scale 1:4,000

0 50 1(
metres

Coord. Sys. GDA 1994 MGA Zone 50

Mandogalup

BUSHFIRE HAZARD LEVEL MAP
PAGE 7

FIGURE 3-3

File Name: W:\Projects\1)Open\Taylor Burrell Barnett\57020_TBB DPLH Mandogalup Improvement Scheme\GIS\Maps\R02 Rev A\57020_03_BHL.mxd
Image Reference: www.nearmap.com© - Imagery Date: 7 September 2019

Figure 3.4: Post-development BHL (to be provided following land use plan)

4. Identification of bushfire hazard issues

4.1 Bushfire context

The Subject Area and sandwich lots are surrounded by:

- Kwinana Freeway, Rural land uses (including market gardening) and residential development to the east
- Anketell Road and The Spectacles wetland to the south
- Bush Forever Sites 268 and 267 and Rural land uses to the west
- City of Kwinana LPS No. 2 Policy Area 11 (Postans East) associated with Alcoa tailings ponds (part of the Alcoa Residue Disposal Area [RDA]) to the west and south-west
- Hope Valley - Wattleup Redevelopment Area to the north-west
- Rural land uses (including market gardening), Urban (residential) land uses, the proposed Rowley Road extension and Frankland Park to the north.

The predominant bushfire hazards within and in proximity to the Subject Area and sandwich lots are associated with vegetation (Class D scrub, Class B woodland and Class A forest) within The Spectacles wetland to the south, Bush Forever sites 267, 268 and 393, as well as vegetated batters to the Alcoa tailings ponds to the west, and unmanaged grassland within rural properties surrounding the Subject Area and sandwich lots. While grassland areas contain lower fuel loads than the conservation areas outlined above, a bushfire in these areas would be fast travelling under strong wind conditions.

Vegetation within The Spectacles wetland to the south, Bush Forever sites 267 and 268 is anticipated to have high fuels loads, comprising Eucalyptus forest and woodlands. These conservation areas have a considerable amount of connectivity to other conservation areas in a north-south direction. On this basis, the vegetation does have the potential to exhibit extended bushfire behaviour, which could travel toward the Subject Area and be exacerbated by strong southerly or northerly wind conditions.

It is considered that the bushfire risk to proposed development posed by these hazards can be managed through standard application of acceptable solutions under the Guidelines, as well as through a direct bushfire suppression response if required. Bushfire mitigation strategies applicable to the proposed development are addressed indicatively in Section 5 of this BMP.

Discussion to be added regarding post-development bushfire hazards both within the site and anticipated surrounding development.

4.2 Bushfire hazard issues

It is understood that residential development is occurring to the northeast of the site and the majority of the vegetation in the north-eastern portion of the site (Lots 2 and 10) is proposed to be cleared. As such, it is anticipated the predominant and permanent bushfire hazards will be associated with the Bush Forever sites located to the south, west and north of the site. Where the development interfaces with intact vegetation, appropriate separation to development (habitable buildings) to achieve a bushfire attack level (BAL) rating of BAL-29 or lower will be required.

Examination of strategic development design in accordance with the development concept and pre and post-development bushfire hazard levels has identified the following bushfire hazard issues to be considered at future planning stages:

- A direct vegetation interface exists between the Subject Area and Bush Forever sites 268 and 393, requiring appropriate separation (asset protection zones; APZs) to habitable buildings to achieve a Bushfire Attack Level (BAL) rating of BAL-29 and increased construction

standards (i.e. where BAL ratings are above BAL-Low and buildings are Classes 1, 2, 3 and associated 10a). The likely (indicative) APZ setbacks required to achieve BAL-29 are:

  - 21 m to Class A forest (flat/upslope) within Bush Forever site 268
  - 17 m to Class B woodland (downslope 0 to 5 degrees) within Bush Forever site 393.

- A direct vegetation interface exists between the sandwich lots and Bush Forever site 267, requiring appropriate separation to habitable buildings to achieve a BAL rating of BAL-29 and increased construction standards (i.e. where BAL ratings are above BAL-Low and buildings are Classes 1, 2, 3 and associated 10a). The likely (indicative) APZ setback required to achieve BAL-29 is 21 m to Class A forest (flat/upslope).
- Future habitable buildings (Classes 1, 2, 3 and associated 10a) within 100 m of vegetated conservation areas (Frankland Park to the northeast, The Spectacles to the south), or within 50 m of Class G grassland, require appropriate separation to habitable buildings to achieve a BAL rating of BAL-29 and require increased construction standards. It is anticipated that sufficient separation to achieve BAL-29 will be provided by the future Rowley Road extension and Anketell Road respectively. In the absence of the Rowley Road extension being implemented, a 21 m APZ is anticipated to be required between Frankland Park and future habitable buildings.

Additionally, the development will be required to ensure adequate water supply for firefighting purposes and appropriate vehicular access and egress provisions for residents and emergency services in accordance with the Guidelines. This is discussed further in Table 5.1.

Commentary required regarding land use plan, once provided (including retention of vegetation within Lots 2 and 10).

Based on the above, Strategen-JBS&G considers the bushfire hazards within and adjacent to project area and the associated bushfire risks are readily manageable through standard management responses outlined in the Guidelines and AS 3959. These responses will be factored into proposed development as early as possible at all stages of the planning process to ensure a suitable, compliant and effective bushfire management outcome is achieved for protection of future life, property and environmental assets.

5. Assessment against the bushfire protection criteria

An acceptable solutions assessment against the bushfire protection criteria is provided in Table.

Table 5.1: Compliance with the bushfire protection criteria (acceptable solutions) of the Guidelines

Bushfire protection criteria	Method of compliance Acceptable solutions	Proposed bushfire management strategies
Element 1: Location	A1.1 Development location	The post-development bushfire hazard level (BHL) assessment identifies that on completion of development, all developable land will comprise either a Low or Moderate bushfire hazard level.
Element 2: Siting and design	A2.1 Asset Protection Zone (APZ)	APZs sufficient to achieve BAL—29 are readily achievable and to be implemented for all proposed lots/ buildings which are subject to a BAL above BAL-LOW. The required APZs are to be identified at future planning stages based on future subdivision/development design and following a BAL contour assessment. Indicative APZs include: • 21 m to Class A forest (flat/upslope) within Bush Forever site 267 and 268, and Frankland Park • 17 m to Class B woodland (downslope 0 to 5 degrees) within Bush Forever site 393. It is noted that additional APZs may be required where vegetation is proposed for retention within the site and sandwich lots (including within the Peel Main Drain and vegetation within Lots 2 and 10). Additionally, areas of vegetation immediately adjacent the site and sandwich lots that is existing at the time of the development may require APZs to ensure appropriate separation to future lots and habitable buildings. APZs are to be implemented and maintained in accordance with Schedule 1 of the Guidelines (Appendix C) and the City's Firebreak and Fuel Hazard Reduction Notice (Appendix D).
Element 3: Vehicular access	A3.1 Two access routes	On completion of development, the existing public road network and proposed public internal roads will need to provide all occupants with the option of travelling to more than two different destinations, including during staging of development. The proximity of the site to major roads including Anketell Road, the Kwinana Freeway, Rowley Road and Mandogalup Road should be utilised to ensure full connectivity across any future development.
	A3.2 Public road	All public roads are to be constructed to the relevant technical requirements of the Guidelines (see Appendix E).
	A3.3 Cul-de-sac (including a dead-end-road)	Cul-de-sacs should be avoided in bushfire prone areas. Any cul-de-sacs required (where no alternative exists), will be less than 200 m in length, will include minimum 17.5 m diameter turn-around heads and are to be constructed to the relevant technical requirements of the Guidelines (see Appendix E).
	A3.4 Battle-axe	Battle-axes should be avoided in bushfire prone areas. Any battle-axes (where no alternative exists), will be less than 600 m in length and will be constructed to the relevant technical requirements of the Guidelines (see Appendix E), including passing bays at 200 m intervals and turn-around areas for fire appliances where battle-axes are longer than 500 m.
	A3.5 Private driveway longer than 50 m	Any private driveways longer than 50 m are to be constructed to the relevant technical requirements of the Guidelines (see Appendix E), including turn-around areas within 50 m of each building, passing bays if driveways are longer than 200 m and additional turn-around areas for fire appliances every 500 m.

Bushfire protection criteria	Method of compliance Acceptable solutions	Proposed bushfire management strategies
	A3.6 Emergency access way	Where connectivity cannot be achieved, an emergency access way (EAW) may be proposed. EAWs are to be constructed to the relevant technical requirements of the Guidelines (see Appendix E) and will need to be signposted, with gates kept unlocked at all times. Each respective landowner will be responsible for maintaining the EAW where it occurs on their land OR following establishment the City will be responsible for maintaining the EAW. The EAW is to be no further than 600 m from a public road at any single point.
	A3.7 Fire service access routes (perimeter roads)	No permanent fire service access routes (FSARs) are anticipated to be required, however, if development and vehicular access construction is to be staged, any proposed temporary FSAR is to be constructed to the relevant technical requirements of the Guidelines (see Appendix E).
	A3.8 Firebreak width	Each stage of development is required to comply with the requirements of Acceptable Solution A3.8 and the annual City Firebreak Notice (see Appendix D) as amended. On completion of the development, firebreak requirements will be dependent on the Firebreak Notice category assigned by the City.
Element 4: Water	A4.1 Reticulated areas	It is anticipated that proposed development within the site and sandwich lots will be connected to reticulated water supply via surrounding development in accordance with Water Corporations Design Standard 63 requirements. It is noted that there are no mapped existing water hydrants located within or immediately adjacent to the site or sandwich lots.
	A4.2 Non-reticulated areas	Where development within the site and sandwich lots is not connected to reticulated water supply dedicated firefighting emergency water tanks will required to be installed by the developer and vested in and maintained by the City. The water supply tank is to be equipped with a hydrant or standpipe and a hardstand and turn-around area suitable for a type 3.4 fire appliance (i.e. kerb to kerb 17.5 m) within 3 m of each tank. Tanks are to be supplied at a ratio of one tank per 25 lots and no more than 2 km from the furthest house.
	A4.3 Individual lots within non-reticulated areas (Only for use if creating 1 additional lot and cannot be applied cumulatively)	This acceptable solution is unlikely to be applicable.

6. Responsibilities for implementation and management of the bushfire measures

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. Aside from the preparation of future BMPs to accompany future subdivision and development applications where appropriate, there are no further items to implement, enforce or review at this strategic stage of the planning process.

Future BMPs prepared for subsequent subdivision and development applications are to meet the relevant commitments outlined in this strategic level BMP, address the relevant requirements of SPP 3.7 (i.e. Policy Measures 6.4 and 6.5 respectively) and demonstrate in detail how the proposed development will incorporate the relevant acceptable solutions or meet the performance requirements of the Guidelines. Future BMPs are to include the following detailed information:

- proposed lot layout, including any public open space (POS) and drainage areas
- detailed landscaping design/plans in regard to POS and drainage areas, consistent with the provisions of this BMP
- post development classified vegetation extent and effective slope
- BAL contour map demonstrating that proposed development areas will achieve BAL–29 or lower (may require designation of building envelopes)
- width and alignment of compliant APZs/setbacks
- confirmation of how bushfire management will be addressed during development staging
- proposed approach to fuel management or AS 3959 application in response to on-site POS
- vehicular access provisions, including demonstration that a minimum of two access routes will be achieved for each stage of development in accordance with Acceptable Solution A3.1
- water supply provisions with regards to reticulated water
- requirements for any future vulnerable land uses, such as provision of a Bushfire Emergency Evacuation Plan (if relevant)
- requirements for any future high-risk land uses, such as provision of a Bushfire Risk Management Plan (if relevant)
- provisions for notification on Title for any future lots with a rating of BAL–12.5 or greater as a condition of subdivision
- compliance requirements with the current City of Kwinana annual firebreak notice as amended
- construction of Class 1, 2, 3 or associated 10a buildings in accordance with AS 3959 to the assessed BAL rating
- requirements for BMP/BAL compliance reports as conditions of subdivision
- compliance with the bushfire protection criteria of the Guidelines
- proposed implementation and audit program outlining all measures requiring implementation and the appropriate timing and responsibilities for implementation.

On the basis of the information contained in this BMP, Strategen-JBS&G considers the bushfire hazards within and adjacent to the Subject Area and the associated bushfire risks are readily

manageable through standard management responses outlined in the Guidelines and AS 3959. Strategen-JBS&G considers that on implementation of the proposed management measures, the Subject Area will be able to be developed with a manageable level of bushfire risk whilst maintaining full compliance with the Guidelines and AS 3959.

7. References

Department of Fire and Emergency Services (DFES) 2019, *Map of Bush Fire Prone Areas*, [Online], Government of Western Australia, available from: https://maps.slip.wa.gov.au/landgate/bushfireprone/

Department of Planning (DoP) 2016, *Visual guide for bushfire risk assessment in Western Australia*, Department of Planning, Perth.

Heddle EM, Loneragan OW & Havel JJ, 1980, *Darling System, Vegetation Complexes*, Forest Department, Perth.

Standards Australia (SA) 2018, Australian Standard *AS 3959–2018 Construction of Buildings in Bushfire-prone Areas*, Standards Australia, Sydney.

Western Australian Planning Commission (WAPC) 2015, *State Planning Policy 3.7 Planning in Bushfire Prone Areas*, Western Australian Planning Commission, Perth.

Western Australian Planning Commission (WAPC) 2017, *Guidelines for Planning in Bushfire Prone Areas*, Version 1.3 August 2017, Western Australian Planning Commission, Perth.

8. Limitations

Scope of services

This report ("the report") has been prepared by Strategen-JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen-JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen-JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen-JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen-JBS&G has also not attempted to determine whether any material matter has been omitted from the data. Strategen-JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen-JBS&G. The making of any assumption does not imply that Strategen-JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen-JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

Strategen-JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by Strategen-JBS&G, and should not be relied upon by other parties, who should make their own enquiries.

Appendix A Landscape concept plan

Appendix B Vegetation classification and photographs

Photo ID: 1

Plot number		Plot 50
Vegetation classification	**Pre-development**	Class G Grassland
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height

Photo ID: 2

Plot number		Plot 9
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 3

Plot number		Plot 50 foreground / Plot 32 background
Vegetation classification	**Pre-development**	Class G Grassland / Class B Woodland
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height / Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 4

Plot number		Plot 57
Vegetation classification	**Pre-development**	Modified to non-vegetated (exclusion 2.2.3.2 [e]) and/or low threat (exclusion 2.2.3.2 [f]) state
	Post-development	Choose an item.
Description / justification		Low threat cultivated gardens and maintained lawns within surrounding properties and non-vegetated areas including roads, footpaths, driveways and building footprints

Photo ID: 5

Plot number		Plot 5 foreground / Plot 28 background
Vegetation classification	**Pre-development**	Class G Grassland / Class B Woodland
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height / Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

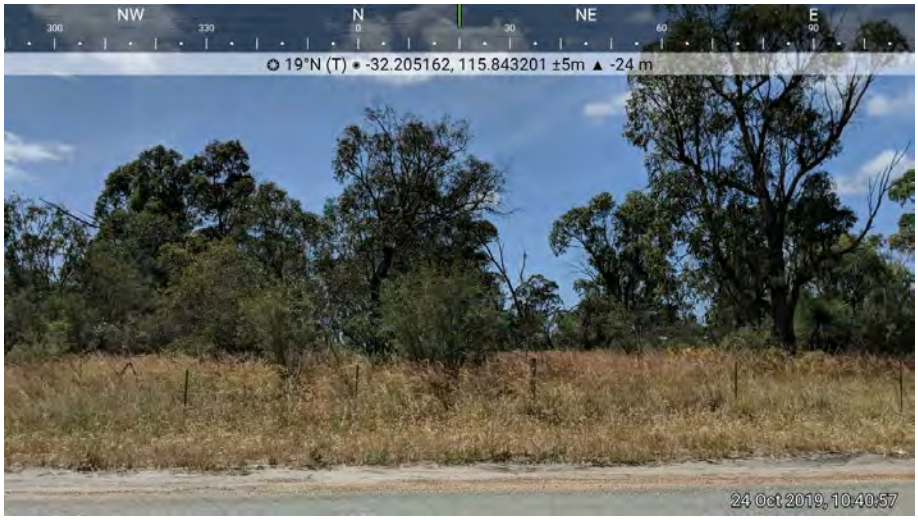


Photo ID: 6

Plot number		Plot 30
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 7

Plot number		Plot 8
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 8

Plot number		Plot 28
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 9

Plot number		Plot 9
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 10

Plot number		Plot 48 foreground / Plot 57 background
Vegetation classification	**Pre-development**	Class G Grassland / Modified to non-vegetated (exclusion 2.2.3.2 [e]) and/or low threat (exclusion 2.2.3.2 [f]) state
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height / Low threat cultivated gardens and maintained lawns within surrounding properties and non-vegetated areas including roads, footpaths, driveways and building footprints

Photo ID: 11

Plot number		Plot 47
Vegetation classification	**Pre-development**	Class G Grassland
	Post-development	Choose an item.
Description / justification		Grassland at maturity, greater than 100 mm in height

Photo ID: 12

Plot number		Plot 47 foreground / Plot 23 background
Vegetation classification	**Pre-development**	Class G Grassland / Class B Woodland
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height / Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 13

Plot number		Plot 24
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 14

Plot number		Plot 24
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 15

Plot number		Plot 6
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 16

Plot number		Plot 57
Vegetation classification	**Pre-development**	Modified to non-vegetated (exclusion 2.2.3.2 [e]) and/or low threat (exclusion 2.2.3.2 [f]) state
	Post-development	Choose an item.
Description / justification		Low threat cultivated gardens and maintained lawns within surrounding properties and non-vegetated areas including roads, footpaths, driveways and building footprints

Photo ID: 17

Plot number		Plot 57
Vegetation classification	**Pre-development**	Modified to non-vegetated (exclusion 2.2.3.2 [e]) and/or low threat (exclusion 2.2.3.2 [f]) state
	Post-development	Choose an item.
Description / justification		Low threat cultivated gardens and maintained lawns within surrounding properties and non-vegetated areas including roads, footpaths, driveways and building footprints

Photo ID: 18

Plot number		Plot 24
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 19

Plot number		Plot 24
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 20

Plot number		Plot 24
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 21

Plot number		Plot 7
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 22

Plot number		Plot 24
Vegetation classification	**Pre-development**	Class A Forest Classified based on potential for vegetation to re-grow with forest structure if left unmanaged and connectivity to Class A Forest vegetation to the south of the easement
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 23

Plot number		Plot 57
Vegetation classification	**Pre-development**	Modified to non-vegetated (exclusion 2.2.3.2 [e]) and/or low threat (exclusion 2.2.3.2 [f]) state
	Post-development	Choose an item.
Description / justification		Low threat cultivated gardens and maintained lawns within surrounding properties and non-vegetated areas including roads, footpaths, driveways and building footprints

Photo ID: 24

Plot number		Plot 21
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 25

Plot number		Plot 45
Vegetation classification	**Pre-development**	Class G Grassland
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height

Photo ID: 26

Plot number		Plot 21
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 27

Plot number		Plot 31
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 28

Plot number		Plot 57
Vegetation classification	**Pre-development**	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])
	Post-development	Choose an item.
Description / justification		Low threat cultivated gardens and maintained lawns within surrounding properties and non-vegetated areas including roads, footpaths, driveways and building footprints

Photo ID: 29

Plot number		Plot 21
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Photo ID: 30

Plot number		Plot 7
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 31

Plot number		Plot 7
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

Photo ID: 32

Plot number		Plot 50 foreground / Plot 28 background
Vegetation classification	**Pre-development**	Class G Grassland / Class B Woodland
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height / Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

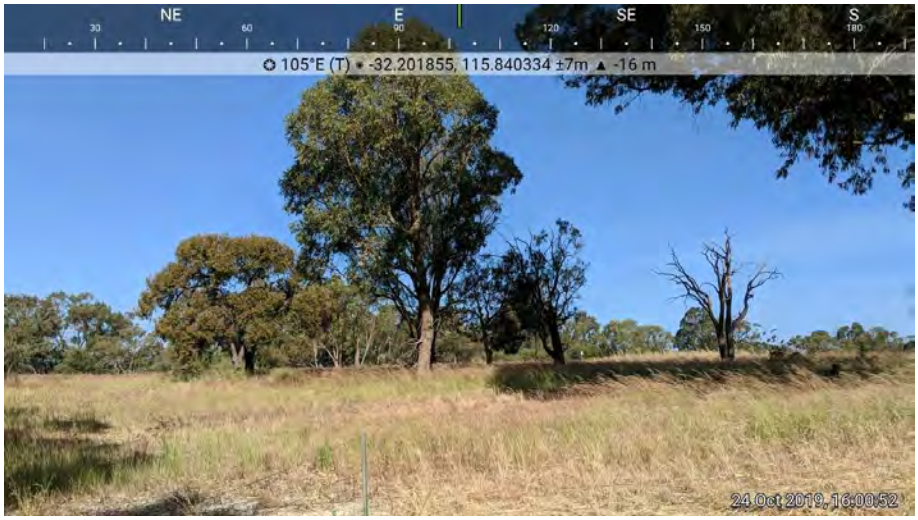


Photo ID: 33

Plot number		Plot 28
Vegetation classification	**Pre-development**	Class B Woodland
	Post-development	Choose an item.
Description / justification		Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

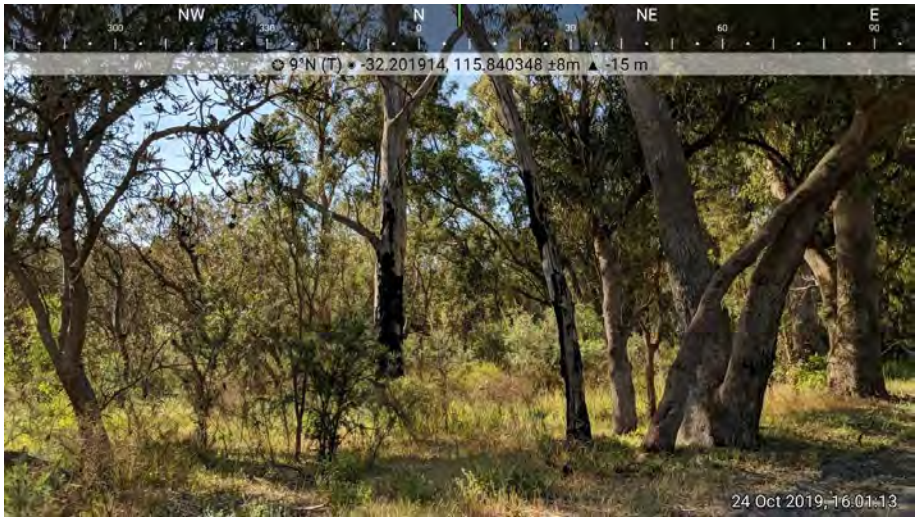


Photo ID: 34

Plot number		Plot 7
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey

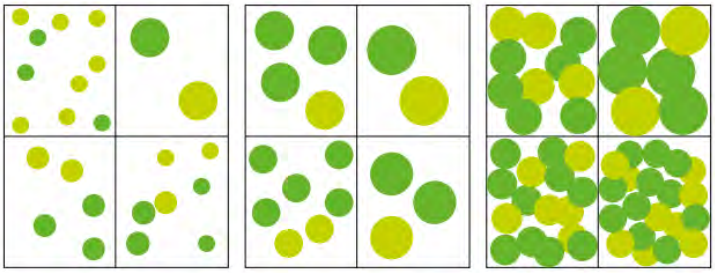
Photo ID: 35

Plot number		Plot 5
Vegetation classification	**Pre-development**	Class A Forest
	Post-development	Choose an item.
Description / justification		Grassland greater than 100 mm in height / Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)

Appendix C APZ standards (Schedule 1; the Guidelines, WAPC 2017)

Schedule 1: Standards for Asset Protection Zones

- **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.



- **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.

Appendix D City of Kwinana Fire Notice

Firebreak Variations

If the owner or occupier considers it **impractical to install a firebreak or comply with this Fire Notice for any reason**, you are required to apply to the City of Kwinana in writing by **30 October that year to obtain approval to install a firebreak in an alternative position.**

The City of Kwinana will confirm acceptance or non acceptance of a firebreak variation in writing to the owner or occupier. If the variation is not approved, the owner or occupier must comply with this Fire Notice in its entirety. Living Green Lawn may be accepted without a firebreak variation.

Previously approved firebreak variations do not need to be reapplied for unless circumstances have changed, or you have been advised in writing by the City of Kwinana of any changes.

Additional Works

Regardless of land size and location, the City of Kwinana or its Bush Fire Control Officers may require owners and/or occupiers to undertake additional work on your property to improve access, and/or undertake further works to reduce a hazard that may be conducive to preventing the outbreak and/or the spread or extension of a fire.

Burning of Garden Refuse

PROHIBITED BURNING PERIODS ONLY

During the declared Prohibited Burning Period, owners and/or occupiers must not undertake any bush or garden refuse burning activities.

RESTRICTED BURNING PERIODS ONLY

During the declared Restricted Burning Period only, owners and/or occupiers may:

- Apply for a permit to burn the bush for bush fire risk mitigation purposes, by following the conditions imposed on a permit to burn as issued by a Bush Fire Control Officer;
- In areas zoned rural by the Metropolitan Region Scheme you may undertake burning of leaves, tree branches, and other dry vegetation in piles no larger than 1.0m³ in size, without a permit to burn, subject to the following conditions:
  - No Flammable Matter (other than that being burned) is to be within five (5) metres of the fire at any time while the fire is burning;
  - The fire is lit between 6pm and 11pm and is completely extinguished before midnight on the same day;
  - At least one person is present at the site of the fire at all times until it is completely extinguished; and
  - When the fire is no longer required, the person ensures that the fire is completely extinguished by the application of water or earth.

Cooking fire

An open fire for the purpose of cooking can be lit during this time providing:

- There is a 3 metre clearing of all flammable material and the fire is in the centre of the clearing;
- The Fire Danger Rating for that day is not Very High or above; and
- The fire is extinguished when you have finished cooking.

UNRESTRICTED BURN PERIODS ONLY

During the Unrestricted Burning Time, owners and/or occupiers in areas zoned rural under the Metropolitan Region Scheme may burn garden refuse and set fire to bush on their land without a permit. Burning of the bush must be undertaken in accordance with all relevant State legislation and Local Government Local Laws.

NO BURNING IN AREA DEFINED AS URBAN AREAS

Pursuant to section, 24G (2) of the *Bush Fires Act 1954*, no garden refuse burning is to be undertaken in areas defined as "Urban" under the Metropolitan Region Scheme without **written approval** of the City of Kwinana.

For information regarding dates for the Unrestricted, Restricted and Prohibited periods please contact the City of Kwinana City Assist office on 9439 0400 or view the City of Kwinana's website, **www.kwinana.wa.gov.au**.

PENALTIES

Failing to comply with this Fire Notice may result in a penalty of up to $5,000.

A person in default of the requirements of this Notice is also liable, whether prosecuted or not, to pay the costs of performing the work directed by the City of Kwinana or its Bush Fire Control Officer.

Any owner and/or occupier who engages a contractor to undertake works on their behalf, is responsible for ensuring that the works completed meet the requirements of this Fire Notice.

Joanne Abbiss,
Chief Executive Officer

City of Kwinana

ADMINISTRATION

Cnr Gilmore Ave and Sulphur Rd,
Kwinana WA 6167
PO Box 21, Kwinana WA 6966

Telephone 08 9439 0200

customer@kwinana.wa.gov.au

www.kwinana.wa.gov.au

City of Kwinana

BUSH FIRES ACT 1954

Fire Notice
City of Kwinana

As of September 2019

Pursuant to the powers contained in section 33 of the *Bush Fires Act 1954*, all property owners and/or occupiers of land within the City of Kwinana are hereby served with a first and final Fire Notice and are required to comply with the requirements set out in this Fire Notice in its entirety.

All land and buildings shall be maintained for such duration and in such positions, dimensions and specifications as required by this Fire Notice or as approved in writing by the City of Kwinana or its Bush Fire Control Officers. The works outlined in this Fire Notice must be completed before the dates listed in this Fire Notice and must be maintained throughout as required by this Fire Notice.

Definitions

"ASSET PROTECTION ZONE" means an area with a radius of 20 metres measured from the external perimeter of the building/s or as stated in your approved Bushfire Attack Level (BAL) assessment, within the boundaries of the lot on which the building/s is situated. Fuel loads in this zone shall be reduced and maintained to 2 tonnes per hectare or less.

"BUSH FIRE CONTROL OFFICER" means an Officer appointed by the City of Kwinana to exercise the powers and duties of a Bush Fire Control Officer appointed under s38(1) of the *Bush Fires Act 1954.*

"BUSH FIRE" means a fire or potential fire, however caused, and includes a fire in a building.

"DEAD END" means a track, firebreak, road or access way that terminates without any means of escape or ability to turn around safely.

"EMERGENCY ACCESS WAYS" are for emergency services vehicles only and are not to be considered as an escape route unless declared as such by the incident controller during an emergency.

"FIREBREAK" means a strip of land 3 metres wide of mineral earth with an additional 0.5 metre strip either side of low fuel area (meaning no grasses or shrubs higher than 50mm) effectively creating a 4 metre wide by 4 metre vertical axis high area that has been cleared of all trees, bushes, grasses, vegetation and all other objects. This includes the trimming back of all overhanging trees, bushes, shrubs and any other objects on or over the firebreak area.

Living Green Lawn may be accepted (without a Firebreak Variation) instead of mineral earth.

"FLAMMABLE" means any bush, plant, tree, grass, vegetation, object, thing or material that may or is likely to catch fire and burn.

"LIVING GREEN LAWN" means soil covered land, planted with grasses or other durable plants, maintained green and less than 50mm in height.

"MINERAL EARTH" means land clear of flammable material, consisting of ploughed or cleared soil, stone, hardstand or any mixture of these.

"TRAFFICABLE" means to be able to travel from one point to another in a fire vehicle on a firm and stable surface, unhindered without any obstruction that may endanger resources. The firebreak must not terminate without provision for egress to a safe place or a cleared turn around area of not less than a 21 metre radius (prior written approval may be required from the City of Kwinana if trees are to be removed). All corners around the firebreak must be radiused.

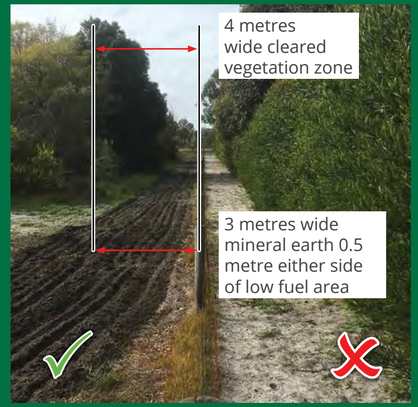
"VERTICAL AXIS" means a continuous vertical uninterrupted line at a right angle to the horizontal line of the firebreak.

Land area – 3,501m² or greater

The works outlined in this section must be completed before 1 December of each year and maintained throughout until 30 April the following year.

Owners and/or occupiers of land that is 3,501m² or greater are required to construct a *firebreak*:

- Inside and along all boundaries of land in a continuous form, or within 10 metres of boundaries adjacent to roads, rail and drain reserves and all public open space reserves;
- Around all sides of any building on the land;



- On all driveways and access ways to houses, sheds and buildings on the land;
- On any land surrounding any place where, wood or timber piles, hay stacks, tyres, flammable liquids, chemicals and gas products are kept on the land, construct a *firebreak*;
- Construct these *firebreaks* in a manner so that they are *trafficable*, contain no *dead ends* and are wide enough for a heavy-duty fire vehicle or a emergency services vehicle to be able to turn the corner without the vehicle being obstructed in anyway; and
- Maintain an *asset protection zone* around all buildings, infrastructure and fixed assets on the property.

Land area – 1,500m² to 3,500m²

The works outlined in this section must be maintained all year round and owners and/or occupiers are required to maintain an *asset protection zone* around all buildings, infrastructure and fixed assets on the property by:

- Having all long grass, weeds, etc. slashed, mowed or trimmed down by other means to a height no greater than 50mm across the entire property; and
- All trees, branches, limbs, etc. which are overhanging any buildings must be trimmed back to a vertical axis height of 4 metres.

Land area up to 1499m²

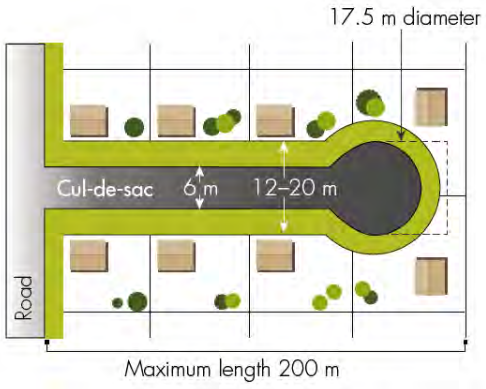
The works outlined in this section must be maintained all year round and owners and/ or occupiers are required to:

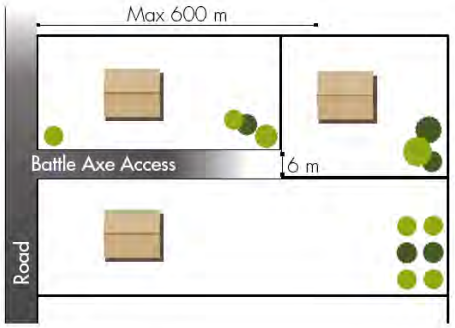
- Have all long grass, weeds, etc. slashed, mowed or trimmed down by other means to a height no greater than 50mm across the entire property; and
- All trees, branches, limbs, etc. which are overhanging any buildings must be trimmed back to a vertical axis height of 4 metres.

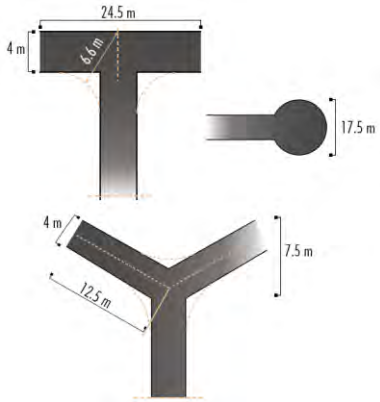
Appendix E Vehicular access technical standards

Two access routes	
Acceptable solution A3.1	Two different vehicular access routes are provided, both of which connect to the public road network, provide safe access and egress to two different destinations and are available to all residents/the public at all times and under all weather conditions.
Explanatory note E3.1	Two access routes: It is essential that residents and the community, as well as emergency services, have safe access and egress from both the subdivision and individual houses/development. It is the developer's responsibility, as part of the Bushfire Hazard Level assessment, to ensure that subdivision and development design allow for bushfire protection criteria to be met regarding driveways and turnaround areas at house sites. It is also necessary that the public have two safe access options leading to two different destinations that can withstand all weather conditions. This applies to access routes leading into a subdivision, as well as those within a subdivision. This acceptable solution allows for the situation if a vehicular access/egress route to a subdivision or lot becomes blocked during a fire then there is an alternative vehicular access/egress route which provides access to a different destination. Accordingly, road widening in lieu of providing two different access routes should not be supported. All access should be suitable to accommodate type 3.4 fire appliances (i.e. fire trucks with a four-wheel-drive 7-tonne chassis). Two-way access should be provided as a public road; however, where a public road cannot be provided, (this will need to be demonstrated by the proponent providing justification for why this cannot be achieved) an emergency access way may be considered

Public roads	
Acceptable solution A3.2	A public road is to meet the requirements in Table 1, Column 1.
Explanatory note E3.2	Trafficable surface: Widths quoted for access routes refer to the width of the trafficable surface. A six metre trafficable surface does not necessarily mean paving width. It could, for example, include four metre wide paving one metre wide constructed road shoulders. In special circumstances, where eight lots or less are being serviced, a public road with a minimum trafficable surface of four metres for a maximum distance of 90 metres may be provided subject to the approval of both the local government and Department of Fire and Emergency Services. Public road design: All roads should allow for two-way traffic to allow conventional two-wheel drive vehicles and fire appliances to travel safely on them.

Cul-de-sac (including a dead-end road)	
Acceptable solution A3.3	A cul-de-sac and/ or a dead end road should be avoided in bushfire prone areas. Where no alternative exists (i.e. the lot layout already exists and/ or will need to be demonstrated by the proponent), the following requirements are to be achieved: • Requirements in Table 1, Column 2 • Maximum length: 200 metres (if public emergency access is provided between cul-de-sac heads maximum length can be increased to 600 metres provided no more than eight lots are serviced and the emergency access way is no more than 600 metres) • Turn-around area requirements, including a minimum 17.5 metre diameter head.
Explanatory note E3.3	In bushfire prone areas, a cul-de-sac subdivision layout is not favoured because they do not provide access in different directions for residents. In some instances it may be possible to provide an emergency access way between cul-de-sac heads to a maximum distance of 600 metres, so as to achieve two-way access. Such links must be provided as right of ways or public access easements in gross to ensure accessibility to the public and fire services during an emergency. A cul-de-sac in a bushfire prone area is to connect to a public road that allows for travel in two directions in order to address Acceptable Solution A3.1. 

Battle-axe	
Acceptable solution A3.4	Battle-axe access leg should be avoided in bushfire prone areas. Where no alternative exists, (this will need to be demonstrated by the proponent) all of the following requirements are to be achieved: • Requirements in Table 1, Column 3 • Maximum length: 600 metres • Minimum width: six metres.
Explanatory note E3.4	In bushfire prone areas, lots with battle-axe access legs should be avoided because they often do not provide two-way access and egress for residents and may be easily blocked by falling trees or debris. In some instances, however; it may be appropriate for battle-axe access to be used to overcome specific site constraints. Where used, they should comply with the minimum standards for private driveways. Passing bays should be provided at 200 metre intervals along battle-axe access legs to allow two-way traffic. The passing bays should be a minimum length of 20 metres, with the combined width of the passing bay and the access being a minimum of six metres. Turn-around areas should allow type 3.4 fire appliances to turn around safely (i.e. kerb to kerb 17.5 metres) and should be available at house sites and at 500 metre intervals along the access leg. 

Private driveway longer than 50 metres	
Acceptable solution A3.5	A private driveway is to meet all of the following requirements: • Requirements in Table 1, Column 3 • Required where a house site is more than 50 metres from a public road • Passing bays: every 200 metres with a minimum length of 20 metres and a minimum width of two metres (i.e. the combined width of the passing bay and constructed private driveway to be a minimum six metres) • Turn-around areas designed to accommodate type 3.4 fire appliances and to enable them to turn around safely every 500 metres (i.e. kerb to kerb 17.5 metres) and within 50 metres of a house • Any bridges or culverts are able to support a minimum weight capacity of 15 tonnes • All-weather surface (i.e. compacted gravel, limestone or sealed).
Explanatory note E3.5	For a driveway shorter than 50 metres, fire appliances typically operate from the street frontage however where the distance exceeds 50 metres, then fire appliances will need to gain access along the driveway in order to defend the property during a bushfire. Where house sites are more than 50 metres from a public road, access to individual houses and turnaround areas should be available for both conventional two-wheel drive vehicles of residents and type 3.4 fire appliances. Turn-around areas should be located within 50 metres of a house. Passing bays should be available where driveways are longer than 200 metres and turn-around areas in driveways that are longer than 500 metres. Circular and loop driveway designs may also be considered. These criteria should be addressed through subdivision design. Passing bays should be provided at 200 metre intervals along private driveways to allow two-way traffic. The passing bays should be a minimum length of 20 metres, with the combined width of the passing bay and the access being a minimum of six metres. Turn-around areas should allow type 3.4 fire appliances to turn around safely (i.e. kerb to kerb 17.5 metres) and should be available at the house sites and at 500 metre intervals along the driveway. 

Emergency access way	
Acceptable solution A3.6	An access way that does not provide through access to a public road is to be avoided in bushfire prone areas. Where no alternative exists (this will need to be demonstrated by the proponent), an emergency access way is to be provided as an alternative link to a public road during emergencies. An emergency access way is to meet all of the following requirements: • Requirements in Table 1, Column 4 • No further than 600 metres from a public road • Provided as right of way or public access easement in gross to ensure accessibility to the public and fire services during an emergency • Must be signposted.
Explanatory note E3.6	An emergency access way is not a preferred option however may be used to link up with roads to allow alternative access and egress during emergencies where traffic flow designs do not allow for two-way access. Such access should be provided as a right-of-way or easement in gross to ensure accessibility to the public and fire emergency services during an emergency. The access should comply with minimum standards for a public road and should be signposted. Where gates are used to control traffic flow during non-emergency periods, these must not be locked. Emergency access ways are to be no longer than 600 metres and must be adequately signposted where they adjoin public roads. Where an emergency access way is constructed on private land, a right of way or easement in gross is to be established.

Fire service access routes (perimeter roads)	
Acceptable solution A3.7	Fire service access routes are to be established to provide access within and around the edge of the subdivision and related development to provide direct access to bushfire prone areas for fire fighters and link between public road networks for firefighting purposes. Fire service access routes are to meet the following requirements: • Requirements in Table 1, Column 5 • Provided as right of ways or public access easements in gross to ensure accessibility to the public and fire services during an emergency • Surface: all-weather (i.e. compacted gravel, limestone or sealed) • Dead end roads are not permitted • Turn-around areas designed to accommodate type 3.4 appliances and to enable them to turn around safely every 500 metres (i.e. kerb to kerb 17.5 metres) • No further than 600 metres from a public road • Allow for two-way traffic • Must be signposted.
Explanatory note E3.7	Fire service access routes should be established to separate bushfire prone areas from developed areas, and to provide access within and around the edge of subdivisions and related development. Fire service access is used during bushfire suppression operations but can also be used for fire prevention work. Fire service access routes should: • Link up with the road network at regular intervals - the development and road network forms part of the fire service access system • Be adequately signposted • Allow for two-way traffic - that is, two fire appliances must be able to safely pass each other • Have an all-weather surface (i.e. compacted gravel, limestone or sealed) • Have erosion control measures in place. Driveways may be used as part of the designated fire service access system, provided they meet the minimum standard for fire service access routes. It is beneficial to link the fire service access routes with individual driveways to allow quick access to properties and houses during fire emergencies. Where gates are used, these should be wide enough to accommodate type 3.4 fire appliances (minimum width of 3.6m) with the design and construction to be approved by the relevant local government. Gates on fire service access routes may be locked to restrict access provided that a common key system is used and such keys are made available for fire appliances and designated fire officers within the local government area and/or surrounding district. Gates should be installed where fences cross fire service access routes. Management and access arrangements should be in place to ensure that the maintenance of fire service access routes will occur in the long term after an area has been subdivided. A number of options can be used to achieve this, including but not limited to: • Individual property owners being responsible for maintaining fire service access routes where these fall on their property • Providing such access as a right-of-way or easement in gross to ensure accessibility to fire services during an emergency; and/or • A levy system administered by local government to cover the cost of maintaining fire service access routes. Such arrangements should be documented in the relevant planning application (such as a structure plan, subdivision plan or development plan) and should be agreed to by local government.

Technical requirement	1	2	3	4	5
	Public road	Cul-de-sac	Private driveway longer than 50 m	Emergency access way	Fire service access routes
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					

© JBS&G Australia Pty Ltd T/A Strategen-JBS&G

This document is and shall remain the property of Strategen-JBS&G. The document may only be used for the purposes for which it was commissioned and in accordance with the Terms of Engagement for the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Document Distribution

Rev No.	Copies	Recipient	Date
A	1 PDF (electronic)	Claire Boland – Taylor Burrell Barnett	31/01/2020
0	1 PDF (electronic)	Claire Boland – Taylor Burrell Barnett	24/03/2020

Document Status

Rev No.	Author	Reviewer	Approved for Issue		
		Name	Name	Signature	Date
A	C O'Brien	Z Cockerill			31/01/2020
0	C O'Brien				24/03/2020

www.jbsg.com.au

Appendix D

Land Supply and Demand Analysis

pracsys.

Department of Planning Lands and Heritage

Improvement Scheme 47: Mandogalup – Land Supply and Demand Analysis

Draft

November 2021

Document Control				
Document Version	**Description**	**Prepared By**	**Approved By**	**Date Approved**
v 1.0	Preliminary Draft Land Supply and Demand Analysis	Dawson Demassiet-Huning	To Be Approved	
v 2.0	Draft Land Supply and Demand Analysis	Dawson Demassiet-Huning	Per Sauer	10 February 2020
v 3.0	Draft Land Supply and Demand Analysis	Dawson Demassiet-Huning	Dawson Demassiet-Huning	4 May 2020
v 4.0	Draft Land Supply and Demand Analysis	Dawson Demassiet-Huning	Dawson Demassiet-Huning	26 October 2021
v 5.0	Draft Land Supply and Demand Analysis	Dawson Demassiet-Huning	Dawson Demassiet-Huning	19 November 2021

Disclaimer

This report has been prepared for **Department of Planning, Lands and Heritage.** The information contained in this document has been prepared with care by the authors and includes information from apparently reliable secondary data sources which the authors have relied on for completeness and accuracy. However, the authors do not guarantee the information, nor is it intended to form part of any contract. Accordingly, all interested parties should make their own inquiries to verify the information and it is the responsibility of interested parties to satisfy themselves in all respects.

This document is only for the use of the party to whom it is addressed and the authors disclaim any responsibility to any third party acting upon or using the whole or part of its contents.

CONTENTS

1 Introduction 5

1.1 Report Structure 5

1.2 Key Findings 6

2 Literature Review 11

2.1 City of Kwinana Employment and Economic Development Study (2019) 12

2.2 City of Kwinana Rural Land Study (2019) 12

2.3 City of Kwinana Local Housing Study (2019) 12

2.4 Southern Metropolitan Peel Sub-Regional Planning Framework (2018) 13

2.5 Kwinana as a Catalyst for Economic Development (2018) 14

2.6 Local Planning Policy 12 – Mandogalup Future Development (2018) 15

2.7 Economic and Employment Lands Strategy (2012) 15

2.8 Jandakot Structure Plan (2007) 16

2.9 Document Review – Key Findings 17

3 Planning Implications for Employment Land 18

4 Economic and Population Overview 21

4.1 Population 22

4.2 Economy 25

5 Land Analysis 32

5.1 Industrial Land 32

5.2 Urban Land 49

5.3 Rural Land 53

6 Land value analysis 56

6.1 Industrial Land Value 56

6.2 Urban Land Value 56

6.3 Rural Land 59

6.4 Key Findings 59

7 Opportunities and Constraints 61

7.1 Industrial Land 61
7.2 Urban Land 62
7.3 Rural Land 64
8 Next Steps 65
9 Appendix 66
9.1 Appendix A – Glossary 66

1 INTRODUCTION

This report has been developed to provide land supply and demand analysis as an input to Improvement Plan 47: Mandogalup (the subject area). The subject area is located in the City of Kwinana. It is approximately 330 ha in area and currently supports agricultural, residential and light industrial uses. The analysis estimates the supply and demand for potential land uses, identifying whether there is a gap or surplus based on current planning frameworks. A broad Study Area is considered to better approximate the demand for different land uses. The findings will be used to develop a scenario model to assist in identifying a suitable mix of land uses that support community and broader government objectives. This initial draft is intended as a working document that is to be updated throughout the project, allowing for input from other technical reports and stakeholder input into scenario models. The current document provides summary demographic and economic information for the subject area and an objective assessment of the supply and demand for Industrial, Urban and Rural land uses.

1.1 Report Structure

This report has been developed based on the requirements of the IP47 project, including:

- A literature review of relevant planning and strategic documents
- Demographic and economic analysis
- Land supply and demand analysis
- Land value analysis
- Opportunities and Constraints for development

The literature review identifies the current land use zoning of the subject area at both State and Local levels. The documents are assessed to understand the potential strategic considerations behind proposed land uses in the subject area. A subsequent analysis is based on the Perth and Peel @ 3.5 million Southern Metropolitan Peel Sub-regional Planning Framework (the Framework) to assess the potential employment required to meet planning targets for the Southern Metropolitan Peel Sub-region.

Demographic analysis is used to assess historic and projected population growth for a defined Study Area and understand potential demographic trends that could be used to feed into land use scenario modelling. Economic analysis investigates employment trends and assesses industries based on their current performance in attracting/supporting labourforce from within the Study Area. Potential high growth industries are identified to understand the type of employment lands that could be required and will be used to inform scenario development for the highest and best use of the subject area.

Land analysis assesses the supply and demand for industrial, residential, commercial and rural land in the Study Area. A gap analysis is undertaken to determine whether the different land uses might have a greater need for additional land; rural land is assessed qualitatively.

Land values are investigated using secondary research and land sales data to develop $/m^2 estimates for the different land uses. These estimates are an indication of demand for the different land uses and can be used to assess the highest and best use of the subject area.

An opportunity and constraint analysis is used to develop a qualitative assessment that summarises the factors that could affect different land uses in a social and economic context. These will be important considerations when evaluating the potential highest and best use of the subject area.

1.2 Key Findings

Literature Review

The Metropolitan Region Scheme currently identifies the subject area as rural and urban deferred zoned land. The Framework identifies the subject area as an industrial investigation area. The City' of Kwinana housing study identifies the area as a location for residential development. A number of City documents highlight that future zoning will be decided by the IP47 project. The Jandakot Structure Plan was developed in 2007 and identified the subject area as suitable for residential development in the long term. A number of planning and development documents highlighted a requirement to safeguard industrial land in the City and broader Southern Metropolitan Sub-region (the Sub-region) in support of employment growth that is required to meet the needs of the growing population. The Framework indicates that there is sufficient undeveloped residential land in the region to support the projected 2050 population.

Economic and Population Review

Demographic analysis identified significant projected population growth in the Sub-region, which is consistent with the historical trend. The Perth and Peel @ 3.5 Million Sub-regional Frameworks have set an Employment Self-sufficiency (ESS) target for the Sub-region of 74%. This target provides guidance regarding the level of employment land capacity required to support the projected population. The Western Trade Coast (WTC) is the primary employment area for export-orientated employment in the Western sector of the Sub-region. In a hypothetical scenario where the current distribution of jobs in employment centres, was maintained, the WTC would need to provide an additional 22,000 employment opportunities, an increase of over 160%. If the WTC only accommodates the planned employment at Latitude 32, 10,000 workers, it would only lead to a 73% increase in employment.[1] This supports the planning and development arguments identified in the literature review that highlight the importance of protecting industrial land uses in the Sub-region, particularly in and around the WTC (i.e. Latitude 32).

Economic analysis was undertaken for a Study Area including the Cities of Kwinana, Rockingham, Cockburn, Armadale and the Shire of Serpentine-Jarrahdale. A large proportion of industry jobs in the Study Area are

[1] Development WA 2021, Latitude 32 Industry Zone. Available from: https://developmentwa.com.au/projects/industrial-and-commercial/latitude-32-industry-zone/about-the-project

occupied by residents of the identified LGAs. Growth will be required in a diverse range of industries in order to meet ESS targets. This will require planning for a variety of future land uses.

Land Analysis

A land analysis was undertaken to assess the supply and demand of different land uses for the designated Study Area. Current and planned industrial land supply was compared with projected industrial land demand. The analysis identified the following:[2]

- **Industrial Land**
  - 3,054 ha of land is available for future industrial uses (excluding the subject area)
  - Demand for industrial land could be between 2,443 and 3,666 by 2041

  Based on conservative uptake projections for industrial land in the Study Area, there is a potential gap in the provision of industrial land.
- **Residential Land**
  - Undeveloped urban land for residential purposes could accommodate 130,220 dwellings at the Framework's minimum target dwelling density for new residential developments of 15 dwellings per gross hectare.
  - The greenfield target for dwellings to 2050 is 129,330 dwellings

  The analysis indicates that the current supply of undeveloped residential land could support the Sub-regional dwelling targets for 2050 based on the Framework's target density per gross hectare.
- **Commercial Floorspace**

  (Retail floorspace from activity centres that support other floorspace uses was used as a proxy for commercial floorspace)
  - Planned retail floorspace in district and regional level centres is 588,000m^2
  - There is a projected need for 589,000m^2 of retail floorspace by 2041 based on current service ratio (floorspace/population)
  - There is a potential need for 729,000m^2 of retail floorspace if higher levels of retail provision are targeted (higher floorspace to population ratio)

  There is a potential gap in commercial/retail floorspace that would depend on the drivers for achieving a higher service ratio in the subject area. Service ratios are measured by floorspace (m^2) per person. The Study Area currently has lower service ratios than the Perth and Peel average.
- **Rural land**
  - The City of Kwinana Rural Land Study identified low levels of demand for rural land that was suitable in size for agricultural activities
  - State policy supports the protection of state, regional and locally significant agricultural areas

[2] For further detail about demand estimates please see Section 5, Land Analysis

- The subject area has not been identified as a priority agricultural precinct[3] – further confirmation of its potential status would be required
- Demand for rural land appears to be low
- Two of the larger businesses related to agriculture in the subject area undertake packing and distribution activities on their properties, which would be suited to industrial land zoning

The land use analysis identified a likely gap in the provision of industrial land in the Study Area under high and medium growth scenarios. There appears to be a sufficient supply of undeveloped residential zoned land to meet the projected population growth to 2050, assuming average density of 15 dwellings per gross ha (based on the targeted gross dwelling density in the Framework).[4] This is further supported by the likely increasing density of residential developments, particularly around Transit Orientated Developments (i.e. high-density development around a train station). There is sufficient commercial floorspace to support projected population growth to 2041 based on the current provision of commercial floorspace compared to population. The Study Area currently has a lower provision rate of retail floorspace than the Greater Perth average (measured in retail floorspace m^2 per resident); if the Greater Perth average provision of retail floorspace per person was targeted for the Study Area, additional retail floorspace could be required before 2041.

State Planning Policy 2.5 has identified a need to protect state, regional or locally significant agricultural precincts in the Metropolitan area. The subject area has not been identified as a significant agricultural precinct, although this should be verified with the Department of Primary Industries and Regional Development. The City's rural land study determined there was limited demand to buy land where agricultural activities could be undertaken, which could be an indication that the area is not a significant agricultural precinct.

Land Value Analysis

The potential land value associated with different land zonings was assessed using secondary research and actual sales data. Results indicate residential land has the highest potential undeveloped land value $/m^2$ followed closely by commercial land for retail purposes (bulky goods and shop retail), industrial land and rural land values. A number of factors need to be considered when evaluating land prices:

- The undeveloped land prices are for serviced land – the cost of providing services for different land uses would vary
- Industrial land values would likely experience upward pressure due to the proximity to the WTC, the smaller lot size associated with non-strategic industries (most likely to locate there) and access to significant transport infrastructure

[3] State Planning Policy 2.5

[4] The undeveloped residential land comparison was made to 2050 as this was the forecast year from the Framework. Other Analyses were compared to 2041 as this was the latest population projection available. If compared to 2041, there would be a greater surplus of urban land.

- The air quality issues relating to the buffer that covers some of the subject area have been identified by DWER as primarily amenity-related. Commercial and Industrial land uses may be considered more suitable in areas covered by the buffer although investigations would be required to confirm this position. Should the uptake of certain land uses be constrained by the amenity issues, this could affect the value of the land when assessing the present value of land over time
- Residential land value for some lots along the western end of the subject area may experience downward pressure due to the proximity to primary industry and industrial activities.[5] [6] Commercial and industrial land values may be unaffected or even benefit from proximity to neighbouring industrial areas
- The final size of lots for different zonings will affect the $/m^2$ value that is achieved. This will be considered further through the scenario modelling process

Opportunities and Constraints

When reviewing the best land uses and land use mix for the subject area from a demand and supply perspective, it is necessary to adopt a regional perspective while also considering the potential effects on the current land holders. The high population growth that is projected for the Sub-region will require a significant amount of employment land, if self-sufficiency targets are to be met. The land analysis projections in this report are conservative and demonstrate there is a likely gap in the amount of zoned industrial land by 2041, based on historical growth patterns.[7] Employment in the Sub-region will need to more than double by 2050; additional industrial land will be essential to supporting this growth.

The subject area is ideally located to serve as non-strategic industrial land, providing a transitional area between the neighbouring strategic industrial land uses and adjacent urban developments. Certain commercial/retail uses could also be considered to support the rapidly growing population. With proximity to both residential population and a strategic employment area, non-strategic industrial and commercial uses will have good access to consumers/customers. The amenity related air quality issues could make commercial and industrial uses more suitable to the subject area although further investigation is required. The proximity to primary industry and industrial uses may put downwards pressure residential land value for land along the western boundary of the subject area. Land values for commercial and industrial uses may be unaffected or even benefit from proximity to the nearby industrial areas.

Although the subject area currently supports agricultural uses, these do not appear to be the best use of the land. Agricultural employment is land intensive; the scale of employment that could be realised is much lower than for industrial or commercial land uses. It also presents the lowest land value for current land holders.

[5] de Vor. F, de Groot. H 2009, 'The Impact of Industrial Sites on Residential Property Values: A Hedonic Pricing Analysis for The Netherlands'. Available from: https://papers.tinbergen.nl/09035.pdf
[6] Kolala et al 2020, Impacts of mining on property values in Kalgoorlie-Boulder, Western Australia'. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0301420719308803
[7] For further detail regarding industrial land projections, please see Section 5, Land Analysis

The current zoning of the subject area as Industrial Investigation is seen to be appropriate from a supply and demand perspective, preserving strategically located land to meet the future employment needs of the region. The potential inclusion of commercial/retail uses could be appropriate as it is compatible with light industrial uses and could be used to transition from those uses to the neighbourhood residential land. Residential land does not appear to be required to meet the projected population growth for the Sub-region. The presence of the amenity related air-quality issues could act as a constraint to residential development in some western parts of the subject area; further investigation is required to assess the potential impacts of amenity issues. Given the importance of providing employment opportunities in the Sub-region, it is suggested that residential development might be more appropriate as a targeted use in specific sections of the subject area (i.e. along the eastern border).

2 LITERATURE REVIEW

There are a number of planning, economic development and strategy documents that are pertinent to the Improvement Scheme. The following documents have been reviewed as part of this assessment:

- Syme and McLeod 2019, '***City of Kwinana Employment and Economic Development Study***'. Available from: Local Planning Strategy - Employment and Economic Development Study (kwinana.wa.gov.au)
- City of Kwinana 2019, '***Rural Land Study***'. Available from: Local Planning Strategy - Rural Lands Study (kwinana.wa.gov.au)
- City of Kwinana 2019, '***Local Housing Study***'. Available from: Local Planning Strategy - Kwinana Housing Study
- Department of Planning, Lands and Heritage 2018, '***The South Metropolitan Peel Sub-regional Planning Framework***'. Available from: https://www.wa.gov.au/sites/default/files/2021-06/FUT-PP-South_Metro_Peel_Sub_Region_March2018_v2.pdf
- FACTbase 2018, '***Kwinana as a Catalyst for Economic Development***'. Available from: https://www.committeeforperth.com.au/documents/factbase-special-report-kwinana-as-a-catalyst-for-economic-development
- City of Kwinana 2018, '***Local Planning Policy No 12 Mandogalup Future Development***'. Available from: https://www.kwinana.wa.gov.au/council/documents,-publications-and-forms/publications-and-forms-(all)/policies/2020/local-planning-policy-no-12-%E2%80%93-mandogalup-future-de
- Western Australian Planning Commission 2012, '***Economic and Employment Lands strategy: non-heavy industrial***'. Available from: https://www.wa.gov.au/government/document-collections/economic-and-employment-lands
- Western Australian Planning Commission 2007, '***Jandakot Structure Plan***'. Available from: https://www.sjshire.wa.gov.au/development-services/planning/planning-on-multiple-lots/structure-plans.aspx

These documents provide an insight into potential uses of the subject area based on trends in the City of Kwinana and surrounding region. They provided different perspectives on capacity and potential demand for different types of land uses. The following sections summarise the key points from each document relating to the land and demand analysis.

2.1 City of Kwinana Employment and Economic Development Study (2019)

This report provides an overview of the economic development needs of the City of Kwinana but does not directly address the subject area. Several key points include:

- The importance of the WTC and the need to preserve Latitude 32 industrial land for strategic uses
- The growing land intensity of industry uses in WTC – the growth in floorspace has outpaced the growth in employment
- The attractiveness of the City of Kwinana for light industrial (non-strategic) land uses and the need to prioritise land for such uses
- Unemployment in the City has been growing at a faster rate than in the Greater Perth area
- Employment opportunities in the City have not grown at the same rate as population

The report also quantifies the future employment growth required to meet the City's population projections. The report estimates that a total of 12,000 jobs are required within the City based on the City's projected population growth and the current ratio of employment to labourforce. The report identifies the need for almost 7,000 of these additional jobs to be in export-orientated industries, which are generally found in strategic employment areas such as the WTC.[8] This supports the premise that areas such as Latitude 32 needs to be preserved for strategic industrial land uses with other areas identified for non-strategic uses.

2.2 City of Kwinana Rural Land Study (2019)

The Rural Land Study provides input into the City of Kwinana's Local Planning Strategy. It aims to identify the issues associated with the City's rural areas and provide guidance to future planning and land use.

The study indicates there are differences in land-use planning between State and Local planning documents for the subject area. It highlights the importance of the IP47 project in providing guidance as to the future land uses permissible in the area.

2.3 City of Kwinana Local Housing Study (2019)

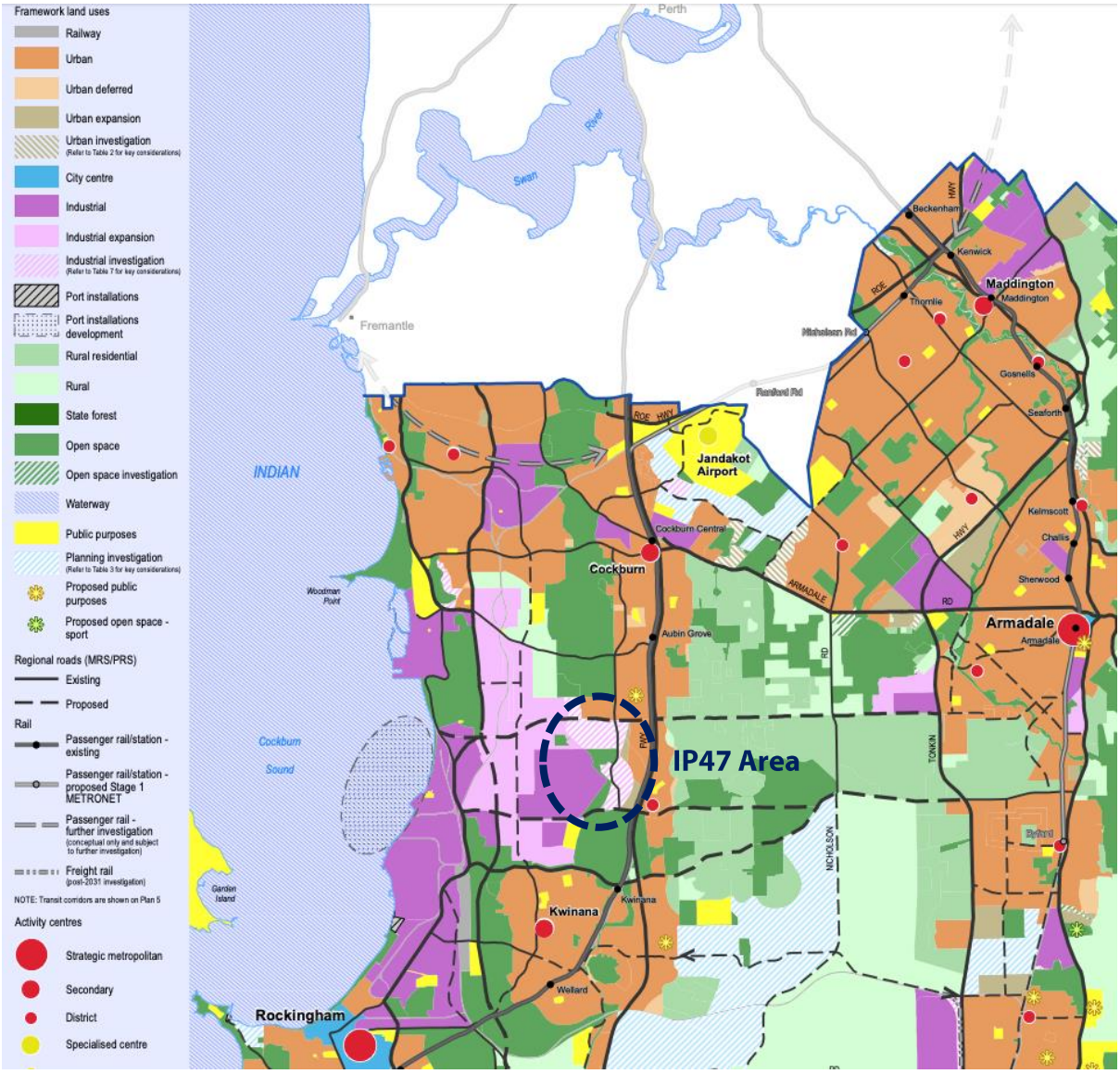
The housing study provides key demographic and population growth estimates to help guide the Local Planning Strategy in ensuring there is sufficient, suitable housing to accommodate the projected population. It identifies the Mandogalup Employment Area (which covers the subject area) as a location that will accommodate an estimated additional 2,408 dwellings between 2016 and 2036. This equates to a population of approximately 7,000 people.

[8] See Section 3, Planning Implications for Employment Land, for further detail about export-orientated employment.

2.4 Southern Metropolitan Peel Sub-Regional Planning Framework (2018)

The Framework provides the roadmap for land use planning in the southern metropolitan area. It assesses the facility, service and infrastructure requirements for a 3.5 million population in Perth and Peel by 2050. The Framework identifies current and future investigation areas for each type of land use. It has defined the subject area as an industrial investigation area (Figure 1).

Figure 1. Framework Map Showing the Subject Area



Source: Department of Planning, Lands and Heritage 2018

The Framework identifies significant population growth in the Sub-region, with the population predicted to grow from 523,430 up to 1,264,450 people by 2050. The population growth will require an additional 302,180 dwellings of which 19,550 are planned for Kwinana alone. According to the Framework there is sufficient

undeveloped land that is suitably classified to support the forecast housing requirements based on the 2050 population targets.

While the labourforce will grow as the population grows, achieving the targeted Employment Self-Sufficiency (ESS) of 74% would require growth in the number of jobs in the Sub-region.[9] Job estimates are developed per sub-regional sector with the Sub-region as a whole requiring an additional 293,750 jobs to achieve its ESS target. The Framework indicates that the western sector (which includes the subject area) will require an additional 121,090 employment opportunities to achieve its ESS target.

Industrial land growth is modelled for non-strategic industrial land. The Sub-region is expected to require an additional 5,920 ha of non-strategic land by 2050; the Western sector is projected to require an additional 2,390 ha over the same timeframe. It estimates that there is a potential gross supply of industrial land in the entire Sub-region of 5,450ha.[10] It should be noted that North East Baldivis is no longer planned as industrial in the Framework, a significant change from the EEL Strategy.

The Framework identifies the need to protect primary production areas in the Metropolitan area as they are important for maintaining local food supply and reducing transport and infrastructure costs. It indicates that rural land should not just be seen as urban or industrial land in waiting. The Framework states that the decision to protect rural land uses should be based on industry trends or needs.

2.5 Kwinana as a Catalyst for Economic Development (2018)

This document undertakes an assessment of the Kwinana Industrial Area and broader WTC. The report is part of the Bigger & Better Beyond the Boom initiative that provides recommendations for diversifying the WA economy.

The report highlights the economic potential of the Kwinana Industrial Area and the importance of protecting the uses in the area. It discusses the proposed amendment to legislate the buffer around the WTC (includes Kwinana Industrial Area) that would further protect the industrial land uses at the WTC and includes sections of the subject area. Key points in the document include:

- *Industrial land and infrastructure must be project ready - that is, available for major projects when they occur. Further supply of strategic industrial land is required and further areas of new light and general industrial land must be preserved for long term time frames.*
- *Industrial land must be protected from encroachment and inappropriate use. For heavy and strategic sites in the Kwinana Complex, this means discouragement of uses which do not contribute to the network in the complex and which do not require the operational protection afforded by the buffer uses around the complex. This particularly includes activities which are large land users but small employers, such as storage, freight and logistics, and large employment uses which could be located*

[9] For a definition of Employment Self-Sufficiency, see Section 3, Planning Implications for Employment Land
[10] Gross area includes land that could have environmental constraints and land needed for roads/buffers. The Framework considers demand and supply in gross terms with demand calculated using an average demand of 164.5 ha per annum.

elsewhere, such as office / business uses. It also requires strict protection of the buffer from residential encroachment. This also applies to light and general industrial land generally.

- *A corollary to this is that is critical that the specific form of any Outer Harbour[11] works is carefully considered to ensure the highest and best long-term use of scarce strategic industrial land is preserved.*

The report highlights the environmental protection concerns regarding the potential health and amenity impacts associated with the Alcoa tailings dam adjacent to the subject area. It is claimed that establishing the buffer around the WTC will ensure that future industrial investors have the confidence required to invest the significant capital required for industrial developments by limiting the potential for residential encroachment on strategic industrial land uses. The availability of industrial land is highlighted as crucial for ensuring there are sufficient high-quality employment opportunities for the current and future population of the City of Kwinana and the wider region.

2.6 Local Planning Policy 12 – Mandogalup Future Development (2018)

The objective of this policy is to provide guidance to landowners, developers and Councilors relating to the the Mandogalup area, including the subject area. The policy aims '*…to ensure that future development, zoning and Structure Planning occurs in a manner consistent with orderly and proper planning of the locality and reflecting the highest and best use of land in the context of the region.*'

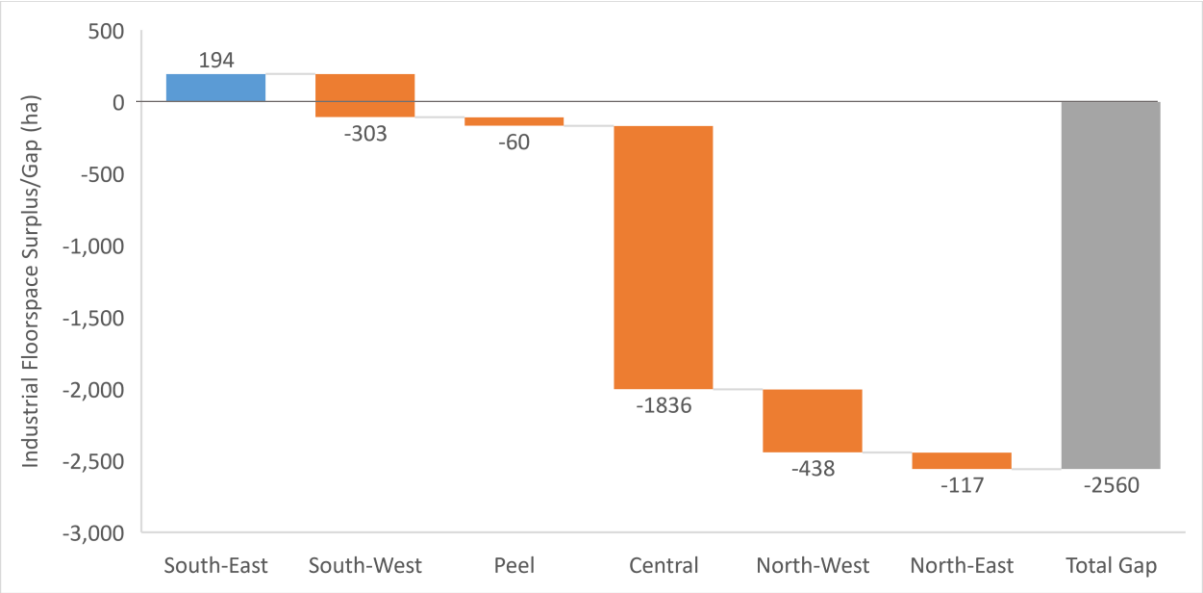
The policy indicates the intention to allow light industrial, commercial services and transitionary land-uses on the subject area. It states that '*Future zoning should seek to avoid the risk of land use conflict in the area by identifying suitable non-sensitive uses that provide adequate spatial separation. Where it is considered unavoidable to place sensitive land uses within this area, the onus will be on the proponent to demonstrate why alternative land uses or design solutions are not suitable.*'

2.7 Economic and Employment Lands Strategy (2012)

The Economic and Employment Lands Strategy (EELS) provides an assessment of the light and general industrial requirements for each of the Metropolitan sub-regions. Demand and supply are forecast to 2036 and compared to current and planned industrial areas; a number of gaps are identified that are relevant to the Study Area (Figure 2).

[11] Outer Harbour refers to the proposed Westport development in the Cockburn sound. The Westport development could see all or a significant proportion of sea container movements passing through the WTC. For further information, please see: https://www.transport.wa.gov.au/projects/westport.asp

Figure 2. EELS Industrial Floorspace Cumulative Gap in Industrial Land to 2036



Source: Department of Planning 2010. Note: There was a slight surplus of industrial land in the South-East Sub-region

EELS identifies a deficit in light industrial land of 2,560ha in the Greater Perth area and a 303ha gap in the South West Metropolitan Sub-region, which includes the subject area. The study highlights a number of key industrial land developments in the Sub-region for future industrial land, including Latitude 32. A number of areas within the Latitude 32 precinct (Stages 4 – 10 and the Extension) could provide light and general industrial land area in the medium and long term, however EELS identified these areas as constrained due to fragmented land holdings and potential environmental considerations. North East Baldivis is highlighted in the strategy as the desired location for future light and general industry development, however EELS was based on a forecast population of 2.2 million by 2031 and has been superseded by the Southern Metropolitan Peel Sub-regional Framework.

2.8 Jandakot Structure Plan (2007)

The structure plan was designed to coordinate and guide the development expectations of a specified region (that includes the subject area), while balancing environmental, infrastructure, lifestyle and community requirements.

The structure plan identifies the Mandogalup area (including the subject area) as having the potential to accommodate almost 10,000 persons in future. The plan discusses the constraints created by the Alcoa tailings dam and indicates that development will need to be deferred or abandoned for affected areas until a buffer no longer applies or land use zoning is changed.

2.9 Document Review – Key Findings

The document review identified several pieces of information relating to acceptable land uses at the subject area and best use of the area in future. Some key findings include:

- The City of Kwinana Rural Land Study and Local Planning Policy 12 are in alignment, both discussing the potential for light industrial and transitional land uses for the subject site
- The City of Kwinana Housing Study indicates that land could accommodate significant residential development by 2036
- The Framework has identified the site as an industrial investigation area. It identifies the need for 5,290 ha of additional industrial land. The document indicates that the City of Kwinana will grow by more than 15,000 dwellings and states that the Sub-region has sufficient land to support the residential development requirements
- The Kwinana as a Catalyst for Economic Development report highlights the strategic importance of the Western Trade Cost and the need to protect its competitive advantage through appropriate buffers. This would limit the potential for residential development on the subject area
- A number of planning and strategy documents identify the importance of the subject area in ensuring the capacity for strategic industrial land uses in the Western Trade Coast area by providing a suitable location for light industrial activities

3 PLANNING IMPLICATIONS FOR EMPLOYMENT LAND

The Southern Metropolitan Peel Sub-regional Planning Framework identifies the population and employment targets for the Sub-region. The Framework has established an Employment Self-Sufficiency (ESS) target for each of the metropolitan sub-regions. ESS is a measure of a region's capacity to employ the local labourforce; specifically, it is the ratio (expressed as a percentage) of the total labour force (local residents who are employed or seeking employment) of a defined area relative to the total number of jobs available in that area. A percentage above 100 indicates a region has more jobs locally than resident workers. The Framework has established an ESS target for the Sub-region of 74% by 2050, requiring an additional 293,750 jobs to meet the employment needs of the local population. The WTC will likely provide a significant component of these employment opportunities, with the Western sector[13] of the Sub-region, which includes the WTC, having a target ESS of 83%, up from its current estimated ESS of 65%. The Western sector will require an additional 121,090 jobs, approximately 41% of the total sub-regional increase in employment. There are two broad types of employment that will contribute to meeting the ESS targets. These are:

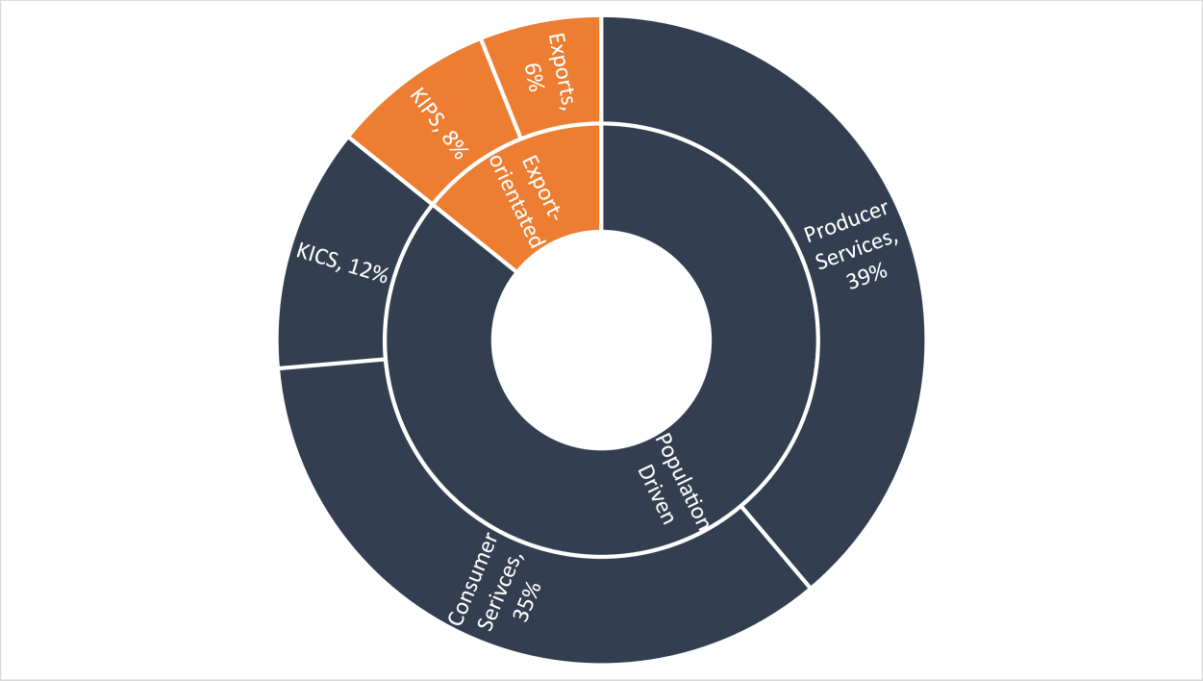
- **Population-driven employment**: Population-driven employment is employment resulting from economic activity servicing the needs of a limited population catchment. This type of employment tends to grow in line with population. This includes; retail and hospitality, construction and industrial services, civic, healthcare and education, and local professional services. Population-driven employment has been summarised in the Pracsys employment quality model as Consumer Services, Knowledge Intensive Consumer Services (KICS) and a component of Producer Services (see Appendix A: Glossary)
- **Export-orientated employment**: Export-orientated employment includes both direct exports, such as mining, tourism and agriculture, and supporting high-knowledge (producer) services such as professional services and IT. This type of employment does not grow in line with population; existing and planned strategic infrastructure guides the agglomeration of highly productive and intense jobs. Areas with industrial land that service external markets can generate substantial export-orientated employment. Export-orientated employment has been summarised in the Pracsys employment quality model as Exports, Knowledge Intensive Producer Services (KICS) and a component of Producer Services (see Appendix A: Glossary)

Population driven employment grows in relation to population and provides a base employment level that contributes towards meeting ESS targets. Population driven employment beyond that which is required to meet the needs of the population is not sustainable as the population only demands a certain amount of goods and services; both population driven and export-orientated employment are required to improve the

[13] The Western sector is comprised of the Cities of Cockburn, Rockingham and Kwinana.

ESS percentage.[14] Export-orientated employment has the capacity to develop through provision of goods and services to larger markets beyond the demands of the local population. The Western sector of the Sub-region currently supports 14% export-orientated employment (Figure 3).

Figure 3. Western Sector – Employment Quality Breakdown (% of total employment)



Source: ABS Census 2016, Pracsys 2019

The ability of the Western sector of the Sub-region to accommodate export-orientated employment will be critical to achieving the employment targets needed to support population growth. The WTC will play a significant role in attracting export-orientated employment to the Sub-region given the strategic industrial land available and future potential projects such as Westport. WTC is currently home to 35% of total export-orientated employment in the Western sector of the Sub-region, despite providing only 18% of total employment. It also has a much higher proportion of Producer Services that are attracted by the export-orientated industry agglomerations. The WTC and adjacent employment land will be critical to ensuring there is sufficient employment growth to support the projected population growth Western sector and broader Sub-region.

Population growth in the Western sector of the Sub-region will be the driver for an additional 74,000 population driven jobs by 2050.[15] The remaining 47,000 jobs required to meet the Framework's target will need to be export-orientated in nature. Should the WTC accommodate future employment growth based on its current share of employment, there would need to be an additional 22,000 employment opportunities

[14] Supported by the discussion presented in the City of Kwinana 2019, Employment and Economic Development Study
[15] Estimated using the Greater Perth population – population driven employment ratio of 0.30, which is substantially higher than the current Study Area ratio of 0.23. This was used as an optimistic outlook for population driven employment in the region which can be more easily influenced by policy

available at the WTC. The WTC currently provides an estimated 13,700 employment opportunities on approximately 3,125 ha of land; the proposed targets could more than double the employment requirements of this industrial area. If future employment growth at WTC is restricted to the targeted 10,000 jobs for Latitude 32, a significant amount of land would be required to accommodate the employment needed to meet ESS targets.[16] The Latitude 32 component of the WTC would likely need to accommodate more strategic industrial land uses that are land intensive and require the buffers afforded by the WTC. It will be necessary to identify additional employment lands that are more suited to light industrial uses, such as the subject area. More detailed land demand analysis assesses the potential gap in demand based on historical floorspace trends and projected industrial land uptake at the WTC.

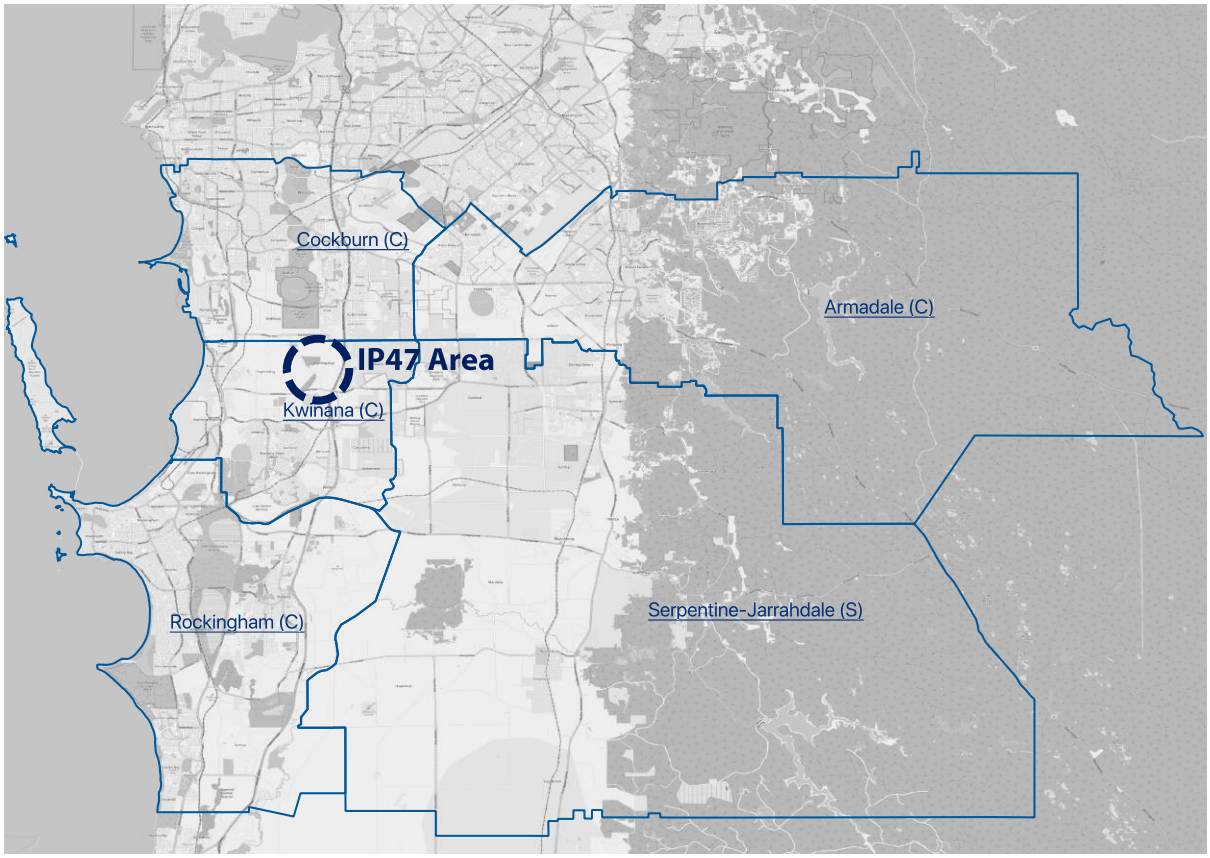
[16] Development WA 2021, Latitude 32 Industry Zone. Available from: https://developmentwa.com.au/projects/industrial-and-commercial/latitude-32-industry-zone/about-the-project

4 ECONOMIC AND POPULATION OVERVIEW

The economic and population analysis considers the City of Kwinana and surrounding Local Governments (the Study Area), including:

- City of Armadale
- City of Cockburn
- City of Rockingham
- City of Serpentine-Jarrahdale

Figure 4. Study Area



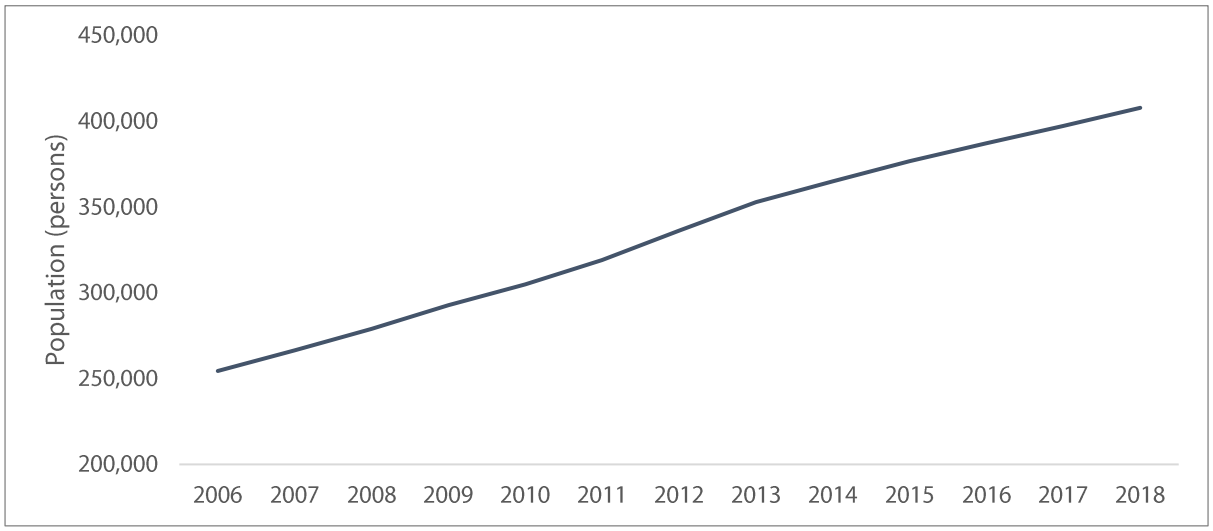
Source: QGIS 2019

The areas surrounding the City of Kwinana have been included to capture the wider demand for and supply of urban, industrial and rural land uses. The Study Area is used for the remainder of the report as a basis for land use analysis.

4.1 Population

Expected population growth underpins planning for dwellings and other supporting infrastructure such as recreation areas and commercial centres. There are approximately 408,000 people the Study Area (Figure 5).

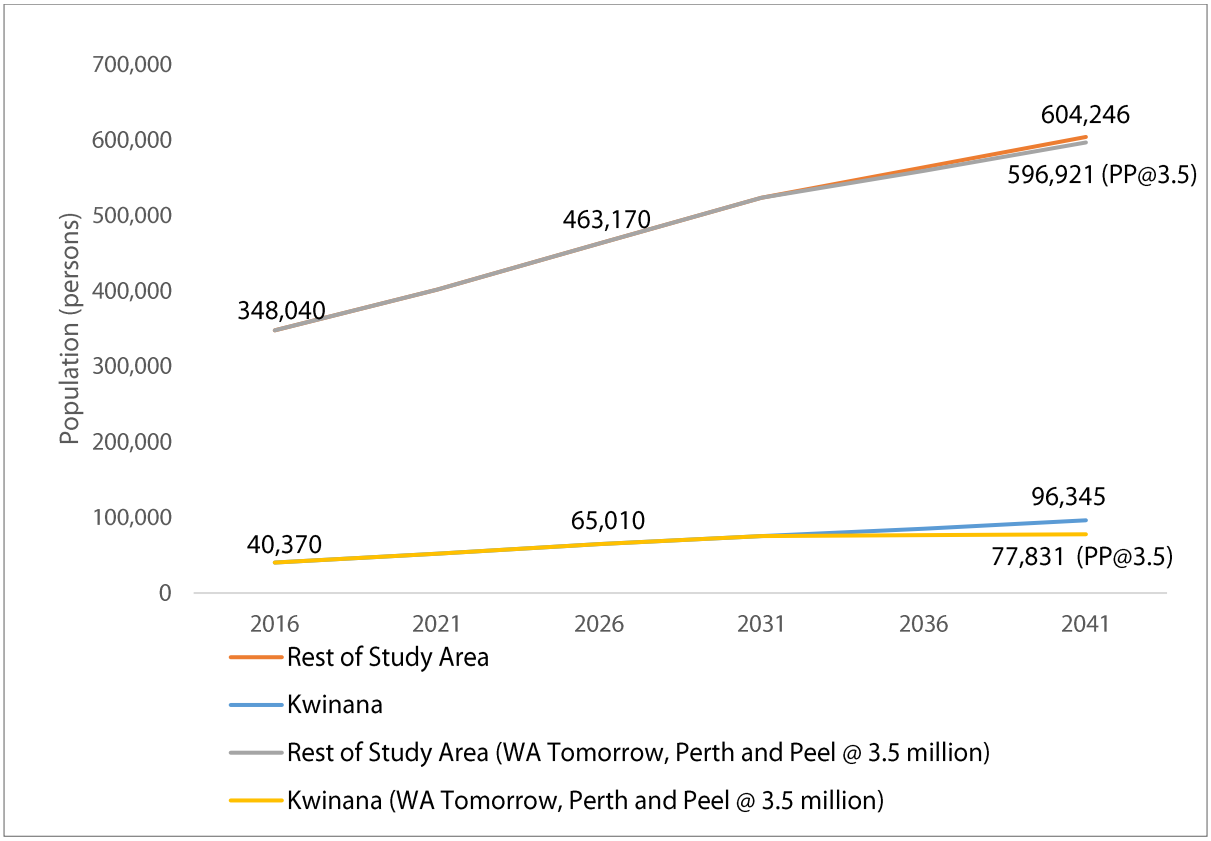
Figure 5. Population Growth Trend (2006 – 2018)



Source: ABS Estimated Residential Population 2018

The annual population growth rate between 2006 and 2016 was 5.1% for the City of Kwinana and 4.0% for the Study Area. Future Population growth projections indicate that both the City and the Study Area will grow significantly over the next 20 years, achieving a total population growth of 80% by 2041, higher than the Greater Perth region which is projected to grow by 77% to 2050 (Figure 6).

Figure 6. Population Growth Projections (2016 - 2041)

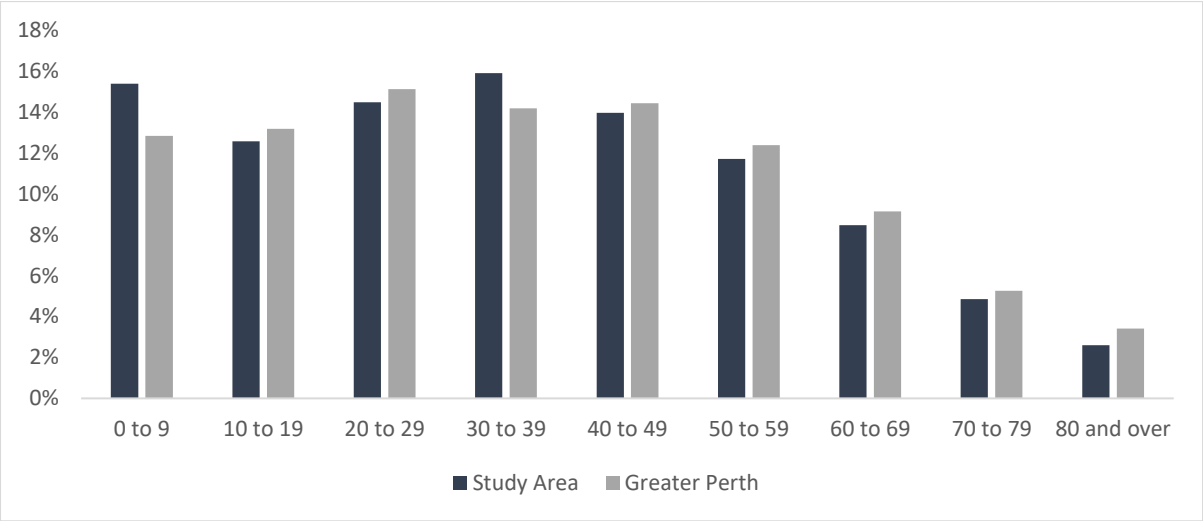


Sources: WA Tommorrow (2019), Forecast.id (2019

Note: WA Tomorrow forecasts were used to project population until 2031. Where available Forecast.id projections were used to project population to 2041, for the councils where the projections ended in 2036, the 2031 – 2036 trend was extrapolated. A comparison has been made to the population that would be achieved through a linear extrapolation from the 2031 WA Tomorrow estimates to the Perth and Peel @ 3.5 million Planning Framework population targets for the Study Area.

The Study Area population has a higher concentration of children under 10 (+3%) and adults between 30 to 39 (+2%) than the Greater Perth population (Figure 7).

Figure 7. Study Area Demographics by Age Group

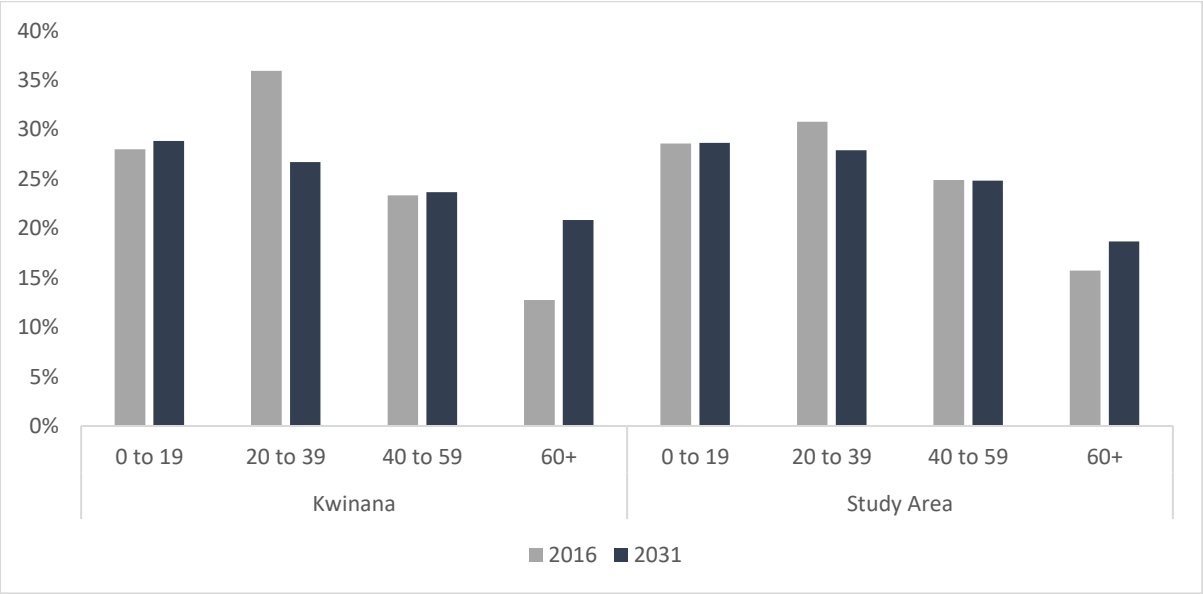


Source: ABS Census 2016

The age demographic can influence the types of infrastructure required to support the local population. This distribution indicates that there might be a greater need for infrastructure that caters to young families.

Over time, both the City of Kwinana and the Study area are going to see decreases in the 20 to 39 age category and increases in the 60+ category, indicating a growing need for age appropriate housing. The City of Kwinana will also see growth in the 0 to 19 age bracket, indicating that there will be continued growth in demand for education and recreation infrastructure/facilities.

Figure 8. Study Area Growth by Age Group

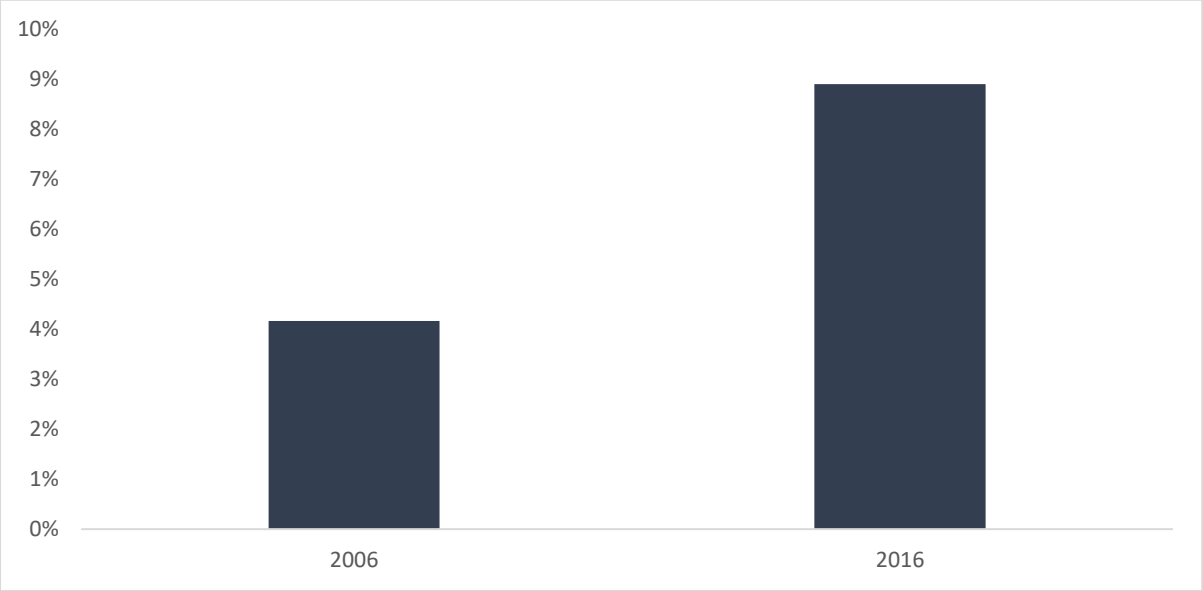


Source: ABS Census 2016, WA Tomorrow 2019

4.2 Economy

Employment in the Study Area grew at a slightly faster rate than population between 2006 and 2016, achieving an annual average growth rate of 4.9%. Despite the significant growth in employment, the unemployment rate nearly doubled over the same period (Figure 9).

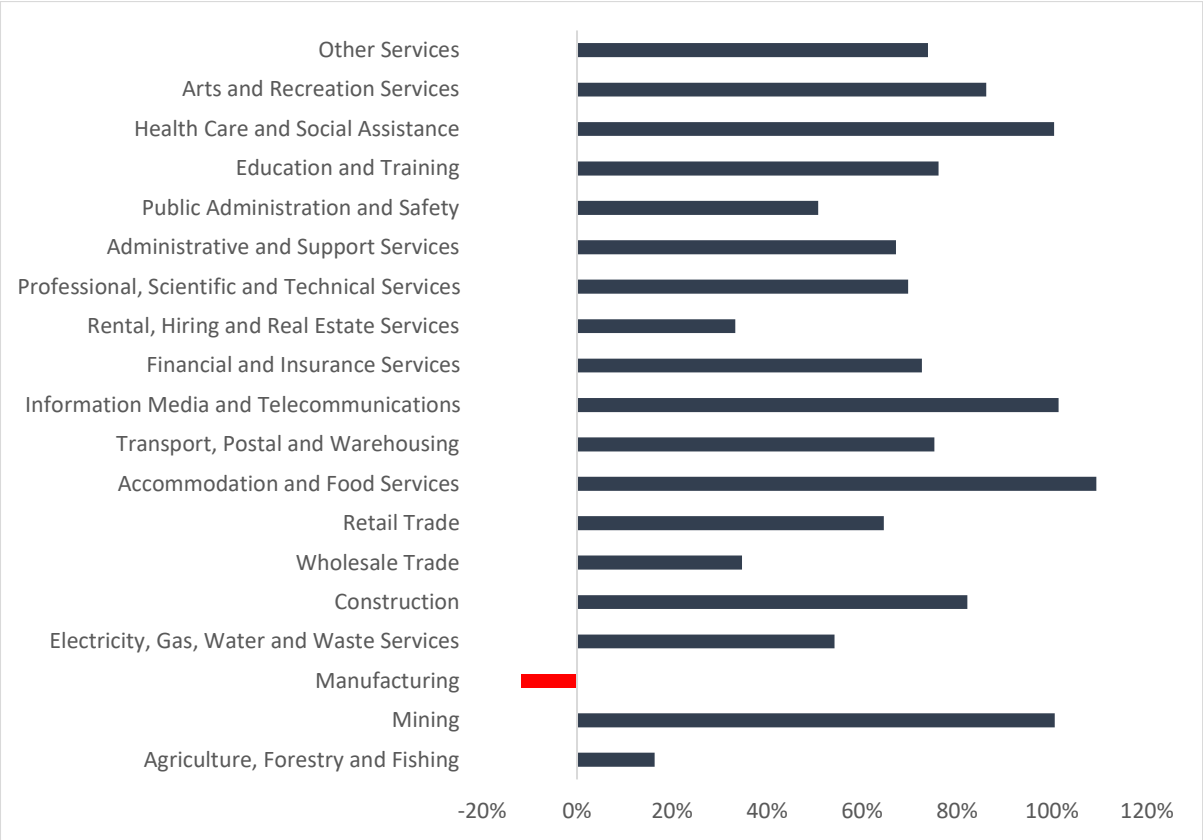
Figure 9. Study Area Unemployment Rate (%) 2006 - 2016



Source: ABS Census 2006 - 2016

Industry changes between 2006 and 2016 show that Manufacturing was the only industry that experienced a decline over that period, which is significant as it was the largest industry of employment in 2006, with 64% more employees than the next biggest industry (Figure 10).

Figure 10. Study Area Percentage Change in Industry Employment, Place of Work 2006 - 2016

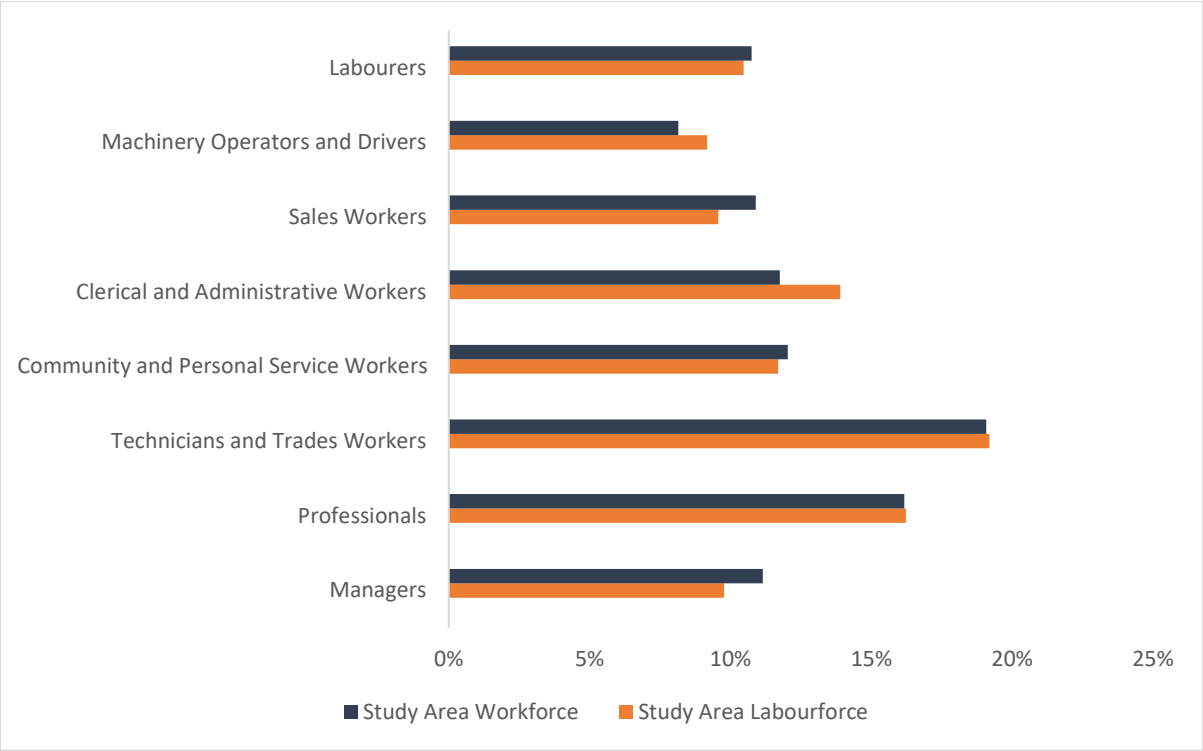


Source: ABS Census 2006 - 2016

This is a broad trend being experienced in the Manufacturing industry and is likely a major contributor to the increase in unemployment in the Study Area, along with other factors such as the downturn in mining. Targeting manufacturing industries would not address this issue due to the continued mechanisation of the industry that reduces the need for human labour in the manufacturing process. It will likely be necessary to provide training opportunities to enable unemployed persons in the region to gain employment in the industries that have high growth potential in the Study Area.

The occupation and industry of residents within an area needs to be aligned with the types of employment available locally to provide residents with the opportunity to work locally. The most common occupations for residents in the Study area are Technicians and Trades Workers and Professionals, both of which can align well with employment found in non-strategic industrial areas (Figure 11).

Figure 11. Study Area Occupations (ABS OCCP Level 1 Classifications)

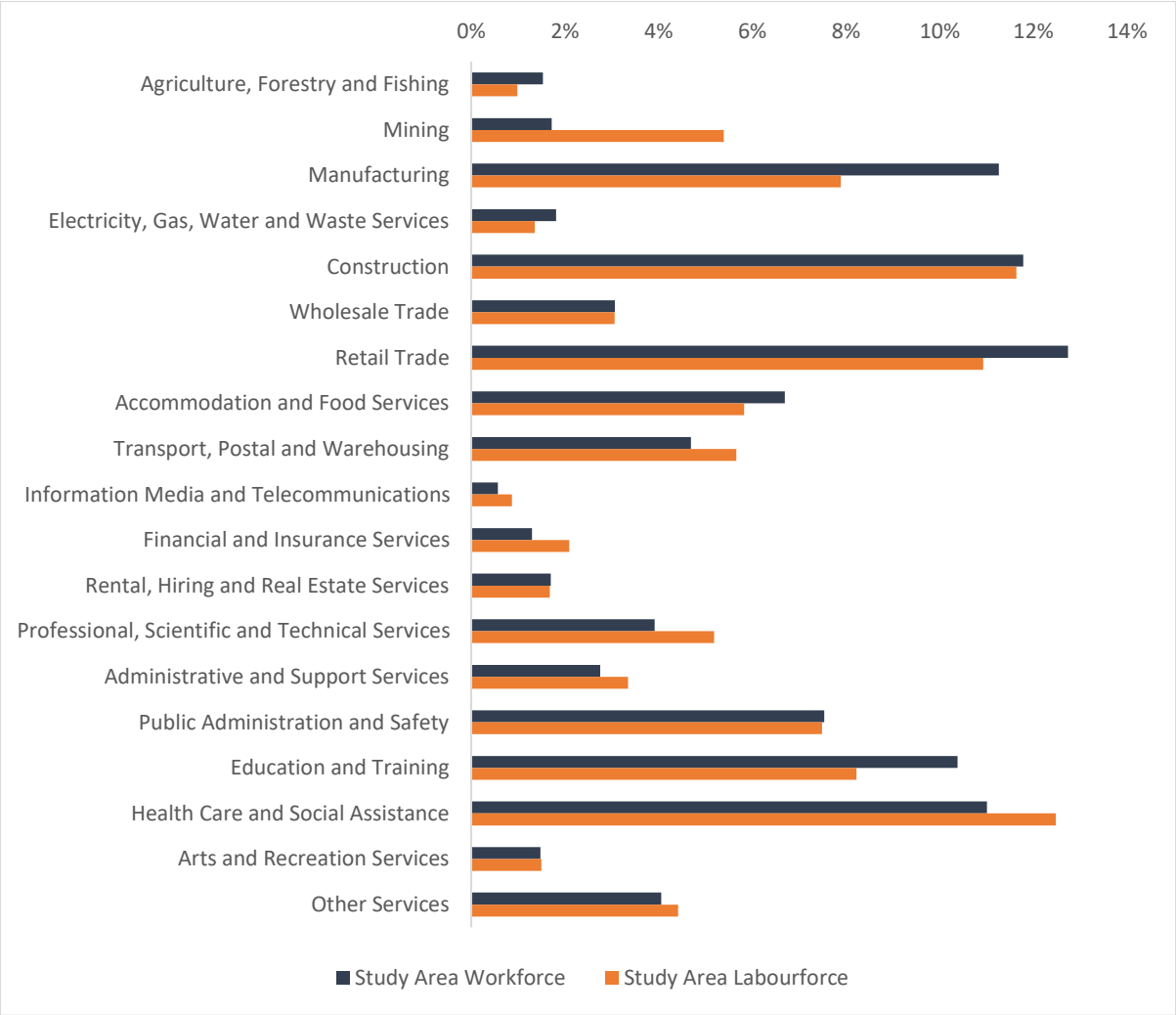


Source: ABS Census 2016

The occupations of residents in the Study Area is relatively well aligned with the types of occupations available in the Study Area (Figure 11: Study Area Workforce). There are potential gaps in employment opportunities for Machine Operators and Drivers, and Administration Workers.

The predominant industries of employment within the Study Area include Healthcare and Social Assistance, Construction and Retail Trade (Figure 12).

Figure 12. Study Area Industry Breakdown



Source: ABS Census 2016

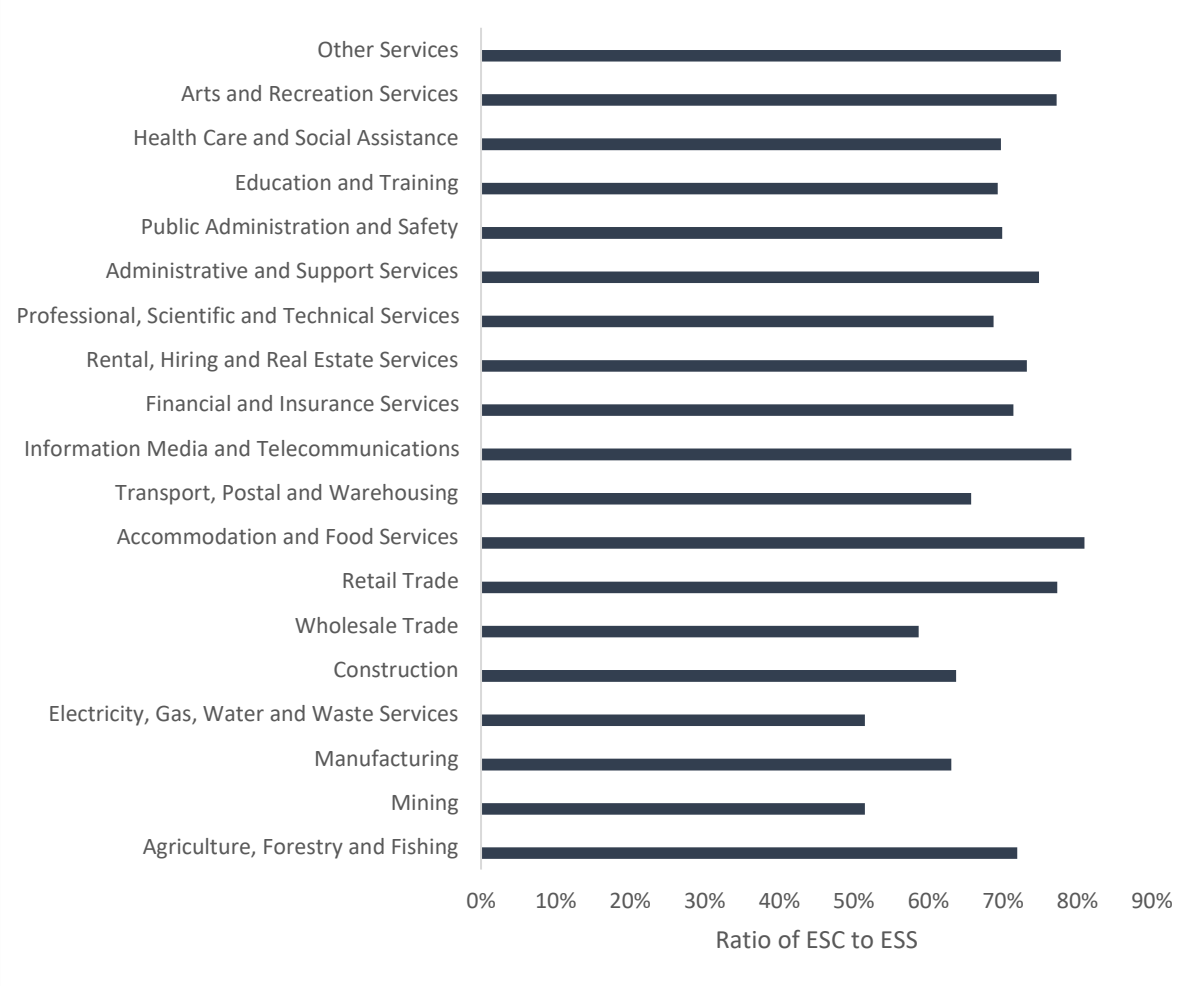
The Study Area Workforce distribution is relatively well aligned with the Labourforce, apart from Mining, Manufacturing, Education and Training, and Retail Trade. This could potentially indicate that additional employment in these industries could be targeted to provide more local employment opportunities for residents working in these industries.

Almost 50% of residents work within the Study Area, a relatively high level of Employment Self-Containment. Outside of the Study Area, Perth City (including Subiaco and the QE 2 Medical Precinct) employs over 14,000 residents, the most of anywhere in Perth. There are also a significant number of DIDO or FIFO positions, with approximately 10,000 residents employed outside of the Metropolitan area.

In order to better understand the relationship between local industry employment and the local labourforce, the industry Economic Self-Sufficiency (ESS) and Economic Self-Containment (ESC) scores have been assessed

for the Study Area.[17] The ratio of ESC to ESS represents the proportion of local jobs that are filled by local labourforce, accounting for the size of the industry locally (specifically, it is the local labourforce that works locally divided by local employment opportunities) (Figure 13).

Figure 13. Study Area Local Labourforce Working Locally Compared to Local Employment Capacity



Sources: ABS Census 2016, Pracsys 2019

Industries in the Study Area achieve a high level of retention of local labourforce with most industries made up of 70% or more local residents. Employment in all industries at a Study Area level is more than 50% occupied by local labourforce. The results indicate that a wide range of industries in the Study Area are successfully attracting local workers. In order to increase the number of residents that work within the Study Area, growth in a diverse range of industries will be required.

A more detailed breakdown of industry growth was undertaken using ANZSIC Level 2 Industry categories and the following detailed summary statistics were identified:

[17] See Section 9.1, Appendix A: Glossary, for further detail.

- 19 out of the top 20 largest industries in the Study Area (based on 2006 figures) outperformed the WA average for that industry in terms of employment change between 2006 and 2016. Key population driven industries include:
    - Comparison and bulky goods retailing
    - Primary and secondary education services
    - Health and aged care services
- 40% of the top 20 largest industries (based on 2016 figures) are located on industrial land
- Of the top 20 industries by Employment Concentration Factor (ECF), 18 are based on industrial land. 50% of these industrial based industries support more than 300 jobs and outperformed the State average over the period 2006 – 2016. A high ECF indicates that there is a greater concentration of employment in and industry in the Study Area when compared to the State as a whole. For a more detailed description of ECF, please see Section 9.1, Appendix A: Glossary.

Potential high growth industries were identified through a Shift Share analysis. 'Shift Share' compares the industry growth in a specified region with the Western Australia benchmark economic growth to determine if the industry is growing more or less in the region than it is in the State economy as a whole. The following criteria were established to ascertain if an industry had high growth potential:

- The industry supported more than 240 employees (the median industry size)
- The industry outperformed the State average growth for that industry
- The industry had an ECF of greater than 1, or the industry grew at a faster rate than population

The following industries met these criteria; industries that locate on industrial land are highlighted in grey (Figure 14).

Figure 14. Potential High Growth Industries

Industry	EFC	Growth	Employment (2016)
Preschool and School Education	1.38	79%	8,770
Construction Services	**1.26**	**82%**	**7,414**
Food and Beverage Services	1.13	118%	6,491
Other Store-Based Retailing	1.26	72%	6,434
Food Retailing	1.44	64%	4,890
Medical and Other Health Care Services	0.93	104%	3,309
Social Assistance Services	1.18	97%	2,915
Hospitals	0.63	114%	2,443
Road Transport	**1.10**	**49%**	**2,299**
Building Construction	**0.86**	**61%**	**2,293**

Industry	EFC	Growth	Employment (2016)
Public Order, Safety and Regulatory Services	1.12	145%	2,264
Residential Care Services	1.04	98%	2,234
Repair and Maintenance	**1.07**	**65%**	**2,044**
Personal and Other Services	0.91	82%	2,024
Building Cleaning, Pest Control and Other Support Services	**0.92**	**77%**	**1,706**
Heavy and Civil Engineering Construction	**1.15**	**115%**	**1,592**
Basic Material Wholesaling	**1.68**	**33%**	**1,171**
Food Product Manufacturing	**1.15**	**42%**	**1,165**
Sports and Recreation Activities	1.42	88%	1,116
Machinery and Equipment Manufacturing	**1.69**	**66%**	**992**
Waste Collection, Treatment and Disposal Services	**2.30**	**198%**	**658**
Gas Supply	**2.74**	**249%**	**401**
Transport, Postal and Warehousing, nfd	**1.14**	**308%**	**241**

Source: ABS Census 2006 – 2016, Pracsys 2019

The Study Area had a number of potential high growth industries in both population-driven and export-orientated industries. The identified population driven industries grew by more than population growth between 2006 and 2016 (population growth was approximately 60%). This indicates that these industries are providing goods and services to population outside of the Study Area or there was previously an under provision of these goods and services in the Study Area (i.e. that jobs in these industries lagged population growth). Growth in export-orientated industries is related to the Study Area's competitive and comparative advantage, such as the agglomeration economies achieved at the WTC. The results indicate that a variety of employment lands will be needed in the Study Area to support a diverse range of employment growth opportunities.

5 LAND ANALYSIS

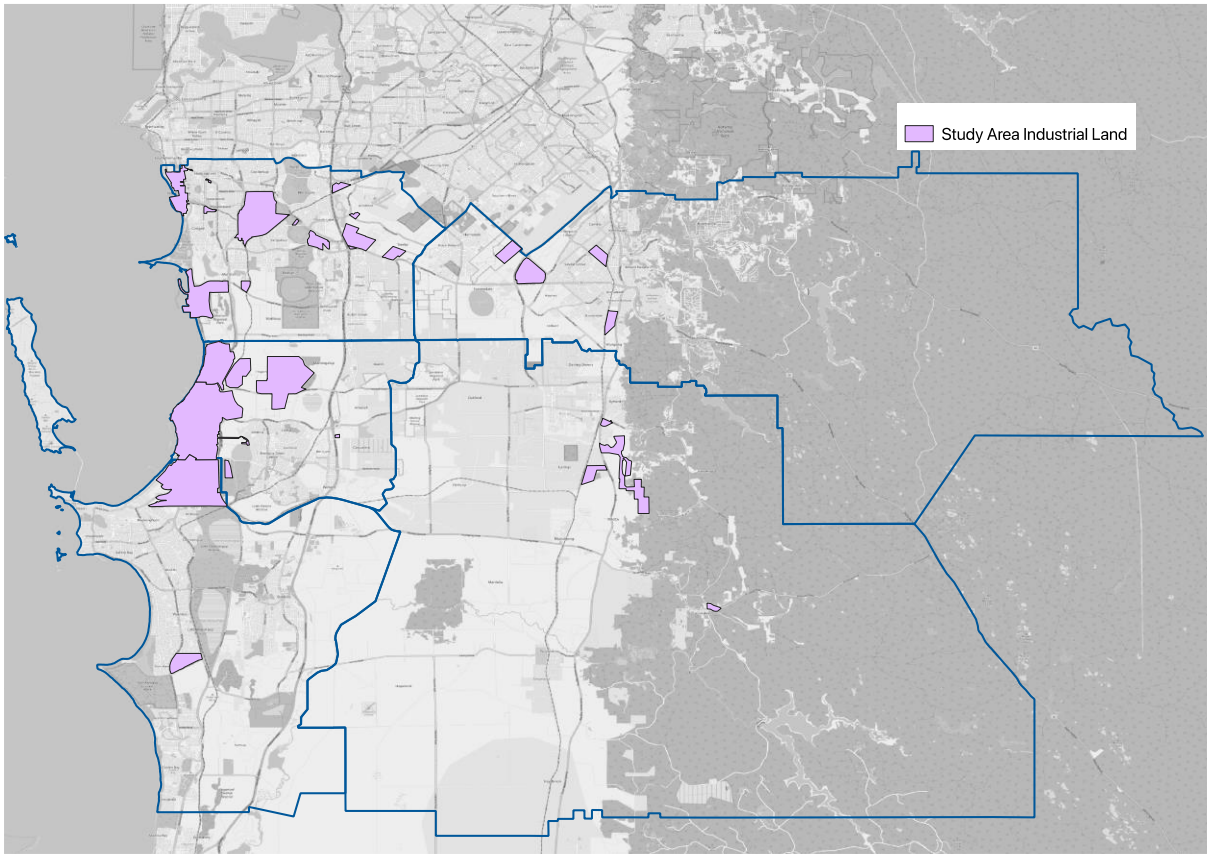
The Land Analysis compares current and planned land supply with projected demand to assess the potential surplus/deficit of land in the Study Area.

5.1 Industrial Land

Current Supply

The Study Area is home to strategic and non-strategic industrial land that supports a significant amount of employment (Figure 15).

Figure 15. Study Area – Industrial Zoned Land

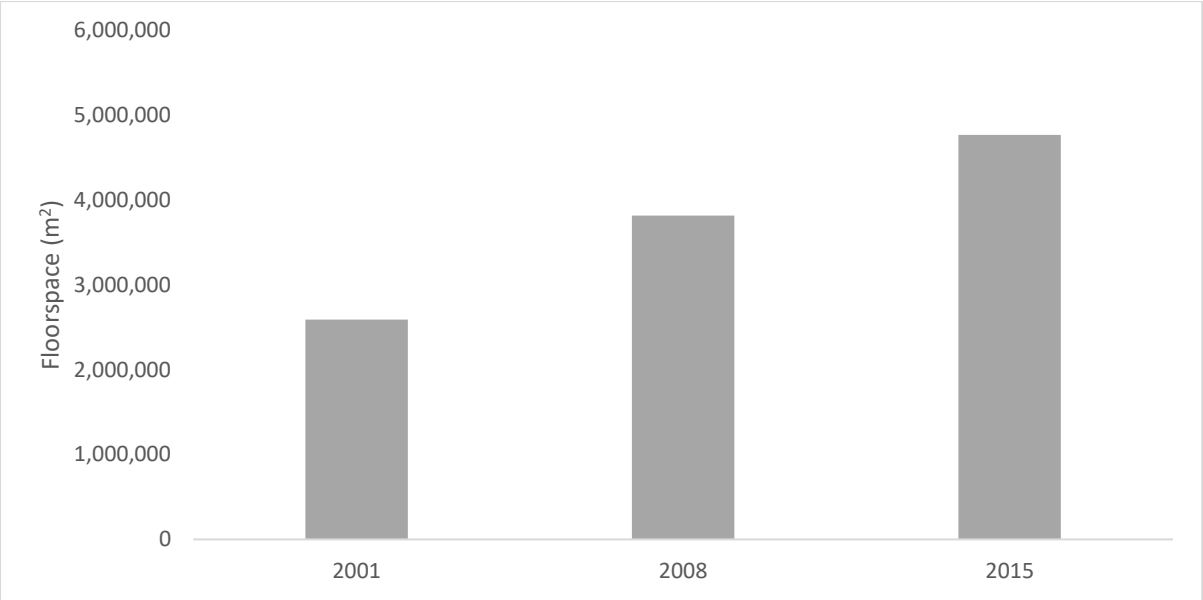


Source: Department of Planning, Lands and Heritage 2019

Between 2001 and 2015, total floorspace in industrial centres in the Study Area grew by approximately 84% (Figure 16).[18]

[18] Department of Planning, Lands and Heritage 2015, Land Use and Employment Survey

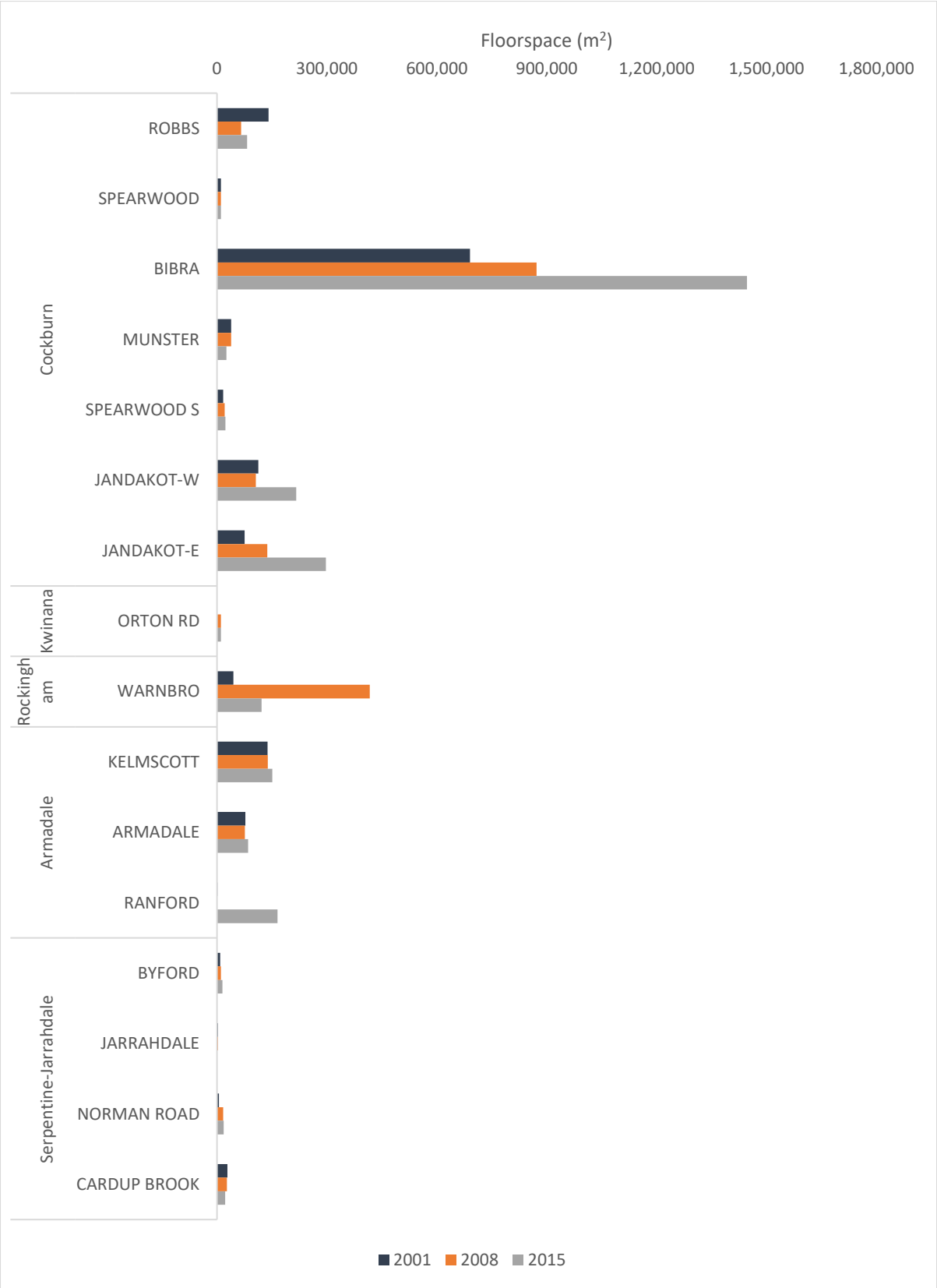
Figure 16. Industrial Floorspace Growth



Source: Department of Planning, Lands and Heritage 2001 - 15

This growth in floorspace appears to have been concentrated in the City of Cockburn which experienced growth in industrial floorspace of approximately 98% and comprises almost 56% of total industrial land within the Study Area. The majority of this growth was in non-strategic industrial land, particularly in the Bibra Industrial area (Figure 17).

Figure 17. Study Area – Non-strategic Industrial Land Growth



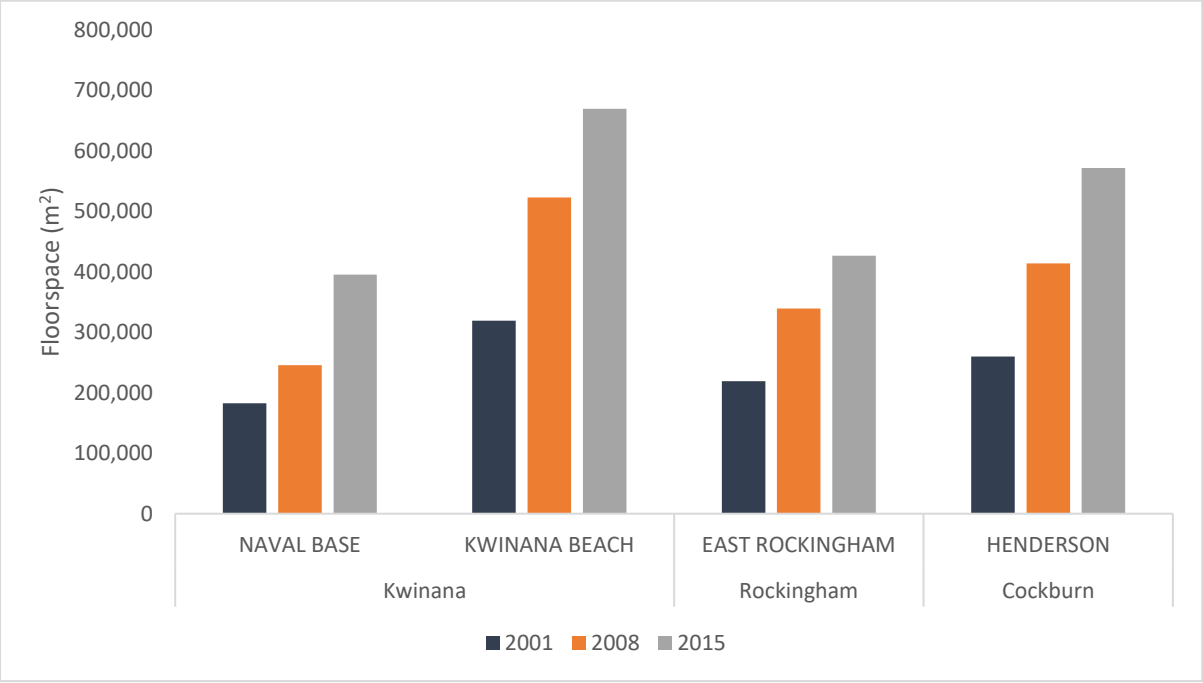
Source: Department of Planning, Lands and Heritage 2001 - 15

While non-strategic industrial areas tend not to accommodate land intensive uses (i.e. heavy industries, food manufacturing, etc.), they do support producer services that supply both export orientated industries and regular consumers. These producer services support higher concentrations of employment and can be important contributors to economic diversity. With the significant growth in the Bibra industrial centre over the evaluation period, the area appears to be fully developed and new industrial areas will likely be needed to support non-strategic industrial land uses within the Study Area.

The other centres that experienced significant growth (in percentage terms) are Jandakot and Ranford, one anchored by the airport and the other being overseen by Development WA. These centres could be considered strategic in nature although the land uses they support are not land intensive and do not require extensive buffers such as those at the WTC. A number of centres experienced slight reductions between 2008 and 2015. The Robbs Road industrial centre, was re-zoned and transitioned to urban land through the North Coogee development to cater to demand for residential development in the area. Where appropriate, industrial land areas should be protected to ensure that non-strategic industrial uses can grow to meet the needs of businesses and residents of the Study Area.

The Cities of Cockburn, Rockingham and Kwinana all experienced growth in their respective strategic industrial areas that form the Western Trade Coast (Figure 18). The total industrial area grew by 110% over the period, an increase of over one million m^2 in floorspace.

Figure 18. WTC Industrial Floorspace Growth



Source: Department of Planning, Lands and Heritage 2001 – 15

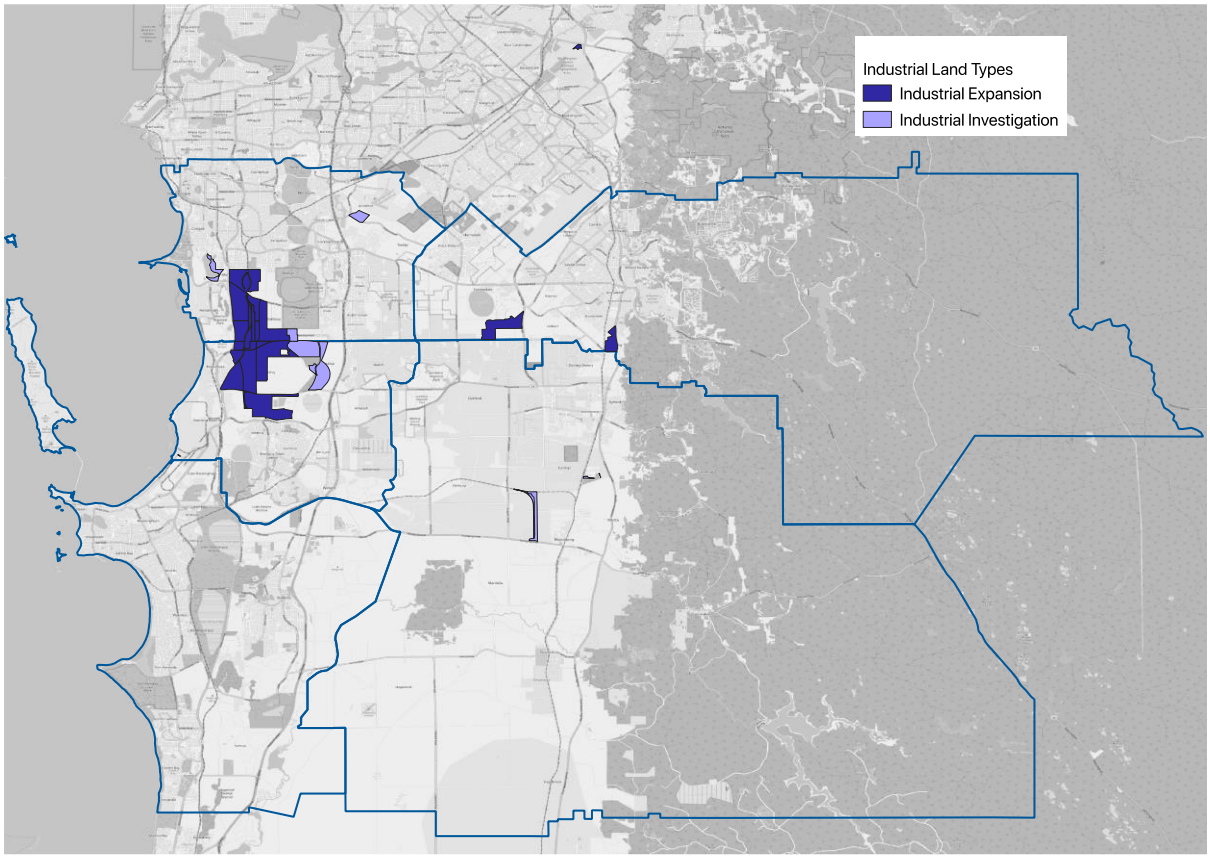
Strategic industrial land is the main source of export-orientated employment for the Study Area, with WTC providing almost 24% of export-orientated employment. Ensuring strategic industrial land remains

unconstrained in the areas adjacent to the WTC will be a critical factor in meeting the export-orientated employment needs of the Study Area and wider region. It is therefore necessary to ensure there are other suitable employment areas that can support the non-strategic industrial uses that are required in the Study Area.

Future Supply

The future supply of industrial land has been estimated using Department of Planning, Lands and Heritage data. Using GIS mapping, it was possible to isolate industrial land areas within the Study Area and estimate total Industrial Investigation and Industrial Expansion areas (Figure 19).

Figure 19. Future Industrial Investigation/Expansion Zoned Land

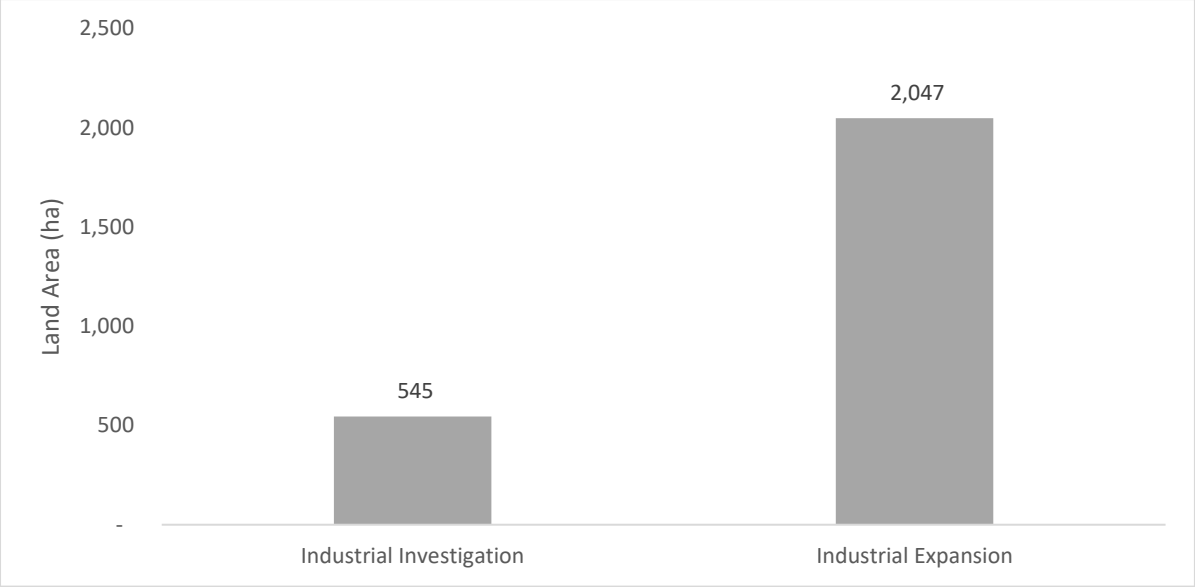


Source: Department of Planning, Lands and Heritage 2019

The total future supply of industrial land in the Study Area is estimated to be 2,592 ha (Figure 20).[19] This is the gross land area and does not account for land required for roads and land that might be environmentally constrained.

[19] Information Provided by The Department of Planning, Lands and Heritage based land zoning data from the Perth and Peel @ 3.5 million Planning Framework.

Figure 20. Future Industrial Land Supply by Type



Source: Department of Planning, Lands and Heritage 2019

The majority of this land (approximately 1,400 ha) is in the Latitude 32 industrial precinct.[20] A number of proposed uses have been highlighted for this land with including a potential intermodal terminal for the proposed Westport development. The intermodal terminal would consume a significant amount of land, potentially in the region of 100 ha for the core terminal area.[21] This would be surrounded by a number of land intensive industries such as storage and warehousing, container parking, etc., limiting the potential for other non-strategic industrial uses

Total future supply has been estimated based on planned industrial land and undeveloped industrial land ().[22] Undeveloped industrial land was estimated in the Economic and Employment Land Monitor (EELM) with estimates specific to the Study Area used in the analysis.

Figure 21. Industrial Land Supply Estimate

	Future Supply	Notes
Undeveloped and Future Industrial Land (Ha)	3,054	This is comprised of: • 892 ha of undeveloped industrial land as reported in EELM • 2,047 ha industrial expansion (includes Latitude 32) • 115 ha industrial investigation (total industrial investigation of 545 ha minus the subject area's 330 ha)

Source: Pracsys 2019, DPLH 2020

[20] Development WA 2019, Latitude 32 Industry Zone. Available from: https://www.landcorp.com.au/Industrial-and-Commercial/Latitude-32-Industry-Zone/

[21] Estimate based on high-level map in City of Kwinana 2019, Employment and Economic Development Study.

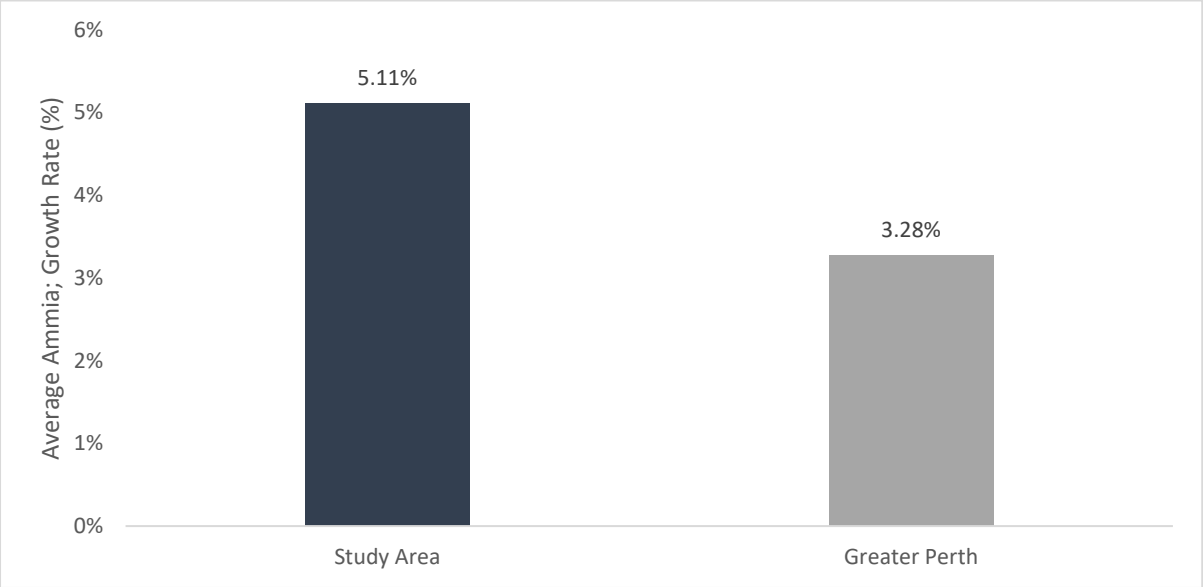
[22] Refers to lots that are zoned for development for the purposes of the specified primary land use category that are recorded as vacant in Landgate's property valuation database.

Land which is classified as unrated has been excluded from this analysis as it is not clear what proportion is remaining to be developed and there are elements that likely form part of the planned industrial expansion and investigation areas.[23]

Industrial Land Demand – Business As Usual

This section develops Business As Usual (BAU) estimates for industrial land demand without consideration of Westport at the WTC (this estimate is provided in the Section entitled **Westport Demand Analysis**). Historical industrial floorspace trends have been used to estimate the potential industrial land demand for the next 20 years. These estimates have been checked against projections in the Perth and Peel @ 3.5 million Planning Framework. Industrial floorspace in the Study Area has grown significantly and at a higher rate than in the Greater Perth region (Figure 22).

Figure 22. Average Industrial Floorspace Growth Comparison – Study Area vs Greater Perth 2001 to 2015



Source Department of Planning, Lands and Heritage 2015

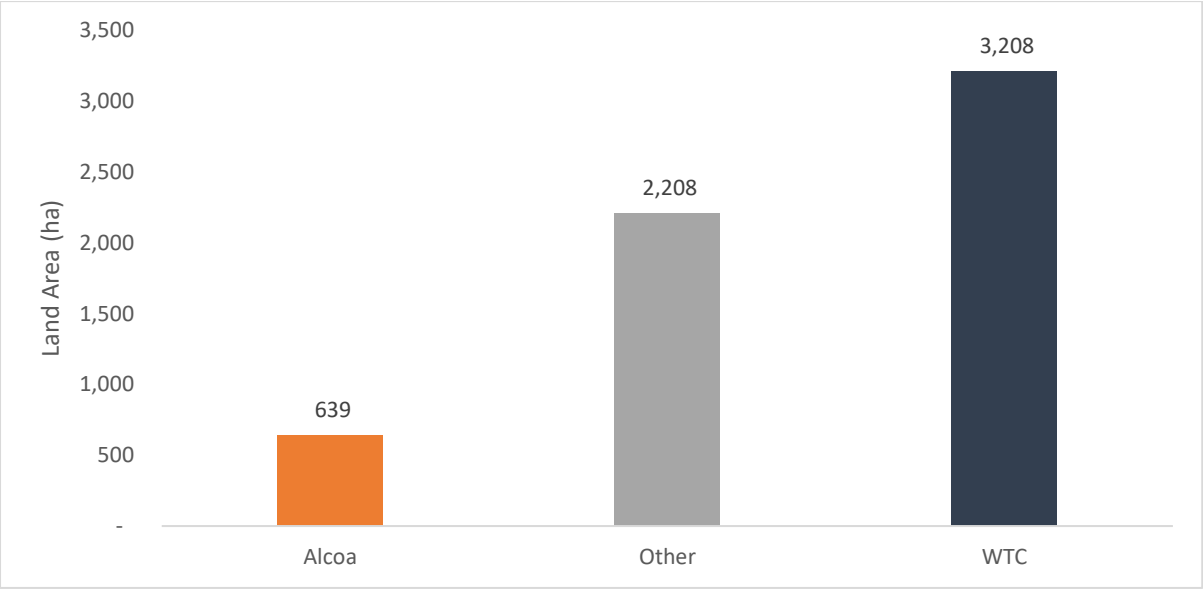
Industrial floorspace was broken down into the following categories:

- The Western Trade Coast
- Other Centres – other industrial areas in the Study Area
- Alcoa (Alcoa land was shown separately as it is currently being used as a Tailings Dam)

The Study Area contains a total of approximately 6,000 ha of industrial zoned land (Figure 23).

[23] Unrated land refers to lots that are zoned for development for the purpose of the specified primary land use category for which no vacant land or premises valuation information has been captured in Landgate's property valuation database. This may include State or local government owned lots or premises exempt from rates, Crown allotments, common property within lots on survey, newly created lots on survey, land otherwise exempt from rates and some public roads which are zoned for the primary land use under the local planning scheme.

Figure 23. Study Area - Total Industrial Land Area



Source: Department of Planning, Lands and Heritage 2015

The ratio of industrial land area to floorspace was determined through the 2015 Land Use and Employment Survey (LUES) to enable projection of the land areas.[24] The following assumptions were used to develop land demand estimates for industrial land:

- Non-strategic Industrial land: a land to floorspace ratio of 6:1 (6 ha of land yields 1 ha of Net Lettable Area) was used to estimate non-strategic industrial land in the Study Area based on floorspace estimates. The ratio is based on selected centres in the Study Area that were mostly developed so as to get an accurate representation of land requirements. Historical floorspace growth trends were then used to develop potential growth scenarios
- Strategic Industrial land – WTC[25]: the Framework indicates that historical land uptake at WTC is approximately 20.9 hectares per annum.[26] This is seen as a conservative estimate of potential future land uptake given the proposed Westport development

The following annual growth estimates were identified for Strategic and Non-strategic industrial land (Figure 24).

[24] Land area was not available for 2008 and 2001. Department of Planning, Lands and Heritage 2016, Land Use and Employment Survey

[25] Strategic industrial land was separated out as it grows at a different rate to light industrial land. It is included in this analysis as it has been suggested that Latitude 32 could be used for either light/general or strategic industrial uses in various documents. The subject area would not be suitable for strategic industrial uses, however it could be suitable for light industrial uses if Latitude 32 is required for more strategic uses.

[26] Department of Planning, Lands and Heritage 2018, Perth and Peel @ 3.5 million Southern Sub-regional Planning Framework

Figure 24. Annual Land Uptake – Historical Trends

	ha per annum	Source	Comparison
Strategic Land (Henderson, Kwinana and Rockingham industrial areas))	20.9	Department of Planning, Lands and Heritage Southern Metropolitan Planning Framework	Based on Sub-regional planning framework – no comparison
Non-strategic land (based on Other Centres' annual growth for the Period 2008 – 2015	63	Department of Planning, Lands and Heritage – LUES data	114ha of industrial land growth per annum is projected for the Sub-region as a whole.[27] The range of 48 to 63 ha per annum for the Study Area is well within this benchmark[28]
Non-strategic land (based on Other Centres' annual growth for the Period 2001 – 2008)	48	Department of Planning, Lands and Heritage – LUES data	

Source: Department of Planning Lands and Heritage (2015, 2018)

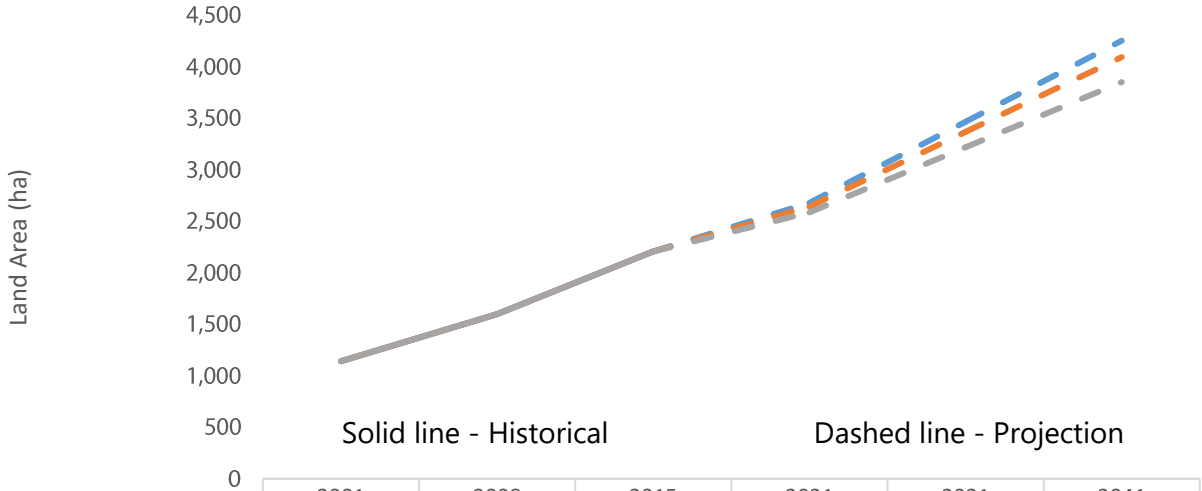
Three industrial land demand scenarios have been developed for Non-strategic industrial land (Figure 25):

- High Growth (79 ha per annum) – The annual demand for non-strategic industrial land increases by the same amount as it did between 2001 and 2015 (63 ha + 15 ha)
- Medium Growth (73 ha per annum) – The annual demand for industrial land increases by an amount equivalent to the projected population growth (the growth estimate accounted for historical and projected growth)
- Low Growth (63 ha per annum) – this scenario assumes the annual increase in industrial land per annum from 2008 to 2015 continues. This is conservative as it does not account for the fact that the growth in quantum of persons per annum is greater now than it was between 2008 and 2015

[27] Ibid

[28] This is based on Western and Eastern sectors. The Study Area includes the vast majority of industrial land for these areas – the only missing local government is the City of Gosnells

Figure 25. Non-strategic industrial land growth scenarios



	2001	2008	2015	2021	2031	2041
High Growth	1,142	1,601	2,208	2,680	3,468	4,256
Medium Growth	1,142	1,601	2,208	2,644	3,370	4,096
Low Growth	1,142	1,601	2,208	2,588	3,221	3,854

Source: Pracsys 2019

It is estimated that there could be demand for an additional 1,646 to 2,048 ha of non-strategic industrial land in the Study Area by 2041.

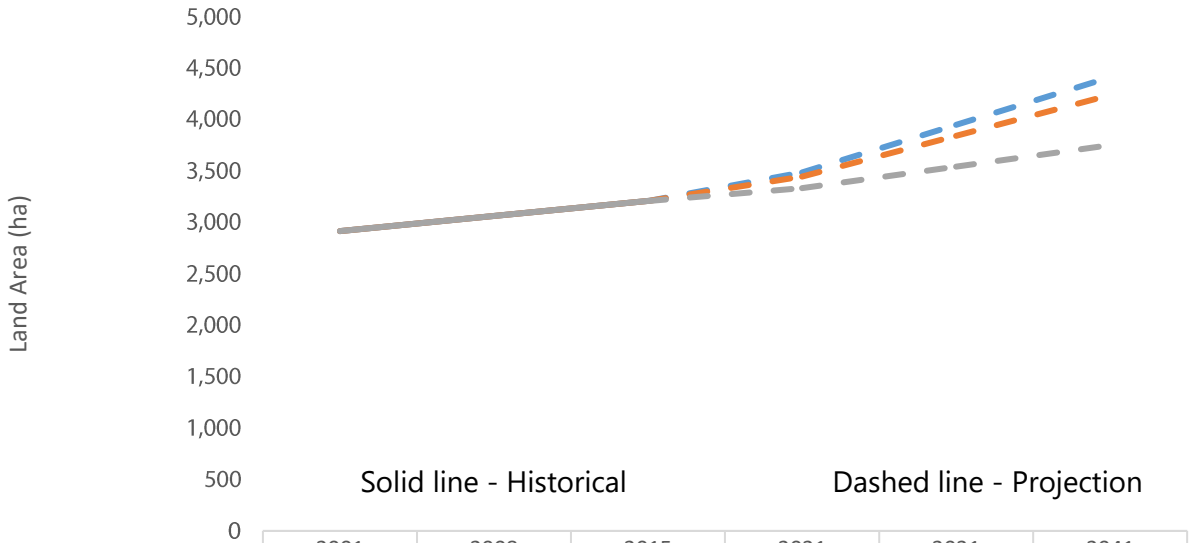
Growth scenarios for strategic industrial land in the WTC were developed using the demand levels identified in the Framework as a base low growth scenario. It has been set as the low growth scenario given the potential for the strategic nature of the WTC and the significant amount of industrial land available at Latitude 32. Three scenarios have been developed:

- High Growth (46 ha per annum) – Assumes that a land to floorspace ratio equivalent to the Non-strategic industrial estimate is realised at WTC and adjacent land areas (6:1 ratio of land area to floorspace). This scenario would represent slightly more land intensive uses at the WTC. Latitude 32 has also been earmarked for some light industrial uses, meaning the Non-strategic benchmark is appropriate.
- Medium Growth (40 ha per annum) – this scenario assumes that the usual 20.9 ha of land uptake occurs and growth in land uses related to the current port activities at WTC occur over a 20-year period. A benchmark land to floorspace ratio from Fremantle port is used to represent slightly less intensive land uses (approximately 2.4 ha of land area per ha of floorspace).[29]
- Low Growth (20.9 ha per annum) – Based on the identified land uptake of the WTC in the Southern Sub-regional Planning Framework[30]

[29] Information Provided by The Department of Planning, Lands and Heritage based land use data from the Perth and Peel @ 3.5 million Planning Framework. Compared to Land Use and Employment Survey floorspace data.
[30] Department of Planning, Lands and Heritage 2018, Perth and Peel @ 3.5 million Southern Sub-regional Planning Framework

Based on these assumptions, the potential growth for WTC related industrial land could be between 543 ha and 1,204 ha by 2041 (Figure 26).

Figure 26. Strategic Land Demand Scenarios



	2001	2008	2015	2021	2031	2041
High Growth	2,915	3,062	3,208	3,486	3,949	4,412
Medium Growth	2,915	3,062	3,208	3,446	3,842	4,238
Low Growth	2,915	3,062	3,208	3,333	3,542	3,751

Source: Pracsys 2019

The total additional demand for industrial land in the Study Area is estimated to be between 2,189 and 3,252 ha by 2041. The following estimates represent the BAU demand scenarios (Figure 27).

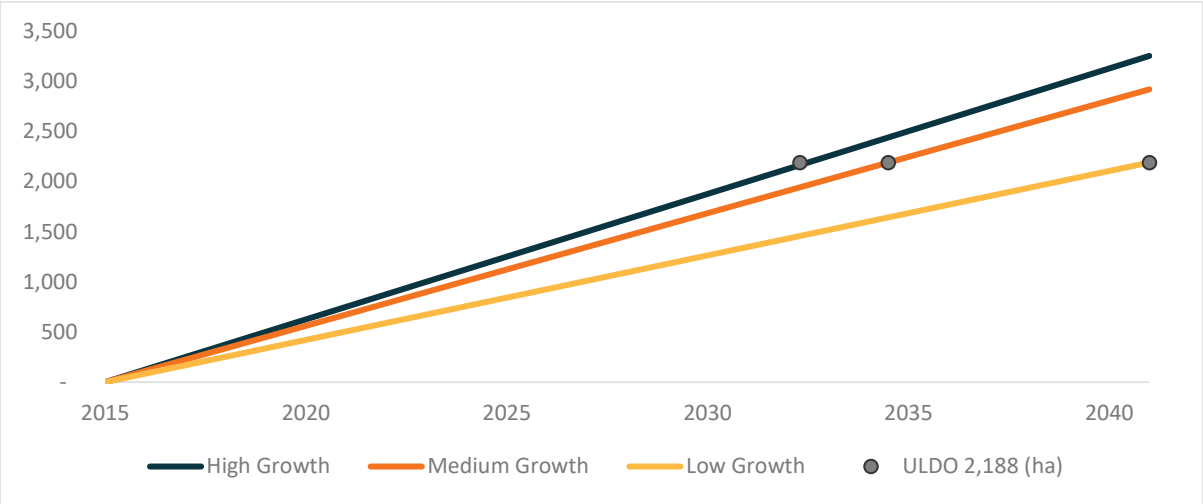
Figure 27. Draft Land Supply and Demand Analysis 2020 – BAU Demand Estimates

Scenario	Land Demand (ha)
Low Growth	2,189
Medium Growth	2,919
High Growth	3,252

Source: Pracsys 2020

These estimates have been compared with the long term ULDO forecast (ten years plus) to determine their goodness-of-fit. The ULDO projection would occur between 2032 and 2041 depending on the scenario applied (Figure 28). ULDO estimates for the Study Area do not include land uptake from Westport activities.

Figure 28. Comparison of Land Supply and Demand Analysis Forecasts and ULDO 10 year plus Demand Estimate for Study Area



Source: Pracsys 2020, ULDO 20/21

Note: The points indicate where on the demand curve the different scenarios achieve the ULDO estimate of 2,188 ha

In the Low Growth scenario, the ULDO demand level is achieved after 20 years and in the medium scenario it is achieved in approximately 15 years (from 2020). This is considered acceptable, and the scenarios have been used to inform the gap analysis at the year 2041

This is a conservative estimate as it only includes average annual growth estimates. The strategic nature of the WTC will attract large land intensive projects such as the Tianqi Lithium factory. These will take up large parcels of land at a time and do not generally occur on an annual basis. This is represented by the current ratio of land area to floorspace in the developed sections of the WTC, which is approximately 17:1. This means that for every single ha of floorspace there are 17 ha of land required. The BAU model used to project land demand has been built to incorporate potential future projects as the IP47 project progresses (non-Westport projects).

Westport Demand Analysis

The land demand from the Westport project has been estimated using benchmarking (for more detail please refer to the Mandogalup Westport Analysis Briefing Note). The benchmark analysis considered a number of ports across Australia. The following method was applied to select potential benchmarks for Westport:

- Purpose of port (i.e. similar mix of export and imports)
- Location (i.e. Metropolitan area)
- Mix of export goods
- Relevant population (i.e. population served)

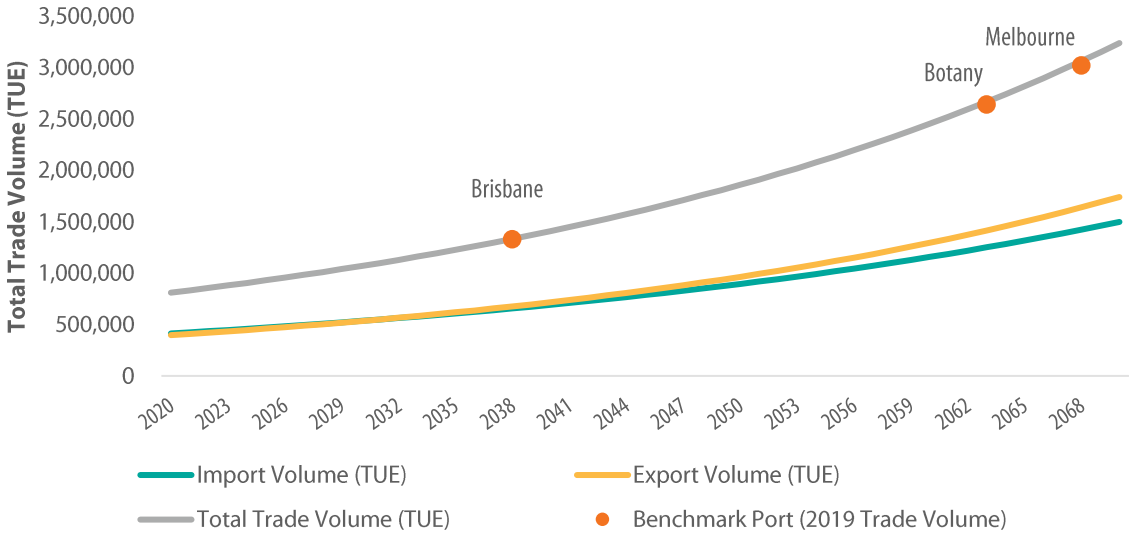
Based on the above criteria a set of benchmarks was identified from which land estimates could be based, Including:

- Melbourne Port

- Botany Port (Sydney)
- Brisbane Port
- Fremantle Port

Deloitte developed trade volume projections for Westport in Twenty-foot Equivalent Units (TEUs). Benchmark port volumes have been identified to demonstrate at which year the Westport development will achieve similar volume as the benchmarks[31] (Figure 29).[32]

Figure 29. Westport Trade Projection Compared to Benchmarks



Source: Port Australia Data 18/19, Deloitte 2019

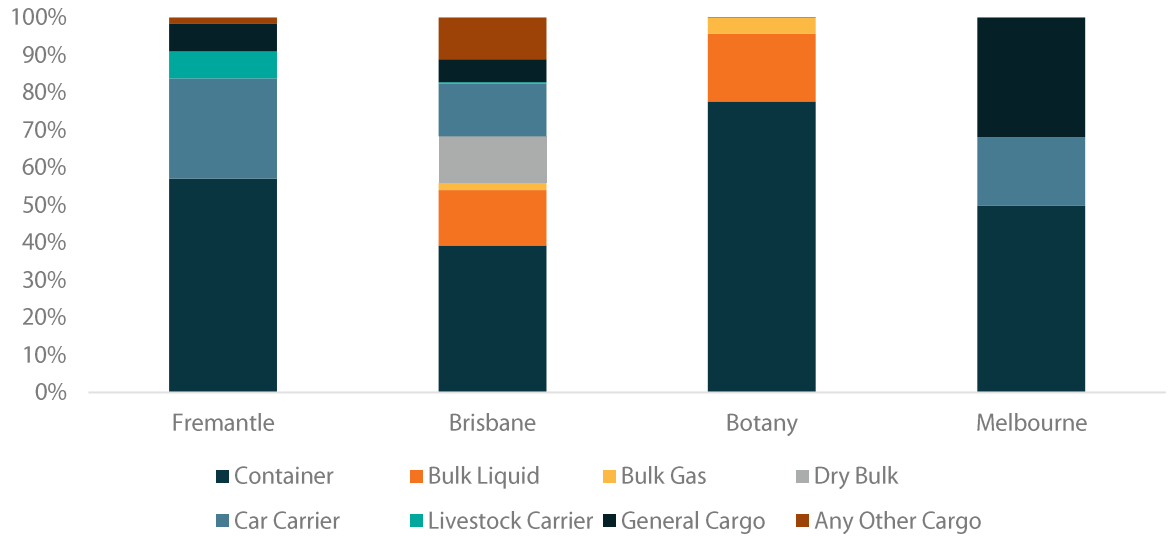
The data for Fremantle Port includes goods that are shipped from Kwinana. The mix of goods was compared between potential benchmarks to identify those that would be appropriate for developing an estimate for additional land that will be required at the WTC due to the container movements that will be supported by Westport (Figure 30).[33]

[31] Volume reference year of 2019

[32] Fremantle supported 788,000 TEU trade volume in 2019, just under the Deloitte Westport estimate for 2020 of 810,000 TEU. This is why Fremantle is not shown in Figure 29

[33] It is assumed that the BAU scenario would include demand for additional land uses associated with the exports that currently leave from the WTC including Bulky Liquid, Bulky Gas and Dry Bulk.

Figure 30. Trade by Classification by Port



Source: Port Australia Data 18/19

Further analysis on the mix of uses identified that Bulk Gas, Bulk Liquid and Dry Bulk are all shipped from Kwinana. Excluding these, the current Fremantle Port is small and is directly related to TUE estimates; it is used as a benchmark for additional land requirements.

Both Brisbane and Botany Ports include high concentrations of Bulk Liquid, Bulk Gas or Dry Bulk. Melbourne Port had lesser levels of Bulk Liquid and Dry Bulk with no Bulk Gas. Based on an aerial analysis of the Ports, it was easier to determine land associated with Bulk Liquids and Dry Bulk uses at Melbourne Port and it was therefore chosen to as a second benchmark for land estimates. The land area used for developing benchmark ratios is provided in (Figure 31).

The area used to estimate land associated with Ports was split into two categories:

- Port Uses
- Port Ancillary Uses

This categorisation has been used to provide low, medium and high estimates to feed into the Land Supply and Demand Analysis.

Defining discrete spatial boundaries poses a challenge due to the strategic benefits a port offers to specific industries. Although defining the actual port land area i.e. the land where freight is stored and ships can dock, is relatively straight forward, defining the secondary boundary where ancillary industry[34] locates is more subjective. However, understanding of the secondary boundary for each port is needed to provide an accurate estimate for land demand.

[34] Ancillary uses include but are not limited to postal and warehousing companies, importers and exporters, and distribution centres for large retailers

Each benchmark port was analysed through satellite imagery and ABS employment information to estimate the extent of these ancillary uses. Once a boundary was determined, an estimate of the total land area was developed (Figure 31).

Figure 31. Benchmark Port Land Estimates

Port	Port Land Area (Ha)	Total Land Area including Ancillary Uses (Ha)
Melbourne	500	708
Fremantle	177	213

Source: Google Maps 2021

Note: port land areas are approximate and have been estimated through desktop analysis.

The import / export trade volume for Fremantle and Melbourne in TEUs was compared to the identified land area categories. This provided an average TEU per ha of port related industrial land to enable quantification of land requirements for Westport (Figure 32).

Figure 32. Benchmark Land to TEU Ratio

PORT	Total Trade Volume (TEU) per Gross Hectare – Port Uses	Total Trade Volume (TEU) per Gross Hectare – Ancillary and Port Uses
Melbourne	6,042	3,500
Fremantle	4,453	3,701
Simple Average of Benchmarks	**5,248**	**3,600**
Weighted Average of Benchmarks	**5,713**	**3,541**

Source: Port Australia 2020, Google Maps 2021

The benchmark ratios have been applied in the following scenarios:

- **Low Growth**: only Port Uses develop in addition to the Low scenario BAU uses, the weighted average Port Uses ratio for Melbourne and Fremantle is applied
- **Medium Growth**: Port Uses and some ancillary uses develop in addition to the Medium scenario BAU uses, the Fremantle Port Uses benchmark ratio is applied (the Fremantle, Port Uses defined area includes some ancillary uses making it appropriate for a medium scenario)
- **High Growth**: Port and Port Ancillary Uses develop in addition to the BAU, the weighted average Port and Port Ancillary use ratio for Melbourne and Fremantle is applied

The ratios have been applied to the Deloitte Trade Volume estimates for Westport (Figure 29) to develop land demand projections based on Westport related activities. These Westport demand estimates are additional to current uses at the WTC and have been combined with the identified BAU demand to estimate total future demand for industrial land (Figure 33).

Figure 33. Westport Additional Land Requirement Estimate 2041 (ha)

Scenario	Westport Demand	BAU Demand	Total Demand
Low Growth	254	2,189	2,443
Medium Growth	325	2,919	3,244
High Growth	414	3,252	3,666

Source: Port Australia 2020, Google Maps 2021, Deloitte 2019

These projections do not incorporate land associated with an intermodal terminal; should an intermodal terminal be developed at Latitude 32 it would be additional demand to that which is identified here.

Future Gap Analysis

The land area gap was developed by comparing the supply of future industrial land with estimated total land demand in 2041, for each scenario (Figure 34). The analysis does not consider the potential constraints that may be posed by land tenure in the subject area and how it may impact transition of certain businesses. The overall supply for land is expected to be fixed at 3,054 ha, whilst the demand is expected to vary from 2,443 ha to 3,666 ha. This results in a gap, where demand exceeds supply, of between 190 ha and 610 ha.

Figure 34. Land Area Gap in 2041 (ha)

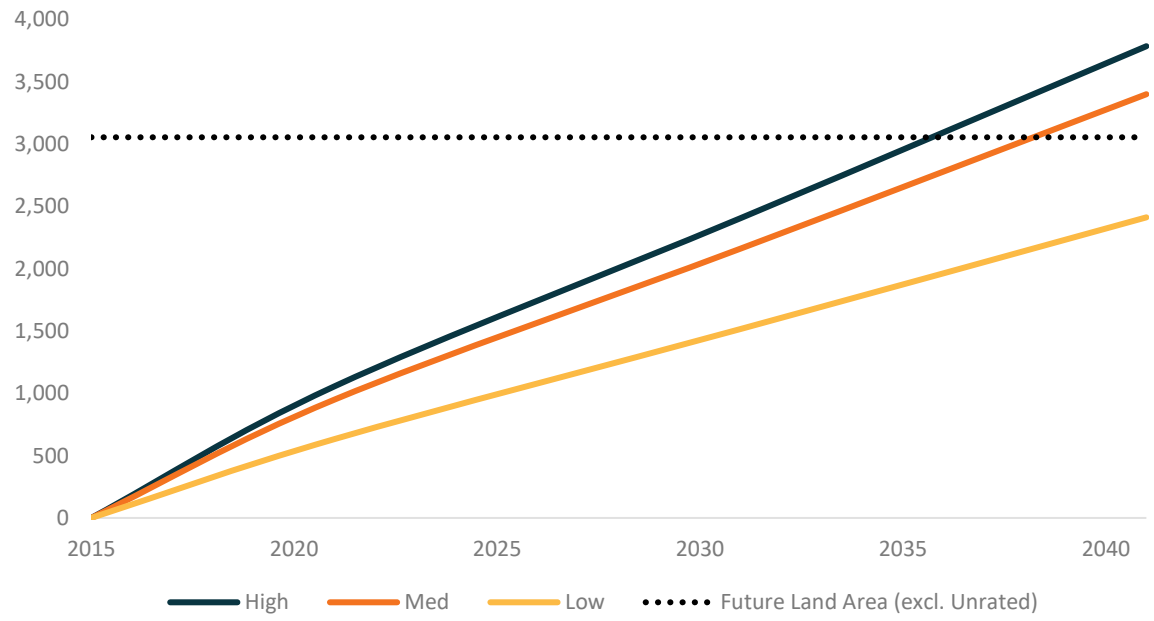
Metric	Low	Medium	High	Notes
Supply	3,054	3,054	3,054	See Section 5.1, Sub-section Future Supply
Demand	2,443	3,244	3,666	See Section 5.1, Sub-sections Industrial Land Demand - BAU And Westport Demand Analysis
Gap/Surplus	611	- 190	- 612	

Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

Note: the similarity between High and Low Gap/Surplus has been reviewed and is purely incidental

Comparing the supply and demand profiles for the area results in demand matching supply in approximately 2036 for the high scenario and 2039 for the medium scenario (**Figure 35**). The low scenario does not reach the future land area supply within the period of study.

Figure 35. Scenario Demand Forecasts



Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

In both Medium and High growth scenarios there is greater demand compared to future industrial supply within the study period, with the gap likely to increase beyond 2041. While the projected demand matches supply at approximately 2036 or later, the current uses at the WTC would feel pressure to transition out of the WTC well before this time point. This is particularly true for Population Driven uses that will experience pressure to transition sooner due to the higher value port-strategic uses that will need land in close proximity to Westport. The total demand for the Transitional Land Use definitions has been estimated at 2041 (Figure 36) (for more detail please refer to the Mandogalup Westport Analysis Briefing Note).

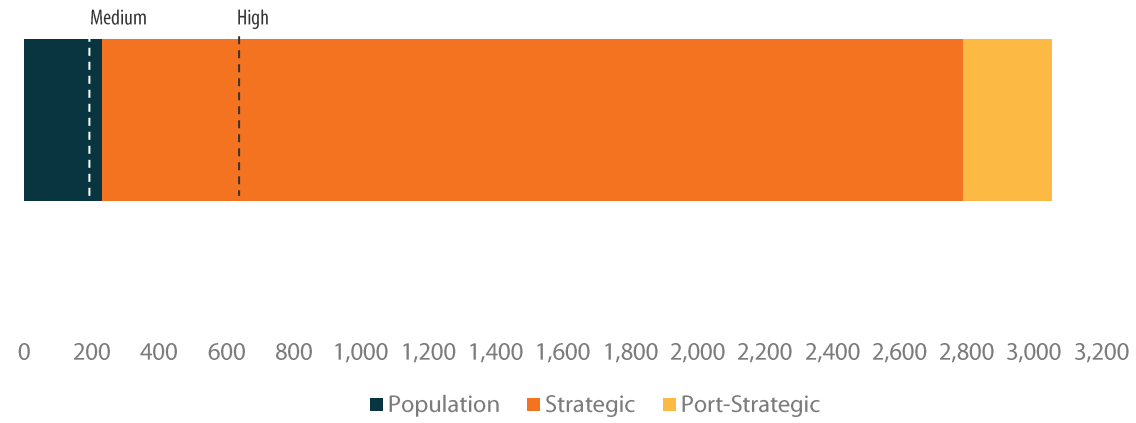
Figure 36. Total Land Demand by Transitional Use 2041

Transitional Use	Area (ha)
Port Strategic	230
Strategic	2,562
Population Driven	263

Sources: DPLH 2016, Pracsys 2021

Figure 37 illustrates this effect for the high and medium scenarios. In the medium scenario almost all Population Driven uses would need to transition out of the WTC and transition first to allow more strategic uses to locate at the WTC. In the high scenario, the entirety of Population Driven uses would transition and some Strategic uses that would be suited to a location near to Westport would need to transition. The high scenario is expected to cause 14.9% of the land demanded by Strategic uses to require a location outside of the WTC.

Figure 37. Gap in Land Area in 2041 by Scenario by total Future Land Demand



Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

The location of Mandogalup between the two identified freight route connections to Westport means it would likely be attractive and suitable to both types of uses. The land scenarios could allow for a mix of these uses through appropriate lots sizes. It is likely that transition areas will be required between more strategic uses and the residential areas to the east of the subject area, meaning these uses should likely be restricted to the western section of the subject area.

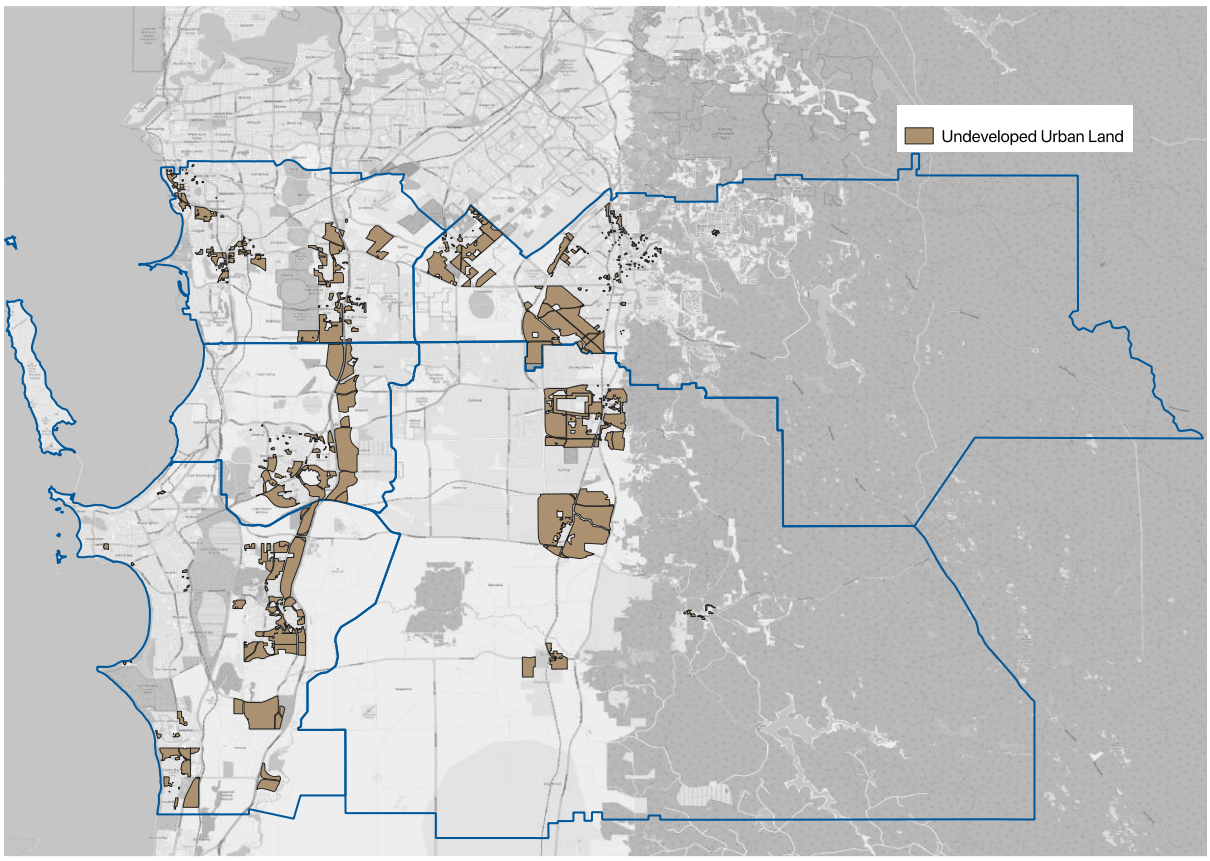
Without the subject area as an Industrial Investigation area, there are potentially significant gaps in the supply of Industrial land in both the medium and high growth scenarios. These projections are only developed until 2041 and do not account for road infrastructure and constrained land, increasing the potential for a gap in the provision of industrial land. Based on the employment targets established by the Sub-regional planning framework to 2050, and assuming that some of this employment will be supported by industrial areas, there will be a requirement for additional industrial land to support the employment needs of the future population. This is consistent with the Framework supply and demand profile which identifies a gap in the provision of industrial land based on a proposed land supply of 5,450 ha and a demand estimate of 5,920 ha. The gap is conservative as growth in strategic industrial land was not included in the Framework's demand estimates.

5.2 Urban Land

Residential Floorspace

The urban land analysis assesses the ability of the Study Area to sustain the projected population growth to 2041. The Department has identified the following land as being Undeveloped Urban Land (Figure 38).

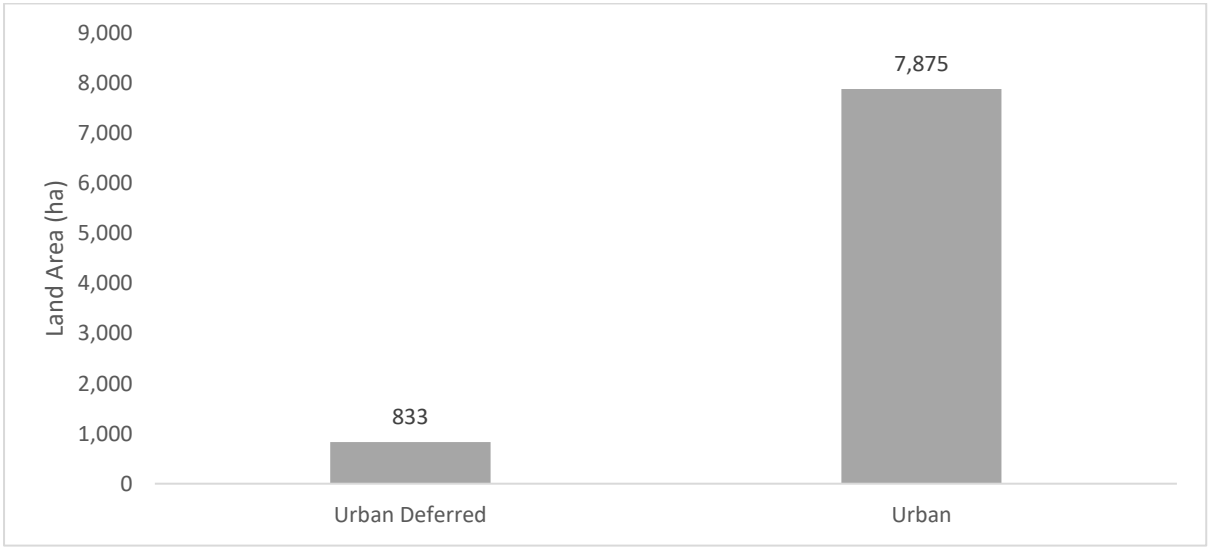
Figure 38. Study Area – Urban Undeveloped Land



Source: Department of Planning, Lands and Heritage 2019

There is a total of approximately 8,700 ha of undeveloped urban land, with only a small amount being Urban Deferred (Figure 39).

Figure 39. Total Undeveloped Urban Land by Type



Source: Department of Planning, Lands and Heritage 2019

Under the Sub-regional Planning Framework, the Study Area will need to accommodate an additional 176,450 dwellings by 2050. The Framework dictates that 47,120 of these dwellings should be infill developments, meaning that 129,330 dwellings will need to be supported by the Undeveloped Urban land. A gap analysis has been undertaken, applying the density target for new residential developments in the Perth and Peel region , which is set to 15 dwellings per gross hectare (Figure 40).[35]

Figure 40. Study Area Urban Land – Gap Analysis

Target Density (dwelling per gross ha)	Urban Deferred (dwelling potential)	Urban (dwelling potential)	Total Potential Dwellings	Target Greenfield Dwellings	Difference
15 dwellings	12,500	118,120	130,620	129,330	1,290

Source: Department of Planning, Lands and Heritage 2018, Pracsys 2019

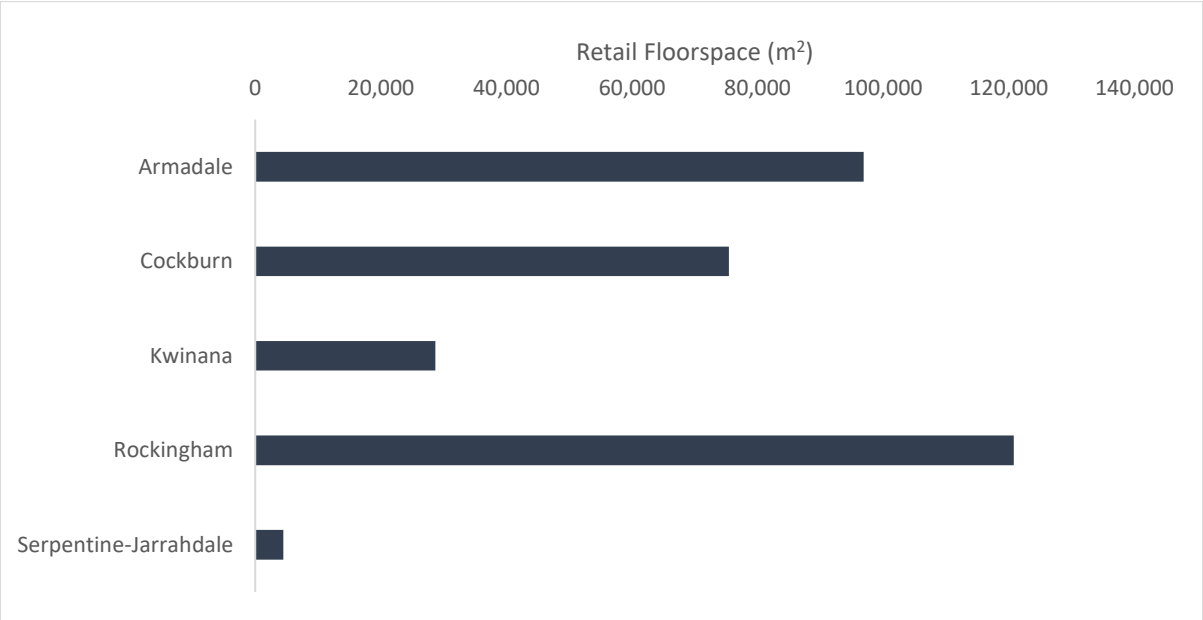
The gap analysis indicates that there is sufficient undeveloped land to cater for the proposed greenfield dwelling target, with a surplus of land equivalent to 1,290 dwellings. This analysis uses the gross density per hectare target established set by Directions 2031 and Beyond and the Framework. Given the proximity of much of the undeveloped land to the freeway and townsites, it is possible that the average density will increase over time, providing additional capacity for future population growth.

Commercial Floorspace

Activity centre floorspace is required to meet the goods and service requirements of the local population. The current supply of activity centres in the Study Area was assessed based on centres that are district level or larger based on State Planning Policy 4.2: Activity Centres in the Perth and Peel Region. Shop Retail and Bulky Goods Retail (Retail floorspace) in these centres was used as a proxy for commercial floorspace in activity centres floorspace as there is information regarding their future development potential across all local governments that make up the Study Area (Figure 41).

[35] Department of Planning, Lands and Heritage 2019, Urban Growth Monitor. Available from: https://www.dplh.wa.gov.au/getmedia/d7d45d85-f90b-4c51-8ff5-5fb857bec2fa/LSD_UGM_10_report_2019

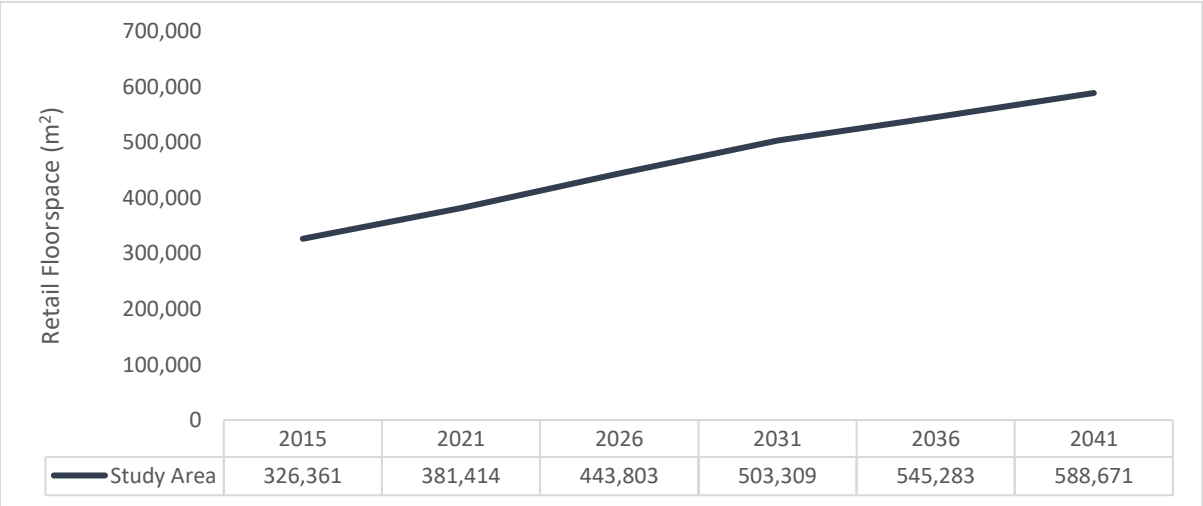
Figure 41. Current Retail Floorspace



Source: Department of Planning, Lands and Heritage 2015

Total Retail floorspace for selected centres in the Study Area is estimated to be approximately 326,000m^2. Activity Centre floorspace is population driven; projected population growth to 2041 was used to assess the demand for Retail floorspace (Figure 42).

Figure 42. Retail Floorspace Projection to 2041



	2015	2021	2026	2031	2036	2041
Study Area	326,361	381,414	443,803	503,309	545,283	588,671

Source: Department of Planning, Lands and Heritage 2015, WA Tomorrow 2019, Forecast.id 2019

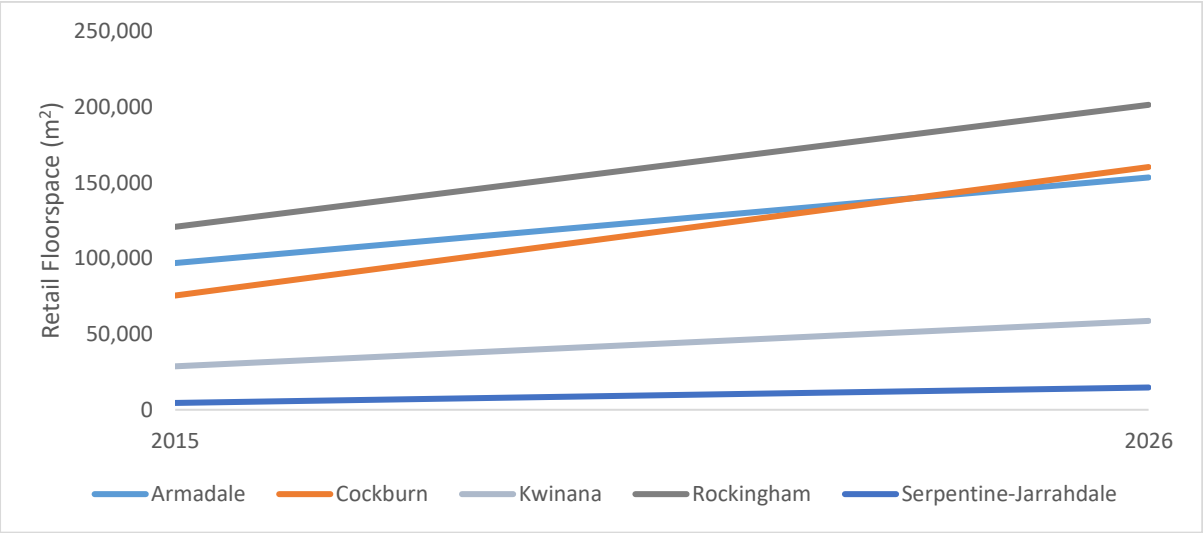
It is estimated that by 2041 the Study Area population will require 589,000m^2 of retail floorspace to meet their goods and service needs. Planning documents were reviewed to estimate the total planned Activity Centre floorspace, these documents include:

- Local commercial strategies

- Local planning strategies
- Structure plans
- Council minutes

The planned Retail floorspace capacity of Activity Centres in the Study Area by 2026 is estimated to be 588,000m^2 (Figure 42).

Figure 43. Urban Land - Gap Analysis



Source: Department of Planning, Lands and Heritage 2015, WA Tomorrow 2019, Forecast.id 2019, Local Government Planning Documents (various years)

The planned retail floorspace to 2026 is able to meet the demand for population driven retail floorspace until 2041. This is based on the current service ratio of the Study Area (23:100), which represents the number of retail jobs to Study Area population; for every 100 persons there are 23 persons employed in population driven employment. Should this be adjusted to the Greater Perth average (30:100), the total retail floorspace demanded by 2041 would increase to 793,000m^2. The potential for this level of growth to occur in the Study Area is dependent on private industry appetite to develop additional floorspace and the ability to accommodate additional activity centres. Should the current level of provision of retail floorspace be maintained there is likely to be sufficient capacity for activity centres in the Study Area. Should the potential for an increased provision of retail floorspace eventuate, additional land area will be required.

5.3 Rural Land

This analysis investigates the potential for productive rural land on the subject area. It does not consider rural living given the State Planning Policy 2.5 states: '*rural residential proposals for rural land that do not align with endorsed sub-regional planning frameworks are considered inconsistent with the policy objectives and shall not be supported*'.

The subject area is currently zoned as rural under the Metropolitan Region Scheme. Productive rural land in the Metropolitan region has been supported through the protection of priority agricultural areas. These areas are selected based on the requirement that they be '*of State, regional or local significance for food production purposes due to its comparative advantage in terms of soils, climate, water (rain or irrigation) and access to services*'.

The subject area is not currently classified as a priority agricultural area, although further investigation with the Department of Primary Industries and Regional Development is required. The subject area is currently home to a number of agricultural business that use the land for a range of activities including:

- Growing fresh produce
- Processing food products
- Packing

The businesses appear to range in size with some providing produce locally and others exporting interstate and even internationally. It appears that two of the larger businesses use their properties within the subject area for packing and distribution services, having large farms in other regions around the State. These businesses would likely also be compatible with industrial zoned land. Potential advantages of rural land at the subject area includes:

- Access to the Kwinana Freeway
- The proposed development of Anketell or Rowley Road will improve access for freight vehicles
- Water is potentially an advantage for local farmers as they are located adjacent to Mandogalup swamp (which forms part of the subject area), meaning there is a high-water table

Between 2011 and 2016, the agriculture industries in the Study Area saw an increase of approximately 27% in employment. Although this was small in absolute terms (330 jobs), it indicates there is a certain level of development potential in the industry.

There are a number of constraints to rural development at the subject area, including:

- Limited potential to expand with Urban Developments on the eastern border, Industrial land to the west and mining activities on the subject area's land
- Environmentally protected land and land that is not suited to agriculture (i.e. the lake in the northwest corner of the subject area)
- Rural residential dwellings to the southwest of the site
- Potential nutrient run off from farming activities

The Kwinana Rural Lands study indicated that there was limited demand in the market currently for large rural land areas in the City of Kwinana. This indicates that current land uses might not be continued by future landowners. There was demand for land as rural living, however this use is not likely to be allowed under State Planning Policy for rural land.

Conclusion

Based on State planning policy, it is evident that the availability of rural land suited to intensive agriculture in the Metropolitan area is shrinking. SPP 2.5 indicates that there is a need to protect priority agricultural land in the metropolitan area as urban land uses are encroaching upon many rural areas and rural residential subdivisions are reducing the land available for intensive agriculture. This being said the analysis also identified that demand to buy this type of land is low in the City of Kwinana.

Maintaining the subject area as an agricultural area could potentially align with State policy; further assessment by the Department of Primary Industries and Regional Development would be required to accurately assess the importance of rural activity in the subject area. This being said, there is a risk that there be no willing proponents to continue agricultural practices on the property in future, creating the potential for the land in the area to go unused, and limiting resale potential due to low rural land values and no development potential. Furthermore, two of the larger businesses' regular activities include packing and distribution which could be maintained under industrial zoned land.

Given the location of the subject area and potential for other land uses, it is possible that the risks associated with maintaining the rural zoning outweigh the potential benefits.

6 LAND VALUE ANALYSIS

This section presents median land values from data that will be used to inform scenario modelling. The value estimates can act as a proxy for demand and are also useful in assessing the best land use scenario. These estimates provide ranges that will be further refined through the scenario modelling with input from consultation and the Department. More detailed land value estimates will be developed for modelling based on the proposed lot sizes by land type in each scenario.

6.1 Industrial Land Value

Industrial land values in Perth have risen slightly in the past year with a 7.36% increase in vacant land values in core precincts. Demand is also high for large land holdings although the supply of these types of lots is limited.[36] Core industrial land values were estimated to be between $350 and $500m^2.

Sales data for vacant industrial land in the Study Area was analysed to determine a potential price range for Industrial land. The median land value for properties sold between 2010 and 2014 were included as there were greater than 15 sales in each year. All values have been escalated to today's dollar value (Figure 44).

Figure 44. Median Value ($/m^2) Analysis of Vacant Industrial Properties

Property	2010	2011	2012	2013	2014
Median Value ($/m^2)	348	334	391	381	382

Source: Department of Planning, Lands and Heritage 2020, WA Treasury 2019

A relatively tight range of between $334m^2 and $391m^2 was identified. The subject area is located adjacent to the freeway with proximity to both the WTC and nearby residential population. It is considered likely that there will be demand for non-strategic industrial uses in the area. Land value estimates are not expected to differ much from the median range identified.

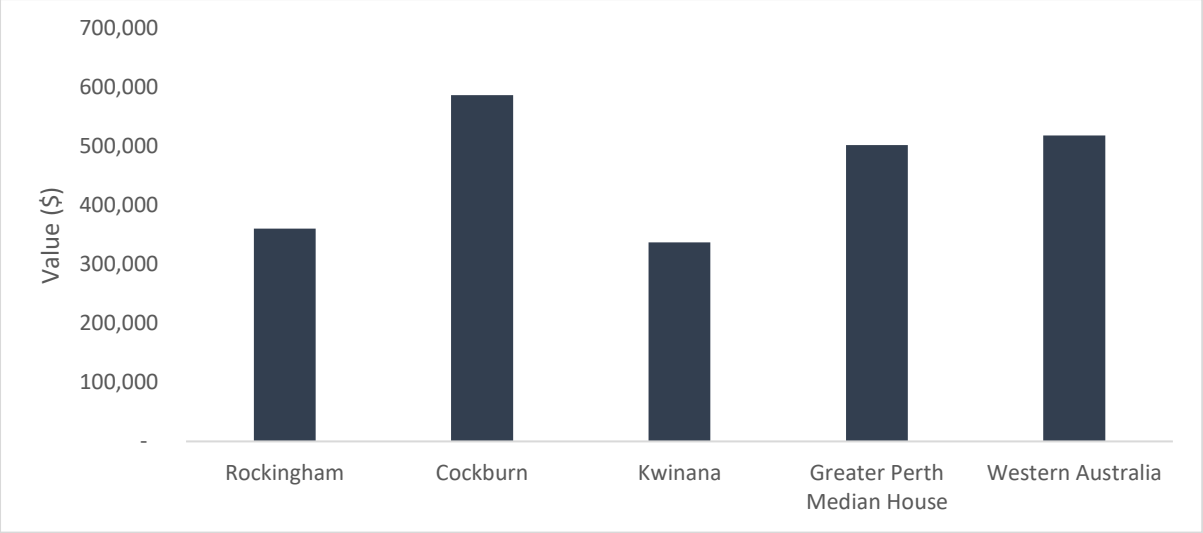
6.2 Urban Land Value

Residential Property

Median values for land in the Cities of Kwinana and Rockingham are well below those in Cockburn and the Greater Perth area (Figure 45).

[36] Colliers 2019, Industrial Research and Forecast Report Second Half. Available from: https://www.colliers.com.au/en-AU/Research/Industrial-Research-and-Forecast-Report-Second-Half-2019

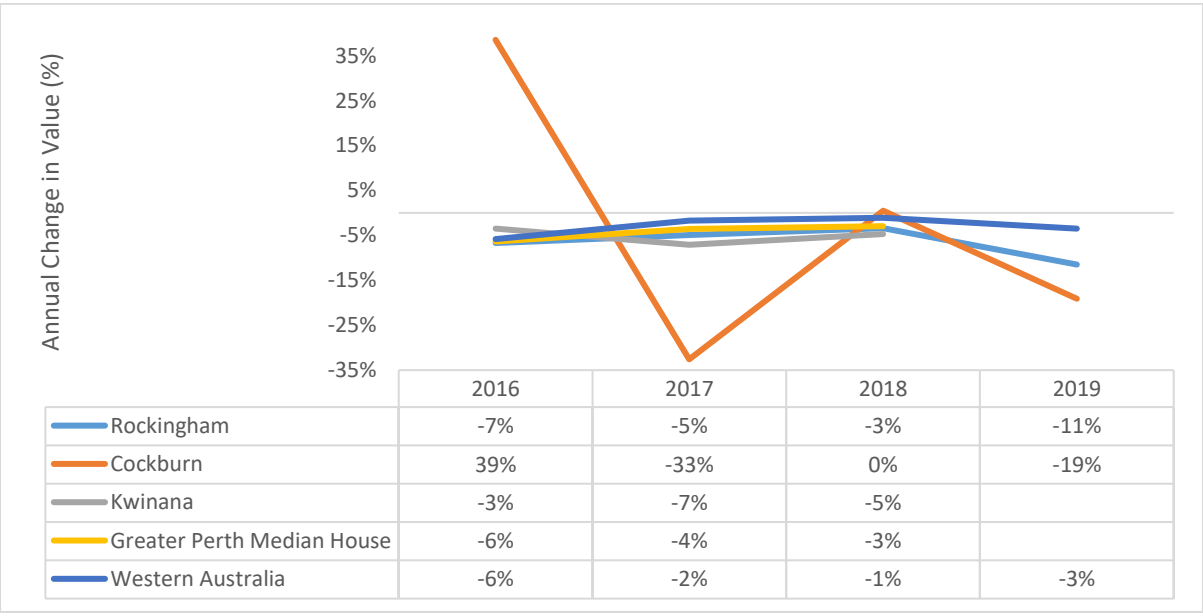
Figure 45. Median Household Values for Areas near the Subject Area vs Greater Perth/WA



Soruce: REIWA 2019, Forecast.id 2018

Median house price trends for Cockburn, Kwinana and Rockingham have been predominantly downward for the past four to five years. The rate of price decrease has been marginally greater than that experienced by the Greater Perth and State as a whole (Figure 46).

Figure 46. Median House Price Trend



	2016	2017	2018	2019
Rockingham	-7%	-5%	-3%	-11%
Cockburn	39%	-33%	0%	-19%
Kwinana	-3%	-7%	-5%	
Greater Perth Median House	-6%	-4%	-3%	
Western Australia	-6%	-2%	-1%	-3%

Soruce: REIWA 2019, Forecast.id 2018

Research was conducted to identify potential vacant land value estimates for the subject area. The Urban Development Institute of Australia (2019) analysed vacant property sales through Landgate data. The Peel region was included to provide an estimate of potential land value based on a larger land size (Figure 47).

Figure 47. Median Value ($/m^2) Analysis of Vacant Residential Properties

Region	Median Size (m^2)	Median Price (%)	Value ($/m^2)
Southwest Sub-region	400	280,000	588
Peel	564	184,500	327

Source: UDIA 2019

The analysis indicates a potential range of $327m^2 to $588m^2 for vacant residential land. Residential sales data was provided by the Department for 2019 with the median price for vacant land sales in the Study Area amounting to $613m^2, and for the suburb of Mandogalup amounting to $662m^2.[39] The final value estimate will be tailored to the final lot sizes that are included in scenarios.

Commercial Property

Commercial property in Perth has seen significant expansion in recent years due to the removal of floorspace limits in the Metropolitan area that restricted the ability of developers to meet growing population demand. This has led to major expansions in a number of centres such as Carousel, Karrinyup, Midland and Joondalup

The recent slowing in retail purchasing would have caused a number of future developments to be placed on hold, including the Morley Galleria and Garden City developments. This trend would likely be limiting the pressure on land values for commercial land.

Property sales data for Mixed Use areas, specifically Retail floorspace (i.e. bulky goods, showroom, etc.) has been analysed to understand the potential value of commercial zoned lots in the subject area (Figure 48).

Figure 48. Value ($/m^2) of Vacant Commercial Properties

Property	Size (m^2)	Price ($)	Value ($/m^2)
Super Lot (reported as multiple individual lots in the data)	25,208	10,725,000	492
L500 ARMADALE RD JANDAKOT	30,304	15,400,000	508
57 SOLOMON RD JANDAKOT	1,984	742,500	433
64 SOLOMON RD JANDAKOT	2,523	1,045,000	479
66 VERDE DR JANDAKOT	2,415	880,000	422
70 VERDE DR JANDAKOT	2,320	880,000	439
74 VERDE DR JANDAKOT	2,318	776,683	388

[39] Department of Planning, Lands and Heritage 2020; Landgate 2019

81 VERDE DR JANDAKOT	2,154	814,000	437

Source: Department of Planning, Lands and Heritage 2020, WA Treasury 2019

Note: values have been escalated from year of sale to present day value for ease of comparison.

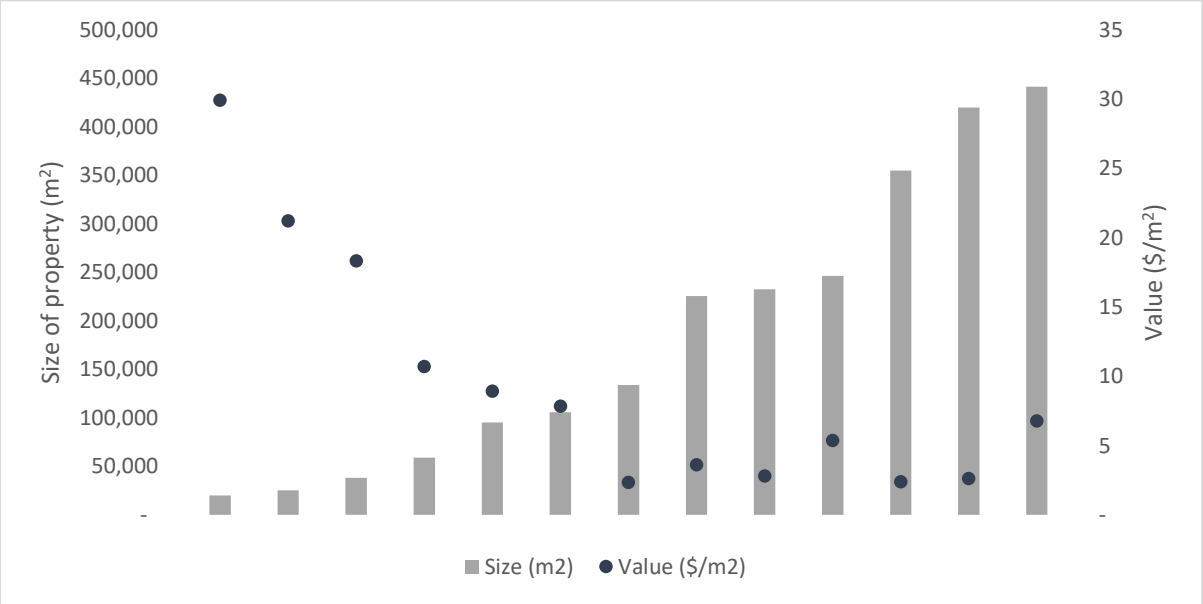
The analysis indicates that land value ($/m^2) for commercial property is potentially less impacted by the size of the property. The properties used for the analysis are located in the Cockburn Central Bulky Goods Retail area to the east of the Kwinana Freeway. These land values are likely higher than what can be achieved at the subject area, however they are for vacant land in a similar location and most were sold in 2010 and 2011, before there was a large bulky goods retail centre.

It is likely that the land values at the subject area would fall within the findings of the data analysis.

6.3 Rural Land

A review of property sales data provided by the Department for the subject area indicates that rural land value per m^2 decreases rapidly after a certain size (Figure 49).

Figure 49. Rural Land Value ($/m^2) vs Size (m^2)



Source: Department of Planning, Lands and Heritage, WA Treasury 2019

Note: values have been escalated from year of sale to present day value for ease of comparison.

Analysis of median value over the past decade indicates that the potential value of rural land ($/m^2) is between $4m$^{2.}$ and $27m^2. Scenario analysis will attempt to account for variability in land value by size of lot.

6.4 Key Findings

The results indicate that rural land uses achieve the lowest $/m^2 of the evaluated land uses. This is due to the large nature of land parcels and the limited development potential. It does also somewhat reflect the lower

demand for this type of land in the Metropolitan area. The other land uses evaluated present a varying degree of land value potential (Figure 50).

Figure 50. Land Value Comparison

Land Use	Range ($/m^2)
Industrial	334 – 391
Urban (Residential)	327 - 662
Urban (Commercial)	388 – 508
Rural	4 - 27

Source: Pracsys 2019

These estimates include the costs associated with servicing the land so that it is development ready. Servicing costs could vary significantly between different land types and should be considered when analysing the estimated land value ranges. For instance, the RBA estimate for physical value of land in the City of Kwinana is approximately $150m^2, significantly lower than the estimated land value range for Urban (Residential) land.[40] There are a number of further considerations to take into account that will affect the land value at the subject area. The proximity of the Alcoa tailings dam and neighbouring industrial activity could put downward pressure on the potential residential land value for some sections of the subject area, specifically along the western boundary. Industrial land values are likely to experience upward pressure as the expected land uses are likely to be non-strategic and require smaller lot sizes, with proximity to the WTC and surround residential population making the location attractive for such uses. Industrial and commercial land may be less affected by the potential amenity issues in areas that fall within the air buffer. This means they could potentially develop quicker and achieve a faster uptake than residential uses, having a positive effect on the long-term value potential of the land.

[40] Reserve bank of Australia 2018, available from: https://www.rba.gov.au/publications/rdp/2018/2018-03/rdp-2018-03-online-appendix.pdf

7 OPPORTUNITIES AND CONSTRAINTS

The potential opportunities and constraints associated with each land type have been assessed in the following sections.

7.1 Industrial Land

Opportunity for industrial land development in the area largely centers around the significant strategic industrial areas adjacent to the subject area. These areas grew significantly between 2008 and 2015 and are likely to continue growing based on the established infrastructure, the potential Westport development and significant agglomeration economies. The City of Kwinana Employment and Economic Development Study highlights the shared infrastructure and significant forward and backward linkages in the area, with many industries in the WTC providing direct inputs into co-located downstream industries. This level of connectivity provides significant advantages in supply chain efficiency and is a major attractor for further industry development. The Perth and Peel @ 3.5 Million Sub-regional Frameworks highlight the importance of protecting future land for non-strategic industrial land uses in terms of future strategic industrial uses to develop in Latitude 32. This would create the potential to further expand the WTC with large land holdings that are suited to major industrial projects, while providing non-strategic transitory land uses in the subject area that act as a buffer between urban areas and the WTC. Any industrial land uses near the urban development areas to the east of the subject area will be limited due to the proximity to residential population, limiting the potential scale and type of industrial development. Industrial land uses will also be constrained by potential ecological factors. The development of industrial land at the subject area has the following opportunities and challenges (Figure 51).

Figure 51. Industrial Land Opportunities and Constraints

Opportunities	Description
Westport	The potential Westport development will create additional demand for supporting industrial land uses in and surrounding the WTC. A number of additional industry uses will likely develop including warehousing and storage, as well as service industries that use non-strategic industrial land
Proximity of WTC	The WTC is a major attractor for heavy industrial uses with a number of State significant developments such as the Tianqi Lithium plant, Kwinana Alumina refinery and Australian Naval Base. These operations support a significant amount of indirect economic activity and are a significant industry attractors as can be seen by the consistently high growth in floorspace from 2001 to 2015 (see Section 5.1, Industrial Land)
Large land holdings	Large land holdings can present opportunities to attract certain high-value industries (i.e. boat manufacturing)
Future development of	The development of Anketell and/or Rowley roads will provide freight vehicles with greater access to the subject area from the freeway and from the subject area to the WTC

Anketell or Rowley Roads	
Access to Kwinana Freeway	Access to Kwinana Freeway is a major opportunity for freight related industries
Suitable transitionary land use	Light industrial uses provide an opportunity to transition between the neighbouring tailings dam/industrial activities and the new urban developments to the east of the subject area.
Constraints	**Description**
Freight and small vehicle conflict	Freight traffic from the subject area will be entering either Anketell or Rowley roads. These roads, particularly Rowley Rd, will be used by residents of the neighbouring residential land creating the potential for conflict between heavy and passenger vehicles. This being said the potential for conflict will be present in any case due to freight vehicles travelling to the WTC.
Bush forever and environmentally sensitive land	There are a number of potentially environmentally sensitive land areas at the subject area. These could constrain the types of industrial activities permissible on certain land parcels within the subject area
Urban development	The urban development between the subject area and the freeway will limit the potential for heavy industries to locate at the site. This means that the area will be limited to supporting non-strategic industrial land uses for much of the site. Although a constraint, this outcome provides the opportunity for the subject area to accommodate uses that would otherwise require land within the WTC, leaving greater land availability in areas such as Latitude 32 to accommodate more strategic industries.
Rural/agricultural land	There are currently a number of land areas being used for intensive agricultural. These uses might not be compatible with certain industrial activities.
Land ownership	The subject area land is somewhat fragmented and mainly privately owned. The number of owners can present difficulty in achieving land assembly. Consultation will be used to determine a suitable land use mix scenario that achieves a positive outcome for the stakeholders involved.

7.2 Urban Land

Urban land development is driven by population growth, both for residential and commercial uses. The Study Area is predicted to see significant growth, with a substantial level of growth projected for the City of Kwinana. The subject area provides high levels of access to road infrastructure with some public transport. There are a number of planned activity centres adjacent to the site that would provide access to goods and services and there are bush forever areas that can provide large areas of open space, increasing the liveability of the area. The subject area would also provide good access to employment with the neighbouring industrial area and easy access to a number of employment centres via public transport, including the CBD. Constraints to residential development in particular are centred around the air-buffer that covers some of the subject area and industrial activities that neighbour the area to the west. A lack of services also means that future urban development will require significant investment, reducing the potential return on investment from property development. Commercial floorspace development could be suited to the site depending on the level of

growth in retail floorspace experienced in the area. There are suitable locations that are adjacent to future major transport routes that would allow a centre to attract high passing traffic with close proximity to residential development. This being said, there is currently a planned neighbourhood and district centre within two kilometers of the subject area, potentially limiting the level of commercial development sustainable at the site. Urban development of the subject area presents the following opportunities and challenges (Figure 52)

Figure 52. Urban Land Opportunities and Constraints

Opportunities	Description
Industrial precincts (proximity to employment)	Urban development at the subject area will locate population near to significant industrial land and potential employment opportunities.
Nearby activity centres	The City of Kwinana has planned a neighbourhood centre at the Urban development to the east of the subject area. There is also a District Centre planned near the intersection of Anketell Road and the Freeway, to the south east of the subject area. This will provide potential residents of the subject area with access to employment and population goods and services.
Nearby open space	There are a number of adjacent Bush Forever sites that can provide public open space for potential residents
Proximity to consumers	A commercial development at the subject area would have close proximity to a large employment centre, passing traffic (assuming it is situated on the newly developed freight route) and nearby residential population
Constraints	**Description**
Alcoa Tailings Dam	The Alcoa Tailings Dam is adjacent to the subject area. There is an air buffer associated with the tailings dam that could negatively impact the potential for Urban Development in some sections of the subject area.
Adjacent industrial uses	There are light industrial land uses on land adjacent to the north west section of the subject area that could reduce the attractiveness of the area as an urban development.
Land is not currently serviced	The subject area is not currently serviced and it is not clear if the current neighbouring service infrastructure could support the potential additional population at the subject area
Rural/agricultural land	Large areas of land at the subject area are currently used for intensive agriculture, with livestock on some land holdings. Should some of these land owners decide to continue operating it could limit the potential for urban development.
Vehicle conflict	The WTC and potential development of Westport means that a significant number of freight vehicles pass through the area, creating potential for conflict with passenger vehicles. Urban development at the subject area will increase the potential for conflict with more passenger vehicles entering and exiting the area.
Proximity to other centres	There are two planned activity centres within 2km of the subject area, limiting commercial development potential

7.3 Rural Land

State policy indicates that state, regional or locally significant agricultural production precincts in the metropolitan areas should be protected from other uses, particularly rural living. There is a certain level of rural activity already being undertaken at the subject area, with land already irrigated and modified. Future development of Westport could create export opportunities for local agricultural producers and strategic industrial land could provide the opportunity for downstream processing such as food production.

Potential constraints to agricultural uses on the site include the limited potential to expand and potential conflict with adjacent industrial/urban developments. Furthermore, demand for large, productive rural lots at the subject area is limited according to the City of Kwinana Rural Lands Study. Rural land uses at the subject area present the following opportunities and challenges (Figure 53).

Figure 53. Rural Land Opportunities and Constraints

Opportunities	**Description**
Industrial land – downstream opportunities	Nearby industrial areas could support food production industries creating the opportunity for an agglomeration of agricultural activity
Westport	Should a sufficient scale of agricultural production be achieved in the subject area there could be the opportunity to export via the potential Westport development. It is unlikely that this scale of development could be achieved however given the land areas available and proximity to residential population.
Kwinana Freeway and freight road development	The upgrade of either Rowley or Anketell Roads and proximity to the freeway provide high levels of access, facilitating road transport of agricultural produce to and from the subject area
Current uses	The land is already being used for agricultural activities, its continued use would require no transition
Constraints	**Description**
Adjacent Urban Land	The new residential developments to the east of the subject area could limit the potential scale and type of agricultural activities in the subject area
Limited room for growth	Agricultural uses at the subject area are constrained in all directions. There are also a number of areas within the subject area that are not suited to agricultural practices due to environmental constraints and an operating sand quarry.
Environmental Considerations	The potential for growth at the subject area would likely also be constrained by the potential for nutrient run off. There are a number of Bush Forever sites adjacent to the subject area, particularly the Spectacles, which could be impacted by an increasing nutrient load.
Land Value	Rural land has a low value per m^2. It is not known what appetite the various landowners have to continue agricultural practices

8 NEXT STEPS

The information presented in this document will be used to develop a scenario model to inform the impact of developing different land uses on the subject area. The model will be developed in liaison with the project team and the Department to account for constraints that limit the amount of land available or the types of land use permissible on certain pieces of land. The model will provide:

- Employment estimates for economic and employment lands developed
- Output and Gross Value Add estimates based on industries that would be attracted by different land uses
- Population figures for urban development
- Local retail expenditure and demand for schools/other population driven facilities
- Land value estimates based on type of land use (broad categories – industrial land value large/small, rural land value large/rural living, urban land value low and medium density

As the project progresses, the scenario model will be used to inform decision making regarding the highest and best use for the subject area, from a supply and demand perspective, in consideration of constraints that are identified by the project team.

This document is intended to be a living document through the project, with updates being based on Department feedback and additional sections being added as scenarios are developed. Pracsys will also be working with the project team and the Department to provide guidance regarding the potential planning controls that can be used to manage and facilitate development of the preferred scenario.

9 APPENDIX

9.1 Appendix A – Glossary

Consumer services (CS)

Consumer services have a high transaction frequency and must locate in close proximity to their customer base in order to deal directly with them. Like retail tenancies, consumer services often locate in centres to minimise trip generation and benefit from convenience good attractors. Consumer services can include real estate agents, travel agents, shoe repair, dry cleaning services and beauty salons.

Employment Concentration Factor

The employment concentration factor (ECF) represents the concentration of a particular industry within a region compared with that industry's strength within the State. An ECF of 1.0 means that an industry has the same concentration in the region as it does the state. An ECF of greater than 1.0 identifies industries that employ a higher proportion of workers in the region than the state average for that same industry. By employing a higher proportion of workers than the state average, the industry is likely producing more goods and services than the region can consume and can therefore export the excess product out of the region.

Measurement of employment concentration factors is useful in urban economic analysis as it provides a strong indication of the agglomeration of an industry or group of industries. Care must be taken as the metric gives no indication of the relative size of the industry, i.e. a region may have a very high ECF with a small number of employees if the industry is small, whilst a low ECF in a large industry may still equate to a significant proportion of employees.

Employment Self-Containment

The proportion of employed residents within a defined area whose jobs are located within that defined area.

Employment Self-Sufficiency

The ratio (expressed as a percentage) of the total labour force (local residents who are employed or seeking employment) of a defined area relative to the total number of jobs available in that area. A percentage above 100 indicates a region has more jobs locally than resident workers

Export-oriented activity (Export)

Export refers to jobs in industries that take advantage of an areas comparative advantage. These are generally thought of as strategic due to growth and development through the export of goods/services and the inflow of funds. Export jobs are producer services, however they tend to occuring in strategic industries such as agriculture, mining, oil and gas and defence. Export jobs are likely to be hands on, involving the physical construction of a marine vessel or operation of machinery on a mine site - as opposed to the mathematical or

scientific analysis carried out by KIPS. Strategic industries tend to require physical infrastructure, such as ports, airports or universities.

Knowledge intensive consumer services (KICS)

Knowledge intensive consumer services are those specialist services that deal directly with consumers, yet typically have a higher productivity and lower transaction frequency. KICS provide a skilled service to consumers that usually requires a higher level of education or training. Depending on the scale of their catchment, KICS may choose to locate within major or regional centres, or larger business districts with greater soft infrastructure and amenity levels. Examples of KICS include general practitioners, accountants, veterinarians and legal services.

Knowledge intensive producer services (KIPS)

Knowledge intensive producer services (KIPS) involve businesses dealing directly with other businesses, rather than consumers. Transactions are less frequent, however generally have a higher monetary value, due to the intellectual property or knowledge involved. KIPS businesses often locate near their client businesses, although with low transaction frequency and good communications infrastructure, they are to an extent 'footloose'. This means they can choose to locate in places with relevant physical infrastructure, high retail amenity, or soft infrastructure such as access to a solid education base. Examples of KIPS are engineers, architects, medical scientists and computer software developers.

Producer services (PS)

Producer services deal directly with other businesses, rather than consumers. Like retail locates close to consumers; wholesale producer services must locate close to the businesses they serve, due to the frequency of transactions required. For example, the Coles distribution warehouses must occupy a central location in order to carry out daily delivery of goods to supermarkets. Producer service industries include manufacturing, construction, and distribution.

Shift share analysis

Shift share analysis is a technique that aims to identify the industries that are most competitive in a defined region, through an analysis of employment growth. Employment growth is broken down into different components to determine what share of the growth can be attributed to growth in the State economy, what percentage can be attributed to the industry mix, and the remainder is then assumed to result from particular competitive strengths developed in the defined region. Shift Share

pracsys.

Department of Planning, Lands and Heritage

Mandogalup Westport Analysis

Briefing Note

November 2021

Document Control				
Document Version	**Description**	**Prepared By**	**Approved By**	**Date Approved**
v 1.0	Mandogalup Westport Analysis – Briefing Note	Mark Timoney	Dawson Demassiet-Huning	17 May 2021
v 2.0	Briefing Note - TBB edits	Mark Timoney Dawson Demassiet-Huning	Dawson Demassiet-Huning	28 May 2021
v 3.0	Briefing Note – Final	Dawson Demassiet-Huning	Dawson Demassiet-Huning	12 August 2021
v 4.0	Briefing Note – Final	Dawson Demassiet-Huning	Dawson Demassiet-Huning	26 October 2021
v 5.0	Briefing Note – Final	Dawson Demassiet-Huning	Dawson Demassiet-Huning	19 November 2021

Disclaimer

This report has been prepared for the **Department of Planning, Lands and Heritage.** The information contained in this document has been prepared with care by the authors and includes information from apparently reliable secondary data sources which the authors have relied on for completeness and accuracy. However, the authors do not guarantee the information, nor is it intended to form part of any contract. Accordingly, all interested parties should make their own inquiries to verify the information and it is the responsibility of interested parties to satisfy themselves in all respects.

This document is only for the use of the party to whom it is addressed and the authors disclaim any responsibility to any third party acting upon or using the whole or part of its contents.

CONTENTS

1 Executive Summary 4

2 Background 6

3 Study Area 7

3.1 Spatial Area 7

3.2 Future Industrial Land Supply 9

4 Current Land Uses 10

5 Future Land Demand 14

5.1 Business as Usual Demand 14

5.2 Westport Benchmark Analysis 16

5.3 Industrial Land Gap Analysis 20

6 Implementation 24

6.1 Catalyst Projects 24

6.2 Locational Considerations 28

6.3 Market Signals 29

7 Conclusion 33

8 Appendices 34

8.1 Appendix 1: WASLUC to Transitional Concordance 34

8.2 Appendix 2: Benchmark Port Boundaries 36

8.3 Appendix 3: Lot Size Assumptions 38

1 EXECUTIVE SUMMARY

This briefing note is an update and an addendum to the 2020 Land Supply and Demand Analysis technical report; and in any areas of inconsistency, the more up to date information in this briefing note (addendum) applies.

This analysis has assessed the land uses at the WTC to be able to understand the effect of Westport on industrial uses as it develops. The analysis does not consider the potential constraints that may be posed by land tenure in the subject area and how it may impact transition of certain businesses. The main land uses at the WTC were broken down into Port Strategic, Strategic and Population Driven uses to identify their level of friction related to moving out of the WTC[1] (Figure 1).

Figure 1. Floorspace by Transitional Land-Use Definition

Transition Category	Floorspace m² (% of total)	Land Area Ha (% of total)
Strategic	805,421 (54%)	1,626 (78%)
Port-strategic	220,007 (15%)	175 (8%)
Population-driven	244,611 (16%)	136 (7%)
N/A (vacant)[2]	229,120 (15%)	151 (7%)
Total	**1,499,159**	**2,087**

Source: DPLH 2016, Pracsys 2021

The potential land demand generated by Westport was estimated using benchmark analysis of major Australian Ports. Three scenarios were developed and combined with the Business-as-Usual land demand scenarios from the IP47 Land Supply and Demand Analysis. Total demand was compared to future industrial land supply to estimate the potential gap in available industrial land at the WTC by 2041. The analysis identified a potential gap of 190 ha in the Medium growth scenario and approximately 612 ha in the High growth scenario (Figure 2).

Figure 2. Land Area Gap in 2041 (ha)

Metric	Low	Medium	High	Notes
Supply	3,054	3,054	3,054	See Section 3.2
Demand	2,443	3,244	3,666	See Section 5.1 and 5.2
Gap/Surplus	611	- 190	- 612	

Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

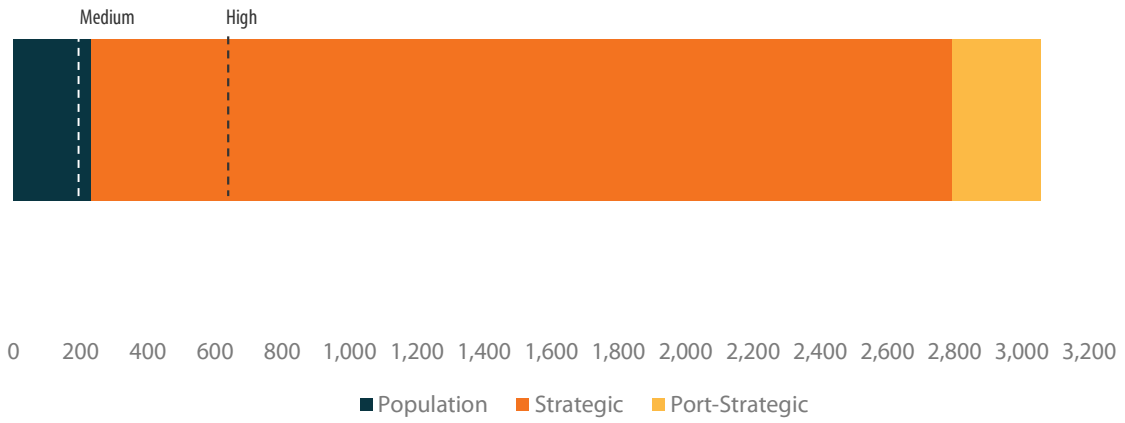
It was determined that in the Medium Growth scenario most Population-Driven uses would transition out of the WTC and in the High scenario, all Population Driven uses and some Strategic uses that would benefit

[1] Definitions of land uses are provided in Figure 7 on page 10

[2] Vacant is assumed to be a component of undeveloped land in the analysis (see Section 3.2). Undeveloped refers to lots that are zoned for development for the purposes of the specified primary land use category that are recorded as vacant in Landgate's property valuation database.

from proximity to the WTC would transition out of the WTC (Figure 3). The following graphic shows the area of land use by transitional category in 2041 and the gap size by scenario.

Figure 3. Gap in Land Area in 2041 by Scenario by total Future Land Demand



Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

Implementation considerations were developed to support decision making around land planning for the Subject Area. Should Strategic uses want to be accommodated at the Subject Area, the planning framework will need to accommodate appropriate zones in the Subject Area, allowing for suitable lot sizes for desired uses and a suitable transition from Strategic uses to residential development from West to East. Planning for Strategic uses is seen as the most flexible option as the development of these uses is likely to occur over a longer timeframe and should demand not eventuate, it is likely that the land could be rezoned to accommodate more population orientated uses.

2 BACKGROUND

Pracsys undertook an investigation of land supply and demand in 2019, providing a draft report in early 2020 as a technical input to the preparation of an Improvement Scheme over the IP 47 area (the Subject Area). At approximately 300 ha, the Subject Area is located in the City of Kwinana and currently supports agricultural, residential and light industrial activities. The analysis estimates the supply and demand for potential land uses, identifying whether there is a likely gap or surplus for each activity type based on the current planning framework.

In August 2020, an independent Westport Taskforce recommended a future land-backed container port be built within the Kwinana Industrial Area. The port is to be connected by an uninterrupted freight corridor via Anketell Road and / or Rowley Road, and Tonkin Highway to the logistics precincts in the outer Perth Metropolitan Area.[3] It could potentially be supported by an enhanced rail network and an intermodal terminal, although this has not been confirmed.

The WA Government accepted the recommendations and is now working to determine the preferred timing for transition of activities from Fremantle to Kwinana. This transition will have significant impact on the activity mix in Kwinana industrial areas and hinterland. A new hierarchy of land uses will emerge based on the location of infrastructure and proximity to the core port operations. In parts of the Western Trade Coast closest to the port, lower order uses (i.e. population driven) will likely make way for an even greater concentration of higher order uses (i.e. port related uses and strategic uses that are export orientated). The process will accelerate in tandem with the transition of activity from Fremantle to Kwinana.

The impact of this transition on the subject area will likely be profound. Lower order uses (i.e. small factory units, bulky retail, etc.) will need a place to relocate. The infrastructure in the area will need to suit the business models and modes of operation (i.e.: business-to-business, business-to-consumer, bulky retail), with different access arrangements, road network design, parking, and provision of services (power, water, sewer, etc).

This report has been developed to quantify the current proportion of lower and higher order uses in the Western Trade Coast area and quantify the amount of industry displacement that might occur due to the Westport plans. This is effectively a more detailed rework of the scenarios from the land supply gap analysis already conducted for the subject area and will be integrated into the Land Supply and Demand Report.

[3] State Government 2020, ' Work underway on Perth's new freight corridor'. Available from: https://www.mediastatements.wa.gov.au/Pages/McGowan/2020/08/Work-underway-on-Perths-new-modern-freight-corridor.aspx

3 STUDY AREA

3.1 Spatial Area

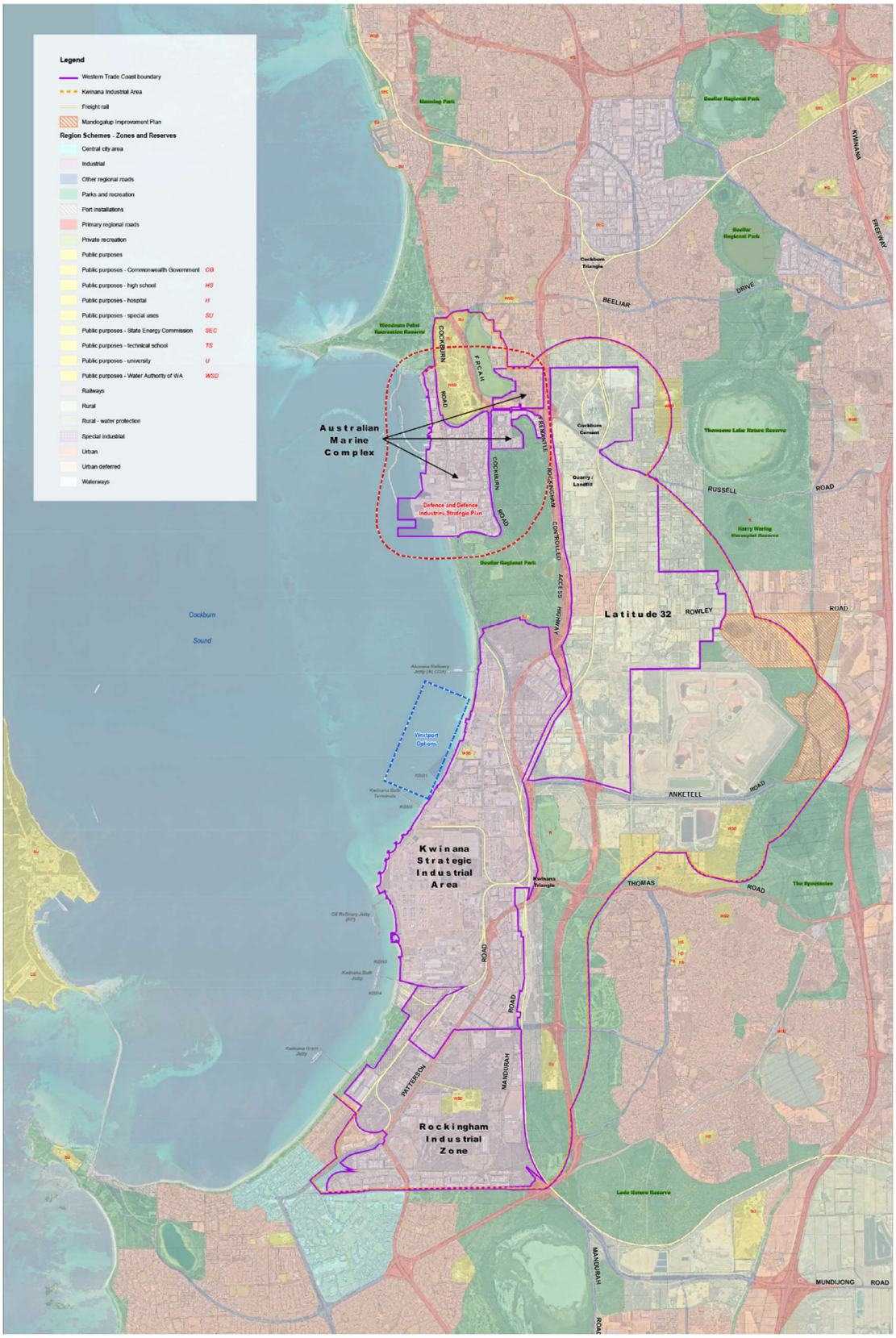
The Land Supply and Demand Analysis identified a Study Area for the project that included the Local Government areas of Armadale, Cockburn, Kwinana, Rockingham and Serpentine Jarrahdale (Figure 4).

Figure 4. Study Area Spatial Area

Source:

The focus of this analysis is the industrial land that makes up the Western Trade Coast (Figure 5). This land includes the Rockingham Industrial Zone, Kwinana Industrial zone, Latitude 32, and the Australian Marine Complex (the boundary on the map below also includes the Subject Area; this area is not included in the analysis).

Figure 5. Western Trade Coast and Proposed Industrial Protection Area



Source: DPLH 2021

3.2 Future Industrial Land Supply

The analysis in this report uses industry analysis and benchmarking to develop land demand estimates that can be compared to planned and developable industrial land. The planned future supply of industrial land was estimated in the Land Supply and Demand Analysis through land identified for industrial expansion, land identified for industrial investigation and an estimate of undeveloped industrial land in the Study Area. Undeveloped industrial land reported in the Economic and Employment Land Monitor has also been included (EELM) (Figure 6).[4]

Figure 6. Industrial Land Supply Analysis

	Future Supply	Notes
Undeveloped and Future Industrial Land (Ha)	3,054	This is comprised of: • 892 ha of undeveloped industrial land as reported in EELM • 2,047 ha industrial expansion (includes Latitude 32) • 115 ha industrial investigation (total industrial investigation of 545 ha minus the subject area's 330 ha)

Source: Pracsys 2019, DPLH 2020

Land which is classified as unrated has been excluded from this analysis as it is not clear what proportion is remaining to be developed and there are elements that likely form part of the planned industrial expansion and investigation areas.[5]

[4] Refers to lots that are zoned for development for the purposes of the specified primary land use category that are recorded as vacant in Landgate's property valuation database.

[5] Unrated land refers to lots that are zoned for development for the purpose of the specified primary land use category for which no vacant land or premises valuation information has been captured in Landgate's property valuation database. This may include State or local government owned lots or premises exempt from rates, Crown allotments, common property within lots on survey, newly created lots on survey, land otherwise exempt from rates and some public roads which are zoned for the primary land use under the local planning scheme.

4 CURRENT LAND USES

The current land uses at the WTC were analysed and the main uses were categorised based on their strategic connection to the future Westport development and the industry uses it will support (Figure 7).

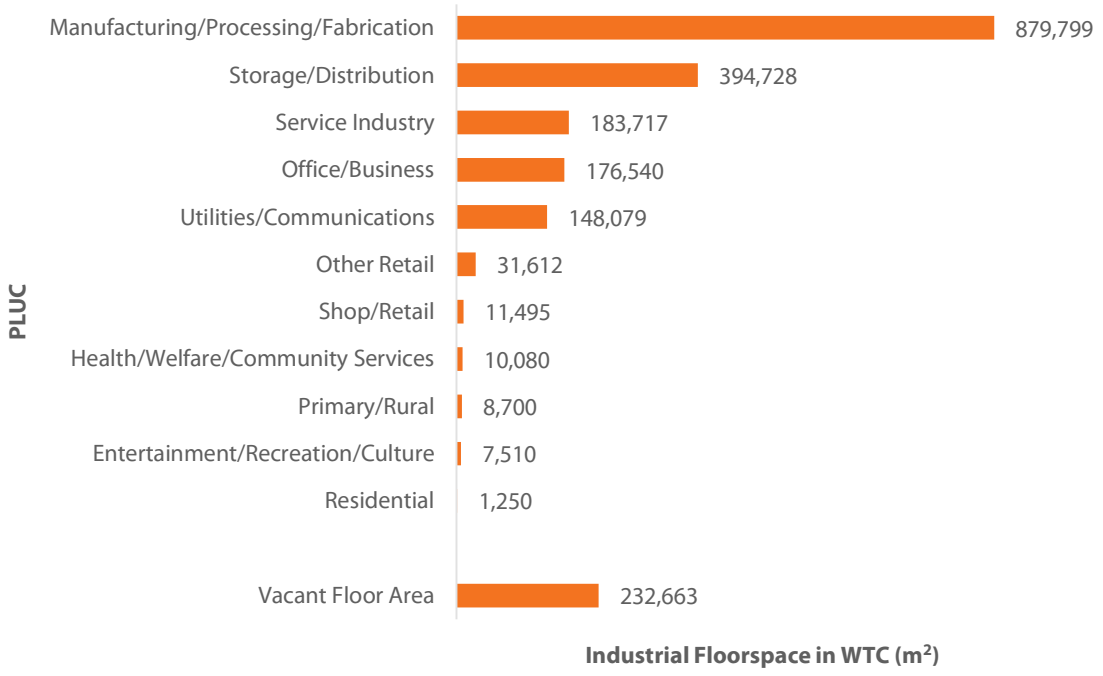
Figure 7. Transitional Land Use Category Definitions

Category	Description
POPULATION-DRIVEN	Population-driven uses that are not location-reliant and can readily be delivered anywhere. These uses are likely to be pushed out of the Western Trade Coast area when Westport is developed.
STRATEGIC	Uses which are related to activities located at the Port and benefit from proximity to the port. These uses can be accommodated at Mandogalup.
PORT-STRATEGIC	Strategic uses which must be located at the Port as they require port infrastructure and relate directly to export activities.

Source: Pracsys 2021

The analysis identified detailed uses at the port using Department of Planning, Land and Heritage Land Use and Employment Survey data. The majority of floorspace at the WTC is estimated to be in the Manufacturing / Processing / Fabrication and Storage / Distribution when assessed by broad Planning and Land Use Categories (Figure 8).

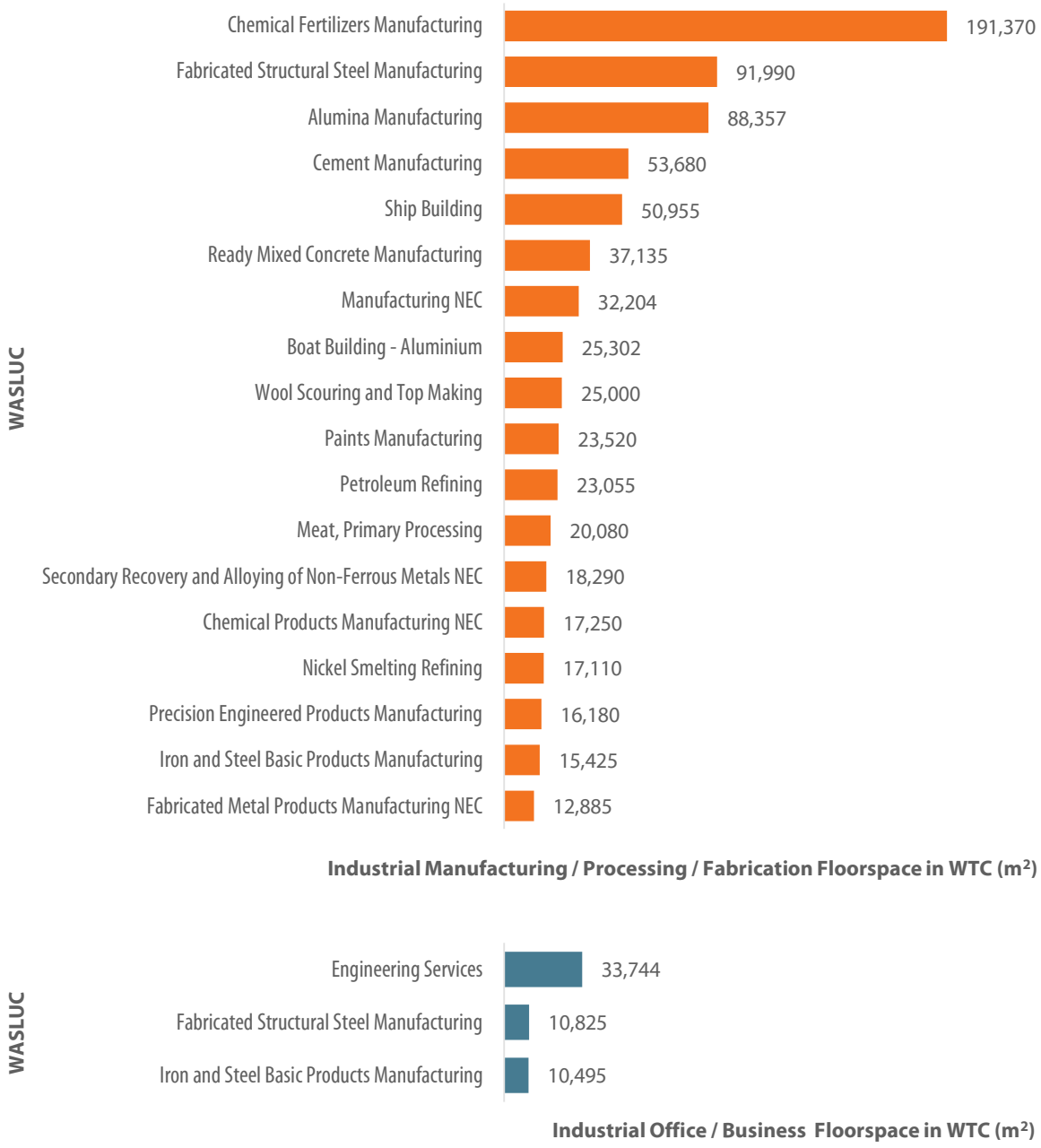
Figure 8. WTC PLUC Floorspace Distribution

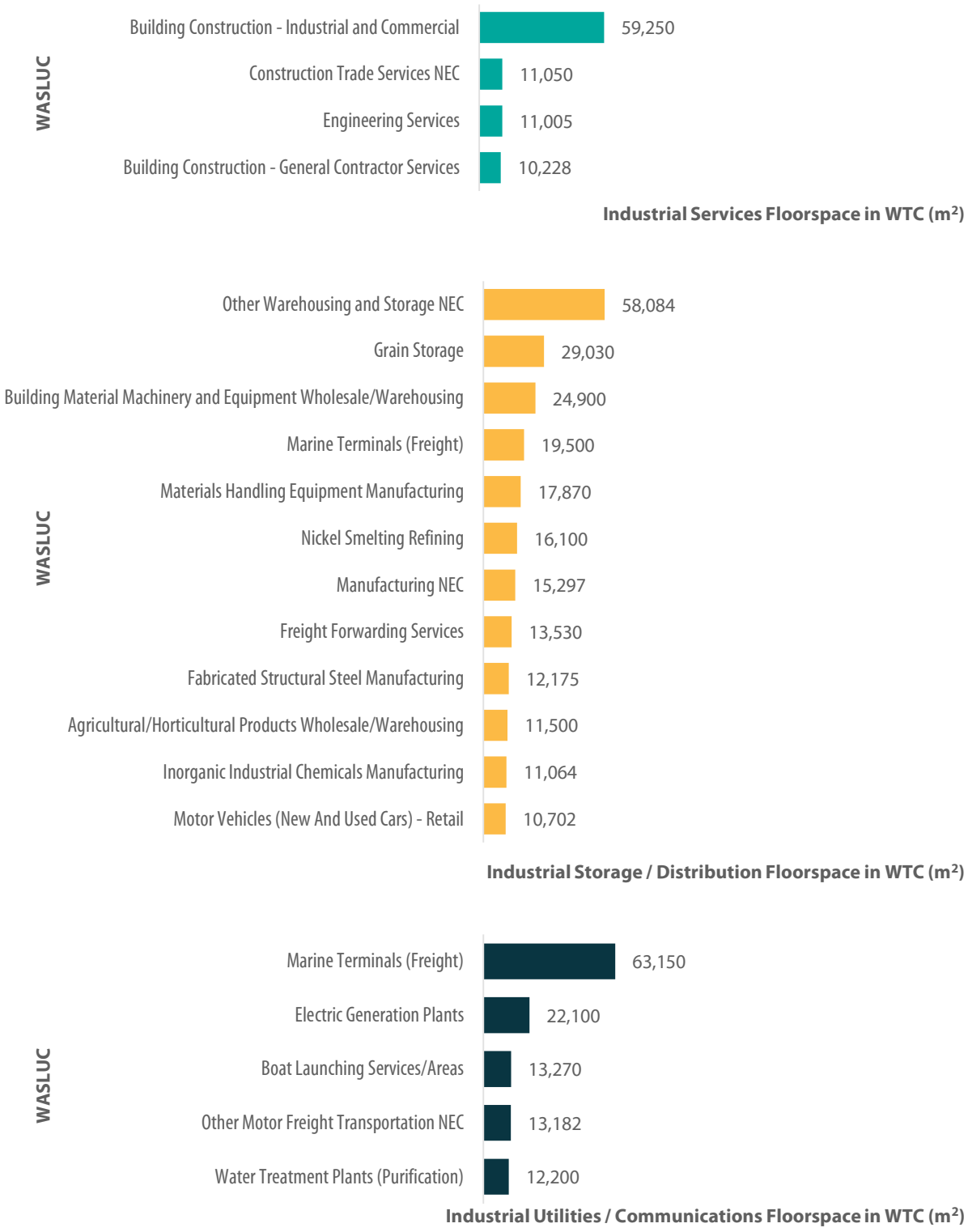


Source: DPLH 2016

In order to breakdown uses by the identified Transitional Land Use categories, LUES data was assessed at the detailed Western Australian Standard Land Use Categories (WASLUC) level (Figure 9).

Figure 9. WASLUC Uses by PLUC (the PLUC is Identified bottom right)





Source: DPLH 2016

A concordance was developed to align WASLUC categories with the Transitional Land-Use definitions (see Appendix 1: WASLUC to Transitional Use Concordance for Main Uses). Applying this concordance, it was possible to estimate the floorspace and land area distribution by Transitional Land-Use definition (Figure 10).

Figure 10. Floorspace by Transitional Land-Use Definition

Transition Category	Floorspace m² (% of total)	Land Area Ha (% of total)
Strategic	805,421 (54%)	1,626 (78%)
Port-strategic	220,007 (15%)	175 (8%)
Population-driven	244,611 (16%)	136 (7%)
N/A (vacant)[6]	229,120 (15%)	151 (7%)
Total	**1,499,159**	**2,087**

Source: DPLH 2016, Pracsys 2021

The first floorspace uses likely to leave the WTC as Westport develops are those classified as Population-Driven. This departure will result due to increased land demand from Port Strategic and Strategic uses that will likely increase the price of land and cost of rent in the WTC. The analysis highlights the significant current level of strategic uses that are not necessarily port related but that will likely look to locate within proximity to Westport as it develops due to the high levels of access provided by road, rail and ship.

The breakdown of land by transitional categories will inform the gap analysis by providing an understanding of the land requirements that may need to be considered at the Subject Area and timing considerations for different uses. The analysis does not consider the potential constraints that may be posed by land tenure in the Subject Area and how it may impact transition of certain businesses.

[6] Vacant is assumed to be a component of undeveloped land. Undeveloped refers to lots that are zoned for development for the purposes of the specified primary land use category that are recorded as vacant in Landgate's property valuation database.

5 FUTURE LAND DEMAND

Future land demand has been assessed based on estimated Business as Usual demand for industrial land at the WTC and demand for port-related industrial land associated with the Westport development:

- The WTC demand (without Westport) was estimated in the Draft Land Supply and Demand Analysis with three different scenarios (low, medium and high). This has been compared with the recently released DPLH Urban Land Development Outlook 2020/21 to ensure consistency
- The Westport development has been benchmarked to National ports based on container imports and exports using Port Australia Data

These elements have been combined to develop a total demand estimate to understand whether there is a surplus or deficit of industrial land at the WTC with the development of port uses associated with Westport. Should there be a deficit, it is likely that the Subject Area will experience demand from industrial uses that transition out of the WTC.

5.1 Business as Usual Demand

The ULDO provides industrial land demand estimates for the following land uses:

- General Industrial
- Light Industrial
- Mixed Business
- Commercial Business Park
- Technological Park
- Warehousing and Distribution
- Transport and Logistics
- Service Commercial

Future industrial land demand was identified for the following areas within the WTC (Figure 11)

Figure 11. ULDO Land Demand Estimates for WTC

	Warehousing and Logistics (ha)	Strategic Industrial (ha)	General Industrial (ha)
Latitude 32	1,226	0	93
East Rockingham Industrial Area	0	372	4
Total	1,226	372	97

Source: DPLH 2020

There is a total projected demand of 1,695 ha for the WTC for the period 10+ years, which does not appear to include potential development of the Australian Marine Complex. The long term (10 years plus) ULDO forecast estimates demand of 2,188 Ha in the Study Area, not accounting for the Westport development.

The previous analysis (Draft Land Supply and Demand Analysis 2020) estimated the demand for industrial land within the Study Area until 2041 under three different growth scenarios (Figure 12).[7] These projections represent the Business as Usual (BAU) demand estimates.

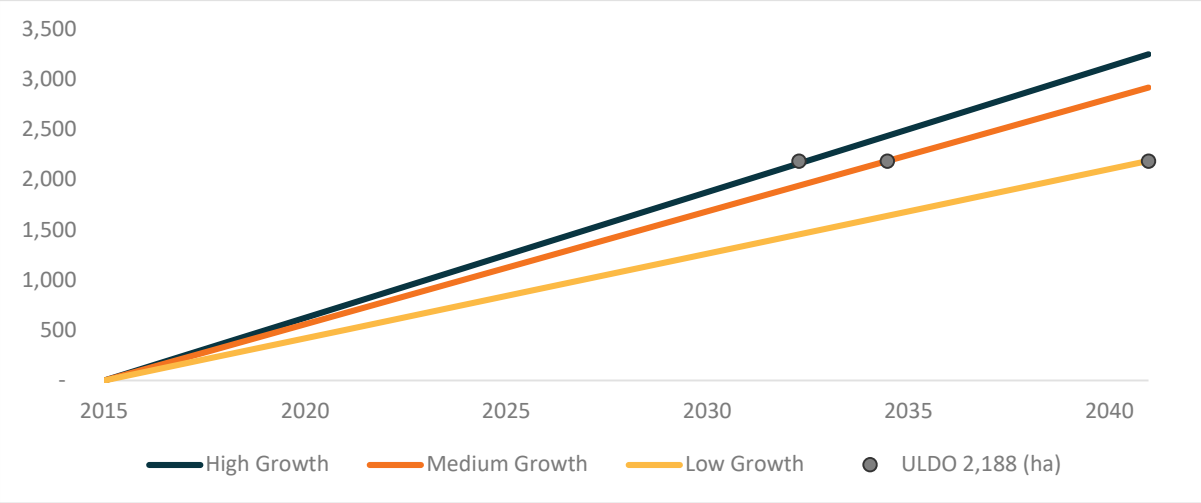
Figure 12. Draft Land Supply and Demand Analysis 2020 – BAU Demand Estimates

Scenario	Land Demand (ha)
Low Growth	2,189
Medium Growth	2,919
High Growth	3,252

Source: Pracsys 2020

These estimates have been compared with the long term ULDO forecast (ten years plus) to determine their goodness-of-fit. The ULDO projection would occur between 2032 and 2041 depending on the scenario applied from the Draft Land Supply and Demand Analysis (Figure 13).

Figure 13. Comparison of Land Supply and Demand Analysis Forecasts and ULDO 10 year plus Demand Estimate for Study Area



Source: Pracsys 2020, ULDO 20/21

Note: The points indicate where on the demand curve the different scenarios achieve the ULDO estimate of 2,188 ha

In the Low Growth scenario, the ULDO demand level is achieved after 20 years and in the medium scenario it is achieved in approximately 15 years (from 2020). This is considered acceptable, and the scenarios have been used to inform the gap analysis at the year 2041.

[7] The methodology for estimating demand is provided in the Draft Land Supply and Demand Analysis Report, Section 5.1, Industrial Land.

There are a number of indicators that show short – medium term demand for land could be growing in the WTC (Figure 14).

Figure 14. Identified Short-Medium Term Demand

Identified Future Demand	Source
The Flinders Development (Latitude 32 Development Area 2) is 90% sold and has already started to be developed	https://developmentwa.com.au/projects/industrial-and-commercial/flinders-precinct/overview
Australian Marine Complex projects being funded by the State Government including a new wharf and ship building facility. Land required unknown	https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/01/Contract-awarded-for-87-point-6-million-dollar-defence-infrastructure-projects.aspx
Kwinana Strategic Industrial area has approximately 87 ha of undeveloped industrial land for which there are already proponents looking to develop	https://developmentwa.com.au/documents/369-kwin1-2019-11-29-kwinana-sia-site-plan-devw0038/viewdocument/369 Map numbers 33 and 32
Rockingham Strategic Industrial Area has approximately 56 ha of undeveloped industrial land for which there are already proponents looking to develop	https://developmentwa.com.au/documents/1350-rockingham-sia-map/viewdocument/1350 Map numbers 5, 8, 9, 10, 13, and 14

5.2 Westport Benchmark Analysis

The benchmark analysis considered ports across Australia. The following method was applied to select potential benchmarks for Westport:

- Purpose of port (i.e. similar mix of export and imports)
- Location (i.e. Metropolitan area)
- Mix of export goods
- Relevant population (i.e. population served)

Based on the above criteria a set of benchmarks was identified from which land estimates could be based, Including:

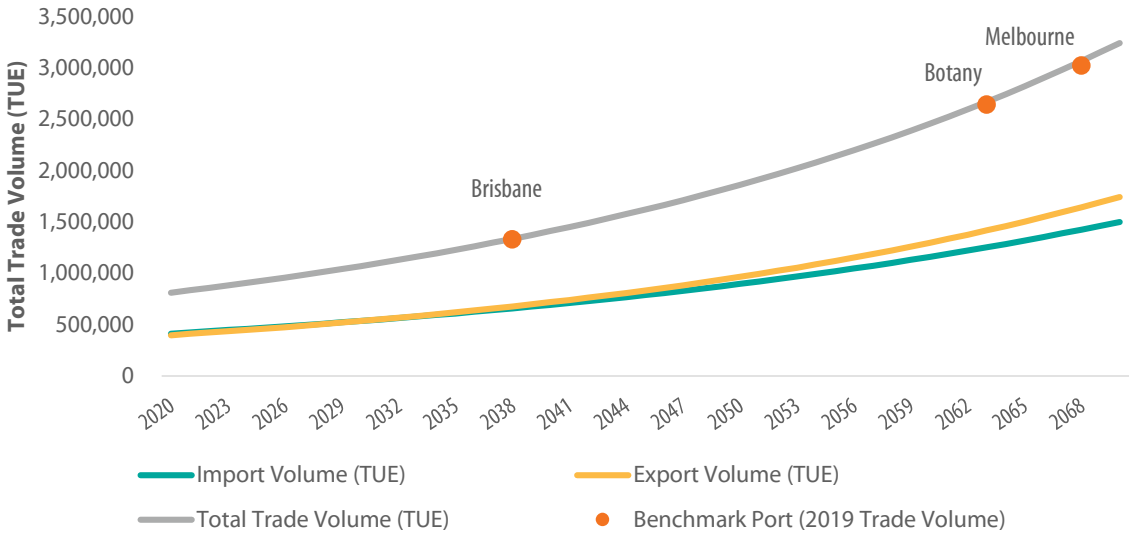
- Melbourne Port
- Botany Port (Sydney)
- Brisbane Port
- Fremantle Port

Deloitte developed trade volume projections for Westport in Twenty-foot Equivalent Units (TEUs). Benchmark port volumes have been identified to demonstrate at which year the Westport development will achieve similar volume as the benchmarks[8] (Figure 15).[9]

[8] Volume reference year of 2019

[9] Fremantle supported 788,000 TEU trade volume in 2019, just under the Deloitte Westport estimate for 2020 of 810,000 TEU. This is why Fremantle is not shown in Figure 15

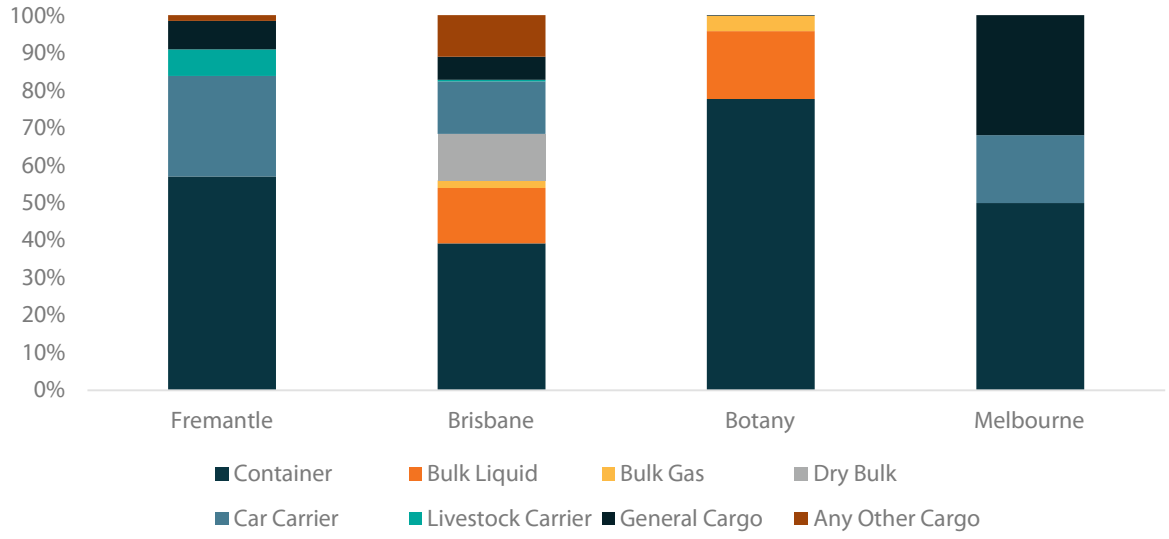
Figure 15. Westport Trade Projection Compared to Benchmarks



Source: Port Australia Data 18/19, Deloitte 2019

The data for Fremantle Port includes goods that are shipped from Kwinana. The mix of goods was compared between potential benchmarks to identify those that would be appropriate for developing an estimate for additional land that will be required at the WTC due to the container movements that will be supported by Westport (Figure 16).[10]

Figure 16. Trade by Classification by Port



Source: Port Australia Data 18/19

[10] It is assumed that the BAU scenario would include demand for additional land uses associated with the exports that currently leave from the WTC including Bulky Liquid, Bulky Gas and Dry Bulk.

Further analysis on the mix of uses identified that Bulk Gas, Bulk Liquid and Dry Bulk are all shipped from Kwinana. Excluding these, the current Fremantle Port is small and is directly related to TUE estimates; it is used as a benchmark for additional land requirements.

Both Brisbane and Botany Ports include high concentrations of Bulk Liquid, Bulk Gas or Dry Bulk. Melbourne Port had lesser levels of Bulk Liquid and Dry Bulk with no Bulk Gas. Based on an aerial analysis of the Ports, it was easier to determine land associated with Bulk Liquids and Dry Bulk uses at Melbourne Port and it was therefore chosen to as a second benchmark for land estimates. The land area used for developing benchmark ratios is provided in Section 8.2 (Figure 31).

The area used to estimate land associated with Ports was split into two categories:

- Port Uses
- Port Ancillary Uses

This categorisation has been used to provide low, medium and high estimates to feed into the Land Supply and Demand Analysis.

Developing Land Benchmark Ratios

Defining discrete spatial boundaries poses a challenge due to the strategic benefits a port offers to specific industries. Although defining the actual port land area i.e. the land where freight is stored and ships can dock, is relatively straight forward, defining the secondary boundary where ancillary industry[11] locates is more subjective. However, understanding of the secondary boundary for each port is needed to provide an accurate estimate for land demand.

Each benchmark port was analysed through satellite imagery and ABS employment information to estimate the extent of these ancillary uses. Once a boundary was determined, an estimate of the total land area was developed (Figure 17).

Figure 17. Benchmark Port Land Estimates

Port	Port Land Area (Ha)	Total Land Area including Ancillary Uses (Ha)
Melbourne	500	708
Fremantle	177	213

Source: Google Maps 2021

Note: port land areas are approximate and have been estimated through desktop analysis.

The import / export trade volume for Fremantle and Melbourne in TEUs was compared to the identified land area categories. This provided an average TEU per ha of port related industrial land to enable quantification of land requirements for Westport (Figure 18).

[11] Ancillary uses include but are not limited to postal and warehousing companies, importers and exporters, and distribution centres for large retailers

Figure 18. Benchmark Land to TEU Ratio

PORT	Total Trade Volume (TEU) per Gross Hectare – Port Uses	Total Trade Volume (TEU) per Gross Hectare – Ancillary and Port Uses
Melbourne	6,042	3,500
Fremantle	4,453	3,701
Simple Average of Benchmarks	**5,248**	**3,600**
Weighted Average of Benchmarks	**5,713**	**3,541**

Source: Port Australia 2020, Google Maps 2021

The benchmark ratios have been applied in the following scenarios:

- **Low Growth**: only Port Uses develop in addition to the Low scenario BAU uses, the weighted average Port Uses ratio for Melbourne and Fremantle is applied
- **Medium Growth**: Port Uses and some ancillary uses develop in addition to the Medium scenario BAU uses, the Fremantle Port Uses benchmark ratio is applied (the Fremantle, Port Uses defined area includes some ancillary uses making it appropriate for a medium scenario)
- **High Growth**: Port and Port Ancillary Uses develop in addition to the BAU, the weighted average Port and Port Ancillary use ratio for Melbourne and Fremantle is applied

The ratios have been applied to the Deloitte Trade Volume (Figure 15) estimates to develop land demand projections based on Westport activities. These Westport demand estimates are additional to current uses at the WTC and have been combined with the identified BAU demand to estimate total future demand for industrial land (Figure 19).

Figure 19. Westport Additional Land Requirement Estimate 2041 (ha)

Scenario	Westport Demand	BAU Demand	Total Demand
Low Growth	254	2,189	2,443
Medium Growth	325	2,919	3,244
High Growth	414	3,252	3,666

Source: Port Australia 2020, Google Maps 2021, Deloitte 2019

These projections do not incorporate land associated with an intermodal terminal; should an intermodal terminal be developed at Latitude 32 it would be additional demand to that which is identified here.

5.3 Industrial Land Gap Analysis

The land area gap was developed by comparing the supply of future industrial land with estimated total land demand in 2041, for each scenario (Figure 20). The analysis does not consider the potential constraints that may be posed by land tenure in the subject area and how it may impact transition of certain businesses. The overall supply for land is expected to be fixed at 3,054 ha, whilst the demand is expected to vary from 2,443 ha to 3,666 ha. This results in a gap, where demand exceeds supply, of between 190 ha and 610 ha.

Figure 20. Land Area Gap in 2041 (ha)

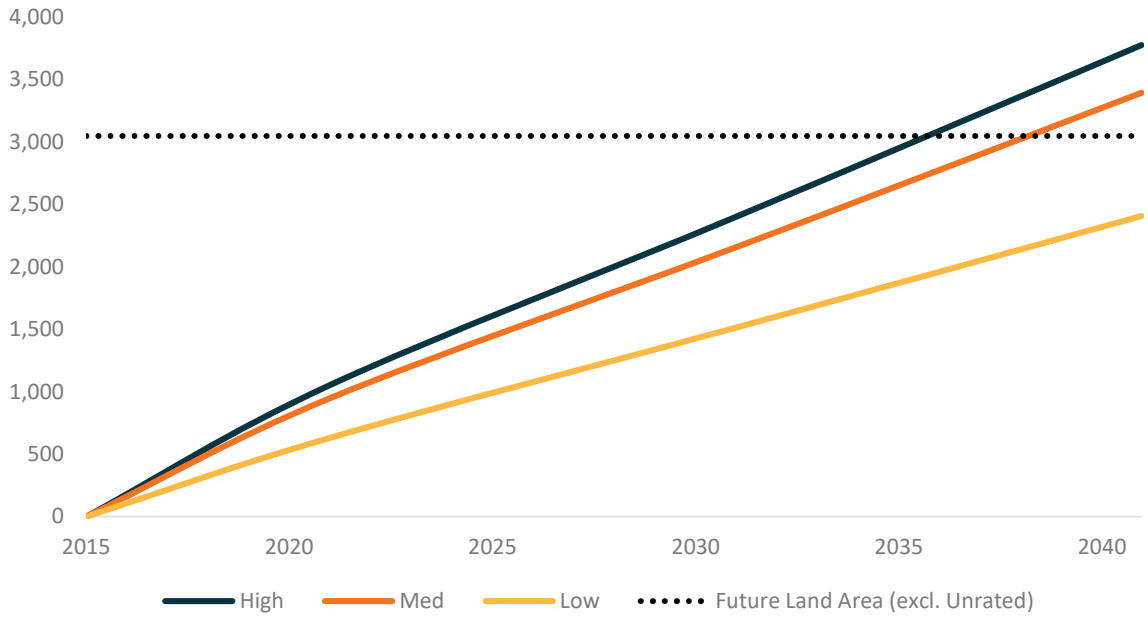
Metric	Low	Medium	High	Notes
Supply	3,054	3,054	3,054	See Section 3.2
Demand	2,443	3,244	3,666	See Section 5.1 and 5.2
Gap/Surplus	611	- 190	- 612	

Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

Note: the similarity between High and Low Gap/Surplus has been reviewed and is purely incidental

Comparing the supply and demand profiles for the area results in demand matching supply in approximately 2036 for the high scenario and 2039 for the medium scenario (Figure 21). The low scenario does not reach the future land area supply within the period of study.

Figure 21. Scenario Demand Forecasts



Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

In both Medium and High growth scenarios there is greater demand compared to future industrial supply within the study period, with the gap likely to increase beyond 2041. While the projected demand matches supply at approximately 2036 or later, the current uses at the WTC would feel pressure to transition out of the WTC well before this time point. This is particularly true for Population Driven uses that will experience

pressure to transition sooner due to the higher value port-strategic uses that will need land in close proximity to Westport. The total demand for the Transitional Land Use definitions has been estimated at 2041 (Figure 22).

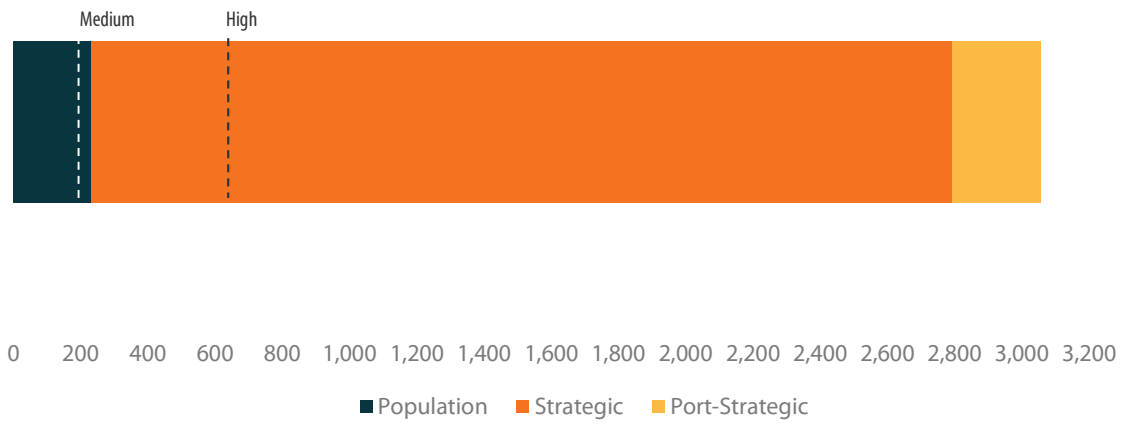
Figure 22. Total Land Demand by Transitional Use 2041

Transitional Use	Area (ha)
Port Strategic	230
Strategic	2,562
Population Driven	263

Sources: DPLH 2016, Pracsys 2021

Figure 23 illustrates this effect for the high and medium scenarios. In the medium scenario almost all Population Driven uses would need to transition out of the WTC and transition first to allow more strategic uses to locate at the WTC. In the high scenario, the entirety of Population Driven uses would transition and some Strategic uses that would be suited to a location near to Westport would need to transition. The high scenario is expected to cause 14.9% of the land demanded by Strategic uses to require a location outside of the WTC.

Figure 23. Gap in Land Area in 2041 by Scenario by total Future Land Demand



Source: DPLH 2016, Port Australia Data 2019 Google Maps 2021, Pracsys 2021

The location of Mandogalup between the two identified freight route connections to Westport means it would likely be attractive and suitable to both types of uses. The land scenarios could allow for a mix of these uses through appropriate lots sizes. It is likely that transition areas will be required between more strategic uses and the residential areas to the east of the Subject Area, meaning these uses should likely be restricted to the western section of the Subject Area (see Section 6, Implementation).

Potential Transition Timing

The main uses at the WTC have been assessed based on their likely transition timing to provide an understanding of which types of uses may depart the WTC first. There are many strategic uses that are likely to stay within the WTC as the identified potential gap in the High scenario would only force some Strategic uses to leave if it eventuated. Those uses that have the least friction to changing location are likely to do so (i.e. a motor freight transport company will be able to move its fleet, a nickel smelter cannot easily develop a new plant) (Figure 24).

Figure 24. High-level Timing Considerations for Transition of Main Uses at WTC

Strategic Use	Order of Transition (1 being soonest, 5 being latest)
Chemical Fertilizers Manufacturing	No Transition Likely
Fabricated Structural Steel Manufacturing	5
Alumina Manufacturing	No Transition Likely
Cement Manufacturing	5
Ready Mixed Concrete Manufacturing	5
Manufacturing NEC	3
Grain Storage	No Transition Likely
Wool Scouring and Top Making	3
Petroleum Refining	No Transition Likely
Secondary Recovery and Alloying of Non-Ferrous Metals NEC	No Transition Likely
Materials Handling Equipment Manufacturing	3
Chemical Products Manufacturing NEC	No Transition Likely
Nickel Smelting Refining	No Transition Likely
Precision Engineered Products Manufacturing	4
Iron and Steel Basic Products Manufacturing	5
Other Motor Freight Transportation NEC	3
Fabricated Metal Products Manufacturing NEC	5
Inorganic Industrial Chemicals Manufacturing	No Transition Likely
Engineering Services	4
Iron and Steel Basic Products Manufacturing	5
Population Driven Use	**Order of Transition (1 being soonest,5 being latest)**
Building Construction - Industrial and Commercial	2
Other Warehousing and Storage NEC	2
Building Material Machinery and Equipment Wholesale/Warehousing	2
Paints Manufacturing	1
Meat, Primary Processing	1
Manufacturing NEC (Under Storage/Distribution PLUC)	2
Agricultural/Horticultural Products Wholesale/Warehousing	1
Construction Trade Services NEC	1
Motor Vehicles (New And Used Cars) - Retail	1

Strategic Use	Order of Transition (1 being soonest, 5 being latest)
Building Construction - General Contractor Services	1

Source: DLPH 2016, Pracsys 2021

It is likely that construction services, agricultural product wholesaling vehicle retailing, and non-port related manufacturing uses would transition out of the WTC in the short term. While there is land available at Latitude 32 in the short-medium term, this land will likely be required for more Strategic uses in the long-term and should be planned accordingly. With the significant investment that will occur through the Westport development, the high growth scenario could eventuate, in which case demand for industrial zoned land from Strategic uses will develop in the medium to long term that would benefit from being able to locate at the Subject Area.

It is unclear how land tenure will affect the transition of land uses to the Subject Area. Identifying suitable uses for different land holdings within the Subject Area and communicating with land holders may facilitate the transition.

6 IMPLEMENTATION

This section discusses the catalyst project drivers, both planned and under consideration, associated with the WTC, Westport and the area surrounding the Subject Area. It provides an understanding of the land considerations for accommodating the uses that could transition from the WTC into the Subject Area and discusses how land considerations will generate market signals for transitioning uses. It also discusses the demand for residential development and associated commercial uses and how one or both of these will need to be integrated with the transitioning uses.

6.1 Catalyst Projects

Catalyst projects in the area will generate demand for land from a variety of uses. Most of these projects will support higher levels of access, opportunities for supply chain efficiencies and incentives for new investment. Different catalyst projects will attract different land uses based on their nature. For instance, major road projects will likely attract light industrial uses to capitalise on proximity to passing freight and passenger vehicles. New manufacturing companies will likely lead to the development of supporting equipment and parts industries. Commercial development and public transport infrastructure will drive demand for residential land.

There are already a number of planned catalyst projects that have been identified and are at different levels of development. These have been summarised below with an understanding of the potential land demand that will be generated.

Road Upgrades

Anketell Road and Rowley Road have been identified as potential primary freight access routes linking the State's Freight Network to Westport.[12] The upgrades could provide dual carriageways from Kwinana Freeway to Westport along the southern and northern borders of the Study Area. The roads would provide access for freight vehicles up to 36.5 metres long, supporting significant road freight capacity. Land adjacent to major freight routes that is proximate to major port infrastructure is likely to attract businesses associated with uses servicing freight industries and highway commercial uses. For example, the following business could be expected to want to locate along an upgraded Anketell road:

- Truck orientated petrol station
- Hiring stores
- Tyre wholesale/retailers
- Mechanics
- Equipment distributors

[12] Fremantle Ports 2020, 'WA Government endorses future container port at Kwinana' Available from: https://www.fremantleports.com.au/news/westport-recommends-future-container-port-at-kwinana

Examples of similar development can be seen along Welshpool Rd (Between Albany Hwy and Roe Hwy) and along Dundas Rd leading to Tonkin Hwy. These uses would be seen as more compatible uses along a major freight route than residential or high traffic generating commercial or retail, particularly with regards to road safety and the potential for conflict between light and heavy vehicles. The level of compatibility will likely depend on the intersection types developed through the Anketell and Rowley Rd upgrades and smaller connecting roads in the Subject Area.

Related Land Uses:

- **Strategic** uses may develop due to high levels of access provided by major freight routes and nearby infrastructure
- **Population Driven** light industrial uses and highway commercial uses are likely to develop due to access to more strategic industries and passing freight vehicles

Intermodal Terminal and Supporting Rail Infrastructure

A major intermodal terminal (IMT) has been discussed at the latitude 32 industrial area to support Westport. It would require up to 205ha[13] and could accommodate infrastructure such as a freight/container handling facility with uses including a container park, offices, warehouses and a distribution centre. The IMT would need to be supported through major upgrades to the rail network including track-doubling the line near the Forrestfield Intermodal Terminal, the Cockburn – Kwinana line, and the connection between the Kwinana Triangle and Kwinana marshalling yard. A new line from the proposed Anketell Triangle to the port would also need to be constructed.[14][15] Intermodal terminals are significant projects that support major freight movements and drive land demand from specific industry uses. Kewdale and Welshpool East Industrial areas have been used to provide an understanding of the potential mix of uses that could developed around an IMT, should one eventuate at the WTC (Figure 25).

Figure 25. IMT Benchmark Ancillary Industry Breakdown

PLUC	Floorspace %
Primary / Rural	0%
Manufacturing / Processing / Fabrication	18%
Storage / Distribution	45%
Service Industry	10%
Shop / Retail	1%
Other Retail	2%

[13] Department of Planning 2020, 'Development Area 6A Structure Plan'. Available from: https://www.dplh.wa.gov.au/getmedia/fa5f20ed-1f4d-4136-87f9-ce23f5022a73/SPL-Cockburn-Latitude-32-Development-Area-6A-Structure-Plan-WAPC-ref-SPN-2227

[14] State Government 2020, 'Westport Stage 2 Report'. Available from: https://www.transport.wa.gov.au/mediaFiles/marine/PROJ_P_Westport_Future_Port_Recommendations_Stage_2_Report_May_2020.pdf

[15] IRJ 2020. 'Rail outline as major component of new Perth port'. Available from: https://www.railjournal.com/freight/rail-outlined-as-major-component-of-new-perth-port/

PLUC	Floorspace %
Office / Business	15%
Health / Welfare / Community Services	< 0%
Entertainment / Recreational & Cultural	< 0%
Residential	0%
Utilities / Communications	8%

Source: Department of Planning 2015

The large majority of development could be expected in Storage and Distribution facilities with significant elements of Manufacturing, Office space (likely as an incidental component of other uses) and Service Industry uses.

Related Land Uses:

- **Strategic** uses would be required for logistics, transport, storage and warehousing uses; manufacturing and service uses may develop in proximity due to supply chain efficiencies.

Strategic Manufacturing Hub

The State Government announced an economic development framework to support a Global Advanced Industries Hub in the WTC .[16] It will support significant investment that is being made into:

- Renewable Hydrogen
- Battery Industry – minerals, materials, technologies and expertise
- Defence industry infrastructure projects at the Australian Marine Complex (see AMC Development)
- LNG opportunities

The development of these uses would capitalise on the already established resource export capacity of the WTC and will support additional downstream manufacturing opportunities. This is seen as a project that if it eventuates will support the High grow scenario from a BAU perspective.

Related Land Uses:

- **Port Strategic** uses will be required to support the export of new resources.
- **Strategic** uses will be required in the form of manufacturing, equipment and professional services.

[16] Mark McGowan 2021. Available from: https://www.markmcgowan.com.au/2021/03/03/wa-labor-to-establish-global-high-tech-manufacturing-hub-south-of-perth/

AMC Development

The State Government has made a significant investment into the AMC through $87.6 million in funding to develop a new vessel transfer path, a new shipbuilding facility, a major wharf extension and upgrade, and three road intersection upgrades.[17] These developments will increase the capacity of the AMC and allow it to support future defence vessels that have specific size requirements. In addition, the State Government is targeting an increase in defence force funding that may require additional development of capacity at AMC.

The State government is also lobbying the Federal government to increase defence spending in WA from $3 billion to $6 billion per annum by 2030.[18] This funding would likely support increased development of the Nationally significant AMC industrial area. This type of development is likely to attract advanced manufacturing industries, specialised professional services and specialised support industries.

Related Land Uses:

- **Port Strategic** uses will be required to support additional capacity for ship related industry.
- **Strategic** uses will be required to support advanced manufacturing, professional service and other servicing needs.

Residential, Commercial and Transport Developments

There are a significant number of projects that will act as drivers for residential development at the Subject Area. These include:

- Employment generating projects. These will generate demand for residential land to a certain extent (i.e. population would want to live within a certain distance to employment but not directly adjacent to industrial uses)
- Residential development to the north and east of the Subject Area
- The potential for a future train station near the Subject Area that improves access to surrounding employment areas.
- Future commercial uses such as the planned shopping centre at the eastern intersection of Anketell Road and Kwinana Fwy and the smaller local centre planned in the residential development to the east of the Subject Area

These projects support demand for residential development. The attractiveness of the Subject Area for residential development is likely to decrease from East to West across the Subject Area approaching the Alcoa property and industrial areas.

Related Land Uses:

- **Population Driven** Commercial uses would develop to attract expenditure from residents. These uses would not be transitioning from WTC but would be new to the area.

[17] State Government 2021. Available from: https://www.mediastatements.wa.gov.au/Pages/McGowan/2021/01/Contract-awarded-for-87-point-6-million-dollar-defence-infrastructure-projects.aspx
[18] Ibid

6.2 Locational Considerations

The uses transitioning from the WTC that could be supported at the Subject Area will have specific requirements to be able to locate in the Subject Area. The following table provides a high-level understanding of the lot, access and conflict considerations that need to be assessed to plan suitable locations for different land uses within the Subject Area (Figure 26). It also considers the requirements for residential development and associated commercial uses. Lot size estimates are presented in Appendix 3, the estimates have been developed using high level benchmarking and require private market testing before being applied to the land.

Figure 26. Land, Access and Conflict Considerations

Land Uses	Land and Access Requirements	Conflict considerations
Strategic	• Medium - large lots • Access for heavy vehicles • Ability to integrate office space • May require buffer	• Conflict with residential development (i.e. noise, noxious industry, etc.) • Conflict with Population Driven Commercial uses (i.e. supermarket)
Population Driven (Light Industrial)	• Medium lot sizes • Frontage to major freight routes • Frontage to local roads	• Potential conflict with residential development. Can be managed with suitable transition to residential (i.e. public open space separation)
Population Driven (Commercial)	• Small – medium lots • Normal road access • Proximate to residential area	• Potential conflict adjacent next to heavy industrial uses due to high small vehicle traffic and potentially pedestrian traffic • Potential conflict along major freight route due to high small vehicle traffic and potentially pedestrian traffic
Residential	• Small lot sizes • Open space requirements • Walkability considerations (i.e. footpaths, bike paths, etc.)	• Conflict with Strategic uses (i.e. noxious industry, etc.) • Potential conflict with major freight routes unless suitable interface (i.e. noise blocking, appropriate access, etc.)

Source: Pracsys 2021

The following table provides a high-level summary of the appropriate locations for transitioning uses, residential development and commercial uses based on the above considerations that can inform land scenario planning (Figure 27).

Figure 27. Appropriate Locations for Land Uses

Desired Land Use	Appropriate location within the Subject Area
Strategic	• Western end of Subject Area with need for separation and potentially buffers to residential developments • Adjacent to either of the primary freight routes • Not suitable in the eastern section of the Subject Area along residential development
Population Driven (Transitioning Light Industrial)	• Western end of Subject Area • Central use between Strategic uses and Population-Driven Commercial uses or residential development • Adjacent to either of the primary freight routes • Eastern section of the Subject Area with appropriate transition to residential development (i.e. public open space separation)
Population Driven (Commercial – not a use transitioning from WTC)	• Eastern section of the Subject Area • Central use between Population Driven light industrial and residential development • Less suitable to Western end of Subject Area due to proximity to industrial uses • Not suitable along major freight routes
Residential	• Eastern section of Subject Area • Not suitable for Western end of Subject Area • Adjacent to Population Driven uses • Not suitable adjacent to major freight routes

6.3 Market Signals

The choices that are made with regards to the development of land at the Subject Area will send signals to the market that guide the uses that locate in the Subject Area. Land development decisions need to be consistent with the needs of desired uses, with an understanding of the industries that might transition from the WTC, their land requirements and potential conflicts they may have with other uses.

Depending on the desired outcome the following points summarise the high-level market signals that should be considered for the Subject Area and the timing of development they will support (Figure 28)

Figure 28. Market Signal Matrix - Position in Subject Area by Lot Size

Position / Lot Size	Small	Medium	Large
Along Major Freight Route	Not appropriate as it would likely attract Population Driven commercial uses or residential development with slow up take due to proximity to major freight route or develops and creates conflict with major freight route	Signal to Population Driven light industrial uses transitioning from WTC as demand arises	Signal to Strategic and Population Driven light industrial uses transitioning from WTC as demand arises

Position / Lot Size	Small	Medium	Large
West	Not appropriate as it would likely attract Population Driven commercial uses or residential development with slow up take due to major Freight route	Signal to Population Driven light industrial uses transitioning from WTC as demand arises. Not appropriate if attempting to accommodate Strategic uses with greater land requirements at the Subject Area	Signal Strategic and Population Driven light industrial uses transitioning from WTC as demand arises
Central	Signal to Population Driven commercial uses or residential development. Short to medium term, not appropriate for residential if Strategic uses are to be accommodated to the West	Signal to Population Driven light industrial uses transitioning from WTC as demand arises	Signal to Strategic and Population Driven light industrial uses transitioning from WTC as demand arises. Not appropriate for some Strategic uses
East	Signal to Population Driven commercial uses or residential development, will develop as other residential areas are completed	Not appropriate without appropriate separation from Residential Development. Population Driven light industrial uses transitioning from WTC as demand arises	Not appropriate as it would likely attract Strategic and Population Driven light industrial uses transitioning from WTC as demand arises

Source Pracsys 2021

A land planning example with consideration of industry requirements has been developed through the following hypothetical scenario:

- The high growth scenario is seen as most likely and both Population Driven and Strategic uses will transition from the WTC
- Strategic uses will require more than the 300 ha available at WTC however not all of the land is suitable to those uses
- A mix of uses is planned, providing as large an area as is possible for Strategic uses without creating conflict with surrounding residential development
- Population Driven uses are planned as a central use in the Subject Area moving from light industrial to commercial West to East
- Residential development is used to link commercial land uses with the residential development to the East of the Subject Area

Based on this scenario the following land planning considerations, resulting market signals and likely development timing have been summarised (Figure 29)

Figure 29. Hypothetical Land Use Mix Scenario

Land Use	Planning Consideration	Market Signal
Strategic	• Land appropriate to strategic uses is identified to the western side of the Subject Area and for some areas along major freight routes • Lots in these areas are identified as medium to large • Road access is planned for heavy vehicles • Appropriate buffers are in place for desired uses	There is a clear signal to the market that Strategic land uses should locate in the Subject Area. This land will develop in the long-term as Strategic use are transitioned from WTC. **Medium-long term development timeframe**
Population Driven	• These uses are identified as the separating uses between Strategic and Residential • A mix of lot sizes similar to what would be developed in a business park is planned with light industrial to the West and commercial to the East • Suitable road interfaces are developed to allow heavy vehicles but provide a safe environment for light vehicle traffic	Population Driven industries would be the first to transition out of the WTC. A business park type layout would attract these uses particularly with the nearby residential areas. **Medium term development timeframe**
Residential Development	• Residential area identified for development along the eastern side of the Subject Area • Buffers or suitable transitional area between residential development and major freight routes • Public open space as link between Population Driven uses and residential development or appropriate commercial uses adjacent (i.e. activity centre	Providing a defined residential zone that interfaces with the adjacent residential development to the East, is suitably separated from Strategic industrial and major freight routes will allow dwelling uptake to continue as surrounding areas are completed **Short – medium term development timeframe**

Source: Pracsys 2021

The potential need for additional land to support Strategic uses related to WTC and Westport is a key consideration. Planning for a high scenario where Strategic uses can be accommodated at the Subject Area will ensure sufficient land is available for future industrial uses. It is also a more flexible option as it would be possible to amend the zoning, should the demand for industrial land not eventuate, to allow for other more population orientated and residential uses due to the long development timeframe. However, if the land is planned for commercial or residential uses it is likely to develop in a shorter timeframe and it would likely be difficult and potentially impossible to change the planning to accommodate future demand for industrial land at the Subject Area.

Site Development Considerations

The different uses that could locate at the Subject Area will likely require different levels of site servicing and lot subdivision. High-level considerations have been developed based on our understanding of the general

needs for different land uses, these are not appropriate to inform site development decisions, appropriate market testing is required (Figure 30)

Figure 30. Site Development Considerations

Land Use	Site Development Considerations
Strategic	• Require flexible lot configurations • Require power however sometimes power requirements are additional to those of the grid capacity. In this case they may use their own power generation requiring access to gas or the use of diesel generators • Require water however these uses can often have to process water instead of using sewer systems or allowing for runoff • Parking requirements would be proponent specific Likely appropriate to allow for flexibility with regards to lots and services (i.e. service to a convenient location then allow proponents to access if required).
Population Driven	• Require different lot sizes but lots can be configured in a standardised layout (i.e. business park format, shopping centre) • Require access to power grid • Require access to water mains • Planning parking ratios would be relevant to these uses • Pedestrian and cyclist considerations would be required for commercial population driven uses Likely appropriate to subdivide a variety of lot sizes and provide services to lots.
Residential Development	• Require standard residential lots • Require access to power grid • Require access to water mains • Pedestrian and cyclist considerations required for Likely appropriate to subdivide lots and provide services to lots.

7 CONCLUSION

This analysis has assessed the land uses at the WTC to be able to understand the effect of Westport on industrial uses as it develops. The main land uses at the WTC were broken down into Port Strategic, Strategic and Population Driven uses to identify their level of friction related to moving out of the WTC.

The potential land demand generated by Westport was estimated using benchmark analysis of major Australian Ports. Three scenarios were developed and combined with the Business-as-Usual land demand scenarios from the IP47 Land Supply and Demand Analysis. Total demand was compared to future industrial land supply to estimate the potential gap in available industrial land at the WTC by 2041.

The analysis identified a potential gap of 190 ha in the Medium growth scenario and approximately 612 ha in the High growth scenario. It was determined that in the Medium Growth scenario most Population-Driven uses would transition out of the WTC and in the High scenario, all Population Driven uses and some Strategic uses that would benefit from proximity to the WTC would transition out of the WTC. It is unclear how land tenure will affect the transition of land uses to the Subject Area. Identifying suitable uses for different land holdings within the Subject Area and communicating with land holders may facilitate the transition.

Implementation considerations were developed to support decision making around land planning for the Subject Site. Should Strategic uses want to be accommodated at the Subject Area, planning needs to send clear signals by appropriately zoning the Subject Area, providing suitable lot sizes for desired uses and ensuring a suitable transition from Strategic uses to residential development from West to East. Planning for Strategic uses is seen as the most flexible option as the development of these uses is likely to occur over a longer timeframe and should demand not eventuate, it is likely that the land could be rezoned to accommodate more population orientated uses.

8 APPENDICES

8.1 Appendix 1: WASLUC to Transitional Concordance

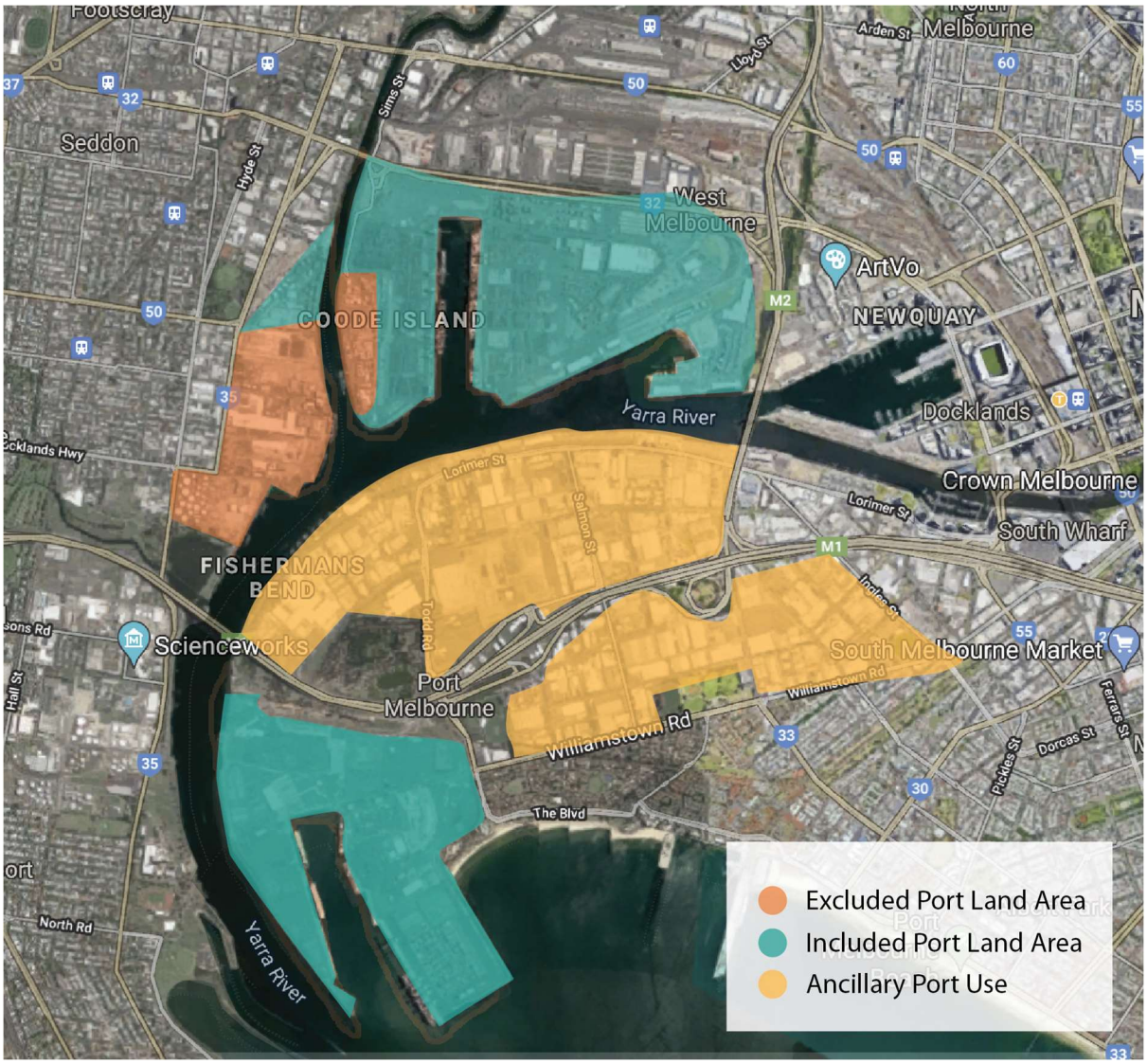
WASLUC DESCRIPTION Proper	Transition Category
Marine Terminals (Freight)	PORT-STRATEGIC
Ship Building	PORT-STRATEGIC
Boat Building - Aluminium	PORT-STRATEGIC
Electric Generation Plants	PORT-STRATEGIC
Marine Terminals (Freight)	PORT-STRATEGIC
Freight Forwarding Services	PORT-STRATEGIC
Boat Launching Services/Areas	PORT-STRATEGIC
Water Treatment Plants (Purification)	PORT-STRATEGIC
Chemical Fertilizers Manufacturing	STRATEGIC
Fabricated Structural Steel Manufacturing	STRATEGIC
Alumina Manufacturing	STRATEGIC
Cement Manufacturing	STRATEGIC
Ready Mixed Concrete Manufacturing	STRATEGIC
Engineering Services	STRATEGIC
Manufacturing NEC	STRATEGIC
Grain Storage	STRATEGIC
Wool Scouring and Top Making	STRATEGIC
Petroleum Refining	STRATEGIC
Secondary Recovery and Alloying of Non-Ferrous Metals NEC	STRATEGIC
Materials Handling Equipment Manufacturing	STRATEGIC
Chemical Products Manufacturing NEC	STRATEGIC
Nickel Smelting Refining	STRATEGIC
Precision Engineered Products Manufacturing	STRATEGIC
Nickel Smelting Refining	STRATEGIC
Iron and Steel Basic Products Manufacturing	STRATEGIC
Other Motor Freight Transportation NEC	STRATEGIC
Fabricated Metal Products Manufacturing NEC	STRATEGIC
Fabricated Structural Steel Manufacturing	STRATEGIC
Inorganic Industrial Chemicals Manufacturing	STRATEGIC
Engineering Services	STRATEGIC
Fabricated Structural Steel Manufacturing	STRATEGIC

WASLUC DESCRIPTION Proper	Transition Category
Iron and Steel Basic Products Manufacturing	STRATEGIC
Building Construction - Industrial and Commercial	POPULATION-DRIVEN
Other Warehousing and Storage NEC	POPULATION-DRIVEN
Building Material Machinery and Equipment Wholesale/Warehousing	POPULATION-DRIVEN
Paints Manufacturing	POPULATION-DRIVEN
Meat, Primary Processing	POPULATION-DRIVEN
Manufacturing NEC	POPULATION-DRIVEN
Agricultural/Horticultural Products Wholesale/Warehousing	POPULATION-DRIVEN
Construction Trade Services NEC	POPULATION-DRIVEN
Motor Vehicles (New And Used Cars) - Retail	POPULATION-DRIVEN
Building Construction - General Contractor Services	POPULATION-DRIVEN

8.2 Appendix 2: Benchmark Port Boundaries

Port of Melbourne

Figure 31. Port of Melbourne with Excluded Dry and Liquid Bulk Areas (Ancillary Uses Included)



Source: Pracsys 2021, Google Maps 2021

Fremantle Port

Figure 32. Fremantle Port with Ancillary Uses Included

Source: Pracsys 2021, Google Maps 2021

8.3 Appendix 3: Lot Size Assumptions

Lot sizes have been developed through benchmarking to similar land areas within the south west of Perth. The estimates have been developed using high level benchmarking and are not suitable to inform land subdivision decisions. It is strongly recommended that private market testing is required before land subdivision decisions can be made.

Figure 33. Lot Size Estimates

Land Uses	Estimated Lot Ranges (m^2)	Notes
Industrial land uses (strategic and population driven)	4,300 – 133,000	This range includes smaller uses such as car wreckers to large uses such as warehouses. Although strategic industrial uses would generally be the larger industrial uses, some population driven industrial uses can require significant space, for example Pickles auctions has a site in excess of 100,000m^2. There may be uses that fall outside of this range both smaller and larger.
Population Driven (Bulky Goods)	1,000 – 15,000	The range is based on a range from small individual operator such as an electronics retailer to a large bulky goods operator such as a Bunnings.
Population Driven (Shop Retail)	1,664 – 9,196	The range represents local to large neighbourhood centres that include uses such as supermarkets, takeaway food services and department stores, among others.
Residential	450	Medium - Low density estimate

Source: DPLH 2020

pracsys.

DPLH

IP47 Employment Estimate Assumptions

JULY 2023

1 INTRODUCTION

The IP47 project is looking to provide a suitable mix of commercial and non-commercial uses at the IP47 site in Mandogalup. The site is influenced by general industrial uses with buffer requirements to the west and residential uses to the east. The site needs to provide a transition from commercial uses (west) to residential uses (east). The Department of Planning, Lands and Heritage (DPLH) has worked with the IP47 project team to define a concept plan of uses for the IP47 area. The potential employment generated by the proposed concept plan needs to be estimated to support planning decision making and to inform traffic modelling.

Pracsys has been approached to provide employment estimates based on the identified concept plan. A benchmark approach has been used based on:

- Previous context through land use and demand analysis for the IP47 project
- Benchmark commercial areas aligned to the type of land use proposed
- DPLH Land Use and Employment Survey (LUES) data
- ABS Census Industry of Employment data

The approach uses benchmarking to develop job to land (ha) ratios that can be used to quantify employment based on land area in the concept plan. Benchmarks have also been used to give an approximate industry breakdown by land type.

2 CONCEPT

The concept being considered by the department is shown below (Figure 2). It includes a mix of residential and commercial uses, including:

- General industrial
- Light industrial
- Commercial
- Local centre

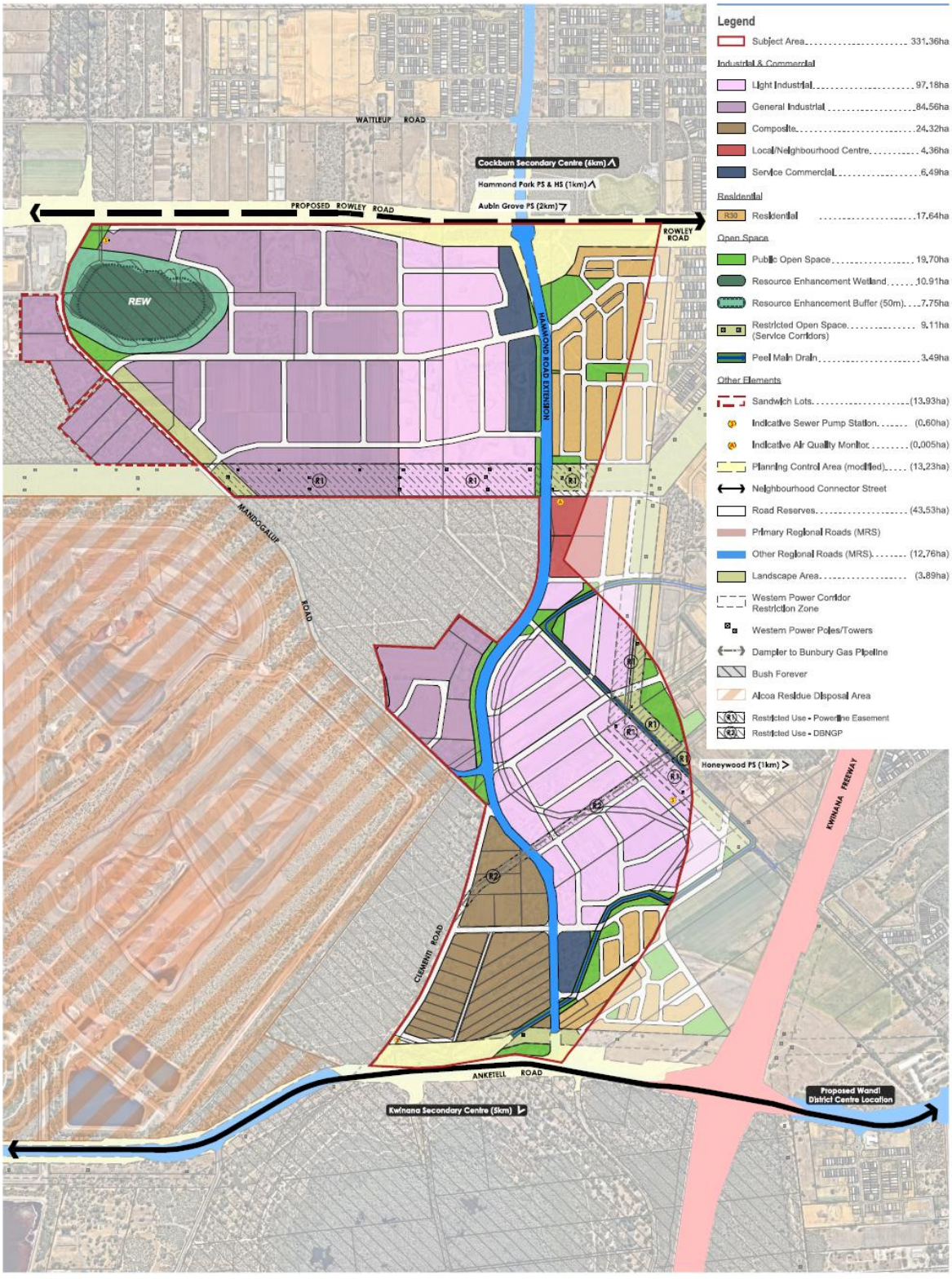
The land area for each type of land use was drawn from DPLH estimates based on the concept. The net developable area (excluding green space) was used to inform the scale of employment achieved (Figure 1).

Figure 1. IP47 Area (ha) by Land Use

Land Use	Net Developable Area (ha)
General Industry	107
Light Industry	95
Commercial	7
Local Centre	2

Source: DPLH 2023

Figure 2. IP47 Concept Map



3 ASSUMPTIONS

A number of key assumptions were made to estimate the employment and industry mix of the IP47 Concept Plan land uses. Industrial land assumptions include:

Industrial Assumptions

- Net lettable area provided by DPLH for IP47 land uses could be approximated by using LUES complex level areas and removing large green spaces; some small green spaces may be included, which would cause a slightly lower employment estimate (see Section 6, Appendix 1: Benchmark Areas)
- At a high level the benchmarks chosen reflect the potential uses that could be accommodated at the site based on its location and characteristics. For instance, if less strategic uses occupy the general industrial zoned land, higher employment estimates are likely to be achieved as these uses tend to be more employment intensive
- The employment estimate is based on full development of IP47 industrial land which is likely to occur in the long term (see Land Supply and Demand Analysis Report)
- Certain industries were excluded from the industry mix for general industrial zoned land as they would likely locate on other land use types such as health services, financial services and other population related uses

The commercial and local centres required additional assumptions due to considerations around activity centre hierarchy and viability of relevant uses at IP47 and in and surrounding centres.

Commercial assumptions

- The approximate commercial area could be in the region of 25,000m^2 and 50,000m^2; both ends of the range were tested, further analysis and research will be required to establish viability, including consideration of market appetite
- The commercial area will be taken up by population orientated uses based on the benchmark, which aligns with the desired transition to residential zoned land; the uses that occupy the area may develop as light industrial in nature depending on the level of demand generated by the surrounding industrial areas and the development of Westport
- Full development of the commercial area is achieved

Local Centre

- It was assumed that the northern local centre would support 1,500m^2 of shop retail floorspace, further analysis and research will be required to establish viability, including consideration of market appetite
- It was assumed the southern local centre (now shown as service commercial uses close to Anketell Rd) would support 500m^2 of shop retail floorspace

- It was assumed that non-retail floorspace would be provided at the northern local centre based on the benchmark estimate for shop retail to non-shop retail uses
- Employment estimates are based on full buildout

The following assumptions are summarised for the Commercial and Local Centre estimates (

Figure 3).

Figure 3. Commercial and Local Centre Assumptions

Floorspace Assumptions	Assumption	Value (m^2)
Commercial Centre	Tested commercial at approximately 50,000m^2 and 25,000m^2, assumed mix of uses based on benchmark	50,000m^2 25,000m^2
Local Centre (SHP)	Assumed local centre will be 1,500m^2 SHP NLA.	1,500
Local Centre (Non-Shop)	Benchmark estimate of Non-NLA floorspace is 1:1.1 compared to SHP (or 45% of total)	1,227
Local Centre / Service Commercial South	Assumed 500m^2 of SHP NLA - convenience and fast food	500

Source: DPLH 2016

4 BENCHMARKS

Benchmarks were identified to determine job to land (ha) ratios and floorspace (m^2) to job ratios for estimating employment, and for high-level industry mixes for each land use type.

4.1 Industrial Benchmarks

Employment benchmarks for industrial land used job to land (ha) ratios to estimate employment. Two benchmarks were used based on the type of industrial land:

- Bibra Industrial Area was used for light industrial uses as it is a more population driven industrial area with higher density of employment
- Henderson Industrial Area was used for General Industrial land as it is a strategic industrial area with port related uses that are more likely to be reflective of general industrial uses that can be expected at IP47

The land area estimates were developed based on DPLH lues complex level data which includes land area and employment estimates (Figure 4).

Figure 4. Industrial Benchmark Data

Benchmark(s)	LUES Jobs[1]	LUES Land Area (ha)	Land Area Removed (ha)
Bibra Industrial Area	10,697	582	23
Henderson Industrial Area	4,692	376	28

Source: DPLH 2016, QGIS 2023

Any large green spaces were identified by desktop review and removed manually. This aligns the estimates with the net land area provided by DPLH for each IP47 land use type and includes roads, footpaths, parking, etc. in the estimate. Section 6, Appendix 1: Benchmark Areas provides map images with areas used to estimate green space and the area estimated (ha).

Figure 5. Industrial Job to Land (ha) Ratios

Relevant Land Use	Benchmark(s)	Value
Light Industrial Land	Bibra Industrial Area	19.41 jobs per ha
Heavy / General Industrial Land	Henderson Industrial Area	13.47 jobs per ha

Source: DPLH 2016, QGIS 2023

These ratios were applied to the net land area of IP47 light and general industrial land respectively to estimate employment.

[1] Total of full time and part time, consistent with ABS Census Employment Data

ABS Census data for employment relevant to each industrial area was used to estimate the potential industry mix. The ABS spatial areas are not exactly aligned to LUES spatial areas; however, they are sufficiently aligned to allow for high-level industry mix estimates (Figure 6).

Figure 6. Benchmark Industry Mix

ABS ANZSIC 1	Henderson	Bibra Industrial
	General Industrial	Light Industrial
Agriculture, Forestry and Fishing	0%	1%
Mining	5%	4%
Manufacturing	47%	23%
Electricity, Gas, Water and Waste Services	2%	3%
Construction	23%	19%
Wholesale Trade	2%	9%
Retail Trade	1%	6%
Accommodation and Food Services	1%	1%
Transport, Postal and Warehousing	2%	10%
Information Media and Telecommunications	0%	0%
Financial and Insurance Services	0%	0%
Rental, Hiring and Real Estate Services	0%	1%
Professional, Scientific and Technical Services	7%	6%
Administrative and Support Services	2%	3%
Public Administration and Safety	6%	3%
Education and Training	0%	2%
Health Care and Social Assistance	0%	1%
Arts and Recreation Services	0%	2%
Other Services	2%	5%

Source: ABS Census 2021

4.2 Commercial and Local Centre Benchmarks

Employment benchmarks for commercial and local centres used floorspace (m^2) to employment ratios to estimate employment. Three benchmarks were identified, one for commercial uses and two (combined) for local centre uses:

- Jandakot-E (part of Cockburn Central, east of the Kwinana Fwy) was used for commercial uses as it has a mix of large format retail and other service commercial uses that are appropriate for commercial zoned land

- Yarra Promenade and The Grange activity centres were used to inform local centre estimates as they are local centres in the Cockburn activity centre hierarchy

These estimates were developed using LUES complex data for industrial and commercial centres and include the following data points (Figure 7).

Figure 7. Commercial and Local Centre Benchmark Data

Benchmark(s)	LUES Jobs[2]	LUES Floorspace (m^2)
Jandakot-E (Cockburn Central)	2,837	297,296
Yarra Promenade and The Grange (SHP)[3]	136	2,489
Yarra Promenade and The Grange (Non-SHP)	38	2,028

Source: DPLH 2016, QGIS 2023

The data was used to develop floorspace (m^2) to job ratios for the relevant floorspace types and applied to the assumed floorspace amounts identified in Section 3, Assumptions (Figure 8).

Figure 8. Commercial and Local Centre Floorspace (m^2) to Job Ratios

Relevant Land Use	Benchmark(s)	Value
Commercial Land	Jandakot-E (Cockburn Central)	104.79m2 per job (NLA)
Activity Centre Land (SHP)	Yarra Promenade and The Grange	20.49m2 per job (NLA)
Activity Centre Land (Non-SHP)	Yarra Promenade and The Grange	61.57m2 per job (NLA)

Source: DPLH 2016

ABS Census data for employment relevant to Jandakot-E spatial area was used to estimate the potential industry mix. The ABS spatial area was not exactly aligned to the LUES spatial area; however, it was sufficiently aligned to allow for high-level industry mix estimates (Figure 6). The local centre industry mix was estimated based on an ABS Spatial area within the City of Cockburn that included local centre employment with other employment in easily identifiable industry categories (i.e. a high school with education industry employment).[4] Industry categories that were not likely to occur in a local centre were removed.

Figure 9. Benchmark Industry Mix

ABS ANZSIC 1	Jandakot-E	Local Centre
	Commercial	
Agriculture, Forestry and Fishing	0%	Excluded
Mining	4%	Excluded
Manufacturing	14%	Excluded
Electricity, Gas, Water and Waste Services	6%	Excluded

[2] Total of full time and part time, consistent with ABS Census Employment Data
[3] These are the averages of the two benchmark centres
[4] Please see Section 7, Appendix 2: Local Centre ABS Spatial Area (Destination Zone)

ABS ANZSIC 1	Jandakot-E	Local Centre
	Commercial	
Construction	18%	Excluded
Wholesale Trade	9%	Excluded
Retail Trade	20%	36%
Accommodation and Food Services	6%	10%
Transport, Postal and Warehousing	4%	6%
Information Media and Telecommunications	0%	1%
Financial and Insurance Services	0%	4%
Rental, Hiring and Real Estate Services	1%	4%
Professional, Scientific and Technical Services	2%	12%
Administrative and Support Services	1%	9%
Public Administration and Safety	1%	5%
Education and Training	4%	Excluded (these uses may occur in local centres, however, were assumed to be excluded from the IP47 centre)
Health Care and Social Assistance	3%	Excluded (these uses may occur in local centres, however, were assumed to be excluded from the IP47 centre)
Arts and Recreation Services	2%	2%
Other Services	6%	12%

Source: ABS Census 2021

5 RESULTS

The assumptions and benchmarks were applied to DPLH data for land area in the IP47 concept. The land uses were identified by zone to inform traffic modelling estimates. Employment estimates are provided by Land Use Type and by Industry Type across the zones. Summary results are provided below for total employment by Land Use Type (Figure 10) and Industry, the full results by zone are provided in the workbook: 'Pracsys Benchmark Employment Modelling 1.0 2023.07.11'.

Figure 10. Employment by Land Use Type

Land Use Type	Sub-category	Total (Ha)
General Industrial	N/A	1,443
Light Industrial	N/A	1,838
Commercial	50,000m^2 NLA Scenario	488
Commercial	25,000m^2 NLA Scenario	244
Local Centre	Shop Retail Uses	98
Local Centre	Non-Shop Retail Uses	20
Total Local Centre	Total Local Centre	118
Total Employment (50,000m^2 Commercial Scenario)		**3,887**

Source: DPLH 2016 / 23

Figure 11. Employment by Land Use Type and Industry (50,000m^2 Commercial Scenario)

ABS ANZSIC 1	General Industrial	Light Industrial	Commercial	Total Local Centre
Agriculture, Forestry and Fishing	-	20	1	-
Mining	72	71	20	-
Manufacturing	678	421	67	-
Electricity, Gas, Water and Waste Services	29	56	31	-
Construction	332	342	86	-
Wholesale Trade	29	174	45	-
Retail Trade	14	108	97	42
Accommodation and Food Services	14	27	27	12
Transport, Postal and Warehousing	29	182	19	7
Information Media and Telecommunications	-	4	1	1
Financial and Insurance Services	-	4	-	4
Rental, Hiring and Real Estate Services	-	14	4	5
Professional, Scientific and Technical Services	101	108	9	14
Administrative and Support Services	29	57	7	10

ABS ANZSIC 1	General Industrial	Light Industrial	Commercial	Total Local Centre
Public Administration and Safety	87	56	5	6
Education and Training	-	44	18	-
Health Care and Social Assistance	-	19	14	-
Arts and Recreation Services	-	31	10	3
Other Services	29	100	28	14
Total	**1,443**	**1,838**	**488**	**118**

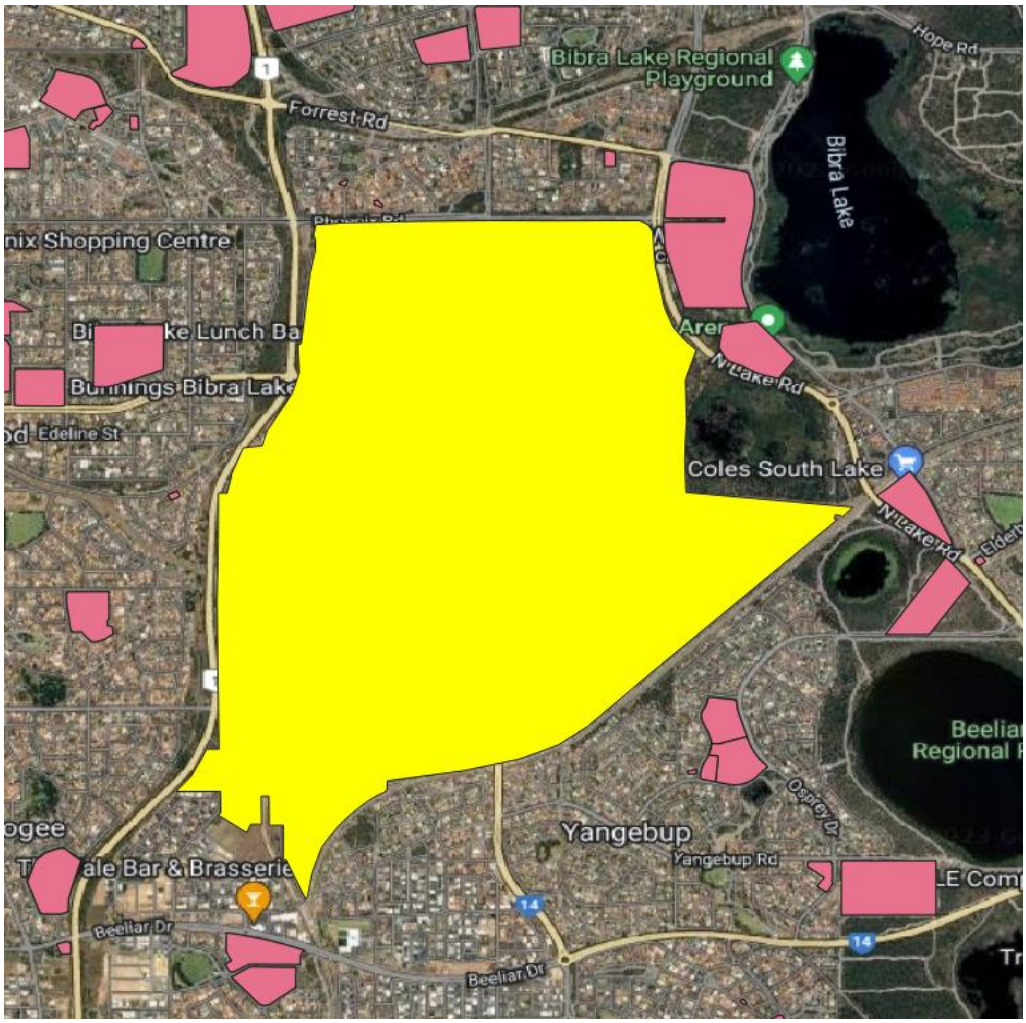
Source: DPLH 2016 / 23, ABS 2021

6 APPENDIX 1: BENCHMARK AREAS

All images are sourced using QGIS software and Google Maps images.

6.1 Bibra Industrial Area

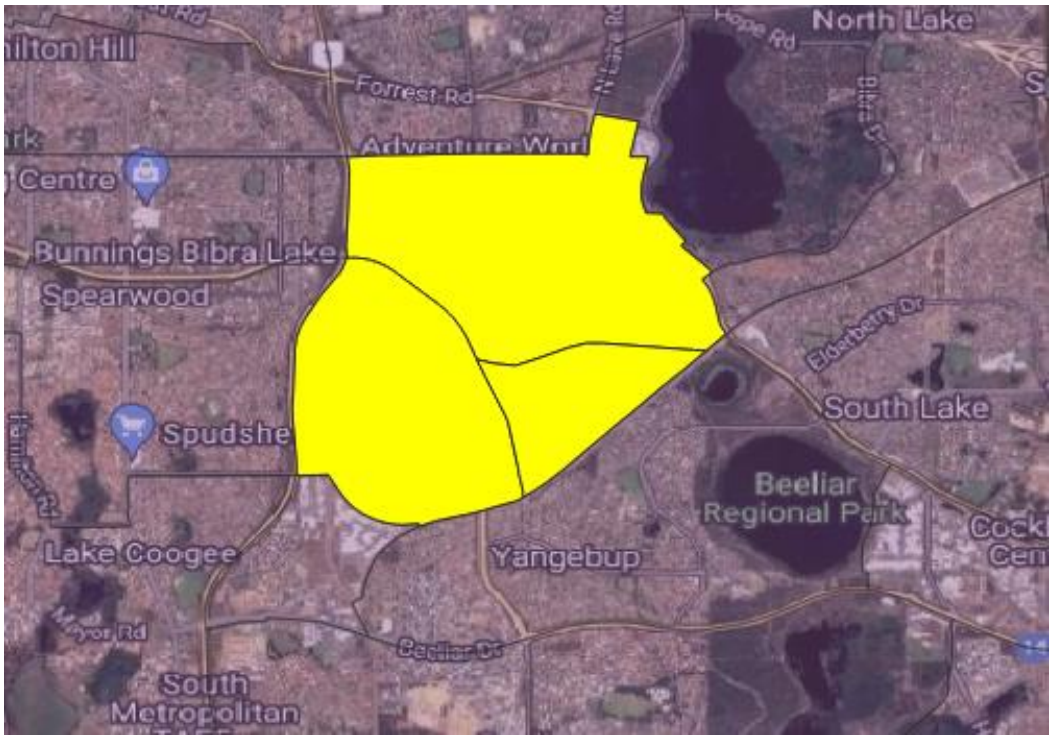
LUES Spatial Area: 582 ha



Green Space Estimate: 23 ha

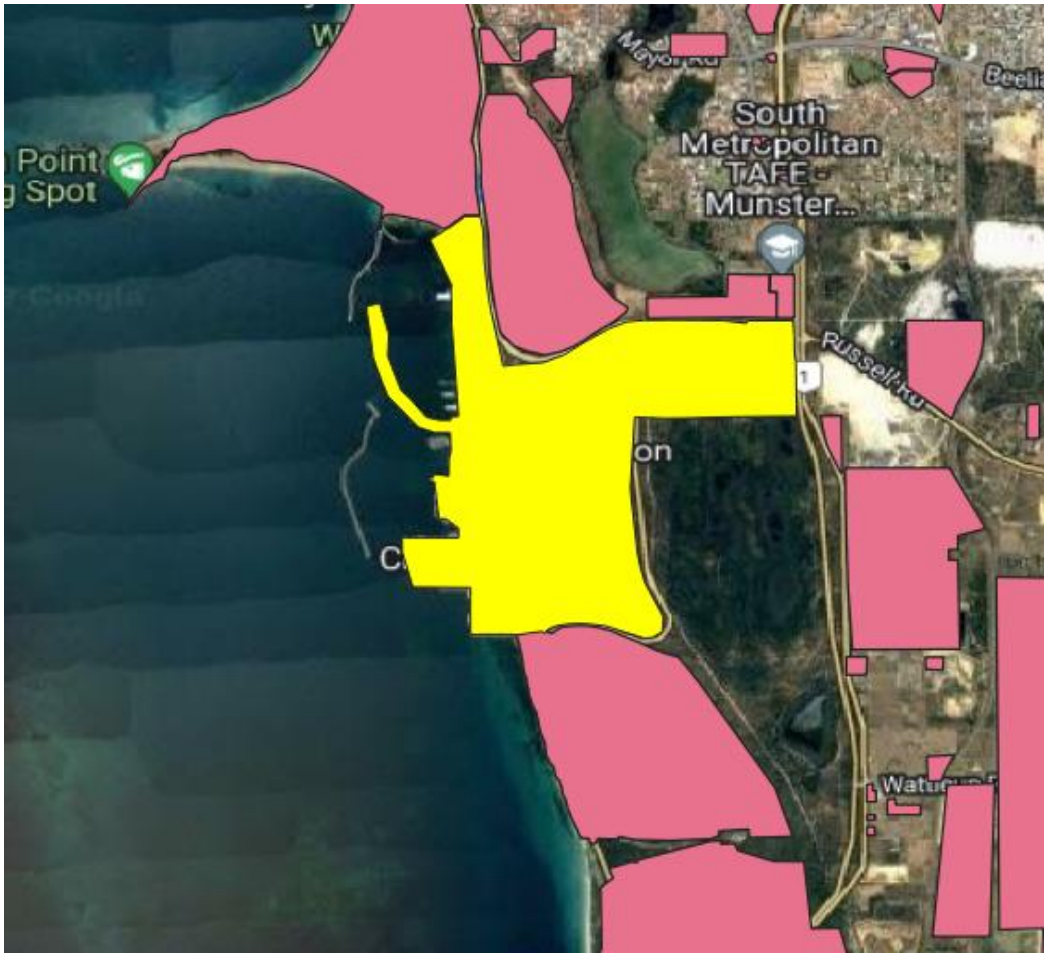
DZNs Used for Industry

511501769
511501778
511501781



6.2 Henderson Industrial Area

LUES Spatial Area: 376 ha



Green Space Estimate 1: 24 ha

Open Space Estimate 2: 4 ha

DZN Used for Industry

511551795

6.3 Jandakot-E Commercial Area (Industrial Complex)

DZN Used for Industry

512600002

6.4 The Grange

6.5 Yarra Promenade

7 APPENDIX 2: LOCAL CENTRE ABS SPATIAL AREA (DESTINATION ZONE)

511481771

Appendix E

Transport Report

flyt

Mandogalup Improvement Scheme

TRANSPORT REPORT

email: info@flyt.com.au twitter.com/flytplan web: www.flyt.com.au

PROJECT	81113-471-FLYT-REP-0002			
Revision	**Description**	**Originator**	**Review**	**Date**
0	Draft Reviewed	AJS/CXS	CAS/TBB/DPLH	09/12/2019
1	Issued	AJS	CAS	27/03/2020
2	Updated Report	MDR	AJS	04/08/2023
3	Final Report	MDR	CXS	16/08/2023

Contents

1. Introduction 6

1.1 Transport Report 6

1.2 Project Background 6

1.2.1 Project Development Phase (2019-2020) 6

1.2.2 Project Finalisation Phase (2023) 6

1.3 Improvement Plan 47 7

1.4 Report Structure 9

2. Improvement Plan Land Use Scenarios 10

2.1 Overview of Land Use Scenarios 10

2.2 Project Development Phase Scenarios (2019-2020) 10

2.2.1 Residential Land Use Scenario 10

2.2.2 Industrial Land Use Scenario 10

2.2.3 Combined Land Use Scenario 11

2.3 Project Finalisation Phase Scenarios (2023) 11

2.3.1 Draft Preferred Land Use Scenario 11

2.3.2 Modified Preferred Land Use Scenario with 25,000m^2 or 50,000m^2 Commercial Floor Area 12

2.3.3 Final Preferred Land Use Scenario with 25,000m^2 Commercial Floor Area 12

3. Regional Perspective 18

3.1 Development Context 18

3.2 Surrounding Land Uses 19

3.2.1 Mandogalup East and Mandogalup West Local Structure Plans 19

3.2.2 Hammond Park 21

3.3 Westport 22

4. Existing Vehicle Movement and Access 25

4.1 Road Network 25

4.1.1 Rowley Road and Wattleup Road 26

4.1.2 Anketell Road 29

4.1.3 Mandogalup Road 32

4.1.4 Other Regional Road Extension to Hammond Road 33
4.2 Restricted Access Vehicle Network 35
4.2.1 Wider RAV Network 36
4.2.2 Oversize Over-mass 37
5. Existing Public Transport 38
5.1 Public Transport Network 38
6. Existing Pedestrian Network 39
6.1 Pedestrian Network 39
7. Existing Cycling Network 41
7.1 Cycling Network 41
7.2 Future Cycling Network 43
8. Analysis of Improvement Plan Land Use Scenarios 44
8.1 High-Level Analysis Method 44
8.2 Vehicle Trip Rates 44
8.3 Traffic Generation 45
8.4 Traffic Distribution 49
9. Final Preferred Land Use Scenario Access Strategy 54
9.1 Main Roads WA ROM Model Data (2051) 54
9.2 Traffic Volumes (2051) 56
9.3 Road Network Hierarchy 60
9.4 Internal Transport Network 63
9.4.1 Restricted Access Vehicle Network 63
9.4.2 Cross Sections 64
9.4.3 Intersections 66
9.5 Access Principles 68
9.5.1 Hammond Road Extension between Rowley Road and Anketell Road 68
9.5.2 Mandogalup Road between Rowley Road and Hammond Road Extension 68
10. Summary 69
10.1 Project Background 69

10.2 Final Preferred Land Use Scenario 69
10.2.1 Traffic Volumes 70
10.2.2 Road Network Hierarchy 70
10.2.3 Restricted Vehicle Access Network 71
10.2.4 Intersections 71
10.2.5 Access Principles 71

Figures

Figure 1 Improvement Plan Area (Source: DPLH) 7
Figure 2 Area considered within Transport Report (source: TBB) 8
Figure 3 Residential land use scenario plan (source: TBB) 13
Figure 4 Industrial land use scenario plan (source: TBB) 14
Figure 5 Combined land use scenario plan (source: TBB) 15
Figure 6 Draft preferred land use scenario plan (source: TBB) 16
Figure 7 Modified/Final preferred land use scenario plan with 25,000m^2 or 50,000m^2 commercial GFA (source: TBB) 17
Figure 8 Regional location of Mandogalup Scheme Area (source: Nearmap) 18
Figure 9 Metropolitan Region Scheme 19
Figure 10 Combined Mandogalup East and West Concept Plan (Source: City of Kwinana) 20
Figure 11 Southern Suburbs District Structure Plan Stage 3 Hammond Park 21
Figure 12 Westport MCA-1 options 23
Figure 13 Westport MCA-2 options (source: DoT) 23
Figure 14 Indicative alignment for Anketell-Thomas Road Freight Corridor (source: Westport) 24
Figure 15 Road hierarchy surrounding Scheme Area (source: Main Roads WA) 25
Figure 16 Posted speed limits surrounding Scheme Area (Source: Main Roads WA) 25
Figure 17 Rowley Road view to west (Source: Google Maps) 26
Figure 18 Rowley Road west of Kwinana Freeway average traffic volumes 2017-18 (source: Main Roads WA Traffic Map) 27
Figure 19 Configuration of Rowley Road and Kwinana Freeway interchange (source: Nearmap) 27
Figure 20 Planning Control Area 156 – Rowley Road (source: DPLH) 28
Figure 21 Anketell Road, view to west. (Source: Google Maps) 29

Figure 22 Anketell Road west of Kwinana Freeway average traffic volumes 2020/2021 (source: Main RoadsTrafficmap) 30
Figure 23 Configuration of Anketell Road and Kwinana Freeway interchange (source: Nearmap) 30
Figure 24 Planning Control Area 157 – Anketell Road (source: DPLH) 31
Figure 25 Mandogalup Road view to south (Source: Flyt) 32
Figure 26 Other Regional Road reservation through Mandogalup 33
Figure 27 Hammond Park – Frankland Avenue Lots 43-44 34
Figure 28 Main Roads WA RAV Network routes (source: Main Roads WA) 35
Figure 29 Overall RAV Network – Perth Metropolitan Region (source: Main Roads WA) 36
Figure 30 Metropolitan Oversize over mass corridors (source: Main Roads WA) 37
Figure 31 Transperth network map 2020 (source: Transperth) 38
Figure 32 Travel time Platform Walking and Cycling 39
Figure 33 Strava Heat Map – Walking and Running 40
Figure 34 Cockburn and Rockingham: Perth comprehensive bike map (Source: DoT) 41
Figure 35 Strava Heat Map – Cycling (source: Strava) 42
Figure 36 Long Term Cycle Network (source: DoT) 43
Figure 37 Land Use Scenarios Vehicle Trip Generation Precincts (base plan source: TBB) 49
Figure 38 Residential Land Use Scenario – Traffic Distribution 51
Figure 39 Industrial Land Use Scenario – Traffic Distribution 51
Figure 40 Combined Land Use Scenario – Traffic Distribution 52
Figure 41 Draft Preferred Land Use Scenario – Traffic Distribution 52
Figure 42 Modified Preferred Land Use Scenario (with 50,000m^2 commercial GFA) – Traffic Distribution 53
Figure 43 Final Preferred Land Use Scenario (with 25,000m^2 commercial GFA) – Traffic Distribution 53
Figure 44 2051 Daily Traffic Volumes (traffic volume source: Main Roads WA / base plan source: TBB) 55
Figure 45 Additional 2051 Daily Traffic Volumes Not Accounted for in Main Roads Land Uses (base plan source: TBB) 57
Figure 46 Total 2051 Daily Traffic Volumes Including Final Preferred Scenario Land Uses (base plan source: TBB) 58
Figure 47 Total 2051 Daily Traffic Volumes Including Final Preferred Scenario Land Uses and Traffic Volumes on Internal Roads (base plan source: TBB) 59
Figure 48 Road Hierarchy for WA – Road Categories and Criteria (source: Main Roads WA) 61
Figure 49 Existing Road Hierarchy Classification (base plan source: TBB) 62

Figure 50 Potential 2051 Road Hierarchy Classification (base plan source: TBB) 62

Figure 51 Potential RAV Network (base plan source: TBB) 63

Figure 52 Potential Distributor Road Cross Sections 65

Figure 53 Proposed Intersection Controls for Major Road Network (base plan source: TBB) 67

Tables

Table 1 Summary of survey data for Mandogalup Road intersections 32

Table 2 Vehicle Trip Rates 44

Table 3 Vehicle Trip Generation for Land Use Scenarios 45

Table 4 Residential Land Use Scenario – Traffic Generation 46

Table 5 Industrial Land Use Scenario – Traffic Generation 46

Table 6 Combined Land Use Scenario – Traffic Generation 47

Table 7 Draft Preferred Land Use Scenario – Traffic Generation 47

Table 8 Modified Preferred Land Use Scenario (with 50,000m^2 commercial GFA) – Traffic Generation 48

Table 9 Final Preferred Land Use Scenario (with 25,000m^2 commercial GFA) – Traffic Generation 48

Table 10 Additional External Vehicle Trips Generated by Land Use Scenarios in 2041 50

1. INTRODUCTION

1.1 Transport Report

This Transport Report has been prepared in support of the Mandogalup Improvement Scheme, located in the City of Kwinana. The purpose of this report is to assess the land use and transport elements of the proposed development scenarios and support the preparation of the Land Use Plan and Improvement Scheme.

This report builds on the previous work completed by Flyt in 2019 and 2020 whilst also incorporating the ongoing planning associated with the progression of the Westport project. The key issues addressed in this Transport Report are:

- Traffic generation from the proposed development scenarios for the Improvement Scheme Area
- Interaction with the external road network – in particular the strategic and freight road network given the industrial land uses with vicinity of the Improvement Scheme Area and recent Westport announcements.

1.2 Project Background

1.2.1 Project Development Phase (2019-2020)

In 2019, Flyt began working with the Department of Planning, Lands and Heritage together with Taylor Burrell Barnett (TBB) to develop three different land use scenarios for the future of the Mandogalup Improvement Scheme, these are:

- Residential land use scenario
- Industrial land use scenario
- Combined land use scenario (residential and industrial land uses).

Elements relating to the progression of the Mandogalup Improvement Scheme were at that time, heavily reliant on the finalisation of the Westport project whereby the ultimate decision on the potential for a new port and its operation capacity would significantly affect the future land uses and transport network in and around Mandogalup. At the time, it was also unclear whether Anketell Road to the south or Rowley Road to the north would be identified as the main freight route connection.

The Westport project was tasked with assessing the long term development of Perth's freight network with a focus on the ports at Fremantle, Kwinana and Bunbury. Throughout 2019, a shortlist of options for the future of Western Australia's port operations was advertised and in August 2020 Westport's Independent Taskforce recommended a new container port in Kwinana which was subsequently endorsed by the State Government.

1.2.2 Project Finalisation Phase (2023)

In March 2023, the Department of Planning, Lands and Heritage (DPLH) together with stakeholders and the project team, identified that the preferred form of development for the Mandogalup Improvement Scheme. The preferred form of development was confirmed as a modified combined scenario featuring significant light and heavy industrial land uses with supporting commercial floorspace and limited residential development with small scale supporting retail.

During the project finalisation phase, the final preferred land use scenario was determined through a process of technical assessment and review from the TBB led consultant team. The preferred land use scenario was finalised through an iterative process of scenario development:

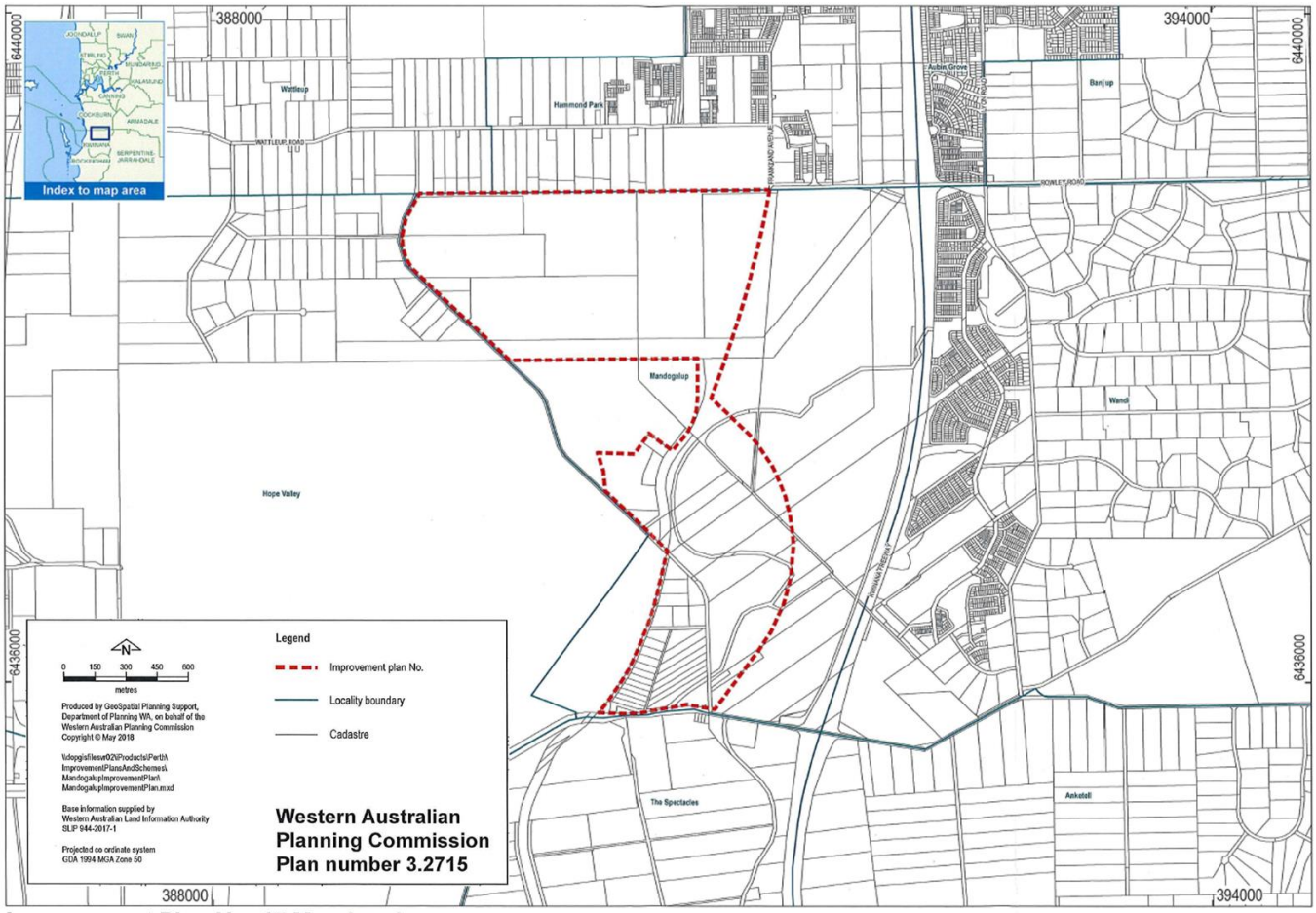
- Draft preferred land use scenario
- Modified preferred land use scenario with 25,000m^2 or 50,000m^2 commercial floor area
- Final preferred land use scenario with 25,000m^2 commercial floor area.

The final preferred land use scenario will support the progression of the new container port in Kwinana, using the Anketell – Thomas Road alignment as the main freight route.

1.3 Improvement Plan 47

In April 2019 the Mandogalup Improvement Plan came into effect. The plan provides the framework for an Improvement Scheme to facilitate future development of the Mandogalup area in the City of Kwinana.

The area subject to the Mandogalup Improvement Plan is shown in Western Australian Planning Commission (WAPC) Plan 3.2715, reproduced as Figure 1. The area is bound by Rowley Road to the north and Anketell Road to the south. The Kwinana Freeway is to the east, and the Kwinana Industrial Area (KIA) is to the west.



Improvement Plan No. 47 Mandogalup

Figure 1 Improvement Plan Area (Source: DPLH)

Improvement Plan 47 covers an area of approximately 330 hectares. Existing land uses include agriculture, horticulture and associated residential dwellings. The Improvement Plan requires that preparation of the improvement scheme be guided by the transport related objective to *facilitate the provision of an effective, efficient, integrated and safe transport network*. In addition to considering the lots within the boundaries of the plan, this report also considers implications for lots flanking the area to the west which front Mandogalup Road. These additional lots are shown in Figure 2.

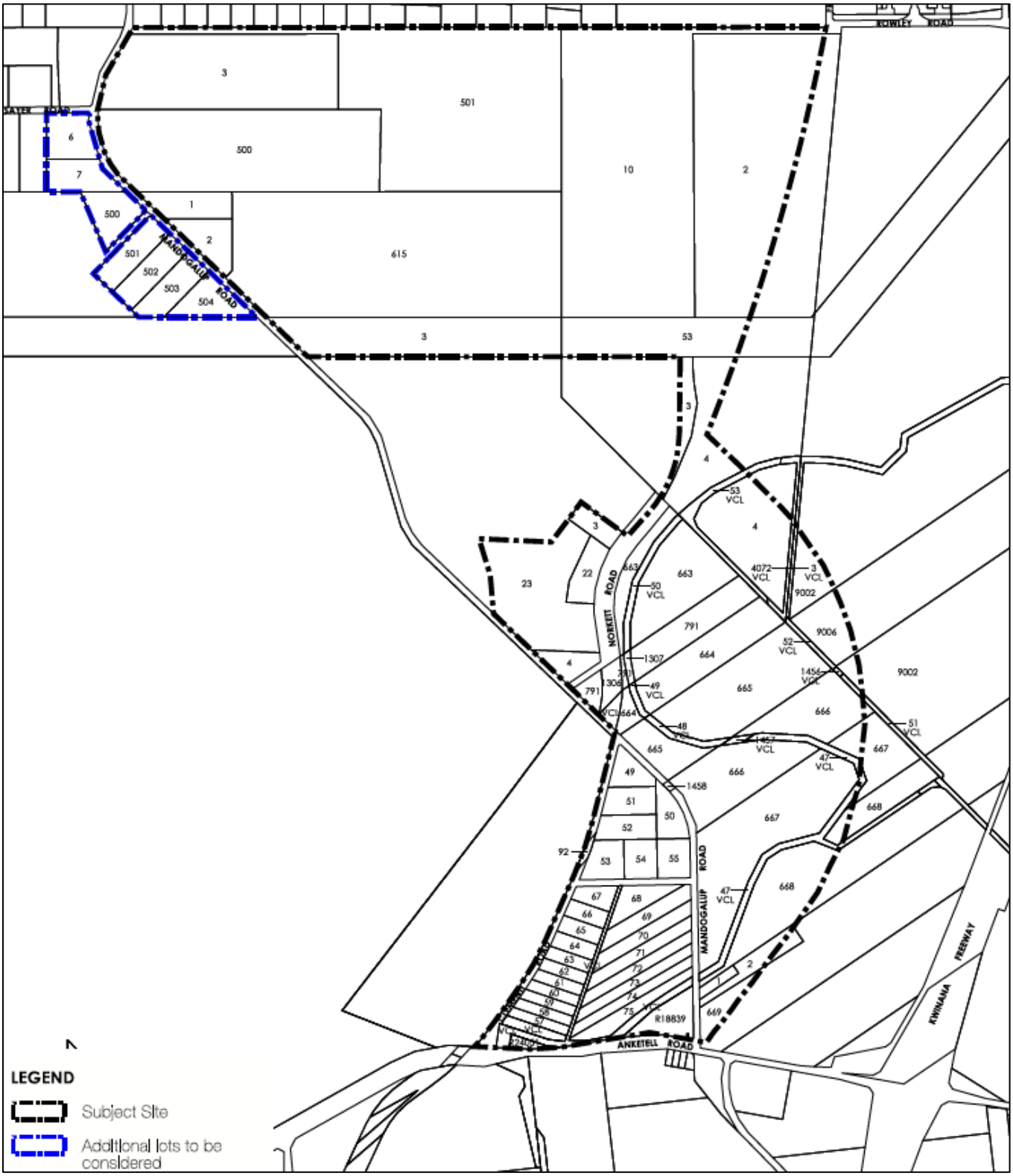


Figure 2 Area considered within Transport Report (source: TBB)

1.4 Report Structure

Outside of the introduction section of the Report, there are eight (8) key areas that are examined within the report, as follows:

- Improvement Plan Land Use Scenarios (Section 2)
- Regional Perspective (Section 3)
- Existing Vehicle Movement and Access (Section 4)
- Existing Public Transport (Section 5)
- Existing Pedestrian Infrastructure (Section 6)
- Existing Cycling Infrastructure (Section 7)
- Analysis of Improvement Plan Land Use Scenarios (Section 8)
- Final Preferred Land Use Scenario Access Strategy (Section 9)

2. IMPROVEMENT PLAN LAND USE SCENARIOS

2.1 Overview of Land Use Scenarios

Six land use scenarios for the Mandogalup Improvement Scheme have been developed to assess and guide the future development of the area – these land use scenarios have been developed to assist the WAPC with decision making regarding planning and future development giving consideration to the site and its environs.

The six land use scenarios developed can be described as follows:

Project Development Phase Scenarios (2019-2020)

- Residential land use scenario
- Industrial land use scenario
- Combined land use scenario.

Project Finalisation Phase Scenarios (2023)

- Draft preferred land use scenario
- Modified preferred land use scenario with 25,000m^2 or 50,000m^2 commercial floor area
- Final preferred land use scenario with 25,000m^2 commercial floor area.

2.2 Project Development Phase Scenarios (2019-2020)

2.2.1 Residential Land Use Scenario

The residential land use scenario features primarily residential development across the Mandogalup Improvement Plan area, with two potential primary school sites identified and two local/neighbourhood centres with supporting commercial floor space also identified.

The residential land use scenario considers at full build-out total yields of 3,330 dwellings with a resident population of 9,330 people.

The plan for the residential land use scenario is shown in Figure 3, and the land uses can be summaries as approximately:

- 3,330 dwellings / 9,330 residents
- 2,000m^2 retail GFA (split across two local/neighborhood centres)
- 11,125m^2 commercial GFA
- 2 primary schools (each with 750 students and 75 staff).

2.2.2 Industrial Land Use Scenario

The industrial land use scenario features primarily industrial development across the Mandogalup Improvement Plan area, with significant commercial floor space and two local/neighbourhood centres also identified.

The industrial land uses are categorised as low intensity, medium intensity or high intensity industrial uses. The scenario identifies up to 244 hectares of industrial land and 14 hectares of composite rural industrial land.

The plan for the industrial land use scenario is shown in Figure 4, and the land uses can be summaries as approximately:

- 244 hectares of industrial land GDA
- 14 hectares of composite rural industrial land GDA
- 59,575m^2 commercial GFA
- 2,000m^2 retail GFA (split across two local/neighborhood centres).

2.2.3 Combined Land Use Scenario

The combined land use scenario features residential development to the east of the Hammond Road Extension and industrial land to the west of the Hammond Road Extension across the Mandogalup Improvement Plan area, with two local/neighbourhood centres with supporting commercial floor space also identified.

The combined land use scenario considers residential land at full build-out total yields of 1,027 dwellings with a resident population of 2,875 people. The industrial land uses are categorised as low intensity, medium intensity or high intensity industrial uses. The scenario identifies up to 160 hectares of industrial land and 30 hectares of composite rural industrial land.

The plan for the combined land use scenario is shown in Figure 5, and the land uses across the plan can be summaries as approximately:

- 1,027 dwellings / 2,875 residents
- 160 hectares of industrial land GDA
- 30 hectares of composite rural industrial land GDA
- 21,680m^2 commercial GFA
- 2,000m^2 retail GFA (split across two local/neighborhood centres).

2.3 Project Finalisation Phase Scenarios (2023)

2.3.1 Draft Preferred Land Use Scenario

In March 2023, the DPLH together with stakeholders and the project team, identified that the preferred form of development for the Mandogalup Improvement Plan area was a modified combined scenario.

The draft preferred land use scenario features residential development to the east of the Hammond Road Extension in the northeast and southeast corners of the improvement plan area, with industrial development to the east of the Hammond Road Extension and through the central areas of the site. The preferred scenario also retains two local/neighbourhood centres with supporting commercial floor space.

The draft preferred land use scenario considered at full build-out a total yield of 1,237 dwellings with a resident population of 3,463 people. The industrial land uses are categorised as light industrial and heavy industrial uses. The scenario identifies up to 179 hectares of industrial land and 24 hectares of composite rural industrial land.

The plan for the draft preferred land use scenario is shown in Figure 6, and the land uses can be summarised as approximately:

- 1,237 dwellings / 3,463 residents
- 179 hectares of industrial land
- 24 hectares of composite rural industrial land GDA
- 56,640m^2 commercial GFA
- 1,500m^2 retail GFA (single local/neighborhood centre).

2.3.2 Modified Preferred Land Use Scenario with 25,000m^2 or 50,000m^2 Commercial Floor Area

In June/July 2023 Pracsys (part of the TBB led consultant team) undertook a benchmarking analysis regarding the number of dwellings, employment numbers and land use floorspace, across locations and developments with a similar context to the Mandogalup Improvement Scheme Area.

The benchmarking exercise concluded that the number of dwellings and commercial floorspace in the draft preferred land use scenario was on the high side – with a range of between 25,000m^2-50,000m^2 commercial floorspace more likely to be deliverable.

As a result, a plan was developed for a modified preferred land use scenario as shown in Figure 7, and the land uses summarised as approximately:

- 779 dwellings / 2,182 residents
- 188.4 hectares of industrial land
- 27.9 hectares of composite rural industrial land GDA
- 25,000m^2 or 50,000m^2 commercial GFA
- 2,000m^2 retail GFA (split across a 1,500m^2 neighborhood centre and smaller 500m^2 local centre).

2.3.3 Final Preferred Land Use Scenario with 25,000m^2 Commercial Floor Area

In July 2023 Flyt undertook high-level trip generation assessment of all scenarios developed to date (see Section 8 for details). Following this assessment and with agreement from DPLH it was agreed that the final preferred land use scenario would include the lower value of 25,000m^2 of commercial GFA.

As a result, a plan was developed for a modified preferred land use scenario as shown in Figure 7, and the land uses summarised as approximately:

- 779 dwellings / 2,182 residents
- 188.4 hectares of industrial land
- 27.9 hectares of composite rural industrial land GDA
- 25,000m^2 commercial GFA
- 2,000m^2 retail GFA (split across a 1,500m^2 neighborhood centre and smaller 500m^2 local centre).

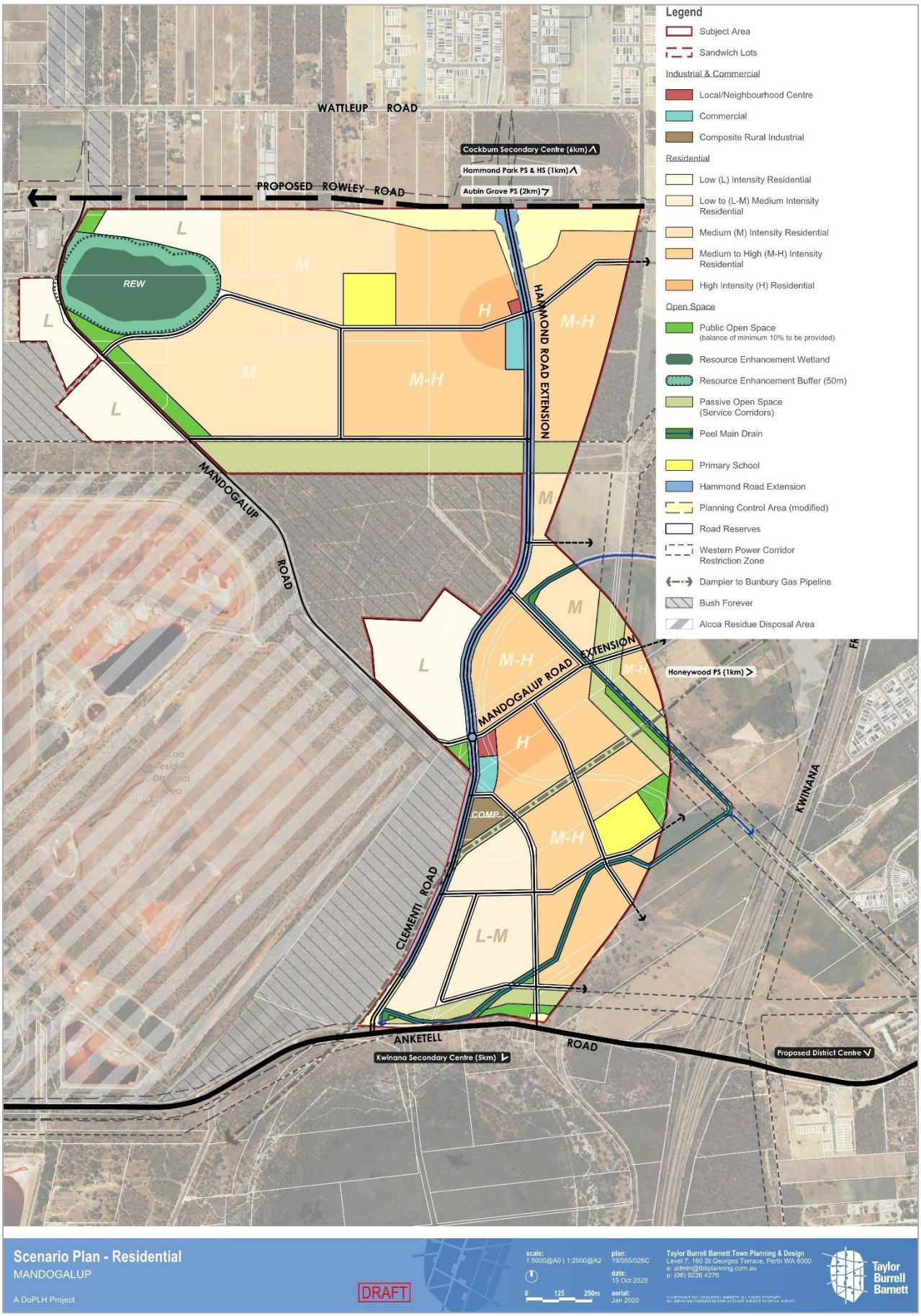


Figure 3 Residential land use scenario plan (source: TBB)

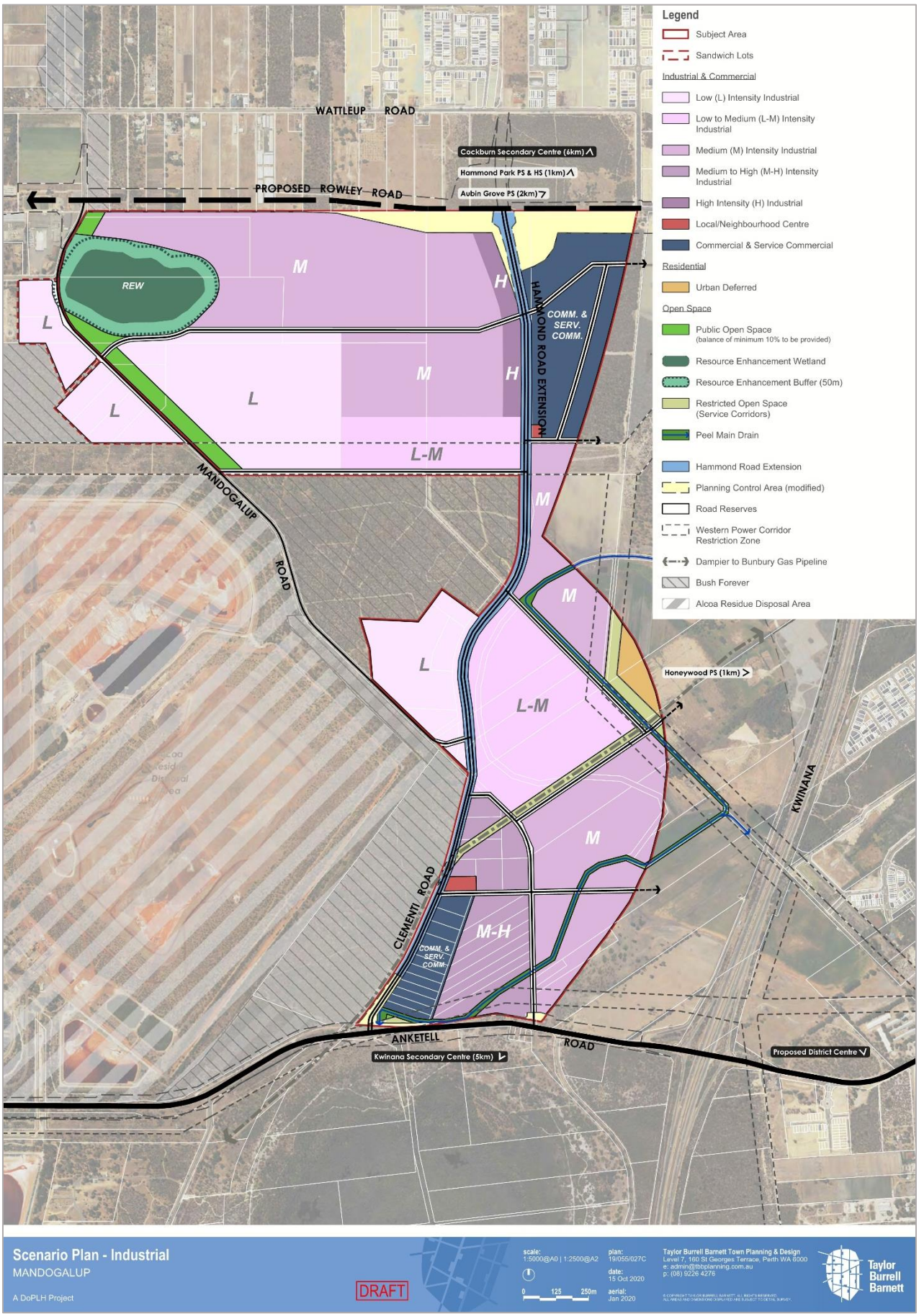


Figure 4 Industrial land use scenario plan (source: TBB)

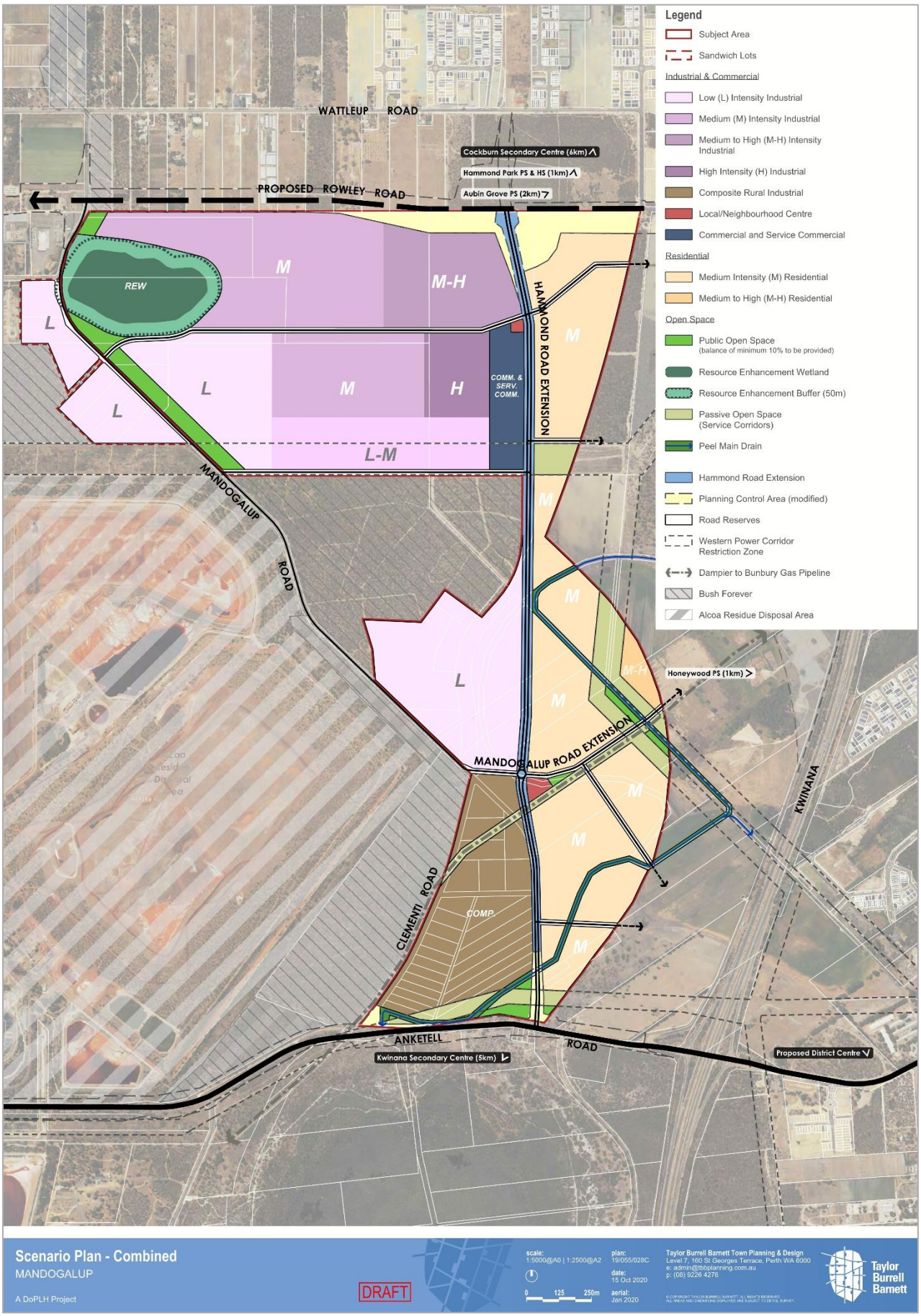


Figure 5 Combined land use scenario plan (source: TBB)

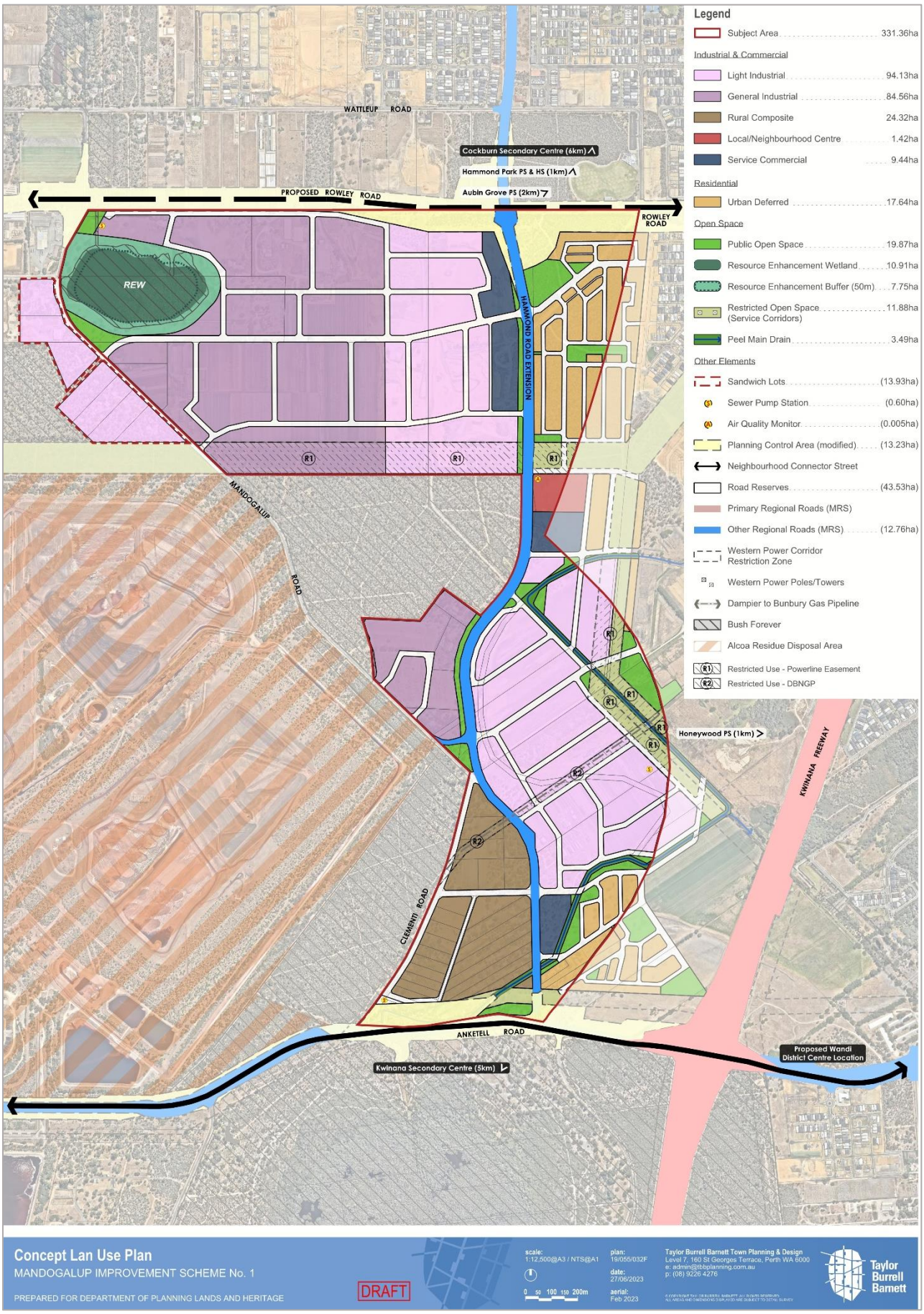


Figure 6 Draft preferred land use scenario plan (source: TBB)

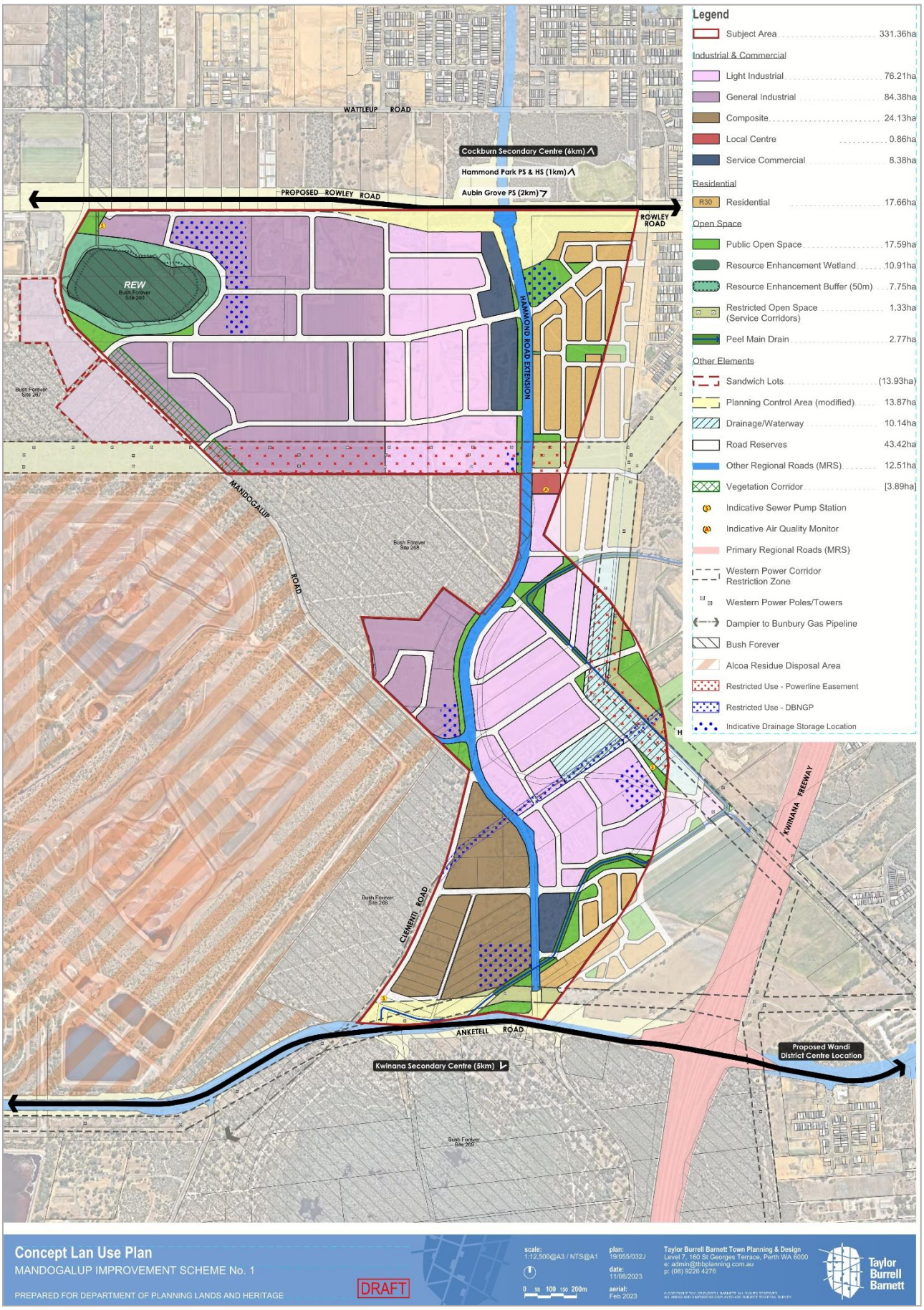


Figure 7 Modified/Final preferred land use scenario plan with 25,000m² or 50,000m² commercial GFA (source: TBB)

3. REGIONAL PERSPECTIVE

3.1 Development Context

The Mandogalup Scheme Area is located between Rowley Road and Anketell Road, east of the Kwinana Freeway and west of Rockingham Road. Existing land uses within the Mandogalup Scheme Area include a Hindu Temple, fire station, rural-residential, agricultural, horticultural and industrial uses.

In the wider context, as shown in Figure 8, Mandogalup is located adjacent to Latitude 32, is 5km east of Kwinana Naval Base and 8km east of the Australian Marine Complex (AMC). Rockingham is 13km to the south and Perth City is 25km to the north.

Figure 8 Regional location of Mandogalup Scheme Area (source: Nearmap)

The current zoning under the Metropolitan Region Scheme (MRS) is predominantly Rural with a small section zoned Urban deferred, as shown in Figure 9. Once the Improvement Scheme is gazetted, all local and regional planning schemes cease to apply.

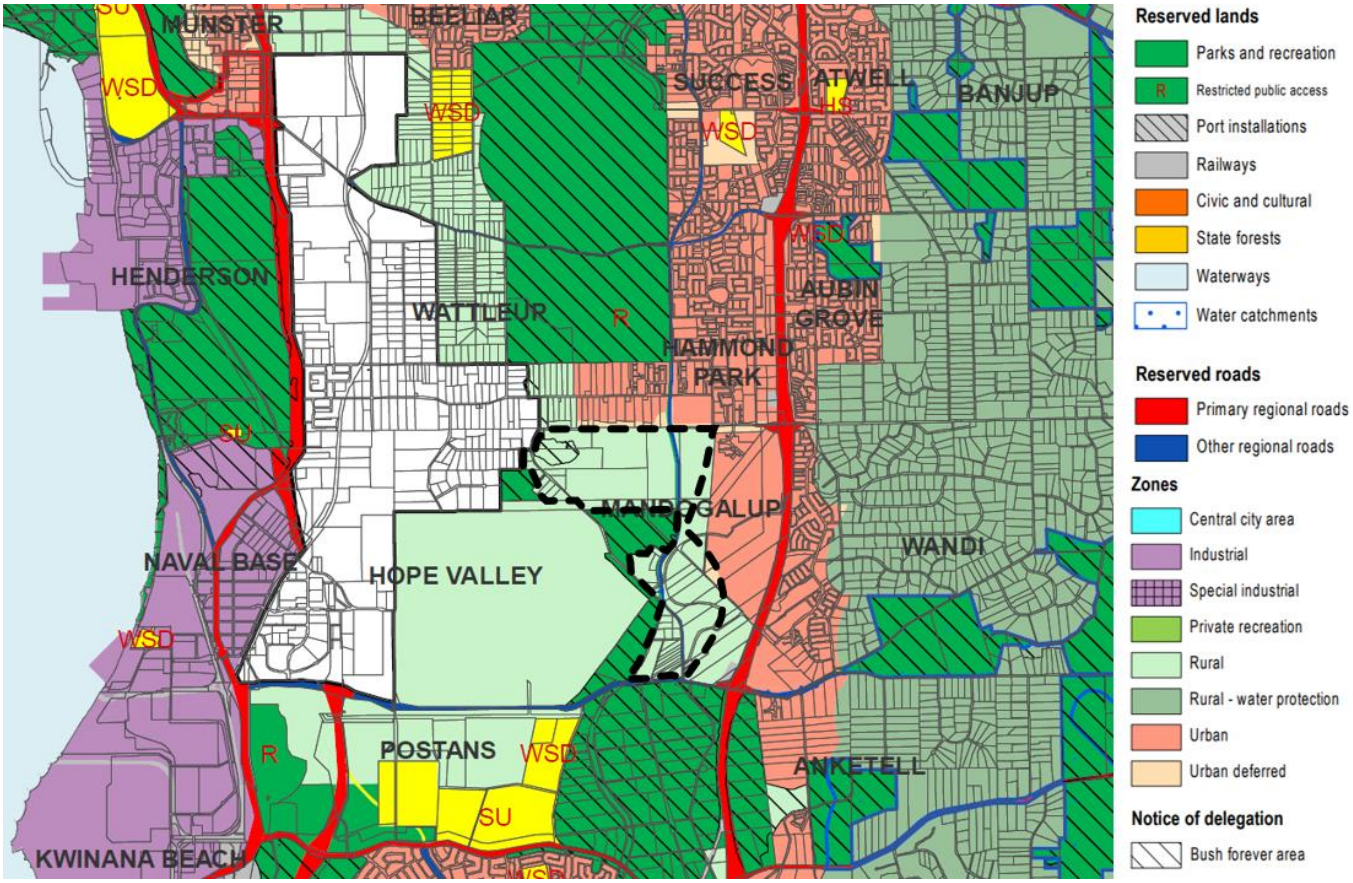


Figure 9 Metropolitan Region Scheme

3.2 Surrounding Land Uses

The subject area shown in Figure 9 is surrounded by various land uses. Land to the east and north east is zoned Urban and Urban Deferred under the MRS. Land on the eastern boundary is set to undergo significant residential development guided by the City of Kwinana's Mandogalup East and Mandogalup West Local Structure Plans.

South of the scheme area is The Spectacles within the Beeliar Regional Park where a 4.7km long Aboriginal Heritage Trail loops around the wetland. To the west are rural and industrial land uses, specifically Alcoa's Kwinana Residue Disposal Area (RDA) as well as a limestone quarry and the Kwinana Town Rubbish Tip.

3.2.1 Mandogalup East and Mandogalup West Local Structure Plans

The Mandogalup East Local Structure Plan (MELSP) and the Mandogalup West Local Structure Plan (MWLSP) depicted in Figure 10, were both endorsed in March 2018 by the WAPC. The MELSP is 42ha in area and proposes a total yield of 581 lots. The MWLSP is 68ha and proposes a total yield of 900 lots, a combined total of 1,481 new lots.

The proposed residential density is R30-R80, and other land uses include a primary school, local centre and public open space. The indicative subdivision layout has been designed using relatively short streets blocks to provide for a permeable and legible pedestrian, cycle and vehicle movement network. The MWLSP and the MELSP propose:

- An off road cycle path which travels north-south along the Neighbourhood Connector, the central movement corridor
- Dual use paths along all access streets
- Two connections to the PSP
- Extension of Hammond Road south to Rowley Road, ultimately connecting with Anketell Road.

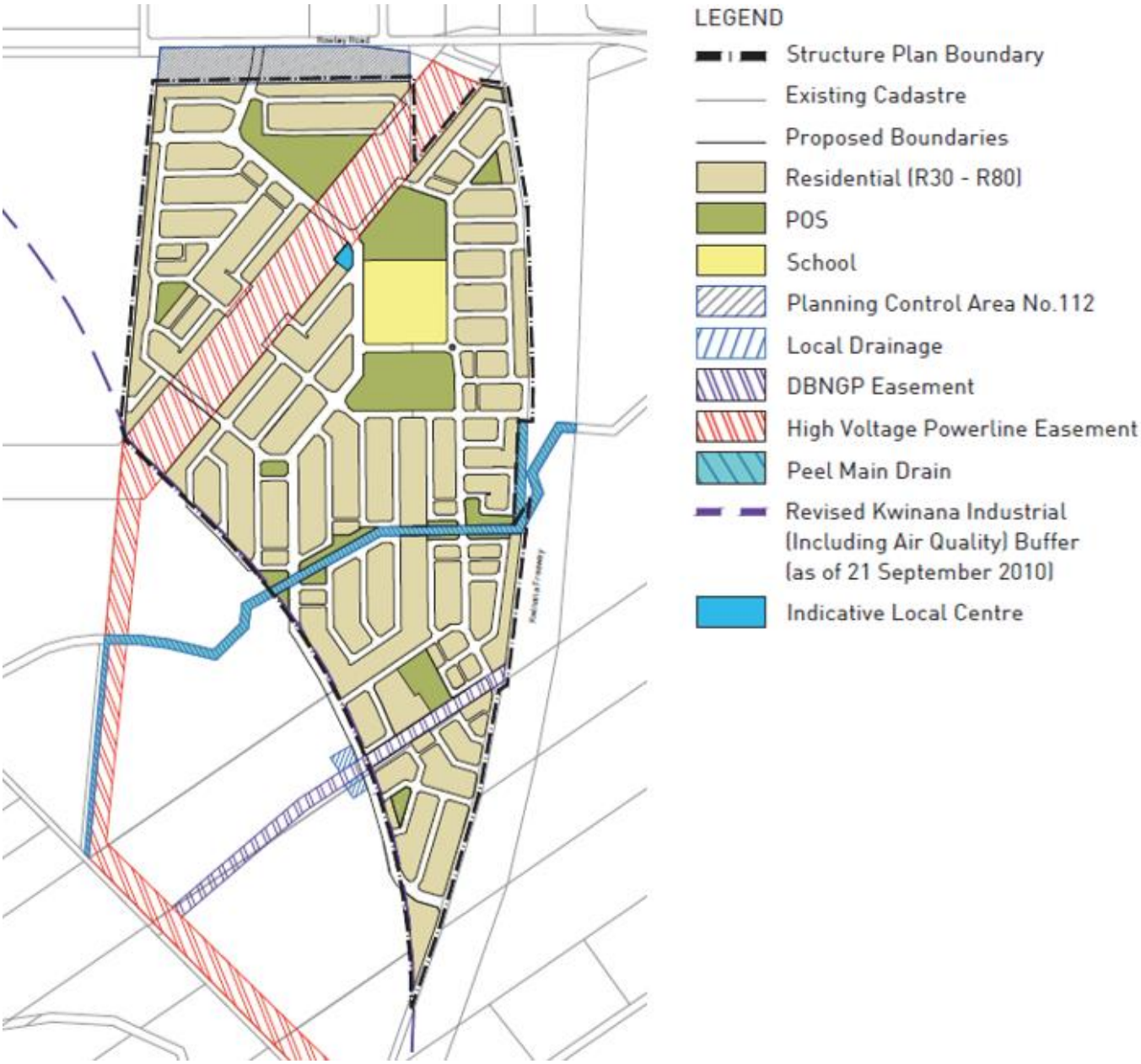


Figure 10 Combined Mandogalup East and West Concept Plan (Source: City of Kwinana)

The proposed road network is based on a grid pattern with most blocks running east-west. The Concept Plan shows roads which can potentially connect into the Mandogalup Scheme Area and are indicative of the future pedestrian, cycle and vehicular network.

3.2.2 Hammond Park

The Southern Suburbs District Structure Plan for Hammond Park was approved in 2012. It is reproduced here as Figure 11.

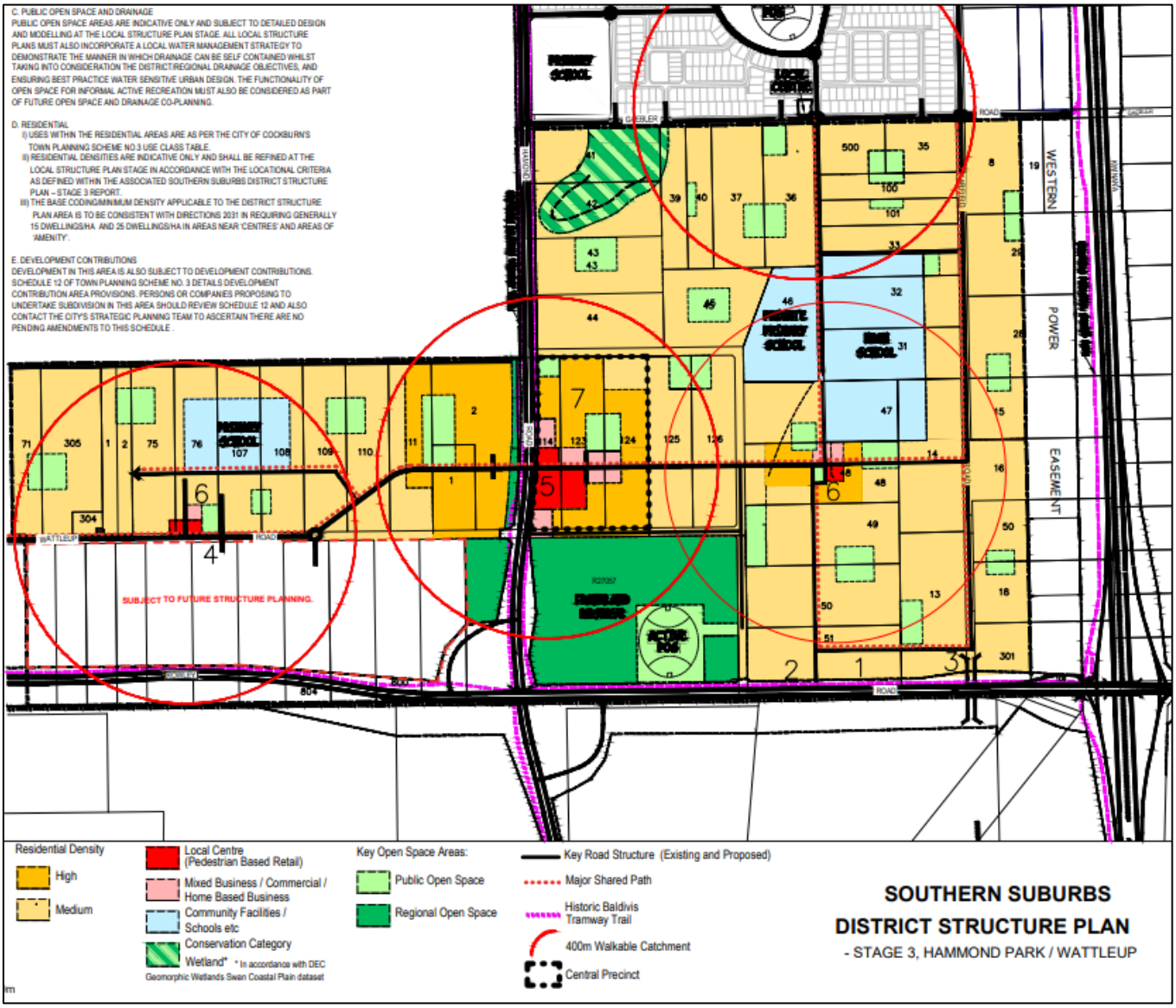


Figure 11 Southern Suburbs District Structure Plan Stage 3 Hammond Park

3.3 Westport

The Westport project has been evolving over the past six years and has long term, strategic implications for land use and transport network planning associated with the scheme area. As set out on the Westport website:

> *"The Westport Taskforce was established by the Minister for Transport in September 2017. Westport was tasked with developing a Strategy to guide the Government on the long-term development and growth of the Inner Harbour at Fremantle; the Outer Harbour at Kwinana; the required rail and road networks; and the potential for the Port of Bunbury to contribute to growing trade needs. The Strategy will look at Perth and the South West's freight, trade and logistics requirements for the next 50-100 years.".*

The project undertook a range of analyses and assessments throughout 2019 that culminated in a level Multi-Criteria Assessment (MCA-1) being completed which refined broad based options looking at port usage in Fremantle, Kwinana and Bunbury and then a more detailed Multi-Criteria Assessment (MCA-2) which ranked the seven remaining options that focused on Fremantle and Kwinana Ports.

The general arrangement of the initial MCA-1 options is shown in Figure 12 and the refined list of options being taken forward for a rapid cost-benefit analysis after the results of MCA-2 are shown in Figure 13.

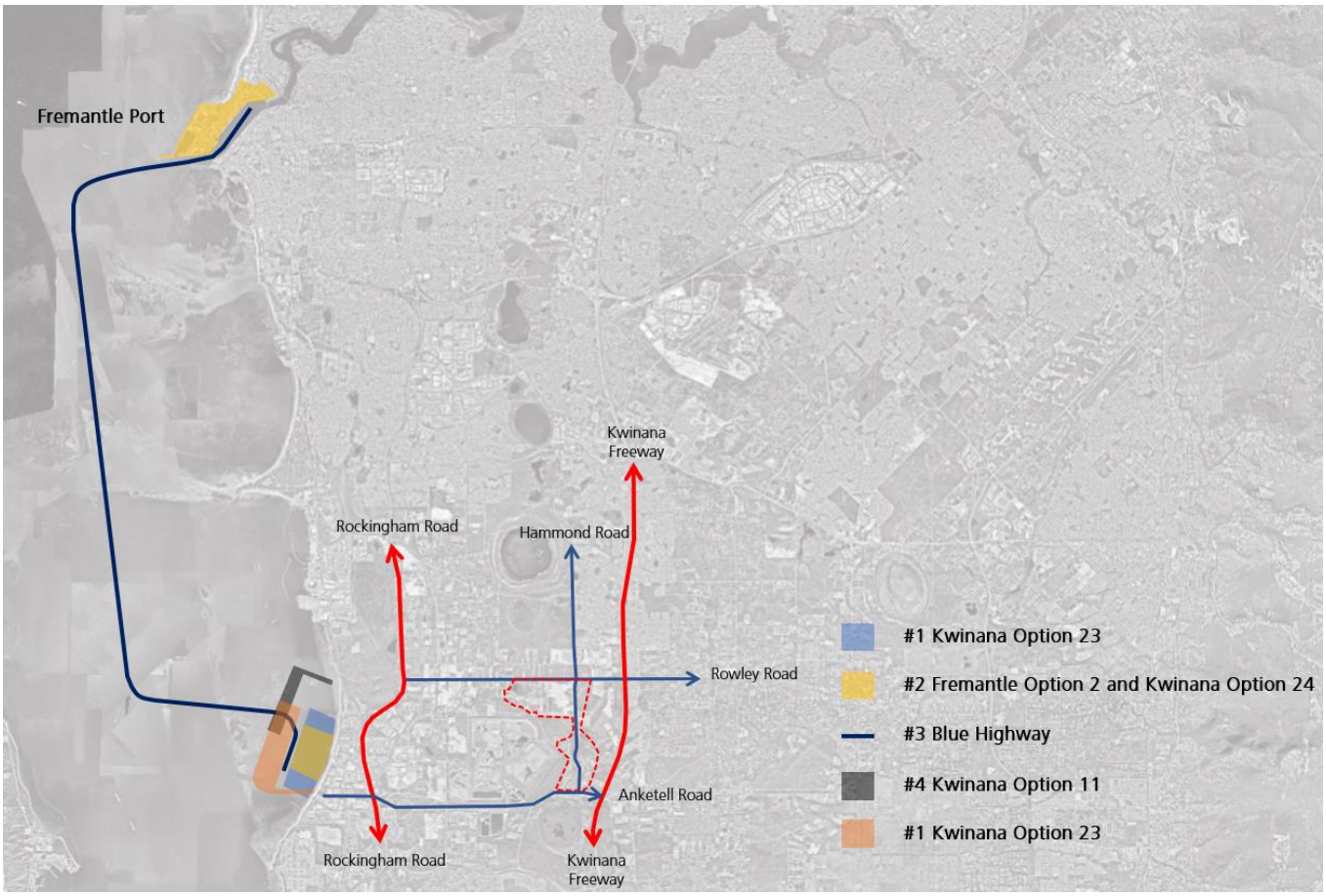


Figure 12 Westport MCA-1 options

Option	Description	Operation
Option A Kwinana	Cockburn Sound North (vicinity Rowley Road) narrow island port with intermodal operations at Latitude 32	End-state
Option B Kwinana	Cockburn Sound South (vicinity Anketell Road) conventional land-backed port	End-state
Option C Kwinana	Cockburn Sound South (vicinity Anketell Road) conventional island port	End-state
Option D Fremantle and Kwinana	Unmodified Fremantle Port shared with Cockburn Sound South (vicinity Anketell Road) medium conventional land-backed port	End-state
Option D2 Fremantle and Kwinana	Unmodified Fremantle Port shared with Cockburn Sound South (vicinity Anketell Road) medium land-backed port transitioning to Cockburn Sound South (vicinity Anketell Road) land-backed port (Option B)	Transition to Option B
Option E Fremantle and Kwinana	Slightly modified Fremantle Port shared with Cockburn Sound South (vicinity Anketell Road) medium conventional land-backed port with Blue Highway	End-state
Option E2 Fremantle and Kwinana	Slightly modified Fremantle Port shared with Cockburn Sound South (vicinity Anketell Road) medium land-backed port with Blue Highway, transitioning to Cockburn Sound South (vicinity Anketell Road) land-backed port (Option B)	Transition to Option B

Figure 13 Westport MCA-2 options (source: DoT)

In August 2020 Westport's Independent Taskforce recommended that a new container port in Kwinana be constructed which was subsequently endorsed by the State Government. In 2022, the Minister for Transport confirmed that Anketell Road would form part of the future freight corridor that the Anketell-Thomas Road Freight Corridor would be the preferred alignment for freight travel to connect the new Kwinana Port with the wider area and key strategic industrial sites.

Anketell Road to the south of the site is planned to become a dedicated freight path and initial designs include a freight bridge constructed 10m above the existing road bridge across Kwinana Freeway, to allow free flowing freight movements without disrupting commuter traffic. Other upgrades on the corridor include:

- Upgrading Thomas and Anketell Roads to four lanes between Tonkin Highway in Oakford and Lyon Road in Anketell and creating two lanes in each direction for general traffic plus dedicated freight only lanes (one in each direction) between Lyon Road and Clementi Road in Mandogalup, which will include new bridges over Kwinana Freeway
- New interchanges, bridges, roundabouts and ramps at Thomas and Kargotich and Thomas and Nicholson roads
- Service roads to provide access to properties on Anketell and Thomas roads
- A shared path along the south side of the corridor for pedestrians and cyclists.

The proposed alignment for the Anketell-Thomas Road Freight Corridor is shown below in Figure 14.

Figure 14 Indicative alignment for Anketell-Thomas Road Freight Corridor (source: Westport)

4. EXISTING VEHICLE MOVEMENT AND ACCESS

4.1 Road Network

Mandogalup's location enables quick and convenient access to the existing and future strategic road network. The Rowley Road corridor abuts the site to the north and Anketell Road is located to the south, both connecting to the Kwinana Freeway approximately 1km to the east of the site, with both corridors providing regional connections.

The existing Main Roads WA road hierarchy for the area is shown in Figure 15, while the speed zoning is shown in Figure 16. There are very few gazetted roads within the scheme area, as described in the following sections.

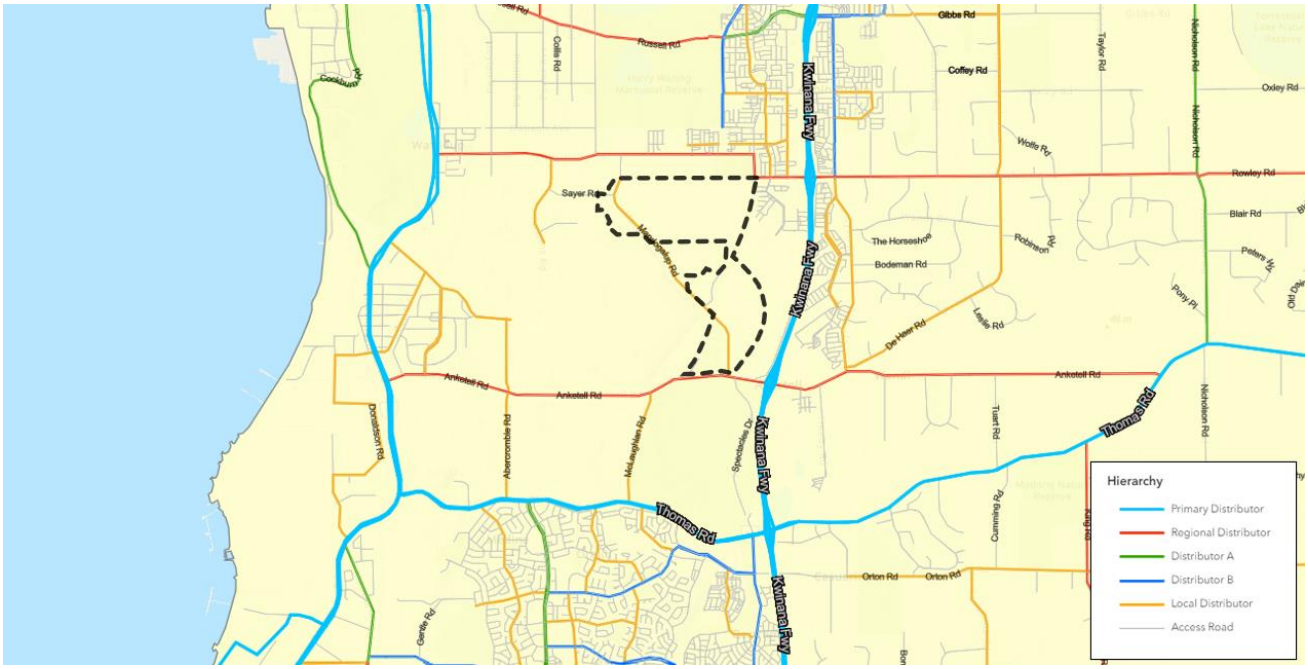


Figure 15 Road hierarchy surrounding Scheme Area (source: Main Roads WA)

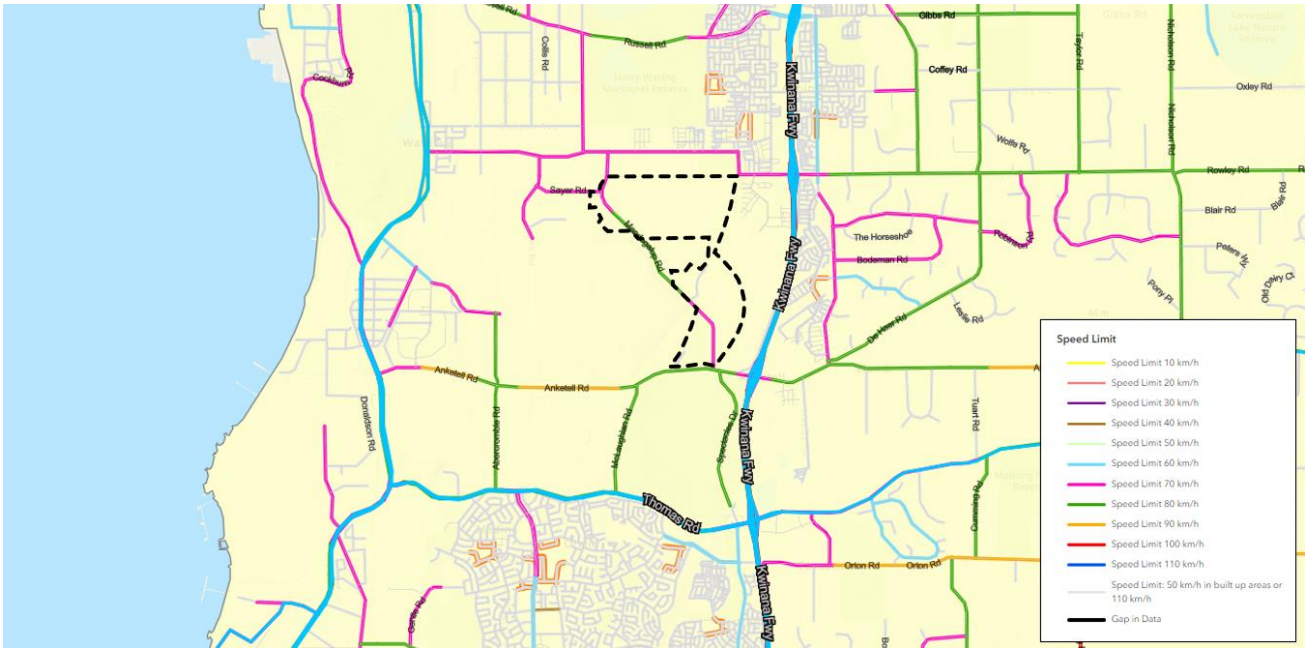


Figure 16 Posted speed limits surrounding Scheme Area (Source: Main Roads WA)

4.1.1 Rowley Road and Wattleup Road

Rowley Road and Wattleup Road run east-west to the north of the site and provide connections between Rockingham Road to the west and Tonkin Highway to the east. They are classed as Regional Distributor roads, with a posted speed limit between 70km/h and 80km/h.

Rowley Road and Wattleup Road are both a single carriageway with one lane in each direction constructed to a width of 8.5m within a 20m road reserve. The cross section of Rowley Road is shown in Figure 17.

Figure 17 Rowley Road view to west (Source: Google Maps)

The most recent traffic counts for Rowley Road at site 7006, immediately west of the Kwinana Freeway, collected by Main Roads WA in 2020/2021, reveals Rowley Road carried an average of 9,450 vehicles Monday to Friday with 17.4% heavy vehicles. (Since 2017/2018, the average volume of weekday vehicles has increased by 1,597 and the proportion of heavy vehicles has increased by 2.5%).

The average weekday profile for traffic volumes and freight vehicle movements along the Rowley Road corridor to the west of Kwinana Freeway are shown in Figure 18. The configuration of the Rowley Road interchange with Kwinana Freeway is shown in Figure 19. At present, the bridge structure over the Freeway reserve is a single lane carriageway with turning lanes to facilitate movement on to the Freeway in both directions however the area within the reserve indicates that there is room for substantial expansion of the carriageway and the interchange itself.

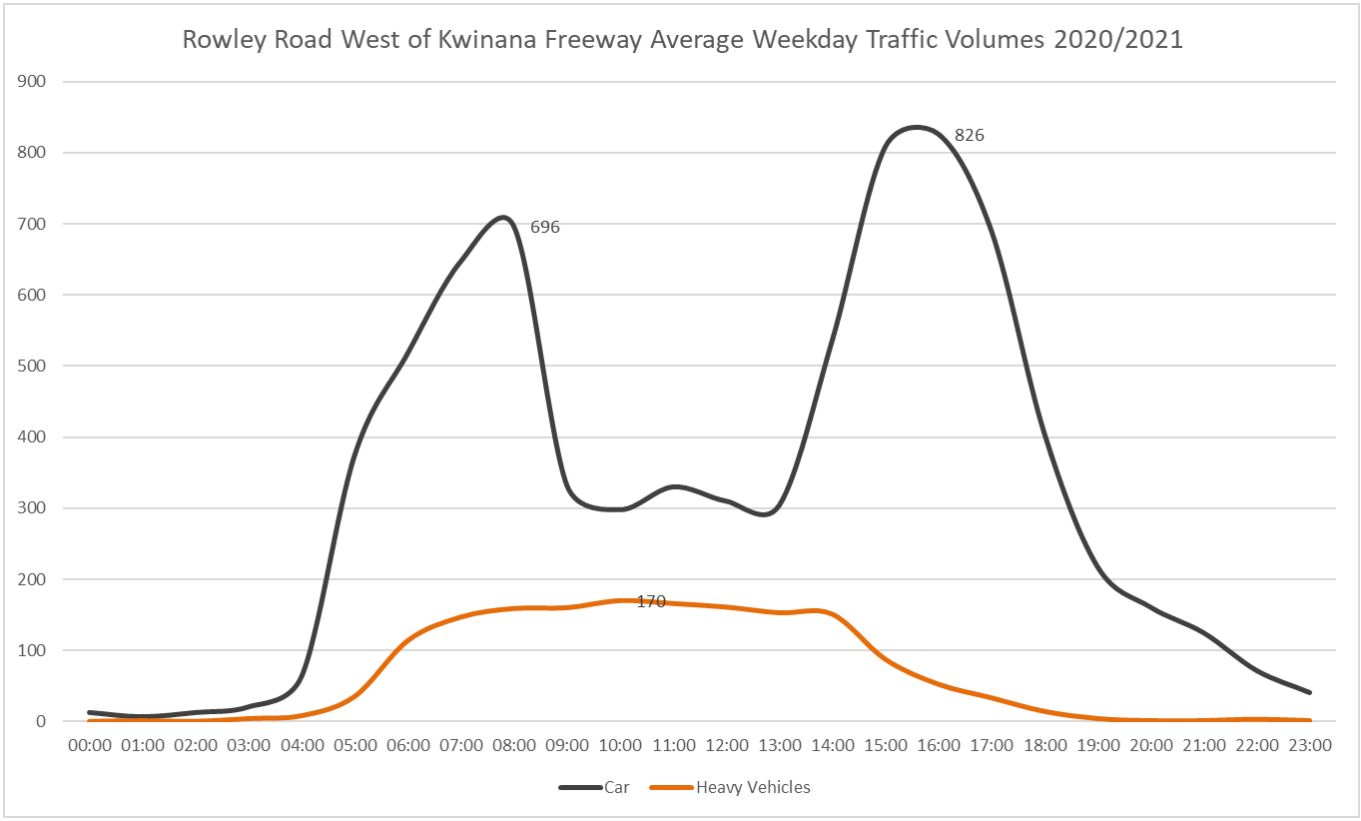


Figure 18 Rowley Road west of Kwinana Freeway average traffic volumes 2017-18 (source: Main Roads WA Traffic Map)

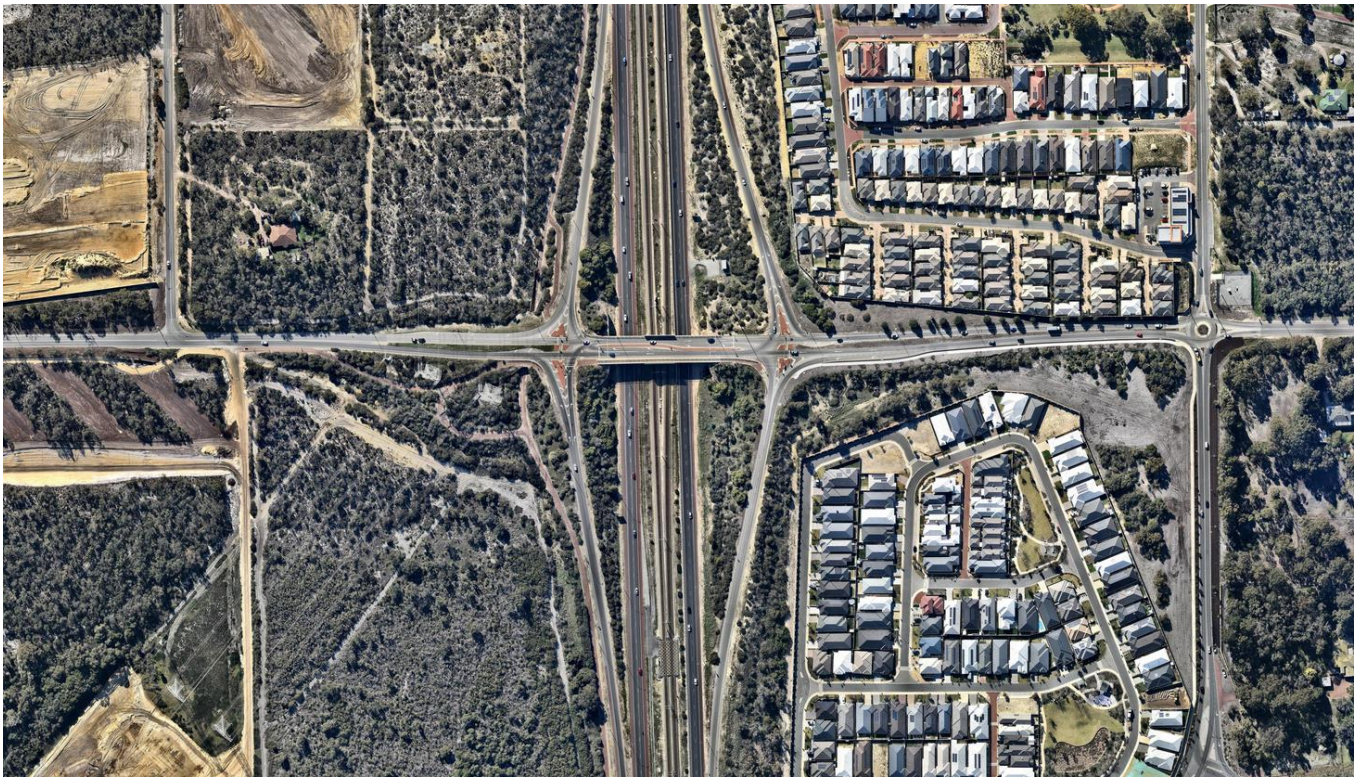


Figure 19 Configuration of Rowley Road and Kwinana Freeway interchange (source: Nearmap)

Rowley Road has historically been identified as a primary freight route to the Kwinana Industrial Area and future container port, however as discussed in Section 3.3 the final outcome from the Westport project confirms the preferred freight route(s) to connect the new Kwinana Port will be along Anketell Road.

In 2020, the Minister for Planning extended the continuation of Planning Control Area 156 over the proposed Rowley Road alignment between Kwinana Freeway and the coast, with Figure 20 showing the section relevant to the scheme area. The purpose of the Planning Control Area is for the protection of the proposed road and rail freight transport access corridor of Rowley Road, between Kwinana Freeway and the coast. The WAPC considers that the Planning Control Area is required to ensure that no further development occurs on this property which might prejudice this purpose until it may be reserved in the Metropolitan Region Scheme. The declaration remains in effect for a period of five years (to expire on 11 September 2025), until enacted or revoked.

Figure 20 Planning Control Area 156 – Rowley Road (source: DPLH)

Within the Improvement Scheme Area, Planning Control Area 156 extends up to 80m into Lot 10 and Lot 501, and up to 84m into Lot 2.

4.1.2 Anketell Road

Anketell Road is classed as a Regional Distributor and is an 'Other Regional Road' under the MRS. The posted speed limit is 80km/h immediately adjacent to the Scheme Area, increasing to 90km/h further west. Anketell Road runs east-west between Rockingham Road to the west and Thomas Road to the east, where it continues eastbound to the South Western Highway as Thomas Road. Anketell Road is constructed as a standard single carriageway, approximately 8m wide. To the east of Mandogalup Road, the Anketell Road reservation is 20m. To the west of Mandogalup Road, the reserve width varies with a minimum width of 30m. The cross section of Anketell Road at the intersection of Mandogalup Road is shown in Figure 21.

Figure 21 Anketell Road, view to west. (Source: Google Maps)

The most recent traffic counts for Anketell Road at site 7003, immediately west of the Kwinana Freeway, collected by Main Roads WA in 2020/2021, reveals Anketell Road was carrying 17,976 average daily vehicles Monday to Friday with 16.9% heavy vehicles. (Since 2017/2018, the average volume of weekday vehicles has increased by 3,676 and the proportion of heavy vehicles has decreased by 2.9%). The profile of the average weekday traffic volumes recorded at this location are shown in Figure 22.

The configuration of the Anketell Road interchange with Kwinana Freeway is shown in Figure 23. At present, the bridge structure over the Freeway reserve is a single lane carriageway however the area within the reserve indicates that there is room for substantial expansion of the carriageway and interchange itself.

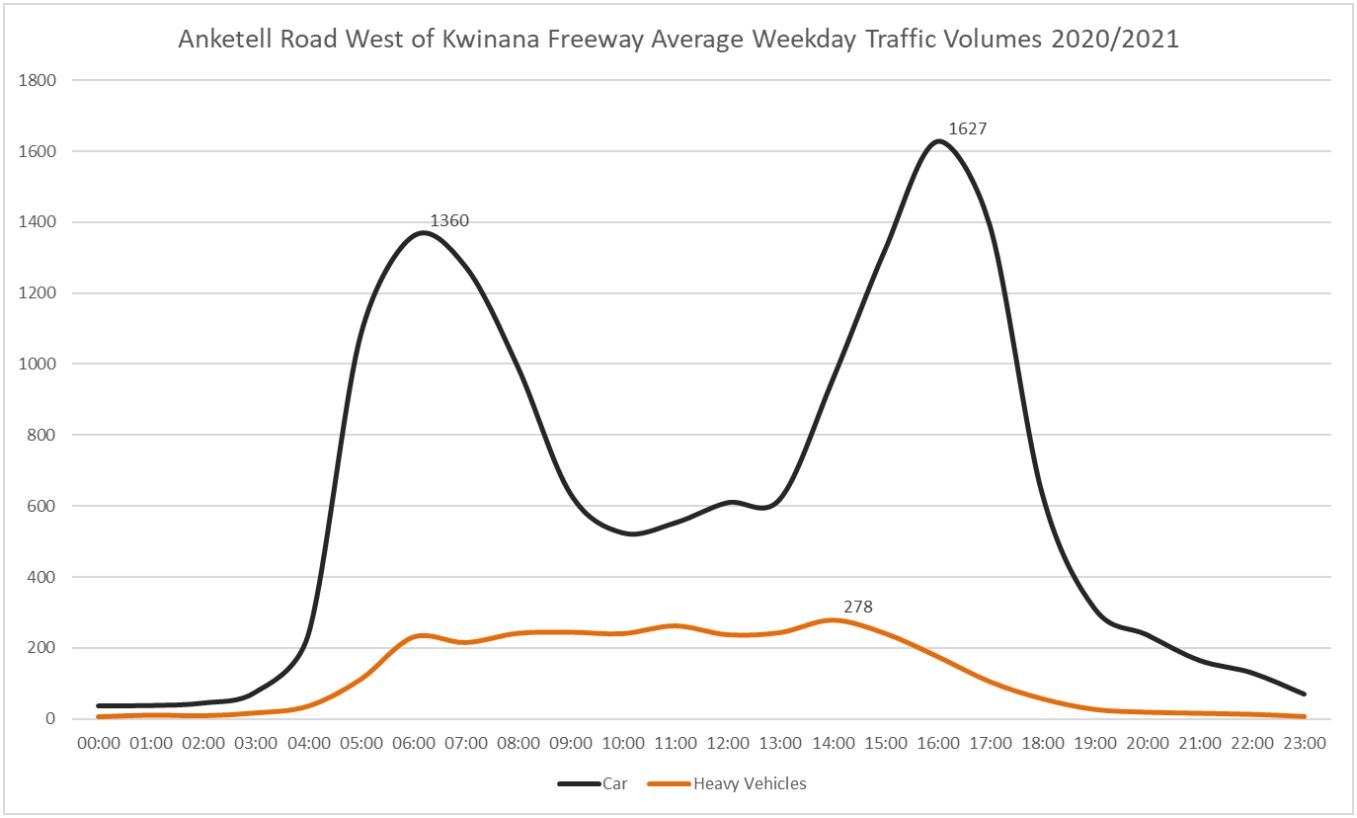


Figure 22 Anketell Road west of Kwinana Freeway average traffic volumes 2020/2021 (source: Main RoadsTrafficmap)

Figure 23 Configuration of Anketell Road and Kwinana Freeway interchange (source: Nearmap)

In 2020, the Minister for Planning extended approval to Planning Control Area 157 over Anketell Road, Kwinana (between Kwinana Freeway and Rockingham Road) with the section relevant to the Scheme Area shown in Figure 24.

Figure 24 Planning Control Area 157 – Anketell Road (source: DPLH)

The purpose of the planning control area is to protect the proposed road freight transport access corridor along Anketell Road between the Kwinana Freeway and Rockingham Road.

The Western Australian Planning Commission considers that the planning control area is required over the whole of the property to ensure that no development occurs on this land which might prejudice this purpose until it may be reserved in the Metropolitan Region Scheme. The declaration remains in effect for a period of five years (to expire on 11 September 2025), until enacted or revoked.

Planning Control Area 157 extends up to 48.5m into Lot 669 and up to 8.9m into Lot 87. Any potential land use abutting the PCA 157 will need to consider its declared ultimate land use as a road and freight rail corridor.

The future of Anketell Road as part of the declared Anketell-Thomas Road Freight Corridor is discussed in more detail in Section 3.3.

4.1.3 Mandogalup Road

Mandogalup Road is classed as a Local Distributor and generally runs north-south between Wattleup Road to the north and Anketell Road to the south. The posted speed limit ranges between 70 and 80km/h. Mandogalup Road is a rural standard single carriageway within a 20m road reserve. There is no pedestrian or cycling infrastructure. A typical cross section is shown in Figure 25.

Figure 25 Mandogalup Road view to south (Source: Flyt)

In October 2020, a video survey was conducted on behalf of Main Roads WA at the northern and southern intersection of Mandogalup Road at Rowley Road to the north and Anketell Road to the south. At the Rowley Road intersection, the survey recorded 4,637 vehicles (13% heavy vehicles) using Mandogalup Road across a 24 hour period, with 491 in the AM peak (6.30-7.30am) and 538 in the PM peak (3.45-4.45pm). Only 22% of the total vehicles travelled during the peak hours.

At the Anketell Road intersection, the volumes are very similar where the survey recorded a total of 4,829 vehicles (7% heavy vehicles) using Mandogalup Road across a 24 hour period, with 515 in the AM peak (6.30-7.30am) and 539 in the PM peak (3.45-4.45pm), where 22% of the total vehicles travelled during the peak hours. The consistency between the volumes at the northern and southern end show that Mandogalup Road is primarily used as a through route with very few vehicles stopping within the Mandogalup area.

A summary of the survey data is shown in Table 1.

Table 1 Summary of survey data for Mandogalup Road intersections

Intersection		TOTAL	Avg HV	Mandogalup Rd	Avg HV	Northbound	Southbound
Rowley Road	24hrs	18326	14%	4637	10%	2267	2370
	AM peak	1803	13%	491	11%	391	100
	PM peak	2010	5%	538	4%	129	409
Anketell Road	24hrs	38436	11%	4829	7%	2383	2446
	AM peak	3586	10%	515	8%	418	97
	PM peak	3906	4%	539	3%	119	420

4.1.4 Other Regional Road Extension to Hammond Road

A north-south 'Other Regional Road' is indicated in the MRS running through the scheme area. The road is planned to intersect with Anketell Road to the south and to the existing alignment of Hammond Road to the north where it continues to Cockburn Central. Planning for this road has already begun, with the allocation of a reserve identified in various structure plans within the City of Cockburn.

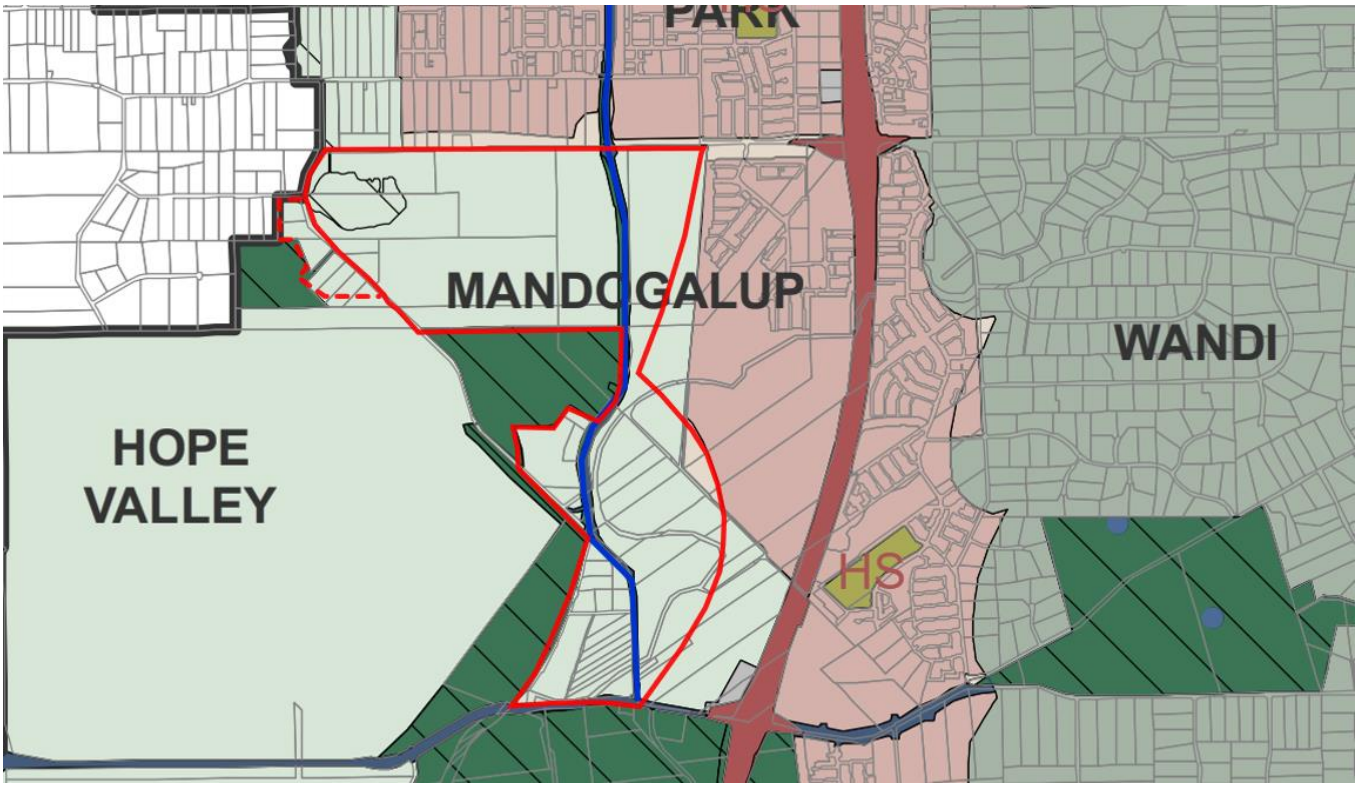


Figure 26 Other Regional Road reservation through Mandogalup

Figure 27 shows a structure plan approved by the City of Cockburn in 2011 with the reserve to accommodate the future Regional Road. City of Cockburn IntraMaps shows that the current reserve for the Regional Road is approximately 40m wide.

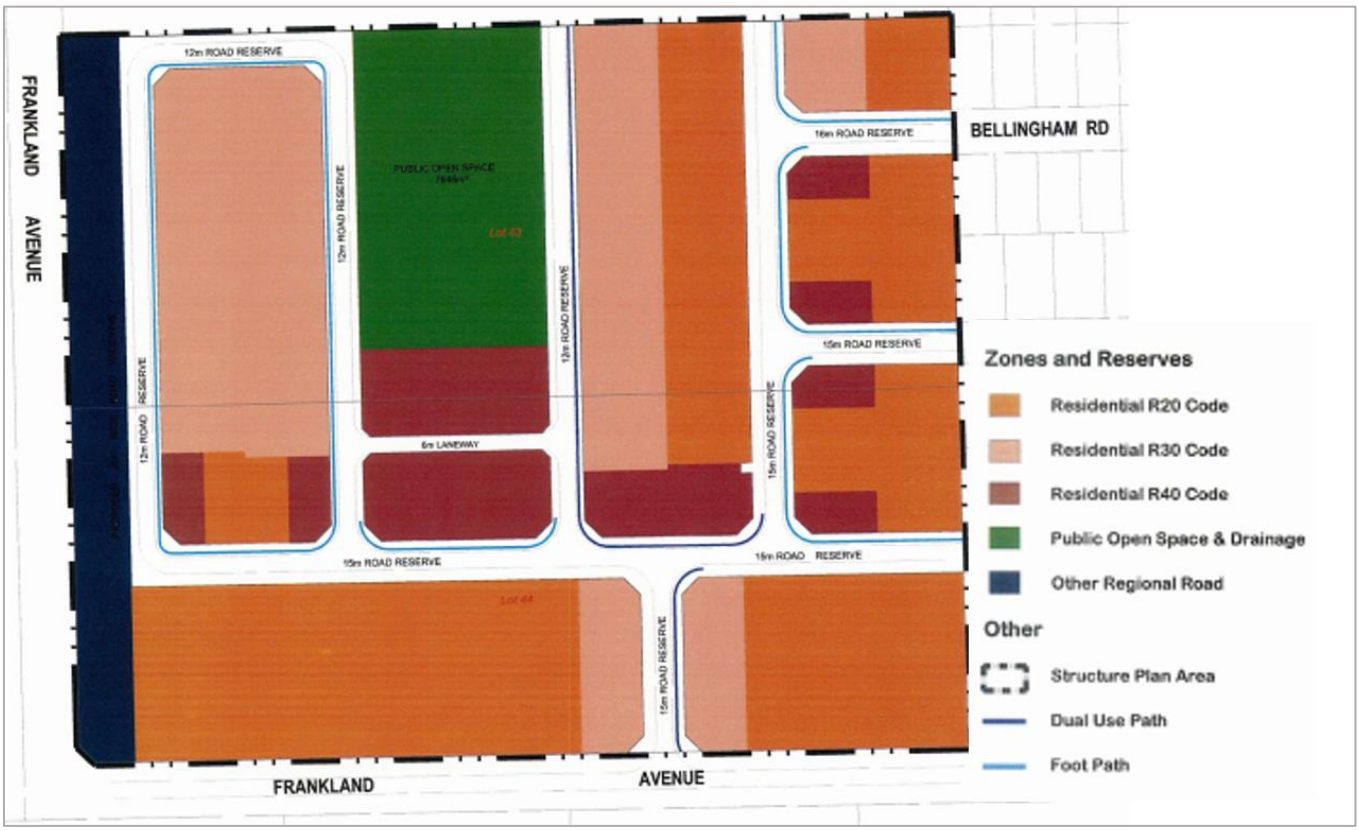


Figure 27 Hammond Park – Frankland Avenue Lots 43-44

The designation as a Regional Road will generally prohibit frontage access (as outlined in DPLH's D.C. Policy 5.1 Regional Roads) to all land uses excluding major shopping, recreation or community centres (or similarly large traffic generators). The safe and efficient movement of traffic is prioritised along Regional Roads and is generally achieved through minimising the number of intersections and driveways.

Within the residential area to the north, the road will function as an Integrator Arterial as outlined in Liveable Neighbourhoods. The function and characteristics of arterial roads is detailed in Liveable Neighbourhoods where the road will most likely have a speed limit up to 60km/h and will cater for between 7,000-25,000 vpd.

4.2 Restricted Access Vehicle Network

The Restricted Access Vehicle Network (RAV) is a mandated classification of state and local roads that is designed to foster the outcomes of the Network Access Strategy developed in 2016 for the Strategic Road Freight Network (SRFN).

The RAV network is a critical infrastructure link for access between the future Kwinana Port and wider transport network. This network will have direct implications for Mandogalup given its proximity to the future Kwinana Port. The existing network in the vicinity of Mandogalup is shown in Figure 28.

Rowley Road, Wattleup Road and Anketell Road are part of Network 4, accommodating vehicles up to 27.5m in length (pocket road train, B-Double). Thomas Road and the Kwinana Freeway are part of Network 7, accommodating vehicles with a maximum length of 36.5m and a mass of up to 107.5 tonnes.

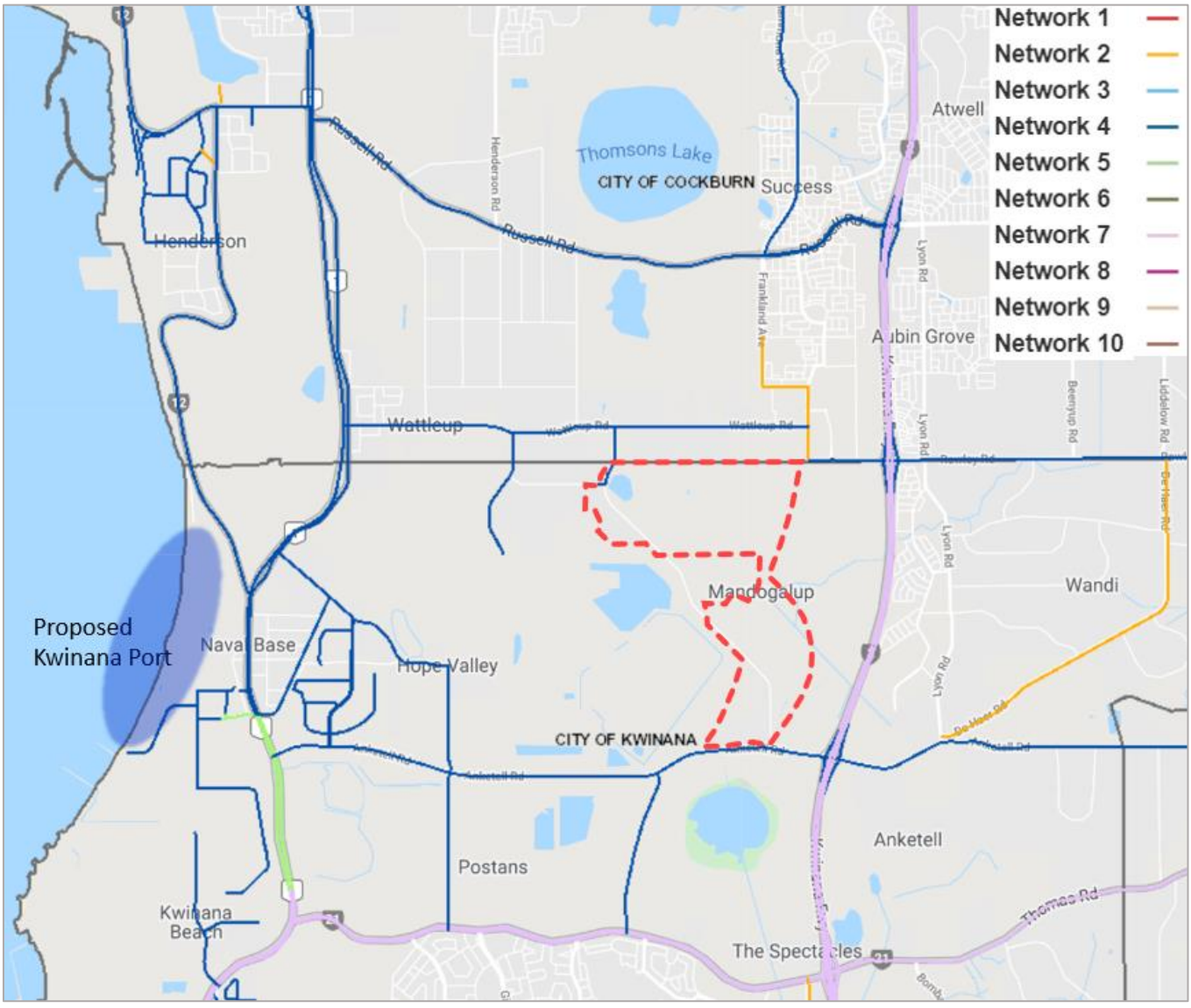


Figure 28 Main Roads WA RAV Network routes (source: Main Roads WA)

The RAVs network is critical to support the development of the industrial land within Mandogalup.

4.2.1 Wider RAV Network

The RAV network covering the metropolitan area is shown in Figure 29. East-west connections along the existing regional road network are particularly critical for development west of Mandogalup that is supported by large volumes of freight vehicle movements.

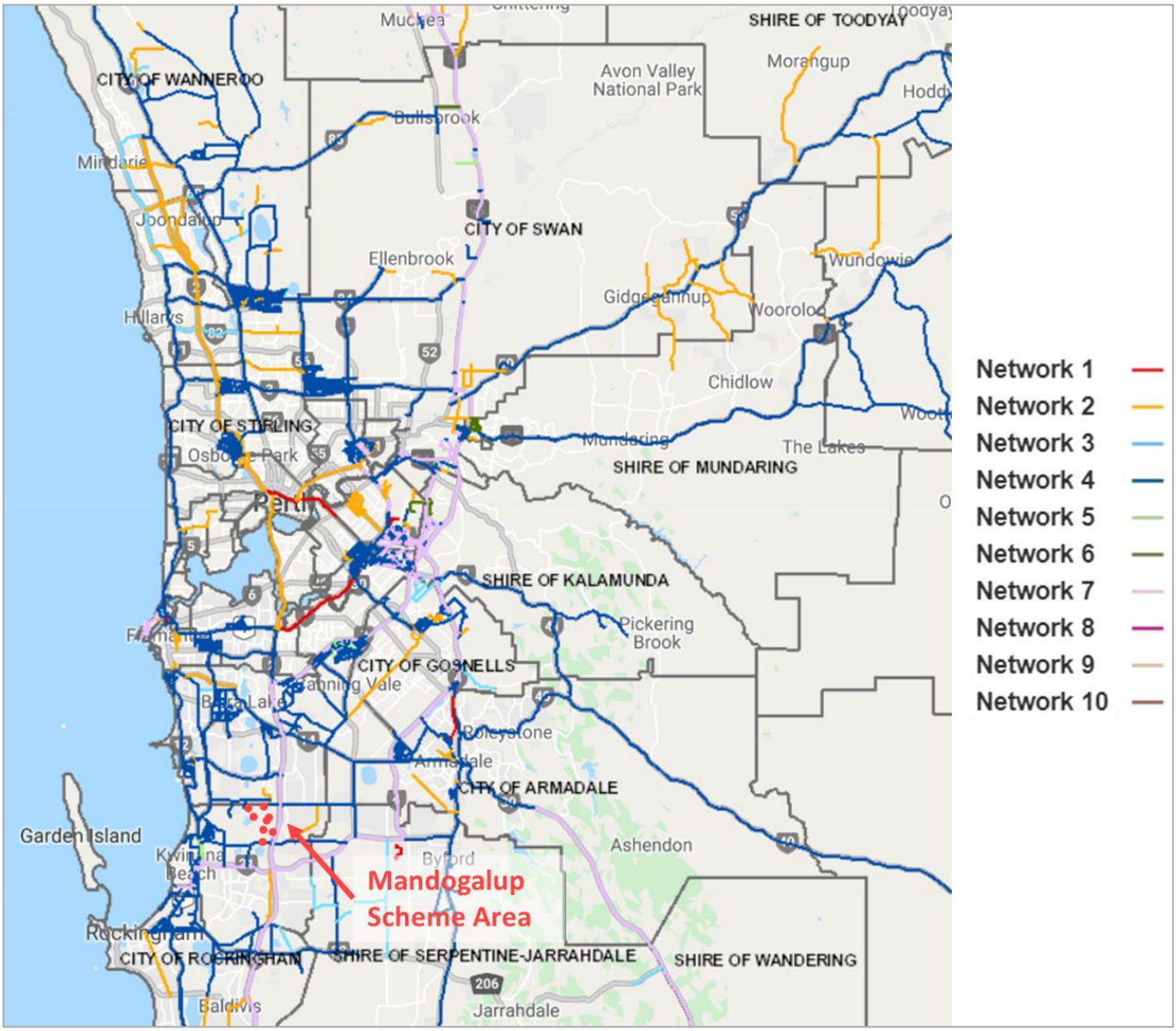


Figure 29 Overall RAV Network – Perth Metropolitan Region (source: Main Roads WA)

4.2.2 Oversize Over-mass

An oversize over-mass (OSOM) vehicle is any Restricted Access Vehicle carrying, or designed to carry, an over-dimensional indivisible load. Typically, an OSOM vehicle and its load can have the following dimensions and mass:

- Up to 8.0 metres in height
- Up to 8.5 metres in width
- Up to 50 metres in length
- Up to 500 tonnes gross mass.

An OSOM corridor is made up of roads capable of accommodating OSOM vehicles as they travel between heavy fabrication centres and the Australian Marine Complex in the Perth Metropolitan area with mine sites, refineries and other industrial areas that require large machinery and plant.

The OSOM network for the Perth metropolitan area is shown in Figure 30. Near Mandogalup, Rockingham Road and Thomas Road form part of an OSOM corridor capable to transporting large loads up to 10m wide. In previous years Anketell Road had been part of the OSOM corridor.

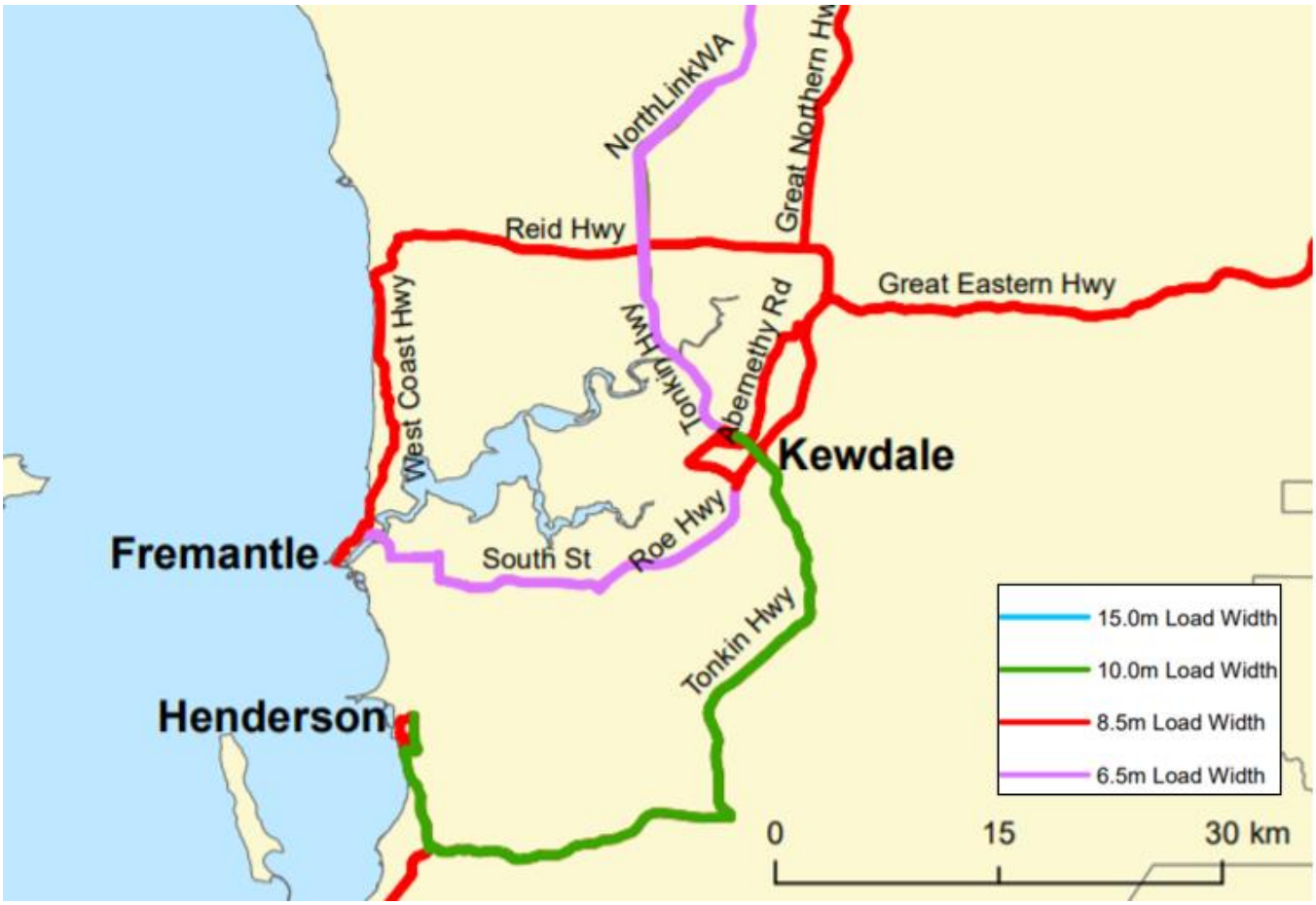


Figure 30 Metropolitan Oversize over mass corridors (source: Main Roads WA)

5. EXISTING PUBLIC TRANSPORT

5.1 Public Transport Network

The existing public transport network adjacent to the scheme area is shown in Figure 31. The network includes Aubin Grove and Kwinana stations on the Mandurah line, which runs within the Kwinana Freeway median, approximately 1.5km to the east of Mandogalup. There is just over 9km distance between Kwinana and Aubin Grove Stations.

Train station feeder bus routes serve the residential land uses to the north, east and south, while to the west Rockingham Road and Cockburn Road carry bus service between Fremantle and Rockingham.

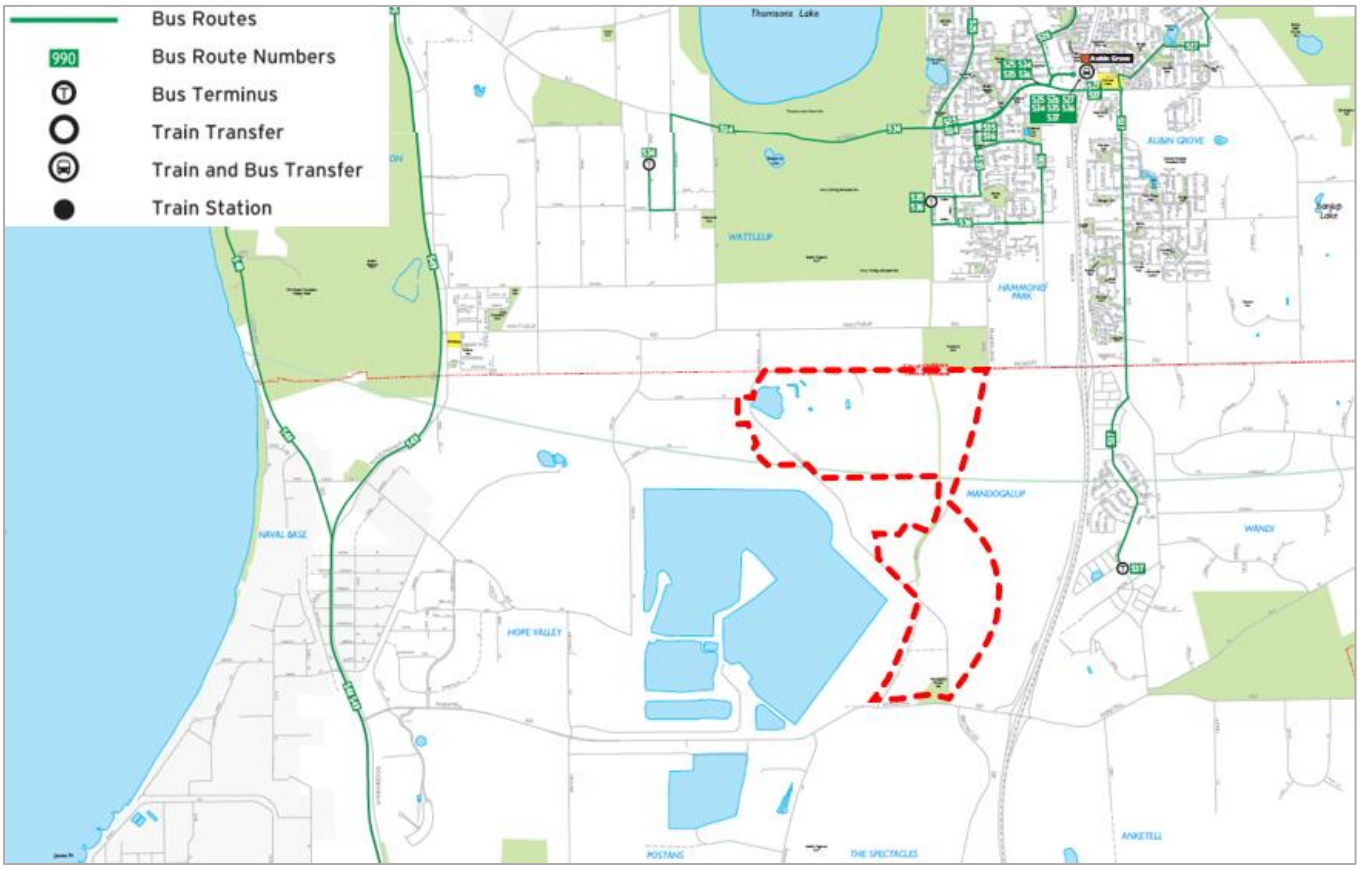


Figure 31 Transperth network map 2020 (source: Transperth)

As identified in the Jandakot Structure Plan (2007) and in the MRS (amendment No. 1032/33), land was reserved for a possible Mandogalup Station located at Rowley Road adjacent to the primary regional road reserve. However, on April 23, 2013, the WAPC resolved the following:

> *"That the Western Australian Planning Commission endorses, that due to the Governments' announcement of a new rail station to be developed at Aubin Grove (Russell Road) on the Perth-Mandurah line, a station is no longer intended to be developed for Mandogalup (Rowley Road); and that the direction of government shall now be reflected in future planning for the area."*

The final decision to remove Mandogalup Station included liaison and input from PTA.

6. EXISTING PEDESTRIAN NETWORK

6.1 Pedestrian Network

There is no existing pedestrian network within the Scheme Area. The limited road network has no pedestrian paths.

To assess potential existing usage, two separate software based tools were examined for outputs – Travel Time and Strava.

The Travel Time application contrasts the various transport modes, using isochrones to demonstrate the extent of movement possible within a timeframe. The 15-minute catchment is shown in Figure 32. The existing walking and cycling networks clearly follow the limited road network.

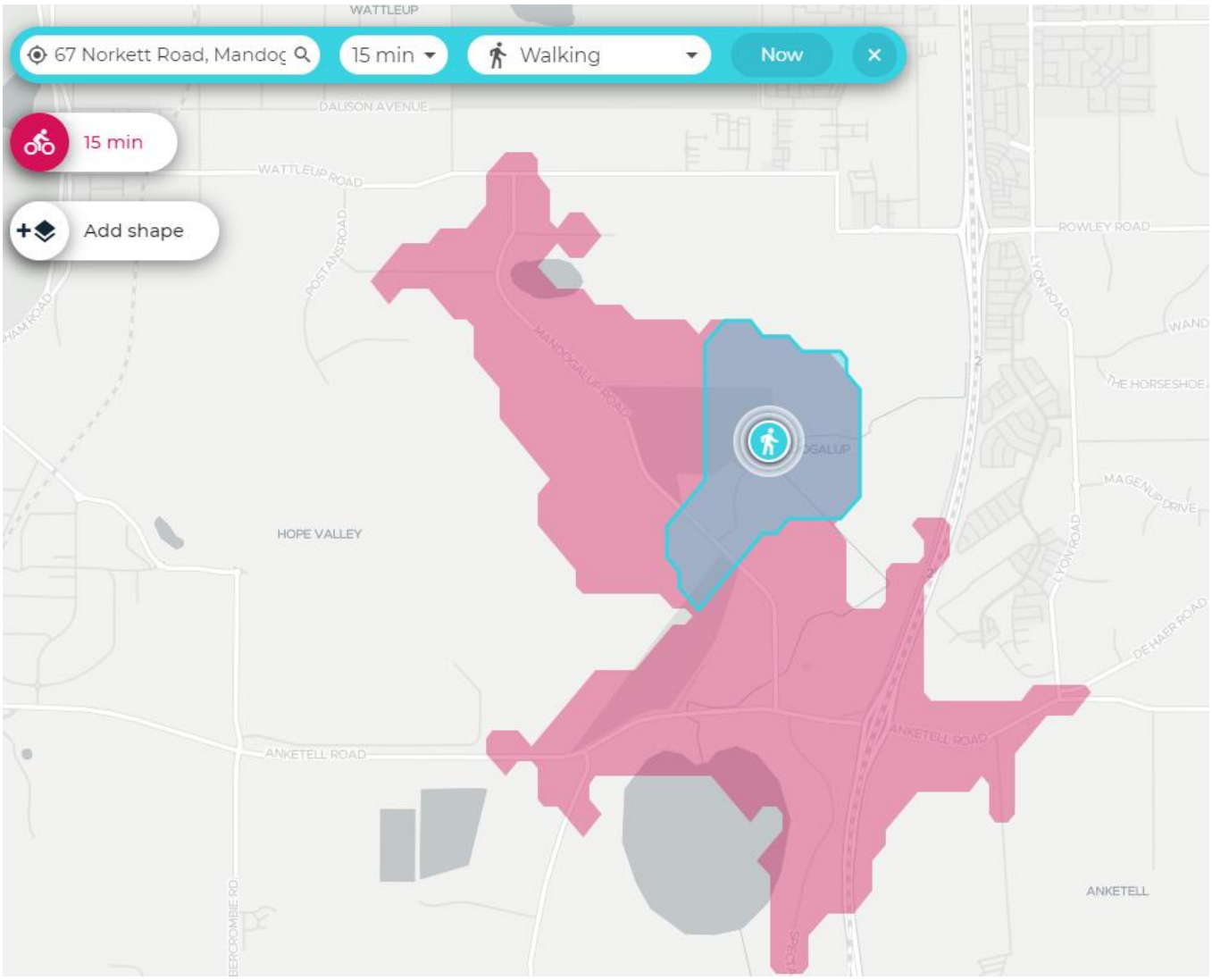


Figure 32 Travel time Platform Walking and Cycling

Strava is a social fitness network, primarily used to track cycling and running exercises, using GPS data. The data can be recorded and displayed as a heat map, showing true and accurate route preferences for walkers, runners and cyclists.

As shown in Figure 33, there is no recorded walking or running activity within the Scheme Area from users of the app, however it is common within the Beeliar Regional Park and the residential area to the east of the Freeway.

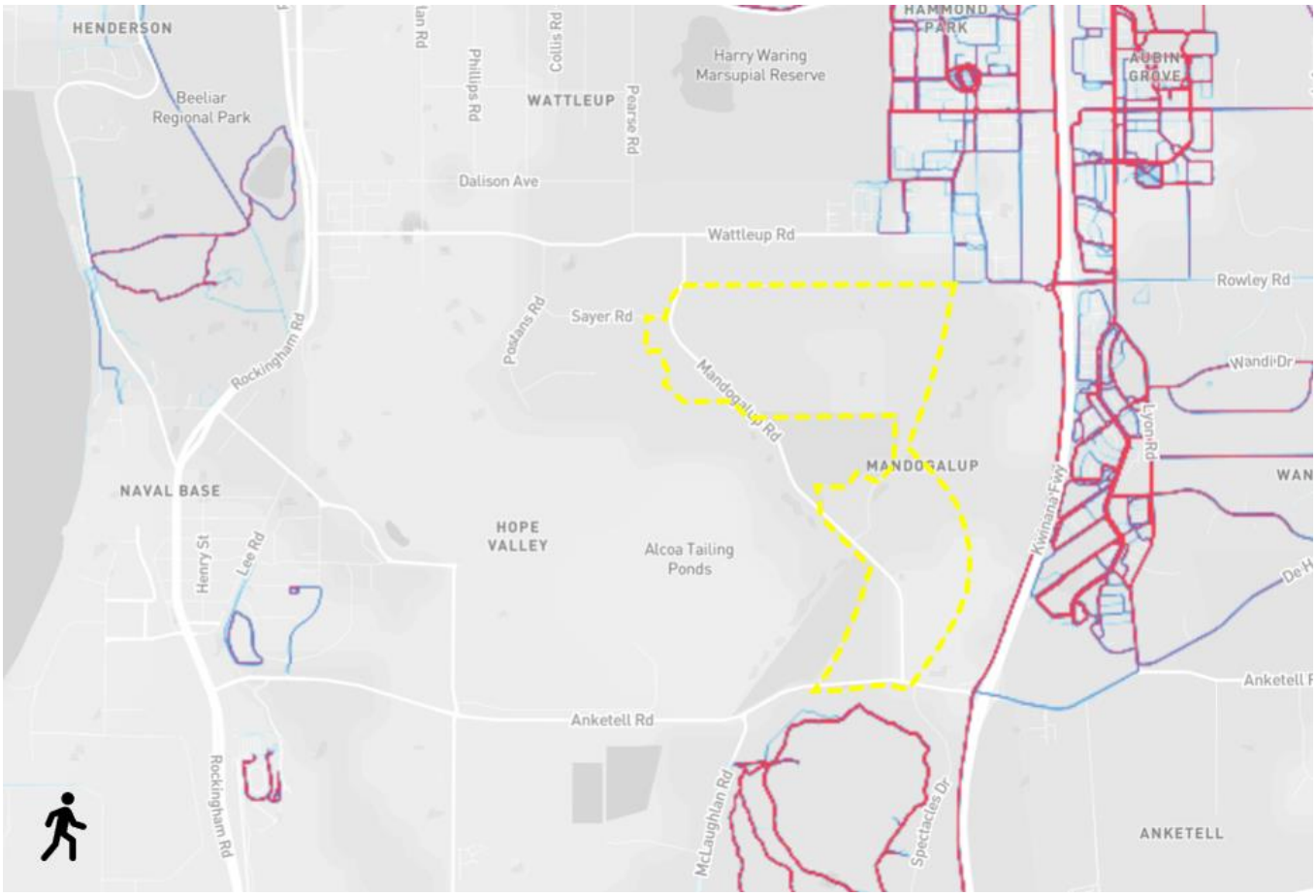


Figure 33 Strava Heat Map – Walking and Running

7. EXISTING CYCLING NETWORK

7.1 Cycling Network

The City of Kwinana's Bike and Walk Plan (2018) is in a draft format and only identifies the key regional routes and no local routes. The date of release of this report predates the finalisation of the Long Term Cycle Network.

The existing cycle network within and around Mandogalup is shown in Figure 34. The main elements include the Principal Shared Path (PSP) which runs north-south along the western side of the Kwinana Freeway and the various Perth Bicycle Network routes along Wattleup Road, Rowley Road, Mandogalup Road and a section of Anketell Road. There has been a recent extension of the PSP network 300m westbound along Rowley Road which is not yet reflected in the Department of Transport mapping.

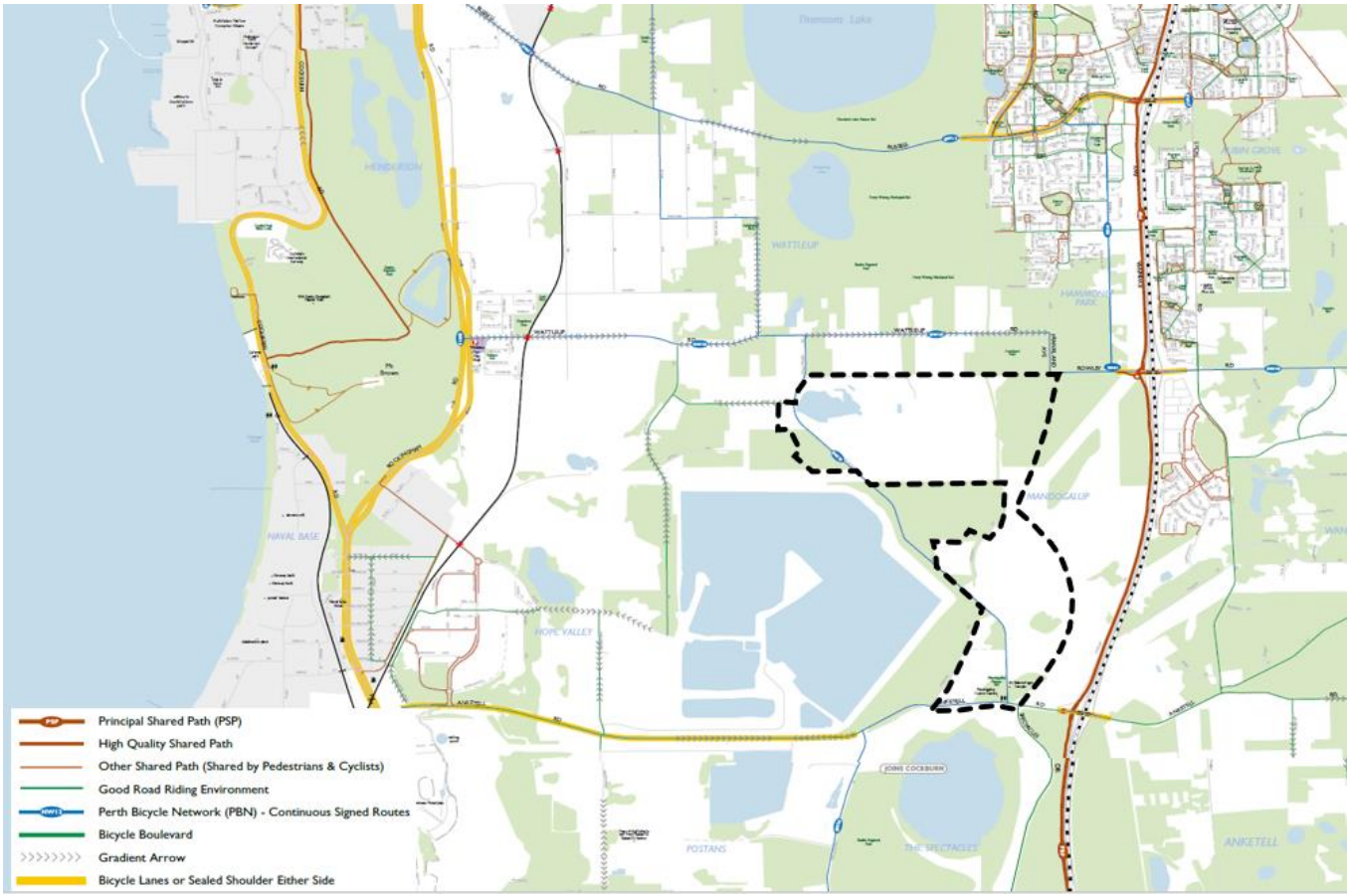


Figure 34 Cockburn and Rockingham: Perth comprehensive bike map (Source: DoT)

The Strava heat map for cycling near Mandogalup shows that there is limited activity along Mandogalup Road with the majority of cycling trips conducted along the Kwinana Freeway PSP (Figure 35).

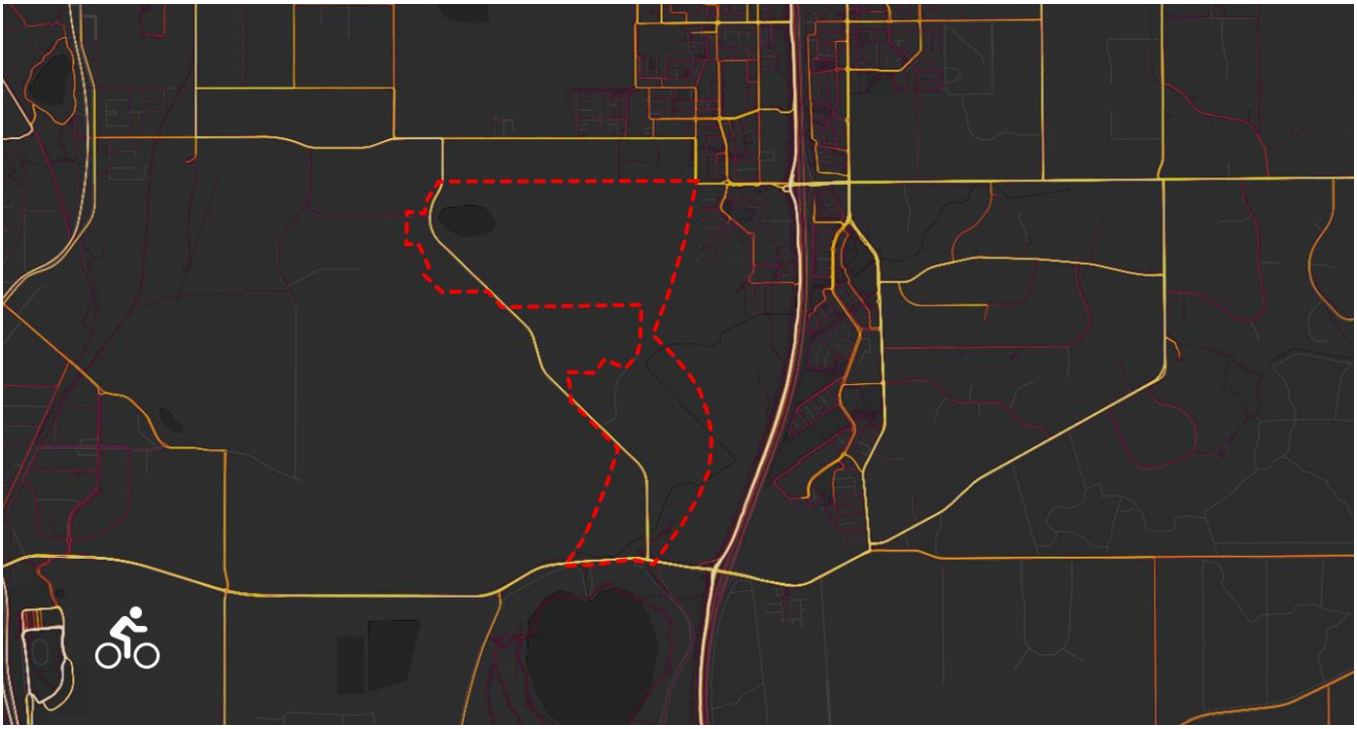


Figure 35 Strava Heat Map – Cycling (source: Strava)

7.2 Future Cycling Network

Between 2018-2020 the Department of Transport worked with 33 local governments across Perth and Peel on the Long Term Cycle Network (LTCN) project. The LTCN project has been a collaboration between State and local governments to agree on an aspirational network of bicycle routes that link parks, schools, community facilities and transport services, to make cycling a convenient and viable option for more people and more journeys.

Figure 36 shows that a Primary Route (typically a Principal Shared Path) will be constructed along Wattleup Road, continuing the existing PSP on Rowley Road. A Secondary Route is proposed to be constructed along the south side of Anketell Road with upgrades forming part of the Anketell-Thomas Road Freight Corridor works from Westport and Main Roads WA.

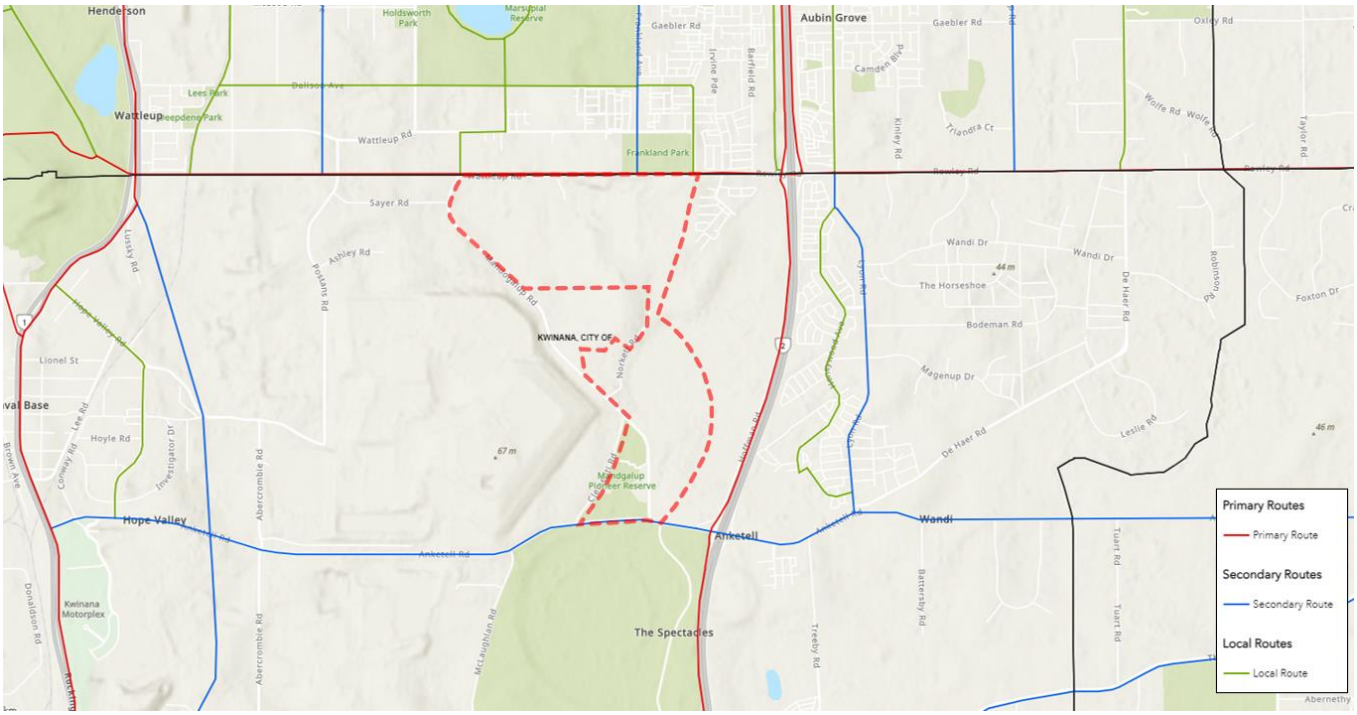


Figure 36 Long Term Cycle Network (source: DoT)

8. ANALYSIS OF IMPROVEMENT PLAN LAND USE SCENARIOS

8.1 High-Level Analysis Method

In 2019 when Flyt began working with DPLH and the TBB team to develop the original three different land use scenarios for the future of the Mandogalup Improvement Scheme (Project Development Phase Scenarios – 2019-2020), it was agreed with State agencies that a first principles approach to trip generation and trip distribution would be the most suitable approach to analyse the scenarios for the Mandogalup Improvement Plan area.

In 2019-2020 Main Roads WA informed the project team that they did not have sufficient resource to run the original three land use scenarios for the Mandogalup Improvement Plan area through the strategic traffic forecasting model ROM – this was due to the ROM model run capacity at the time being used by key strategic transport projects across the METRONET program and Westport project.

As such, Flyt agreed with Main Roads WA to use a first principles approach to traffic generation and distribution to assess the relative impacts of the three land use scenarios – the trip rates and trip distribution were agreed with Main Roads WA.

The high-level first principles analysis of the original three land use scenarios was presented in a series of presentations to stakeholders and the project team and updated a number of times to reflect modifications to each of the three scenarios (this work took place across late-2020). It is understood by Flyt that this analysis was used by DPLH and the project team to support the development of the preferred land use scenario.

For the purposes of consistency the Project Finalisation Phase Scenarios (2023) draft, modified and final preferred land use scenarios have also been assessed using the same first principles approach to traffic generation and distribution to enable a comparison against the original three land use scenarios from 2019-2020.

8.2 Vehicle Trip Rates

Table 2 sets out the vehicle trip rates used for the first principles approach to traffic generation and source of the rates.

Table 2 Vehicle Trip Rates

Land Use	Unit	Peak Hour Vehicle Trip Rate	Daily Vehicle Trip Rate	Trip Rate Source
Residential	Dwellings	0.8	10.0	WAPC TIA Guidelines (2016)
School	Pupils	1.0	2.0	WAPC TIA Guidelines (2016)
	Staff	1.0	2.0	
Commercial	100m^2 GFA	2.0	16.0	Daily - Rates used by Flyt for Nambeelup / Australian Marine Complex / Clarence Beach Rd industrial areas assessments. Peak - WAPC TIA Guidelines (2016)
Retail	100m^2 GLA	12.5	121.0	NSW Guide to Traffic Generating Developments (2002)
Industrial	Per Hectare GDA	7.29	60.75	Daily – Main Roads WA input from Latitude 32 Area 4 Structure Plan industrial trip rate of 60.75 trips per ha of GDA. Peak - Main Roads WA input from Latitude 32 Area 4 Structure Plan industrial trip rate that peak trips are 12% of daily trips.
Rural Industrial	Per Hectare GDA	3.65	30.38	Agreed assumption with Main Roads WA that composite rural industrial land uses would have half the trip rate used for Industrial land use.

8.3 Traffic Generation

Applying the agreed vehicle trip rates for the high-level analysis of the land use scenarios produces total peak hour vehicle trips between 2,500-3,500 across the six scenarios and total daily vehicle trips between 22,300-30,500.

For the purposes of the high-level assessment the following assumptions were made:

- All retail vehicle trips across the six scenarios are internal trips within the Mandogalup Improvement Plan area and the retail land use does not generate external vehicle trips from outside of the area.
- All student vehicle trips in the residential scenario are internal trips within the Mandogalup Improvement Plan area and the school sites do not generate external student vehicle trips from outside of the area.
- All residential, school staff, commercial, industrial and rural industrial vehicle trips across the six scenarios generate external trips – with all vehicle trips associated with these land uses accessing the road network external to the Mandogalup Improvement Plan area as part of their trip.

Table 3 shows a comparison of the vehicle trips expected to be generated by the six land use scenarios. The vehicle trip generation comparison shows:

- The combined land use scenario generates the lowest level of peak hour and daily traffic.
- The residential and industrial scenarios generate similar levels of peak hour traffic, but the residential scenario generates significantly more vehicle trips across the day compared to the industrial scenario.
- The draft preferred scenario generates the highest level of peak hour and daily traffic.
- The draft preferred scenario generates a significant level of daily external vehicle trips as a result of the high level of employment generating industrial and commercial land uses.
- The draft preferred scenario generates a low level of daily internal vehicle trips as a result of the reduced retail floor space within the draft preferred scenario compared to other land use scenarios.
- The modified preferred scenario (with 50,000m^2 commercial GFA) generates lower levels of peak hour and daily traffic than the draft preferred scenario, due to the reduction in dwellings, but still slightly more peak hour traffic than any of the original three scenarios from 2019-2020.
- The final preferred scenario (with 25,000m^2 commercial GFA) generates lower levels of peak hour and daily traffic than both the draft preferred and modified preferred scenarios, due to the reduction in dwellings and commercial floor area across the final preferred scenario.
- The final preferred scenario generates similar levels of traffic to the combined scenario from 2019-2020.

Table 3 Vehicle Trip Generation for Land Use Scenarios

Vehicle Trips	Residential Scenario	Industrial Scenario	Combined Scenario	Draft Preferred	Modified Preferred (with 50,000m^2 commercial GFA)	Final Scenario (with 25,000m^2 commercial GFA)
Peak Hour – Total Vehicle Trips	**3,047**	**3,021**	**2,531**	**3,516**	**3,098**	**2,598**
Peak Hour – External Vehicle Trips	1,303	2,809	2,318	3,357	2,886	2,386
Peak Hour – Internal Vehicle Trips	1,744	213	213	159	213	213
Daily – Total Vehicle Trips	**28,787**	**24,780**	**22,316**	**30,571**	**26,524**	**22,524**
Daily – External Vehicle Trips	23,667	22,723	20,259	29,028	24,467	20,467
Daily – Internal Vehicle Trips	5,121	2,057	2,057	1,543	2,057	2,057

Table 4 to Table 9 show the detailed trip generation breakdown for each of the six scenarios – providing a detailed breakdown for each land use within the scenario.

As shown in the tables, each of the six scenarios has been split into three precincts (Precinct 1 = northern part of the site / Precinct 2 = central part of the site / Precinct 3 = southern part of the site), this is to assist with the traffic distribution analysis outlined in Section 8.4.

Table 4 Residential Land Use Scenario – Traffic Generation

Land Use / Veh Trips	PRECINCT 1	PRECINCT 2	PRECINCT 3	TOTAL	Trip Rate	Trip Rate Notes
Residential (no. dwellings)	1,975	400	955	3,330		
Residential - Peak Hour Veh Trips	1,580	320	764	2,664	0.8	WAPC TIA Guidelines (2016)
Residential - Daily Veh Trips (Med)	15,800	3,200	7,640	26,640	10.0	Empirical conversion rate from peak hour to daily residential trips
Commercial GFA (sqm)	6,473	0	4,652	11,125		
Commercial - Peak Hour Veh Trips	129	0	93	223	2.0	WAPC TIA Guidelines (2016)
Commercial - Daily Veh Trips	1,036	0	744	1,780	16.0	Rates used by Flyt for Nambeelup / Australian Marine Complex / Clarence Beach Rd industrial areas
Retail GFA (sqm)	500	0	1,500	2,000		
Retail GLA (sqm)	425	0	1,275	1,700	0.85	Assumption that 85% of GFA represents GLA
Retail - Peak Hour Veh Trips	53	0	159	213	12.5	NSW Guide to Traffic Generating Developments (2002)
Retail - Daily Veh Trips	514	0	1,543	2,057	121.0	NSW Guide to Traffic Generating Developments (2002)
Primary School (no. schools)	1	0	1	2		
Students	766	0	766	1,532	0.46	Average PS students per dwelling based on Alkimos and Piara Waters suburb analysis (x4 PS)
Staff	77	0	77	153	0.1	Average PS staff ratio to students on Alkimos and Piara Waters suburb analysis (x4 PS)
Students - Peak Hour Veh Trips	766	0	766	1,532	1.0	WAPC TIA Guidelines (2016)
Staff - Peak Hour Veh Trips	77	0	77	153	1.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Students - Daily Veh Trips	1,532	0	1,532	3,064	2.0	WAPC TIA Guidelines (2016)
Staff - Daily Veh Trips	153	0	153	306	2.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Industrial GDA (ha)	0	0	0	0		
Industrial - Peak Hour Veh Trips	0	0	0	0	7.29	Based on Latitude 32 Area 4 Structure Plan industrial trip rate assumption that peak hour trips are 12% of daily trips
Industrial - Daily Veh Trips	0	0	0	0	60.75	Based on Latitude 32 Area 4 Structure Plan industrial trip rate of 60.75 trips per hectare of GDA
Composite Rural Industrial (ha)	0	0	2	2		
Composite Rural Industrial - Peak Hour Veh Trips	0	0	7	7	3.65	Based on half the trip rate used for Industrial land use
Composite Rural Industrial - Daily Veh Trips	0	0	61	61	30.38	Based on half the trip rate used for Industrial land use
PEAK HOUR - TOTAL VEH TRIPS	1,786	320	941	3,047		
PEAK HOUR - EXTERNAL VEH TRIPS	967	320	16	1,303	43%	% of peak hour trips to/from locations external to Mandogalup
PEAK HOUR - INTERNAL VEH TRIPS	819	0	925	1,744	57%	% of peak hour trips to/from locations internal to Mandogalup
DAILY - TOTAL VEH TRIPS	16,989	3,200	8,598	28,787		
DAILY - EXTERNAL VEH TRIPS	14,943	3,200	5,524	23,667	82%	% of daily trips to/from locations external to Mandogalup
DAILY - INTERNAL VEH TRIPS	2,046	0	3,075	5,121	18%	% of daily trips to/from locations internal to Mandogalup

Table 5 Industrial Land Use Scenario – Traffic Generation

Land Use / Veh Trips	PRECINCT 1	PRECINCT 2	PRECINCT 3	TOTAL	Trip Rate	Trip Rate Notes
Residential (no. dwellings)	0	0	0	0		
Residential - Peak Hour Veh Trips	0	0	0	0	0.8	WAPC TIA Guidelines (2016)
Residential - Daily Veh Trips (Med)	0	0	0	0	10.0	Empirical conversion rate from peak hour to daily residential trips
Commercial GFA (sqm)	25,276	0	34,299	59,575		
Commercial - Peak Hour Veh Trips	506	0	686	1,192	2.0	WAPC TIA Guidelines (2016)
Commercial - Daily Veh Trips	4,044	0	5,488	9,532	16.0	Rates used by Flyt for Nambeelup / Australian Marine Complex / Clarence Beach Rd industrial areas
Retail GFA (sqm)	500	0	1,500	2,000		
Retail GLA (sqm)	425	0	1275	1,700	0.85	Assumption that 85% of GFA represents GLA
Retail - Peak Hour Veh Trips	53	0	159	213	12.5	NSW Guide to Traffic Generating Developments (2002)
Retail - Daily Veh Trips	514	0	1,543	2,057	121.0	NSW Guide to Traffic Generating Developments (2002)
Primary School (no. schools)	0	0	0	0		
Students	0	0	0	0	0.46	Average PS students per dwelling based on Alkimos and Piara Waters suburb analysis (x4 PS)
Staff	0	0	0	0	0.1	Average PS staff ratio to students on Alkimos and Piara Waters suburb analysis (x4 PS)
Students - Peak Hour Veh Trips	0	0	0	0	1.0	WAPC TIA Guidelines (2016)
Staff - Peak Hour Veh Trips	0	0	0	0	1.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Students - Daily Veh Trips	0	0	0	0	2.0	WAPC TIA Guidelines (2016)
Staff - Daily Veh Trips	0	0	0	0	2.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Industrial GDA (ha)	140	56	48	244		
Industrial - Peak Hour Veh Trips	1,021	408	350	1,779	7.29	Based on Latitude 32 Area 4 Structure Plan industrial trip rate assumption that peak hour trips are 12% of daily trips
Industrial - Daily Veh Trips	8,505	3,402	2,916	14,823	60.75	Based on Latitude 32 Area 4 Structure Plan industrial trip rate of 60.75 trips per hectare of GDA
Composite Rural Industrial (ha)	14	0	0	14		
Composite Rural Industrial - Peak Hour Veh Trips	51	0	0	51	3.65	Based on half the trip rate used for Industrial land use
Composite Rural Industrial - Daily Veh Trips	425	0	0	425	30.38	Based on half the trip rate used for Industrial land use
PEAK HOUR - TOTAL VEH TRIPS	1,577	408	1,036	3,021		
PEAK HOUR - EXTERNAL VEH TRIPS	1,524	408	877	2,809	93%	% of peak hour trips to/from locations external to Mandogalup
PEAK HOUR - INTERNAL VEH TRIPS	53	0	159	213	7%	% of peak hour trips to/from locations internal to Mandogalup
DAILY - TOTAL VEH TRIPS	12,974	3,402	8,404	24,780		
DAILY - EXTERNAL VEH TRIPS	12,460	3,402	6,861	22,723	92%	% of daily trips to/from locations external to Mandogalup
DAILY - INTERNAL VEH TRIPS	514	0	1,543	2,057	8%	% of daily trips to/from locations internal to Mandogalup

Table 6 Combined Land Use Scenario – Traffic Generation

Land Use / Veh Trips	PRECINCT 1	PRECINCT 2	PRECINCT 3	TOTAL	Trip Rate	Trip Rate Notes
Residential (no. dwellings)	315	315	397	1,027		
Residential - Peak Hour Veh Trips	252	252	318	822	0.8	WAPC TIA Guidelines (2016)
Residential - Daily Veh Trips (Med)	2,520	2,520	3,176	8,216	10.0	Empirical conversion rate from peak hour to daily residential trips
Commercial GFA (sqm)	21,680	0	0	21,680		
Commercial - Peak Hour Veh Trips	434	0	0	434	2.0	WAPC TIA Guidelines (2016)
Commercial - Daily Veh Trips	3,469	0	0	3,469	16.0	Rates used by Flyt for Nambeelup / Australian Marine Complex / Clarence Beach Rd industrial areas
Retail GFA (sqm)	500	0	1,500	2,000		
Retail GLA (sqm)	425	0	1275	1,700	0.85	Assumption that 85% of GFA represents GLA
Retail - Peak Hour Veh Trips	53	0	159	213	12.5	NSW Guide to Traffic Generating Developments (2002)
Retail - Daily Veh Trips	514	0	1,543	2,057	121.0	NSW Guide to Traffic Generating Developments (2002)
Primary School (no. schools)	0	0	0	0		
Students	0	0	0	0	0.46	Average PS students per dwelling based on Alkimos and Piara Waters suburb analysis (x4 PS)
Staff	0	0	0	0	0.1	Average PS staff ratio to students on Alkimos and Piara Waters suburb analysis (x4 PS)
Students - Peak Hour Veh Trips	0	0	0	0	1.0	WAPC TIA Guidelines (2016)
Staff - Peak Hour Veh Trips	0	0	0	0	1.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Students - Daily Veh Trips	0	0	0	0	2.0	WAPC TIA Guidelines (2016)
Staff - Daily Veh Trips	0	0	0	0	2.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Industrial GDA (ha)	131	29	0	160		
Industrial - Peak Hour Veh Trips	955	211	0	1,166	7.29	Based on Latitude 32 Area 4 Structure Plan industrial trip rate assumption that peak hour trips are 12% of daily trips
Industrial - Daily Veh Trips	7,958	1,762	0	9,720	60.75	Based on Latitude 32 Area 4 Structure Plan industrial trip rate of 60.75 trips per hectare of GDA
Composite Rural Industrial (ha)	0	5	25	30		
Composite Rural Industrial - Peak Hour Veh Trips	0	18	91	109	3.65	Based on half the trip rate used for Industrial land use
Composite Rural Industrial - Daily Veh Trips	0	152	759	911	30.38	Based on half the trip rate used for Industrial land use
PEAK HOUR - TOTAL VEH TRIPS	1,641	482	409	2,531		
PEAK HOUR - EXTERNAL VEH TRIPS	1,587	482	249	2,318	92%	% of peak hour trips to/from locations external to Mandogalup
PEAK HOUR - INTERNAL VEH TRIPS	53	0	159	213	8%	% of peak hour trips to/from locations internal to Mandogalup
DAILY - TOTAL VEH TRIPS	13,947	4,434	3,935	22,316		
DAILY - EXTERNAL VEH TRIPS	13,433	4,434	2,393	20,259	91%	% of daily trips to/from locations external to Mandogalup
DAILY - INTERNAL VEH TRIPS	514	0	1,543	2,057	9%	% of daily trips to/from locations internal to Mandogalup

Table 7 Draft Preferred Land Use Scenario – Traffic Generation

Land Use / Veh Trips	PRECINCT 1	PRECINCT 2	PRECINCT 3	TOTAL	Trip Rate	Trip Rate Notes
Residential (no. dwellings)	824	0	413	1,237		
Residential - Peak Hour Veh Trips	659	0	331	990	0.8	WAPC TIA Guidelines (2016)
Residential - Daily Veh Trips (Med)	6,589	0	3,307	9,896	10.0	Empirical conversion rate from peak hour to daily residential trips
Commercial GFA (sqm)	42,480	0	14,160	56,640		
Commercial - Peak Hour Veh Trips	850	0	283	1,133	2.0	WAPC TIA Guidelines (2016)
Commercial - Daily Veh Trips	6,797	0	2,266	9,062	16.0	Rates used by Flyt for Nambeelup / Australian Marine Complex / Clarence Beach Rd industrial areas
Retail GFA (sqm)	1,500	0	0	1,500		
Retail GLA (sqm)	1,275	0	0	1,275	0.85	Assumption that 85% of GFA represents GLA
Retail - Peak Hour Veh Trips	159	0	0	159	12.5	NSW Guide to Traffic Generating Developments (2002)
Retail - Daily Veh Trips	1,543	0	0	1,543	121.0	NSW Guide to Traffic Generating Developments (2002)
Primary School (no. schools)	0	0	0	0		
Students	0	0	0	0	0.46	Average PS students per dwelling based on Alkimos and Piara Waters suburb analysis (x4 PS)
Staff	0	0	0	0	0.1	Average PS staff ratio to students on Alkimos and Piara Waters suburb analysis (x4 PS)
Students - Peak Hour Veh Trips	0	0	0	0	1.0	WAPC TIA Guidelines (2016)
Staff - Peak Hour Veh Trips	0	0	0	0	1.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Students - Daily Veh Trips	0	0	0	0	2.0	WAPC TIA Guidelines (2016)
Staff - Daily Veh Trips	0	0	0	0	2.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Industrial GDA (ha)	115	46	18	179		
Industrial - Peak Hour Veh Trips	841	332	132	1,305	7.29	Based on Latitude 32 Area 4 Structure Plan industrial trip rate assumption that peak hour trips are 12% of daily trips
Industrial - Daily Veh Trips	7,011	2,766	1,097	10,874	60.75	Based on Latitude 32 Area 4 Structure Plan industrial trip rate of 60.75 trips per hectare of GDA
Composite Rural Industrial (ha)	0	0	24	24		
Composite Rural Industrial - Peak Hour Veh Trips	0	0	89	89	3.65	Based on half the trip rate used for Industrial land use
Composite Rural Industrial - Daily Veh Trips	0	0	738	738	30.38	Based on half the trip rate used for Industrial land use
PEAK HOUR - TOTAL VEH TRIPS	2,350	332	834	3,516		
PEAK HOUR - EXTERNAL VEH TRIPS	2,190	332	834	3,357	95%	% of peak hour trips to/from locations external to Mandogalup
PEAK HOUR - INTERNAL VEH TRIPS	159	0	0	159	5%	% of peak hour trips to/from locations internal to Mandogalup
DAILY - TOTAL VEH TRIPS	20,397	2,766	7,408	30,571		
DAILY - EXTERNAL VEH TRIPS	18,854	2,766	7,408	29,028	95%	% of daily trips to/from locations external to Mandogalup
DAILY - INTERNAL VEH TRIPS	1,543	0	0	1,543	5%	% of daily trips to/from locations internal to Mandogalup

Table 8 Modified Preferred Land Use Scenario (with 50,000m² commercial GFA) – Traffic Generation

Land Use / Veh Trips	PRECINCT 1	PRECINCT 2	PRECINCT 3	TOTAL	Trip Rate	Trip Rate Notes
Residential (no. dwellings)	597	0	182	779		
Residential - Peak Hour Veh Trips	478	0	146	623	0.8	WAPC TIA Guidelines (2016)
Residential - Daily Veh Trips (Med)	4,776	0	1,456	6,232	10.0	Empirical conversion rate from peak hour to daily residential trips
Commercial GFA (sqm)	36,768	0	13,232	50,000		
Commercial - Peak Hour Veh Trips	735	0	265	1,000	2.0	WAPC TIA Guidelines (2016)
Commercial - Daily Veh Trips	5,883	0	2,117	8,000	16.0	Rates used by Flyt for Nambeelup / Australian Marine Complex / Clarence Beach Rd industrial areas
Retail GFA (sqm)	1,500	0	500	2,000		
Retail GLA (sqm)	1,275	0	425	1,700	0.85	Assumption that 85% of GFA represents GLA
Retail - Peak Hour Veh Trips	159	0	53	213	12.5	NSW Guide to Traffic Generating Developments (2002)
Retail - Daily Veh Trips	1,543	0	514	2,057	121.0	NSW Guide to Traffic Generating Developments (2002)
Primary School (no. schools)	0	0	0	0		
Students	0	0	0	0	0.46	Average PS students per dwelling based on Alkimos and Piara Waters suburb analysis (x4 PS)
Staff	0	0	0	0	0.1	Average PS staff ratio to students on Alkimos and Piara Waters suburb analysis (x4 PS)
Students - Peak Hour Veh Trips	0	0	0	0	1.0	WAPC TIA Guidelines (2016)
Staff - Peak Hour Veh Trips	0	0	0	0	1.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Students - Daily Veh Trips	0	0	0	0	2.0	WAPC TIA Guidelines (2016)
Staff - Daily Veh Trips	0	0	0	0	2.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Industrial GDA (ha)	124.3362	45.2884	18.7400	188.3646		
Industrial - Peak Hour Veh Trips	906	330	137	1,373	7.29	Based on Latitude 32 Area 4 Structure Plan industrial trip rate assumption that peak hour trips are 12% of daily trips
Industrial - Daily Veh Trips	7,553	2,751	1,138	11,443	60.75	Based on Latitude 32 Area 4 Structure Plan industrial trip rate of 60.75 trips per hectare of GDA
Composite Rural Industrial (ha)	0	0	27.9361	27.9361		
Composite Rural Industrial - Peak Hour Veh Trips	0	0	102	102	3.65	Based on half the trip rate used for Industrial land use
Composite Rural Industrial - Daily Veh Trips	0	0	849	849	30.38	Based on half the trip rate used for Industrial land use
PEAK HOUR - TOTAL VEH TRIPS	2,119	330	649	3,098		
PEAK HOUR - EXTERNAL VEH TRIPS	1,960	330	596	2,886	93%	% of peak hour trips to/from locations external to Mandogalup
PEAK HOUR - INTERNAL VEH TRIPS	159	0	53	213	7%	% of peak hour trips to/from locations internal to Mandogalup
DAILY - TOTAL VEH TRIPS	18,212	2,751	5,560	26,524		
DAILY - EXTERNAL VEH TRIPS	16,670	2,751	5,046	24,467	92%	% of daily trips to/from locations external to Mandogalup
DAILY - INTERNAL VEH TRIPS	1,543	0	514	2,057	8%	% of daily trips to/from locations internal to Mandogalup

Table 9 Final Preferred Land Use Scenario (with 25,000m² commercial GFA) – Traffic Generation

Land Use / Veh Trips	PRECINCT 1	PRECINCT 2	PRECINCT 3	TOTAL	Trip Rate	Trip Rate Notes
Residential (no. dwellings)	597	0	182	779		
Residential - Peak Hour Veh Trips	478	0	146	623	0.8	WAPC TIA Guidelines (2016)
Residential - Daily Veh Trips (Med)	4,776	0	1,456	6,232	10.0	Empirical conversion rate from peak hour to daily residential trips
Commercial GFA (sqm)	18,384	0	6,616	25,000		
Commercial - Peak Hour Veh Trips	368	0	132	500	2.0	WAPC TIA Guidelines (2016)
Commercial - Daily Veh Trips	2,941	0	1,059	4,000	16.0	Rates used by Flyt for Nambeelup / Australian Marine Complex / Clarence Beach Rd industrial areas
Retail GFA (sqm)	1,500	0	500	2,000		
Retail GLA (sqm)	1,275	0	425	1,700	0.85	Assumption that 85% of GFA represents GLA
Retail - Peak Hour Veh Trips	159	0	53	213	12.5	NSW Guide to Traffic Generating Developments (2002)
Retail - Daily Veh Trips	1,543	0	514	2,057	121.0	NSW Guide to Traffic Generating Developments (2002)
Primary School (no. schools)	0	0	0	0		
Students	0	0	0	0	0.46	Average PS students per dwelling based on Alkimos and Piara Waters suburb analysis (x4 PS)
Staff	0	0	0	0	0.1	Average PS staff ratio to students on Alkimos and Piara Waters suburb analysis (x4 PS)
Students - Peak Hour Veh Trips	0	0	0	0	1.0	WAPC TIA Guidelines (2016)
Staff - Peak Hour Veh Trips	0	0	0	0	1.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Students - Daily Veh Trips	0	0	0	0	2.0	WAPC TIA Guidelines (2016)
Staff - Daily Veh Trips	0	0	0	0	2.0	Assumption based on WAPC TIA Guidelines (2016) approach to student veh trips
Industrial GDA (ha)	124.3362	45.2884	18.7400	188.3646		
Industrial - Peak Hour Veh Trips	906	330	137	1,373	7.29	Based on Latitude 32 Area 4 Structure Plan industrial trip rate assumption that peak hour trips are 12% of daily trips
Industrial - Daily Veh Trips	7,553	2,751	1,138	11,443	60.75	Based on Latitude 32 Area 4 Structure Plan industrial trip rate of 60.75 trips per hectare of GDA
Composite Rural Industrial (ha)	0	0	27.9361	27.9361		
Composite Rural Industrial - Peak Hour Veh Trips	0	0	102	102	3.65	Based on half the trip rate used for Industrial land use
Composite Rural Industrial - Daily Veh Trips	0	0	849	849	30.38	Based on half the trip rate used for Industrial land use
PEAK HOUR - TOTAL VEH TRIPS	1,752	330	516	2,598		
PEAK HOUR - EXTERNAL VEH TRIPS	1,592	330	463	2,386	92%	% of peak hour trips to/from locations external to Mandogalup
PEAK HOUR - INTERNAL VEH TRIPS	159	0	53	213	8%	% of peak hour trips to/from locations internal to Mandogalup
DAILY - TOTAL VEH TRIPS	15,271	2,751	4,502	22,524		
DAILY - EXTERNAL VEH TRIPS	13,728	2,751	3,987	20,467	91%	% of daily trips to/from locations external to Mandogalup
DAILY - INTERNAL VEH TRIPS	1,543	0	514	2,057	9%	% of daily trips to/from locations internal to Mandogalup

8.4 Traffic Distribution

As previously outlined in Section 8.1, in 2019-2020 Main Roads WA informed the project team that they did not have sufficient resource to run the original three land use scenarios for the Mandogalup Improvement Plan area through the strategic traffic forecasting model ROM – this was due to the ROM model run capacity at the time being used by key strategic transport projects across the METRONET program and Westport project.

As such, Flyt agreed with Main Roads WA to use a first principles approach to traffic generation and distribution to assess the relative impacts of the three land use scenarios – the trip rates and trip distribution were agreed with Main Roads WA.

As shown in Figure 37, each of the six scenarios has been split into three precincts (Precinct 1 = northern part of the site / Precinct 2 = central part of the site / Precinct 3 = southern part of the site), this is to assist with the traffic distribution analysis.

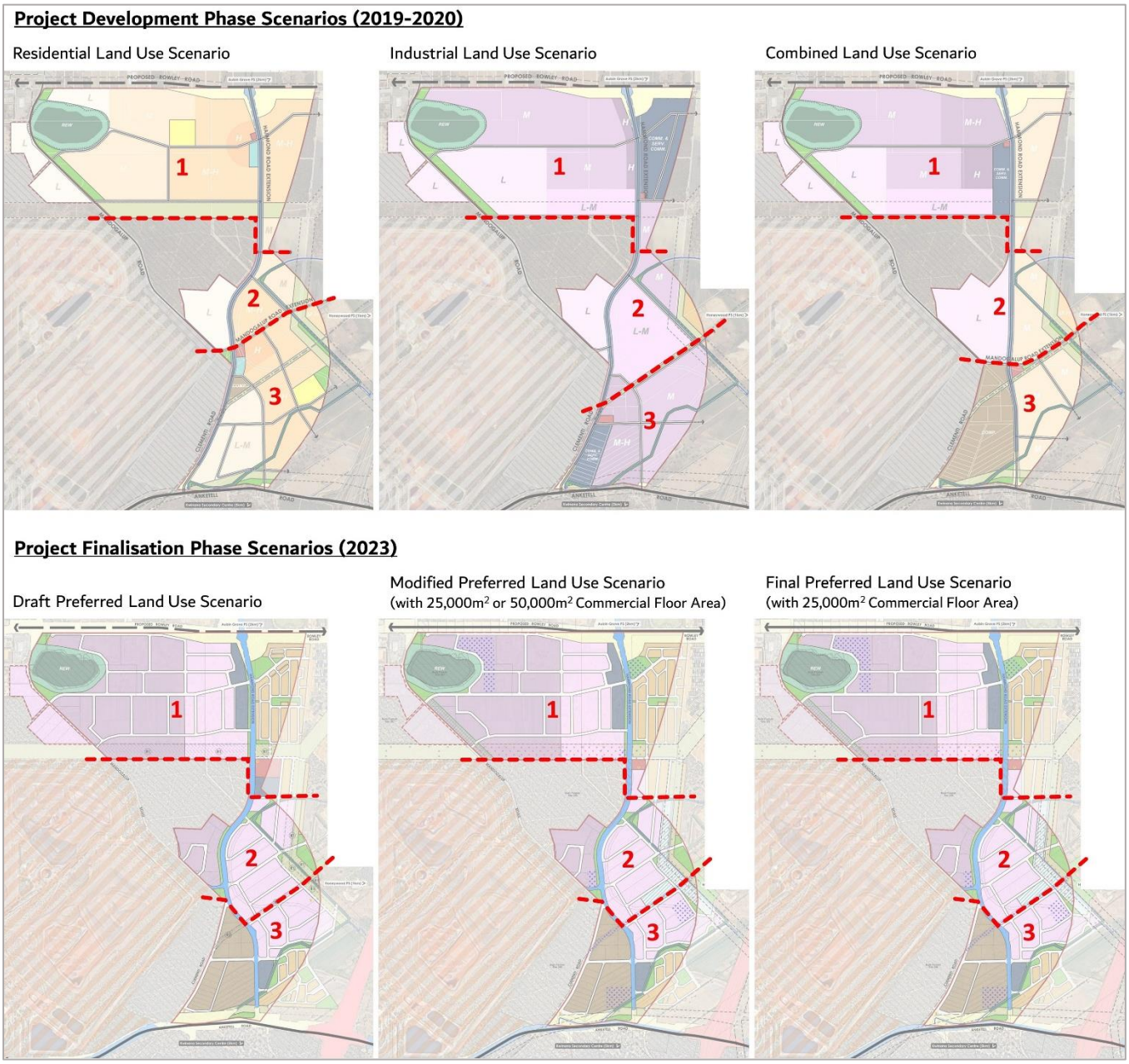


Figure 37 Land Use Scenarios Vehicle Trip Generation Precincts (base plan source: TBB)

In 2019-2020 Main Roads WA were able to provide a ROM model plot from their 2041 model run for a modelled scenario that only included existing land uses within the Mandogalup Improvement Scheme Area and did not reflect the proposed land uses for the area as developed as part of this project.

As such, it was agreed with Main Roads WA that the first principles approach to assessment the traffic distribution impacts of the six scenarios would be based on the following assumptions:

- Traffic volumes analysis focused on the key external corridors of Rowley Road and Anketell Road.
- Traffic volume analysis to consider potential increase in traffic volumes on the key external corridors for each land use scenario compared to the base case 2041 existing situation.
- All external vehicle trip generated by the land use scenario from Precinct 1 (northern part of the site) to be distributed by the Rowley Road corridor.
- All external vehicle trip generated by the land use scenario from Precinct 2 (central part of the site) and Precinct 3 (southern part of the site) to be distributed by the Anketell Road corridor.
- Distributional split between east and west traffic to be based on the land use scenario – with less east traffic (towards the new port/industrial areas) in the Residential scenario (c.20% east / c.80% west) compared with the Industrial scenario (c.80% east / c.20% west) – and with the Combined Scenario (and all subsequent Draft Preferred, Modified Preferred and Final Preferred scenarios) with east-west distributions between the Residential and Industrial scenarios (c.40%-50% east / c.50%-60% west).

Table 10 shows the increase in daily external vehicle trips generated by each of the six land use scenarios above the 4,500vpd expected to be produced by land uses within the Mandogalup Improvement Scheme Area from the land uses included within the Main Roads WA ROM model run for 2041.

Table 10 Additional External Vehicle Trips Generated by Land Use Scenarios in 2041

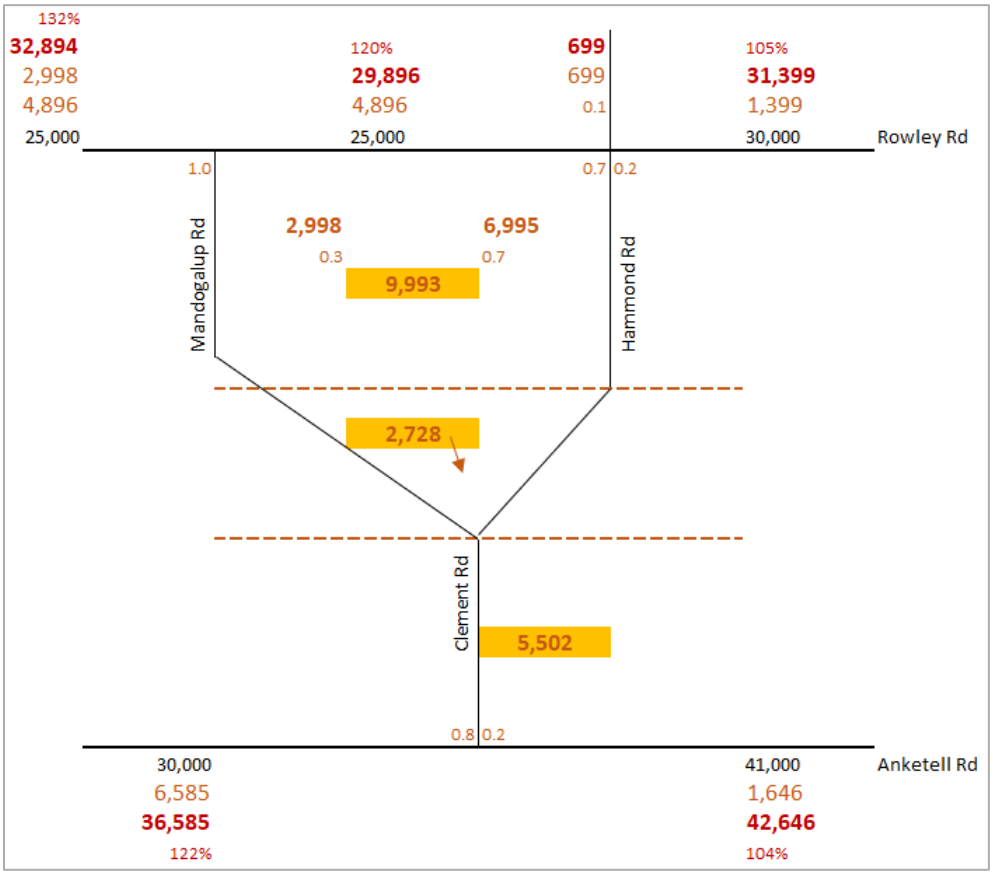
Vehicle Trips	Residential Scenario	Industrial Scenario	Combined Scenario	Draft Preferred	Modified Preferred (with 50,000m² commercial GFA)	Final Scenario (with 25,000m² commercial GFA)
Daily – Additional Total Vehicle Trips above 4,500vpd	19,167	18,223	15,759	24,528	19,967	15,967
Daily – % Increase in Total Vehicle Trips above 4,500vpd	*426%*	*405%*	*350%*	*545%*	*444%*	*355%*

The analysis shows that of the six scenarios the Combined Scenario and Final Preferred Scenario are expected to generate the fewest external vehicle trips on the key external road network surrounding the Mandogalup Improvement Scheme Area – which was an important consideration for key project stakeholders such a Main Roads WA and the City of Kwinana.

Figure 38 to Figure 43 show the approximate distributions of traffic from each of the six land use scenarios and the approximate increase traffic on the key external road network corridors of Rowley Road and Anketell Road. The Final Preferred land use scenario shows that the Improvement Scheme Area could generate traffic volumes that result in:

- Rowley Road to the east of the site having a 9% increase in traffic from 30,000vpd to 32,550vpd and to the west of the site having a 27% increase in traffic from 25,000vpd to 31,850vpd in 2041.
- Anketell Road to the east of the site having a 8% increase in traffic from 41,000vpd to 44,150vpd and to the west of the site having a 7% increase in traffic from 30,000vpd to 32,100vpd in 2041.

Figure 38 Residential Land Use Scenario – Traffic Distribution



LEGEND

10,000	Main Roads WA ROM 2041 traffic
10,000	Mandogalup Improvement Plan area traffic
10,000	**Combined Main Roads WA ROM 2041 traffic and Mandogalup Improvement Plan area traffic.**
110%	% increase in traffic between Main Roads WA ROM 2041 traffic and Mandogalup Improvement Plan area traffic.

Figure 39 Industrial Land Use Scenario – Traffic Distribution

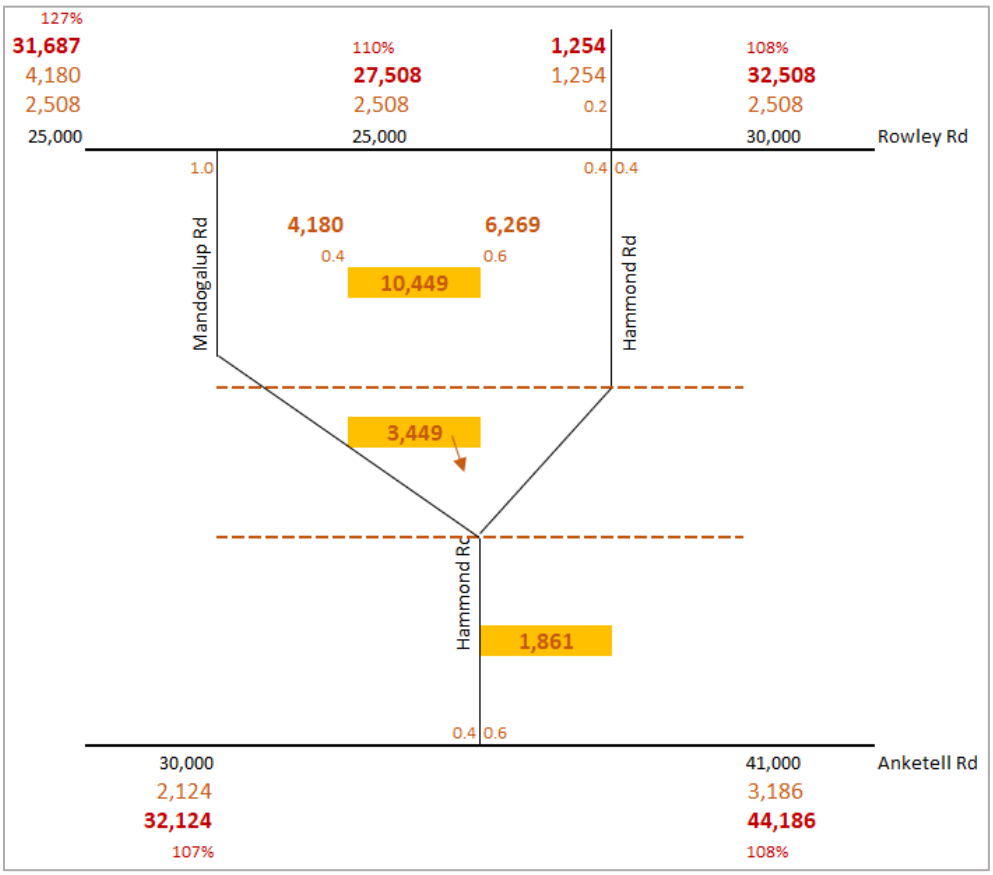
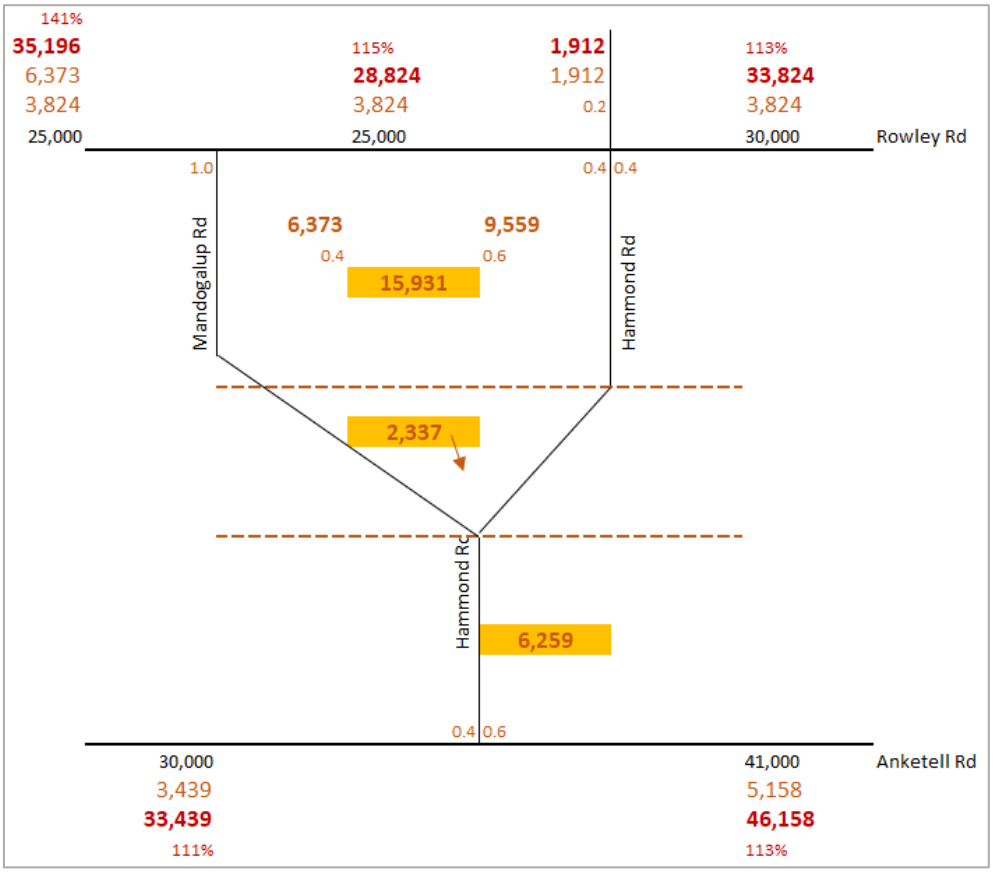


Figure 40 Combined Land Use Scenario – Traffic Distribution



LEGEND

10,000	Main Roads WA ROM 2041 traffic
10,000	Mandogalup Improvement Plan area traffic
10,000	**Combined Main Roads WA ROM 2041 traffic and Mandogalup Improvement Plan area traffic.**
110%	% increase in traffic between Main Roads WA ROM 2041 traffic and Mandogalup Improvement Plan area traffic.

Figure 41 Draft Preferred Land Use Scenario – Traffic Distribution

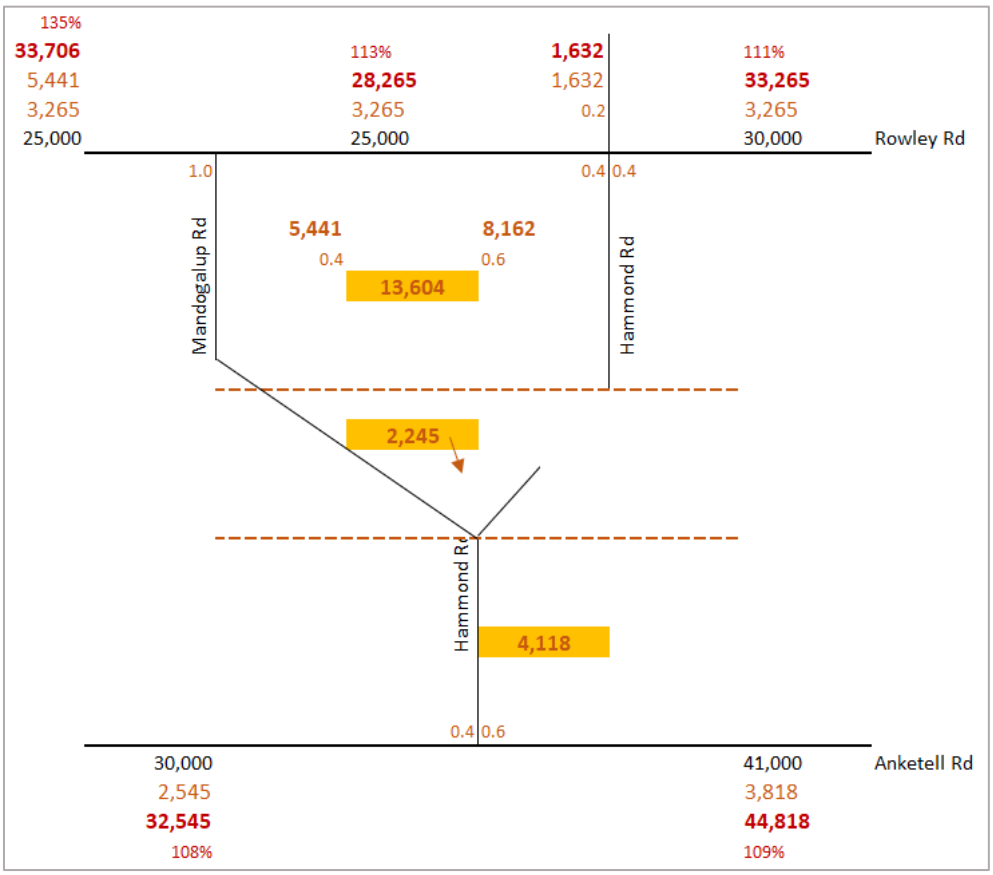


Figure 42 Modified Preferred Land Use Scenario (with 50,000m² commercial GFA) – Traffic Distribution

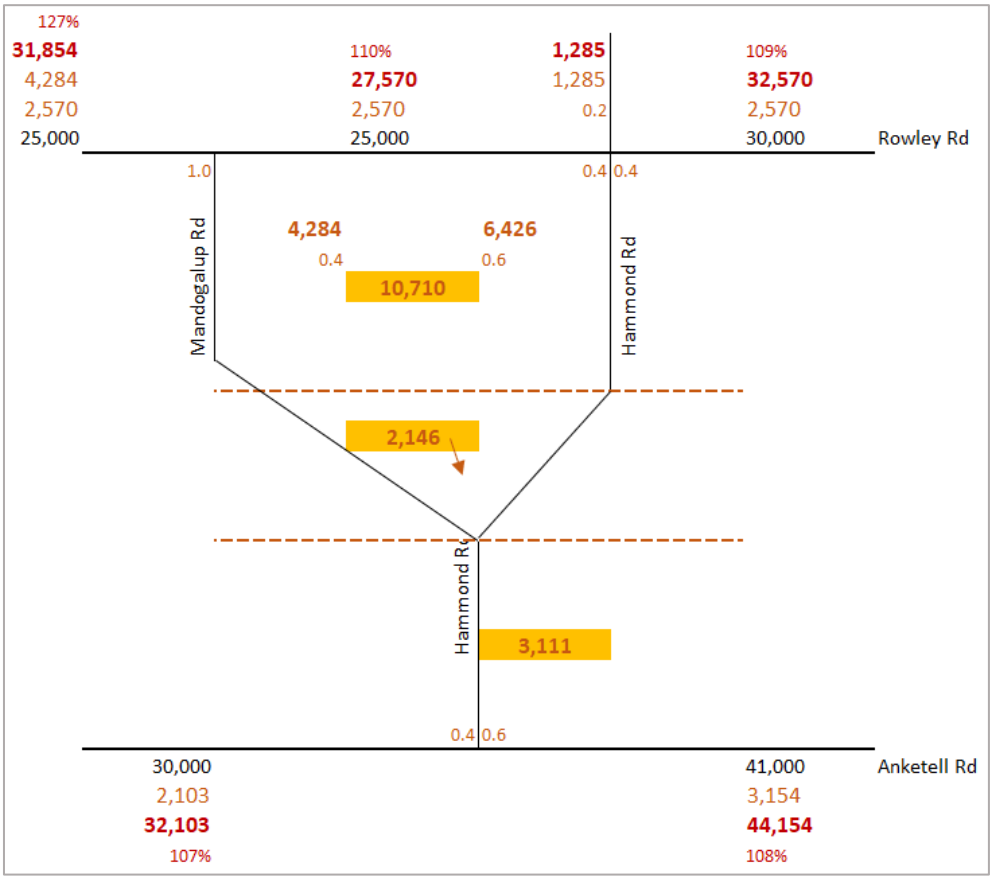


Figure 43 Final Preferred Land Use Scenario (with 25,000m² commercial GFA) – Traffic Distribution

9. FINAL PREFERRED LAND USE SCENARIO ACCESS STRATEGY

9.1 Main Roads WA ROM Model Data (2051)

In April/May 2023 Main Roads WA provided DPLH and the project team with ROM model outputs for the 2051 land use scenario. The ROM model outputs were provided by Main Roads WA to support the project team with assessing the Final Preferred Scenario for the Mandogalup Improvement Plan area. The ROM model outputs were provided for the following 2051 land use scenario:

- 2051 DAEDS land use data – all day traffic volumes (v33)

The ROM model outputs were provided with the caveat from DPLH that the 2051 land use scenario run within the Main Roads WA ROM model did not fully consider all the land uses being proposed within the Final Preferred Scenario for the Mandogalup Improvement Plan area – and only accounted for approximately 70% of the Final Preferred Scenario land use assumptions.

In addition, Main Roads WA provided DPLH and the project team with a series of select link analysis plots from the 2051 ROM model to provide additional context as to the origin and destination of traffic along particular links within the Mandogalup Improvement Plan area.

The select link plots show that in the ROM model there is a high through traffic movement across the Mandogalup Improvement Plan area between the Kwinana Freeway south of Anketell Road and the Rockingham Road-Stock Road corridor to access Spearwood, Hamilton Hill, Fremantle and beyond. This movement is via Kwinana Freeway-Anketell Road-Hammond Road Extension-Mandogalup Road-Rowley Road-Rockingham Road-Stock Road.

With the planned future upgrades to both the Rowley Road and Anketell Road corridors, it would not be expected in the future that the Hammond Road Extension-Mandogalup Road corridor would be used as a significant through route to access the Kwinana Freeway – with traffic expected to travel the length of Rowley Road between the Freeway and Rockingham Road-Stock Road corridor. It is possible that the 2051 land use scenario run within the ROM model which does not include approximately 30% of the proposed land uses for the Mandogalup Improvement Plan area is making this through movement more attractive than it ordinarily will be with the additional traffic associated with the extra 30% of land uses. For the purposes of this analysis all demands across the network remain unchanged from the ROM model plots.

Figure 44 shows the 2051 daily traffic volumes on the proposed road network through the Mandogalup Improvement Plan area and the primary road network surrounding the area. The 2051 daily traffic volumes can be summarised as:

- Hammond Rd north of Rowley Rd - 8,000-10,500 vpd in each direction
- Hammond Rd Extension between Rowley Rd and Mandogalup Rd - 9,500-10,500 vpd in each direction
- Hammond Rd Extension between Mandogalup Rd and Anketell Rd - 17,500-18,500 vpd in each direction
- Mandogalup Rd between Rowley Rd and Hammond Rd Extension - 8,500-10,000 vpd in each direction
- Rowley Rd to the east of Hammond Rd Extension - 18,000-23,000 vpd in each direction
- Rowley Rd to the west of Mandogalup Rd - 21,000-22,000 vpd in each direction
- Anketell Rd to the east of Hammond Rd Extension - 22,000-25,500 vpd in each direction
- Anketell Rd to the west of Hammond Rd Extension - 15,000-19,000 vpd in each direction

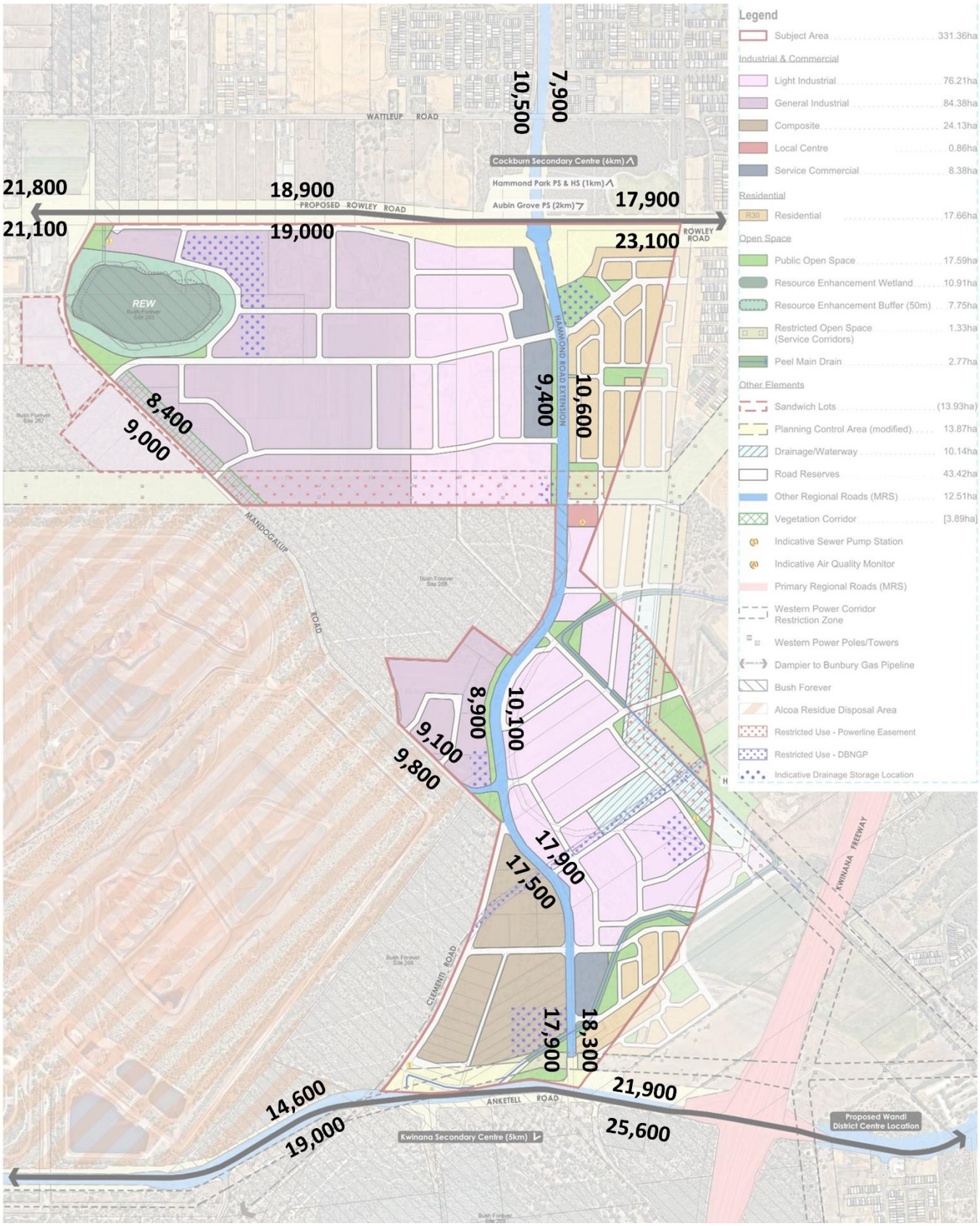


Figure 44 2051 Daily Traffic Volumes (traffic volume source: Main Roads WA / base plan source: TBB)

9.2 Traffic Volumes (2051)

As outlined in Section 9.1, the Main Roads WA ROM model outputs were provided with the caveat from DPLH that the 2051 land use scenario run within the Main Roads WA ROM model did not fully consider all the land uses being proposed within the Final Preferred Scenario for the Mandogalup Improvement Plan area – and only accounted for approximately 70% of the Final Preferred Scenario land use assumptions.

To account for the 2051 daily traffic volumes in the ROM model outputs not accounting for 30% of the land uses proposed for the Final Preferred Scenario – Flyt calculated the approximate 30% of traffic Mandogalup Improvement Plan area traffic generated by the Final Preferred Scenario that was not being reflected in the 2051 ROM outputs.

Figure 45 shows the additional 2051 daily traffic volumes not accounted for in the Main Roads ROM model outputs. The approximate additional 2051 daily traffic volumes can be summarised as:

- Hammond Rd north of Rowley Rd - 100 vpd in each direction
- Hammond Rd Extension between Rowley Rd and Mandogalup Rd - 900 vpd in each direction
- Hammond Rd Extension between Mandogalup Rd and Anketell Rd - 800 vpd in each direction
- Mandogalup Rd between Rowley Rd and Hammond Rd Extension - 600 vpd in each direction
- Rowley Rd to the east of Hammond Rd Extension - 400 vpd in each direction
- Rowley Rd to the west of Mandogalup Rd - 1,000 vpd in each direction
- Anketell Rd to the east of Hammond Rd Extension - 500 vpd in each direction
- Anketell Rd to the west of Hammond Rd Extension - 300 vpd in each direction

Figure 46 shows the total 2051 daily traffic volumes – a combination of the 2051 ROM model outputs volumes and the additional 2051 daily traffic to reflect the full land uses proposed as part of the Final Preferred Scenario for the Mandogalup Improvement Plan area. The total 2051 daily traffic volumes can be summarised as:

- Hammond Rd north of Rowley Rd - 8,000-10,600 vpd in each direction
- Hammond Rd Extension between Rowley Rd and Mandogalup Rd - 10,300-11,500 vpd in each direction
- Hammond Rd Extension between Mandogalup Rd and Anketell Rd - 18,300-19,100 vpd in each direction
- Mandogalup Rd between Rowley Rd and Hammond Rd Extension - 9,000-9,800 vpd in each direction
- Rowley Rd to the east of Hammond Rd Extension - 18,300-23,500 vpd in each direction
- Rowley Rd to the west of Mandogalup Rd - 22,100-22,800 vpd in each direction
- Anketell Rd to the east of Hammond Rd Extension - 22,400-26,1000 vpd in each direction
- Anketell Rd to the west of Hammond Rd Extension - 14,900-19,300 vpd in each direction

Figure 47 shows the total 2051 daily traffic volumes across the key internal road network across the Mandogalup Improvement Plan area. The internal traffic volumes are based on a breakdown of land uses across discreate areas of the Mandogalup Improvement Plan site, as provided by TBB.

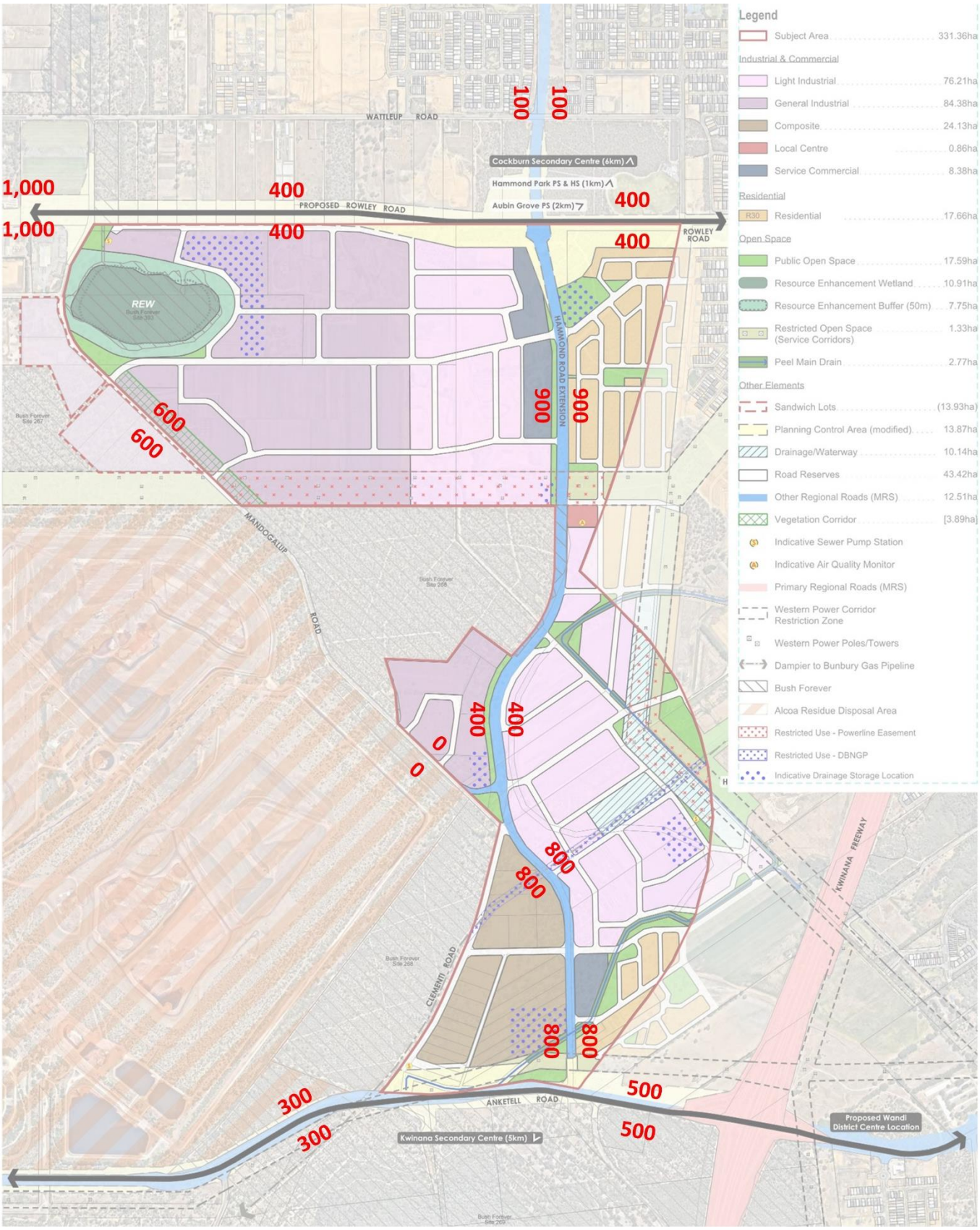


Figure 45 Additional 2051 Daily Traffic Volumes Not Accounted for in Main Roads Land Uses (base plan source: TBB)

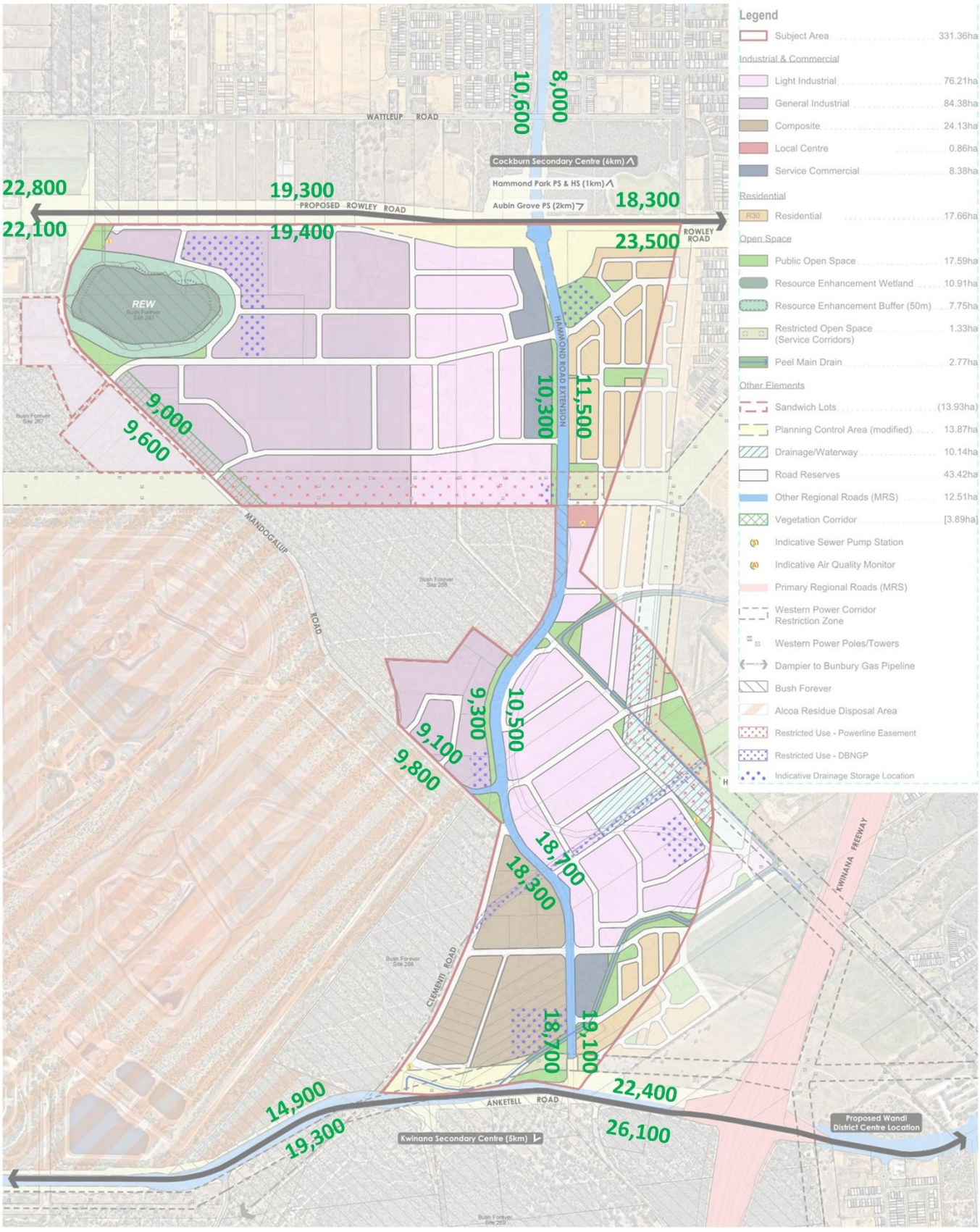


Figure 46 Total 2051 Daily Traffic Volumes Including Final Preferred Scenario Land Uses (base plan source: TBB)

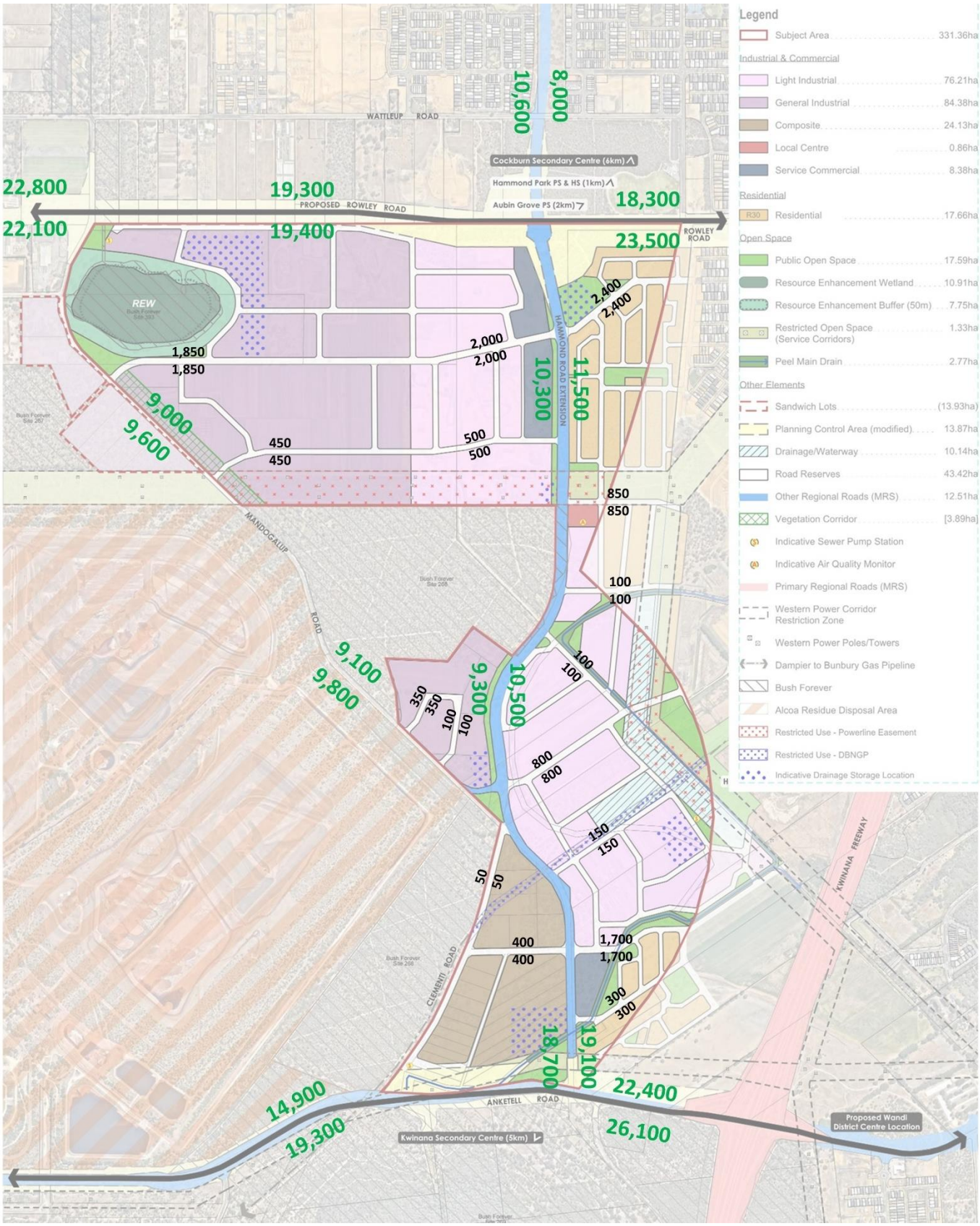


Figure 47 Total 2051 Daily Traffic Volumes Including Final Preferred Scenario Land Uses and Traffic Volumes on Internal Roads (base plan source: TBB)

9.3 Road Network Hierarchy

All road across Western Australia are categorised under Main Roads WA Road Network Hierarchy. A description of each road hierarchy category is outlined below.

Primary Distributors:

Provide for major regional and inter-regional traffic movement and carry large volumes of generally fast moving traffic. Some are strategic freight routes and all are State Roads. They are managed by Main Roads Western Australia.

Regional Distributors: Rural (Non Built-Up Areas)

Roads that are not Primary Distributors but which link significant destinations and are designed for efficient movement of people and goods within and beyond regional areas. They are managed by local government.

District Distributors A: Urban Area Roads (Built-Up Area)

Carry traffic between industrial, commercial and residential areas and generally connect to Primary Distributors. These are likely to be truck routes and provide only limited access to adjoining property. They are managed by local government.

District Distributor B: Urban Area Roads (Built-Up Area)

Perform a similar function to type A District Distributors but with reduced capacity due to flow restrictions from access to and roadside parking alongside adjoining property. These are often older roads with a traffic demand in excess of that originally intended. District Distributor A and B roads run between land-use cells and generally not through them, forming a grid which would ideally space them around 1.5 kilometres apart. They are managed by local government.

Local Distributor: Urban Area Roads (Built-Up Area)

Roads that carry traffic within a cell and link District Distributors or Regional Distributors at the boundary, to access roads. The route of Local Distributors should discourage through traffic so that the cell formed by the grid of District Distributors only carries traffic belonging to, or serving the area. These roads should accommodate buses, but discourage trucks.

Access Roads:

Provide access to abutting properties with amenity, safety and aesthetic aspects having priority over the vehicle movement function. These roads are bicycle and pedestrian friendly. They are managed by local government.

Figure 48 outlines the Main Roads WA road hierarchy for Western Australia and the criteria for each of the road categories.

CRITERIA	PRIMARY DISTRIBUTOR (PD) (see Note 2)	DISTRICT DISTRIBUTOR A (DA)	DISTRICT DISTRIBUTOR B (DB)	REGIONAL DISTRIBUTOR (RD)	LOCAL DISTRIBUTOR (LD)	ACCESS ROAD (A)
Primary Criteria						
1. Location (see Note 3)	All of WA incl. BUA	Only Built Up Area.	Only Built Up Area.	Only Non Built Up Area. (see Note 4)	All of WA incl. BUA	All of WA incl. BUA
2. Responsibility	Main Roads Western Australia.	Local Government.	Local Government.	Local Government.	Local Government.	Local Government.
3. Degree of Connectivity	High. Connects to other Primary and Distributor roads.	High. Connects to Primary and/or other Distributor roads.	High. Connects to Primary and/or other Distributor roads.	High. Connects to Primary and/or other Distributor roads.	Medium. Minor Network Role Connects to Distributors and Access Roads.	Low. Provides mainly for property access.
4. Predominant Purpose	Movement of inter regional and/or cross town/city traffic, e.g. freeways, highways and main roads.	High capacity traffic movements between industrial, commercial and residential areas.	Reduced capacity but high traffic volumes travelling between industrial, commercial and residential areas.	Roads linking significant destinations and designed for efficient movement of people and goods between and within regions.	Movement of traffic within local areas and connect access roads to higher order Distributors.	Provision of vehicle access to abutting properties
Secondary Criteria						
5. Indicative Traffic Volume (AADT)	In accordance with Classification Assessment Guidelines.	Above 8 000 vpd	Above 6 000 vpd.	Greater than 100 vpd	Built Up Area - Maximum desirable volume 6 000 vpd. Non Built Up Area – up to 100 vpd.	Built Up Area - Maximum desirable volume 3 000 vpd. Non Built Up Area – up to 75 vpd.
6. Recommended Operating Speed	60 – 110 km/h (depending on design characteristics).	60 – 80 km/h.	60 – 70 km/h.	50 – 110 km/h (depending on design characteristics).	Built Up Area 50 - 60 km/h (desired speed) Non Built Up Area 60 – 110 km/h (depending on design characteristics).	Built Up Area 50 km/h (desired speed). Non Built Up Area 50 – 110 km/h (depending on design characteristics).
7. Heavy Vehicles permitted	Yes.	Yes.	Yes.	Yes.	Yes, but preferably only to service properties.	Only to service properties.
8. Intersection treatments	Controlled with appropriate measures e.g. high speed traffic management, signing, line marking, grade separation.	Controlled with appropriate measures e.g. traffic signals.	Controlled with appropriate Local Area Traffic Management.	Controlled with measures such as signing and line marking of intersections.	Controlled with minor Local Area Traffic Management or measures such as signing.	Self controlling with minor measures.
9. Frontage Access	None on Controlled Access Roads. On other routes, preferably none, but limited access is acceptable to service individual properties.	Prefer not to have residential access. Limited commercial access, generally via service roads.	Residential and commercial access due to its historic status Prefer to limit when and where possible.	Prefer not to have property access. Limited commercial access, generally via lesser roads.	Yes, for property and commercial access due to its historic status. Prefer to limit whenever possible. Side entry is preferred.	Yes.
10. Pedestrians	Preferably none. Crossing should be controlled where possible.	With positive measures for control and safety e.g. pedestrian signals.	With appropriate measures for control and safety e.g. median/islands refuges.	Measures for control and safety such as careful siteing of school bus stops and rest areas.	Yes, with minor safety measures where necessary.	Yes.
11. Buses	Yes.	Yes.	Yes.	Yes.	Yes.	If necessary (see Note 5)
12. On-Road Parking	No (emergency parking on shoulders only).	Generally no. Clearways where necessary.	Not preferred. Clearways where necessary.	No – emergency parking on shoulders – encourage parking in off road rest areas where possible.	Built Up Area – yes, where sufficient width and sight distance allow safe passing. Non Built Up Area – no. Emergency parking on shoulders.	Yes, where sufficient width and sight distance allow safe passing.
13. Signs & Linemarking	Centrelines, speed signs, guide and service signs to highway standard.	Centrelines, speed signs, guide and service signs.	Centrelines, speed signs, guide and service signs.	Centrelines, speed signs and guide signs.	Speed and guide signs.	Urban areas – generally not applicable. Rural areas - Guide signs.
14. Rest Areas/Parking Bays	In accordance with Main Roads' *Roadside Stopping Places Policy*.	Not Applicable.	Not Applicable.	Parking Bays/Rest Areas. Desired at 60km spacing.	Not Applicable.	Not Applicable.

Figure 48 Road Hierarchy for WA – Road Categories and Criteria (source: Main Roads WA)

Figure 49 shows the existing road hierarchy classification for the Rowley Road, Anketell Road and Mandogalup Road-Hammond Road corridors. Both Rowley Road and Anketell Road are classified as Regional Distributor roads, and the Mandogalup Road-Hammond Road corridor is classified as a Local Distributor road.

Figure 50 show the potential 2051 road hierarchy classification of the key road network corridors in proximity to the Mandogalup Improvement Plan area. The potential 2051 road hierarchy is explained below:

Rowley Road

- Remain Regional Distributor with upgraded corridor to carry 18,500-23,500 vpd in each direction
- To provide a link between significant destinations – Kwinana Freeway and future port site

Anketell Road

- Remain Regional Distributor with upgraded corridor to carry 15,000-26,000 vpd in each direction
- To provide a link between significant destinations – Kwinana Freeway and future port site

Hammond Road north of Rowley Road

- Remain a Distributor B road with the proposed Mandogalup Improvement Plan area land uses expected to have a moderate impact on traffic volumes on Hammond Road north of Rowley Road.

Hammond Road Extension between Rowley Road and Anketell Road

- Classified as a Distributor A road required to carry between 10,500-19,000 vpd in each direction
- Frontage access to be limited to commercial land use access only, generally via service roads

Mandogalup Road between Rowley Road and Hammond Road Extension

- Classified as a Distributor B road required to carry between 9,000-10,000 vpd in each direction
- Frontage access to be limited where possible for both residential and commercial land uses

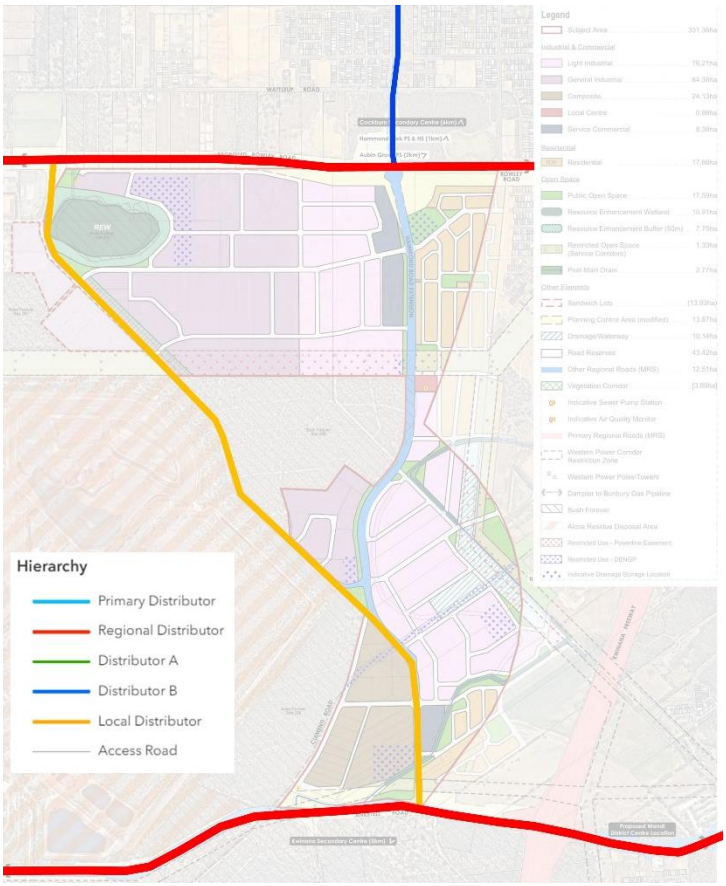


Figure 49 Existing Road Hierarchy Classification (base plan source: TBB)

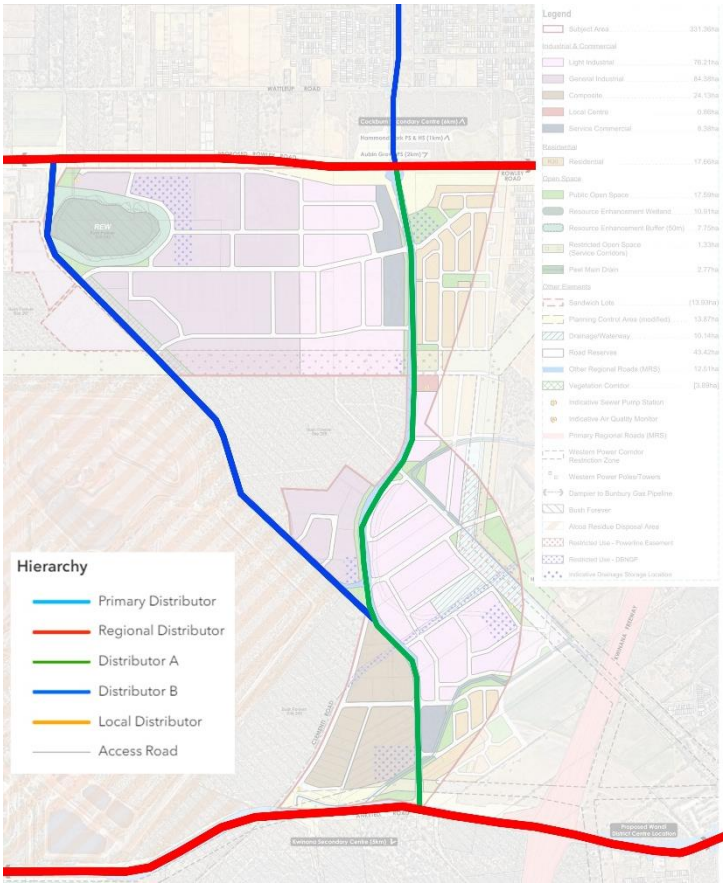


Figure 50 Potential 2051 Road Hierarchy Classification (base plan source: TBB)

9.4 Internal Transport Network

9.4.1 Restricted Access Vehicle Network

The road network abutting the light industrial land uses should be designed to support Network 4 RAVs, while the road network within the general industrial area should be capable of accommodating Network 7 RAVs, in the event that the Anketell Road Freight Corridor is upgraded to accommodate RAV Network 7.

The general industrial land uses are located in the north west of Mandogalup, with a small area to the north of the intersection between Mandogalup Road and the Hammond Road Extension. It is proposed for the Hammond Road Extension to provide the RAV Network 7 connection between Anketell Road and the general industrial area. The intersections along the length of the Hammond Road Extension should be capable of accommodating RAV Network 7 vehicles. Any roundabouts would require a central island diameter of at least 32-35m.

The proposed RAV Network for Mandogalup is shown in Figure 51.

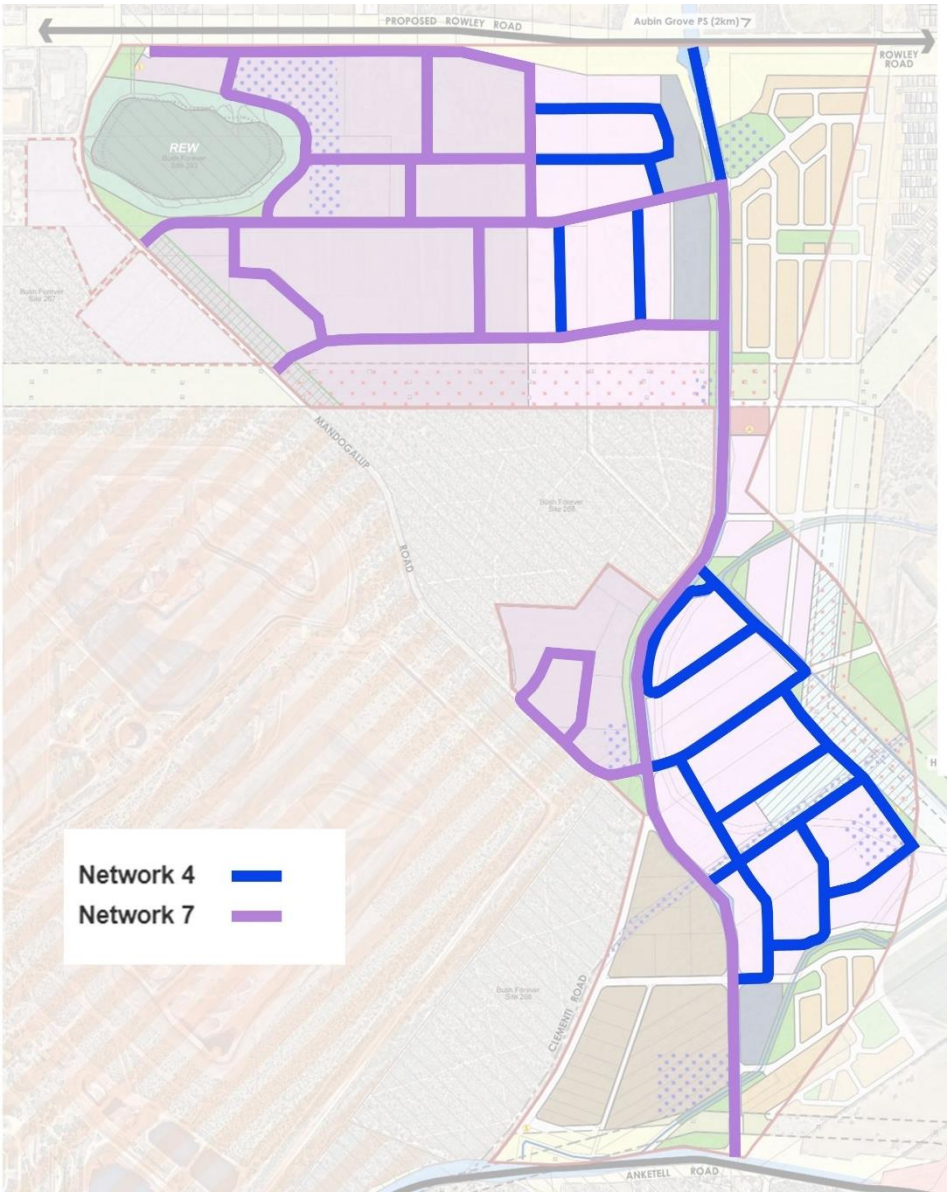


Figure 51 Potential RAV Network (base plan source: TBB)

The minor industrial access roads can be constructed to a width of 10m within a reserve of 20, 25 or 30m depending on the requirements for services and drainage. Intersections should have 10m x 10m truncations to facilitate turns by the large vehicles. Any four-way intersections between minor industrial roads should be roundabout controlled which may require localised widening of each intersecting road reserve to at least 30m.

9.4.2 Cross Sections

Potential cross sections have been developed for the distributor road network. The cross sections take into account the road hierarchy, forecast traffic volumes, frontage access conditions, and the requirement to accommodate restricted access vehicles. Final verge widths have not been set, as these may depend on drainage, servicing and environmental issues.

The proposed cross sections are illustrated in Figure 52 and described as follows:

Hammond Road Extension (Rowley Road to Mandogalup Road)

- 36 – 56m road reserve to accommodate volumes up to 22,000 vpd (including RAV Network 7).
- 8m carriageways for 2 lanes of traffic in each direction.
- 10m median to accommodate RAV turning movements and right turning lanes.
- 5-15m verges to allow for turning lanes to develop in advance of priority controlled intersections, appropriate footpaths and vegetation

Hammond Road Extension (Mandogalup Road to Anketell Road)

- 52 – 67m road reserve to accommodate volumes up to 38,000 vpd (including RAV Network 7) with a 7m wide service road on the western side to access the existing land uses.
- 10m carriageways for 2 lanes of traffic in each direction and a shoulder.
- 10m median to accommodate RAV turning movements.
- Sufficient verge width to develop left turning (deceleration) lanes in advance of priority controlled intersections, appropriate footpaths and vegetation.

Mandogalup Road (Rowley Road to start of RAV network)

- 31 – 41m road reserve to accommodate volumes up to 18,600 vpd (no restricted access vehicles).
- 7m carriageways for 2 lanes of traffic in each direction.
- 7m median to accommodate right turning lanes.
- 5-15m verges for turning left lanes to develop in advance of priority controlled intersections, appropriate footpaths and vegetation.

Mandogalup Road (Hammond Road Extension to extent of RAV network)

- 36 – 56m road reserve to accommodate volumes up to 19,000 vpd (including RAV Network 7).
- 8m carriageways for 2 lanes of traffic in each direction.
- 10m median to accommodate RAV turning movements and right turning lanes.
- 5m verge on the western side as there will be no need for left turning lanes (western side abuts bush forever and Alcoa residue disposal area).
- 5-15m verges on eastern side which allows for turning lanes to develop in advance of priority controlled intersections, appropriate footpaths and vegetation.

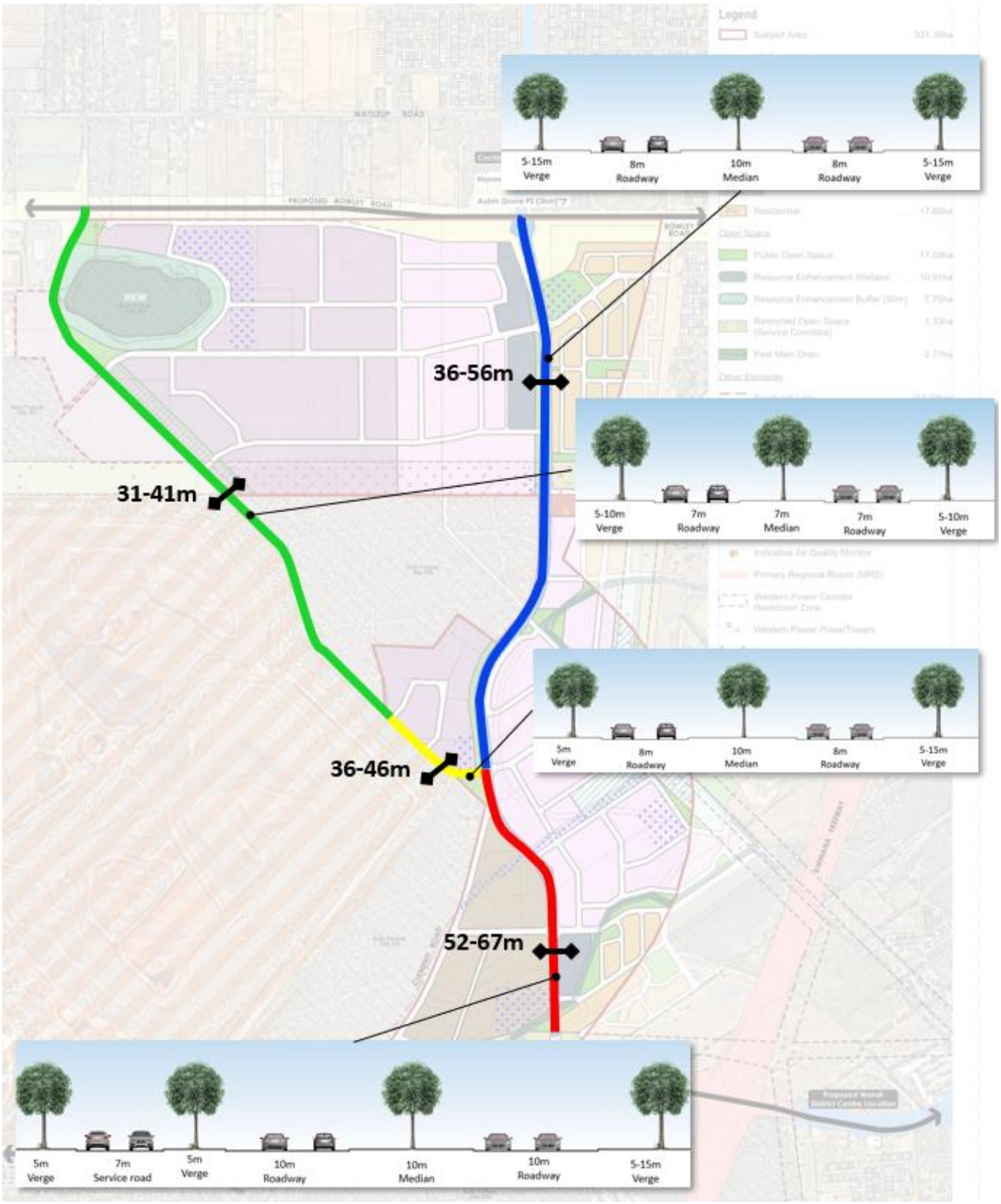


Figure 52 Potential Distributor Road Cross Sections

The minor industrial access roads should have a width of 10m within a reserve of at least 20m. The full reserve width will depend on drainage and servicing requirements.

9.4.3 Intersections

The range of intersection controls are based on the road hierarchy, intersection spacing, surrounding land uses and the largest expected vehicle size. The proposed controls for intersections along the distributor road network (Hammond Road Extension and Mandogalup Road) are shown in Figure 53.

The four-way intersections along the distributor road network are proposed as roundabouts, to be initially constructed as one lane roundabouts which can then be upgraded to include two circulating lanes.

The three-way intersections of internal access roads with the distributor network would be priority controlled (either stop or give-way sign access) with some intersections restricted to left in left out movements. The right turn restriction will allow for safer turning movements and will encourage larger freight vehicle movements to utilise the safer higher order intersections and therefore manage which routes they take.

A signalised intersection is proposed for the three-way intersection near the commercial centre. Traffic signal control will provide a safer environment for pedestrians in the vicinity of the commercial centre land uses.

Intersections between minor streets which are not shown in Figure 53 will most likely take the form of:

- Priority control (nominally give-way) for three-way intersections
- Single lane roundabout control for four-way intersections.

For the road network within the industrial area, the predominant form of intersection control should be priority controlled three-way, constructed without any median treatments to facilitate the movement of restricted access vehicles. The very limited four-way intersections will be roundabout controlled.

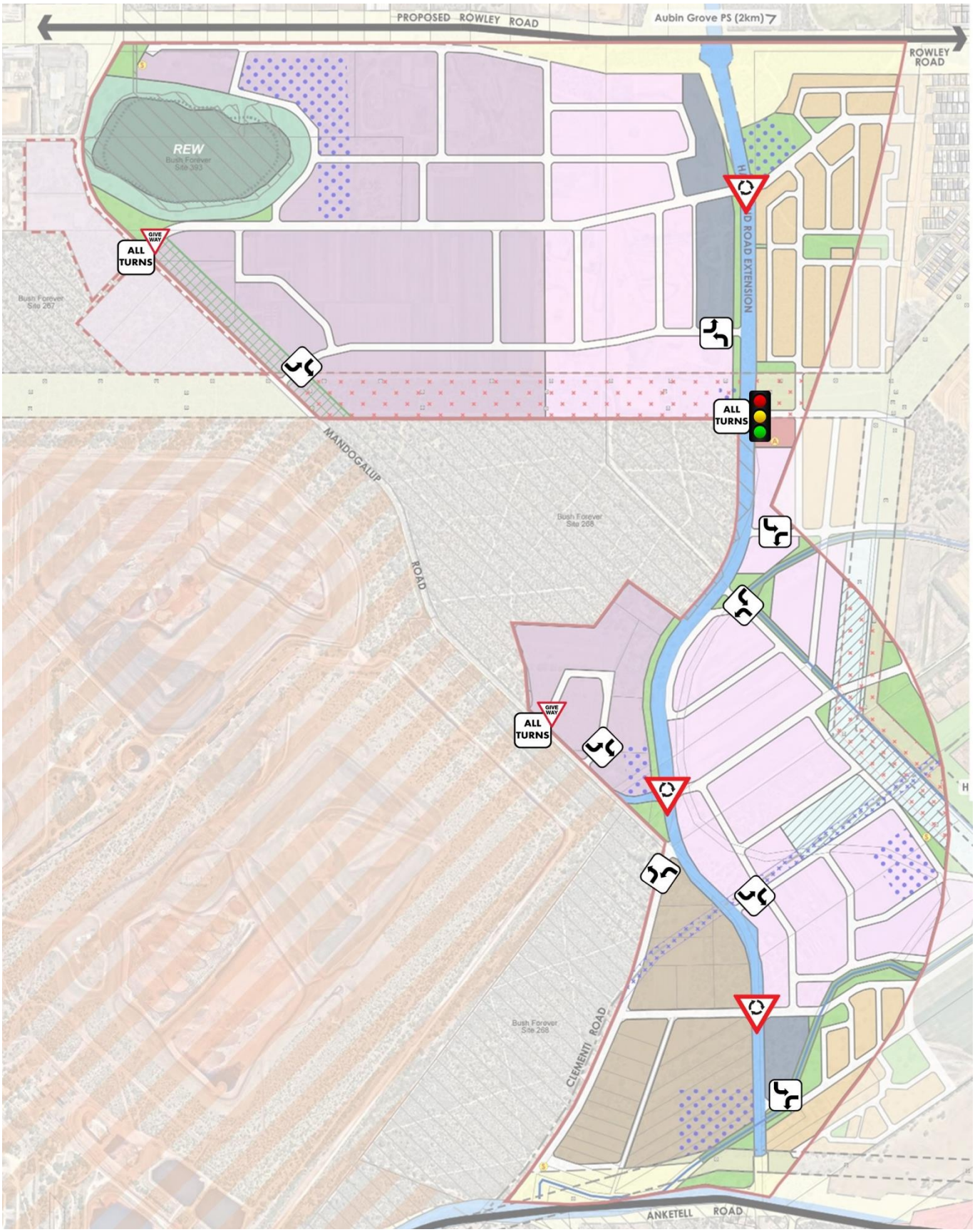


Figure 53 Proposed Intersection Controls for Major Road Network (base plan source: TBB)

9.5 Access Principles

9.5.1 Hammond Road Extension between Rowley Road and Anketell Road

Given the forecast traffic volumes, the Hammond Road Extension will ultimately be constructed as a dual carriageway. Another consideration is the designation as an “Other Regional Road” in the MRS. For new developments, direct frontage access should not be permitted, unless the development is a significant traffic generator such as major shopping, recreation, or community centres. In this scenario, appropriate left and right turn pockets should be provided to reduce any impact to through traffic.

For lower traffic generating developments, in lieu of direct frontage access, access can be obtained from side roads and service roads where required.

Properties with existing frontage access will maintain this access until redevelopment occurs, however this will be restricted to left in left out movements as a median and second carriageway are constructed. The speed limit along the section of the Hammond Road Extension with existing frontage access should be limited to 60km/h.

For properties with existing frontage access which generate high volumes of traffic, or heavy vehicle traffic, left turn pockets may be required to reduce any impact to through traffic.

9.5.2 Mandogalup Road between Rowley Road and Hammond Road Extension

For new developments, direct frontage access should not be permitted, with access instead obtained from side roads or service roads. Where there are no side road or service road alternatives (in the vicinity of the general industrial sandwich lots in the western portion of the Improvement Plan) direct access could be considered with adjacent lots sharing crossovers where practical, and left turn pockets provided to reduce the impact to through traffic.

Properties with existing frontage access will maintain this until redevelopment occurs, however this will be restricted to left in left out movements once a median and second carriageway are constructed.

The speed limit along Mandogalup Road should be limited to 70km/h.

10. SUMMARY

This Transport Report has been prepared in support of the Mandogalup Improvement Scheme, located in the City of Kwinana. The purpose of this report is to assess the land use and transport elements of the proposed development scenarios and support the preparation of the Land Use Plan and Improvement Scheme.

10.1 Project Background

In 2019, Flyt began working with the Department of Planning, Lands and Heritage together with TBB to develop three different land use scenarios for the future of the Mandogalup Improvement Scheme, these are:

- Residential land use scenario
- Industrial land use scenario
- Combined land use scenario (residential and industrial land uses).

In March 2023, the DPLH together with stakeholders and the project team, identified that the preferred form of development for the Mandogalup Improvement Scheme. The preferred form of development was confirmed as a modified combined scenario featuring significant light and heavy industrial land uses with supporting commercial floorspace and limited residential development with small scale supporting retail. The final preferred land use scenario was determined through a process of technical assessment and review from the TBB led consultant team. The preferred land use scenario was finalised through an iterative process of scenario development:

- Draft preferred land use scenario
- Modified preferred land use scenario with 25,000m^2 or 50,000m^2 commercial floor area
- Final preferred land use scenario with 25,000m^2 commercial floor area.

10.2 Final Preferred Land Use Scenario

In June/July 2023 Pracsys (part of the TBB led consultant team) undertook a benchmarking analysis regarding the number of dwellings, employment numbers and land use floorspace, across locations and developments with a similar context to the Mandogalup Improvement Scheme Area. The benchmarking exercise concluded that the number of dwellings and commercial floorspace in the draft preferred land use scenario was on the high side – with a range of between 25,000m^2-50,000m^2 commercial floorspace more likely to be deliverable.

In July 2023 Flyt undertook high-level trip generation assessment of all scenarios developed to date and following this assessment, and with agreement from DPLH, it was agreed that the final preferred land use scenario would include the lower value of 25,000m^2 of commercial GFA.

The final preferred scenario land uses can be summarised as approximately:

- 779 dwellings / 2,182 residents
- 188.4 hectares of industrial land
- 27.9 hectares of composite rural industrial land GDA
- 25,000m^2 commercial GFA
- 2,000m^2 retail GFA (split across a 1,500m^2 neighborhood centre and smaller 500m^2 local centre).

10.2.1 Traffic Volumes

In April/May 2023 Main Roads WA provided DPLH and the project team with ROM model outputs for the 2051 land use scenario. The ROM model outputs were provided by Main Roads WA to support the project team with assessing the Final Preferred Scenario for the Mandogalup Improvement Plan area. The ROM model outputs were supplemented with additional 2051 daily traffic volumes expected to be generated from land uses proposed to form the Final Preferred Scenario for the Mandogalup Improvement Plan area. The total 2051 daily traffic volumes can be summarised as:

- Hammond Rd north of Rowley Rd - 8,000-10,600 vpd in each direction
- Hammond Rd Extension between Rowley Rd and Mandogalup Rd - 10,300-11,500 vpd in each direction
- Hammond Rd Extension between Mandogalup Rd and Anketell Rd - 18,300-19,100 vpd in each direction
- Mandogalup Rd between Rowley Rd and Hammond Rd Extension - 9,000-9,800 vpd in each direction
- Rowley Rd to the east of Hammond Rd Extension - 18,300-23,500 vpd in each direction
- Rowley Rd to the west of Mandogalup Rd - 22,100-22,800 vpd in each direction
- Anketell Rd to the east of Hammond Rd Extension - 22,400-26,1000 vpd in each direction
- Anketell Rd to the west of Hammond Rd Extension - 14,900-19,300 vpd in each direction

The 2051 daily traffic volumes expected to be generated along the key road network corridors within the Mandogalup Improvement Plan area can be summarised as:

- Through the main residential area in the northeast - 2,400 vpd in each direction
- Through the main light and heavy industrial area in the north - 500-2,000 vpd in each direction
- In proximity of the neighbourhood centre - 850 vpd in each direction
- Through the light industrial area in the south - 100-800 vpd in each direction
- In proximity of the commercial area in the south - 1,700 vpd in each direction
- In proximity of the composite rural industrial land in the south - 400 vpd in each direction

10.2.2 Road Network Hierarchy

The potential 2051 road hierarchy classification for key road network corridors can be summarised as follows:

Rowley Road

- Remain Regional Distributor with upgraded corridor to carry 18,500-23,500 vpd in each direction
- To provide a link between significant destinations – Kwinana Freeway and future port site

Anketell Road

- Remain Regional Distributor with upgraded corridor to carry 15,000-26,000 vpd in each direction
- To provide a link between significant destinations – Kwinana Freeway and future port site

Hammond Road Extension (between Rowley Road and Anketell Road)

- Classified as a Distributor A road required to carry between 10,500-19,000 vpd in each direction
- Frontage access to be limited to commercial land use access only, generally via service roads

Mandogalup Road (between Rowley Road and Hammond Road Extension)

- Classified as a Distributor B road required to carry between 9,000-10,000 vpd in each direction
- Frontage access to be limited where possible for both residential and commercial land uses

10.2.3 Restricted Vehicle Access Network

The road network abutting the light industrial land uses should be designed to support Network 4 RAVs, while the road network within the general industrial area should be capable of accommodating Network 7 RAVs, in the event that the Anketell Road Freight Corridor is upgraded to accommodate RAV Network 7.

The general industrial land uses are located in the north west of Mandogalup, with a small area to the north of the intersection between Mandogalup Road and the Hammond Road Extension. It is proposed for the Hammond Road Extension to provide the RAV Network 7 connection between Anketell Road and the general industrial area. The intersections along the length of the Hammond Road Extension should be capable of accommodating RAV Network 7 vehicles. Any roundabouts would require a central island diameter of at least 32-35m.

10.2.4 Intersections

The range of proposed intersection controls are based on the road hierarchy, intersection spacing, surrounding land uses and the largest expected vehicle size. The proposed controls for intersections along the distributor road network (Hammond Road Extension and Mandogalup Road) are shown in Figure 53.

10.2.5 Access Principles

Hammond Road Extension (between Rowley Road and Anketell Road)

- Hammond Road Extension will ultimately be constructed as a dual carriageway.
- For new developments, direct frontage access should not be permitted, unless the development is a significant traffic generator such as major shopping, recreation, or community centres. In this scenario, appropriate left and right turn pockets should be provided to reduce any impact to through traffic.
- For lower traffic generating developments, in lieu of direct frontage access, access can be obtained from side roads and service roads where required.
- Properties with existing frontage access will maintain this access until redevelopment occurs, however this will be restricted to left in left out movements as a median and second carriageway are constructed.
- The speed limit along the Hammond Road Extension with existing frontage access should be limited to 60km/h.

Mandogalup Road (between Rowley Road and Hammond Road Extension)

- For new developments, direct frontage access should not be permitted, with access instead obtained from side roads or service roads.
- Where there are no side road or service road alternatives (in the vicinity of the general industrial sandwich lots in the western portion of the Improvement Plan) direct access could be considered with adjacent lots sharing crossovers where practical, and left turn pockets provided to reduce the impact to through traffic.
- Properties with existing frontage access will maintain this until redevelopment occurs, however this will be restricted to left in left out movements once a median and second carriageway are constructed.
- The speed limit along Mandogalup Road should be limited to 70km/h.

Appendix F

Infrastructure and Engineering Services Assessment

Mandogalup Improvement Scheme

Infrastructure & Engineering Services Assessment

Prepared for: Department of Planning, Lands and Heritage

Date: 26 March 2020

Prepared by: Jermayne Fabling

Ref: 43798

Wood & Grieve Engineers now part of Stantec
Ground Floor, 226 Adelaide Terrace, Perth WA 6000
Tel: +61 8 6222 7000 Email: perth@wge.com.au www.wge.com.au

\\WGE-PER-FS-01\PROJECTS\43798\PROJECT DOCUMENTATION\CIVIL\DOCUMENTS & REPORTS\CI-RE_001.DOCX

WOOD & GRIEVE ENGINEERS

NOW PART OF

Stantec

Revision

Revision	Date	Comment	Prepared By	Approved By
0	14/1/20	Original Issue	J. Fabling	J. Fabling
1	26/3/20	Minor Amendments	J Fabling	J. Fabling

Contents

1. Introduction 1

2. Wastewater 1

2.1 Existing Wastewater Assets 1
2.2 Water Corporation Servicing Advice 1

3. Water Reticulation 2

3.1 Existing Water Reticulation Assets 2
3.2 Water Corporation Servicing Advice 2

4. Electricity Infrastructure 2

4.1 Existing Infrastructure 2
4.2 Infrastructure Capacity & Proposed Upgrades 2

5. Telecommunications 2

5.1 Existing Infrastructure 2

6. Gas 3

6.1 Existing Infrastructure 3

Appendix A Water Corporation Wastewater Planning

Appendix B Existing Water Reticulation

Appendix C Existing Western Power Transmission Lines

Appendix D Existing Western Power 22kV Overhead Power Lines

Appendix E Existing Telstra Assets

Appendix F Existing Optus Assets

Appendix G Existing ATCO Gas Assets

1. Introduction

Wood & Grieve Engineers (now part of Stantec) have been engaged to provide Consulting Civil Engineering Services for the preparation of an Infrastructure and Engineering Services Assessment for incorporation into a draft Land Use Plan and draft Mandogalup Improvement Scheme.

The subject site for this advice is defined within Mandogalup Improvement Plan 47.

The contents of this report are preliminary and will require review once appropriate land uses are determined for the site.

Servicing investigations have been undertaken to establish the availability of the existing utility services infrastructure in the area and their tentative capacity to service the proposed development.

2. Wastewater

2.1 Existing Wastewater Assets

The project site is not currently serviced by the Water Corporation's wastewater scheme.

Currently existing improvements with the subject site utilising localised onsite disposal methods.

2.2 Water Corporation Servicing Advice

The subject site falls within the catchment of the Water Corporation's Thompsons Lake – SD174 Wastewater Conceptual Planning Long Term Scheme area.

The long term planning for wastewater disposal from the subject site consists of four proposed wastewater pumping stations and associated discharge pressure mains as follows:

- Thompson Lake Pump Station G – Type 40 located adjacent to Wattleup Road discharging to a gravity sewer near Parradoxa Road on Wattlelup Road. This serves the northern sector of the site.
- Thompson Lake Pump Station N – Type 40 located near the intersection of Rowley Road and Mandogalup Road discharging to a gravity sewer near Frankland Road and Pratco Vista. This serves the north west sector of the site.
- Thompson Lake Pump Station J – Type 180 located east of the intersection of Clement Road and Mandogalup Road discharging to a gravity DN300 sewer near Canopus Loop on Barfield Road. This serves the southern sector of the site.
- Thompson Lake Pump Station L – Type 40 located near the intersection of Anketell Road and Clementi Road discharging to Pump Station J.

Please refer to the attached Appendix A detailing the preliminary location and gravity catchments of each of these wastewater pumping stations.

We highlight that the location of the gravity sewers connecting through to the pump station sites and the discharge pressure mains traverse a number of private properties, which will require significant coordination and cooperation to allow for resolution of land matters to facilitate construction.

If constructed in their ultimate locations, it is anticipated that ultimately the cost of the works would be recouped as part of the Water Corporations Capital Investment Programme (CIP). This would however be subject to CIP reviews and warrants in due course.

3. Water Reticulation

3.1 Existing Water Reticulation Assets

The majority of the subject site is not currently serviced as part of the Water Corporation's water supply scheme.

The nearest water reticulation main is located within Rowley Road, near Irvine Parade. This is detailed within Appendix B

3.2 Water Corporation Servicing Advice

Future water distribution mains, subject to the nature the development of the subject site are planned by the Water Corporation as part of their Capital Investment Programme. If constructed in their ultimate locations, it is anticipated that ultimately the cost of these works would be recouped as part of the Water Corporations Capital Investment Programme (CIP). This would however be subject to CIP reviews and warrants in due course.

4. Electricity Infrastructure

4.1 Existing Infrastructure

The Mandogalup Improvement Plan 47 area contains a number of Western Power Corporation's overhead power transmission lines, which include:

- 330kV Kwinana to Southern Terminal Line (2 lines)
- 132kV Kwinana to Southern Terminal Lines
- 330kV Muja to Southern Terminal/Kemerton Line
- 330kV Kwinana to Northern Terminal Line

These lines traverse the subject area in various location as detailed in Appendix C.

A number of 22kV high voltage overhead power land are located within the subject site to facilitate power supplies to existing properties. The location of these overhead high voltage power lines is detailed within Appendix D.

4.2 Infrastructure Capacity & Proposed Upgrades

Currently Western Power Corporation's Network Capacity Mapping Tool is showing approximately 25MVA to 30MVA of network capacity is available.

It is anticipated that this capacity would be ample for development of the Improvement Plan area, however this will require review once the extent of the proposal has been developed. This may require the installation of new underground 22kV feeder cables from the nearest zone substations to the development areas.

5. Telecommunications

5.1 Existing Infrastructure

The site is currently serviced by Telstra infrastructure located within existing road reserves throughout the subject site, which provide services to the existing properties. This existing infrastructure includes copper and optic fibre services, which are shown as attached in Appendix E.

Optus Telecommunications infrastructure is also located within the site and is shown in Appendix F.

6. Gas

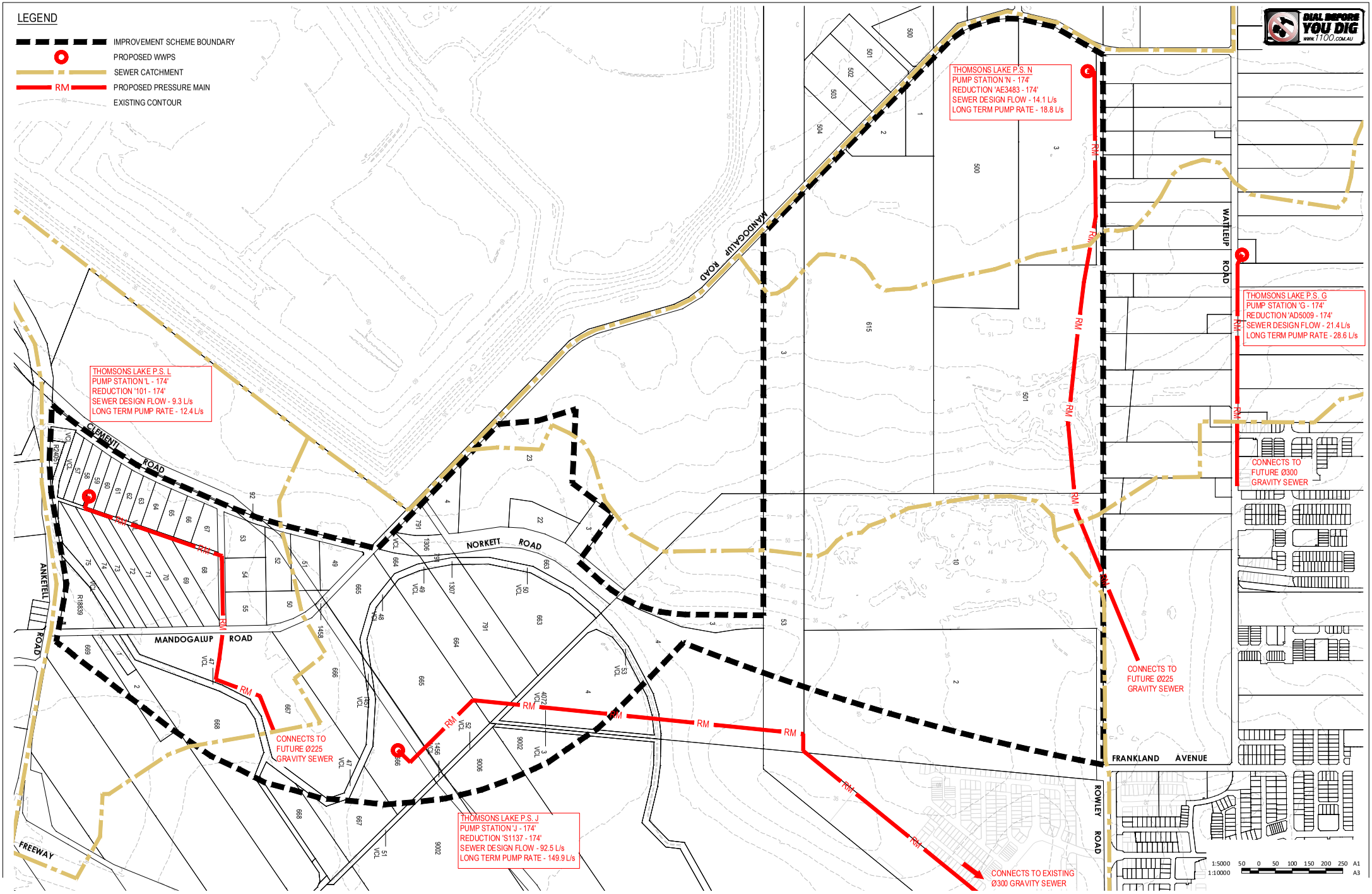
6.1 Existing Infrastructure

The project site is not currently serviced by reticulated gas.

The nearest existing Atco Gas gas mains are located to the north of the subject site within the Rowley Road. Subject to the nature of the development proposal and road reserve linkages it is envisaged gas mains may be extended through the subject site from the north. The existing reticulated gas mains near the site are detailed within Appendix G.

The Dampier to Bunbury Natural Gas Pipeline (DBNGP) traverses the southern sector of the site. Depending on the nature of future developments significant development setbacks and controls may be required.

Appendix A Water Corporation Wastewater Planning



DATE PLOTTED: 15/01/2020 11:35:14 AM BY: DANIEL PRATT

CAD FILE: CI-050-EX-P1.DWG

REV	DESCRIPTION	DRW	DGN	VER	APPROVED	DATE	WAPC No.
A	PRELIMINARY ISSUE	DPA	DPA	JF	J. FABLING	14/01/2020	

PCG-94*
CO-ORDS
mAHD
DATUM
3.2715

DEPARTMENT OF PLANNING, LANDS & HERITAGE
ARCHITECT/CLIENT

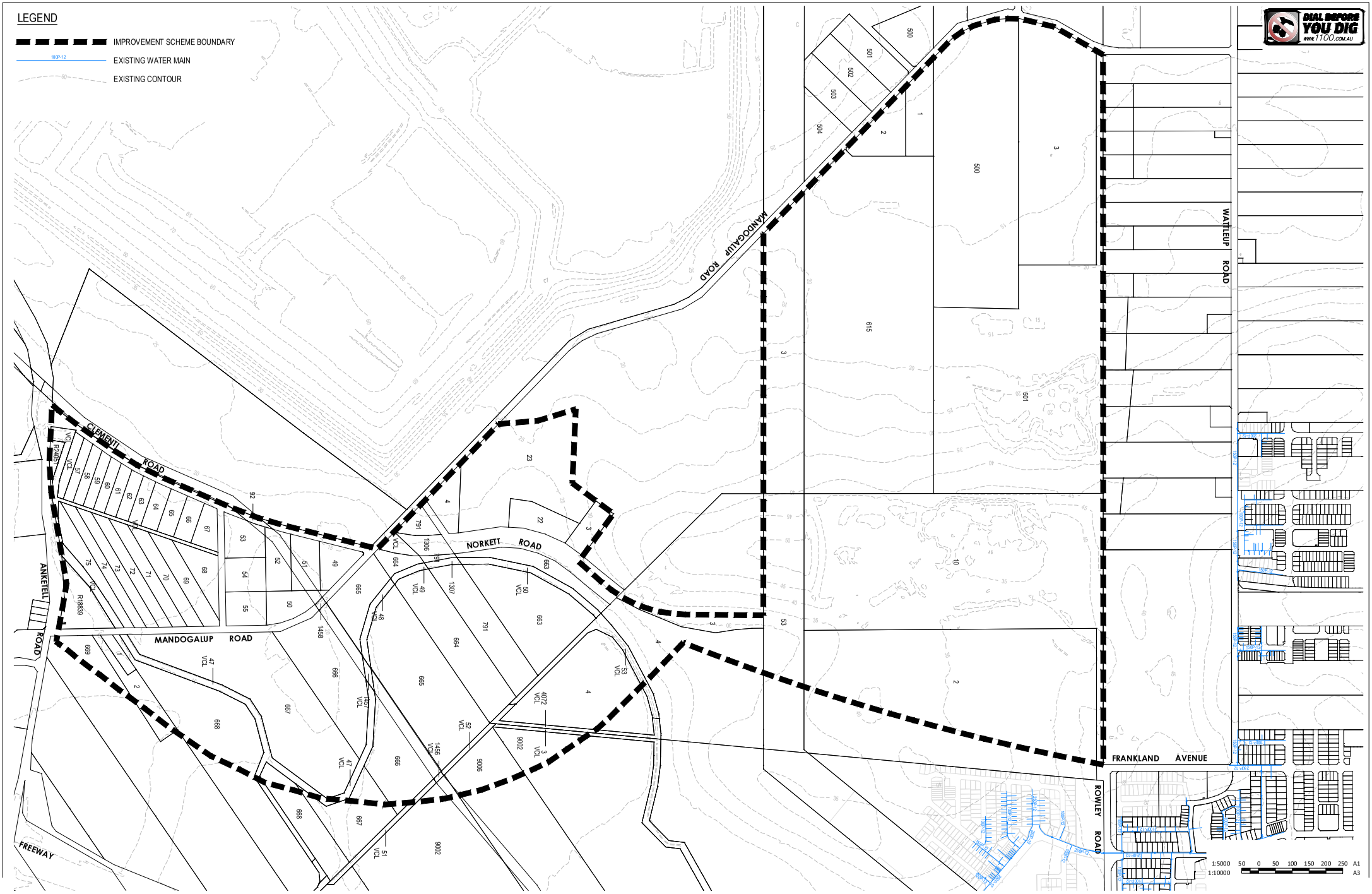
MANDOGALUP IMPROVEMENT SCHEME
WASTEWATER PLANNING
PROJECT/TITLE

Stantec

PRELIMINARY
NOT FOR CONSTRUCTION
CIVIL

1:5000	43798	CI-050-EX-P1	A
SCALE @ A1	PROJECT No	DRAWING No	REV

Appendix B Existing Water Reticulation



REV	DESCRIPTION	DRW	DGN	VER	APPROVED	DATE	WAPC No.
A	PRELIMINARY ISSUE	DPA	DPA	JF	J. FABLING	14/01/2020	

PCG-94*
CO-ORDS
mAHD
DATUM
3.2715

DEPARTMENT OF PLANNING, LANDS & HERITAGE
ARCHITECT/CLIENT

MANDOGALUP IMPROVEMENT SCHEME
WATER PLANNING
PROJECT/TITLE

Stantec

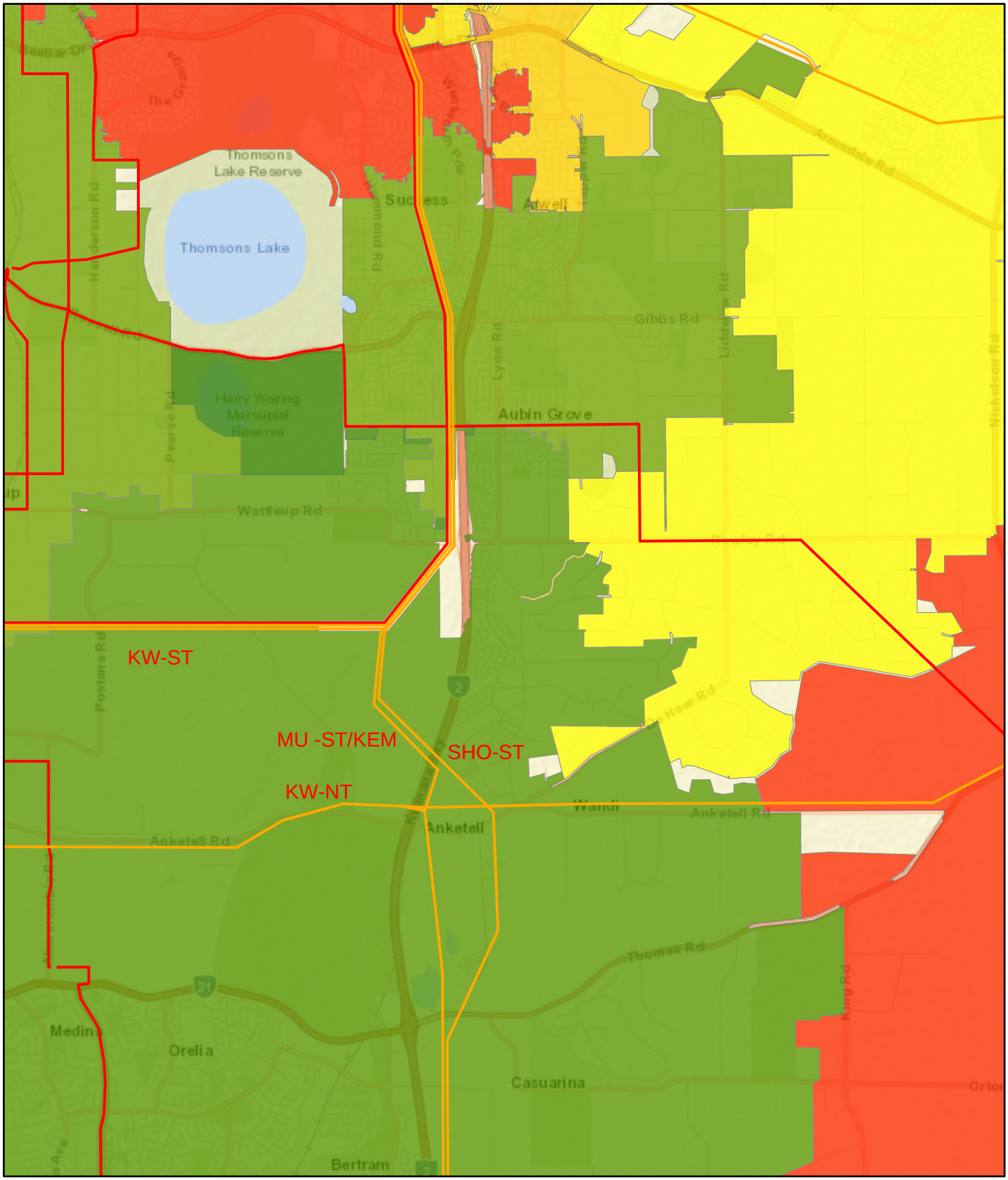
PRELIMINARY
NOT FOR CONSTRUCTION
CIVIL

1:5000	43798	CI-050-EX-P2	A
SCALE @ A1	PROJECT No	DRAWING No	REV

DATE PLOTTED: 15/01/2020 11:35:51 AM BY: DANIEL PRATT
CAD FILE: C:\DOS\EX-P2.DWG

Appendix C Existing Western Power Transmission Lines

Network Capacity Mapping Tool



13/01/2020, 9:25:21 am

1:72,224

0 0.5 1 2 mi

0 0.75 1.5 3 km

High Voltage Transmission Lines : WP-004

- 132
- 330

Forecast Remaining Capacity 2017: WP-009

- => 30 MVA
- 25 <= x < 30 MVA
- 15 <= x < 20 MVA
- 10 <= x < 15 MVA
- < 5 MVA

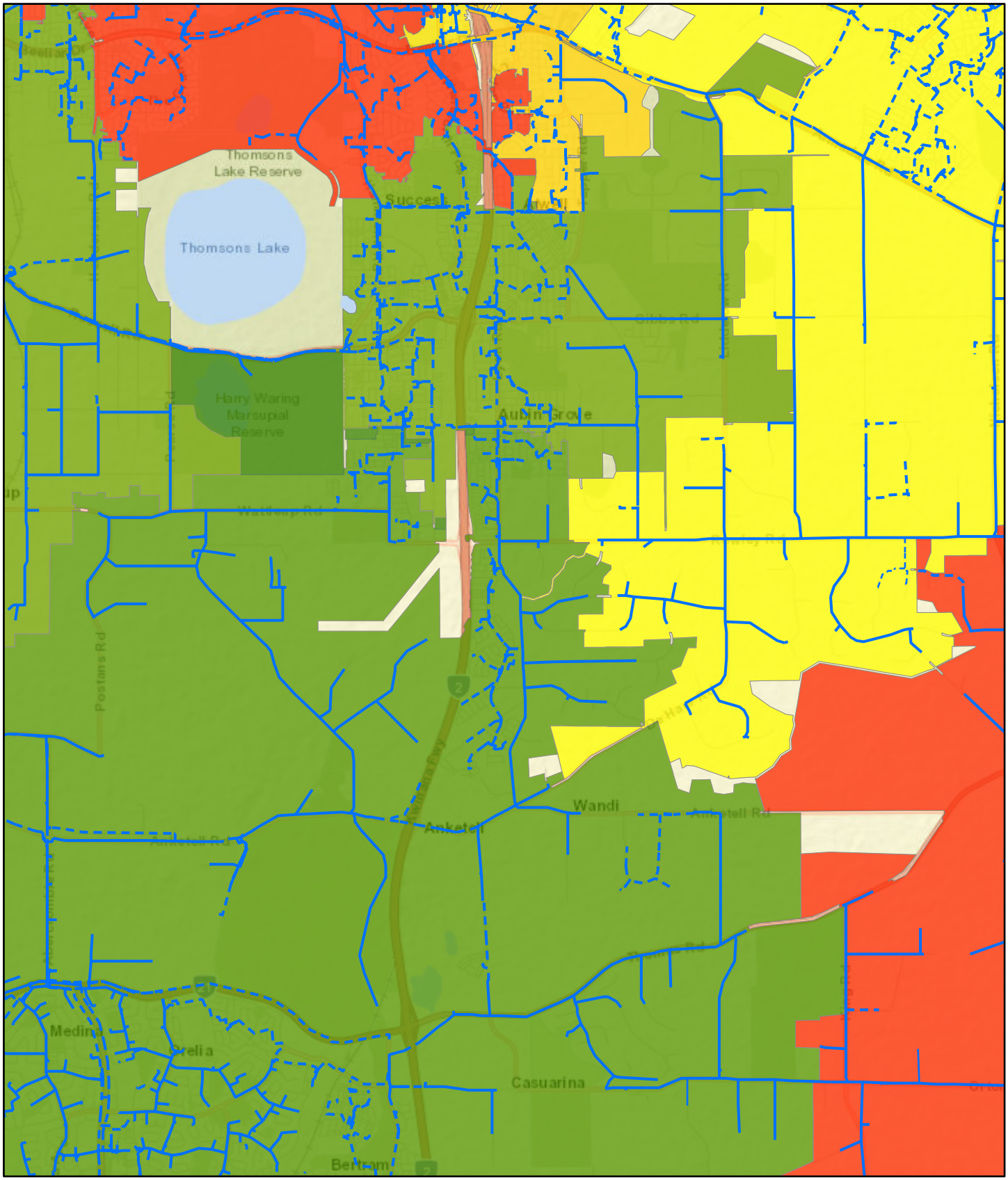
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Plans printed from the Network Capacity Mapping Tool (NCMT) are indicative

© Western Power 2016

Appendix D Existing Western Power 22kV Overhead Power Lines

Network Capacity Mapping Tool



13/01/2020, 9:26:57 am

1:72,224

0 0.5 1 2 mi

0 0.75 1.5 3 km

High Voltage Distribution Lines : WP-003

- HVOH 1Ph
- HVOH 3Ph
- HVUG 1Ph
- HVUG 3Ph

- 25 <= x < 30 MVA
- 15 <= x < 20 MVA
- 10 <= x < 15 MVA
- < 5 MVA

Forecast Remaining Capacity 2017: WP-009

- => 30 MVA

Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Plans printed from the Network Capacity Mapping Tool (NCMT) are indicative

© Western Power 2016

Appendix E Existing Telstra Assets

LEGEND

IT'S HOW WE CONNECT

For more info contact a Telstra Accredited Locater or Telstra Plan Services 1800 653 935

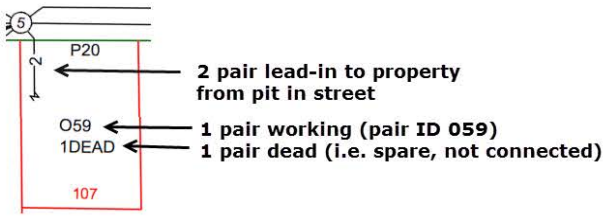
Exchange
(major cable present)

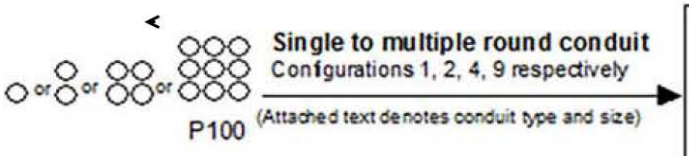
Footway access chamber
(can vary from 1-lid to 12-lid)

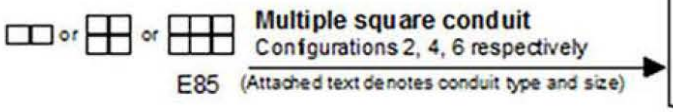
or **Pillar/cabinet**
(above the ground / free standing)

Above ground complex equipment housing (eg RIM)
Please Note: This equipment is powered by 240V electricity.

OC **other carrier**







Some examples of conduit type and size:
A - Asbestos cement, P - PVC / plastic, C - Concrete, GI - Galvanised iron, E - Earthenware.
Conduit sizes *nominally* range from 20mm to 100mm.

P50	50mm PVC conduit
P100	100mm PVC conduit
A100	100mm asbestos cement conduit
E 85	85mm square earthenware conduit

Cable jointing pit
(number indicating pit type)

Elevated cable joint
(above ground joint on buried cable)

Telstra Plant in shared utility trench

Aerial Cable
(above ground)

Aerial Cable
(attached to joint use pole e.g. power)

Direct buried cable

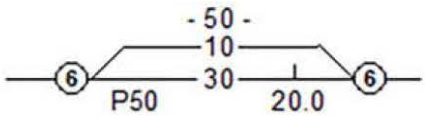
M **Marker post installed**

TR **Buried transponder**

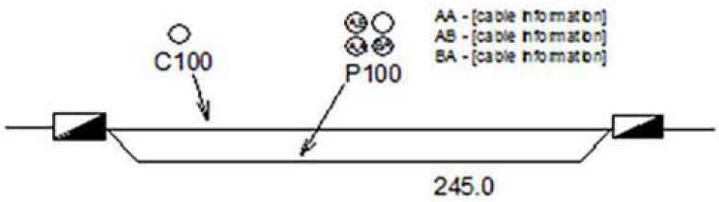
MT **Marker, transponder**

SMOF **Optical fibre cable direct buried**

Some examples of how to read Telstra plans:

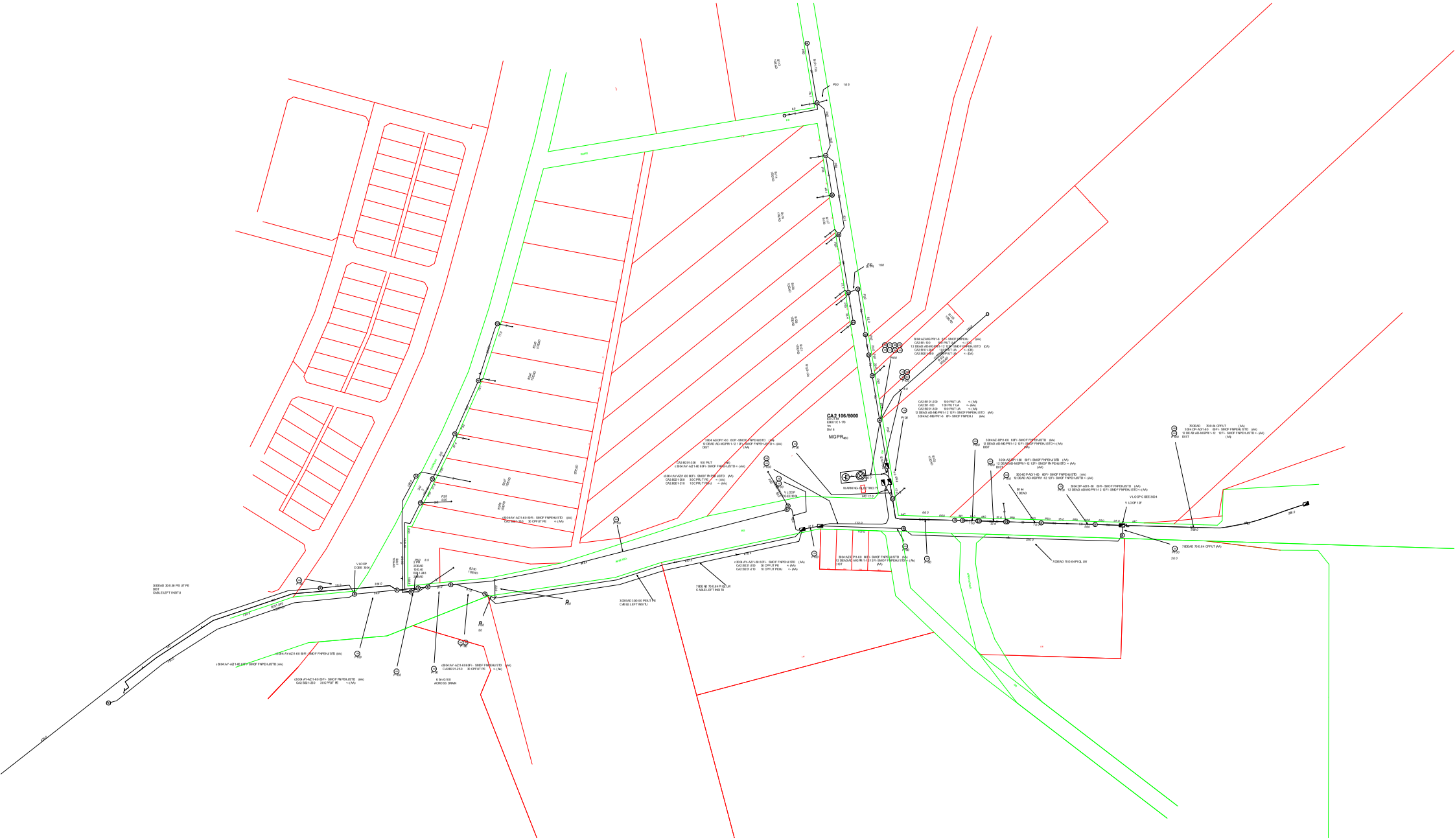


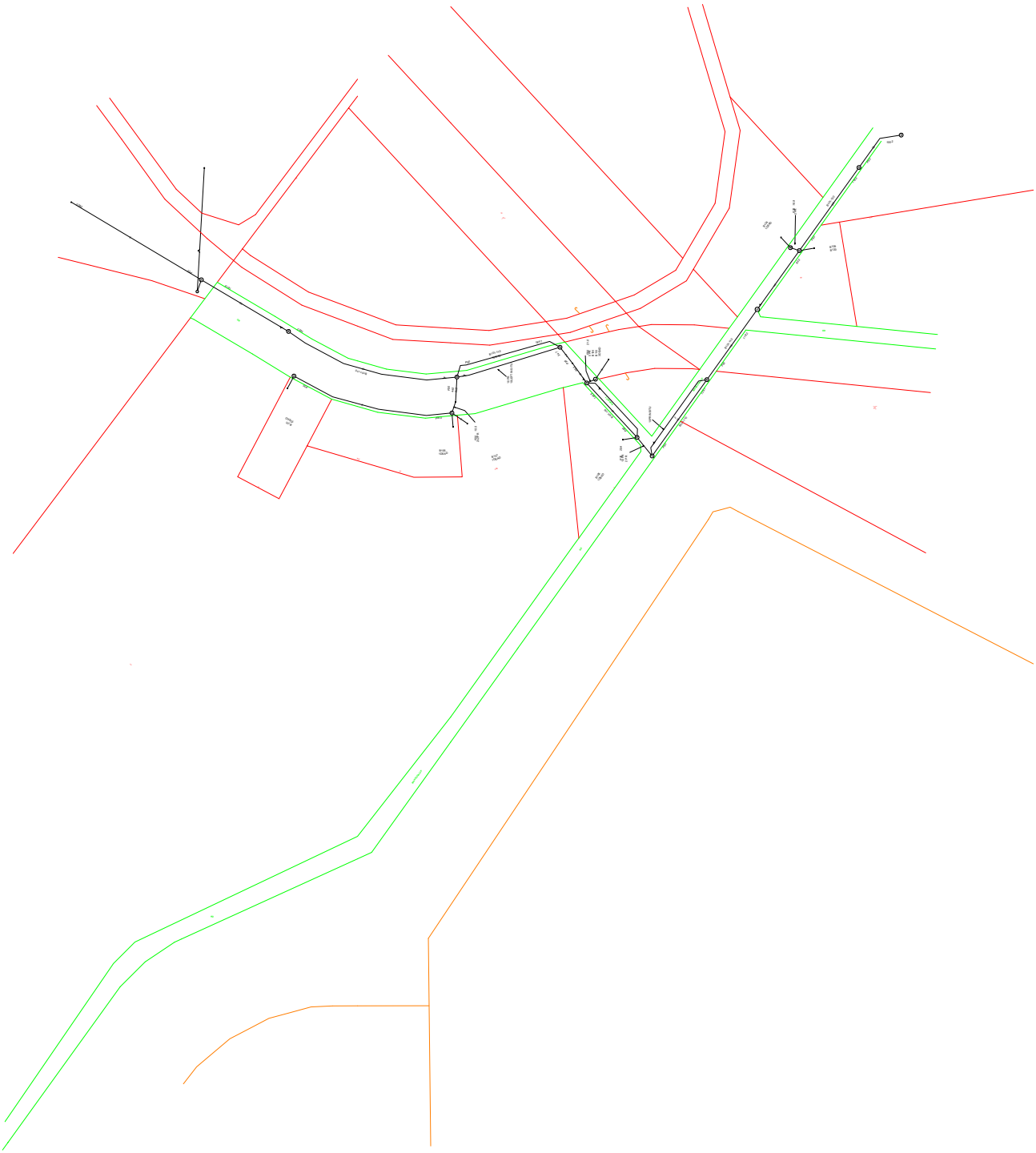
One 50mm PVC conduit (P50) containing a 50-pair and a 10-pair cable between two 6-pits, 20.0m apart, with a direct buried 30-pair cable along the same route.

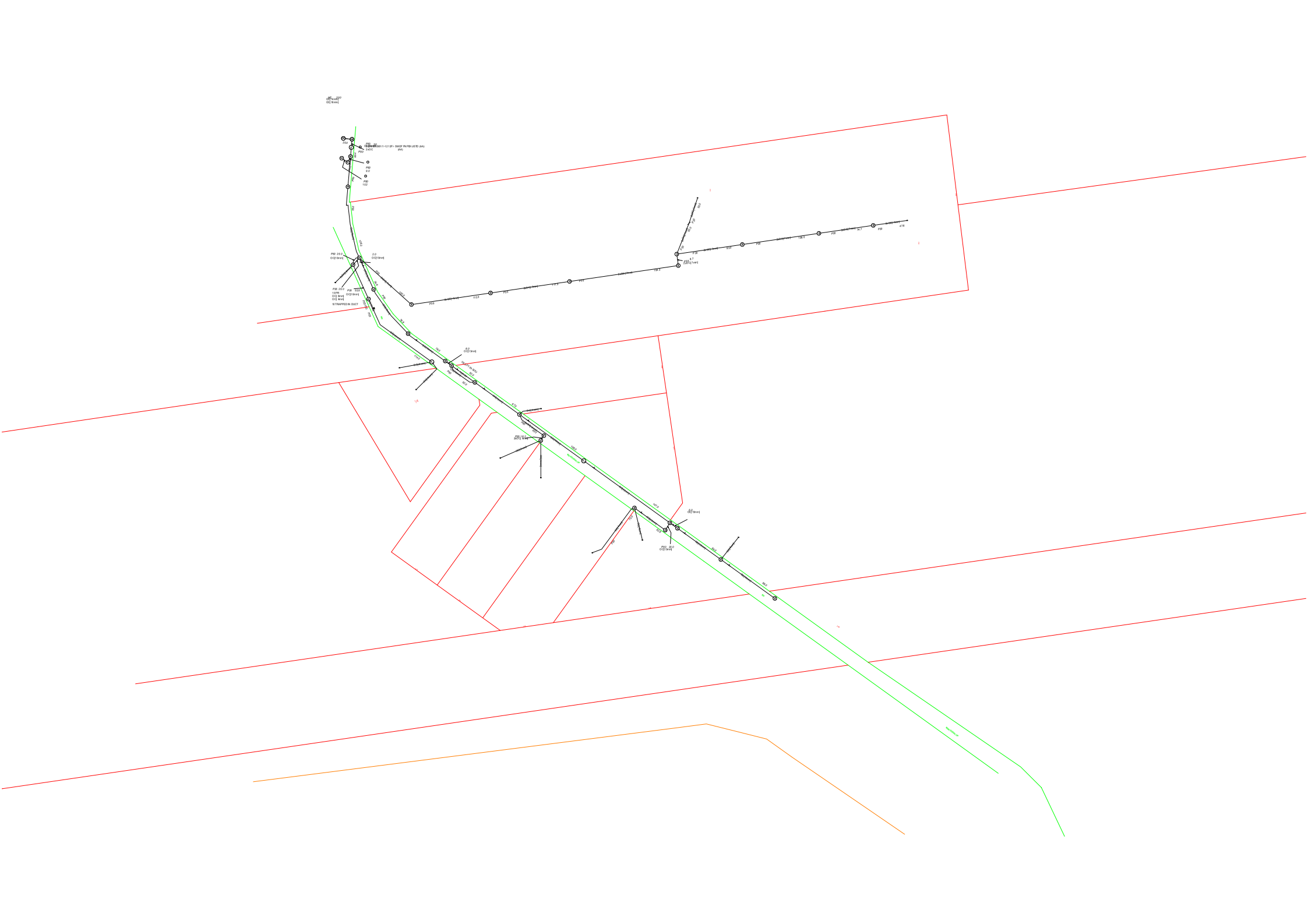


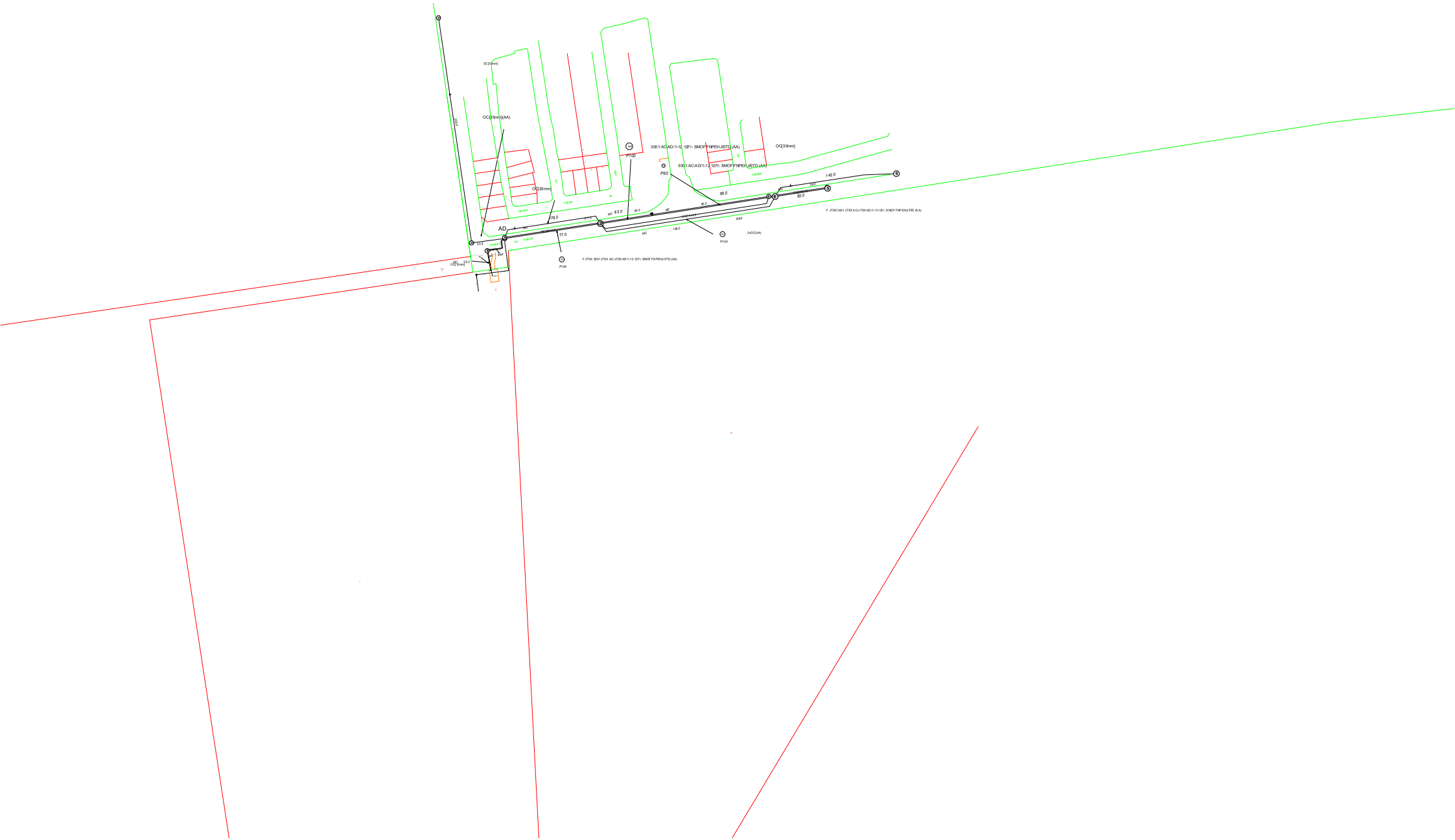
Two separate conduit runs between two footway access chambers (manholes) 245m apart. A nest of four 100mm PVC conduits (P100) containing assorted cables in three ducts (one being empty) and one empty 100mm concrete duct (C100) along the same route.

WARNING: Telstra plans and location information conform to Quality Level 'D' of the Australian Standard AS 5488 - Classification of Subsurface Utility Information. As such, Telstra supplied location information is indicative only. Spatial accuracy is not applicable to Quality Level D. Refer to AS 5488 for further details. Telstra does not warrant or hold out that its plans are accurate and accepts no responsibility for any inaccuracy shown on the plans. FURTHER ON SITE INVESTIGATION IS REQUIRED TO VALIDATE THE EXACT LOCATION OF TELSTRA PLANT PRIOR TO COMMENCING CONSTRUCTION WORK. A plant location service is an essential part of the process to validate the exact location of Telstra assets and to ensure the asset is protected during construction works. The exact position of Telstra assets can only be validated by physically exposing it. Telstra will seek compensation for damages caused to its property and losses caused to Telstra and its customers.

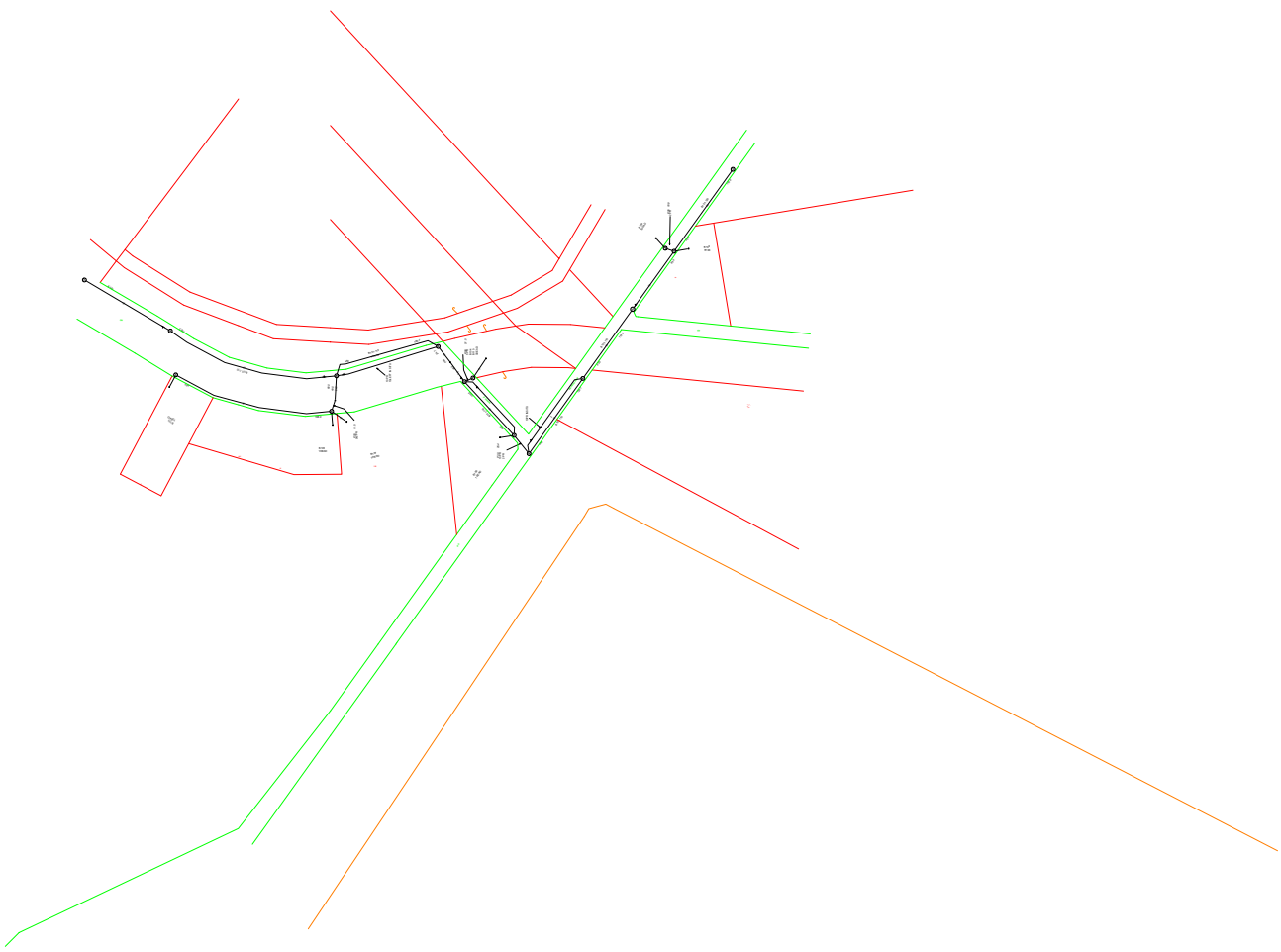

CA2 106/8000
MGPR
V LOOP
V LOOP 1P
V LOOP C GEE 3304
7 DEAD 700.64 P/U
7 DEAD 700.64 P/U QL UR
7 DEAD 700.64 P/U
7 DEAD 700.64 P/U
7 DEAD 700.64 P/U

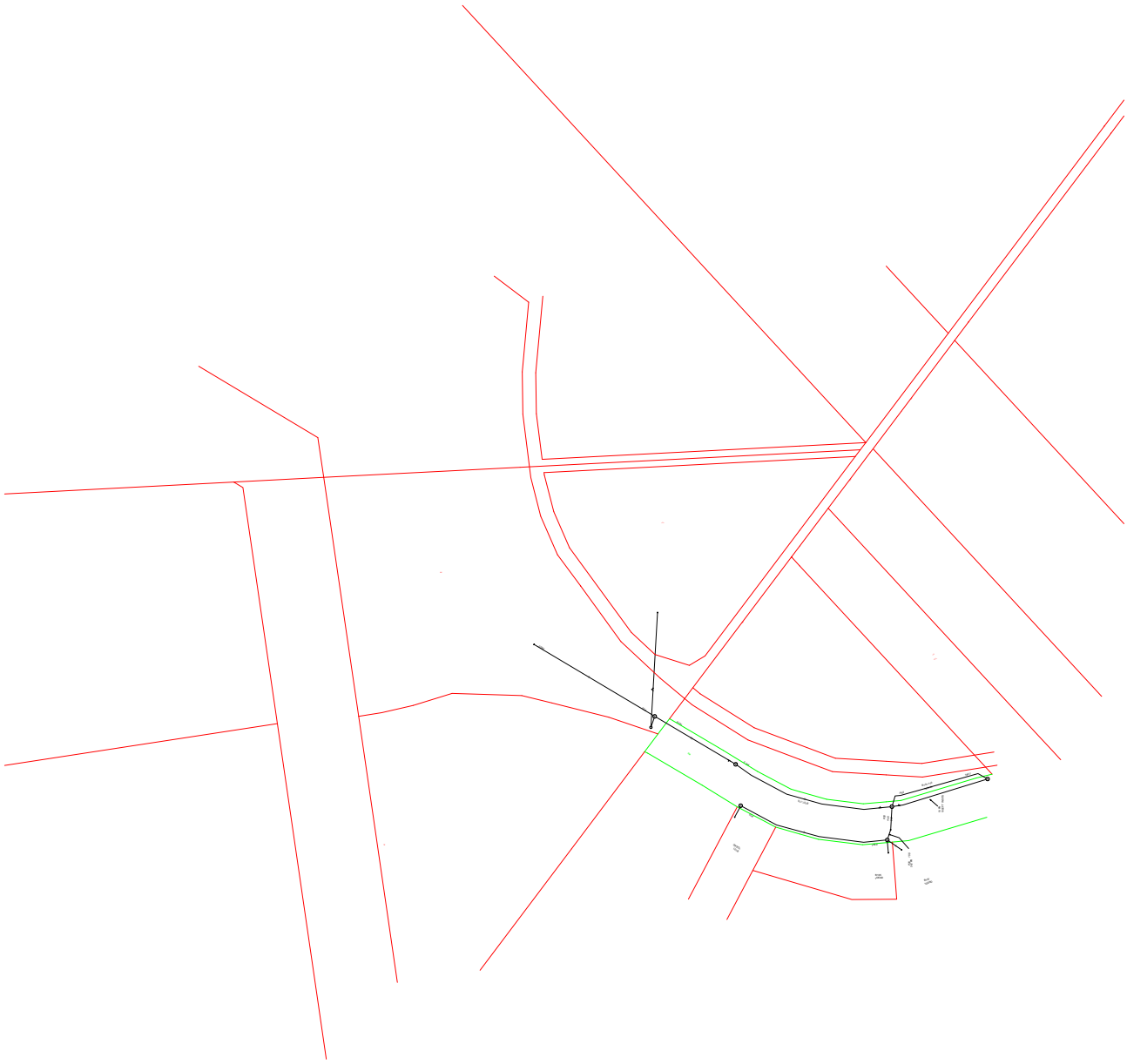


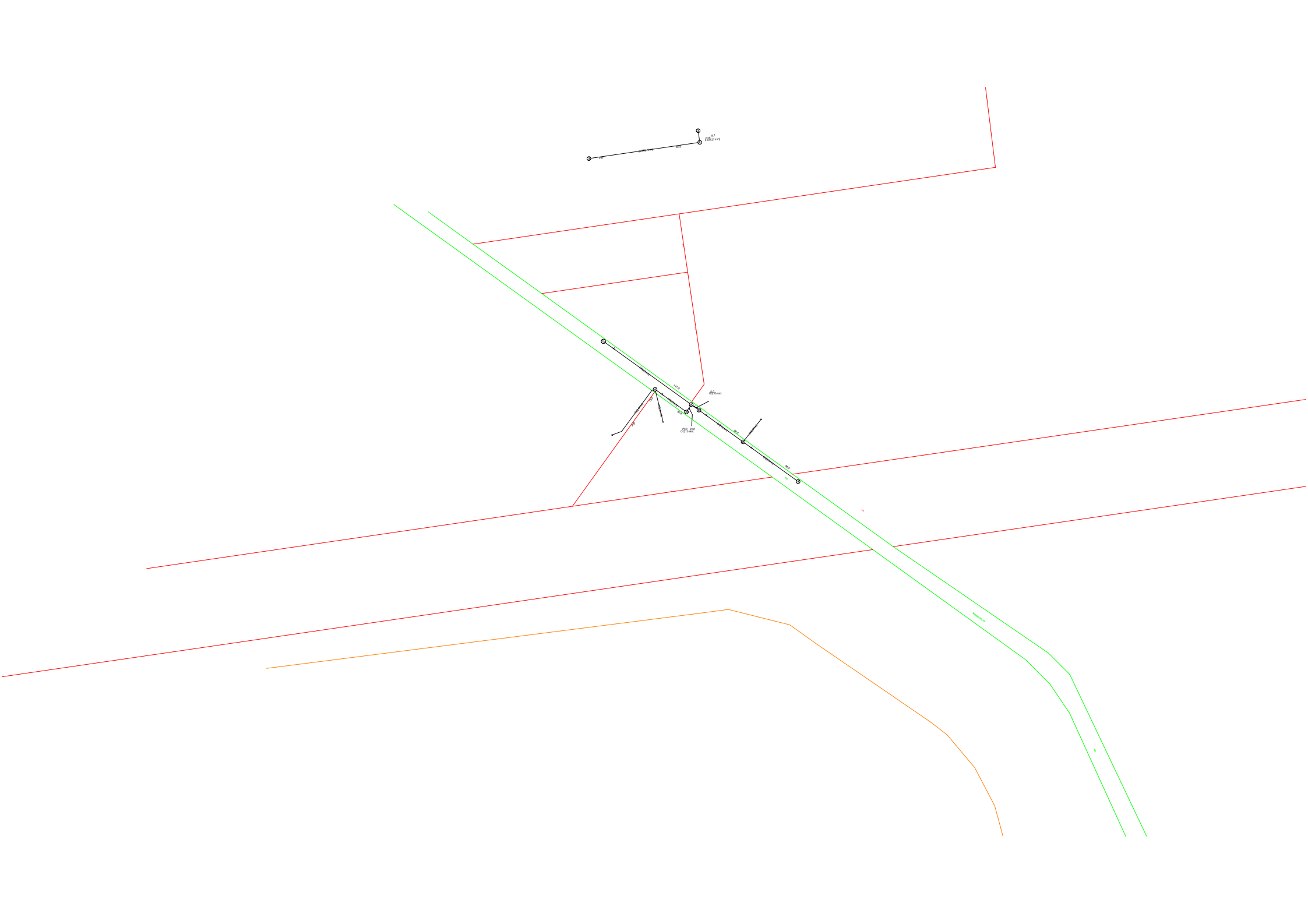



OC[35mm]
OC[35mm](AA)
OC[35mm]
OC[35mm]
3.00:1 AC-AD/1-12 12F/- SMOF FNPEHJSTD (AA)
3.00:1 AC-AD/1-12 12F/- SMOF FNPEHJSTD (AA)
P1.00
P5.0
P1.00
P1.00
AD
63.0
78.0
77.0
95.0
80.0
42.0
198.0
2xOC(AA)
F JTSX 3001 JTSX AC-JTSX AD/1-12 12F/- SMOF FNPEHJ STD (AA)
F JTSX 3001 JTSX A C-JTSX AD/1-12 12F/- S MOF FNPEHJ STD (A A)

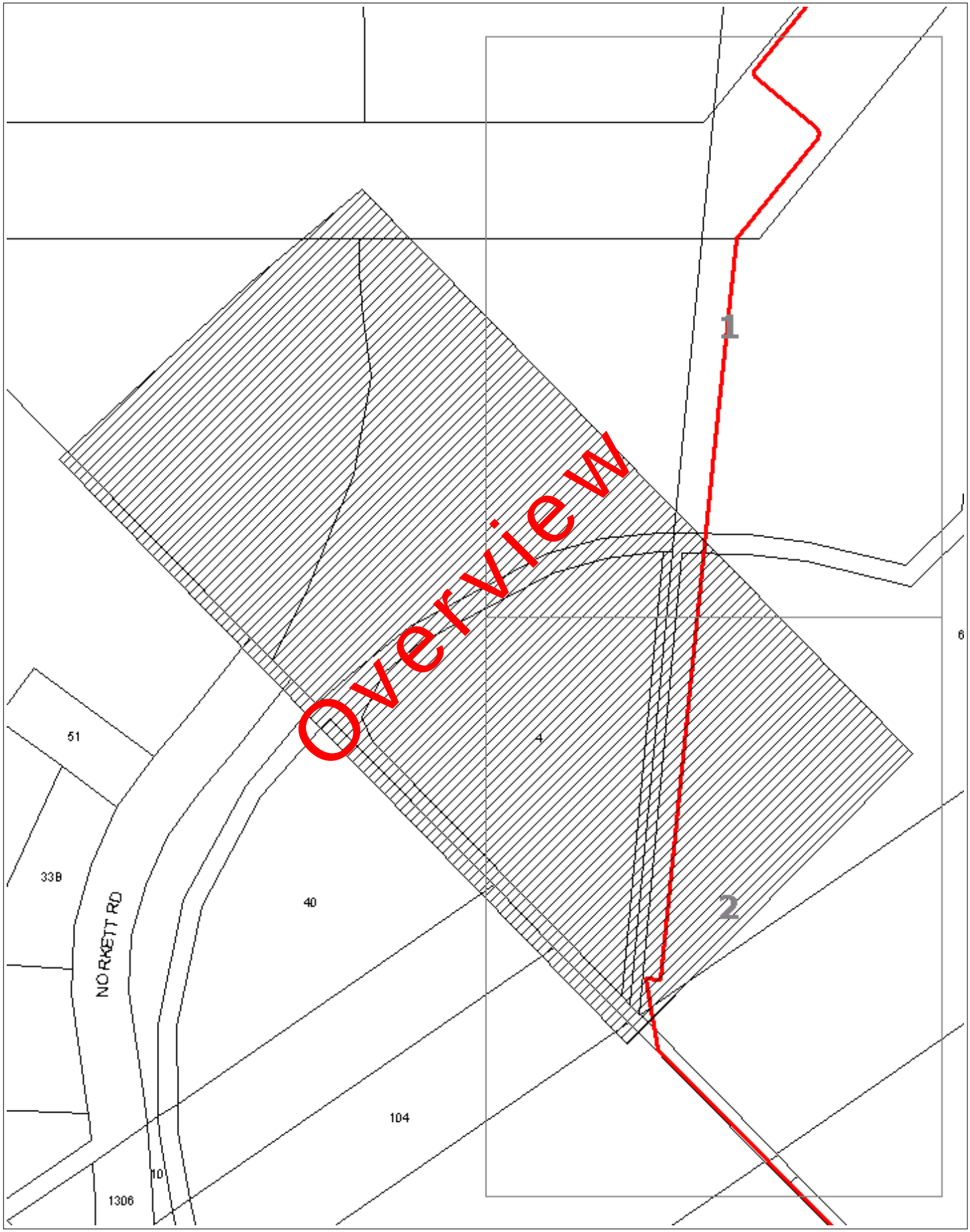
B101
12EAD
168.0
P28
B101-110
16
142.3
RD
16
181.6
P28
2607.0







Appendix F Existing Optus Assets

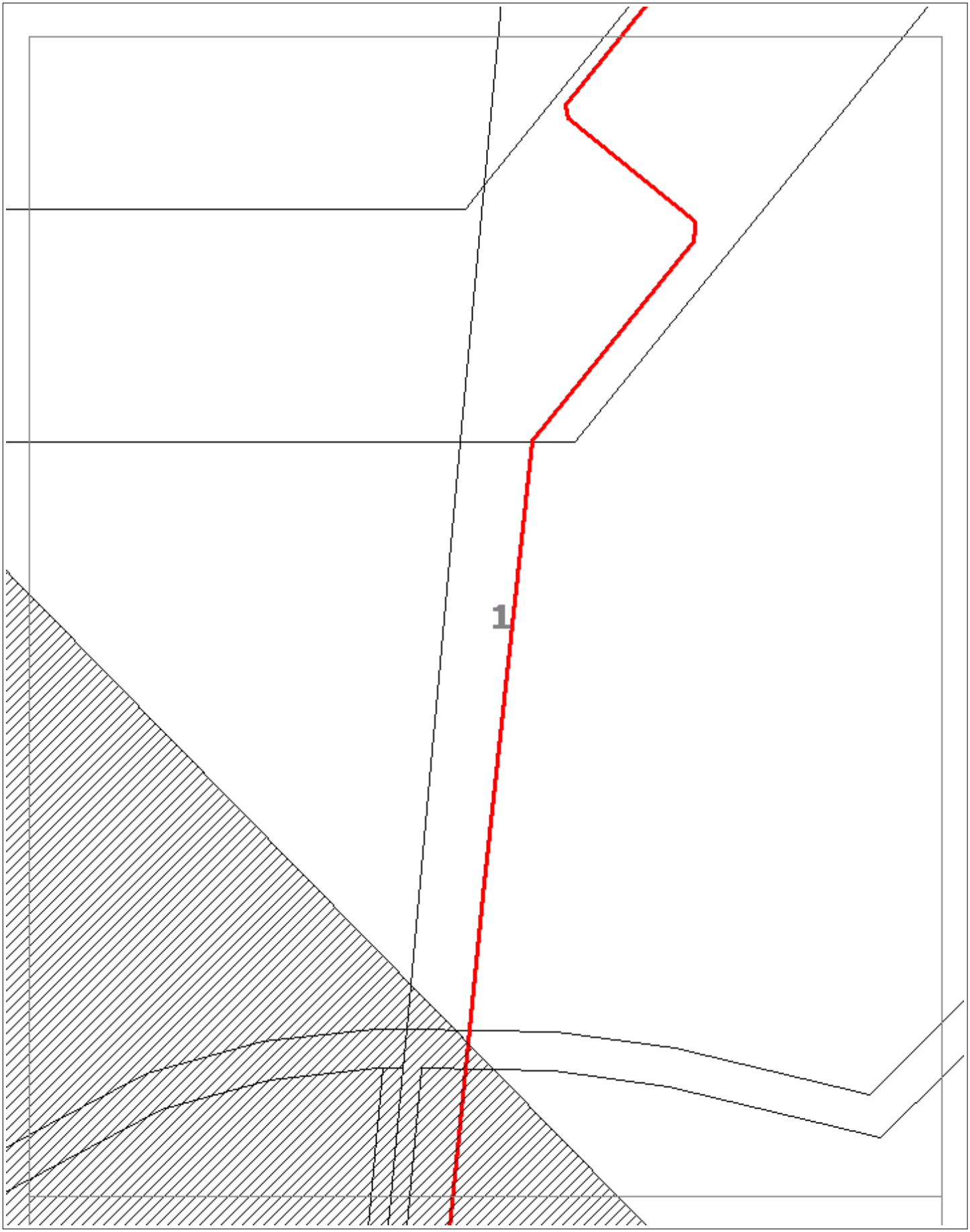


WARNING: This document is confidential and may also be privileged. Confidentiality nor privilege is not waived or destroyed by virtue of it being transmitted to an incorrect addressee. Unauthorised use of the contents is therefore strictly prohibited. Any information contained in this document that has been extracted from our records is believed to be accurate, but no responsibility is assumed for any error or omission.
Optus Plans and information supplied are valid for 30 days from the date of issue. If this timeline has elapsed please raise a new enquiry.

Sequence Number: 93725691

Date Generated: 13/01/2020

For all Optus DBYD plan enquiries –
Email: Fibre.Locations@optus.net.au
For urgent onsite assistance contact 1800 505 777
Optus Limited ACN 052 833 208

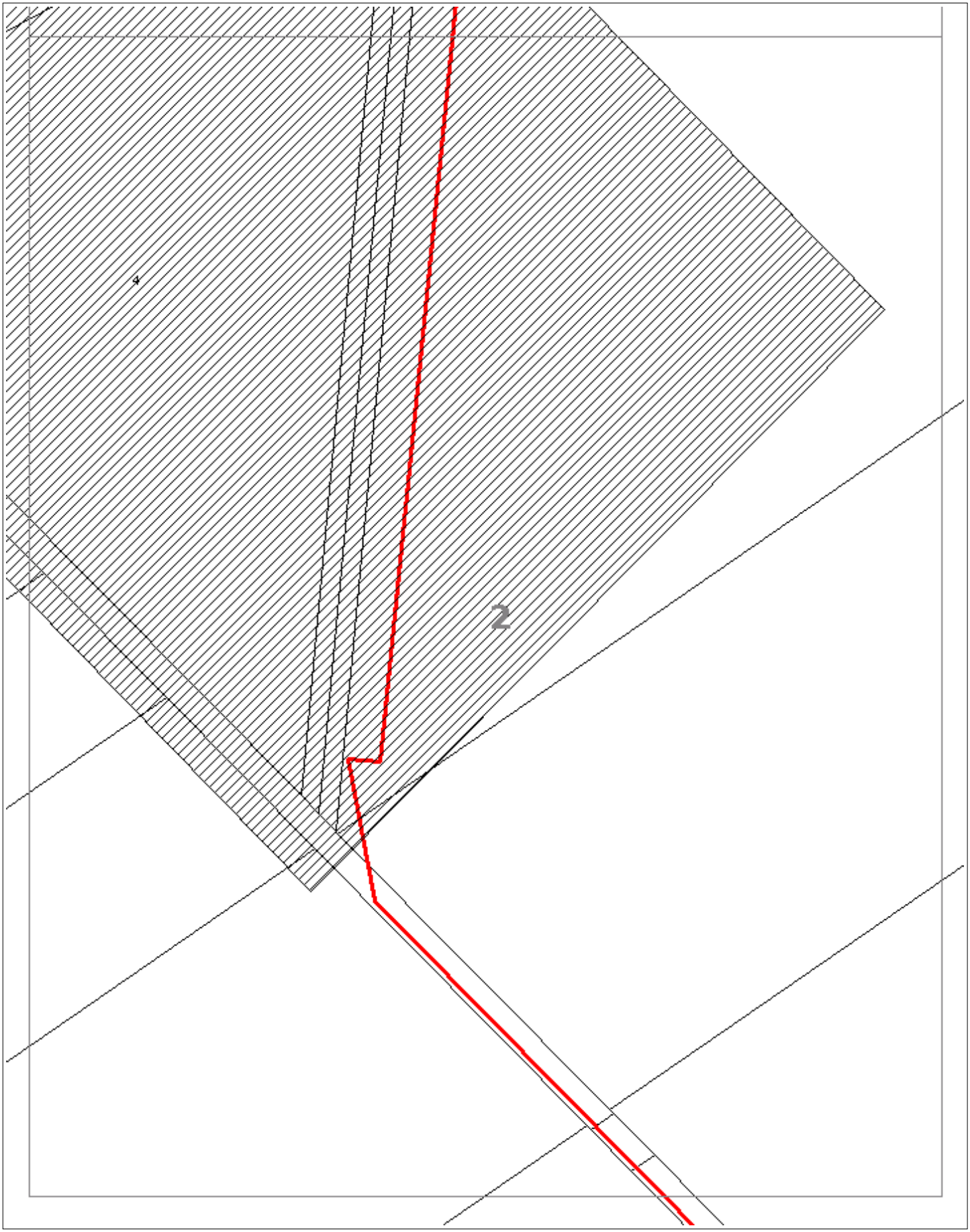


WARNING: This document is confidential and may also be privileged. Confidentiality nor privilege is not waived or destroyed by virtue of it being transmitted to an incorrect addressee. Unauthorised use of the contents is therefore strictly prohibited. Any information contained in this document that has been extracted from our records is believed to be accurate, but no responsibility is assumed for any error or omission.
Optus Plans and information supplied are valid for 30 days from the date of issue. If this timeline has elapsed please raise a new enquiry.

Sequence Number: 93725691

Date Generated: 13/01/2020

For all Optus DBYD plan enquiries –
Email: Fibre.Locations@optus.net.au
For urgent onsite assistance contact 1800 505 777
Optus Limited ACN 052 833 208



WARNING: This document is confidential and may also be privileged. Confidentiality nor privilege is not waived or destroyed by virtue of it being transmitted to an incorrect addressee. Unauthorised use of the contents is therefore strictly prohibited. Any information contained in this document that has been extracted from our records is believed to be accurate, but no responsibility is assumed for any error or omission.
Optus Plans and information supplied are valid for 30 days from the date of issue. If this timeline has elapsed please raise a new enquiry.

Sequence Number: 93725691

Date Generated: 13/01/2020

For all Optus DBYD plan enquiries –
Email: Fibre.Locations@optus.net.au
For urgent onsite assistance contact 1800 505 777
Optus Limited ACN 052 833 208

Appendix G Existing ATCO Gas Assets

GIS SYMBOLS SHEET

EXISTING GAS NETWORK

- High Pressure
- Polyethylene High Pressure
- City High Pressure
- Medium Pressure
- Albany Medium Pressure
- Medium Low Pressure
- Low Pressure
- Not Gassed
- Service
- High Pressure Service

ASSOCIATED INFRASTRUCTURE

- Associated Asset

PROPOSED GAS NETWORK

- Proposed Main

ABANDONED GAS NETWORK

- Abandoned Gas Main
- Abandoned Gas Main Sold
- Abandoned Valve
- Abandoned Fitting

DUCTS AND SLEEVES

- Duct
- Horizontal Boring
- Sleeve
- Road Crossing
- Concrete Slab

TOPOGRAPHY

- ATCO Easement
- Fence
- Building
- Kerb
- Water Boundary
- Contour Line
- Elevation Point

FEATURE LINES

- Miscellaneous Line
- Reference Line
- Gas Indicator Line
- Gas Pit
- DOC 1.2m — Arrow Pointer with Text

VALVES

- High Pressure
- High Pressure Service
- Main
- Service
- Isolation

GATE STATIONS

- Gate Station
- Pressure Reducing Station
- L.P.G. Tank

REGULATOR SETS

- Distribution Regulator
- Boundary Regulator

TELEMETRY MONITORING DEVICE

- Non Billing Meter
- Pressure Monitoring Device

DELIVERY POINTS

- Service Point
- Meter
- Interval Meter
- Meter Set

FEATURE POINTS

- SC — Side Elevation
- Obstacle
- See Details
- NC — Not Connected
- SV — Gas Service
- Sign
- OLS — Offline Service
- Linked Reference Document
- PLS — Pre-Laid Service
- PLSS — Pre-Laid Service Stairs
- PLST — Pre-Laid Service Tee
- BL — Asset ends on Building / Property Line
- CoD — Asset ends on Direction Peg

PROTECTION DEVICES

- T — Test Point
- PM — Potential Monitoring
- Odorant Test Point
- E — Earthing
- Bond Wire
- Bond Junction
- R — Rectifier
- IJ — Insulation Joint
- A — Anode
- GB — Ground Bed
- EM — Earth with Mitigation
- FS — Foreign Structure Monitoring
- IJM — Insulation Joint with Mitigation

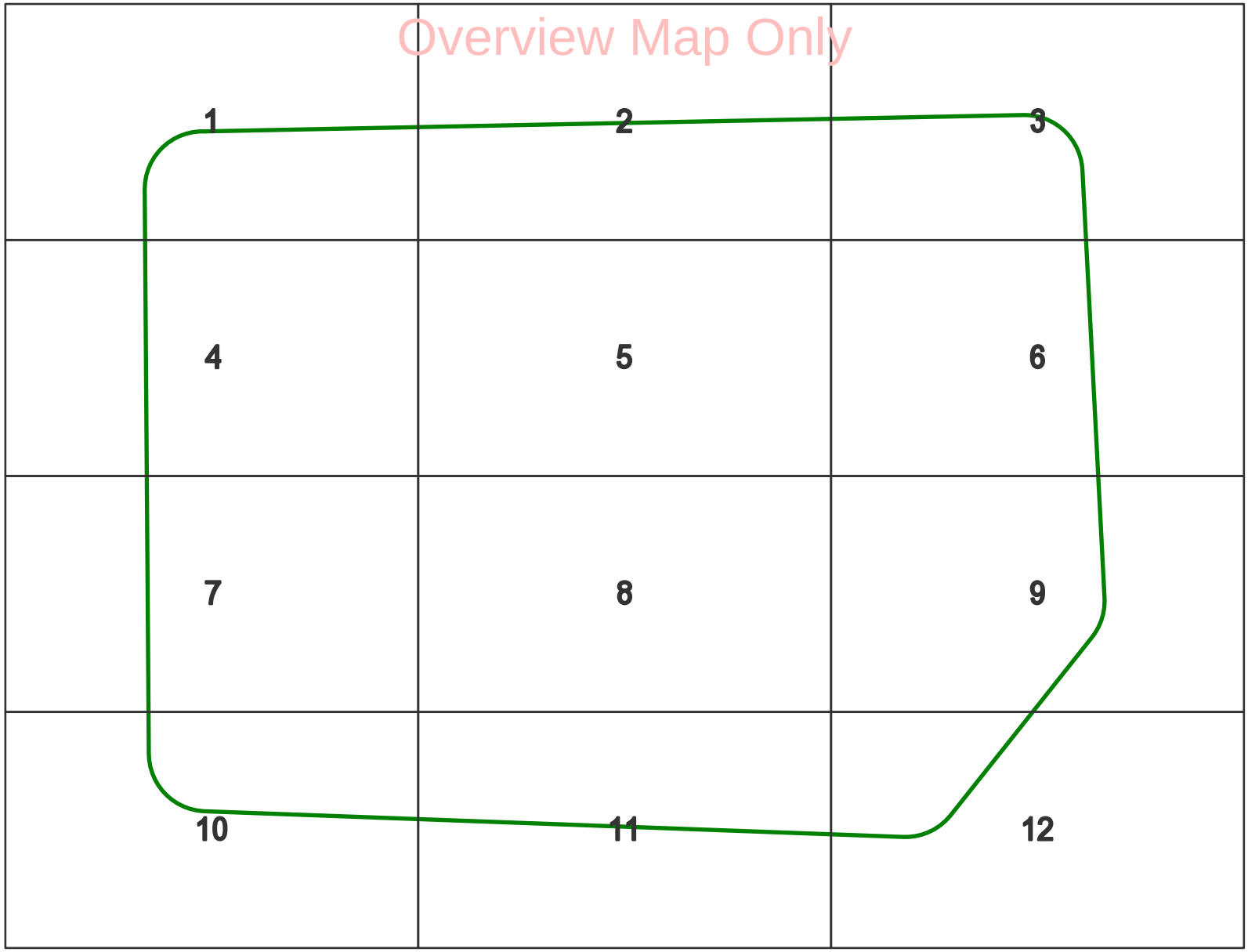
FITTINGS

- Syphon
- Coupling
- Expansion Joint
- Main Cross
- Reducer
- Stopple
- Flange
- Change Node
- Thredolet
- Tapping Band
- Bend
- Elbow
- Monolithic Joint
- End Cap
- Tee
- Transition
- Three-Way Tee
- Short Stop
- Weldolet
- Socket
- Spherical Tee
- Tapping Tee
- Barrier
- Squeeze Off

FEATURE POLYGONS

- Hard Digging
- Proving Gas Location
- Pressure Upgrade
- Licence Area
- Not Gassed
- Suburb
- Local Government Authority

Overview Map Only



Sequence No: 93722882
Job No: 18847270
Map Tile:
Date:13/01/2020
Scale: 1:6150
Location: Mandogalup Road, Mandogalup 6167

© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N
W E
S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate

Sequence No: 93722882 | Map Tile: 1 | Scale: 1:1500

Job No: 18847270 | Date: 13/01/2020 | Location: Mandogalup Road, Mandogalup 6167

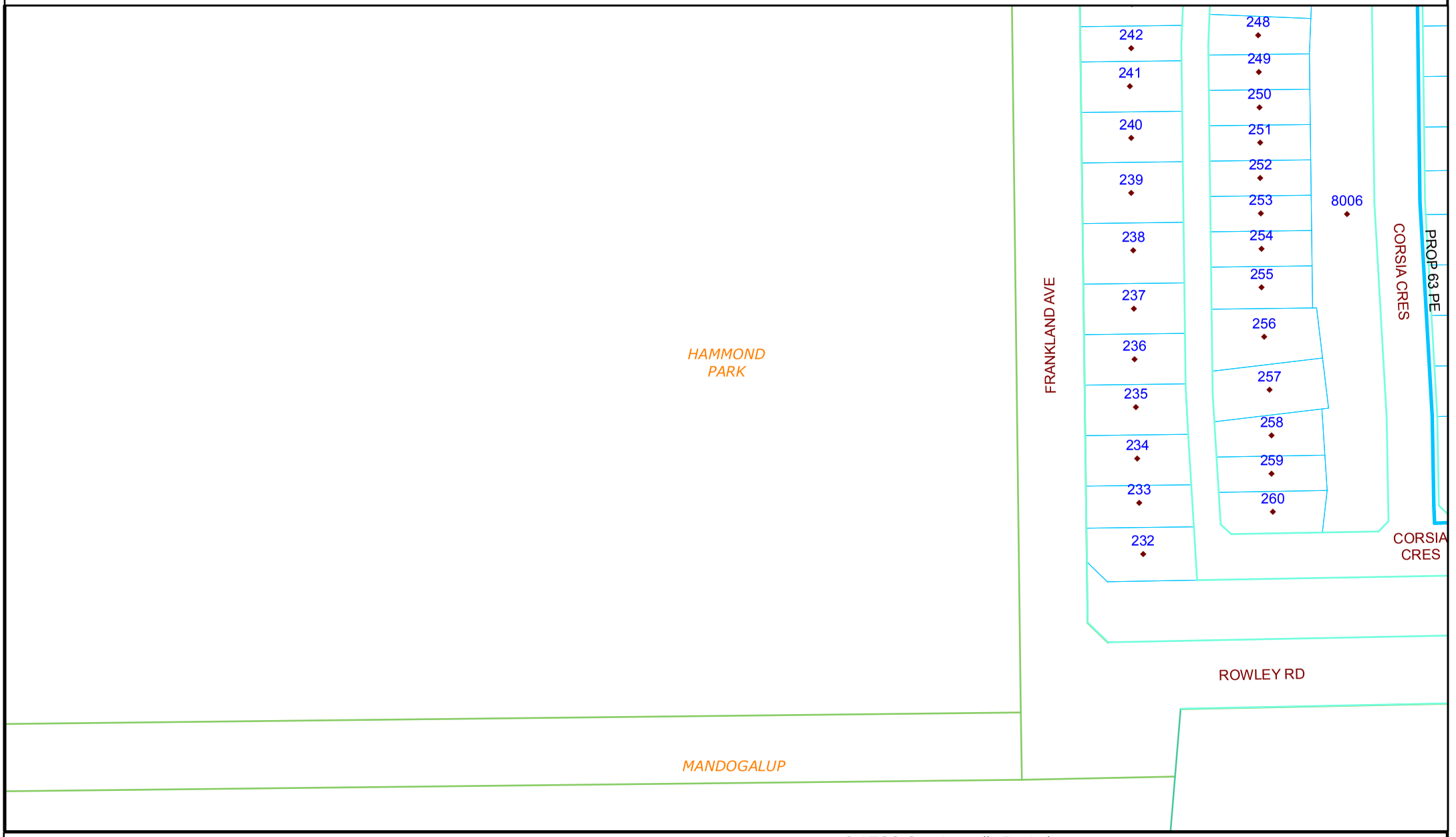
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N
W E
S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the
Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 Map Tile: 2 Scale: 1:1500

Job No: 18847270 Date: 13/01/2020 Location: Mandogalup Road, Mandogalup 6167

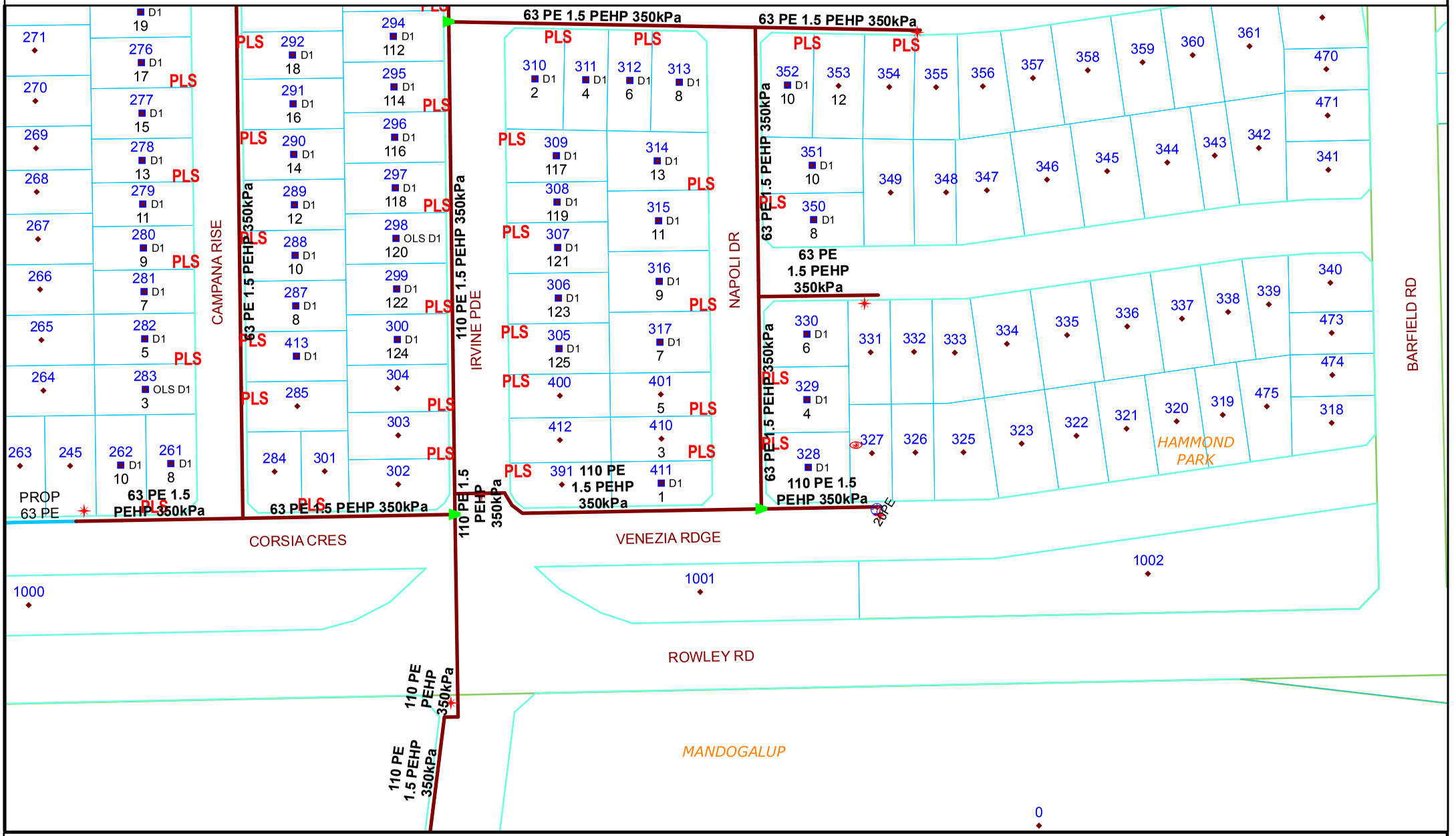
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N
W E
S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



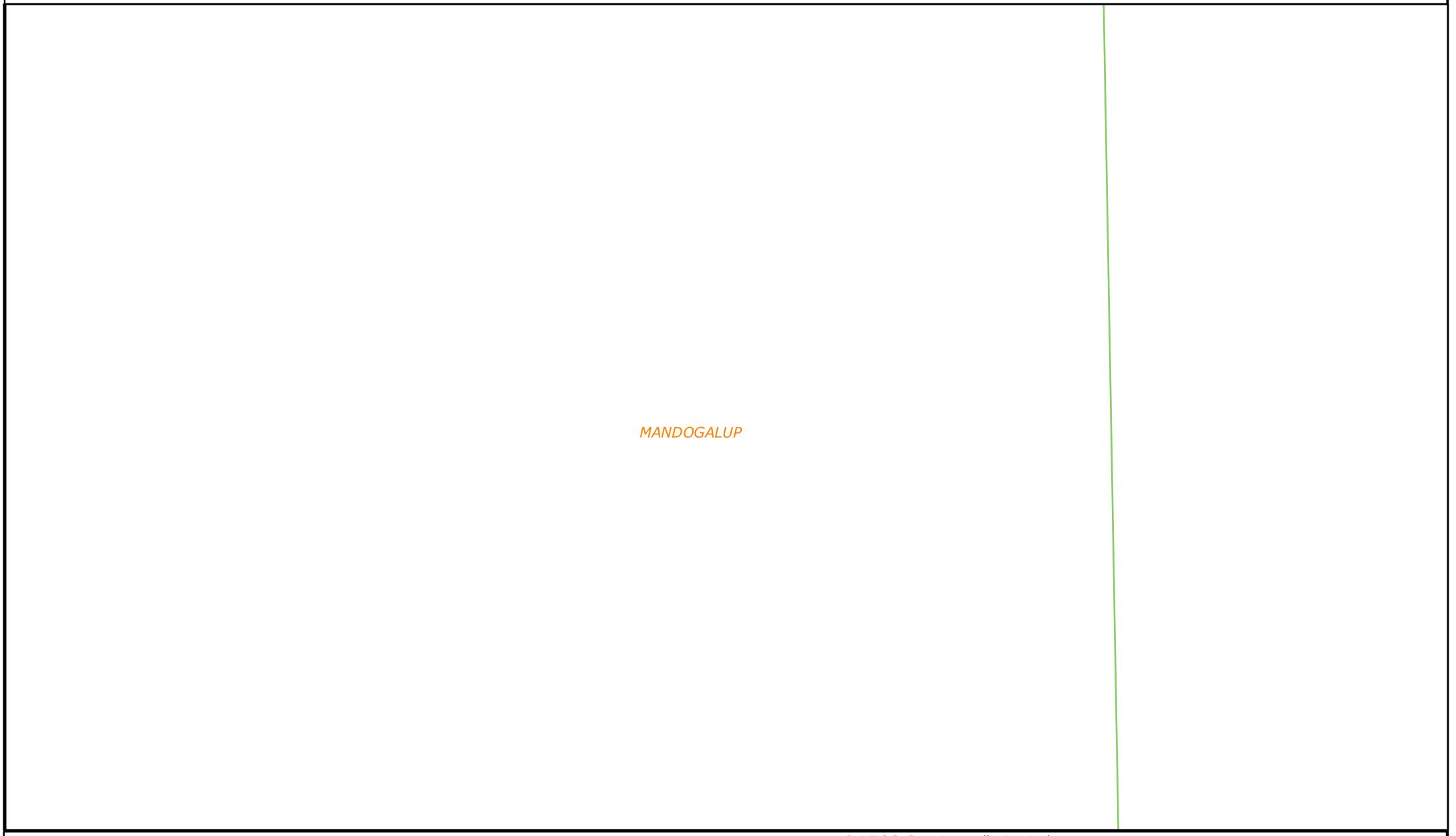
Sequence No: 93722882 Map Tile: 3 Scale: 1:1500

Job No: 18847270 Date: 13/01/2020 Location: Mandogalup Road, Mandogalup 6167

© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882
Map Tile: 4
Scale: 1:1500

Job No: 18847270
Date: 13/01/2020
Location: Mandogalup Road, Mandogalup 6167

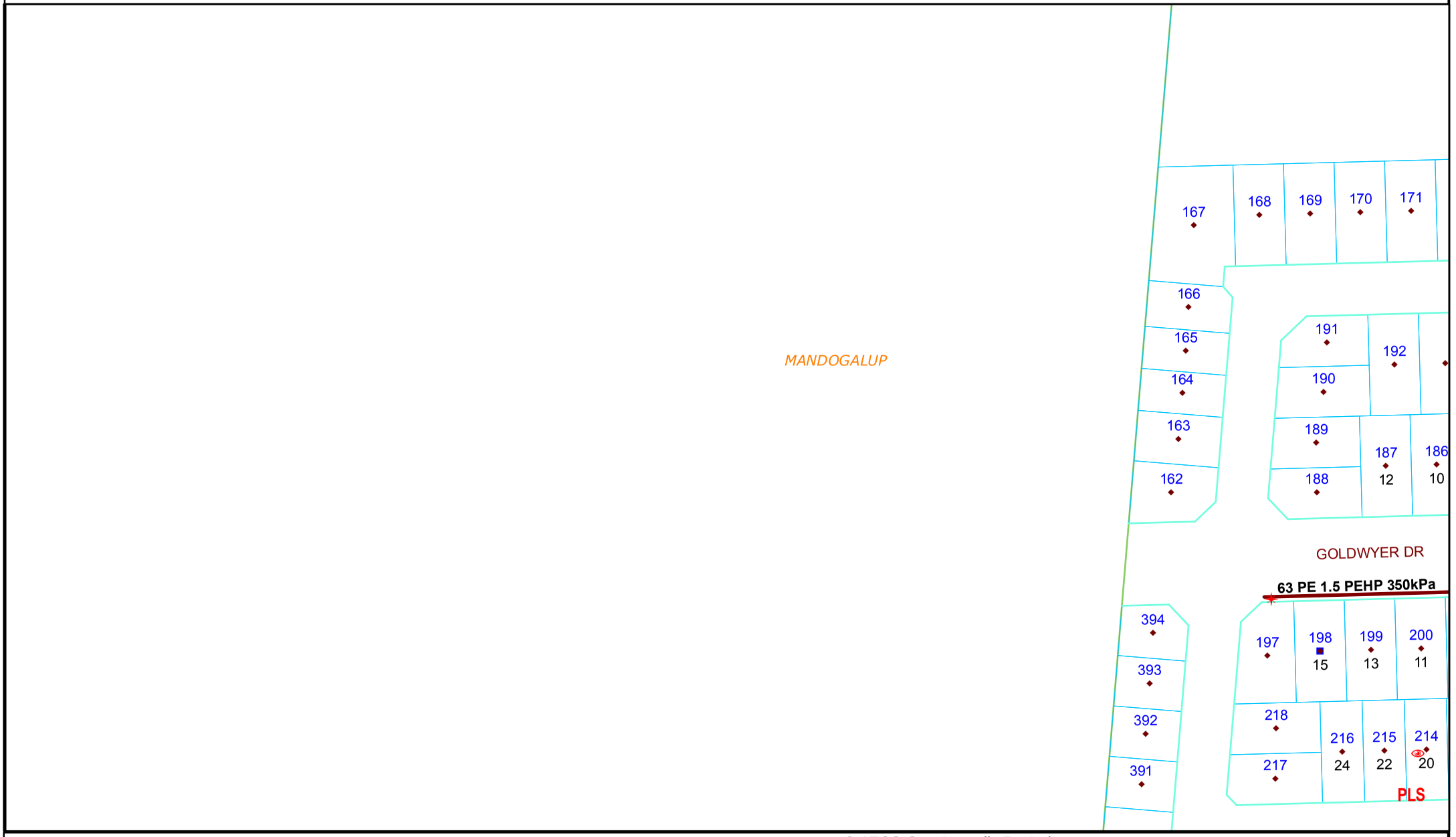
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N
W E
S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 | Map Tile: 5 | Scale: 1:1500

Job No: 18847270 | Date: 13/01/2020 | Location: Mandogalup Road, Mandogalup 6167

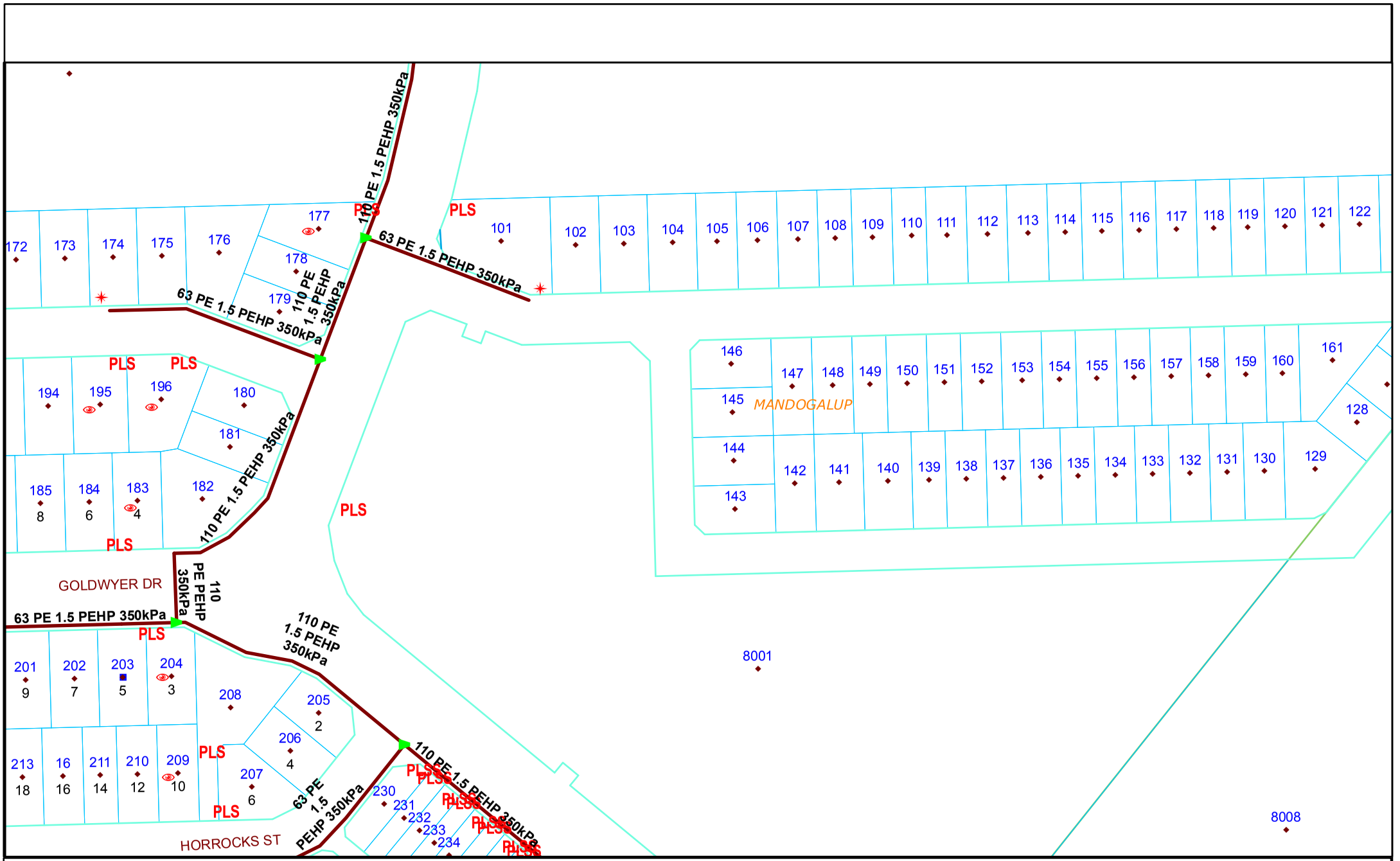
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N W E S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 Map Tile: 6 Scale: 1:1500

Job No: 18847270 Date:13/01/2020 Location: Mandogalup Road, Mandogalup 6167

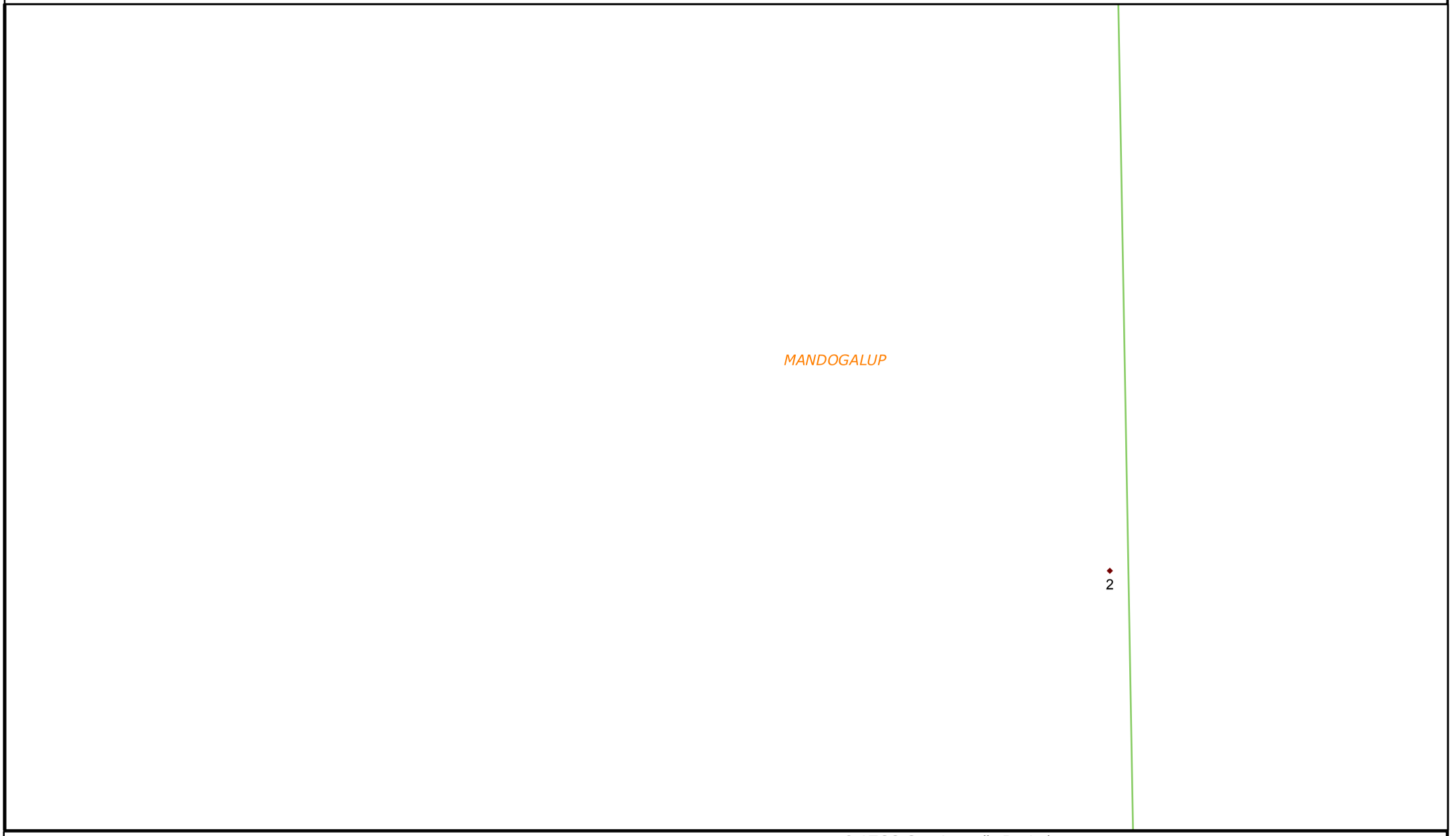
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N W E S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 | Map Tile: 7 | Scale: 1:1500

Job No: 18847270 | Date: 13/01/2020 | Location: Mandogalup Road, Mandogalup 6167

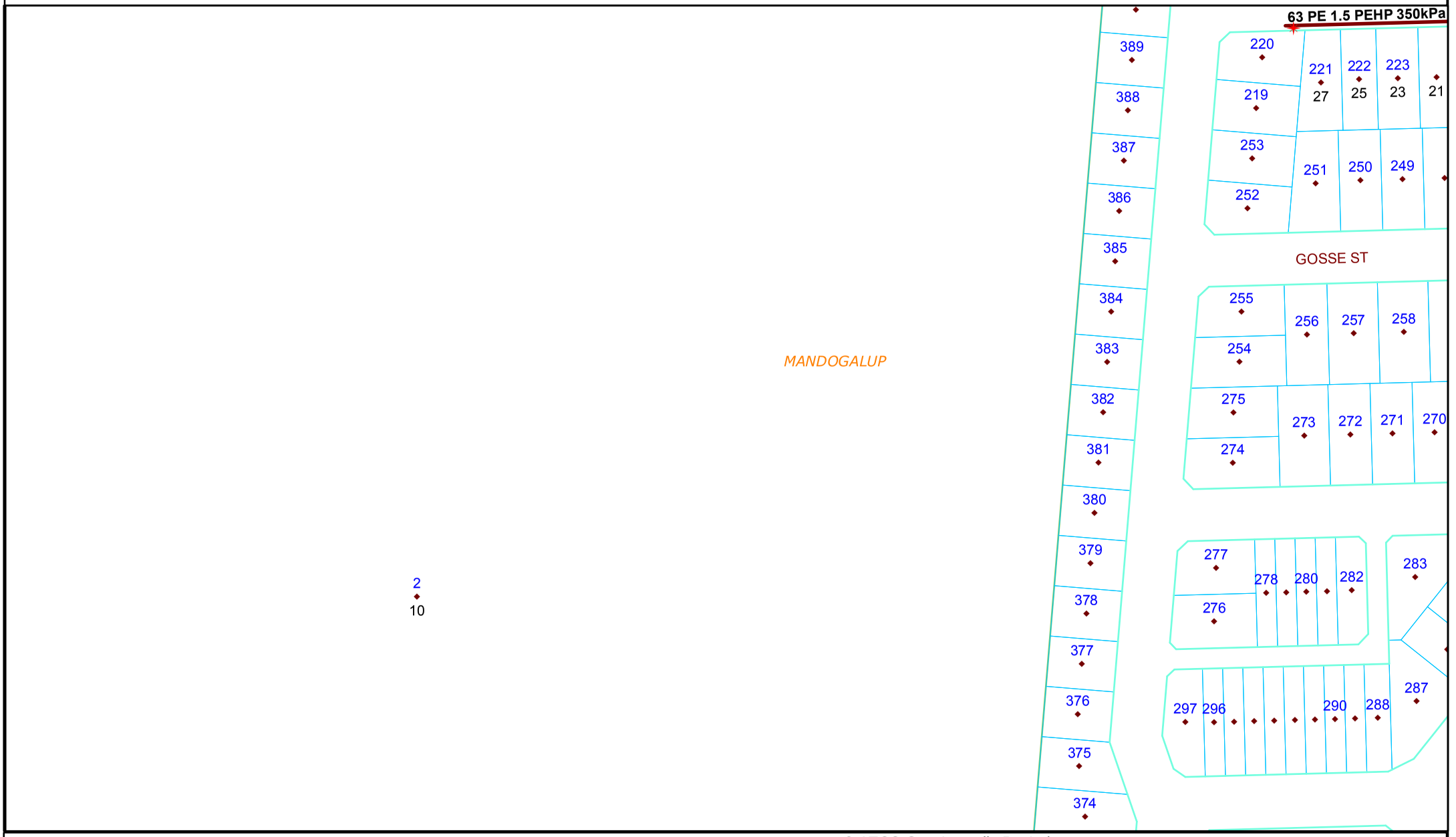
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N
W E
S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 | Map Tile: 8 | Scale: 1:1500

Job No: 18847270 | Date: 13/01/2020 | Location: Mandogalup Road, Mandogalup 6167

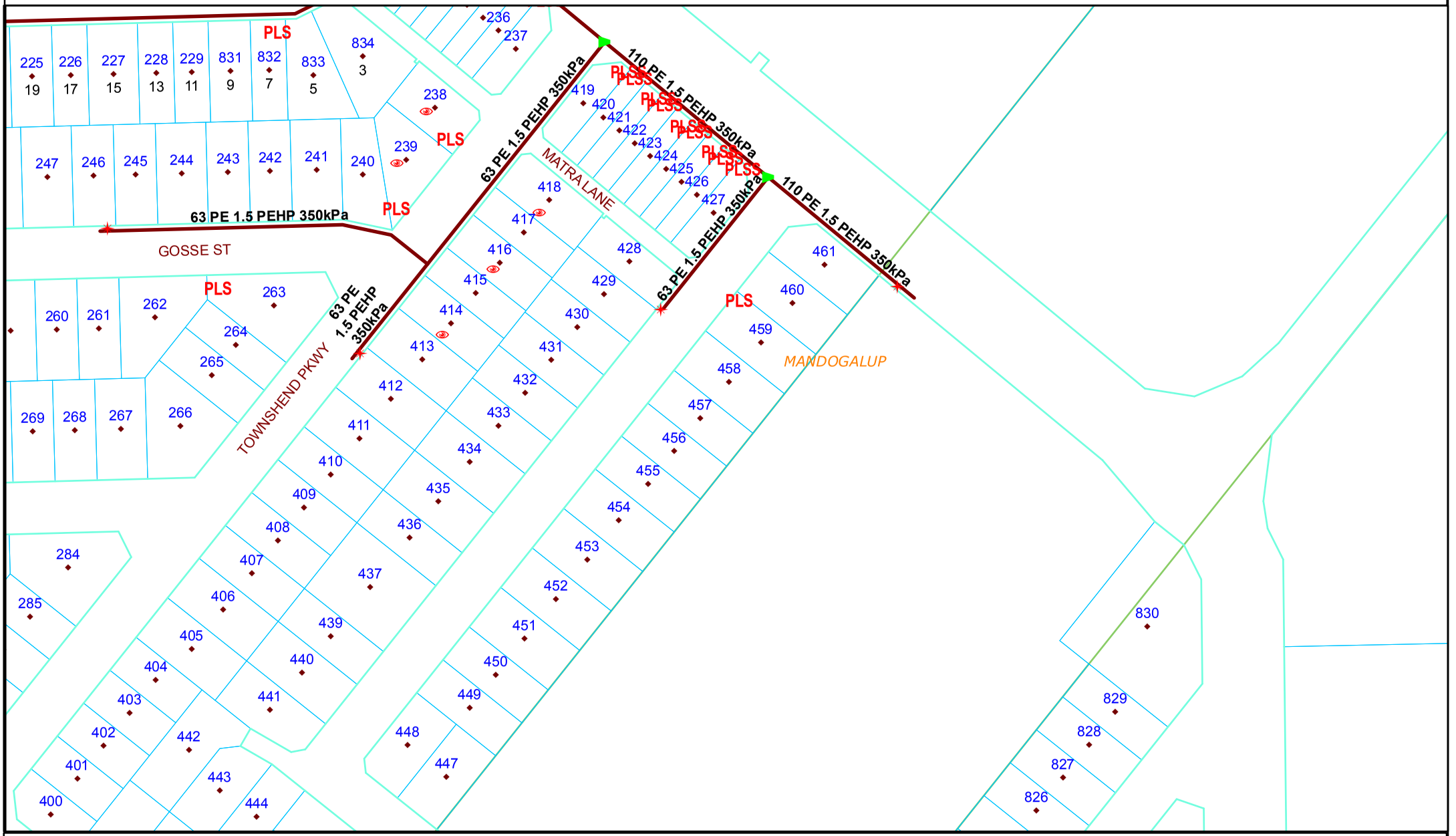
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N
W E
S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 | Map Tile: 9 | Scale: 1:1500

Job No: 18847270 | Date: 13/01/2020 | Location: Mandogalup Road, Mandogalup 6167

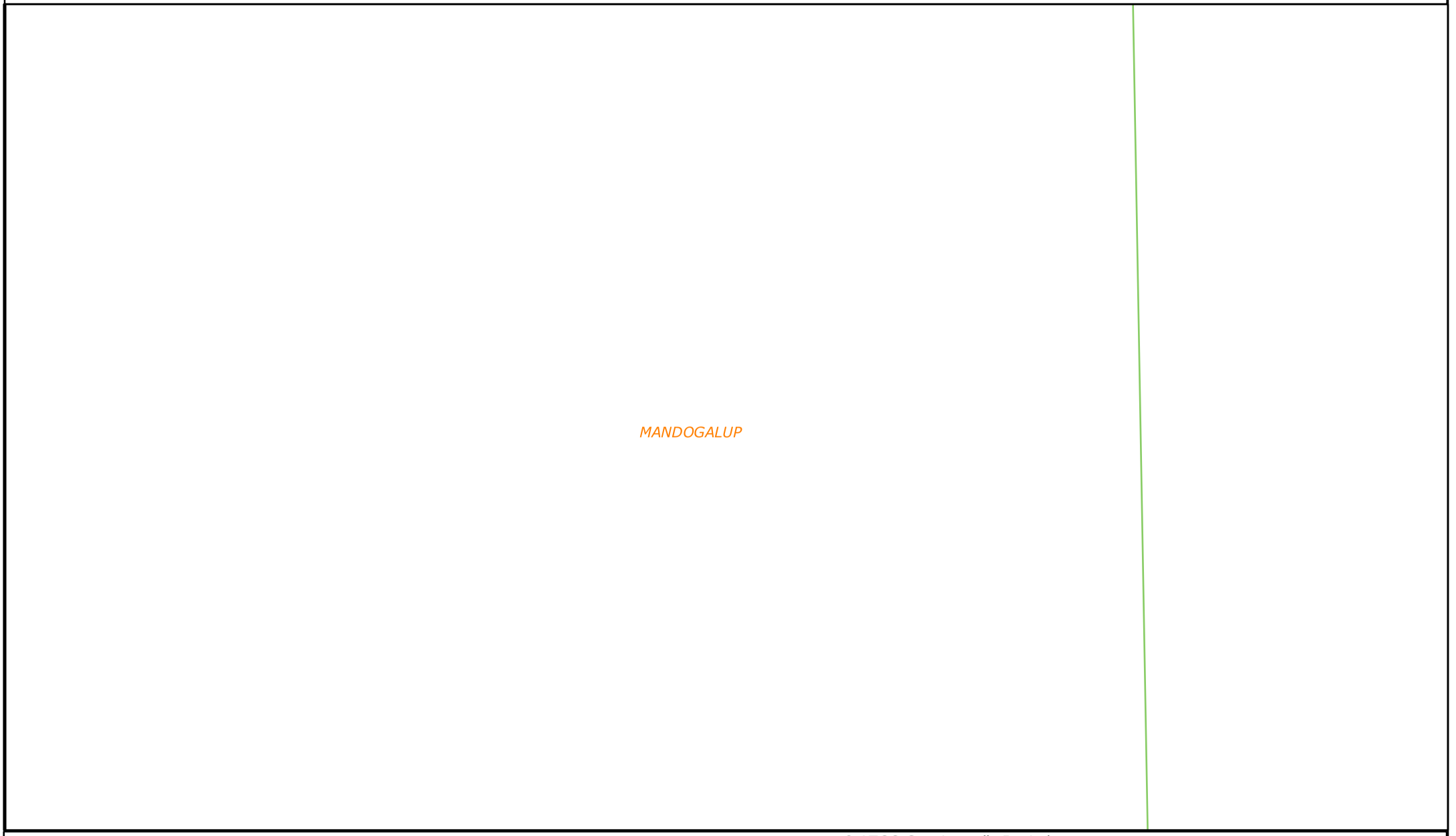
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N W E S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882
Map Tile: 10
Scale: 1:1500

Job No: 18847270
Date: 13/01/2020
Location: Mandogalup Road, Mandogalup 6167

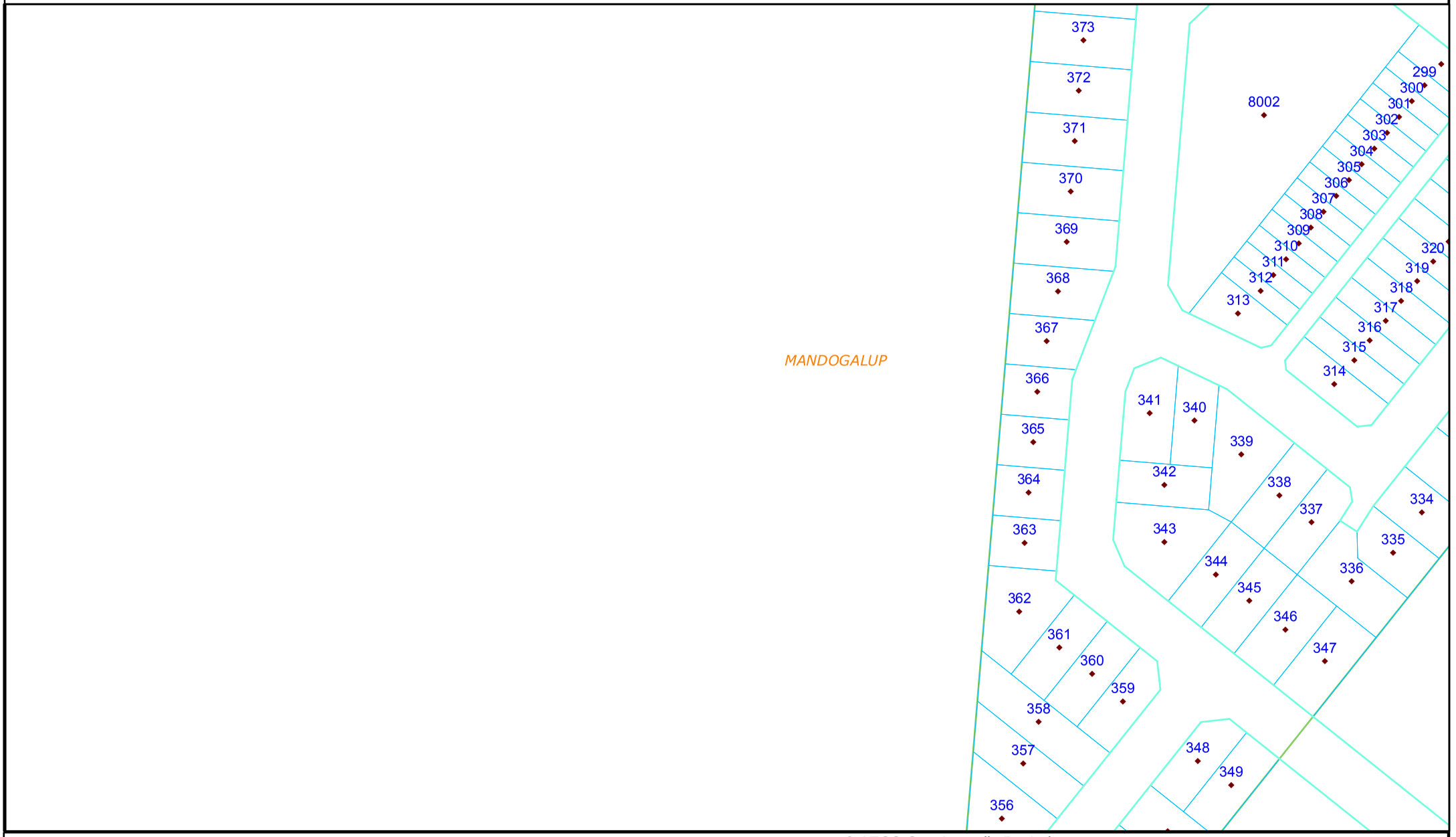
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N
W E
S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 | Map Tile: 11 | Scale: 1:1500

Job No: 18847270 | Date: 13/01/2020 | Location: Mandogalup Road, Mandogalup 6167

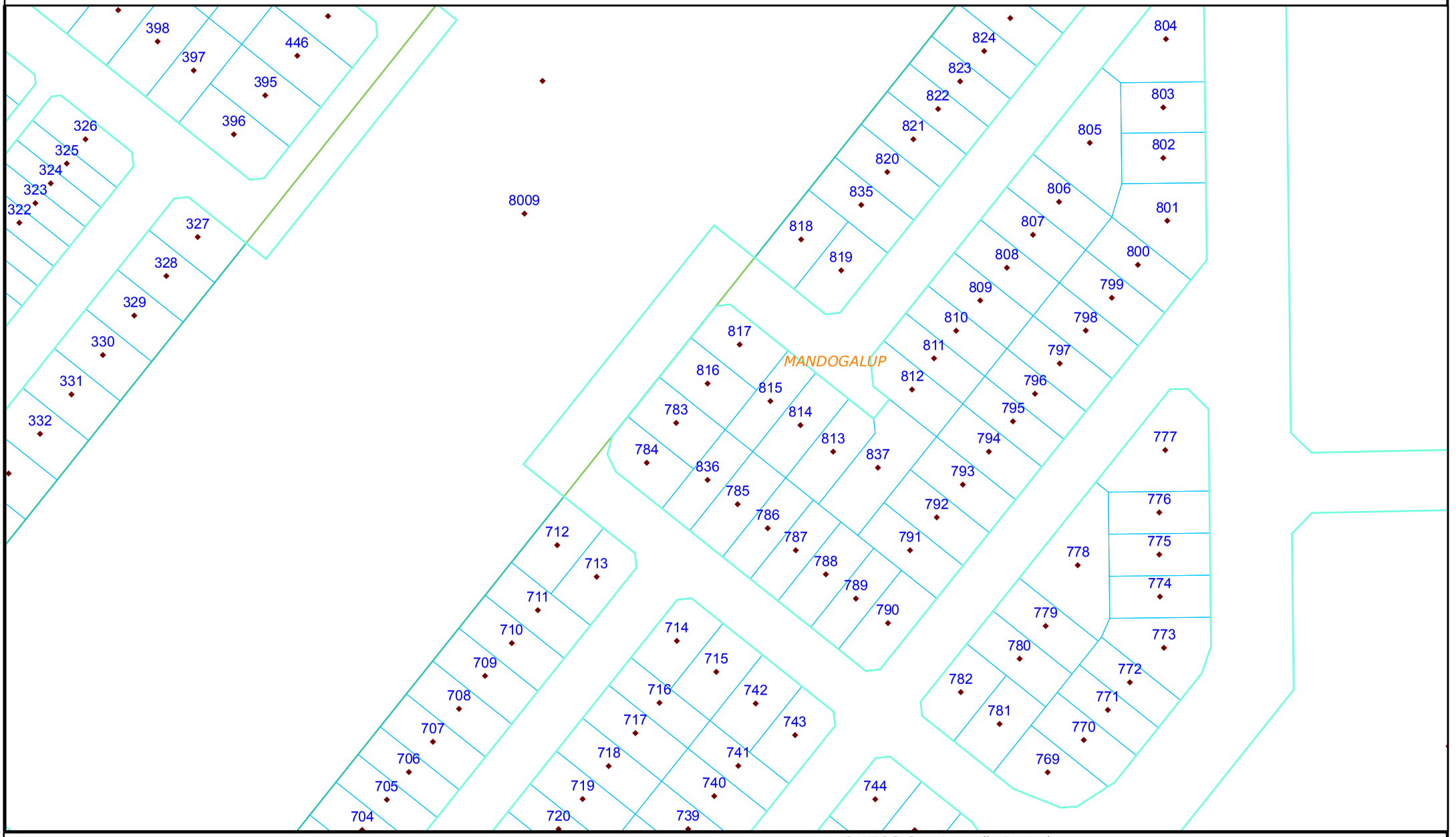
© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N W E S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate



Sequence No: 93722882 | Map Tile: 12 | Scale: 1:1500

Job No: 18847270 | Date: 13/01/2020 | Location: Mandogalup Road, Mandogalup 6167

© ATCO Gas Australia Pty Ltd
ABN 90 089 531 975

N W E S

ATCO

Please read all **warnings**, conditions and information on the attached "Underground Asset Details" information sheet. This plan is issued subject to that information and those conditions and **warnings** (including, but not limited to, the "NO HOT WORKS" warning). Plans are current for only **30 days** from date of request, indicative only and not warranted to be accurate. It is your responsibility to carefully locate underground assets and follow safe work practises and procedures (eg pot-holing). ATCO Gas Australia will seek compensation for damage caused to assets.

© Western Australian Land Information Authority trading as Landgate
Based on information provided by and with the permission of the Western Australian Land Information Authority trading as Landgate

Appendix G

Transportation Noise Assessment

Lloyd George Acoustics
PO Box 717
Hillarys WA 6923
T: 9401 7770
www.lgacoustics.com.au

Transportation Noise Assessment

Mandogalup Improvement Scheme

Reference: 19065057-01D

Prepared for:
Strategen Environmental

Report: 19065057-01D

Lloyd George Acoustics Pty Ltd

ABN: 79 125 812 544

PO Box 717
Hillarys WA 6923

www.lgacoustics.com.au

T: 9401 7770

Contacts	Daniel Lloyd	Terry George	Matt Moyle	Olivier Mallié	Ben Hillion
E:	daniel@lgacoustics.com.au	terry@lgacoustics.com.au	matt@lgacoustics.com.au	olivier@lgacoustics.com.au	ben@lgacoustics.com.au
M:	0439 032 844	0400 414 197	0412 611 330	0439 987 455	0457 095 555

This report has been prepared in accordance with the scope of services described in the contract or agreement between Lloyd George Acoustics Pty Ltd and the Client. The report relies upon data, surveys, measurements and results taken at or under the particular times and conditions specified herein. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by the Client. Furthermore, the report has been prepared solely for use by the Client, and Lloyd George Acoustics Pty Ltd accepts no responsibility for its use by other parties.

Date:	Rev	Description	Prepared By	Verified
12-Dec-19	0	Draft Issue for Client Comment	Ben Hillion	Olivier Mallié
23-Jan-20	A	Minor revision	Ben Hillion	
25-Mar-20	B	Updated Noise Maps	Ben Hillion	
25-Mar-20	C	Minor revision	Ben Hillion	
27-Mar-20	D	Minor revision	Ben Hillion	

Table of Contents

1 INTRODUCTION 1

2 CRITERIA 2

3 METHODOLOGY 3

3.1 Site Measurements 3

3.2 Noise Modelling 4

3.2.1 Ground Topography 5

3.2.2 Traffic Data 5

3.2.3 Ground Attenuation 6

3.2.4 Parameter Conversion 6

4 RESULTS 7

4.1 Noise Monitoring 7

4.2 Noise Modelling 8

5 ASSESSMENT 12

List of Tables

Table 2-1 Noise Targets for Noise-Sensitive Land-Use 2

Table 3-1 Noise Relationship Between Different Road Surfaces 5

Table 4-1 Measured Average Noise Levels – Kwinana Freeway 7

Table 4-2 Measured Average Noise Levels - Anketell Road 7

List of Figures

Figure 1-1 Extent of Subject area (Source : City of Kwinana) _____ 1

Figure 3-1 Photo of Kwinana Freeway Logger (hidden in bushes) _____ 4

Figure 3-2 Photo of Anketell Road Logger _____ 4

Figure 4-1 Noise Monitoring Results – Kwinana Freeway _____ 8

Figure 4-2 Noise Monitoring Results – Anketell Road _____ 9

Figure 4-3 Future Noise Contour Plot - Daytime _____ 10

Figure 4-4 Future Noise Contour Plot – Night time _____ 11

Appendices

A Acceptable Treatment Packages

B MRWA Traffic Data

C Terminology

1 INTRODUCTION

Improvement Plan 47: Mandogalup (IP47), gazetted on 12 April 2019, affects approximately 330 hectares of land in the Mandogalup locality in the City of Kwinana. The IP47 land is zoned Rural and Urban Deferred under the Metropolitan Region Scheme (MRS). The IP47 land is bound by Rowley Road to the north and Anketell Road to the south. The Kwinana Freeway is to the east, and the Alcoa residue storage area and Kwinana Industrial Area is to the west.

The extent of the subject area is shown on *Figure 1-1*.

Kwinana Freeway is within 470 metres to the east, and Anketell Road adjacent to the south, and, as such, potential noise impacts from transportation (road traffic) must be considered.

This report addresses future noise from Kwinana Freeway and Anketell Road, future noise from Rowley Road and the proposed Hammond Road extension do not form part of this assessment.

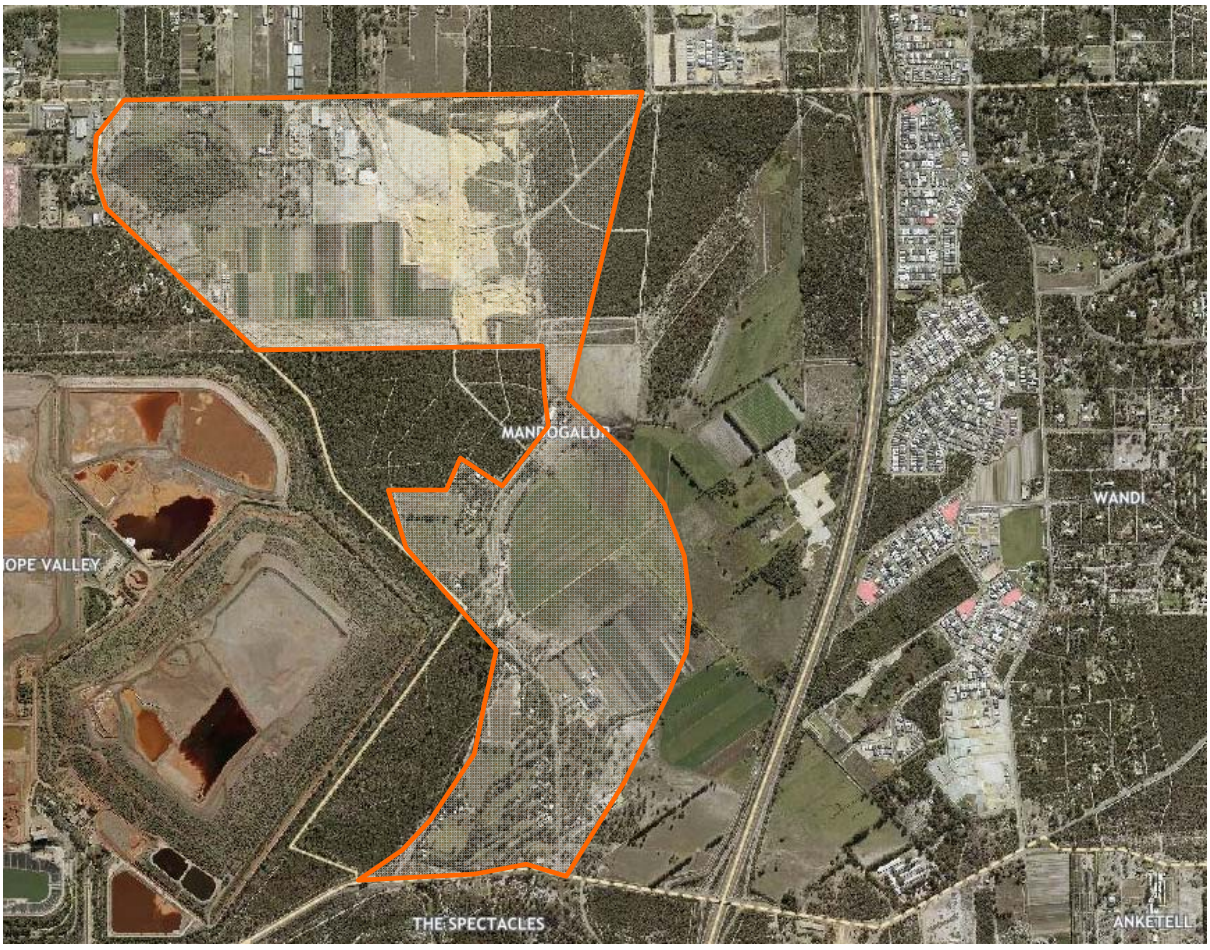


Figure 1-1 Extent of Subject area (Source : City of Kwinana)

Appendix B contains Main Roads WA supplied traffic data which forms the basis of this assessment.

Appendix C contains a description of some of the terminology used throughout this report.

2 CRITERIA

The criteria relevant to this assessment is provided in *State Planning Policy No. 5.4 Road and Rail Noise* (hereafter referred to as SPP 5.4) produced by the Western Australian Planning Commission (WAPC). The objectives of SPP 5.4 are to:

- Protect the community from unreasonable levels of transport noise;
- Protect strategic and other significant freight transport corridors from incompatible urban encroachment;
- Ensure transport infrastructure and land-use can mutually exist within urban corridors;
- Ensure that noise impacts are addressed as early as possible in the planning process; and
- Encourage best practice noise mitigation design and construction standards

Table 2-1 sets out noise targets that are to be achieved by proposals under which SPP 5.4 applies. Where the targets are exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.

Table 2-1 Noise Targets for Noise-Sensitive Land-Use

Outdoor Noise Target		Indoor Noise Target	
55 dB $L_{Aeq(Day)}$	50 dB $L_{Aeq(Night)}$	40 dB $L_{Aeq(Day)}$ (Living and Work Areas)	35 dB $L_{Aeq(Night)}$ (Bedrooms)

Notes:

- Day period is from 6am to 10pm and night period from 10pm to 6am.
- The outdoor noise target is to be measured at 1-metre from the most exposed, habitable[1] facade of the noise sensitive building.
- For all noise-sensitive land-use and/or development, indoor noise targets for other room usages may be reasonable drawn from Table 1 of Australian Standard/New Zealand Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors (as amended) for each relevant time period.
- Outdoor targets are to be met at all outdoor areas as far as is reasonable and practicable to do so using the various noise mitigation measures outlined in the Guidelines.

The application of SPP 5.4 is to consider anticipated traffic volumes for the next 20 years from when the noise assessment is undertaken.

In the application of the noise targets, the objective is to achieve:

- indoor noise levels specified in *Table 2-1* in noise-sensitive areas (e.g. bedrooms and living rooms of houses and school classrooms); and
- a reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and childcare centres, the design of outdoor areas should take into consideration the noise target.

[1] A habitable room is defined in State Planning Policy 3.1 as a room used for normal domestic activities that includes a bedroom, living room, lounge room, music room, sitting room, television room, kitchen, dining room, sewing room, study, playroom, sunroom, gymnasium, fully enclosed swimming pool or patio.

It is recognised that in some instances, it may not be reasonable and/or practicable to meet the outdoor noise targets. Where transport noise is above the noise targets, measures are expected to be implemented that balance reasonable and practicable considerations with the need to achieve acceptable noise protection outcomes.

3 METHODOLOGY

Noise measurements and modelling have been undertaken generally in accordance with the requirements of SPP 5.4 and associated Guidelines[2] as described in *Section 3.1* and *Section 3.2*.

3.1 Site Measurements

Noise monitoring was undertaken at two (2) locations in order to:

- Quantify the existing noise levels;
- Determine the differences between different acoustic parameters ($L_{A10,18hour}$, $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$); and
- Calibrate the noise model for existing conditions.

The instruments used were:

- an ARL Type 316 noise data logger (S/N: 15-301-468), located 9 metres from the edge of Kwinana Freeway, with the microphone 1.4 metres above ground level (refer *Figure 3-1*). The logger was programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels.
- An ARL Type Ngara noise data logger (S/N 878115), located 18 metres from the edge of Anketell Road, with the microphone 1.4 metres above ground level (refer *Figure 3-1*). The logger was programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels.
- These instruments comply with the instrumentation requirements of *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The loggers were field calibrated before and after the measurement session and found to be accurate to within +/- 1 dB. Lloyd George Acoustics also holds current laboratory calibration certificate for the loggers.

[2] Road and Rail Noise Guidelines, September 2019

Figure 3-1 Photo of Kwinana Freeway Logger (hidden in bushes)

Figure 3-2 Photo of Anketell Road Logger

The noise data collected was verified by inspection and professional judgement. Where hourly data was considered atypical, an estimated value was inserted.

3.2 Noise Modelling

The computer programme *SoundPLAN 8.1* was utilised incorporating the *Calculation of Road Traffic Noise* (CoRTN) algorithms, modified to reflect Australian conditions. The modifications included the following:

- Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. By splitting the noise source into three, allows for less barrier attenuation for high level sources where barriers are to be considered.
- Note that a -8.0 dB correction is applied to the exhaust and -0.8 dB to the engine (based on Transportation Noise Reference Book, Paul Nelson, 1987), so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;
- Adjustments of -0.8 dB and -1.7 dB have been applied to the predicted levels for the 'free-field' and 'at facade' cases respectively, based on the findings of *An Evaluation of the U.K. DoE Traffic Noise Prediction*; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group (March 1983).

Predictions are made at heights of 1.4 m above ground floor level, which represents the noise level at a typical single storey house. The noise is predicted at 1.0 metre from an assumed building facade resulting in a + 2.5 dB correction due to reflected noise.

Various input data are included in the modelling such as ground topography, road design, traffic volumes etc. These model inputs are discussed in the following sections.

3.2.1 Ground Topography

Topographical data was 2008 LIDAR data provided by JDA hydrological consultants.

Existing buildings have also been included as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. All buildings are assumed to be single storey with a height of 3.5 metres.

Future buildings associated with subdivisions within IP47 area have not been included.

3.2.2 Traffic Data

Traffic data includes:

- Road Surface – The noise relationship between different road surface types is shown in *Table 3-1*.

Table 3-1 Noise Relationship Between Different Road Surfaces

Road Surfaces						
Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.5 dB	-2.5 dB

The existing road surface is open graded asphalt on Kwinana Freeway and dense graded asphalt on Anketell Road, and these are the road surface type used in the assessment.

- Vehicle Speed – The existing and future posted speeds are 100 km/hr on Kwinana Freeway and 80 km/hr on Anketell Road.

- Traffic Volumes – Existing (2016) and forecast (2041) traffic volumes were provided by Main Roads WA (Clare Yu, Traffic Modelling Analyst, Reference: #41247, dated 12 July 2019). A validation plot was also provided allowing the Main Roads WA traffic volume model to be calibrated against actual counts. All 3 plots are provided in Appendix B.

The year 2016 traffic data provided by Main Roads WA for Kwinana Freeway and Anketell Road was used to set up the noise model, and the resulting noise model output was calibrated using actual noise measurements summarised in *Figures 4-1* and *4-2*.

For the future scenario, which forms the basis of this assessment, the year 2041 traffic data provided by Main Roads WA for Kwinana Freeway and Anketell Road was input into the noise model to generate future noise maps presented in *Figure 4-3* and *4-4*.

Should there be any additional future changes in road alignment, road surface type, traffic volumes or traffic speed these would mandate another noise study to reflect the changes.

3.2.3 Ground Attenuation

The ground attenuation has been assumed to be 0.0 (0%) for the road, 1.0 (100%) for open space sanded and grassed areas. Note 0.0 represents hard reflective surfaces such as water and 1.0 represents absorptive surfaces such as grass.

3.2.4 Parameter Conversion

The CoRTN algorithms used in the *SoundPlan* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. SPP 5.4 however uses $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$. The relationship between the parameters varies depending on the composition of traffic on the road (volumes in each period and percentage heavy vehicles).

As noise monitoring was undertaken, the relationship between the parameters is based on the results of the monitoring – refer *Section 4.1*.

4 RESULTS

4.1 Noise Monitoring

The results of the noise monitoring on Kwinana Freeway are summarised in *Table 4-1* and shown graphically in *Figure 4-1*.

Table 4-1 Measured Average Noise Levels – Kwinana Freeway

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Monday 21 October 2019	73.4	69.9	71.0	66.1
Tuesday 22 October 2019	72.8	69.5	70.8	64.2
Wednesday 23 October 2019	74.0	71.1	72.0	68.5
Thursday 24 October 2019	74.0	71.0	71.9	68.2
Friday 25 October 2019	74.0	70.9	71.8	68.1
Weekday Average	**73.6**	**70.5**	**71.5**	**67.0**

The average differences between the weekday $L_{A10,18hour}$ and $L_{Aeq(Day)}$ is 2.1 dB and this conversion has been used in the modelling. The average differences between the weekday $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ is 4.5 dB, meaning daytime noise levels are higher by 4.5 dB on average. This same difference has been assumed to exist in future years. As such, it is the night time noise levels that will dictate compliance since these are at less than 5 dB higher than night-time levels.

Table 4-2 Measured Average Noise Levels - Anketell Road

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Friday 15 November 2019	65.1	65.0	63.9	66.6
Monday 18 November 2019	64.5	62.1	62.3	61.8
Tuesday 19 November 2019	62.5	60.0	60.2	59.4
Wednesday 20 November 2019	66.8	66.2	65.6	67.3
Thursday 21 November 2019	64.8	66.3	66.1	66.8
Weekday Average	**64.8**	**63.9**	**63.6**	**64.4**

The average differences between the weekday $L_{A10,18hour}$ and $L_{Aeq(Day)}$ are 2.1 dB and 1.2 dB for Kwinana Freeway and Anketell Road respectively, and these conversions have been used in the modelling. The average differences between the weekday $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ are 4.5 dB and -0.8 dB for Kwinana Freeway and Anketell Road respectively. In the case of Anketell Road, this means the night time levels are higher by 0.8 dB compared to daytime levels, which is attributable to night time heavy vehicle activity on Anketell Road. These same differences have been assumed to exist in future years.

4.2 Noise Modelling

The noise modelling is provided in *Figure 4-3* as an $L_{Aeq(Day)}$ and *Figure 4-4* as an $L_{Aeq(Night)}$ noise level contour plots being for the future traffic conditions. As the night time scenario is the scenario dictating compliance, it can be seen from *Figure 4-4* that predicted noise levels at the nearest lots will be above the ***target*** and therefore noise control is to be considered.

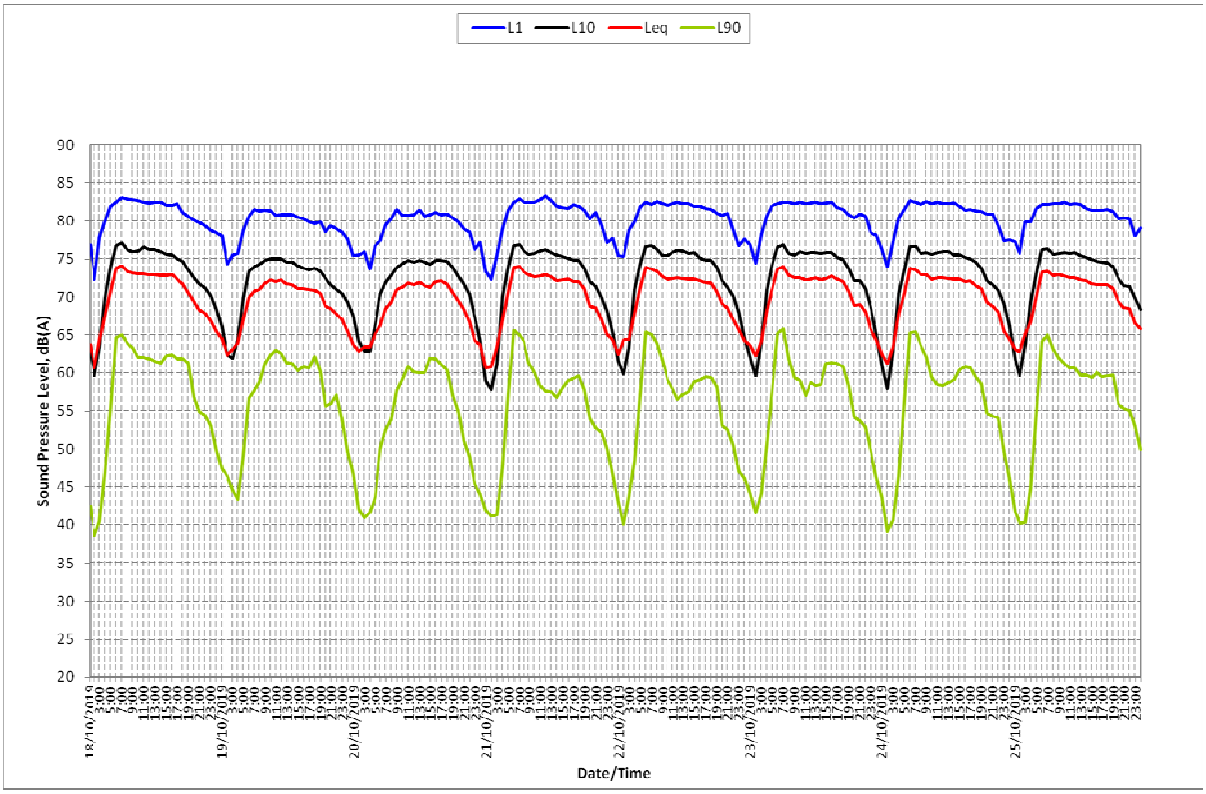


Figure 4-1 Noise Monitoring Results – Kwinana Freeway

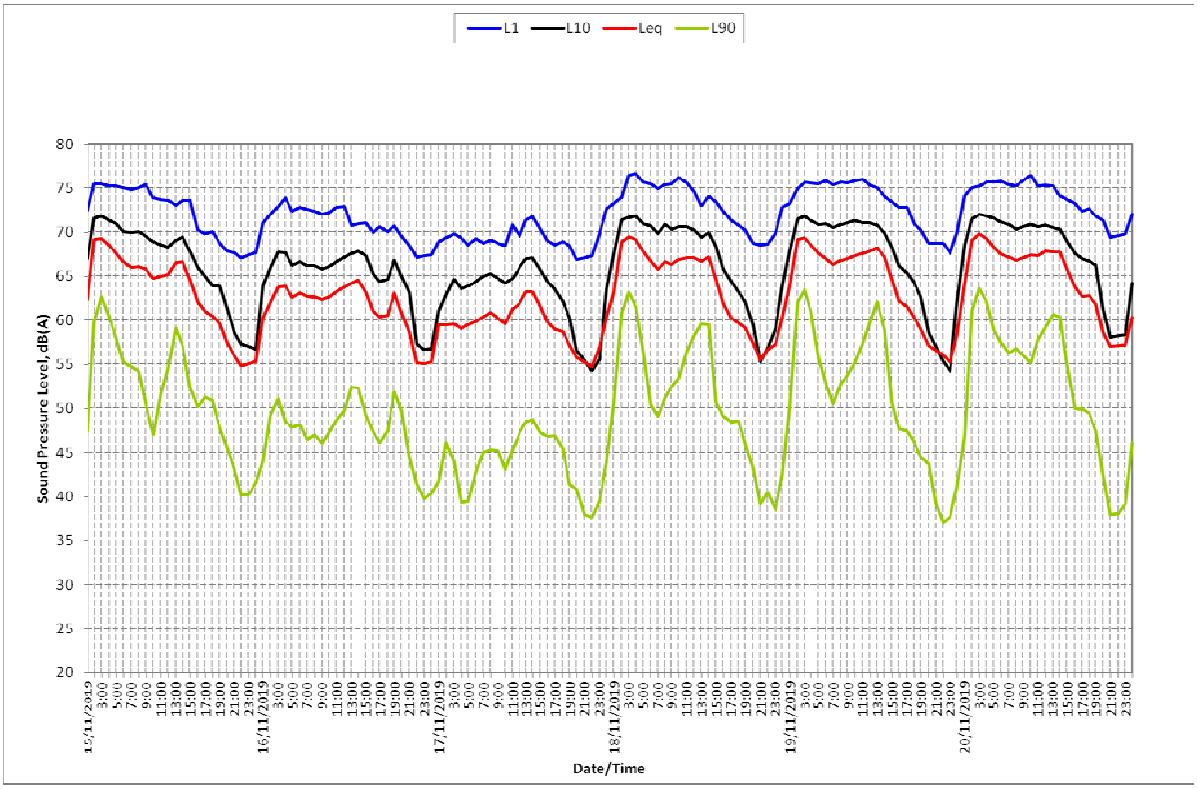
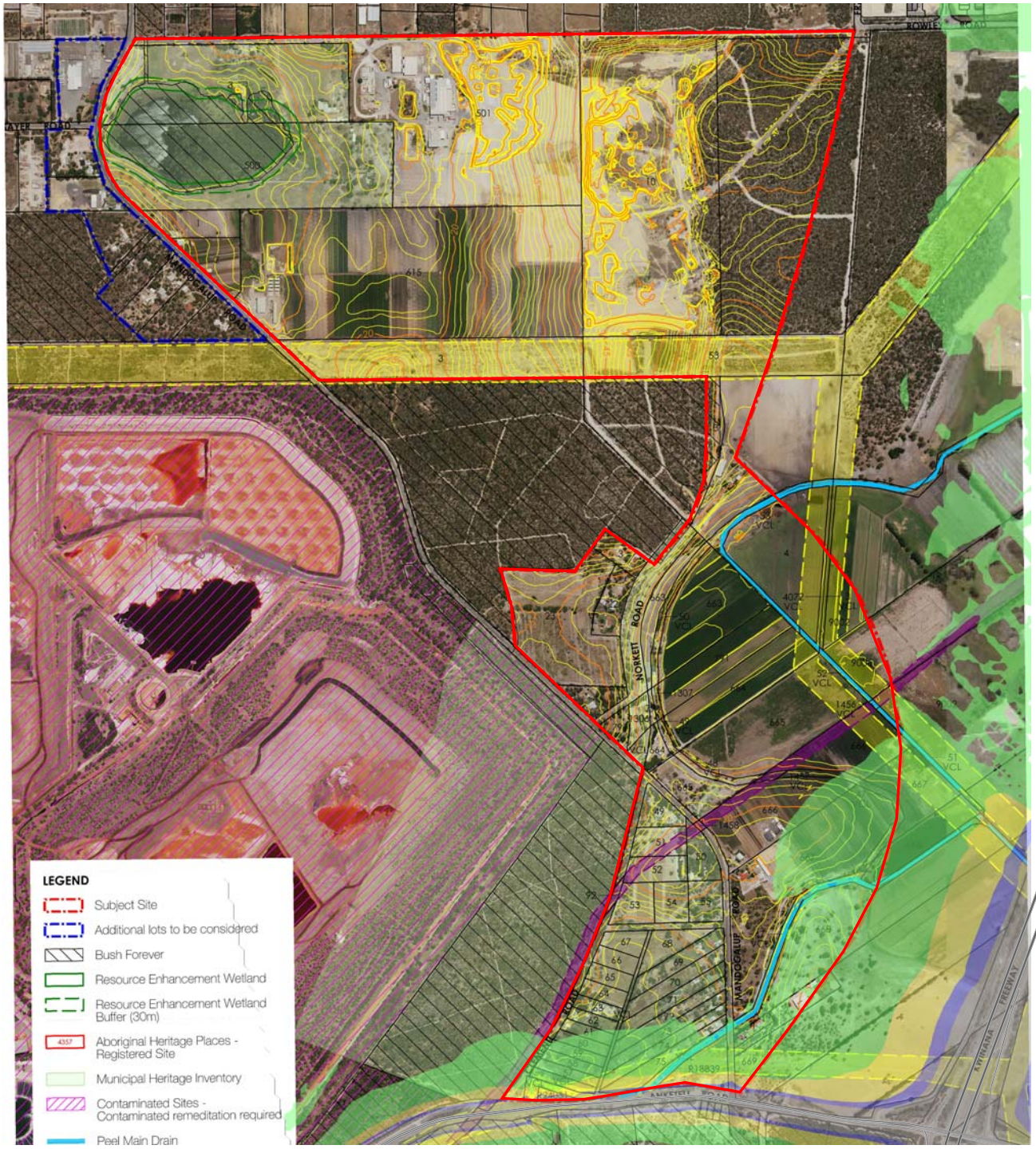


Figure 4-2 Noise Monitoring Results – Anketell Road



Mandogalup Improvement Plan 47
Future Noise Level Contours: Daytime

Year 2041

$L_{Aeq(Day)}$ Noise Level Contours Based on Future Conditions
1.4 metre above ground level

SoundPlan v8.1
CoRTN Algorithms

12 December 2018

Signs and symbols

- Road
- Improvement plan outline

Noise levels $L_{Aeq,Day}$ dB

<= 55	
<= 56	Exposure A
<= 57	
<= 58	
<= 59	Exposure B
<= 60	
<= 61	
<= 62	
<= 63	Exposure C
<= 64	
<= 65	
<= 66	
> 66	Exposure D

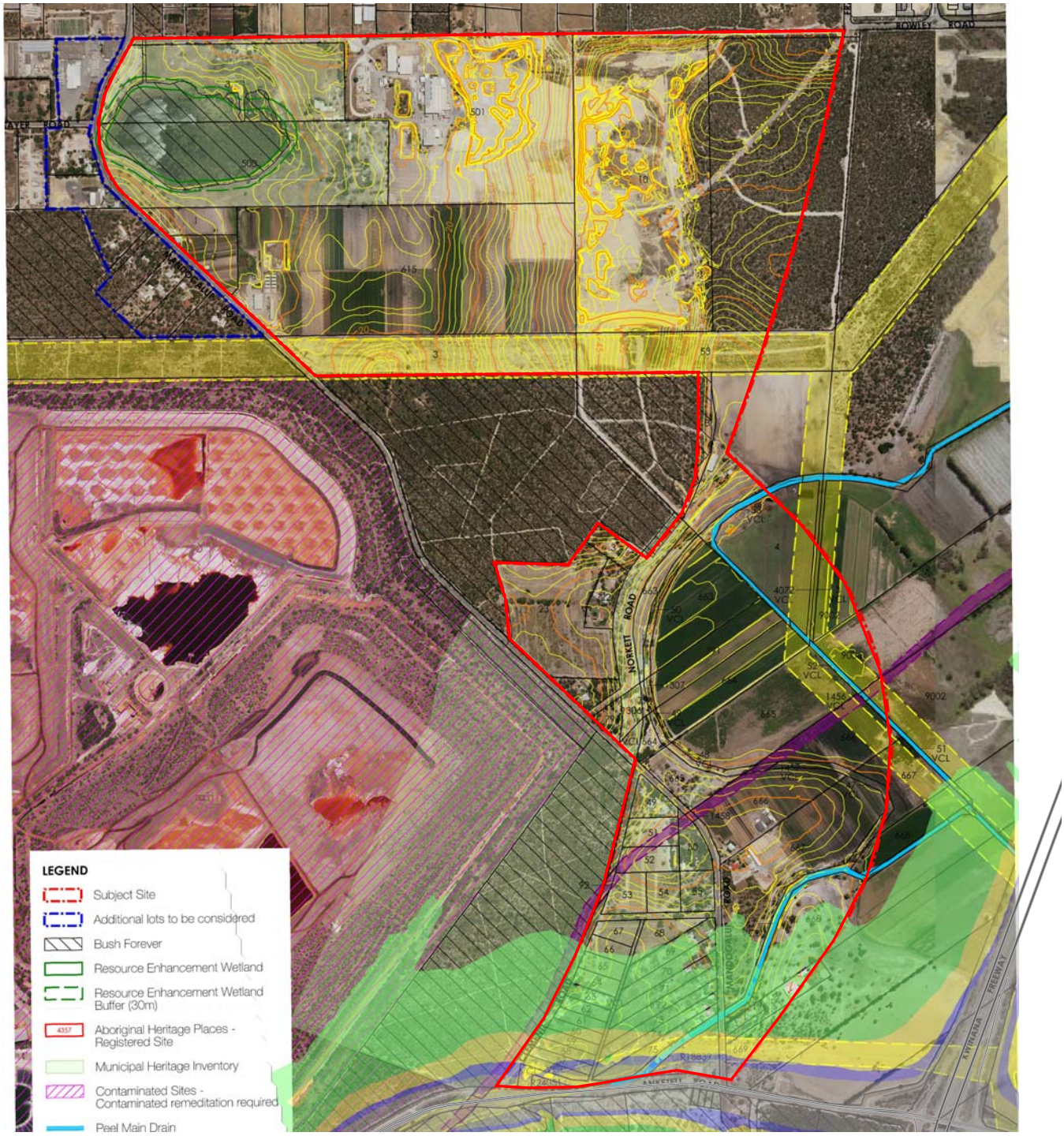
SPP 5.4 (Sep 2019)

Lloyd George Acoustics
PO Box 717
HILLARYS WA 6923
(08) 9401 7770

Length Scale 1:10000

0 50 100 200 300 400 m

Figure 4-3



Mandogalup Improvement Plan 47
Existing Noise Level Contours: Night time

$L_{Aeq(Night)}$ Noise Level Contours Based on Future Conditions
1.4 metre above ground level
Year 2041

SoundPlan v8.1
CoRTN Algorithms

12 December 2018

Signs and symbols

- Road
- Improvement plan outline

Noise levels $L_{Aeq,Night}$ dB

<= 50	
<= 51	Exposure A
<= 52	
<= 53	
<= 54	Exposure B
<= 55	
<= 56	
<= 57	
<= 58	Exposure C
<= 59	
<= 60	
<= 61	
> 61	Exposure D

SPP 5.4 (Sep 2019)

Lloyd George Acoustics
PO Box 717
HILLARYS WA 6923
(08) 9401 7770

Length Scale 1:10000

0 50 100 200 300 400 m

Figure 4-4

5 ASSESSMENT

The objectives of SPP 5.4 are to achieve:

- indoor noise levels specified in *Table 2-1* in noise-sensitive areas (e.g. bedrooms and living rooms of houses and school classrooms); and
- a reasonable degree of acoustic amenity for outdoor living areas on each residential lot.

Where the outdoor noise targets of *Table 2-1* are achieved, no further controls are necessary.

Future commercial premises with a noise sensitive nature (e.g. residential, education buildings, medical buildings, places of worship, hotels) are recommended to be located outside the outdoor target noise contour on *Figure 4-3* and *Figure 4-4* (i.e. away from Anketell Road and Kwinana Freeway).

Industrial or commercial premises that are not noise sensitive would be best located closer to the transport corridors as these buildings may provide noise barrier effects to sensitive uses behind them.

Note future noise impact from Rowley and Hammond Road do not form part of this assessment.

For future noise sensitive premises where the outdoor noise target will be exceeded according to *Figure 4-3* or *Figure 4-4* (e.g. for lots in close proximity to Anketell Road or Kwinana Freeway) the following is recommended:

- Investigate the effectiveness of noise walls at reducing road traffic noise levels,
- Allow residential development outside of the noise contours highlighted in *Figure 4-3* and *Figure 4-4*. Where residential or mixed use lots are proposed within the noise contours, the following Packages (refer Appendix A) will be required:
    - Package A where exposure levels are between 51 dB and 53 dB $L_{Aeq(Night)}$;
    - Package B where exposure levels are between 54 dB and 57 dB $L_{Aeq(Night)}$;
    - Package C where exposure levels are between 58 dB and 61 dB $L_{Aeq(Night)}$;

      Alternative constructions from the deemed to satisfy packages may be acceptable if supported by a report undertaken by a suitably qualified acoustical consultant (member from of the Association of Australasian Acoustical Consultants (AAAC)), once the lots specific building plans are available.
- All affected lots are to have notifications on lot titles as per SPP 5.4 requirements – refer *Appendix A*.

Appendix A

ACCEPTABLE TREATMENT PACKAGES

The packages and information provided on the following pages are taken from *Road and Rail Noise Guidelines* (September 2019).

Where outdoor and indoor noise levels received by a noise-sensitive land-use and/or development exceed the policy's noise target, implementation of quiet house requirements is an acceptable solution.

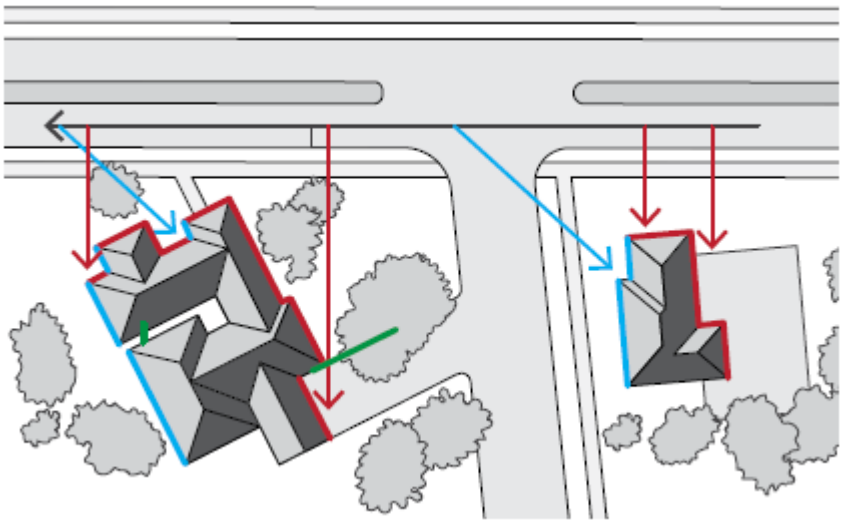
The quiet house packages are not the only solution to achieving acceptable internal transport noise levels. A suitably qualified acoustical engineer or consultant may also determine more tailored acoustic design requirements for buildings in a transport noise corridor by carrying out acoustic design in accordance with relevant industry standards. This includes the need to meet the relevant design targets specified in AS/NZS 2107:2016 for road traffic noise.

With regards to the packages, the following definitions are provided:

- **Facing** the transport corridor (red): Any part of a building façade is 'facing' the transport corridor if any straight line drawn perpendicular (at a 90 degree angle) to its nearest road lane or railway line intersects that part of the façade without obstruction (ignoring any fence).

- **Side-on** to transport corridor (blue): Any part of a building façade that is not 'facing' is 'side-on' to the transport corridor if any straight line, at any angle, can be drawn from it to intersect the nearest road lane or railway line without obstruction (ignoring any fence).

- **Opposite** to transport corridor (green): Neither 'side on' nor 'facing', as defined above.



Quiet House Package A

56-58 dB $L_{Aeq(Day)}$ & 51-53 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas
External Windows	Facing	• Up to 40% floor area ($R_w + C_{tr} \geq 28$): o Sliding or double hung with minimum 10mm single or 6mm-12mm-10mm double insulated glazing; o Sealed awning or casement windows with minimum 6mm glass. • Up to 60% floor area ($R_w + C_{tr} \geq 31$): o Sealed awning or casement windows with minimum 6mm glass.	• Up to 40% floor area ($R_w + C_{tr} \geq 25$): o Sliding or double hung with minimum 6mm single or 6mm-12mm-6mm double insulated glazing; • Up to 60% floor area ($R_w + C_{tr} \geq 28$); • Up to 80% floor area ($R_w + C_{tr} \geq 31$).
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	No specific requirements	
External Doors	Facing	• Fully glazed hinged door with certified $R_w + C_{tr} \geq 28$ rated door and frame including seals and 6mm glass.	• Doors to achieve $R_w + C_{tr} \geq 25$: o 35mm Solid timber core hinged door and frame system certified to R_w 28 including seals; o Glazed sliding door with 10mm glass and weather seals.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less.	
	Opposite	No specific requirements	
External Walls	All	• $R_w + C_{tr} \geq 45$: o Two leaves of 90mm thick clay brick masonry with minimum 20mm cavity; o Single leaf of 150mm brick masonry with 13mm cement render on each face. o One row of 92mm studs at 600mm centres with: ▪ Resilient steel channels fixed to the outside of the studs; and ▪ 9.5mm hardboard or fibre cement sheeting or 11mm fibre cement weatherboards fixed to the outside; ▪ 75mm thick mineral wool insulation with a density of at least 11kgkg/m^3; and ▪ 2 x 16mm fire-rated plasterboard to inside.	
Roofs and Ceilings	All	• $R_w + C_{tr} \geq 35$: o Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard.	
Outdoor Living Areas		At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2 metres height above ground level.	

Quiet House Package B

59-62 dB $L_{Aeq(Day)}$ & 54-57 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas
External Windows	Facing	• Up to 40% floor area ($R_w + C_{tr} \geq 31$): o Fixed sash, awning or casement with minimum 6mm glass or 6mm-12mm-6mm double insulated glazing. • Up to 60% floor area ($R_w + C_{tr} \geq 34$): o Fixed sash, awning or casement with minimum 10mm glass or 6mm-12mm-10mm double insulated glazing.	• Up to 40% floor area ($R_w + C_{tr} \geq 28$): o Sliding or double hung with 6mm-12mm-10mm double insulated glazing; o Sealed awning or casement windows with minimum 6mm glass. • Up to 60% floor area ($R_w + C_{tr} \geq 31$); • Up to 80% floor area ($R_w + C_{tr} \geq 34$).
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Doors	Facing	• Fully glazed hinged door with certified $R_w + C_{tr} \geq 31$ rated door and frame including seals and 10mm glass.	• Doors to achieve $R_w + C_{tr} \geq 28$: o 40mm Solid timber core hinged door and frame system certified to R_w 32 including seals; o Fully glazed hinged door with certified $R_w + C_{tr} \geq 28$ rated door and frame including seals and 6mm glass.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Walls	All	• $R_w + C_{tr} \geq 50$: o Two leaves of 90mm thick clay brick masonry with minimum 50mm cavity between leaves and 50mm glasswool or polyester insulation (R2.0+). Resilient ties used where required to connect leaves. o Two leaves of 110mm clay brick masonry with minimum 50mm cavity between leaves and 50mm glasswool or polyester insulation (R2.0+). o Single leaf of 220mm brick masonry with 13mm cement render on each face. o 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face. o Single leaf of 90mm clay brick masonry with: ▪ A row of 70mm x 35mm timber studs or 64mm steel studs at 600mm centres; ▪ A cavity of 25mm between leaves; ▪ 50mm glasswool or polyester insulation (R2.0+) between studs; and ▪ One layer of 10mm plasterboard fixed to the inside face.	
Roofs and Ceilings	All	• $R_w + C_{tr} \geq 35$: o Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard ceiling with R3.0+ fibrous insulation.	
Outdoor Living Areas		At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2.4 metres height above ground level.	

Quiet House Package C

63-66 dB $L_{Aeq(Day)}$ & 58-61 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas
External Windows	Facing	• Up to 20% floor area ($R_w + C_{tr} \geq 31$): o Fixed sash, awning or casement with minimum 6mm glass or 6mm-12mm-6mm double insulated glazing. • Up to 40% floor area ($R_w + C_{tr} \geq 34$): o Fixed sash, awning or casement with minimum 10mm glass or 6mm-12mm-10mm double insulated glazing.	• Up to 40% floor area ($R_w + C_{tr} \geq 31$): o Fixed sash, awning or casement with minimum 6mm glass or 6mm-12mm-6mm double insulated glazing. • Up to 60% floor area ($R_w + C_{tr} \geq 34$): o Fixed sash, awning or casement with minimum 10mm glass or 6mm-12mm-10mm double insulated glazing.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Doors	Facing	• Not recommended.	• Doors to achieve $R_w + C_{tr} \geq 30$: o Fully glazed hinged door with certified $R_w + C_{tr} \geq 31$ rated door and frame including seals and 10mm glass; o 40mm Solid timber core side hinged door, frame and seal system certified to R_w 32 including seals. Any glass inserts to be minimum 6mm.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Walls	All	• $R_w + C_{tr} \geq 50$: o Two leaves of 90mm thick clay brick masonry with minimum 50mm cavity between leaves and 50mm glasswool or polyester insulation (R2.0+). Resilient ties used where required to connect leaves. o Two leaves of 110mm clay brick masonry with minimum 50mm cavity between leaves and 50mm glasswool or polyester insulation (R2.0+). o Single leaf of 220mm brick masonry with 13mm cement render on each face. o 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face. o Single leaf of 90mm clay brick masonry with: ▪ A row of 70mm x 35mm timber studs or 64mm steel studs at 600mm centres; ▪ A cavity of 25mm between leaves; ▪ 50mm glasswool or polyester insulation (R2.0+) between studs; and ▪ One layer of 10mm plasterboard fixed to the inside face.	
Roofs and Ceilings	All	• $R_w + C_{tr} \geq 40$: o Concrete or terracotta tile roof with sarking, or metal sheet roof with foil backed R2.0+ fibrous insulation between steel sheeting and roof battens; o R3.0+ insulation batts above ceiling; o 2 x 10mm plasterboard ceiling or 1 x 13mm sound-rated plasterboard.	
Outdoor Living Areas		At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2.4 metres height above ground level.	

Mechanical Ventilation requirements

In implementing the acceptable treatment packages, the following mechanical ventilation / air-conditioning considerations are required:

- Acoustically rated openings and ductwork to provide a minimum sound reduction performance of R_w 40 dB into sensitive spaces;
- Evaporative systems require attenuated ceiling air vents to allow closed windows;
- Refrigerant based systems need to be designed to achieve National Construction Code fresh air ventilation requirements;
- Openings such as eaves, vents and air inlets must be acoustically treated, closed or relocated to building sides facing away from the corridor where practicable.

Notification

Notifications on title advise prospective purchasers of the potential for noise impacts from major transport corridors and help with managing expectations.

The Notification is to state as follows:

This lot is in the vicinity of a transport corridor and is affected, or may in the future be affected, by road and rail transport noise. Road and rail transport noise levels may rise or fall over time depending on the type and volume of traffic.

Appendix B

Traffic Data

2016 ROM24 Base Scenario - Link Volume Plot for Mandogalup Noise Assessment
All Day

MODEL ASSUMPTIONS

LANDUSE: 2016 ROM24 MLUFS Land Use
NETWORK: 2016 ROM24 Network (20-Year Network Development Plan)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

Terms & Conditions :
MRWA Traffic Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations. This data should not be used for any purpose other than the stated purpose for which it was requested from MRWA. The MRWA ROM is for estimating regional traffic volumes on regional and major local roads, and it should not be used for estimating local traffic on local roads. The MRWA ROM includes local roads but this is to provide connectivity in the model. MRWA Traffic Modelling Data should be interpreted by an experienced/qualified person. This data should not be used in making decisions relating to commercial or residential developments.

mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Clare Yu 9323 4967
MRWA Reference Job #41247
Fri 12 Jul 2019
T:\VOYAGER\JOBS_V2019\41247\Reports\LVP\41247_Y16_All Day_LVP_Mandogalup.VPR

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- >=4 Lanes Each Direction
- Percentage of Heavy Vehicle

MRWA Transport Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations

cube

(Licensed to Main Roads WA)

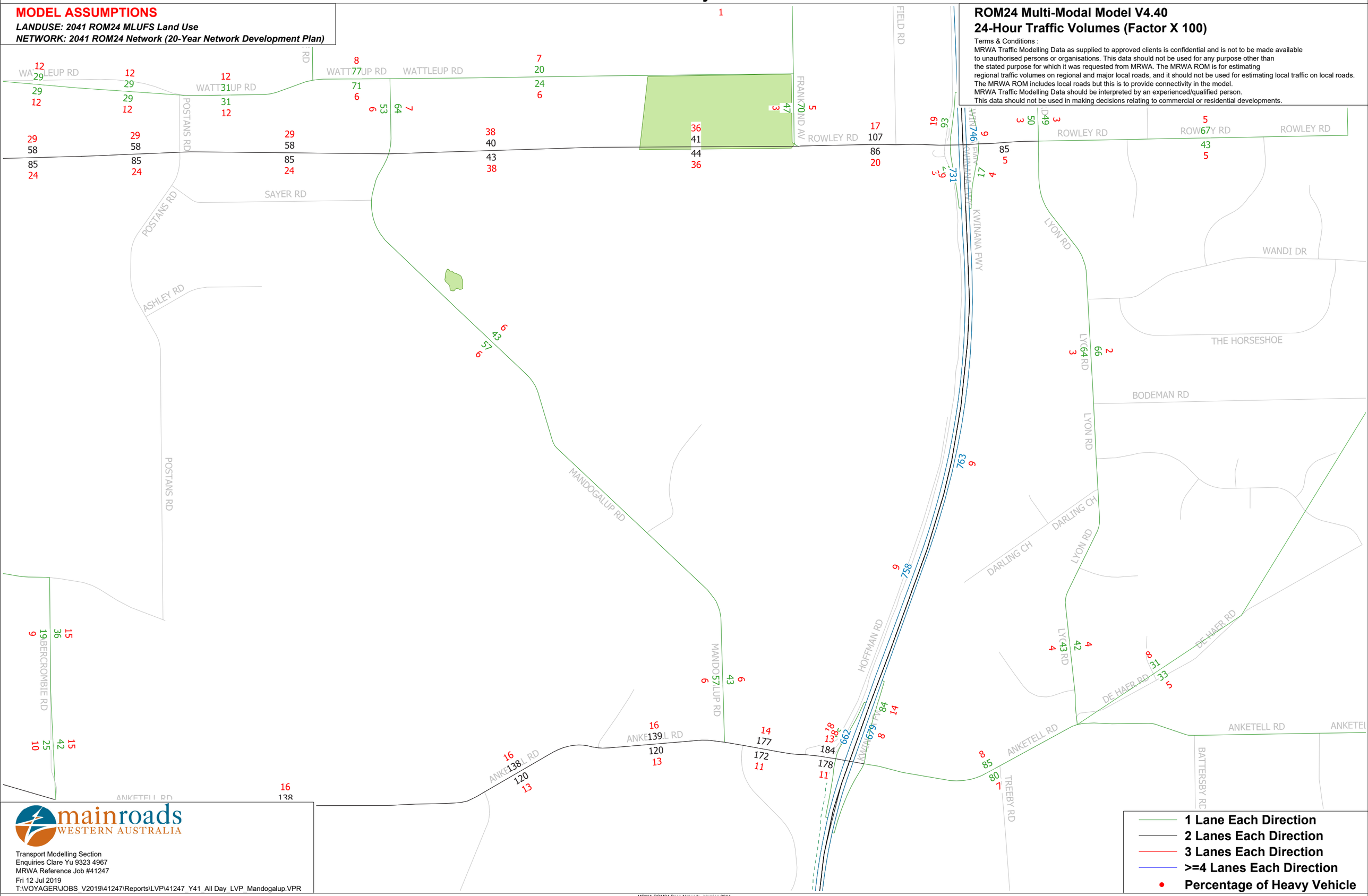
2041 ROM24 MLUFS Scenario - Link Volume Plot for Mandogalup Noise Assessment
All Day

MODEL ASSUMPTIONS

LANDUSE: 2041 ROM24 MLUFS Land Use
NETWORK: 2041 ROM24 Network (20-Year Network Development Plan)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)

Terms & Conditions :
MRWA Traffic Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations. This data should not be used for any purpose other than the stated purpose for which it was requested from MRWA. The MRWA ROM is for estimating regional traffic volumes on regional and major local roads, and it should not be used for estimating local traffic on local roads. The MRWA ROM includes local roads but this is to provide connectivity in the model.
MRWA Traffic Modelling Data should be interpreted by an experienced/qualified person.
This data should not be used in making decisions relating to commercial or residential developments.



mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Clare Yu 9323 4967
MRWA Reference Job #41247
Fri 12 Jul 2019
T:\VOYAGER\JOBS_V2019\41247\Reports\LVP\41247_Y41_All Day_LVP_Mandogalup.VPR

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- >=4 Lanes Each Direction
- Percentage of Heavy Vehicle

MRWA ROM24 Base Network - Version 2014
MRWA Transport Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations

cube

(Licensed to Main Roads WA)

2016 ROM24 - Validation Plot for Mandogalup Noise Assessment
All Day

MODEL ASSUMPTIONS

LANDUSE: 2016 ROM24 MLUFS Land Use
NETWORK: 2016 ROM24 Network (20-Year Network Development Plan)

ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes & Observed Volumes

Terms & Conditions :
MRWA Traffic Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations. This data should not be used for any purpose other than the stated purpose for which it was requested from MRWA. The MRWA ROM is for estimating regional traffic volumes on regional and major local roads, and it should not be used for estimating local traffic on local roads. The MRWA ROM includes local roads but this is to provide connectivity in the model. MRWA Traffic Modelling Data should be interpreted by an experienced/qualified person. This data should not be used in making decisions relating to commercial or residential developments.

WATTLEUP RD
POSTANS RD
SAYER RD
ASHLEY RD
ABERCROMBIE RD
MANDOGALUP RD
ANKETELL RD
FRANKLAND AV
FIELD RD
ROWLEY RD
KWINANA FWY
LYON RD
WANDI DR
THE HORSESHOE
BODEMAN RD
DARLING CH
DE HAER RD
HOFFMAN RD
TREEBY RD
BATTERSBY

38100 43800
36200 44100
1000 1200
39200 49700
47500 37600
43000 31800
34000 42200

1 Lane Each Direction
2 Lanes Each Direction
3 Lanes Each Direction
>=4 Lanes Each Direction
2016 Modelled
2016 Observed

mainroads WESTERN AUSTRALIA

Transport Modelling Section
Enquiries Clare Yu 9323 4967
MRWA Reference Job #41247
Fri 12 Jul 2019
T:\VOYAGER\JOBS_V2019\41247\Reports\Validation\41247_Validation_Mandogalup.Vpr

MRWA ROM24 Base Network - Version 2014
MRWA Transport Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations

cube

(Licensed to Main Roads WA)

Appendix C

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}
An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

Noise-sensitive land use and/or development
Land-uses or development occupied or designed for occupation or use for residential purposes (including dwellings, residential buildings or short-stay accommodation), caravan park, camping ground, educational establishment, child care premises, hospital, nursing home, corrective institution or place of worship.

About the Term 'Reasonable'

An assessment of reasonableness should demonstrate that efforts have been made to resolve conflicts without comprising on the need to protect noise-sensitive land-use activities. For example, have reasonable efforts been made to design, relocate or vegetate a proposed noise barrier to address community concerns about the noise barrier height? Whether a noise mitigation measure is reasonable might include consideration of:

- The noise reduction benefit provided;
- The number of people protected;
- The relative cost vs benefit of mitigation;
- Road conditions (speed and road surface) significantly differ from noise forecast table assumptions;
- Existing and future noise levels, including changes in noise levels;
- Aesthetic amenity and visual impacts;
- Compatibility with other planning policies;
- Differences between metropolitan and regional situations and whether noise modelling requirements reflect the true nature of transport movements;
- Ability and cost for mobilisation and retrieval of noise monitoring equipment in regional areas;
- Differences between Greenfield and infill development;
- Differences between freight routes and public transport routes and urban corridors;
- The impact on the operational capacity of freight routes;
- The benefits arising from the proposed development;
- Existing or planned strategies to mitigate the noise at source.

About the Term 'Practicable'

'Practicable' considerations for the purposes of the policy normally relate to the engineering aspects of the noise mitigation measures under evaluation. It is defined as "reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge" (*Environmental Protection Act 1986*). These may include:

- Limitations of the different mitigation measures to reduce transport noise;
- Competing planning policies and strategies;
- Safety issues (such as impact on crash zones or restrictions on road vision);
- Topography and site constraints (such as space limitations);
- Engineering and drainage requirements;
- Access requirements (for driveways, pedestrian access and the like);
- Maintenance requirements;
- Bushfire resistance or BAL ratings;
- Suitability of the building for acoustic treatments.

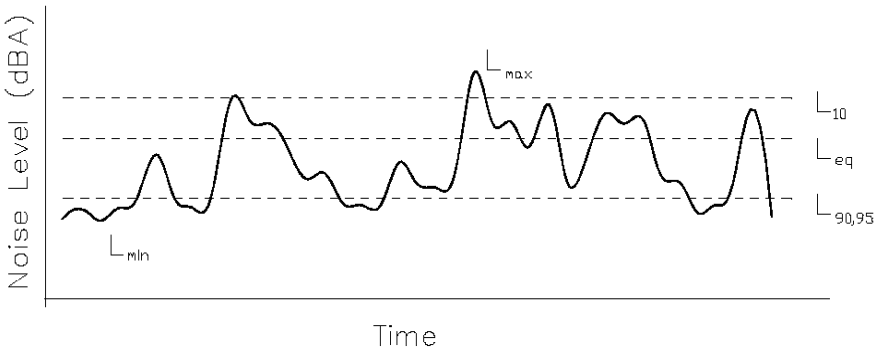
R_w

This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is a single number rating determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB. The higher the R_w value, the better the acoustic performance.

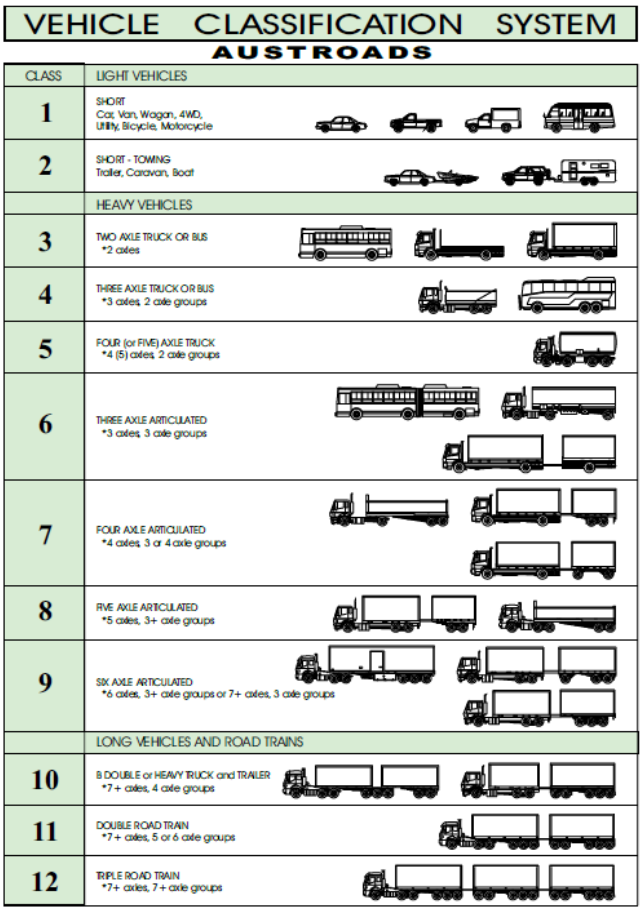
C_{tr}

This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of –4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

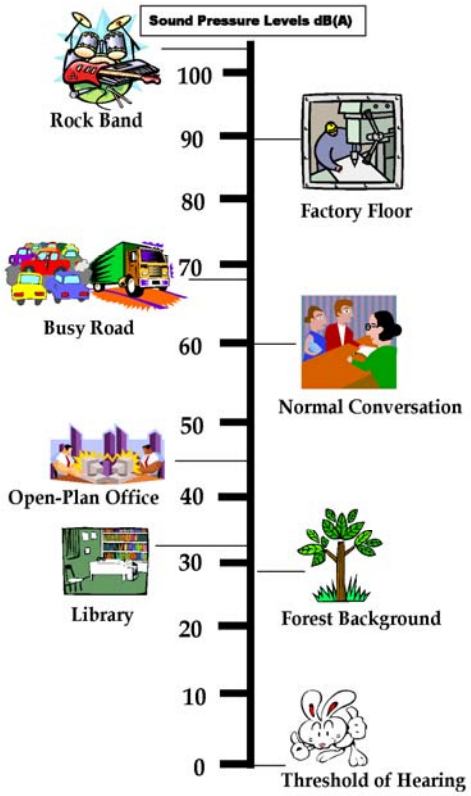
Chart of Noise Level Descriptors



Austroads Vehicle Class



Typical Noise Levels



Appendix H

Hammond & Mandogalup Road – Road Design Report

Department of **Planning, Lands and Heritage**

GOVERNMENT OF WESTERN AUSTRALIA

DPLH401523 - Hammond & Mandogalup Road

Road Concept Land Reservation Study – Road Design Report

Prepared for the Department of Planning, Lands and Heritage

June 2024

Project Number P23078

Document Number BGE-P23078-REP-0001

Revision D

OPPORTUNITIES THROUGH EXCELLENCE

bgeeng.com

BG&E

Table of Contents

Executive Summary vi

Abbreviations vii

1. Introduction 8
   - 1.1 Purpose 8
   - 1.2 Background 8
   - 1.3 Literature review 10
2. Existing conditions 19
   - 2.1 Existing MRS and Road Layout 19
   - 2.2 Existing Road Hierarchy 20
   - 2.3 Existing Speed Limit 21
   - 2.4 Existing Topography & Geology 21
   - 2.5 Constraint Investigation 21
   - 2.6 Future Road Projects 23
3. Design Basis 26
   - 3.1 Design Standards 26
   - 3.2 Design Inputs 26
   - 3.3 Design Criteria 27
4. Planning Design Concept 29
   - 4.1 Typical Cross Section 31
   - 4.2 Tramway Reserve 32
   - 4.3 Road Alignment & Vertical Geometry 32
   - 4.4 Roundabouts & Intersections 35
   - 4.5 Drainage 40
   - 4.6 Access Strategy 41
   - 4.7 Pedestrians and Cyclists 43
   - 4.8 Public Transport 45
   - 4.9 Utilities 45
   - 4.10 Design Risk 46
5. Improvement Scheme Reservation 47
6. Conclusion 48

Design Limitations 49

List of Appendices

Appendix A – Design Drawings 51

Appendix B – Scheme and Concept Plans 52

Appendix C – Constraints Mapping 53

Appendix D – Calculations 54

List of Figures

Figure 1.1 – Draft IP47 Scheme Map (source: www.wa.gov.au) 8
Figure 1.2 – Locality Plan 9
Figure 1.3 – Geomorphic Wetlands (source: Strategen JBS&G) 11
Figure 1.4 – ASS Risk (source: Strategen JBS&G) 12
Figure 1.5 – Black Cockatoos and Tuart Woodlands (source: Strategen JBS&G) 13
Figure 1.6 – TEC Areas – Banksia Woodland and Tuart Woodlands SCP (source: Strategen JBS&G) 14
Figure 1.7 – Bush Forever sites (source: Strategen JBS&G) 15
Figure 1.8 – Geology (source: JDA, 2023, Figure 6) 16
Figure 1.9 – Traffic Volumes (source: Flyt, 2023, Figure 47) 17
Figure 2.1 – Existing Metropolitan Regional Scheme (source: DPLH) 19
Figure 2.2 – Existing Road Hierarchy (source: MRWA Road Information Mapping System) 20
Figure 2.3 – Existing Speed Limit (source: MRWA Road Information Mapping System) 21
Figure 2.4 – Westport Preferred Infrastructure (source: westport.wa.gov.au) 23
Figure 2.5 – Ultimate Anketell Thomas Road Freight Corridor (source: westport.wa.gov.au) 24
Figure 2.6 – Planning Control Area 168 – Anketell Road (source: www.wa.gov.au) 24
Figure 2.7 – Planning Control Area 156 – Rowley Road (source: www.wa.gov.au) 25
Figure 4.1 – Locality Plan and Areas 30
Figure 4.2 – Typical Cross Section for Area 1 31
Figure 4.3 – Typical Cross Section for Area 2 31
Figure 4.4 – Typical Cross Section for Area 3 32
Figure 4.5 – Southern Roundabout 36
Figure 4.6 – Central Roundabout 37
Figure 4.7 – Signalised Intersection 38
Figure 4.8 – Northern Roundabout 39
Figure 4.9 – LILO Intersection 40
Figure 4.10 – Access Strategy in Area 1 42
Figure 4.11 – Access Strategy in Area 2 43
Figure 4.12 – Cyclist Strava Heatmap (source: Strava) 44
Figure 4.13 – DoT Long Term Cycle Network Plan (source: DoT) 45

List of Tables

Table 3.1 – Technical References 26
Table 3.2 – Design Inputs 27
Table 3.3 – Road Design Criteria 28
Table 3.4 – Drainage Basin Design Criteria 28
Table 4.1 – Area and Intersection Definition 29
Table 4.2 – Area 1 Constraints 33
Table 4.3 – Area 2 Constraints 34

Table 4.4 – Area 3 Constraints 35
Table 4.5 – Roundabout Features 36
Table 4.6 – Basin Sizing 41
Table 4.7 – Design Risk 46

This Report has been prepared for the sole benefit of the Department of Lands, Planning and Heritage. Except as required by law, no third party may use or rely on, this Report unless otherwise agreed by BG&E in writing. The analysis, calculations and assessment undertaken by BG&E to form the information and opinions contained in this Report is limited to the Scope of Services agreed between BG&E and the Department of Lands, Planning and Heritage, as specified in the Agreement.

The design deliverables provided by BG&E for the purposes of the Report have been produced in accordance with normal prudent practice and by reference to applicable industry standards, guidelines and assessment criteria in existence at the date of this Report.

This Report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by BG&E for use of any part of this Report in any other context.

To the extent permitted by law, BG&E expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by the [Client] for using this Report other than as specified by the Agreement. Any third party using or relying on this Report does so at its own risk and BG&E does not admit that any action, liability or claim may exist

Revision	Date	Description	Prepared	Reviewed	Approved
A	17/01/2024	Draft	JW	SS	SS
B	25/01/2024	Issued for Review	JW	SS	SS
C	27/05/2024	Issued for Review	JW	SS	SS
D	05/06/2024	Final	JW	SS	SS

Executive Summary

The Mandogalup Improvement Plan 47 (IP47) is a planning initiative implemented by the State Government of Western Australia within the City of Kwinana. Its purpose is to establish a strategic planning framework for future development and land use in the area.

The Road Reservation study detailed in this report focuses on road planning for the extension of Hammond Road to Norkett Road and the upgrade of Mandogalup Road. The study includes carriageway pattern and profile drawings, as well as additional Metropolitan Regional Scheme (MRS) modifications. These modifications will eventually be gazetted to provide clarity for stakeholders and those impacted by the changes.

Mandogalup Road is currently classified as an Other Regional Road (ORR) and has a 20m road reserve. It features a rural standard with a single unkerbed carriageway. In contrast, Norkett Road, which will be replaced by the new Hammond Road extension, has a wider 60m ORR reserve with, similarly, a single unkerbed carriageway. This existing carriageway terminates approximately 600m north of the Mandogalup-Norkett Road intersection, whilst the 60m wide ORR reserve extends further north and connects with future Rowley Road. The surrounding area is predominantly rural, with parks and recreation areas.

The study area has notable environmental elements, including Bush Forever Area 268 on the south-western side of Mandogalup Road, immediately west of Clementi Road. There are also threatened ecological communities on the north-eastern side of the new Hammond Road alignment, where a Banksia Woodland thrives, and Tuart Woodlands on the southern side. The new road alignment also affects the habitat of Carnaby Cockatoos, with their habitat trees found from the central to the southern side of the new road alignment. In addition, there are heritage and social aspects to consider, such as the Heritage listed Soldier Settler Homes on the south-western portion of Mandogalup Road and a place of worship to the south-eastern area. The Baldivis Tramway Reserve is situated within the existing Clementi Road reserve and intersects with Mandogalup-Norkett Road. There are also utility infrastructure constraints, including Western Power Overhead Transmission Lines, which is deemed as a significant design risk, the Dampier-Bunbury Gas Pipeline south of the Mandogalup-Norkett Road intersection, and the Water Corporation Main Drain located in the central area and on the southern side of the site.

Currently, neither Mandogalup Road nor Norkett Road accommodate active transport or public transportation options. Mandogalup Road serves as a Local Distributor, facilitating traffic flow to Anketell Road, a Regional Distributor located south of the area. The future Rowley Road interchange, situated to the north, is also designated as a Regional Distributor. Speed limits along the existing Mandogalup Road vary, with the southern portion limited to 60km/h and the northern section allowing speeds of up to 70km/h. Anticipated developments in the region, such as the Westport Corridor, Latitude 32, Australian Marine Complex, and the Kwinana Industry Area, are expected to contribute to significant traffic growth. The presence of the Kwinana Freeway to the east will further increase traffic in the area. It is projected that the traffic volume in both directions will reach approximately 40,000 vehicles per day to the south of the subject area and 20,000 vehicles per day to the north.

To accommodate the growing traffic, a new road typical section with a dual-lane dual carriageway, shoulders, medians, kerbs, and a shared path has been proposed. The new alignment includes three new roundabouts, one new signalised intersection, and one new unsignalised left-in-left-out intersection. The design vehicle is that of RAV4 between Anketell Road and the new northern roundabout. RAV7 has been designed between the future Rowley Interchange and the northernmost roundabout. The roundabout design has undergone several iterations, taking into account feedback and client requirements. Changes include adjusting the location of the southernmost roundabout to minimize impact to existing lots, switching the position of the northernmost roundabout with the left-in-left-out intersection to meet the minimum distance requirement for the future Rowley Interchange's on-off ramp, and tightening the entry path radius of the roundabouts to meet lower-entry speed requirements. Preliminary sizing of drainage basins has also been completed to account for the additional land reservation.

The report concludes in support of the Hammond Road extension and the upgrade of Mandogalup Road, providing design drawings to support the proposed changes.

Abbreviations

Abbreviation	Description
the Project	DPLH401523 - Hammond & Mandogalup Road
AEP	Annual Exceedance Probability
AGRD	Austroads Guide to Road Design
AHD	Australian Height Datum
AS	Australian Standard
ASS	Acid Sulphate Soil
ASD	Approach Sight Distance
BG&E	BG&E Pty Ltd (ACN 150 804 603)
DoT	Department of Transport
DPLH	Department of Planning, Lands and Heritage
DWMS	District Water Management Strategy
ESA	Environmentally Sensitive Area
LILO	Left-in-left-out
IP47	Improvement Plan 47
LSP	Local Structure Plan
LTCN	Long Term Cycle Network
LWMS	Local Water Management Strategy
MRWA	Main Roads Westerns Australia
ORR	Other Regional Road
PCA	Planning Control Area
RB	Roundabout
REW	Resource Enhancement Wetland
RL	Reduced Level
ROM	Regional Operations Model
SCP	Swan Coastal Plain
SISD	Safe Intersection Sight Distance
SSD	Stopping Sight Distance
TEC	Threatened Ecological Communities
TWL	Top Water Level
vpd	Vehicles per day
WC	Water Corporation

1. Introduction

1.1 Purpose

The purpose of the study is to undertake the detailed road planning for Hammond Road extension to Norkett Road and the upgrade of Mandogalup Road. Specifically, the study aims to define its layout, and to prepare land protection plans suitable for inclusion in the Metropolitan Region Scheme (MRS). Carriageway pattern, profile and land protection plans for Hammond Road and Mandogalup Road are to be produced to define and support the reservation requirements.

1.2 Background

The Mandogalup Improvement Plan 47 (IP47) is a comprehensive planning initiative undertaken by the State Government of Western Australia that is located within the City of Kwinana. The plan aims to establish a strategic planning framework for the Mandogalup area, located approximately 26km south of Perth CBD and within the City of Kwinana. IP47 came into effect on April 12, 2019. It covers approximately 330 hectares of land and aims to provide a comprehensive planning framework for the future development and land use in the area. The subsequent scheme developed is given the name 'Improvement Scheme No.1' which includes a Scheme Map, as shown in Figure 1.1.

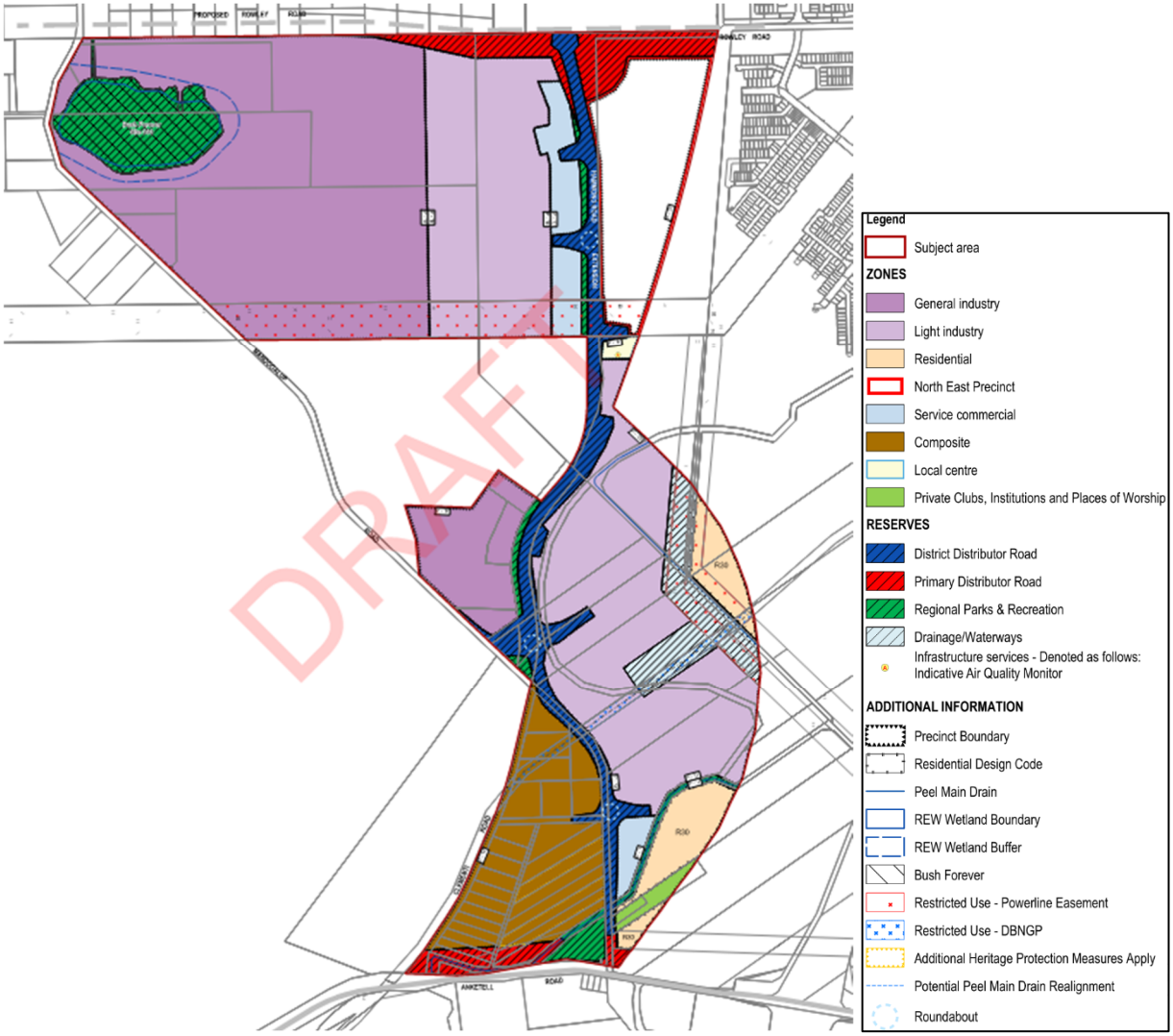


Figure 1.1 – Draft IP47 Scheme Map (source: www.wa.gov.au)

This area is situated east of the Kwinana and Rockingham Industrial Areas; east of the Australian Marine Complex; and west of a major transport corridor in the form of Kwinana freeway and Perth-Mandurah railway. It is proximate to public open spaces such as the Beeliar Regional Park. Just to the west of the area, there is the Hope-Valley Wattleup

Redevelopment Area (Latitude 32) and the Alcoa Refinery. Finally, it interfaces directly with Anketell Road which is the backbone of MRWA's Westport Corridor.

The traffic volume in the area, as a function of its proximity to major road corridors and industrial complex, is anticipated to far exceed what the current road network could tolerate. The improvement scheme indicates that Hammond Road is to be extended southwards, replacing the existing Norkett Road and upgrades a portion of the existing Mandogalup Road. This is shown in Figure 1.2. This report endeavours to discuss design philosophy and rationale against existing conditions such as environmental, social, and engineering.

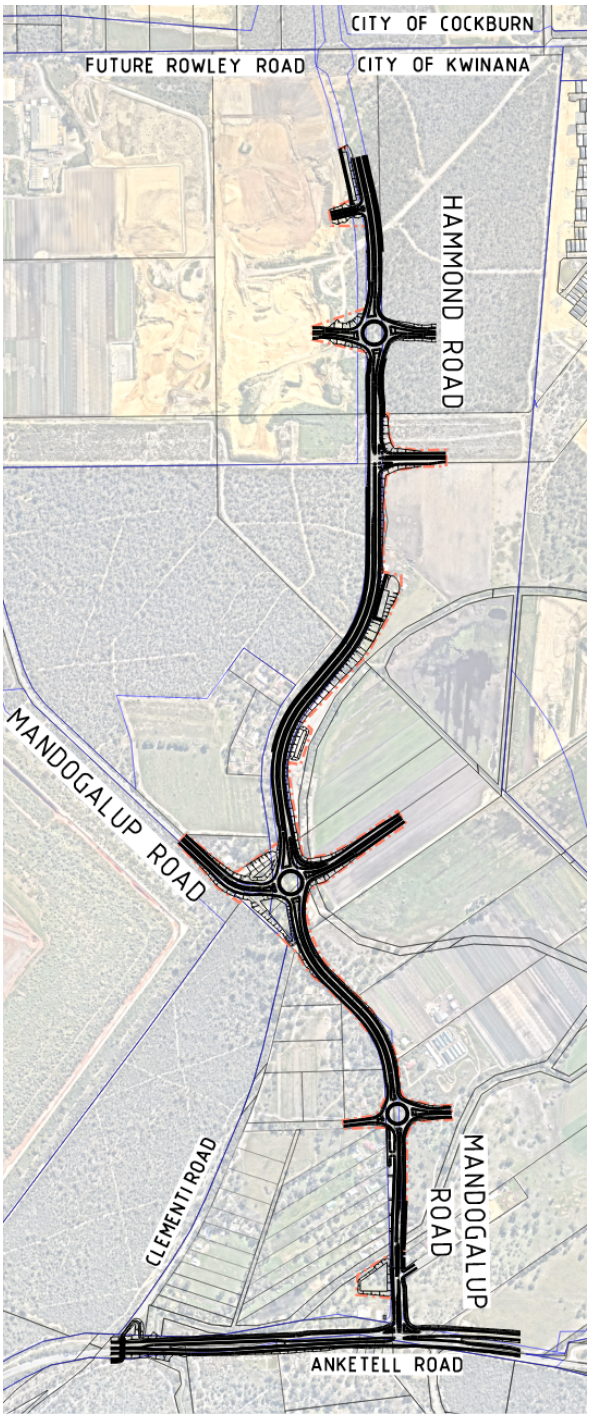


Figure 1.2 – Locality Plan

1.3 Literature review

A number of other studies have been undertaken in the area, these include land use, environmental, drainage and traffic studies. They have been reviewed to provide project context and information to ensure this study's consideration of issues, constraints and interface requirements. These reports include:

- Environmental Assessment Report – Mandogalup Improvement Scheme (Strategen JBS&G, 2021 – 57020-124538 Rev 2) and its appended sub-reports
- District Water Management Strategy – Mandogalup Improvement Scheme (JDA, 2023 - J6778e)
- Transport Report – Mandogalup Improvement Scheme (Flyt, 2023 – 81113-471-FLYT-REP-0002 Rev 3)

The main outcomes and issues identified in each report with relevance to this study are outlined below.

1.3.1 Environmental Assessment Report, Strategen, 2021

The environmental aspects that have influenced the preparation of the Scheme are described in this section. The information summarized here is based on the comprehensive Environmental Assessment Report prepared by Strategen JBS&G, 2021.

According to the Environmental Assessment Report, there are 2 types of Geomorphic Wetlands in the subject areas, shown in Figure 1.3. They are Resource Enhancement wetlands and Multiple Use wetlands. Towards the south and the middle of subject area contain the Multiple Use wetlands which by definition still have few remaining important attributes and functions, whilst the Resource Enhancement wetland is located to the north-western corner of the subject area. A Resource Enhancement wetland is defined as a wetland that may have been partially modified but still support substantial ecological attributed and function. The Resource Enhancement wetland does not interact directly with the new Hammond Road extension design and its land reservation study.

The Acid Sulphate Soil (ASS) mapping for the scheme area, shown in Figure 1.4, indicates a moderate to high risk of ASS occurring within Geomorphic Wetlands. This is consistent with our understanding that clayey site may be more prone to ASS risk.

Figure 1.5 shows the location of trees with Black Cockatoo habitats. These trees dotted across the scheme area with populous habitats shown towards the central and southern side of the scheme plan. Two Threatened Ecological Communities also have been identified in the subject area. They are shown on Figure 1.6, with Banksia Woodland towards the north in Lot 2 and Tuart Woodlands towards the south. In the Strategen's report, it is found that the Banksia Woodland Communities is in 'very good' condition, whilst the Tuart Woodland is 'good' condition.

Bush Forever site 268 is located directly west of the subject area (west of Clementi Road), whilst 267 and 393 are located on the northwestern edge of the area adjacent to Mandogalup Road and do not interact with the proposed Hammond Road alignment. This is indicated in Figure 1.7. According to the report, the improvement scheme offers a chance to preserve and improve conservation areas and ecological linkages by keeping vegetation and trees intact. It also allows for the creation of ecological linkages or "green links". The report notes that the most obvious opportunity to enhance the existing mapped regional ecological linkage is and surrounding Bush Forever site 393, including the REW and associated buffer, where rehabilitation would result in an improved environmental outcome.

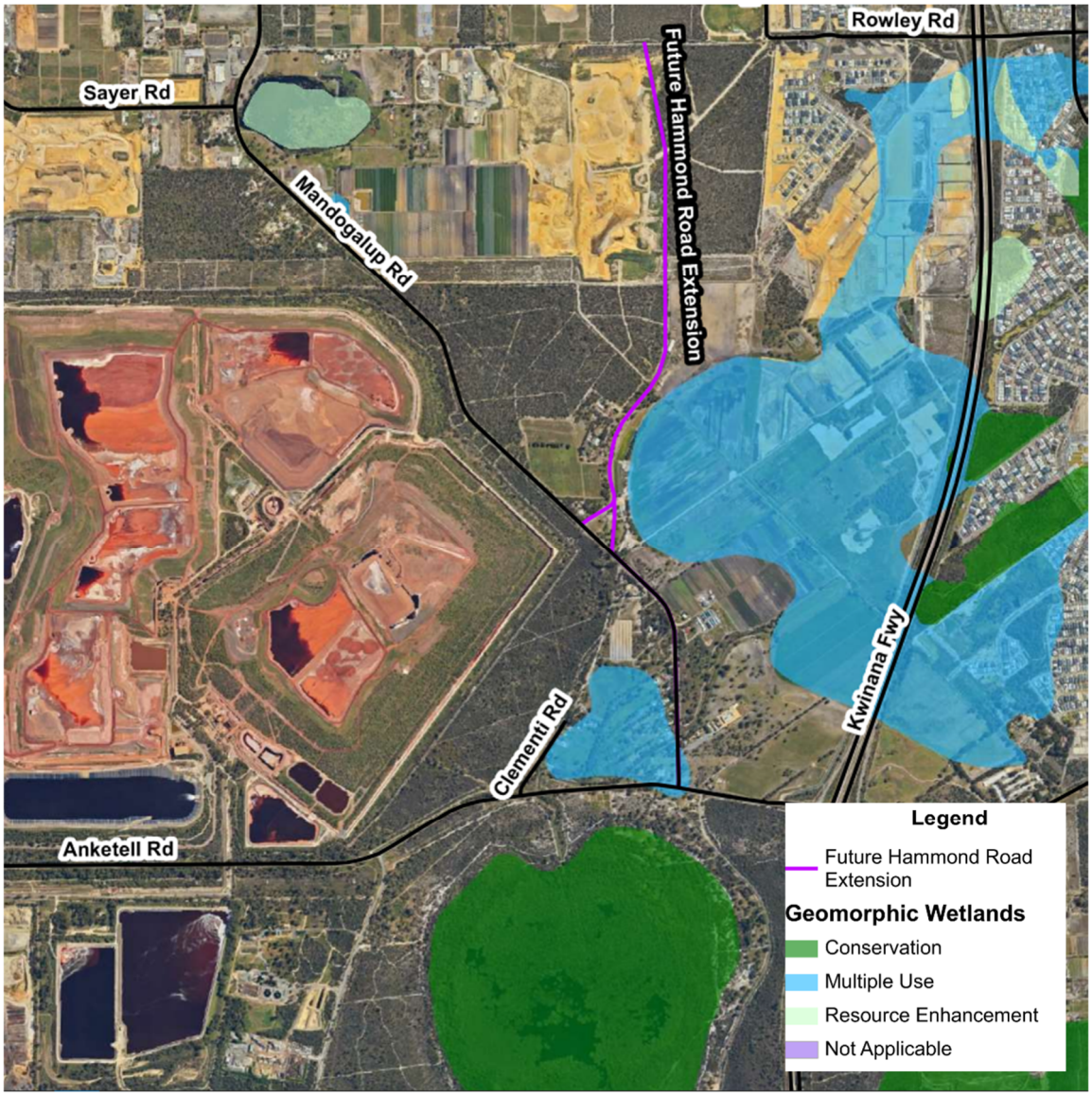
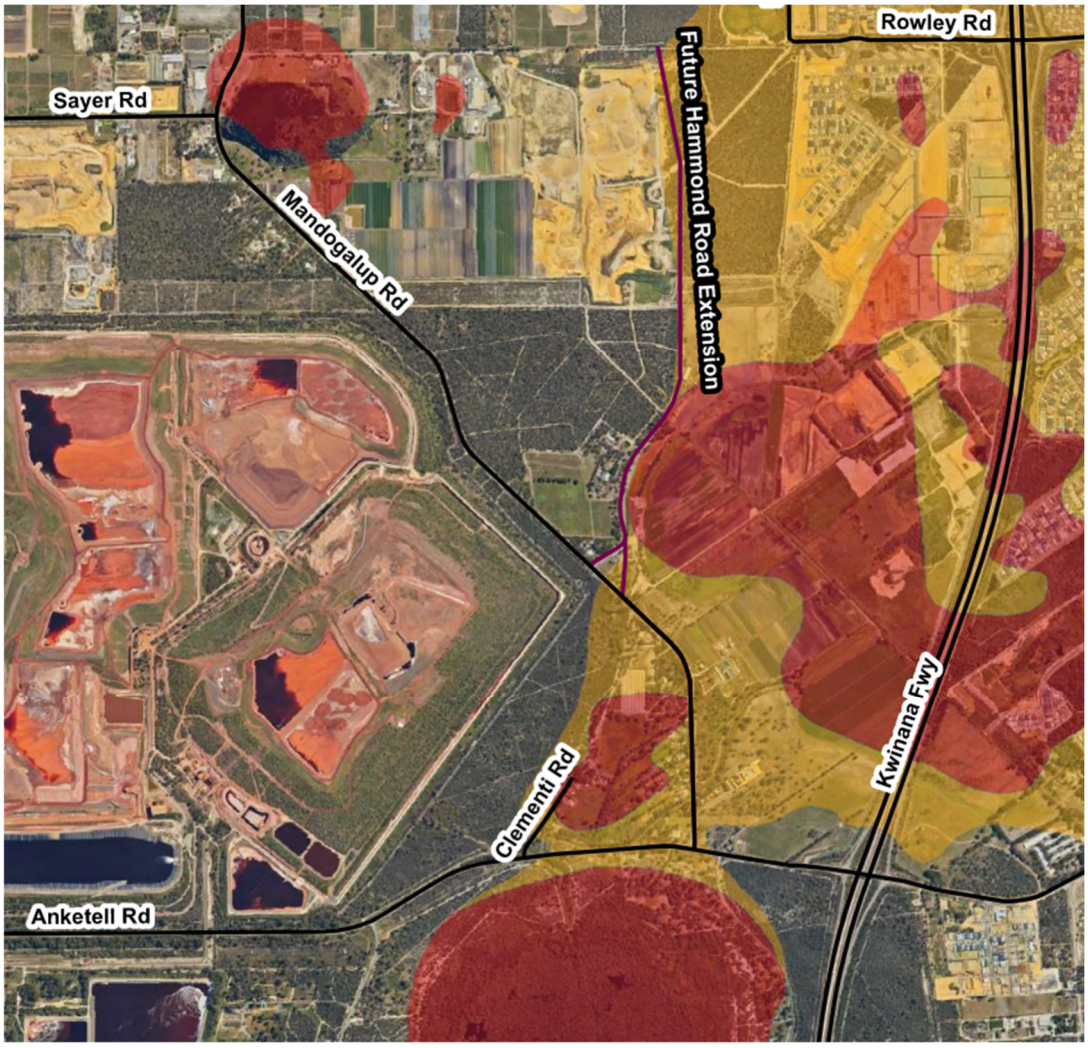


Figure 1.3 – Geomorphic Wetlands (source: Strategen JBS&G)



Legend

Future Hammond Road Extension

Acid Sulphate Soil Risk

1 - High to moderate risk of ASS occurring within 3m of natural soil surface

2 – Moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface

Figure 1.4 – ASS Risk (source: Strategen JBS&G)

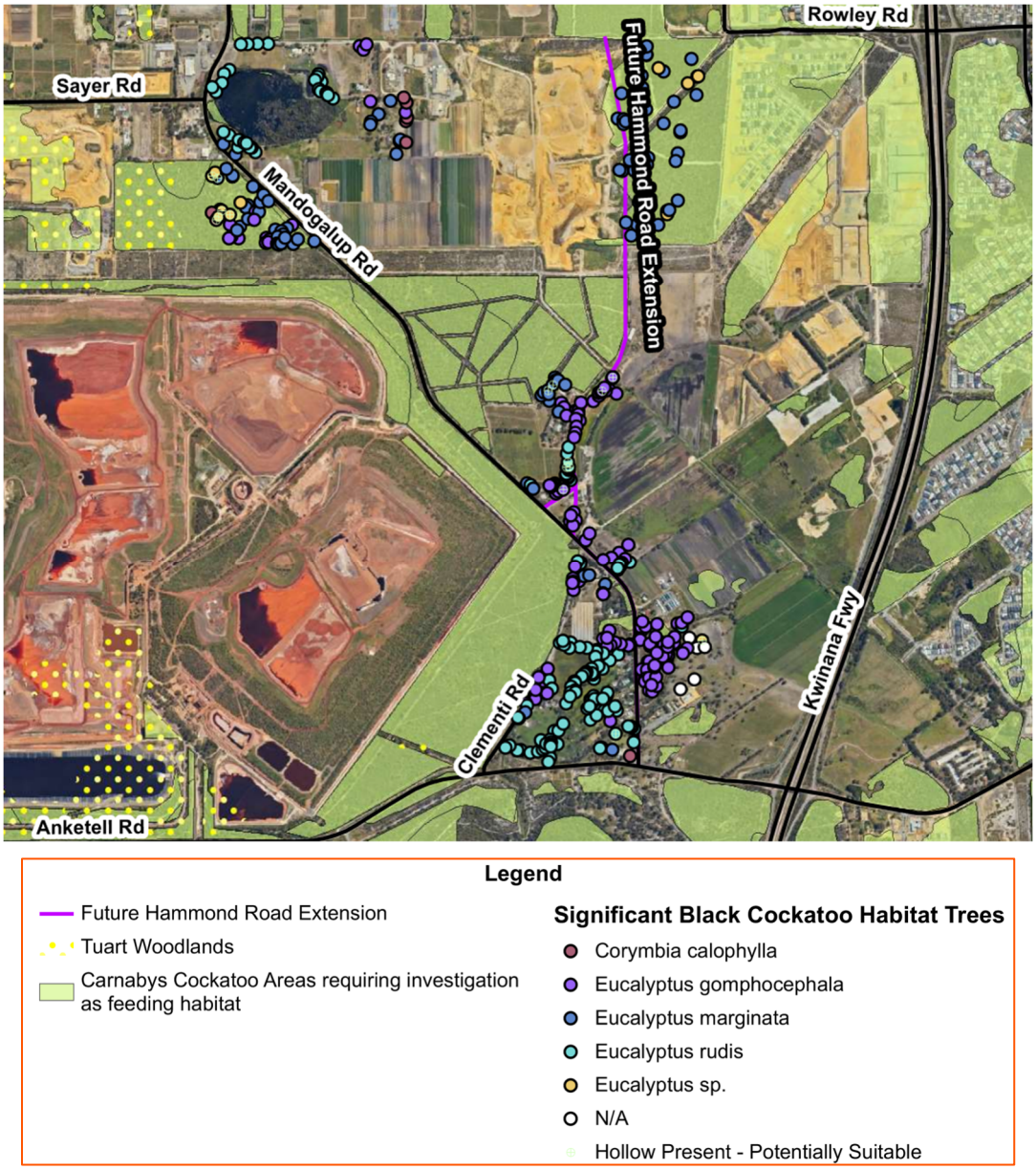


Figure 1.5 – Black Cockatoos and Tuart Woodlands (source: Strategen JBS&G)

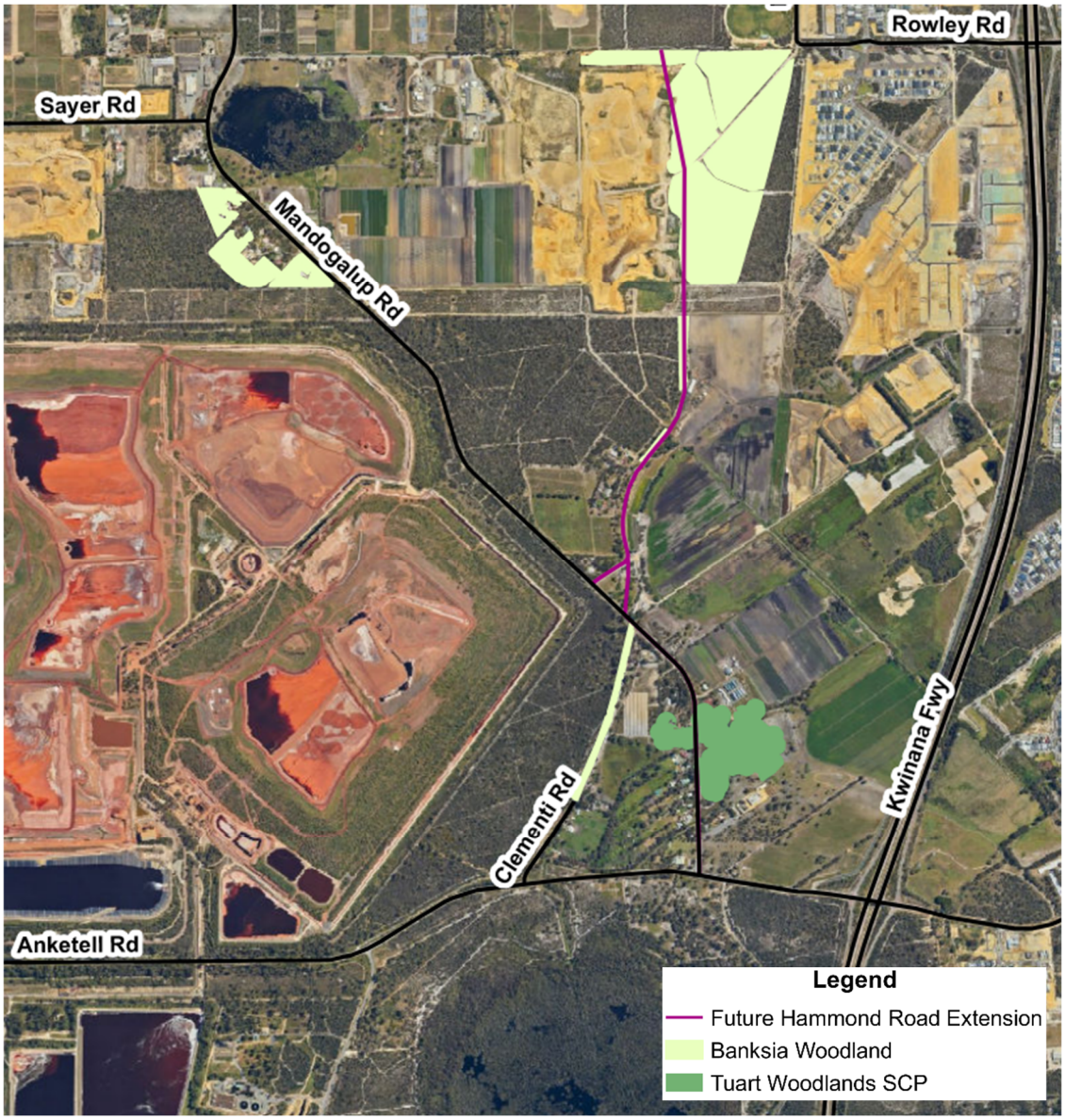


Figure 1.6 – TEC Areas – Banksia Woodland and Tuart Woodlands SCP (source: Strategen JBS&G)

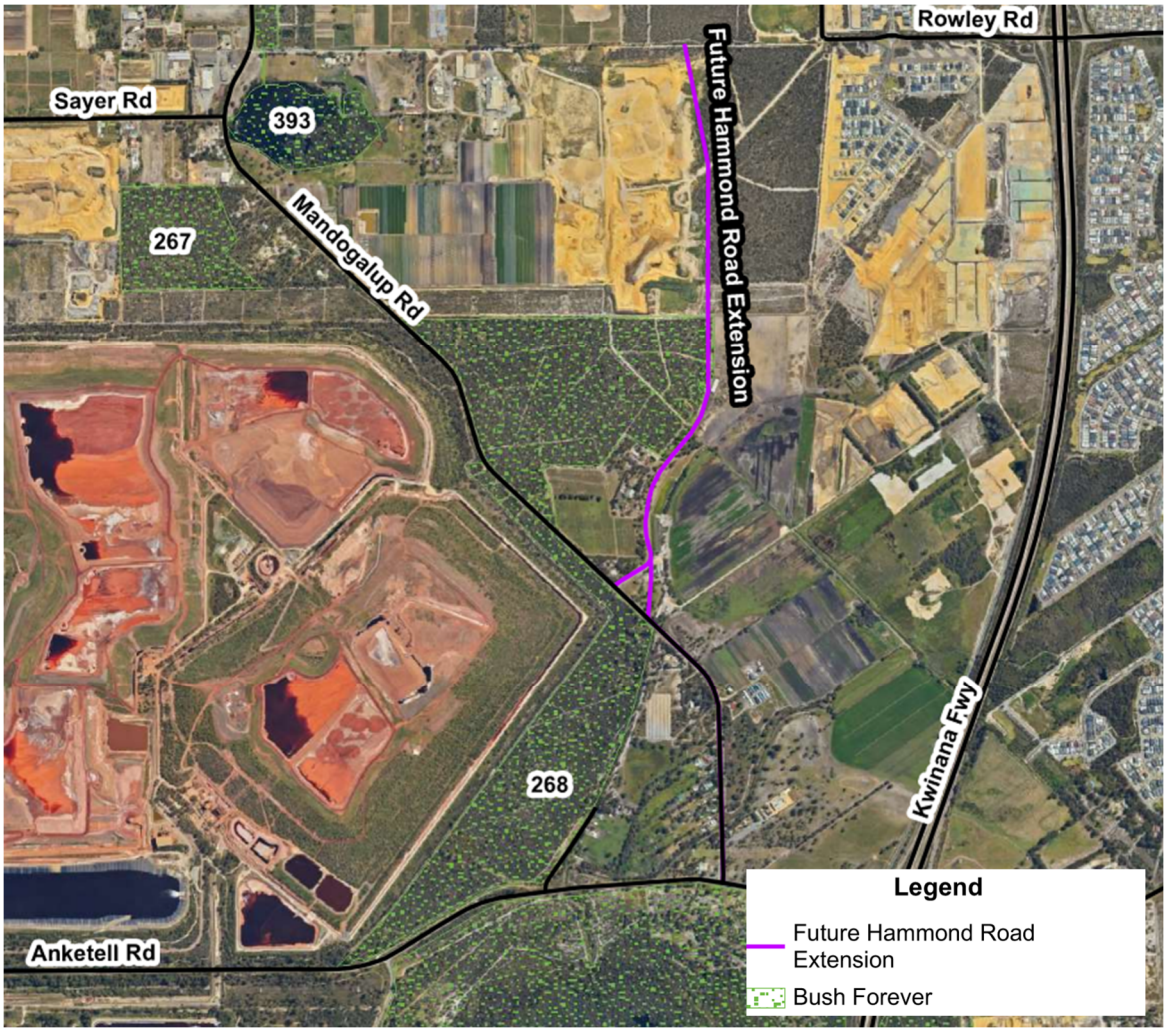


Figure 1.7 – Bush Forever sites (source: Strategen JBS&G)

1.3.2 District Water Management Strategy, JDA, 2021

The DWMS and hydrology aspects of the improvement scheme were explored and documented by JDA Consultant Hydrologist, report reference number J6778e. According to the report, the existing surface hydrology mainly consists of surface water flowing towards Water Corporation's Peel Main Drain. The Main Drain flows from north-eastern side of the subject site to south-west, towards Anketell Road. Conversely, surface water runoff in the north-eastern section of the site would infiltrate within Banksia Woodlands and does not contribute to the overall catchment of the Water Corporation's Main Drain. Based on our review of JDA's report, it should be noted that the north-western catchment area contributes to a Resource Enhancement Wetland and also known as Bush Forever site 393.

The report also detailed groundwater borehole readings, particularly near the southern and central part of the subject area where lower clearance to groundwater was detected, whilst higher clearance in northern area was recorded. This is consistent with publicly available data on Perth Groundwater Atlas Map, which indicates a max clearance of 5m in the southern and central area and rises to 20m towards the north. The report suggested refinement of groundwater data through pre-development monitoring in the next stage. It is also likely that areas near Peel Main Drain and Mandogalup Swamp would require subsoil drainage to manage and control any potential rise in water levels in the post-development environment. In the northern area, where much of the western sections are cleared for quarrying or market garden, the report anticipates higher groundwater recharge rate. It is important to note that any pavement design undertaken needs to consider these constraints and allow for a reasonable clearance to groundwater and/or any alternative treatment as required.

JDA's report also discussed the Alcoa Residue Storage Area due west of the subject area. This site is a known contaminated site. The report noted that other investigations by Parsons Brinckerhoff, 2007 and Rockwater, 2019 revealed presence of high pH, alkalinity, electrical conductivity, and salinity due to leakage of sodium carbonate and

hydroxide from residue storage ponds. The initial assessment of the Residue Storage Area indicated that alkali groundwater contamination had spread towards Lot 89 Mandogalup Road, which is situated west of Mandogalup Road within the Subject Area. Although Lot 89 is listed as a contaminated site, it is not included in the publicly available Contaminated Sites Database. According to Rockwater, 2019, there is a region of increased alkali contamination on the eastern side, extending approximately 100 meters beyond the eastern boundary of the Alcoa property. The distance between the western lots of the Subject Area and the Alcoa Residue Storage Area is around 200 meters wide. JDA's report advised of a Preliminary Site Investigation (PSI) to monitor the water quality along the western boundary of the subject area. This assessment is necessary to evaluate the possible movement of contamination further east and its potential impact. The results of this assessment may have an impact on proposed earthworks cut/fill strategy; and subsequently finished road levels in the subject area.

The geology in the subject site consists of three main geological units: sandy silt (M_{S5}), sand (S_7 and S_8). The M_{S5} unit is found in wetland areas where Water Corporation's Peel Main and Sub Drain bisect it. While the S_7 unit is predominantly in the western side of the new Hammond Road and Mandogalup Road alignment; and the S_8 unit is mainly in the eastern part of the subject area.

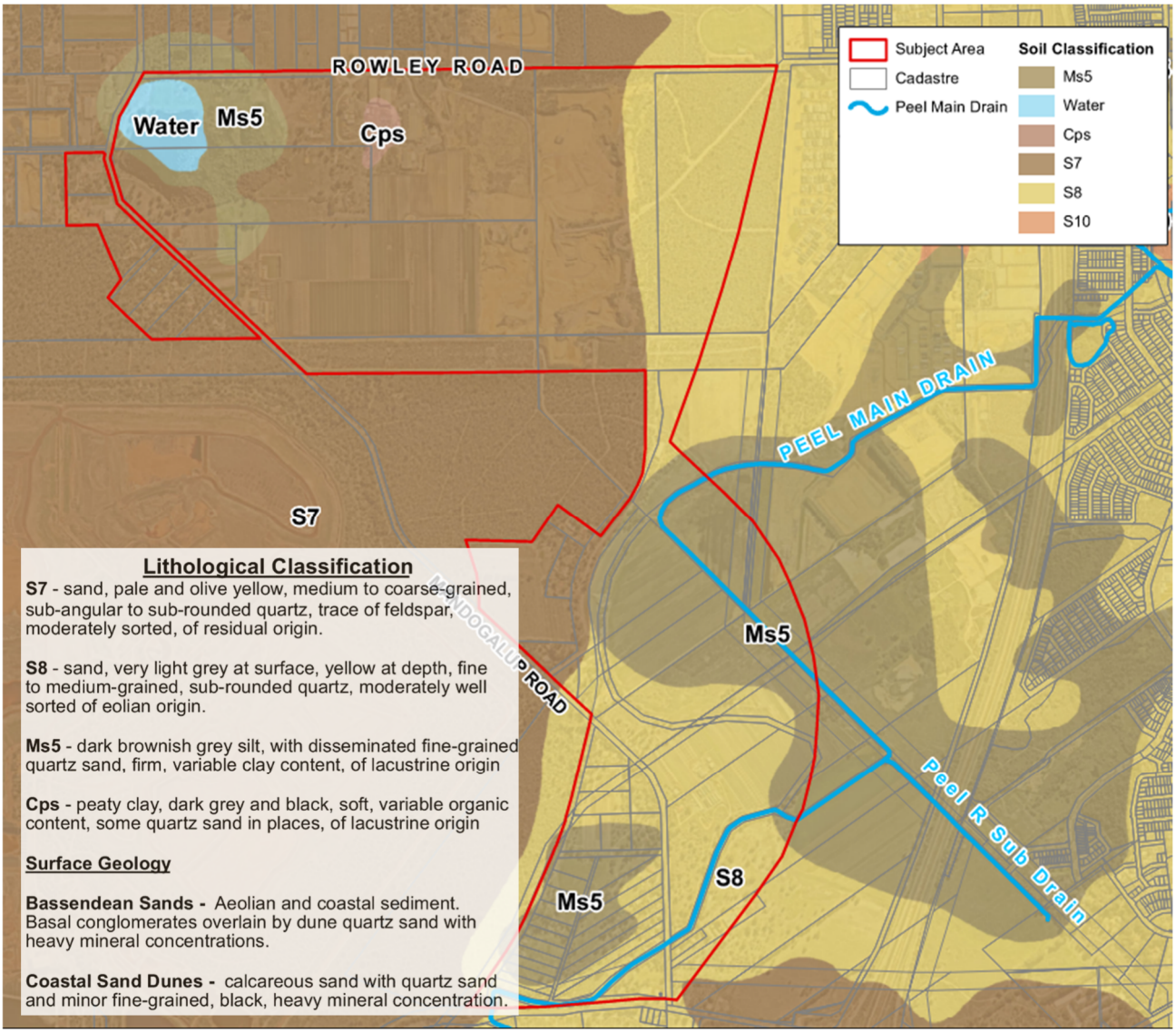


Figure 1.8 – Geology (source: JDA, 2023, Figure 6)

1.3.3 Mandogalup Improvement Scheme - Transport Report, Flyt, 2023

Flyt, 2023 introduces the report by stating their findings are built upon previous work completed by Flyt itself in 2019 and 2020, whilst including concurrent planning project along Anketell Road, namely MRWA's Westport Corridor project.

The report outlines a number of land use scenarios before the final preferred layout. In March 2023, the proponents, identified the preferred scenario with significant light and heavy industries, with supporting commercial zones and restricted residential sites. ROM model outputs were provided by MRWA to support the preferred scenario. Additional traffic volume is also incorporated due to the proposed land use. The predicted traffic for Hammond Road extension and Mandogalup Road is below.

- Hammond Rd Ext between Rowley Rd and Mandogalup Rd - 10,300-11,500 vpd in each direction
- Hammond Rd Ex between Mandogalup Rd and Anketell Rd - 18,300-19,100 vpd in each direction
- Mandogalup Rd between Rowley Rd and Hammond Rd Ext - 9,000-9,800 vpd in each direction

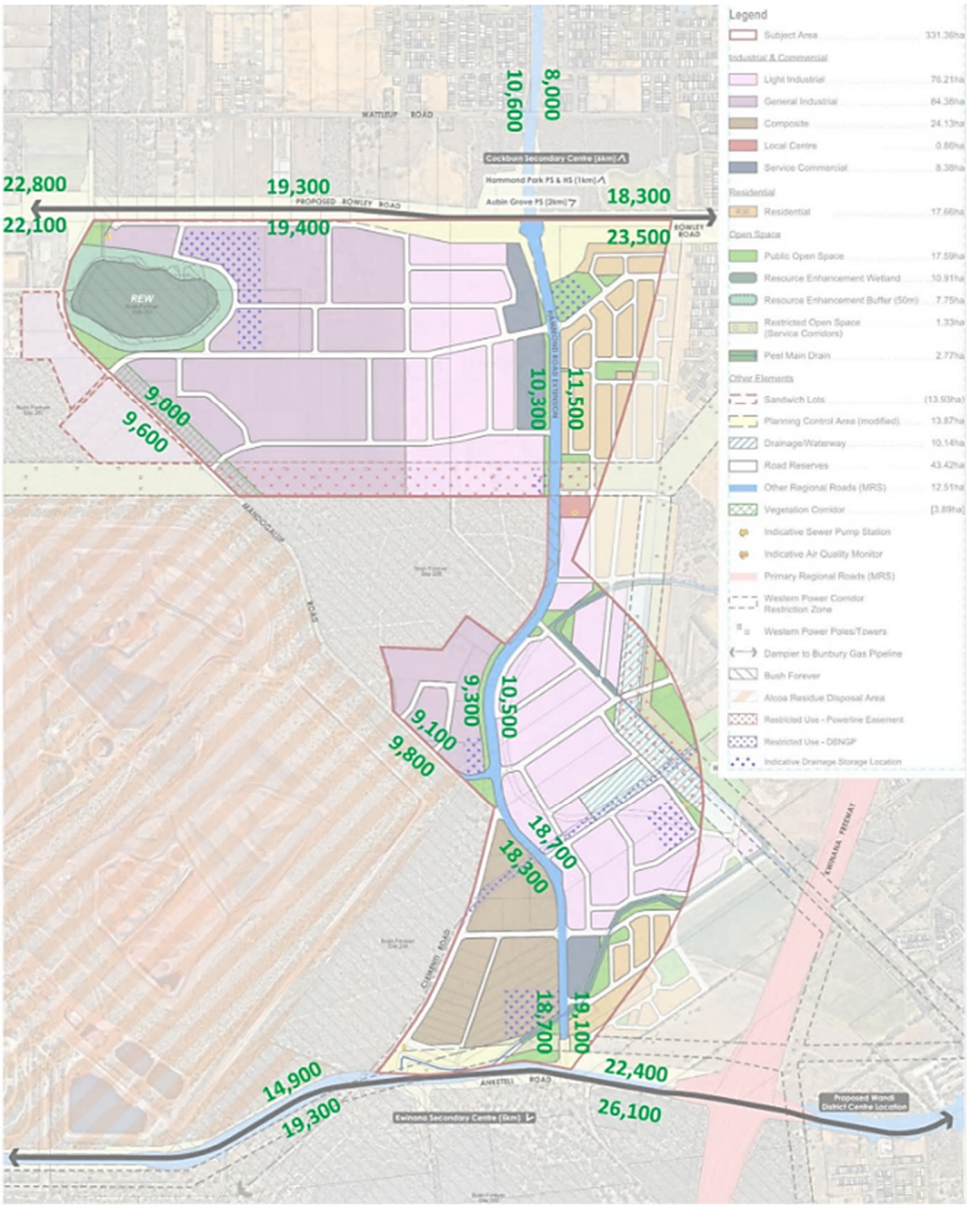


Figure 1.9 – Traffic Volumes (source: Flyt, 2023, Figure 47)

The reclassification of Mandogalup Road as Distributor B Road; and Hammond Road extension as Distributor A Road is also required based on Flyt's report. Accommodation of RAV 4 vehicle for Mandogalup Road is required, with internal roads to accommodate up to RAV 7 when Anketell Road is upgraded as part of Westport Corridor project.

Flyt's report also recommends the Hammond Road Extension is to be constructed as a dual carriageway. For new developments, direct frontage access is only permitted if development is a significant traffic generator with left or right turn pockets. Alternatively, for lower traffic generating developments, access can be obtained from side roads and

service roads. Existing properties that currently have frontage access will maintain this access until redevelopment occurs. It is worth noting that, once a median and second carriageway are constructed, the access will be restricted to left in left out movements. To ensure safety, the report recommends the speed limit along the Hammond Road Extension with existing frontage access should be limited to 60km/h.

Similarly, for Mandogalup Road direct frontage access should not be permitted for new developments. Instead, access should be obtained from side roads or service roads. In cases where there are no alternative side roads or service roads, direct access could be considered, with adjacent lots sharing crossovers where practical with left turn pockets provided to minimize the impact on through traffic. Properties with existing frontage access along Mandogalup Road will retain this access until redevelopment occurs, after which it is limited to left in left out movements once a median and second carriageway are constructed. To ensure safety, the report recommends speed limit of 70km/h.

2. Existing conditions

2.1 Existing MRS and Road Layout

The existing Mandogalup Road features a 20m road cadastre and is classified as an ORR as shown in Figure 2.1. It is of rural standard with a single unkerbed carriageway.

The existing Norkett Road, which the study aims to replace as Hammond Road, has an existing 60m wide road cadastre with unkerbed single carriageway. This comprises a 40m ORR corridor width adjacent to the 20m wide Tramway Parks and Recreation reserve. The formalised road pavement of Norkett Road terminates some 500m from the existing Mandogalup-Norkett intersection and is currently fenced off north of this point. An overview from aerial imagery suggested no formalised road pavement has been constructed past north of the fence.

The predominant zoning in this area is that of rural with parks and recreation on the western side of the Mandogalup Road and southern side of Anketell Road. Further east towards Kwinana Freeway, the zoning is predominately urban.

In their existing states, both roads have no provision for active transport such as footpaths or cycle paths, nor public transport.

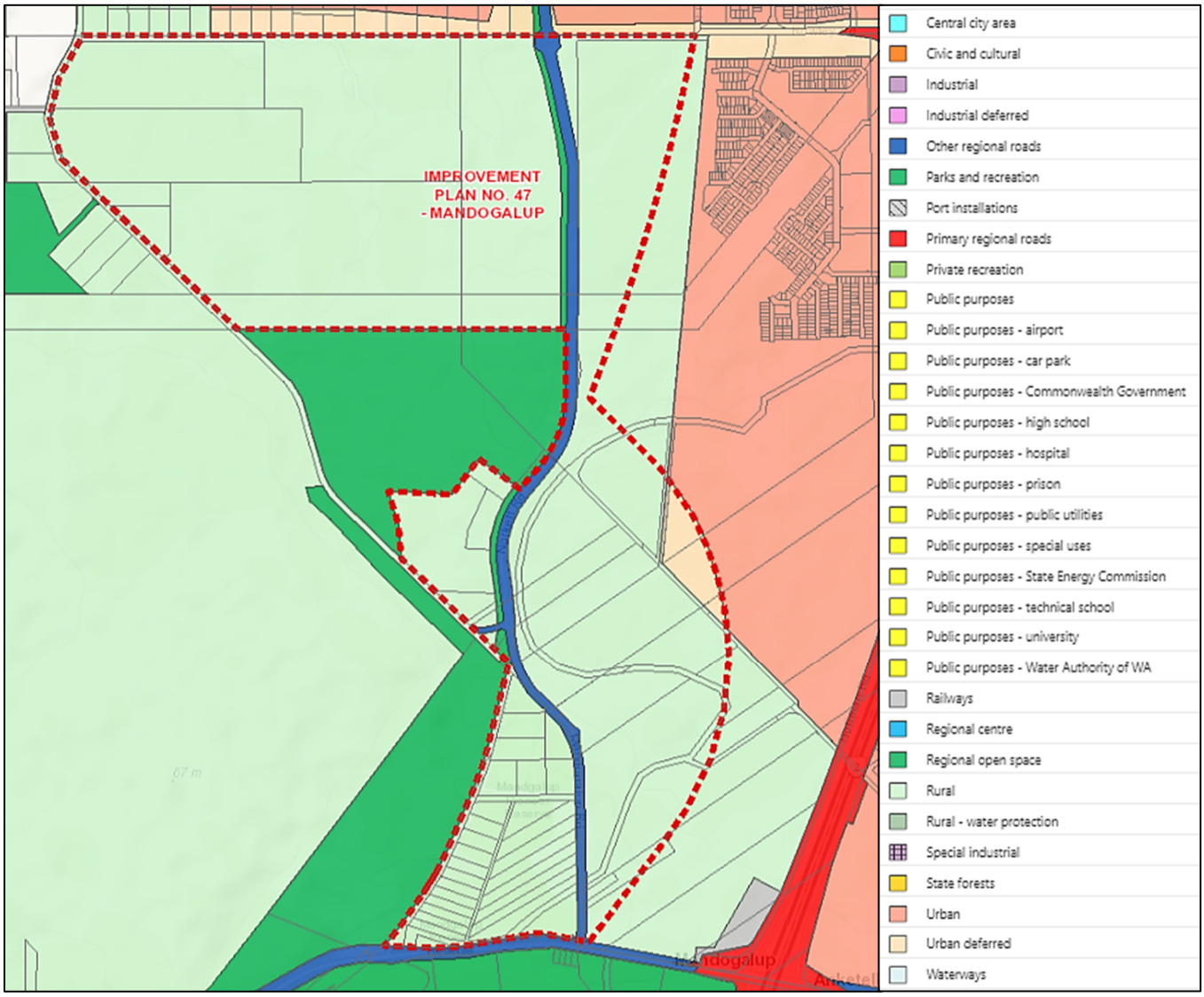


Figure 2.1 – Existing Metropolitan Regional Scheme (source: DPLH)

2.2 Existing Road Hierarchy

The existing Mandogalup Road is categorised as a Local Distributor that distributes for Anketell Road, a Regional Distributor to the south of the subject area. To the east, lies Kwinana Freeway, a Primary Distributor that runs north south. On the northern side of the project area, there is Rowley Road, which is categorized as a Regional Distributor, similar to Anketell Road.

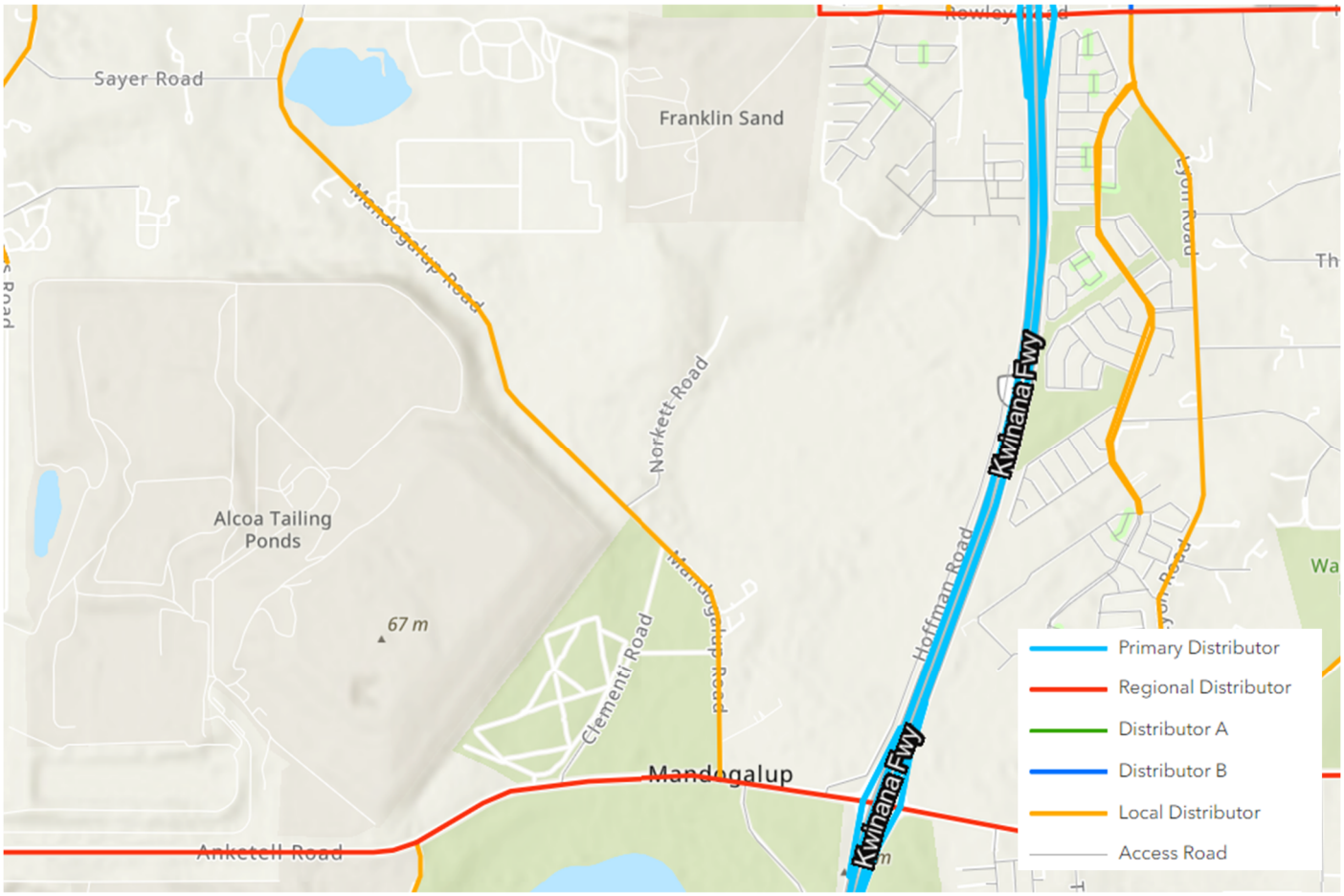


Figure 2.2 – Existing Road Hierarchy
(source: MRWA Road Information Mapping System)

2.3 Existing Speed Limit

The speed limit on Mandogalup is currently shown as 70km/h on the southern portion, namely between the Norkett Road-Mandogalup Road intersection and Anketell Road, whilst the northern portion shows a speed limit of 80km/h.

Anketell Road is currently posted at 80km/h where it interfaces with Mandogalup Road. The speed limit goes up to 90km/h heading west of this location. Towards the north of the subject area, Rowley Road shows a speed limit of 60km/h.

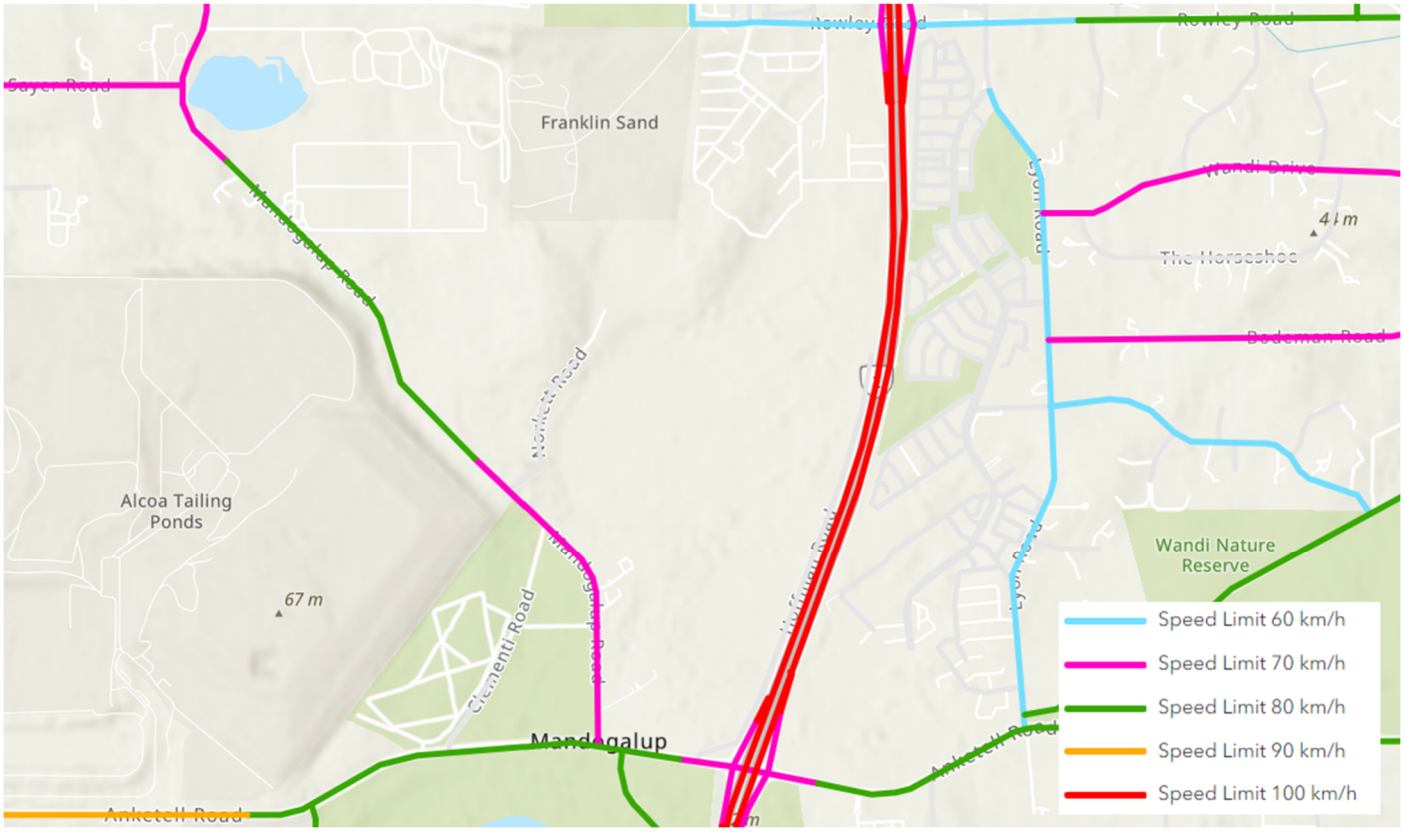


Figure 2.3 – Existing Speed Limit
(source: MRWA Road Information Mapping System)

2.4 Existing Topography & Geology

Existing LiDAR survey has been provided by the DPLH at the inception of the project. The general topographic data is consistent with various publicly available GIS's, with

- generally lower levels in Mandogalup Road that range from 14mAHD to 18mAHD.
- slightly higher and more consistent levels as Mandogalup Road travels north towards Norkett Road. The level ranges from 17mAHD to 19mAHD.
- and, a climb in level in the heading to Rowley Road on the northern side of the area. The level starts at approximately 19mAHD on the southern side to 38mAHD on the northern end. In this area, there is also a dominant crossfall from west to east.

Our road alignment borders two types of surface geologies shown in Figure 1.8, seemingly dividing the subject area in half. On the western side of the road, the site geology is that of Tamala Limestone – Aeolian calcarenite, variably lithified, leached quartz sand; and Bassendean Sand on the east. There is also a pocket of swamp and lacustrine deposits (peat, peaty sand and clay) in the central area of the site, where a section of Water Corporation's Peel Main Drain is.

2.5 Constraint Investigation

In this section, we will discuss a series of constraints that have been identified based on the information gathered from previous sections. These constraints interact directly with the new road design and encompass various aspects such

as heritage & social considerations, environmental factors, and utility infrastructure. Understanding and addressing these constraints is essential for the planning and design development process. These constraint maps can be found in Appendix C.

2.5.1 Heritage and Social Constraints

Several heritage and social constraints have been identified:

- Aboriginal Heritage Place: An Aboriginal Heritage Place, known as place 4360 is located some 600m north of Mandogalup-Norkett Road intersection. The location is where Norkett Road reserve terminates on the north and shows an absence of legal road reserve.
- Historic Heritage Places and existing rural lots: The Soldier Settler Homes on the south-western portion Mandogalup Road, specifically Lots 70, 73, and 74, are listed as heritage sites. The new road widening needs to be rationalised as to avoid impacts to their landholdings. It is also worth noting that there are other existing residential lots fronting Mandogalup Road which due considerations need to be given.
- Place of Worship: The existence of a place of worship (Bala Murgan Hindu Temple) in the south-eastern part of the subject area adds to the social consideration and should be taken into account during the design process. Some of the derived considerations may include access and encroachment of new road footprint.
- Baldivis Tramway Reserve: The existing Baldivis Tramway Reserve, which is situated within the existing Clementi Road cadastre, connects to the subject road at Mandogalup-Norkett Road intersection. It then continues northwards and stays within a Parks and Recreation Reserve some 600m north-east of Mandogalup-Norkett Road intersection.

2.5.2 Environmental Constraints

Several environmental constraints identified are list below:

- Bush Forever Area 268: The location of Bush Forever Area 268 is shown in Figure 1.7. It is covers the south-western side of Mandogalup Road – sandwiched between Alcoa's Residual Storage Area and the existing residential lots. The bush forever site also spans northwards and terminates just south of Lot 10, the sand quarrying site north-east of Mandogalup Road.
- TEC: The presence of any threatened ecological communities shown in Figure 1.6, necessitates their protection and conservation. This is especially applicable for vegetation in 'very good' condition. One such place is on the north-western side of Hammond Road extension, where a Banksia Woodland thrives; whilst Tuart Woodlands on the southern section is said to be in 'good condition'.
- Potential Carnaby Cockatoo's Habitat: Being a habitat for the protected bird species, requires protection and measures to minimize disturbances during the design and construction phases. These habitat trees are show in Figure 1.5. They are predominantly present from the central to the south of the new road alignment, with patchy findings towards the northern side.
- Acid Sulphate Soil: ASS-prone areas are as described in Figure 1.4. These areas interact with the new road alignment towards the south and near the central area. While it is possible to implement treatment strategies to mitigate their impact, it is often more effective to prioritize avoidance as the best course of action. The clayey composition of these areas is also expected to result in a lower infiltration rate and would restrict placement of basins.

2.5.3 Utility Infrastructure

Several utility-related constraints have been identified:

- WP Overhead Transmission Lines: Considerations must be made to ensure vertical clearance and avoid clashes with the Western Power overhead transmission lines located just south of Lot 2 and 10.
- Dampier to Bunbury Gas Pipeline: The Dampier to Bunbury gas pipeline, which traverses Lot 50 to 53, south of the Mandogalup-Norkett Road intersection, necessitates the inclusion of a vertical cover requirement in the road design. It is crucial to carefully consider the vertical geometry to avoid cutting into the existing ground, as this could potentially compromise the integrity of the pipeline cover.

- Water Corporation Main Drain: The Water Corporation's Main Drain, which crosses Mandogalup Road through Lot 75 on the southern side, directs water flow towards the Spectacle south of Anketell Road, a designated Conservation Wetland. Additionally, the upstream portion of this Main Drain interacts with the road alignment in the central area, coinciding with one of the two REW's in the vicinity.

Addressing these existing constraints is crucial for the successful implementation of the Mandogalup Improvement Plan 47 and Scheme No 1. By incorporating appropriate measures, the project can be carried out in a manner that respects heritage, protects the environment, and ensures the smooth functioning of utilities.

2.6 Future Road Projects

2.6.1 Westport Corridor – Anketell Road

The Westport project is part of the State Government's plan to move container trade from Fremantle to Kwinana. The preferred design, as shown in Figure 2.4, includes a new port in Kwinana supported by upgrades to the road and rail freight network and logistics hub.

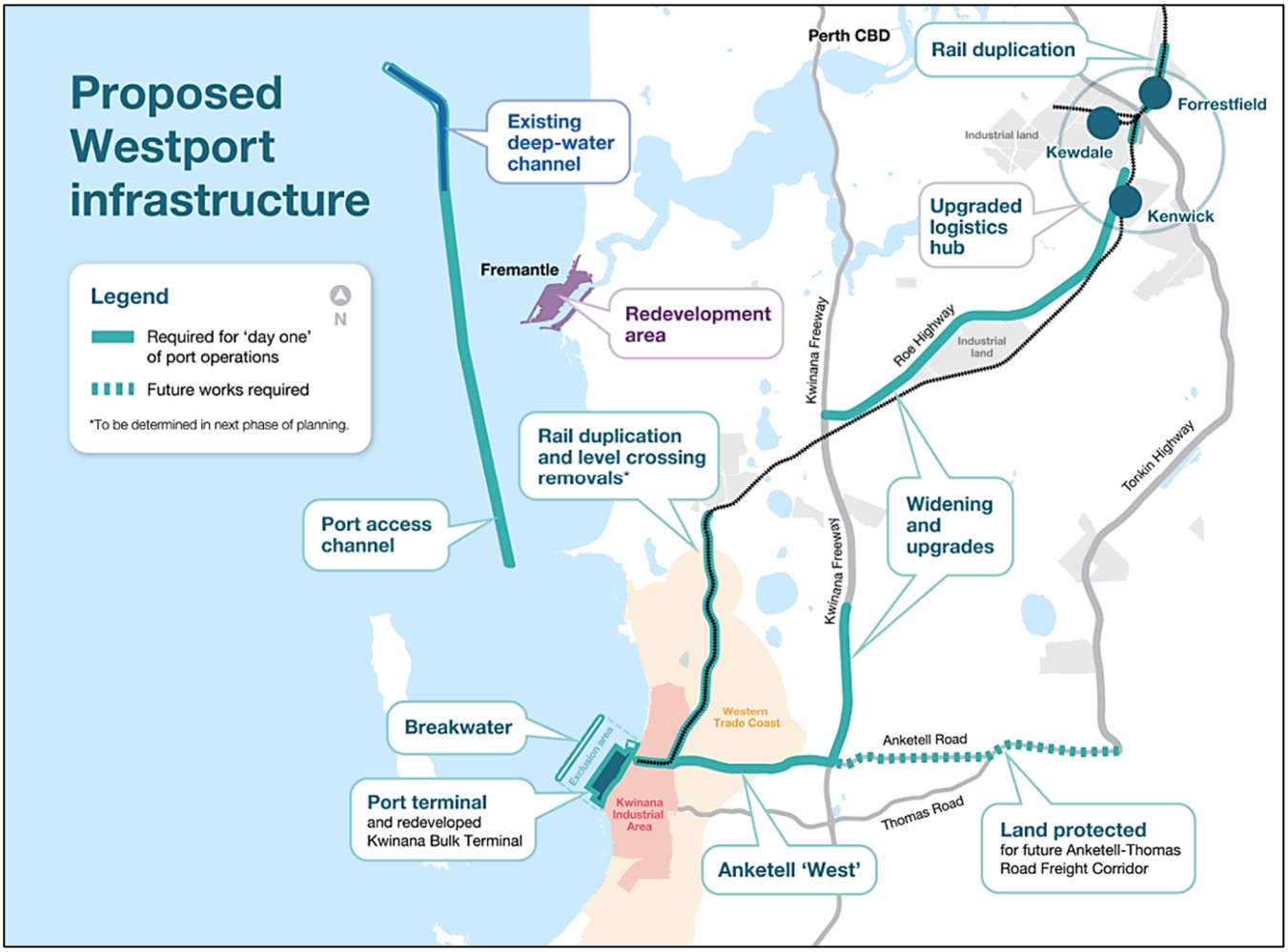


Figure 2.4 – Westport Preferred Infrastructure (source: westport.wa.gov.au)

As part of this preferred design, Anketell and Thomas Roads would form part of the future freight corridor that would connect the new Kwinana Port with Tonkin Highway while improving access to the wider area and key strategic industrial sites. This future road corridor includes:

- Upgrading Anketell and Thomas Rd's to four lanes between Leath Rd in Kwinana to Tonkin Hwy in Oakford
- Interchanges at Rockingham Road, Armstrong Road, Abercrombie Road and Mandogalup Road
- New bridges over Kwinana Freeway

- Dedicated freight only corridor (one lane in each direction)
- New interchanges at Lyon Road, Kargotich Road and Nicholson Road
- Shared paths along the corridor for pedestrians and cyclists

The proposed alignment for the Anketell-Thomas Road Freight Corridor is shown in Figure 2.5. Notably, Planning Control Area 168 has been established to provide land protection of said corridor. Figure 2.6 shows a portion of PCA 168 where Westport's Anketell Road interfaces with Mandogalup Road.

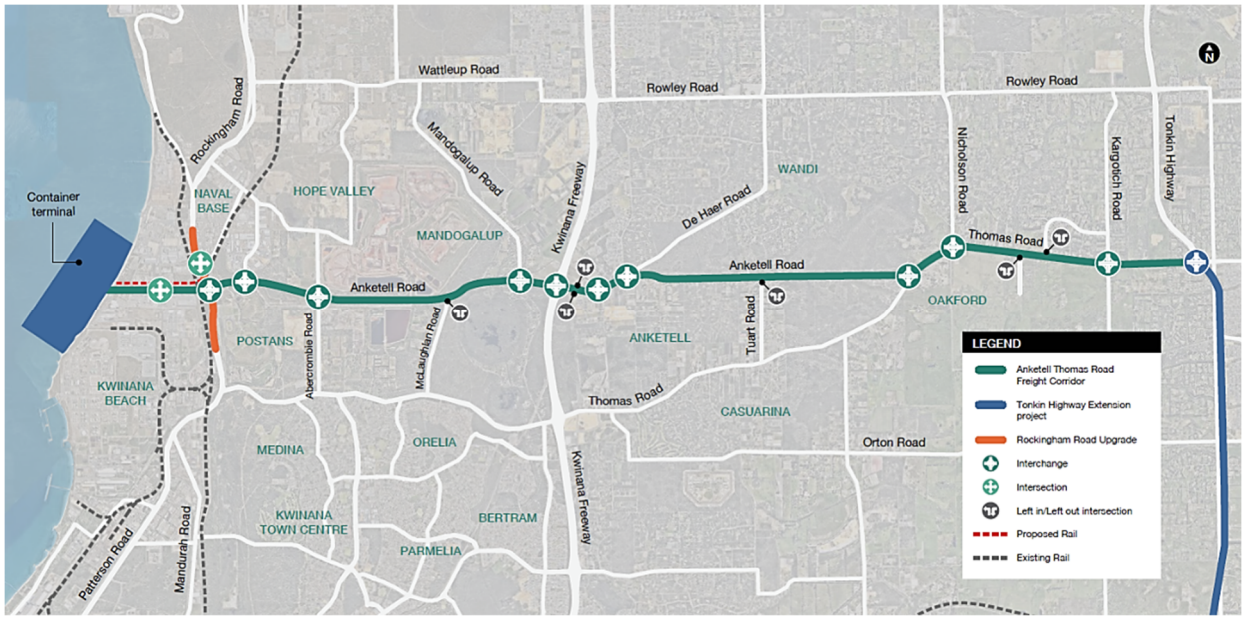


Figure 2.5 – Ultimate Anketell Thomas Road Freight Corridor (source: westport.wa.gov.au)

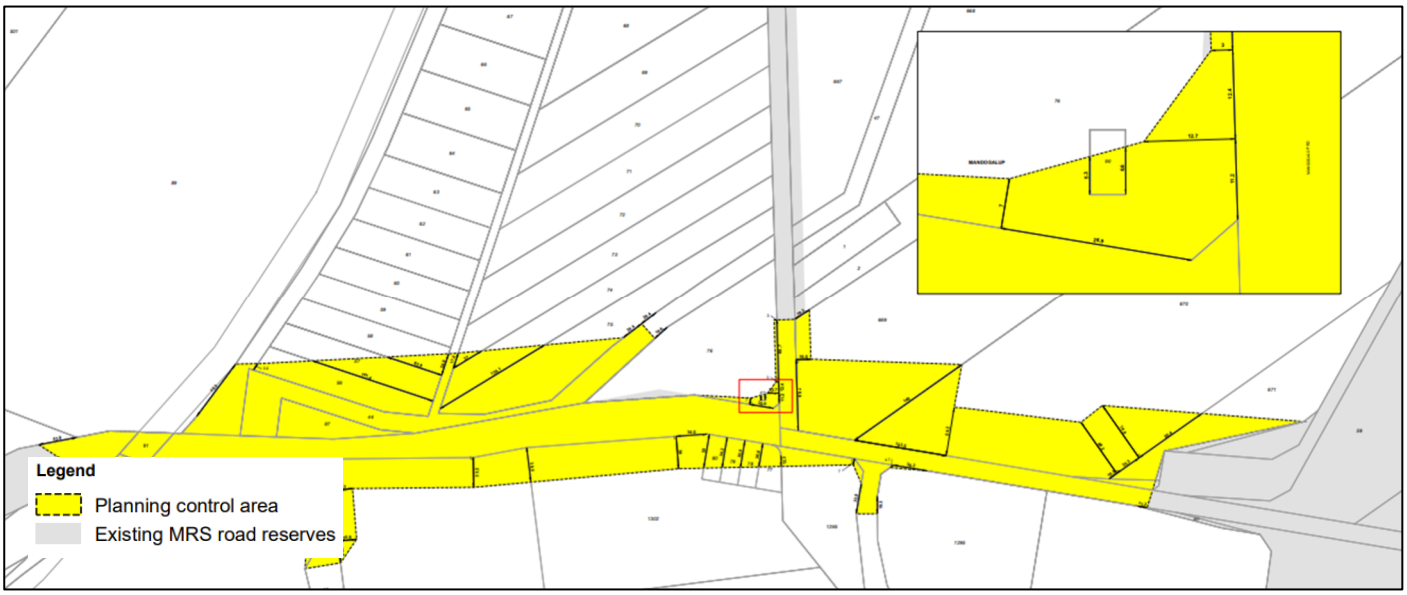


Figure 2.6 – Planning Control Area 168 – Anketell Road (source: www.wa.gov.au)

2.6.2 Rowley Road

Although no longer the preferred route to future Kwinana port, it is still an important route that connects to the Kwinana Industrial Area. With the establishment of Planning Control Area 156, it aims to protect the proposed road and rail freight corridor towards the coast. A section of Rowley PCA is shown in Figure 2.7 interfacing with the new Hammond Road extension.

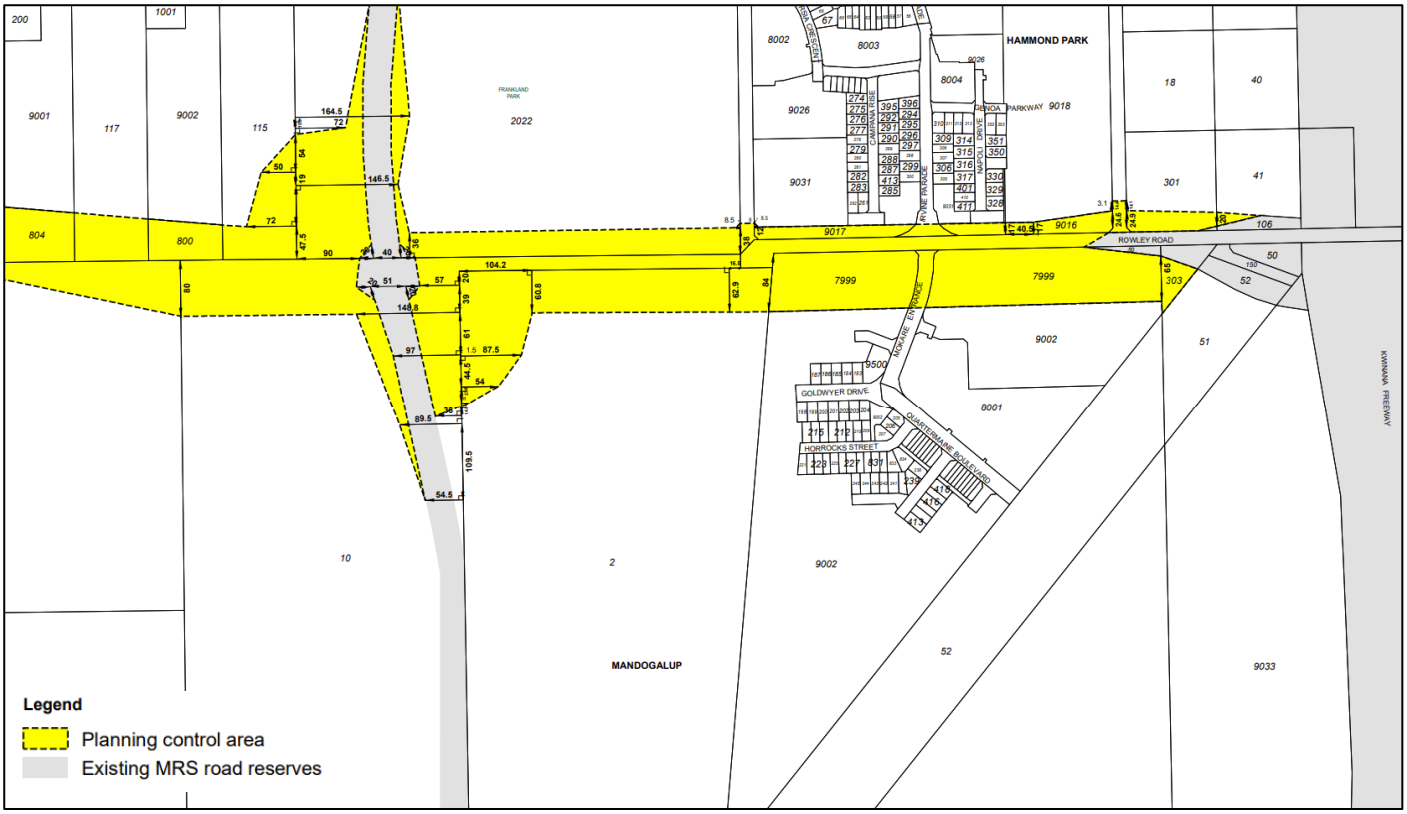


Figure 2.7 – Planning Control Area 156 – Rowley Road (source: www.wa.gov.au)

3. Design Basis

3.1 Design Standards

The Road Design is based on the technical references listed in Table 3.1. These technical references are listed in the order of precedence for the event of any inconsistency, ambiguity, or discrepancy between documents.

Standard or Guideline	Relevant Chapters / Parts
Project Specific Specification	-
Project General Specification	-
Project Client Requirements Documents	DPLH401523 - Request V1.docx DPLH401523 - Attachment 1 to Request - Study Area and Proposed Access Strategy DPLH401523 - Attachment 2 Preferred Scheme Land Use Scenario DPLH401523 - Attachment 3 to Request - November 1993 HAMMOND ROAD
Austroads Guide to Road Design (AGRD)	Part 3 – Geometric Design Part 4 – Intersections and Crossings Part 4A – Unsignalised and Signalised Intersections Part 4B – Roundabouts Part 5 – Drainage – General and Hydrology Considerations Part 5A – Drainage – General and Hydrology Considerations Part 5B – Drainage – Open Channels, Culverts and Floodways Part 6 – Roadside Design, Safety and Barriers Part 6A – Paths for Walking and Cycling Part 6B – Roadside Environment
MRWA Supplements to AGRD	Part 3 – Geometric Design Part 4 – Intersections and Crossings Part 4A – Unsignalised and Signalised Intersections Part 4B – Roundabouts Part 5 – Drainage – General and Hydrology Considerations Part 5A – Drainage – General and Hydrology Considerations Part 5B – Drainage – Open Channels, Culverts and Floodways Part 6 – Roadside Design, Safety and Barriers Part 6A – Paths for Walking and Cycling Part 6B – Roadside Environment
Austroads Design Vehicles and Turning Path Templates Guide	Austroads Design Vehicles and Turning Path Templates

Table 3.1 – Technical References

3.2 Design Inputs

The various design inputs received are listed below.

Type	Source	Name
New Hammond Road – 2D roundabout layout	SMEC through DPLH	• 3006599-CP01-B • 3006599-CP02-B • 3006599-CP03-B • 3006599-CP04-B • 3006599-LR01-B • 3006599-LR02-B • 3006599-LR03-B • 3006599-LR04-B • 3006599-TX01-A
Future Rowley Interchange – plan and profile & PCA	MRWA through DPLH	• 200221-36.pdf • 20221-32-1.pdf • desrowley_ Clipped for DPLH.dgn

Type	Source	Name
Lidar of existing topography	DPLH	• Contours_05m_LiDAR_Derived.dgn
Existing cadastre boundary	DPLH	• Cadastre_ReducedAttributes.dgn
Zones and reserves	DPLH	• RS_ZonesAndReserves,dgn
Environmentally sensitive and constrained areas	DPLH	• FEA_JBSG_TuartWoodlandSCP_20231110.shp • BOU_JBSG_StudyArea_20231109.shp • FEA_JBSG_30mREWBuffer_20231109.shp • FEA_JBSG_APZ_20231109.shp • FEA_JBSG_BanksiaWoodlandSCP_20231109.shp • FEA_JBSG_SandwichLots_20231109.shp • FEA_JBSG_VegCond_20231109.shp • LOC_JBSG_SigBCHab_20231109.shp
Updated scheme and concept plan	DPLH	• Attachment 3 - Draft Mandogalup Improvement Scheme No. 1 - Scheme Map - modified.pdf • Attachment 4 - Draft Mandogalup Improvement Scheme No. 1 - Concept Plan - modified.pdf

Table 3.2 – Design Inputs

3.3 Design Criteria

The Road Design has been developed in accordance with the design criteria set out in the documents listed in Section 3.1. Key criteria are summarised in Table 3.3 and Table 3.4 for convenience.

Parameter	Value
Road	
General	
Design Speed	80km/h
Posted Speed	70km/h
Sight Distance	
Reaction Time	2.0 seconds
Stopping Sight Distance (Car, 1.1m to 0.2m)	114m
Stopping Sight Distance (Truck, 2.4m to 0.2m)	130m
Approach Sight Distance (Car, 1.1m to 0m)	114m
Safe Intersection Sight Distance (Car, 1.1m to 1.25m)	181m
Vertical Geometry	
Min Vertical Grade (kerbed)	0.3%
Max Vertical Grade	5.0%
Min tangent (between reverse VC) = 0.2V	16m
Min tangent (between compound VC) = 0.4V	32m
Min K for car SSD (crest VC) for S<L h1 = 1.1, h2 = 0.2 – Absolute Minimum h1 = 1.1, h2 = 0.2 – Desirable Minimum h1 = 1.1, h2 = 0.0 – Absolute Minimum h1 = 1.1, h2 = 0.0 – Desirable Minimum	 11.8 14.7 24.0 29.9
K for sag (comfort & appearance) - Absolute Minimum - Desirable Minimum	 21 28
Horizontal Geometry	
Design Vehicle	27.5m B-Double – Area 1 & 2

Parameter	Value
	36.5m B-Triple – Area 3
f (des max)	0.16 for speed = 80km/h 0.19 for speed = 70km/h
Min R for adverse cross fall	1250m
Min R for 4.5% super for operating speed = 80km/h	MRWA – 310m AustRoad – 270m Based on f (des max) – 243m
Min R for 4.5% super for operating speed = 70km/h	MRWA – 230m AustRoad – 180m Based on f (des max) – 164m

Table 3.3 – Road Design Criteria

Parameter	Value
Drainage Basin	
Software	PC Sump (as recommended by MRWA)
General	
Region	Perth Metro
Location	Rockingham
Effective service life / Planning horizon	Year 2060
Consequence of Failure	Medium
AEP	1% (100 yr ARI)
Basin sloped if unwalled	1:4
Freeboard to overtopping road	300mm
Deep Water Table Model	
Saturated Hydraulic Conductivity	2 m/day
Soil Suction	-11 cm
Porosity	0.3
Shallow Water Table Model	
Saturated Hydraulic Conductivity	2 m/day in expected sandy areas 0.5 m/day in expected clayey areas
Aquifer Storage Coefficient	0.2
Base of Aquifer	-20 mAHD

Table 3.4 – Drainage Basin Design Criteria

4. Planning Design Concept

In this report, the study area has been divided into three areas: Area 1, Area 2, and Area 3. This division is based on the similarity of design considerations and constraints within each area. The report frequently refers to these areas as to discuss various aspects related to them.

Area	Location	Intersection
Area 1	CH 0.00 to CH 600 Between Anketell Road to the Clementi-access-road roundabout. Mandogalup Road is bordered by • To the west, existing residential sites • To the east, an existing place of worship and TEC area	• 1 x roundabout (known as the 'southern roundabout')
Area 2	CH 600 to CH 1300 Between the Clementi connector road roundabout and the existing Norkett-Mandogalup intersection. The Mandogalup is bordered by • To the west, existing residential sites • To the east, a few existing businesses with proposed light industry zoning	• 1 x roundabout (known as the 'central roundabout')
Area 3	CH 1300 to CH3000 Between the 'central roundabout' to the future Rowley interchange. The new road is bordered by • To the west, some existing residential sites on the southern side and a sand quarry business towards the north. For the proposed zoning, this western area is to be zoned industry / service commercial. • To the east, proposed light industry zoning and a TEC area (Banksia Woodland) towards the future Rowley interchange.	• 1 x roundabout (known as the 'northern roundabout') • 1 x signalised all-movement intersection • 1 x unsignalised LILO intersection

Table 4.1 – Area and Intersection Definition

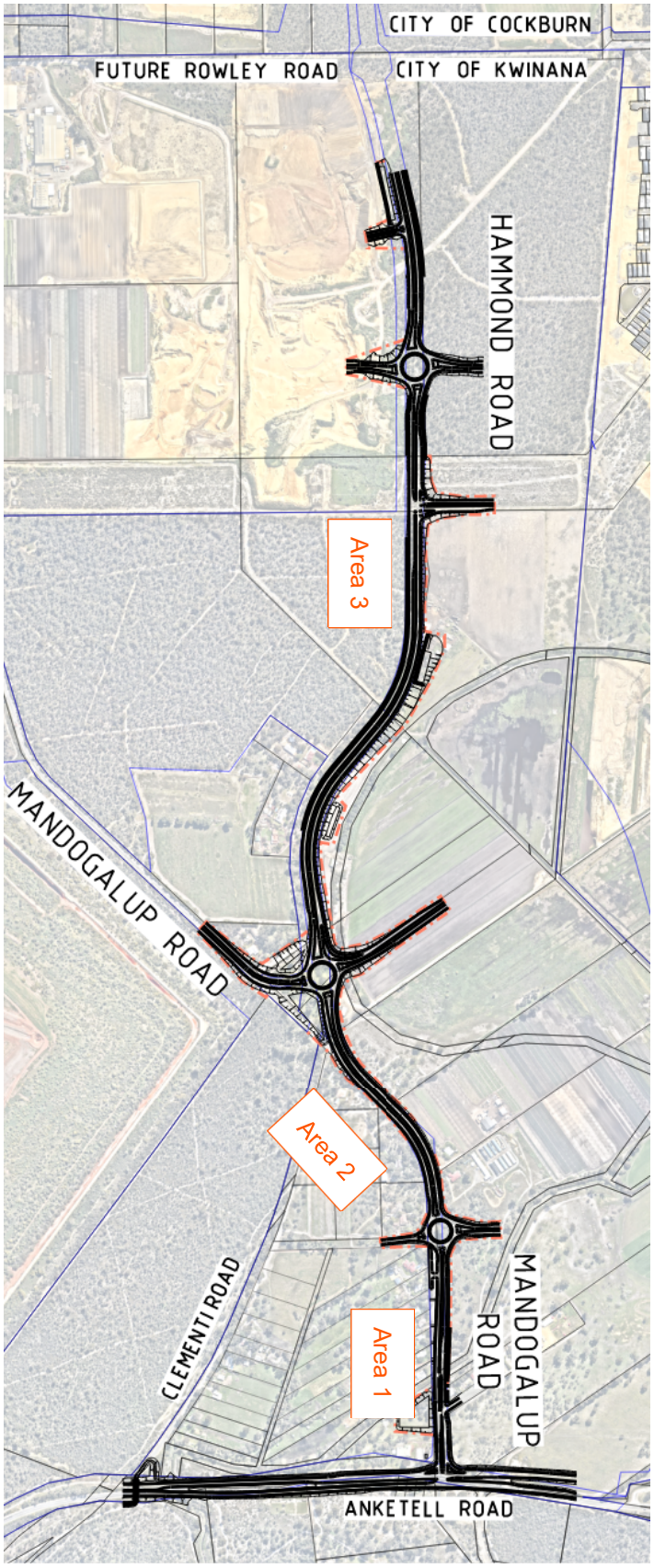


Figure 4.1 – Locality Plan and Areas

4.1 Typical Cross Section

The below typical sections have been discussed and refined upon feedbacks.

4.1.1 Area 1

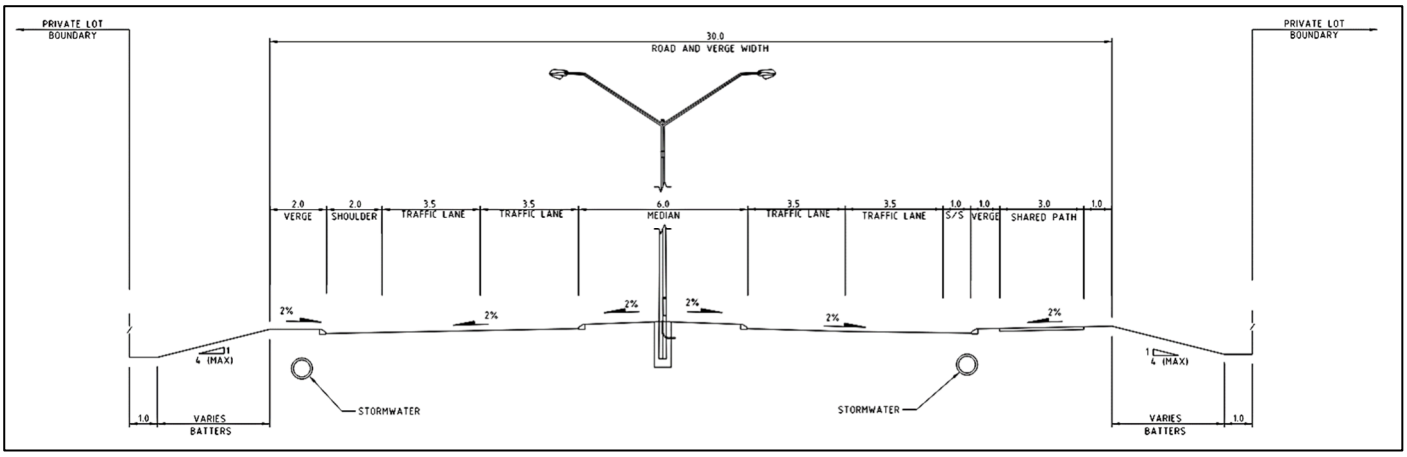


Figure 4.2 – Typical Cross Section for Area 1

The cross section for Area 1 features

- 6m median width allows for a southbound U-turn lane for the existing composite lots west of Mandogalup Road; and also right-in & LILO access to the existing place of worship to the east. This also generally aligns with median widths on dual carriageway roads in the City of Kwinana.
- 2m western verge, 5m eastern verge (allowing for a shared path and fencing as needed). The 3m shared path on the east is to cater for cyclist coming from the east. i.e. new Anketell Road shared path.
- 2m western shoulder allowance for on-road cycling which also acts as additional width to account for LILO vehicles braking as they enter special rural lots.
- 1m eastern shoulder – no allowance for on-road cycling. The assumption is for the cyclist to utilise the 3m shared path.

4.1.2 Area 2

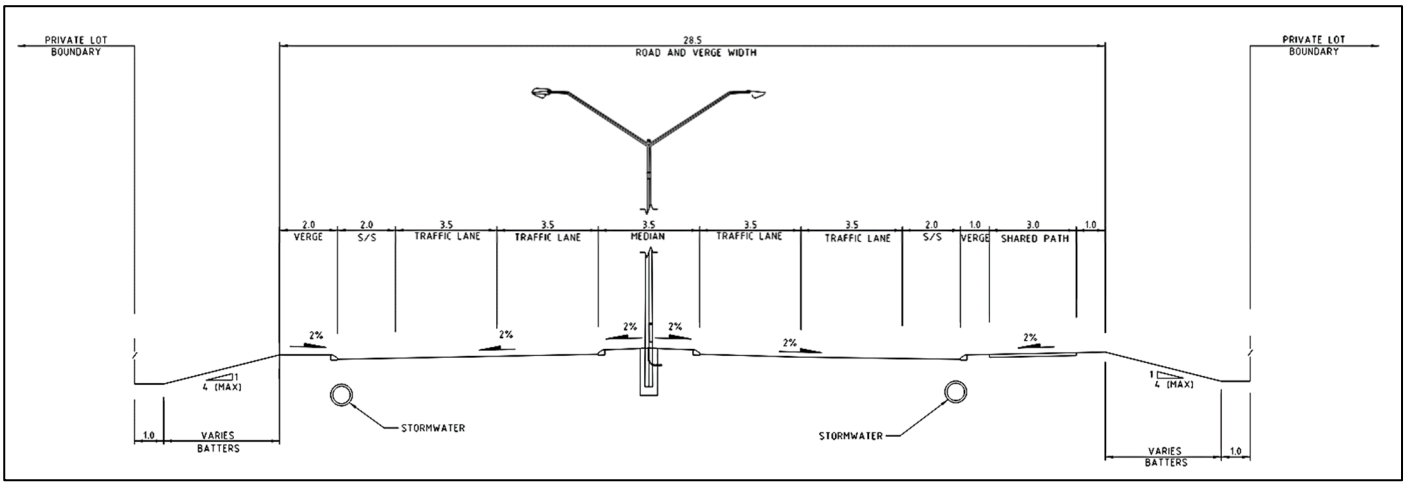


Figure 4.3 – Typical Cross Section for Area 2

The cross section for Area 2 features

- 3.5m median with streetlight as minimum prescribed by MRWA standards. No allowance for slip lanes / turn pockets as the southern RB and central RB can be utilised as pseudo U-turn facilities.
- 2m shoulder width allowance for on-road cyclist from Area 1 and new Clementi-connector-road
- 2m western verge, 5m eastern verge to accommodate the 3m shared path.

4.1.3 Area 3

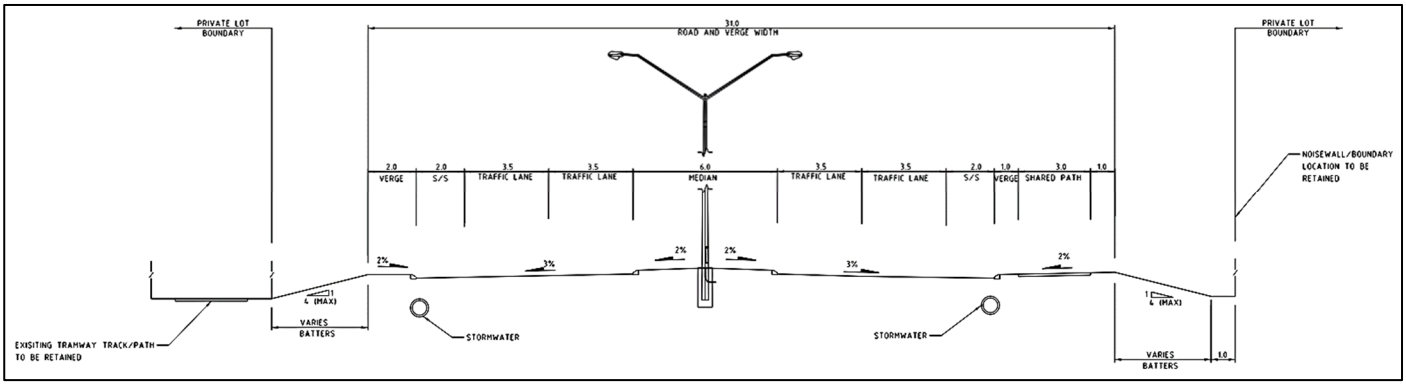


Figure 4.4 – Typical Cross Section for Area 3

The cross section for Area 3 features

- 6m median width allows for turn pockets at new signalised intersection and future U-turn lanes.
- 2m shoulder widths continued from Area 2 allowing for on-road cycling
- 3m shared path continued from Area 2 on the eastern side
- 20m Tramway reserve allowance to the west of the new Hammond Road reserve

4.2 Tramway Reserve

Whilst tramway legal cadastre terminates just south of existing Norkett Road-Mandogalup Road Intersection (new central roundabout), an existing Park and Recreation reserve already exists for the tramway north of this location. The new road design reflects this arrangement with the 20m wide tramway reserve abutting the western verge of the new Hammond Road as shown on Figure 4.4.

4.3 Road Alignment & Vertical Geometry

On the southern end of the study area, the upgraded Mandogalup Road is designed to tie into Anketell Road, which forms part of MRWA's Westport project. The Anketell Road-Mandogalup Road intersection is proposed to be a signalised intersection as interim solution with an ultimate grade separation of the freight only corridor over the signalised intersection. The extent of this intersection upgrade falls outside the scope of this road reserve review study. The extent of the Westport Anketell Road/Mandogalup Road intersection works terminates immediately north of the temple access.

The first 600m of the new road alignment is dotted with existing residential lots to the west and to a lesser extent, up to CH1700 just before the northern portion of Bush Forever Site 268. To minimised impacts to the residents in the first CH600, the horizontal alignment deviates slight east in order to create enough space for a 'pseudo' service road for access to Lot 69 and 70, just before the southern roundabout.

The vertical geometry then rises to approximately RL 22mAHD at CH 750 then falls gently. There is a set of 260R reverse curves from approximately CH650 to CH1100 as the road joins the central roundabout.

North of the central roundabout, it features another set of a wider reverse curves of approximate 280R and 350R. This occurs approximately between CH1400 and CH2000. To the east at approximately CH 1100 to CH 2000, there is a partially drained swamp and Water Corporation's Main Drain that the road alignment and associated earthworks have been designed to circumvent.

At CH1800, the new road alignment also climbs quickly as it follows that of the existing topography. As there is a natural cross fall from west to east, the new road design requires retaining walls in order to stay within the existing MRS as far as reasonably practicable. Towards the north, there is also a Western Power 330kV corridor that bisects the alignment at approximately CH2300, an existing sand quarry site to the west and another pristine bushland to the east. Section 4.3.1 below provides a summary of constraints that influenced the design, often striking a balance between desirable design and acceptable social / environmental outcomes.

4.3.1 Design Constraints

4.3.1.1 Area 1 – CH 0 to CH 600

Chainages & Constraints	Design approach
CH 0.00 to CH 600 To the west, there are existing rural residential lots to be considered. To the east, there is an existing place of worship.	To achieve an acceptable social outcome for the community, the southern roundabout has been shifted north-east of the existing road reserve to avoid impact to these lots. The design has also opted for a short service road to services 2 of northernmost lots, whilst others have LILO access arrangements with U-turn facility and a roundabout. The access to the existing place of worship has been designed to be LILO and right-in with a proposed low retaining to contain road footprint. The overall access strategy is further discussed in Section 4.6.
CH 200 Water Corporation Main Drain crossing road alignment	The impact on this asset has been mitigated by reducing cut in the existing alignment, retaining the status quo of levels. This has the added benefit of reducing cut or fill batters spilling outside of the road formation, minimising the road reserve footprint.
CH 200 to CH 600 Threated Ecological Communities (TEC) to the east	The new alignment has been carefully considered to reduce impact on the TEC (Banksia Woodland) area to the east. As mentioned above, the road vertical profile is maintained as close to the existing as possible, to reduce high differentiate, whilst also conforming with Austroads/MRWA design standards. A retaining wall is also proposed to reduce an otherwise larger road footprint.

Table 4.2 – Area 1 Constraints

4.3.1.2 Area 2 – CH 600 to CH 1300

Constraints	Design approach
CH 600 Southern roundabout north-east shift	The north-east RB shift in 'Area 1' has resulted in encroachment into existing eastern lots that were less impacted. While the design avoids impacts to existing dwellings and businesses in this area, some minor realignment of driveways and accesses will be required. The road alignment between the southern and central roundabouts has been centralized within the nominated corridor resulting in land impacts to Lot 49.
CH 600 to CH 1100 The existing road reserve's horizontal curve is sub-optimal for design speed	The existing ORR boundary features tight radii of approximately 260m R. This is less than the minimum 310m R for desirable superelevation, e=4.5% as prescribed by MRWA. Hence, the existing boundary is deemed not conducive to a speed environment of 80kmph. However, it is expected that the operating speed in this area is likely to be less than that, due to the short distance between the two roundabouts and a set of reserve curve. In addition, based on first principle calculation of 'f (des max)', minimum radius of 243m R is required at 80kpmh and 164m R at 70kmph. Please see Table 3.3 for these values.
CH 850 Dampier Bunbury Gas main crossing road alignment	The impact on this asset has been mitigated by reducing cut in the existing alignment, retaining the status quo of levels. This has the added benefit of reducing cut or fill batters spilling outside of the road formation, minimising the road reserve footprint.

Constraints	Design approach
CH 1000 to CH 3000 Tramway reserve	The majority of the tramway reserve is in Area 3, please see Table 4.4 for discussion
CH 1100 to CH 1300 Drained swamp to the east and Acid Sulphate Soil risk (ASS)	The anticipated poorer soil properties in the north-eastern section of area 2 have prohibited the placement of any large basins due to its low infiltration rate. In addition, technical reports provided by DPLH show moderate to high ASS risk.

Table 4.3 – Area 2 Constraints

4.3.1.3 Area 3 – CH 1300 to CH 3000

Constraints	Design approach
CH 1000 to CH 3000 Tramway reserve	There is an existing listed tramway corridor on Clementi Road, and it joins the project corridor near the central roundabout. From that point on, the existing tramway corridor runs north along existing Norkett Road and connects into an existing Parks and Recreation reserve near the end of Norkett Road. The tramway corridor is proposed to be extended north to the future Rowley Road interchange. The proposed tramway corridor will be located on the west side of the new road alignment and with a nominal 20m reserve width.
CH 1300 to CH 1950 Drained swamp to the east and Acid Sulphate Soil risk (ASS) & Water Corporation Main Drain	The anticipated poorer soil properties as mentioned in above Table 4.3 – Area 2 Constraints is also applicable in this area. Two smaller basins have been placed on the outskirt of the clayey ASS-risk area in order to maximised developable lands and achieve desirable social outcome of minimizing disruption to nearby properties. The Water Corporation Main Drain is also an additional constraint. This is seen as a critical asset that should not be encroached, including any new earthworks batter.
CH 1650 to CH 2250 Bush Forever area to the west and sloping existing terrain	In this area, the existing terrain slopes down considerably to the east. This coincides with the Bush Forever site 268 on the west side of the alignment. A retaining wall is to be constructed in-lieu of earthworks batter to avoid any works in the Bush Forever site.
CH 1900 to CH 2000 Walled basin	A basin has been proposed in this area in an effort to minimise road footprint downstream (south). Due to its sloping topography, a retaining wall is proposed against the basin on one side in order to combat an otherwise large basin batters.
CH2250 to CH 2400 Western Power 330kV powerline and easement	An existing 330kV powerline corridor crosses the proposed signalised intersection. Consultation with Western Power will be necessary to understand vertical and horizontal clearances between the road and the powerline. The alignment of the new signalised intersection clashes with the 330kV towers. We see this as a major project risk. This will require costly relocation of the towers or the relocation of the intersection to the south with implications to developable lands.

Constraints	Design approach
CH 2400 to CH 3000 Quarry site to west, TEC site to the east	The sand quarry site to the west has been mined to a reduced level of approximately 18m AHD. Its interaction with the new Hammond Road results in extensive batters as new Hammond Road finished level is approximately 35m AHD. Significantly lowering the profile of the new Hammond Road will have significant impacts to the TEC (Banksia Woodland) site to the east. Retaining walls might be a possible partial solution, as any bottom-up walls such as limestone or L-shaped will need temporary sheet piles / cut batter to the wall footing level. Any top-down approach such as bored piles has significant cost implication. In addition, any notable level changes will need to be communicated to MRWA as the planning for future Rowley interchange is in progress.
CH3000 and beyond New Hammond Road's proximity to future Rowley Road interchange	The new Hammond Road alignment ties in both horizontally and vertically to the currently available Rowley Road interchange design. However, as part of an external stakeholder engagement with MRWA, the proximity of Hammond's new northern RB came into question. MRWA indicated that the roundabout needed to be 300m from the on-off ramp of Rowley interchange. As a result, the roundabout was moved further south, and its original location was replaced with a LILO.

Table 4.4 – Area 3 Constraints

4.4 Roundabouts & Intersections

This section documents the design approach to undertaking the roundabout design. Fundamentally, a good roundabout design is one that reduces:

- approach speed pre-entry; and
- angle of conflict when a conflict does happen.

To achieve the approach speed criteria, Austroad prescribes a maximum approach entry radius of 55m and pre-deflection (i.e. a set of closely-spaced reserve curve) if speed is above 80 km/h. Further discussions are provided in the following table.

Design Feature	Design approach
Roundabout pre-deflection	Austroad notes that pre-deflection on roundabout approaches is desirable (not mandatory) in speed environments greater than 80 km/hr. The proposed posted speed on Hammond/Mandogalup Roads will be 70 km/hr. In particular, in the section of Hammond/Mandogalup Roads between the central roundabout and Anketell Road, the operating speed is likely to be less given the closely spaced intersections. Austroad also notes that pre-deflection curves are most effective on single lane approaches. Given the new road will be designed to cater for RAV vehicles, pre-deflection often produces wider traffic lanes which then reduces the effectiveness of speed control for light vehicles. Based on the above, pre-deflection curves have not been provided in the current design. It should also be noted that this design approach also minimises the road footprint to stay within existing road reserve corridor as much as possible. Alternative speed mitigation treatments such as raised safety platforms can be considered. Past projects with such implementations are Armadale-Northlake Road project and the Leach Hwy/Welshpool Road grade separated roundabout. The platforms provide the added benefit of controlling vehicle speeds on approach to pedestrian crossings.

Design Feature	Design approach
Offset roundabout	Designing roundabouts on heavy vehicle routes can be challenging in terms of satisfying Austroads roundabout design requirements. This is further exacerbated by the need to minimise the design footprint to maximise the benefits of the Mandogalup Improvement Scheme. In order to meet the required Austroads 55m entry radius criteria, the approaches to the roundabout have been offset. In essence, the design shifts the approach lanes towards the median and results in a tighter approach radius.

Table 4.5 – Roundabout Features

4.4.1 Area 1 - Southern Roundabout

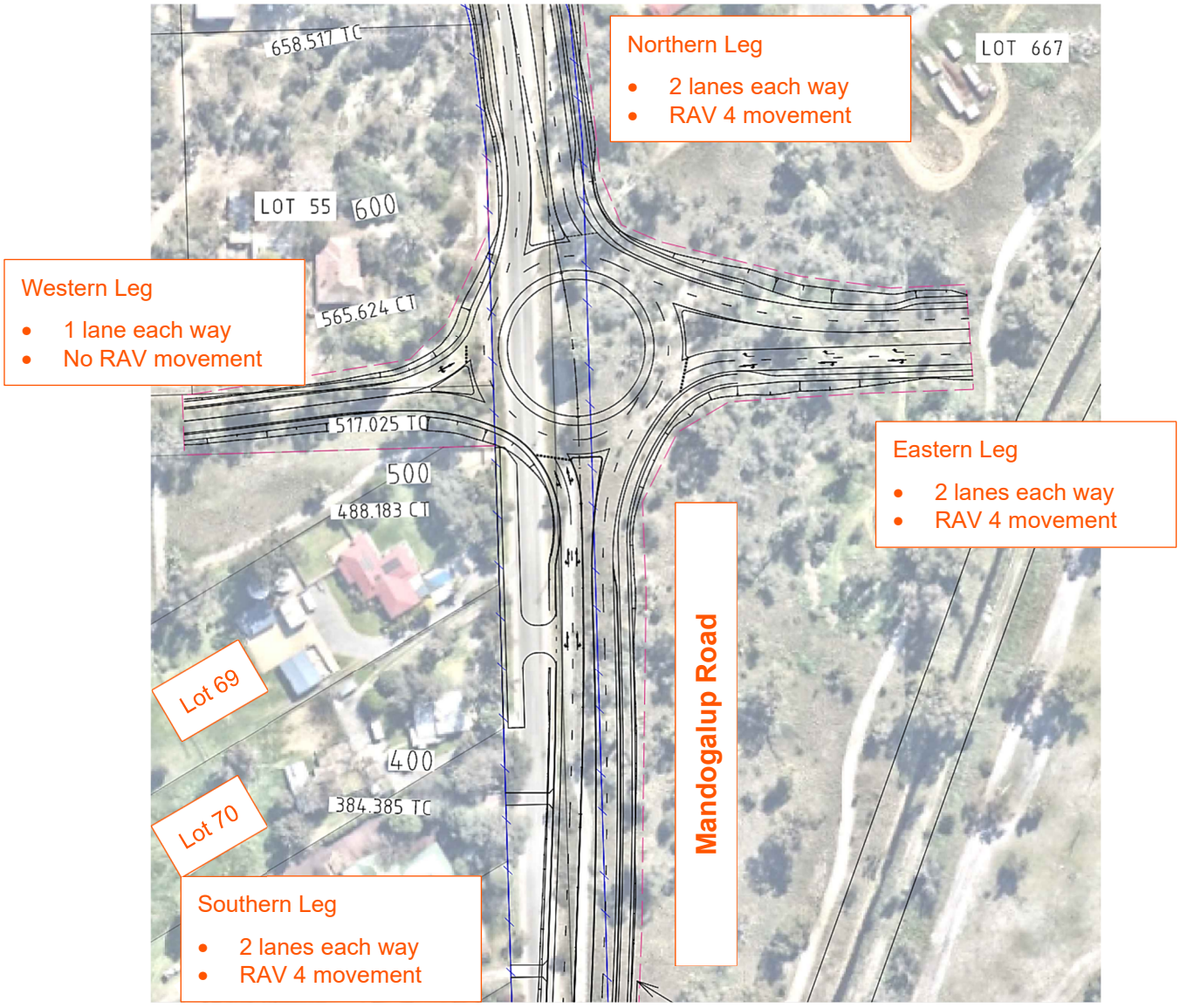


Figure 4.5 – Southern Roundabout

The southern roundabout features

- A roundabout radius of 26m with a 3m wide over-run apron to facilitate RAV vehicles' trailer encroachment during turning manoeuvre.
- Western leg leads to existing Clementi Road and is not designed for RAV movements.

- Design vehicle is RAV 4 for northbound, southbound movements through this southern roundabout. Additional RAV 4 movements on the eastern leg have been allowed for.
- The roundabout was originally located centrally within the current road reserve corridor but has been shifted as part of the access strategy. For further detail, refer to Section 4.6. The original roundabout location was closer to Lot 69, impacting the existing driveway access as well as being in close proximity to the property's entertaining area. To achieve a better social outcome, the roundabout was shifted north-east to reduce impacts to Lot 69.
- Immediately to the south of the roundabout, a service road has been designed to facilitate access to existing Lot 69 and Lot 70 as direct accesses would be too close to the roundabout entry. The access strategy is further discussed in Section 4.6.

4.4.2 Area 2 – Central Roundabout

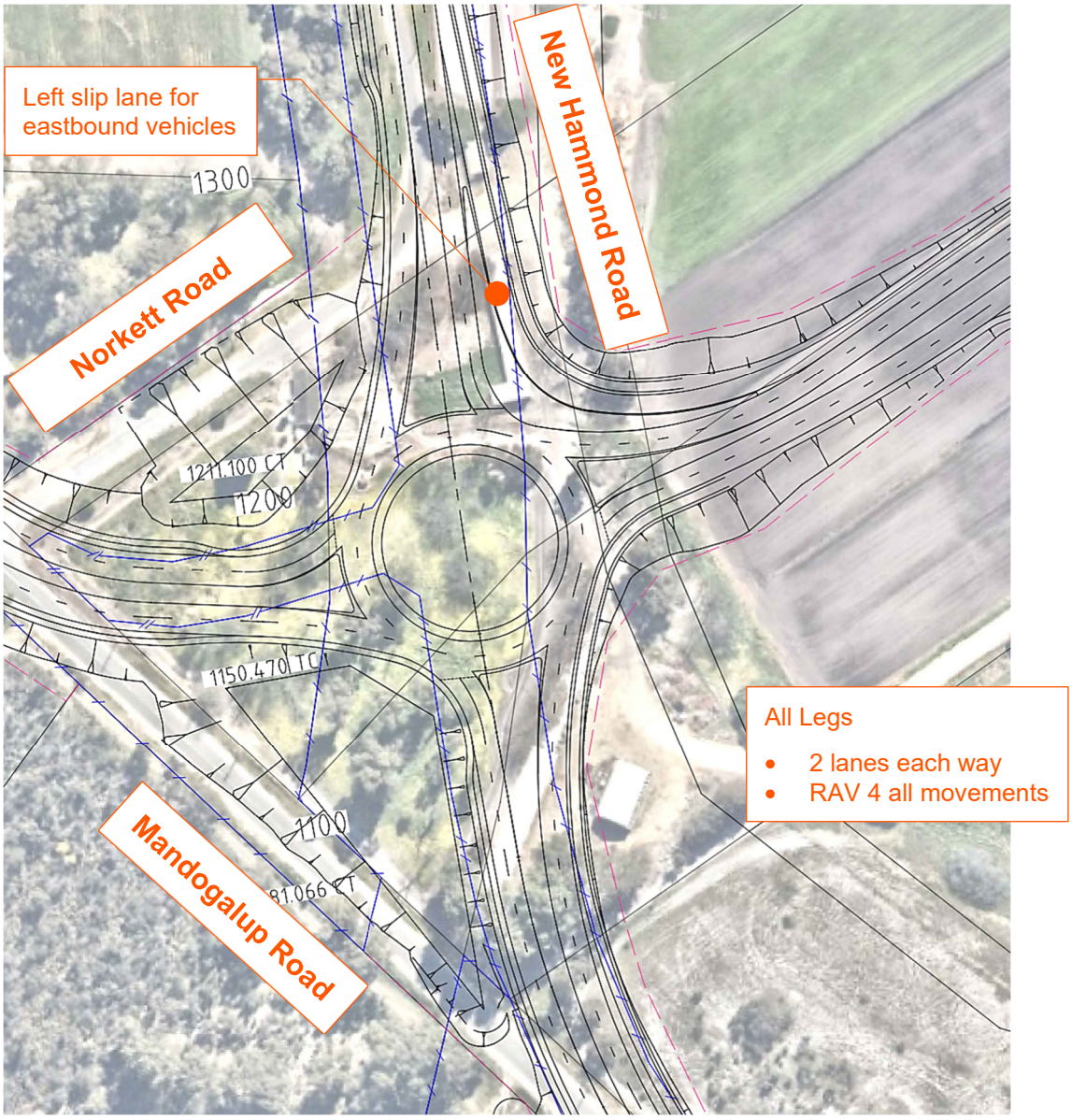


Figure 4.6 – Central Roundabout

The central roundabout features

- A roundabout radius of 30m with a 3m wide over-run apron to facilitate RAV vehicles' trailer encroachment manoeuvre.
- A new western leg that connects existing Mandogalup Road with the new dual carriageway. It is worth noting that the existing Mandogalup Road is a single carriageway unkerbed road.

- Approach sight distance on the western leg is controlled by the horizontal alignment that has been limited to stay within the existing MRS corridors as much as possible. Additional delineation will be necessary to highlight the sharper curvature and reinforce the need to slow down on approach to the roundabout.
- A new access road for the eastern leg. The eastern section of this area is a partially drained swamp with ASS risk.
- Design vehicle is RAV 4 for all movements.

4.4.3 Area 3 – All Movement Signalised Intersection

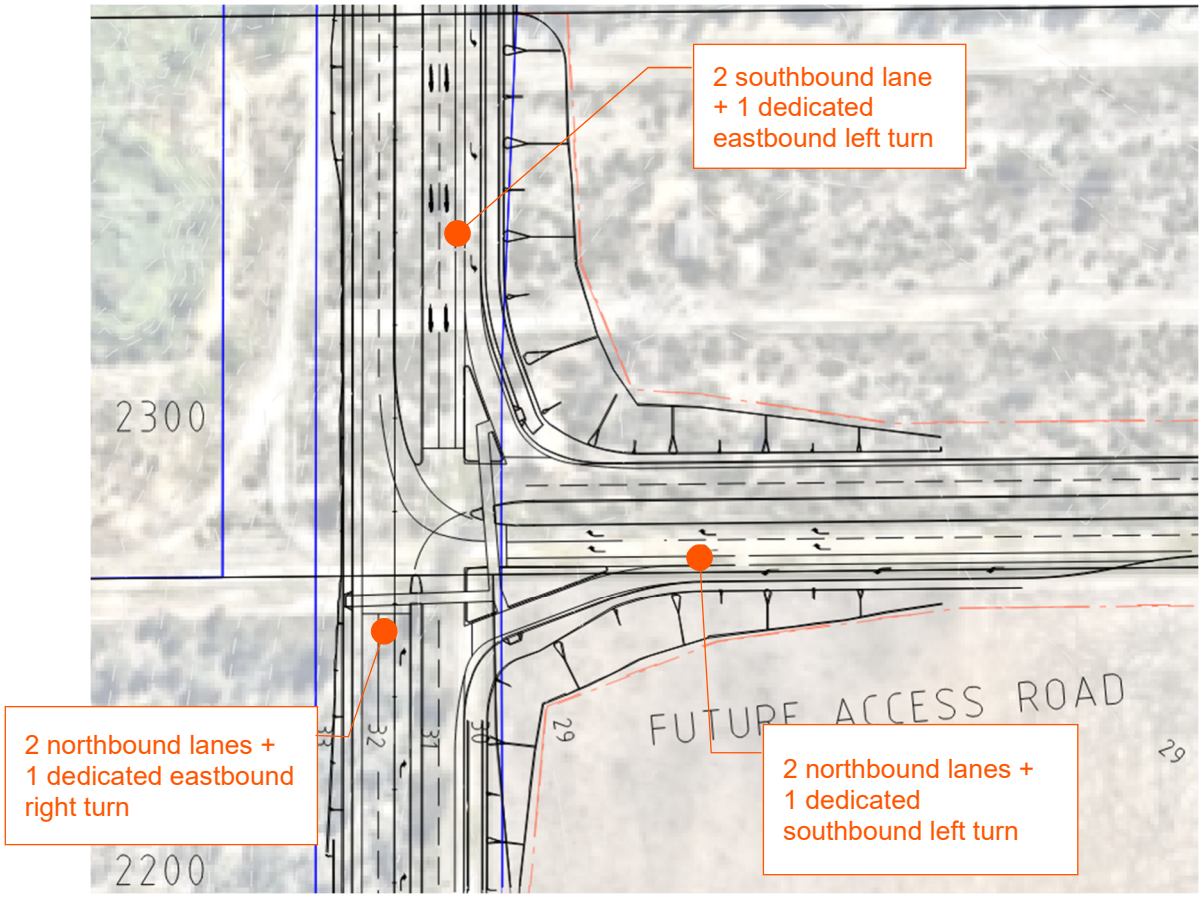


Figure 4.7 – Signalised Intersection

The proposed intersection layout was based on SIDRA assessment undertaken by DPLH. The features of the intersection are listed below.

- There are 2 northbound-only traffic lanes and 1 dedicated north-to-east bound right-turn lane.
- There are 2 southbound-only traffic lanes and 1 dedicated south-to-east bound left turn lane.
- On the eastern leg, there are 2 northbound-only lanes and 1 dedicated west-to-south bound left turn lane.
- An as of right vehicle (19.0m semi-trailer) has been assumed as the design vehicle for the eastern leg.
- This intersection bisects Western Power 330kV corridor and possibly impacts one of the 330kV angle towers. The risk and resolution is discussed in Table 4.7.
- It is also worth noting that any signalised intersection requires the approval of MRWA through their traffic signal approval process.

4.4.4 Area 3 – Northern Roundabout

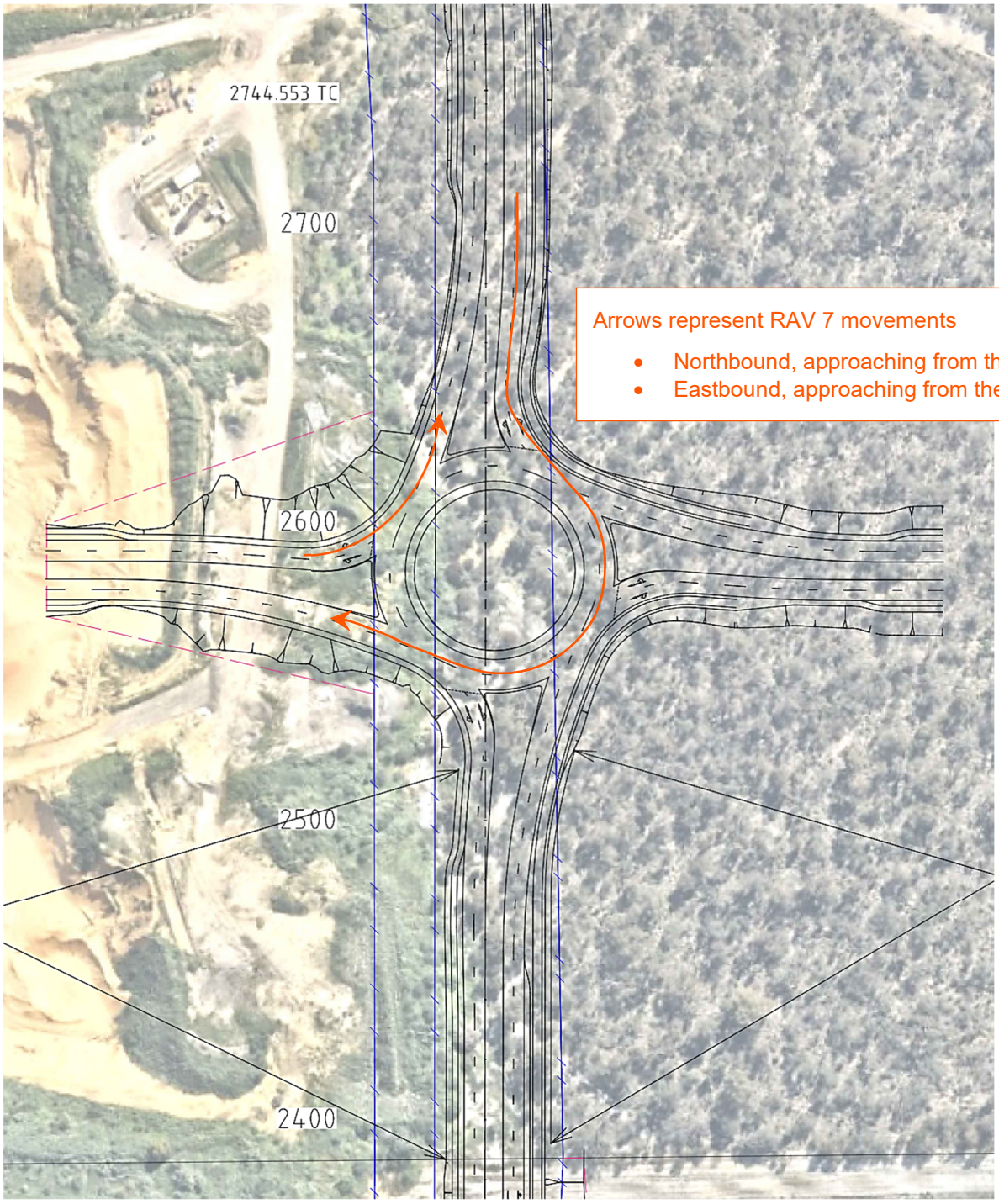


Figure 4.8 – Northern Roundabout

The northern roundabout includes the following features:

- A roundabout radius of 30m with a 3m wide over-run apron to facilitate RAV vehicles' trailer encroachment manoeuvre.
- New western leg interfaces with an existing sand quarry site. The discussion is listed in Table 4.4, under '*CH 2400 to CH 3000 Quarry site to west, Bush Forever to the east*'.
- New eastern leg provides connectivity to the future subdivision and interacts with an Environmentally Sensitive Area as listed in Table 4.4
- The western leg (access road) has been designed to accommodate RAV 7 movements to and from the Rowley Road interchange.

- This roundabout was originally designed 200m north of this location. Based on MRWA's advice regarding minimum separation to the future Rowley Road Interchange, the intersection locations in this area was revised to maximise separation to the roundabout.

4.4.5 Area 3 – LILO Un-signalised Intersection

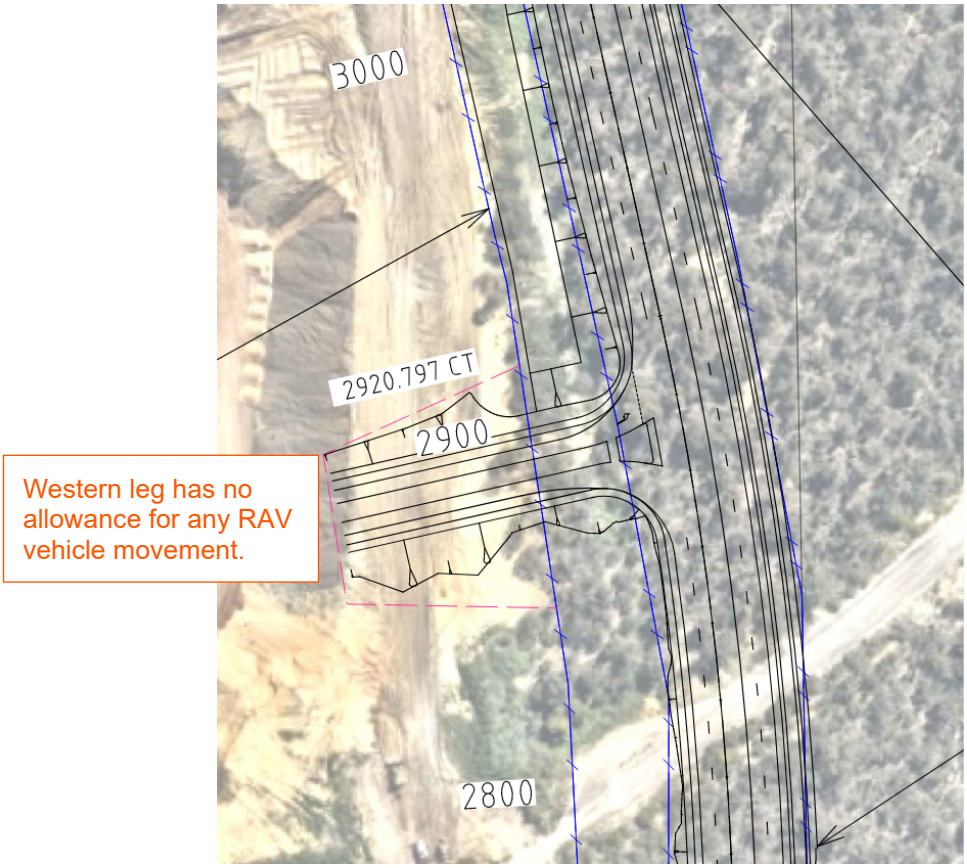


Figure 4.9 – LILO Intersection

The features of this LILO (Left In, Left Out) intersection are outlined below:

- As noted above, this intersection location has been repositioned to improve traffic flow between the Rowley Road interchange and the northern roundabout.
- The design makes no allowance for any RAV vehicle entry or exit on the new eastern access. All RAV vehicles are expected to use the northern roundabout access instead as there is a greater separation to the Rowley Road interchange; thus, enhancing acceleration and lane changing opportunities for RAV vehicles.
- As with the northern roundabout, this intersection interfaces with the existing sand quarry site on the west and an ESA on the east as listed in Table 4.4.

4.5 Drainage

There are no existing formalised pits and pipes in the area, as anticipated of a rural standard unkerbed road. Stormwater in its existing state sheet-flows to the road verges and/or roadside table drains where provided. Based on report from JDA, 2023, and as indicated in Section 1.3.2 – District Water Management Strategy, a big portion of the surface water makes its way to Water Corporation's Main and Subdrain, with surface water on the northern-eastern portion of the site infiltrating in ground.

As part of this reservation study, the duplication of the road to current standards results in kerbing for the full extents of Mandogalup/Hammond Roads. Hence, the proposed drainage strategy is to capture road runoff via pit and pipe drainage networks into designated basins. The basin locations have been proposed and sized to inform additional

land requirements. The general spatial constraints for the road layout, as per discussed in Section 4.3.1, can also be applied to basins. Table 4.6 below outlines the basin information and should be read in conjunction with Table 3.4. It is important to note that assumptions made regarding infiltration rates and substrate types need to be verified at the next stage of the design, with refinement and basin down-sizing a possibility. It is worth noting that Basin 1, 3A and 3B are modelled with 'Shallow Water' model in PC Sump. Basin 1's base RL is within 1m of maximum groundwater level, whereas Basin 3A and 3B are situated on the outskirt of expected clayey area.

Basin ID	Chainage	Model	Basin Base Area	Basin Base RL	*Allowable Max. TWL	Catchment Area	Calculated Max. TWL
1	CH 100 - 200	Shallow Water	3000m^2	13m AHD	13.9m AHD	Impervious 2.6ha Pervious 0.7ha	13.85m AHD
2A	CH 1100 - 1150	Deep Water	3100m^2	16.2m AHD	17.4m AHD	Impervious 3.1ha Pervious 1.8ha	16.84m AHD
2B	CH 1200 - 1250	Deep Water	570m^2	16.7m AHD	17.9m AHD	Impervious 1.2ha Pervious 0.6ha	17.82m AHD
3A	CH 1500 - 1600	Shallow Water	650m^2	16.4m AHD	18m AHD	Impervious 1.2ha Pervious 0.9ha	17.99m AHD
3B	CH 1900 - 2000	Shallow Water	1300m^2	18.9m AHD	20.9m AHD	Impervious 1.9ha Pervious 1.2ha	20.75m AHD
3C	CH 2900 - 3000	Deep Water	1350m^2	30.3m AHD	32.1m AHD	Impervious 3.3ha Pervious 1.4ha	32.08m AHD

Table 4.6 – Basin Sizing

*Allowable TWL with 300mm freeboard to the road

4.6 Access Strategy

The vehicle access strategy has been informed by the Improvement Scheme and the nominated access locations for the planned development. The new Hammond Road will effectively become a control of access road with limited frontage access. In the southern section of the project area. the new Mandogalup Road alignment needs to consider implication on existing properties and their accesses.

In Area 1 as shown Figure 4.10, existing properties to the west are impacted. Several access strategies were discussed with DPLH and considered. They are listed below.

- Option A – Frontal service road has impacts to dwellings with approximately six dwellings impacted. Lot 69 is a dog training business and is significantly impacted. This option also has a bearing on the existing heritage-listed 'Soldiers Settlement' lot 70, 73 and 74.
- Option B – Rear service road has benefits – avoids dwellings, possible connector road to lots east of Water Corporation Main Drain easement but will require egress towards the bushfire area. Lot 69 is impacted least compared to Option A.
- Option C – Direct access LILO is a good option but does not comply with access strategy objectives i.e. limiting direct property access onto ORR. However, the roundabout does allow for U-turn movements and a median U-turn facility to the south.
- Option D – Possible option of shifting roundabout to the north or to the east. Both have land impacts, and the eastern option impacts developable land and Tuart Woodlands/TEC; whereas northern option impacts Lot 55.

Option D was preferred by DPLH and subsequently the roundabout was shifted northwest.

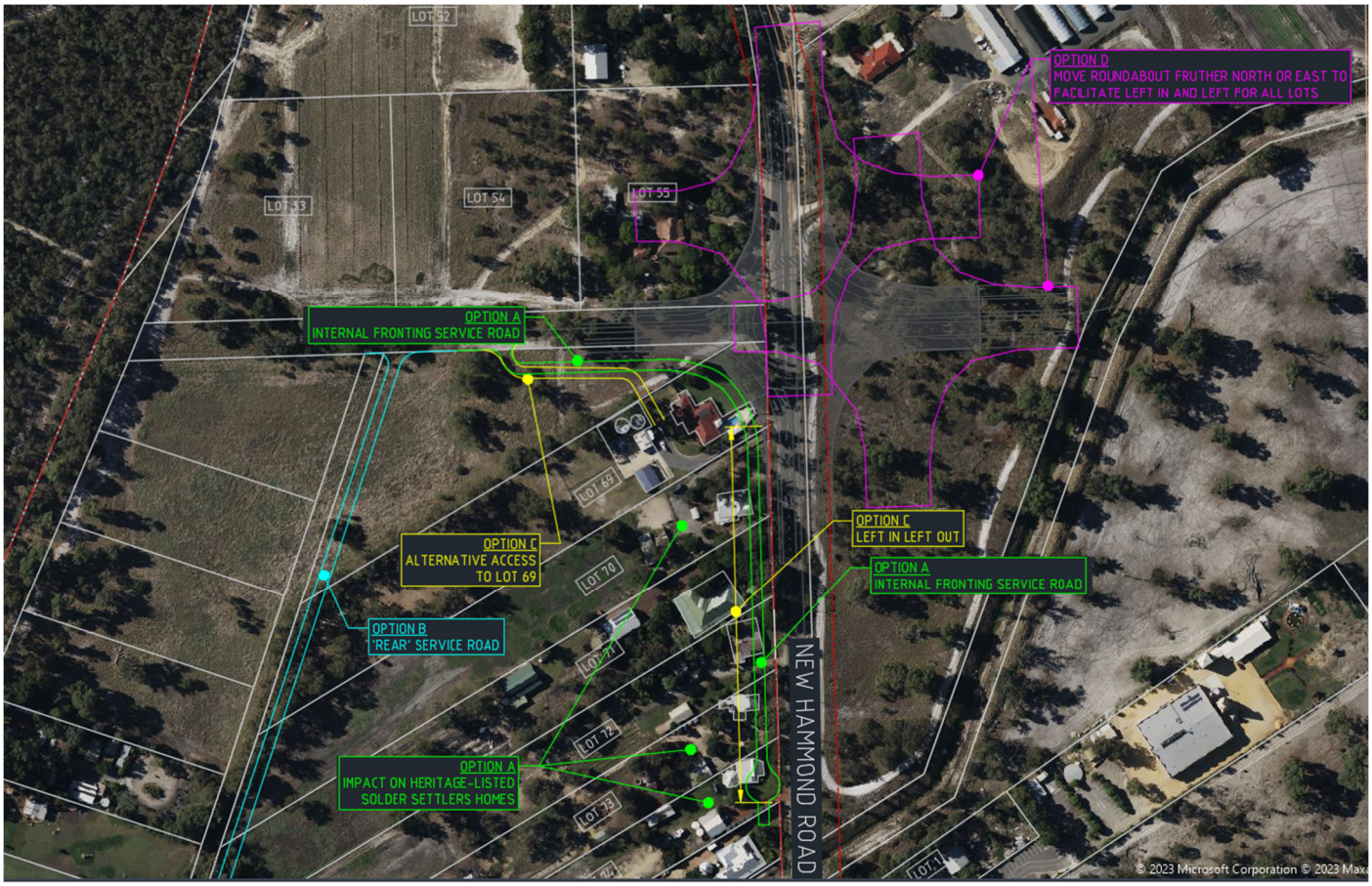


Figure 4.10 – Access Strategy in Area 1

In Area 2 as shown in Figure 4.11, the four options are listed below.

- Option 1 – Clementi extension to facilitate access to land locked Lot 51 & 52. Clementi Rd reserve north of connector road may present environmental challenges and will require careful consideration.
- Option 2 – Internal service roads share the land impacts amongst landowners and provides safer access onto a low volume road
- Option 3 – LILO option, although does not comply with access strategy objectives i.e. limiting direct property access onto ORR, but it has least amount of 'impact' in this situation

Subsequently, DPLH provided feedback on their preference for Option 3.

Figure 4.11 – Access Strategy in Area 2

4.7 Pedestrians and Cyclists

Within the project study area, there are limited pedestrian path facilities and insufficient shoulder width for on-road cycling. Both Anketell Road and Rowley Road also have limited active transport infrastructure. Based on Strava, a widely used pedestrian/cycling app, cyclists frequent the existing Mandogalup Road and utilise it as a north-south connector, as a secondary option to Kwinana Freeway's PSP, as shown in Figure 4.12. Given the lack of facilities, no pedestrian activity has been recorded on Strava along Mandogalup Road.

The DoT Long Term Cycle Network (LTCN) Plan provides direction for future active transport infrastructure to ensure that both state and local governments continue to deliver improved cycle networks throughout the state. Adjacent to the project area, the LTCN Plan, as shown in Figure 4.13, maintains the primary PSP route on Kwinana Highway while developing additional primary route corridors along Rockingham Road to the west and Rowley Road to the north. Anketell Road is to become a secondary cycle route connecting between the primary routes along Rockingham Road and the Kwinana Freeway. Hammond Road, north of Rowley Road, is proposed as a secondary route. With the planned development through the Mandogalup Improvement Scheme, it is prudent to consider a secondary path network between Rowley Road and Anketell Road.

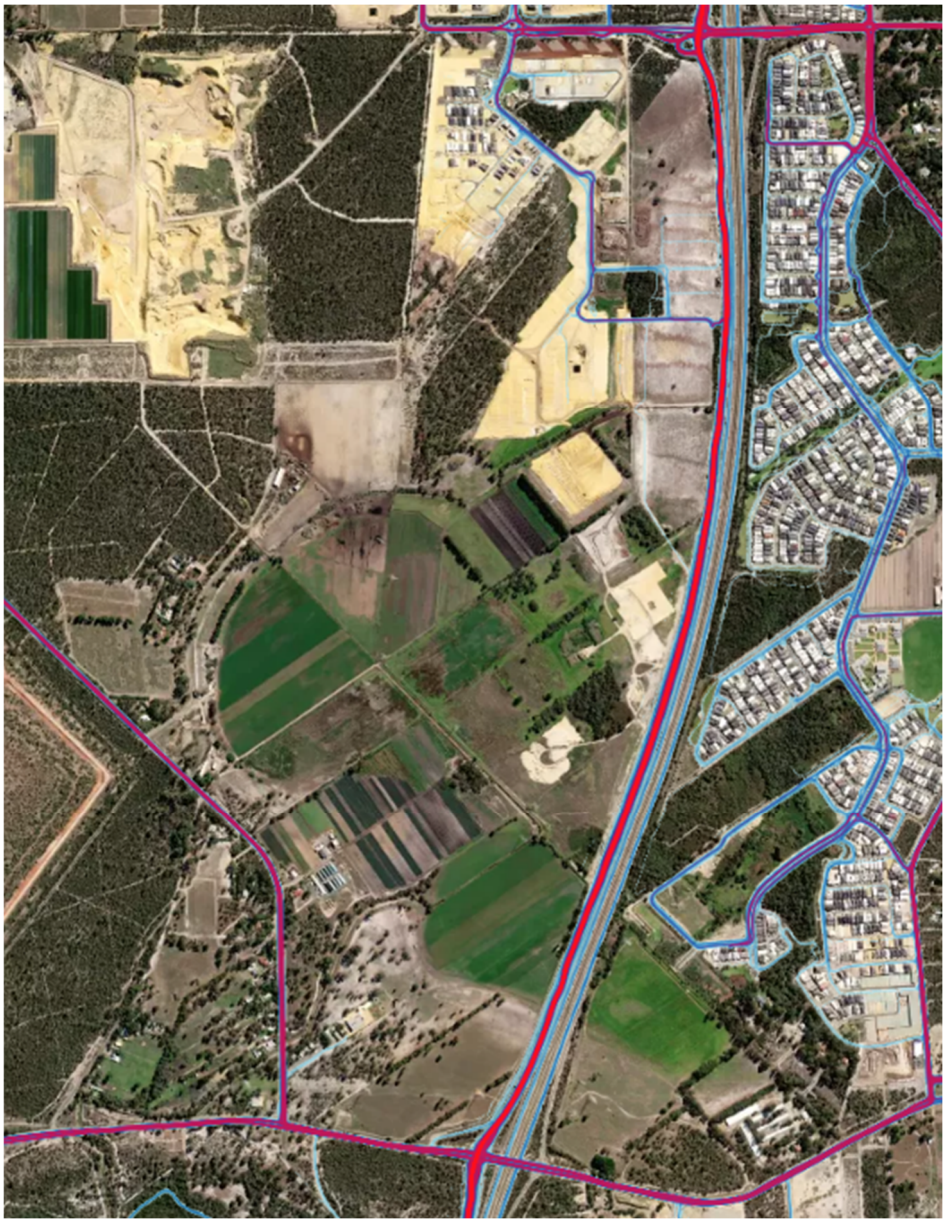


Figure 4.12 – Cyclist Strava Heatmap (source: Strava)

*A stronger red represents higher used frequency. For instance, Kwinana Fwy has a higher usage than the existing Mandogalup Rd.

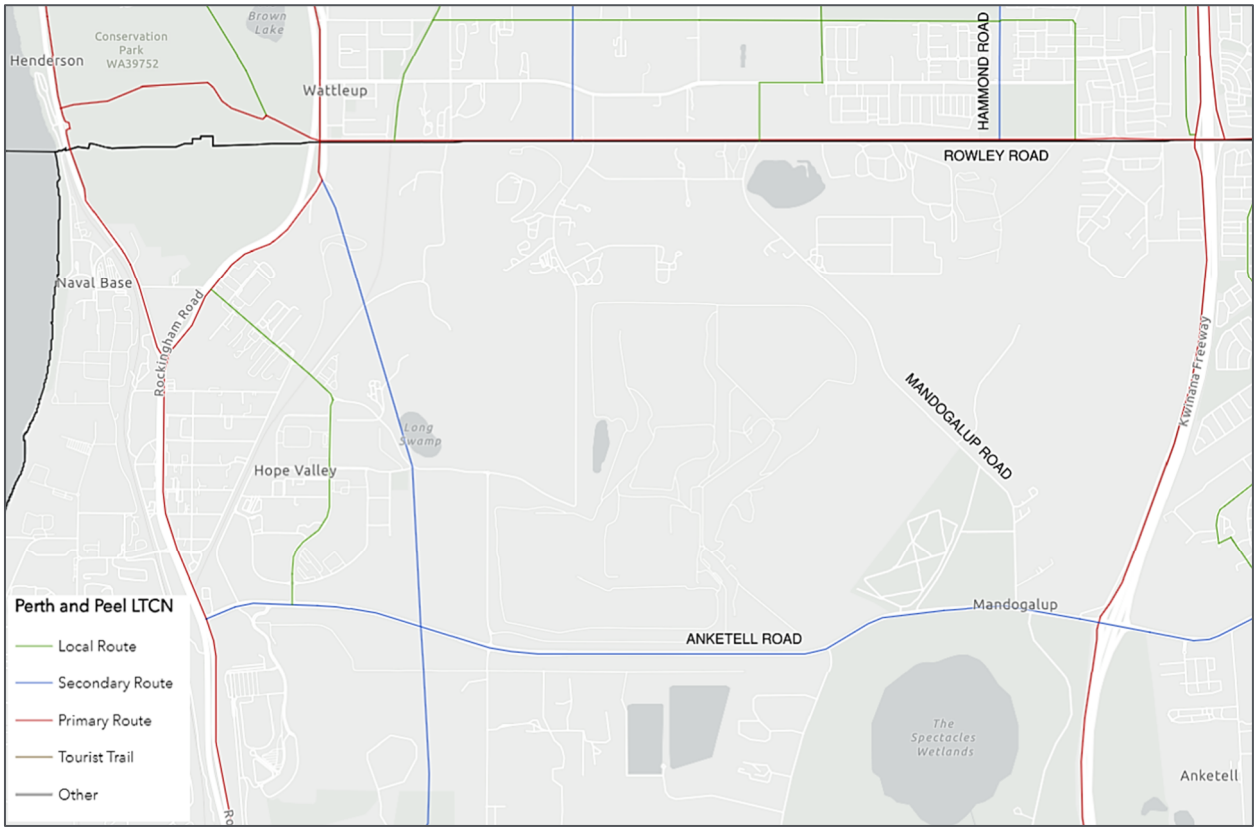


Figure 4.13 – DoT Long Term Cycle Network Plan (source: DoT)

With the establishment of MRWA's Westport Project and its associated road network upgrade in the area, it is anticipated that cyclist volume should rise with new active transport infrastructure to support the demand. As a result, incorporating active transport infrastructure as part of this project is prudent.

As per Section 4.1 – Typical Cross Section, the road design has incorporated varying degrees of active transport infrastructure either on its shoulders or verges. They are as below.

- Area 1
  - On the west side, 2m wide shoulder
  - On the east side, 1m wide shoulder with a 3m shared path
- Area 2 and 3
  - On the west side, 2m wide shoulder
  - On the east side, 2m wide shoulder with a 3m shared path

4.8 Public Transport

There are currently no existing bus routes in the area nor any anticipated future planning information available. The new road layout has not allowed for bus embayments nor dedicated bus lanes, but localised verge widening is possible to accommodate bus stops. It is expected that public transport demands will be generated by the activation of the Improvement Scheme and Hammond Road will likely become an important north-south corridor to provide connectivity to the train stations along Kwinana Freeway. PTA is to be consulted for clarity for future bus route and associated provisions.

4.9 Utilities

There is no existing Water Corporation sewer or water infrastructure in the area. However, as noted in Section 4.3.1 – Design Constraints, there are various Water Corporation Main and Sub-drains in the area. They are at

- Approximately CH 200, with the new Mandogalup Road widening and road crossing over it. Our design vertical geometry of the road ensures the current cover to the Main Drain is kept, maintaining the status quo.

The existing Main Drain culvert structure will need to be extended to accommodate the extra width of the new road.

- Approximate CH 1300 to CH1950 to the east of the new road alignment. The new road alignment and its batter do not encroach into the WC easements

There are also Western Power infrastructure as noted below:

- Overhead distribution lines that run on the east site of the new Hammond Road from CH0 to approximately CH1800 as formalised road formation terminates on the existing Norkett Road. These distribution lines can be undergrounded quite readily.
- There is a 330kV transmission line easement at approximately CH 2250 to CH 2400. At this location, one of 330kV angle towers clashes with the signalised intersection. This design risk is documented in Table 4.7.

There is also a critical gas main, known as Dampier Bunbury Natural Gas Pipeline, which crosses the new Mandogalup Road at approximately CH 850. The impact on this asset has been mitigated by minimising new earthworks across asset.

4.10 Design Risk

In this section, we endeavour to discuss risk, their perceived severity, and resolution.

Risk	Severity	Resolution
Overhead 330kV in area 3 is clashing with the signalised intersection. CH 2300	Significant risk	Perform a feature survey to determine exact location of towers. If a clash exists, either relocate the signalised intersection south or the clashing 330kV power tower.
Overhead 330kV in area 3 is close to the new Hammond Road CH2350	Moderate risk	Perform a feature survey to determine exact location of towers. Liaison with Western Power to confirm required vertical clearance and horizontal offsets. Retaining walls can be proposed to mitigate batter spills
Access to Lot 2 at the roundabout to be confirmed CH2600	Moderate risk	DPLH to coordinate with developers to confirm access location and boundary.
Infiltration rate at the outskirt of partially drained swamp CH1550 and CH1950	Moderate risk	Two smaller basins have been proposed at the outskirt of the partially drained swamp. High level GIS shows a clayey soil condition and ASS-risk prone. It is recommended a geotechnical investigation is performed to ascertain infiltration rate and thickness of clogged layer.
Geotech drainage infiltration input	Low risk	We have assumed an infiltration rate of 2m/day. This needs to be further confirmed by geotechnical investigation with in-situ testing.
Quarry site CH 2500 to CH 3000+	Low risk	The existing levels of the sand quarry at the northern extremity is much lower than the proposed Hammond Road level. This could potentially trigger a redesign for the new Hammond Road. However, it is noted that this outcome is unlikely due to other constraints such as impact to Bush Forever to the east and road geometric concerns.

Table 4.7 – Design Risk

5. Improvement Scheme Reservation

The recommended concept design is shown in Appendix A – Design Drawings. The proposed land protection boundary has been developed to accommodate the key features outlined in this report.

Generally, the proposed road corridor is 40m wide with an additional allowance for a 20m corridor width for the Baldivis Tramway Reserve. The Improvement Scheme should include reservations for provision below :

- Accommodate 2 lanes in each direction on the new Hammond Road extension and the upgraded Mandogalup Road as distributor roads
- Accommodation of the three roundabouts and two intersections along the road alignment
- Allowance for new access roads and realignment of existing Mandogalup Road near Norkett Road
- Drainage basins footprint
- Mitigation of constraints to achieve social and environmental outcomes
- Earthworks batters to improve constructability if not in conflict with higher priority constraints
- Access to Lot 2 is currently on-hold pending DPLH's guidance as descripted in Section 4.10.

6. Conclusion

This report provides an overview of the design constraints, criteria, and considerations taken into account during the Land Reservation Study for Mandogalup Road and Hammond Road. It supports the upgrade of Mandogalup Road and the extension of Hammond Road, with detailed carriageway patterns and profile drawings included in Appendix A. The design concept has been carefully developed, taking into consideration the existing MRS and outlining any necessary modifications to ensure the protection of the land for future inclusion.

There are various constraints on this project and achieving a desirable social and environmental outcome plays a crucial part in the road design process. For instance, coordination for access to existing lots with current owners, resulted in the decision to relocate the southern roundabout during the design development phase. The presence of a place of worship and the existence of Threatened Ecological Communities, such as Tuart Woodlands to the south and Banksia Woodlands to the north, influence land reservation decision. The project also considers the preservation of habitats for Black Cockatoos, the avoidance of encroachment on Water Corporation Main Drains and Western Power's transmission line, as well as the challenges posed by likely low infiltration of clayey soil in proximity to basins.

These environmental and social considerations must be balanced with the increased traffic demand in the area due to neighbouring developments like the Westport Corridor, Latitude 32, Australian Marine Complex, and the Kwinana Industry Area.

While this road reservation review study has endeavoured to identify a suitable road design footprint, the following items require further consideration:

- Hydrogeological investigation and modelling to confirm groundwater levels and drainage basin configuration or refinement.
- Ensure traffic modelling on Mandogalup/Hammond Roads considers planned future upgrades on Anketell Road and Rowley Road along with other recently planned future network changes.
- Based on the anticipated future traffic volumes, a consolidated Anketell Road/Mandogalup Road noise assessment will be necessary to understand the level of noise mitigation treatments required for sensitive receptors on the southern section of Mandogalup Road. The current road design has assumed internal property noise treatments in lieu of noise walls.
- Consultation with PTA/Transperth to understand public transport requirements beyond the provisions documented in this report.
- Consultation with affected landowners to gauge support for and/or understand issues with the proposed access strategy.
- Consultation with Western Power and Water Corporation on the proposed impacts and ensure the proposed land requirement boundary allows for the required services modification/relocation.
- Consultation with DoT and relevant interest groups regarding the proposed path strategy including treatments for the Baldivis Tramway across intersecting roads.

Design Limitations

The Road Design has been developed based on the assumptions, qualifications and limitations listed below.

- BG&E's design is reliant upon information provided by the principal and third parties, where listed in Section 3.2. The accuracy of the design is, therefore, limited by the accuracy of this reliance information. BG&E has made no independent verification of this information and assumes no liability for any inaccuracies in or omissions to that information.
- In preparing the Report, BG&E assumes that:
  - other consultants and contractors are responsible for performing and coordinating services that do not form part of the Services;
  - DPLH or a third party is responsible for obtaining any approvals to enable BG&E to perform the Services without restriction;
- BG&E makes no warranty, statement or representation of any kind concerning the suitability of the site for any purpose or the permissibility of any use, development or re-development of the site.
- Any use, development or re-development of the site for any purpose by any person may require planning and other approvals and, in some cases, environmental regulatory authority and accredited site auditor approvals. BG&E offers no opinion as to whether the current use has any or all approvals required, is operating in accordance with any approvals, the likelihood of obtaining any approvals, or the conditions and obligations which such approvals may impose, which may include the requirement for additional works.
- BG&E makes no determination or recommendation regarding a decision to provide or not to provide financing with respect to the use and/or development of the site.
- This Report is subject to the conditions and limitations of the site at the time it was prepared. BG&E accepts no responsibility for any changes in site conditions or in the information reviewed that have occurred after this time.
- Inspections undertaken in respect of this Report are limited to [visual inspections] only and are constrained by the particular site conditions, such as the location of buildings, road geometry and structures already in place (see section 3.1 of this Report).
- BG&E's scope specifically excludes the following:
  - Lighting and signal design
  - Services relocation and protection design
  - Flooding assessment
  - Safe Systems Assessment
  - Surveying
  - Geotechnical services
  - Approvals from any statutory authority
  - Providing legal or regulatory advice
  - Providing cost estimates

Coordination of design activities with other consultants

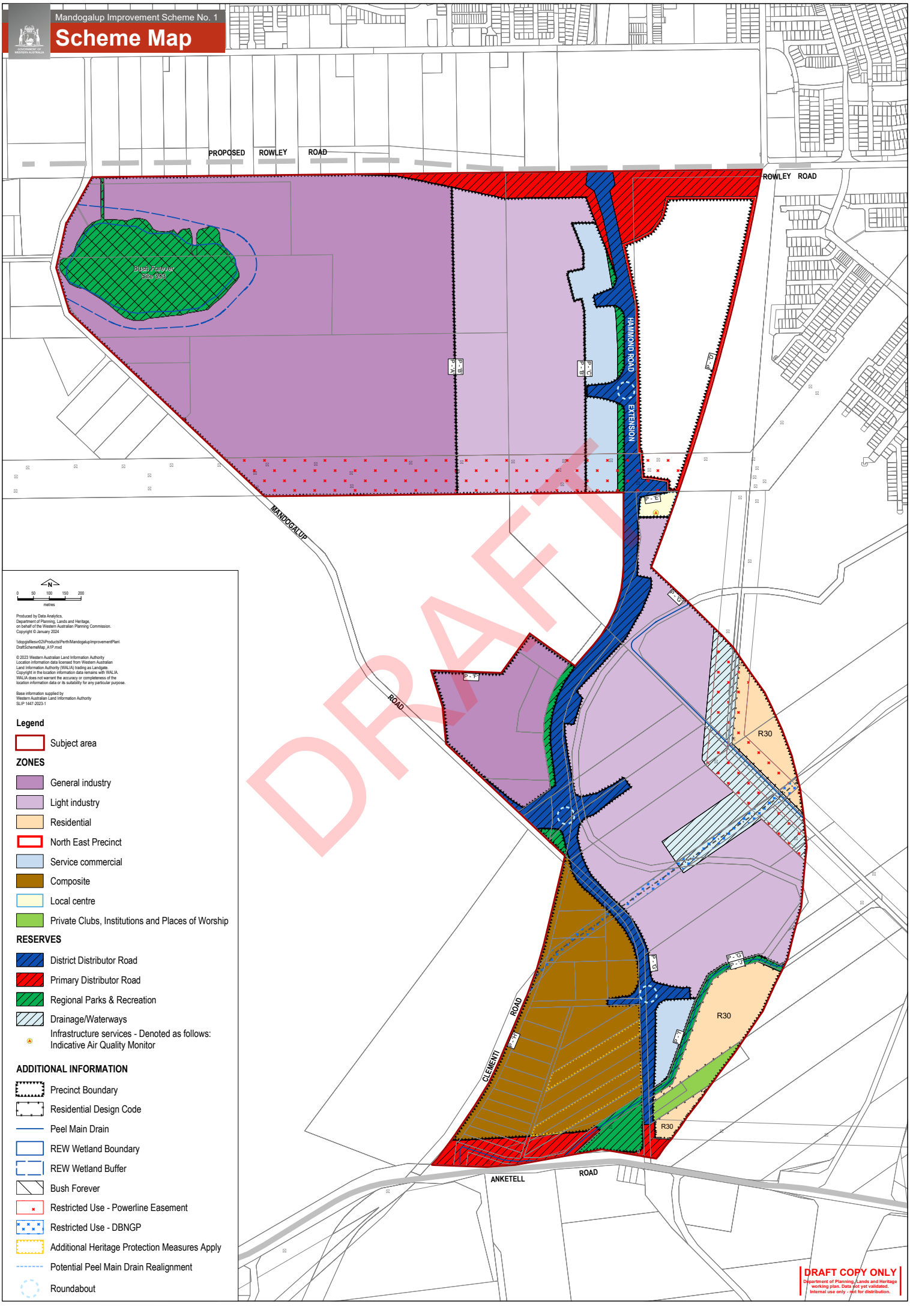
Appendices

Appendix A – Design Drawings

Appendix B – Scheme and Concept Plans

Mandogalup Improvement Scheme No. 1

Scheme Map



N

0 50 100 150 200
metres

Produced by Data Analytics,
Department of Planning, Lands and Heritage,
on behalf of the Western Australian Planning Commission.
Copyright © January 2024

\\dopgisfilesvr02\Products\Perth\Mandogalup\ImprovementPlan\DraftSchemeMap_A1P.mxd

© 2023 Western Australian Land Information Authority
Location information data licensed from Western Australian Land Information Authority (WALIA) trading as Landgate.
Copyright in the location information data remains with WALIA.
WALIA does not warrant the accuracy or completeness of the location information data or its suitability for any particular purpose.

Base information supplied by
Western Australian Land Information Authority
SLIP 1447-2023-1

Legend

- Subject area

ZONES

- General industry
- Light industry
- Residential
- North East Precinct
- Service commercial
- Composite
- Local centre
- Private Clubs, Institutions and Places of Worship

RESERVES

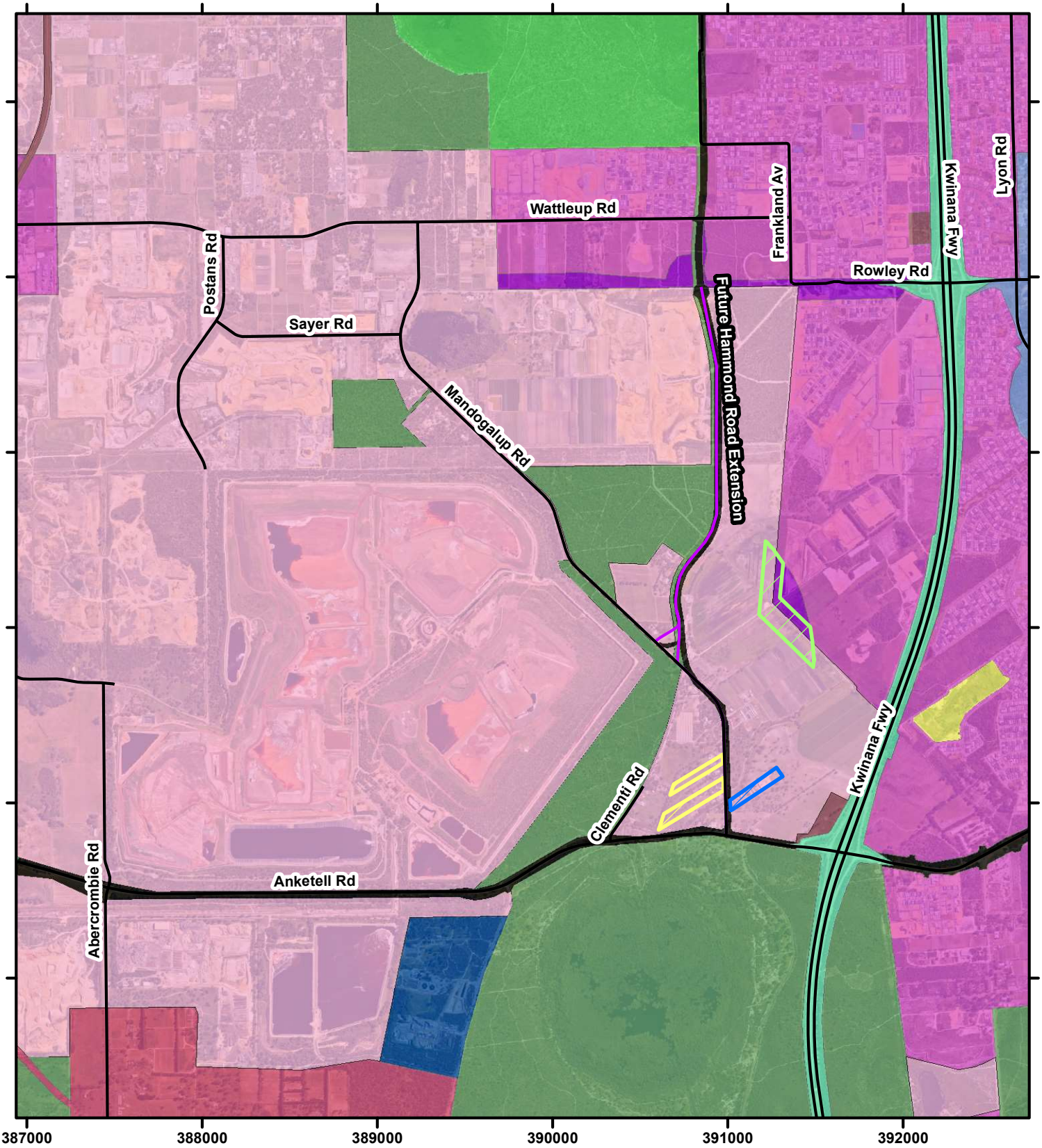
- District Distributor Road
- Primary Distributor Road
- Regional Parks & Recreation
- Drainage/Waterways
- Infrastructure services - Denoted as follows: Indicative Air Quality Monitor

ADDITIONAL INFORMATION

- Precinct Boundary
- Residential Design Code
- Peel Main Drain
- REW Wetland Boundary
- REW Wetland Buffer
- Bush Forever
- Restricted Use - Powerline Easement
- Restricted Use - DBNGP
- Additional Heritage Protection Measures Apply
- Potential Peel Main Drain Realignment
- Roundabout

DRAFT COPY ONLY
Department of Planning, Lands and Heritage working plan. Data not yet validated. Internal use only - not for distribution.

Hammond & Mandogalup Roads: Metropolitan Region Scheme



Legend

Future Hammond Road Extension

Special Areas

- Heritage
- Heritage, Temple
- Infrastructure, Power Easement

Metropolitan Region Scheme Zones and Reserves

- Other regional roads
- Parks and recreation
- Parks and recreation - restricted public access
- Primary regional roads
- Public purposes - Water Authority of WA
- Public purposes - high school
- Public purposes - special uses
- Railways
- Rural
- Rural - water protection
- Urban
- Urban deferred

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

N

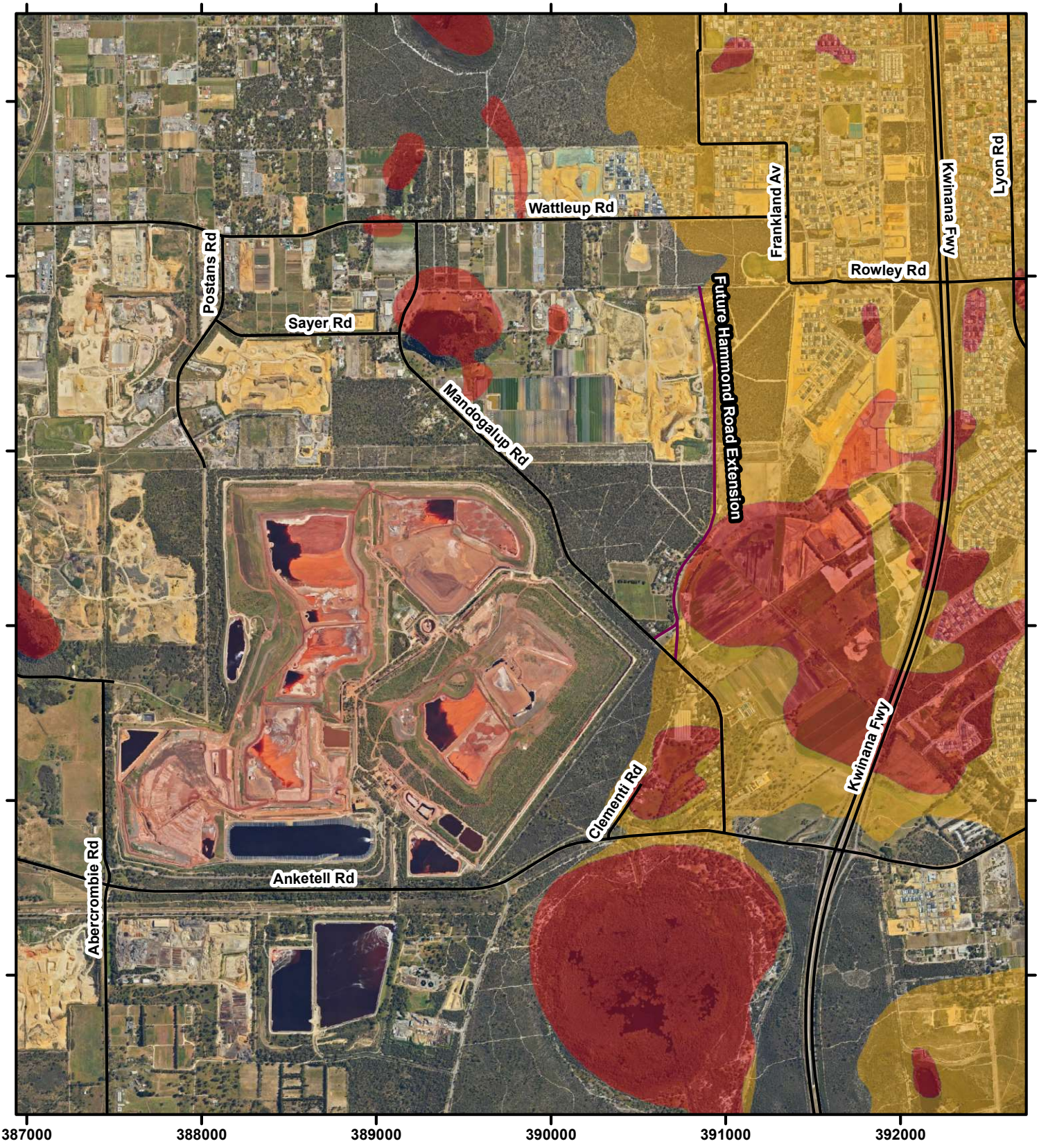
0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Metropolitan Region Scheme.mxd

Appendix C – Constraints Mapping

Hammond & Mandogalup Roads: Acid Sulphate Soil Risk



Legend

Future Hammond Road Extension

Acid Sulphate Soil Risk

1 - High to moderate risk of ASS occurring within 3m of natural soil surface

2 – Moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Acid Sulphate Soil Risk.mxd

Hammond & Mandogalup Roads: Black Cockatoos and Tuart Woodlands

Legend

- Future Hammond Road Extension
- Tuart Woodlands
- Carnabys Cockatoo Areas requiring investigation as feeding habitat

Significant Black Cockatoo Habitat Trees

- Corymbia calophylla
- Eucalyptus gomphocephala
- Eucalyptus marginata
- Eucalyptus rudis
- Eucalyptus sp.
- N/A
- Hollow Present - Potentially Suitable

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

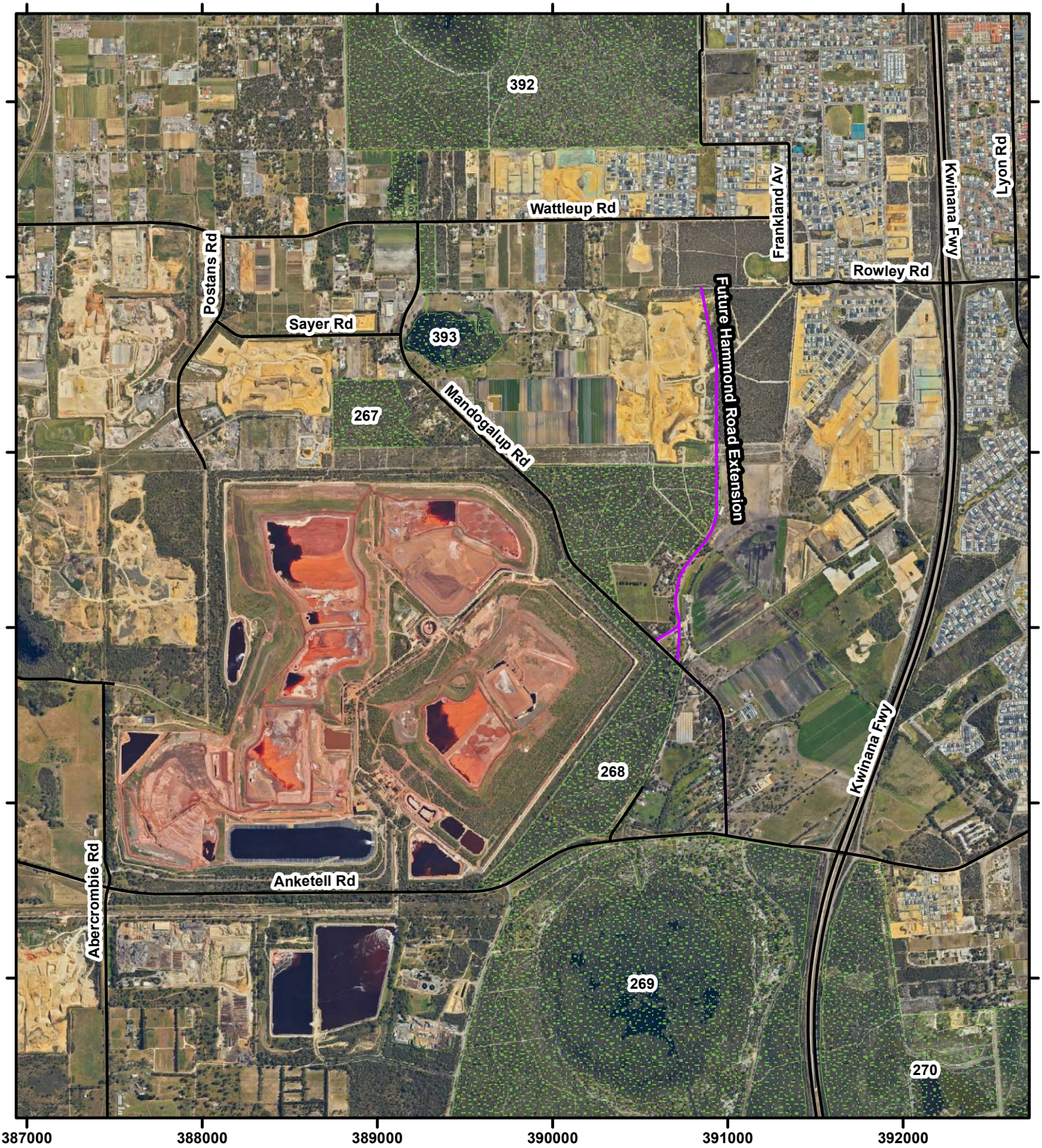
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Black Cockatoos and Tuart Woodlands.mxd

Hammond & Mandogalup Roads: Bush Forever



Legend

- Future Hammond Road Extension
- Bush Forever

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

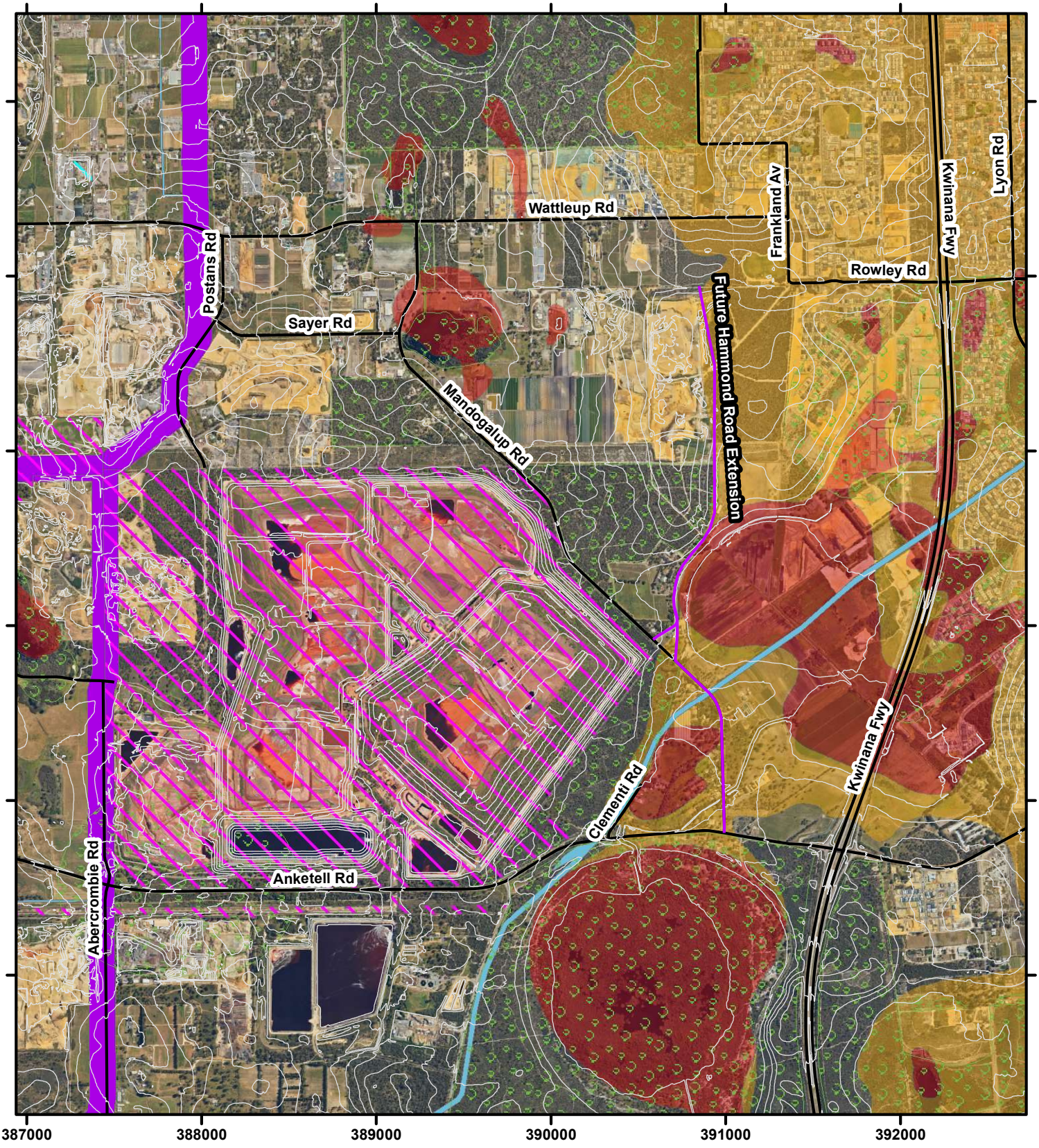
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Bush Forever.mxd

Hammond & Mandogalup Roads: Engineering



Legend

- Future Hammond Road Extention
- 5m Contours

Contaminated Sites

- Contaminated - remediation required
- Contaminated - restricted use
- Environmentally Sensitive Areas

Pipelines

- Parmelia Pipeline
- Dampier to Bunbury Pipeline

Acid Sulphate Soil Risk

- 1 - High to moderate risk of ASS occurring within 3m of natural soil surface
- 2 – Moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

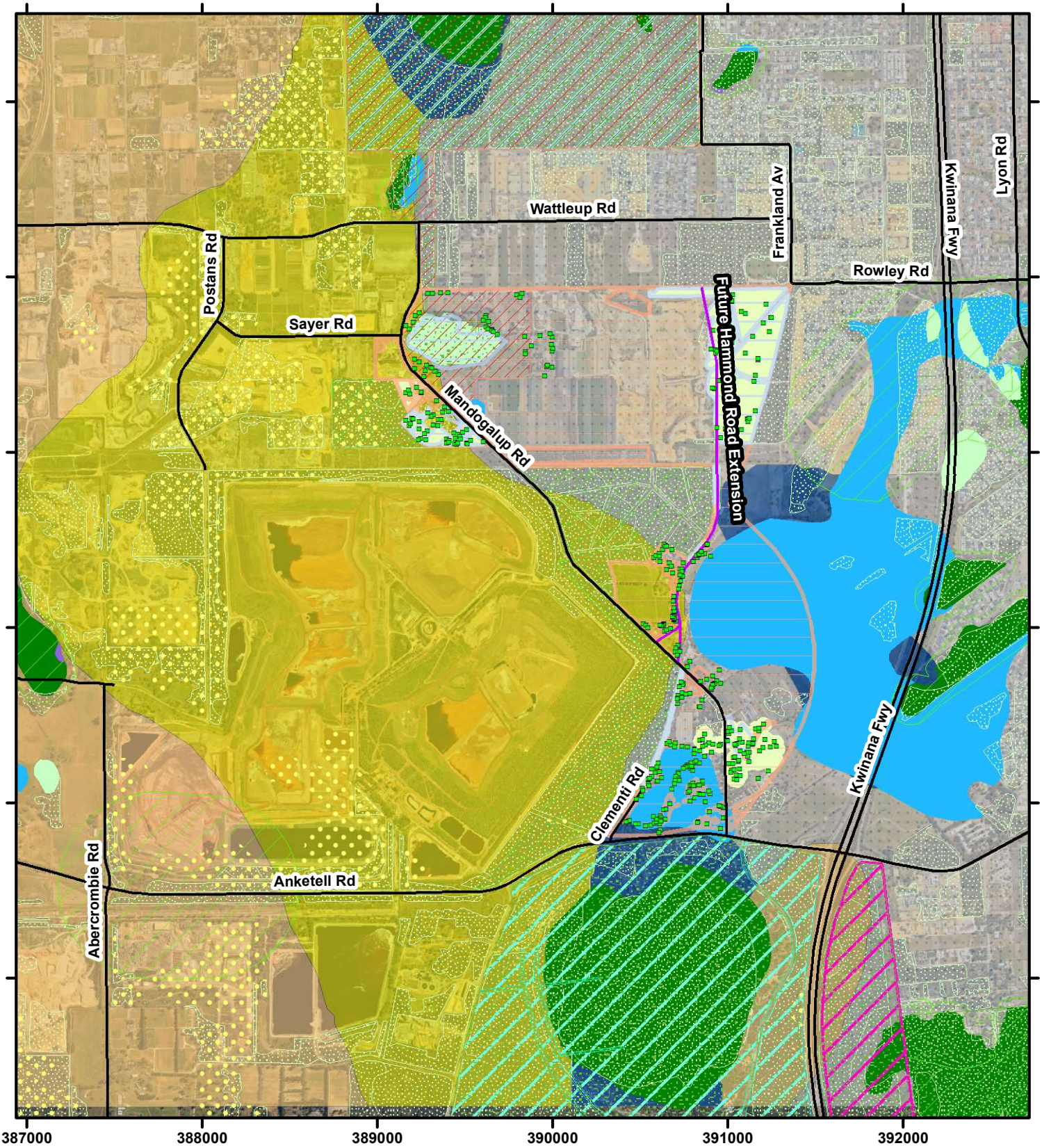
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Engineering.mxd

Hammond & Mandogalup Roads: Environment



Legend

- Future Hammond Road Extension
- Significant Black Cockatoo Habitat Trees
- EPA Redbook Recommended Conservation Reserve M93
- Bush Forever
- Carnabys Cockatoo Areas requiring investigation as feeding habitat
- Tuart Woodlands
- Threatened Ecological Communities
- Environmentally Sensitive Areas

Regional Parks

- Beeliar Regional Park
- Jandakot Regional Park

Geomorphic Wetlands

- Conservation
- Multiple Use
- Resource Enhancement
- Not Applicable

Vegetation Condtion

- Completely degraded to Good
- Good to Very Good

Vegetation Complexes

- Bassendean Complex-Central and South
- Karrakatta Complex-Central and South
- Cottesloe Complex-Central and South
- Herdsman Complex

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

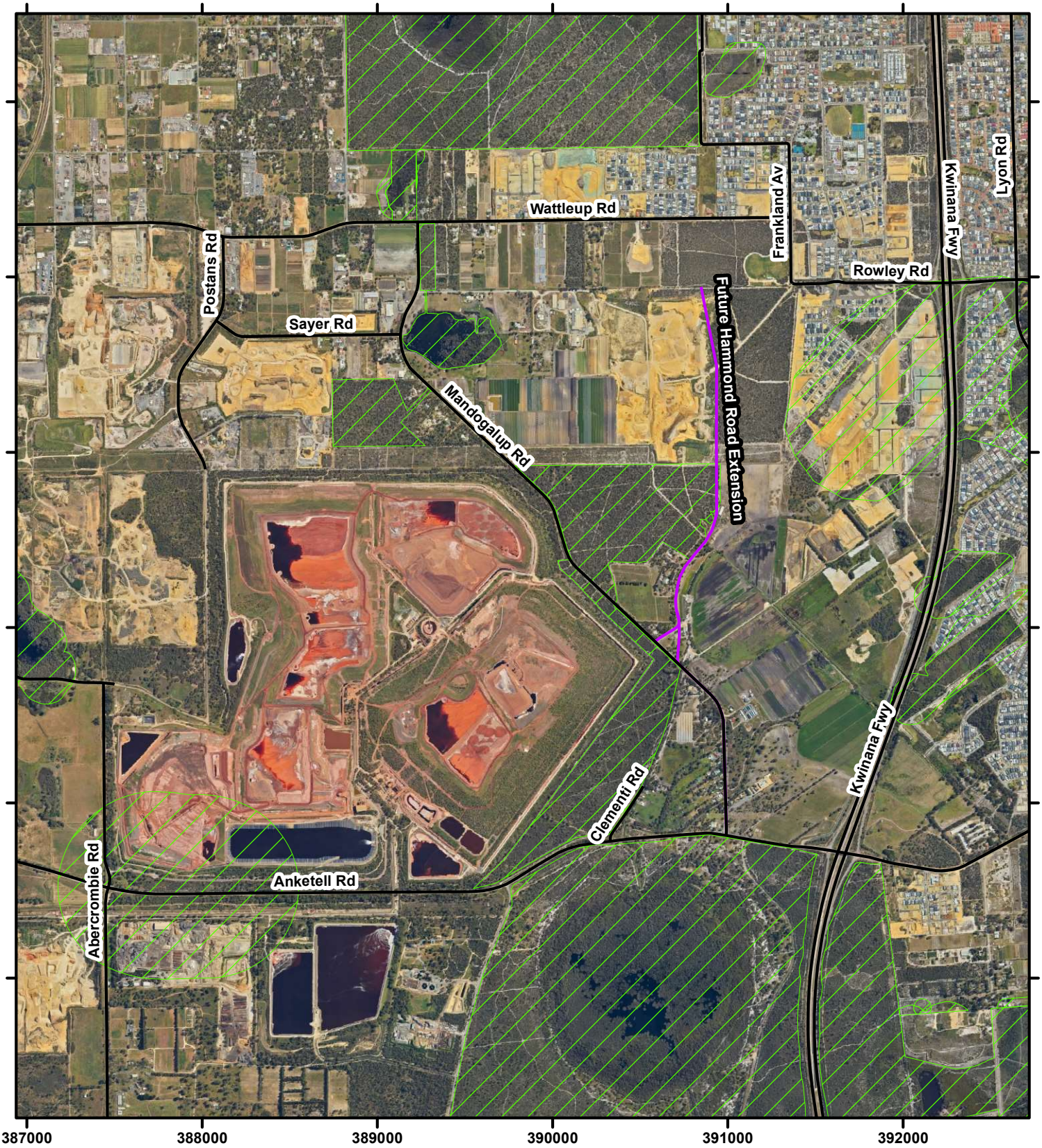
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Environment.mxd

Hammond & Mandogalup Roads: Environmentally Sensitive Areas



Legend

- Environmentally Sensitive Areas
- Future Hammond Road Extension

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

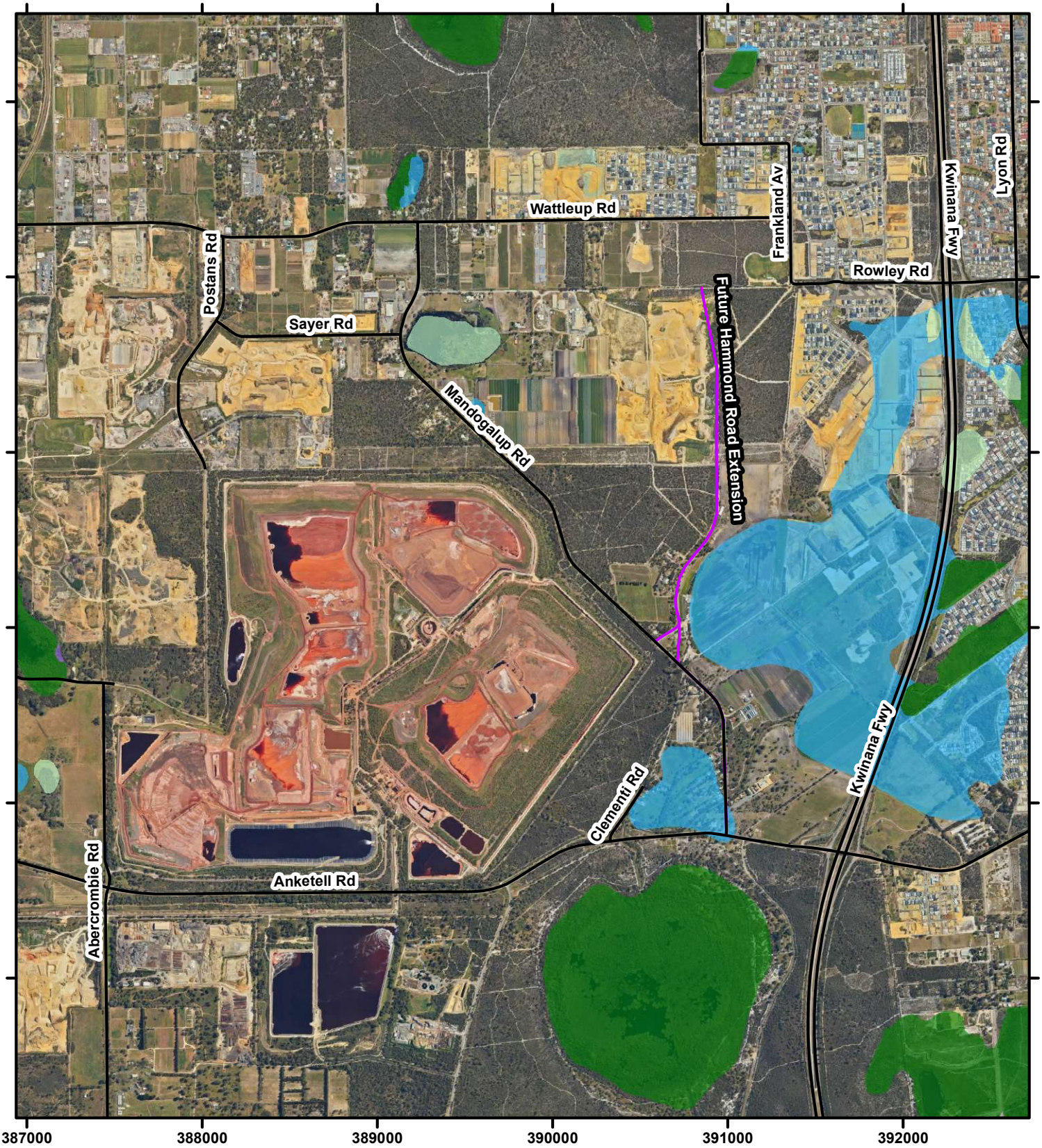
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Environmentally Sensitive Areas.mxd

Hammond & Mandogalup Roads: Geomorphic Wetlands



Legend

- Future Hammond Road Extension

Geomorphic Wetlands

- Conservation
- Multiple Use
- Resource Enhancement
- Not Applicable

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

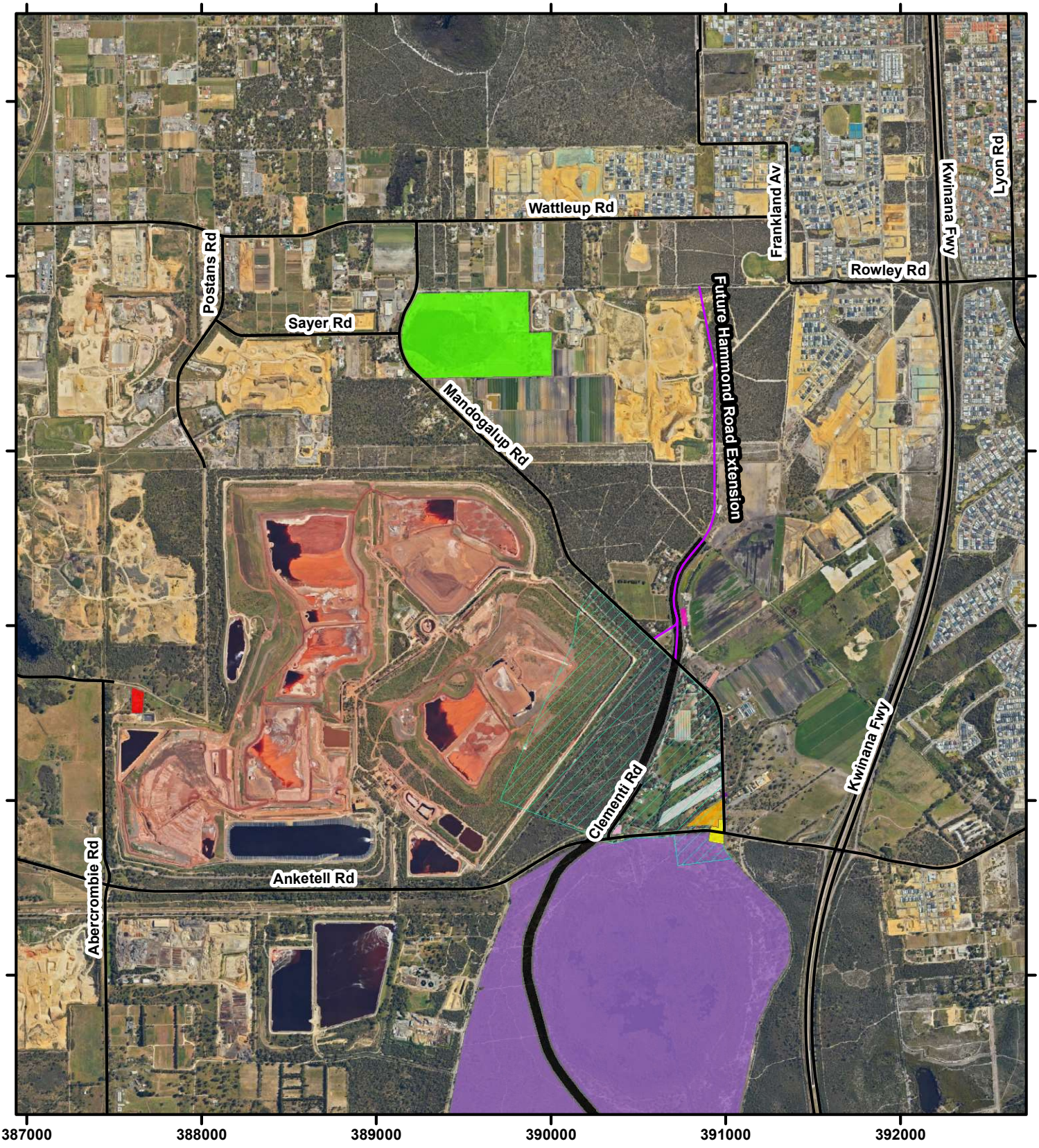
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Geomorphic Wetlands.mxd

Hammond & Mandogalup Roads: Municipal Heritage Inventory



Legend

- Future Hammond Road Extension

Municipal Heritage Inventory

- 6 Mile Site
- 7 Mile Site ("Sevvy" to later settlers)
- Balmanup Post Office - Site of
- Hall Reserve - Mandogalup
- Heritage Farm
- Jolly's Bridge
- Lake Wattleup / Sayer Road Swamp
- Mandogalup Post Office (fmr)
- Mandogalup School - Site of
- Mandogalup Townsite
- Soldier Settler Homes
- The Spectacles Wetland
- Tramway Reserve - site
- White Bridge

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Municipal Heritage Inventory.mxd

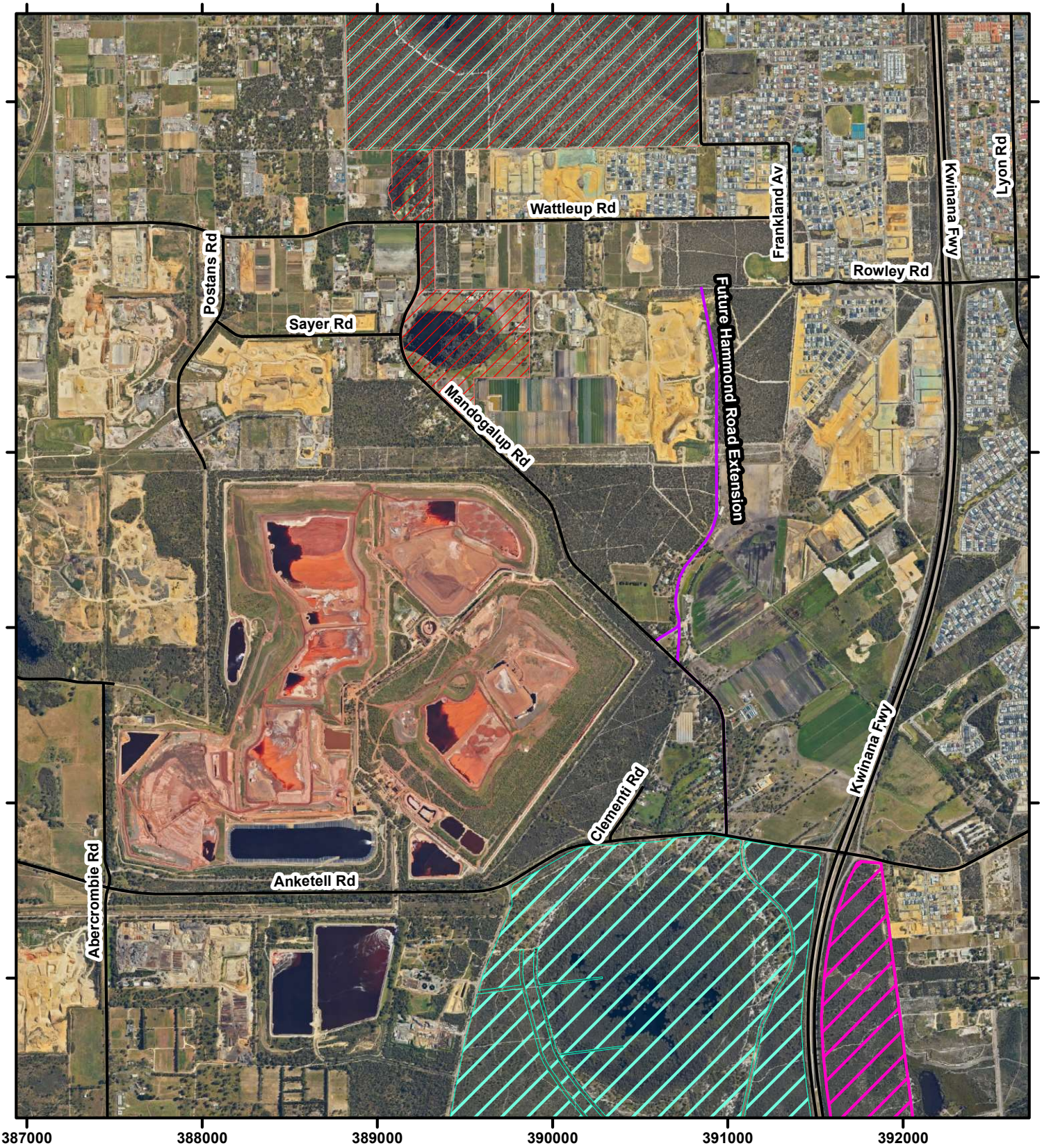
ACKNOWLEDGEMENT	BG&E
DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

N

0 0.25 0.5 1 Km

Hammond & Mandogalup Roads: Parks and Reserves



Legend

- Future Hammond Road Extension
- EPA Redbook Recommended Conservation Reserve M93

Regional Parks

- Beeliar Regional Park
- Jandakot Regional Park

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

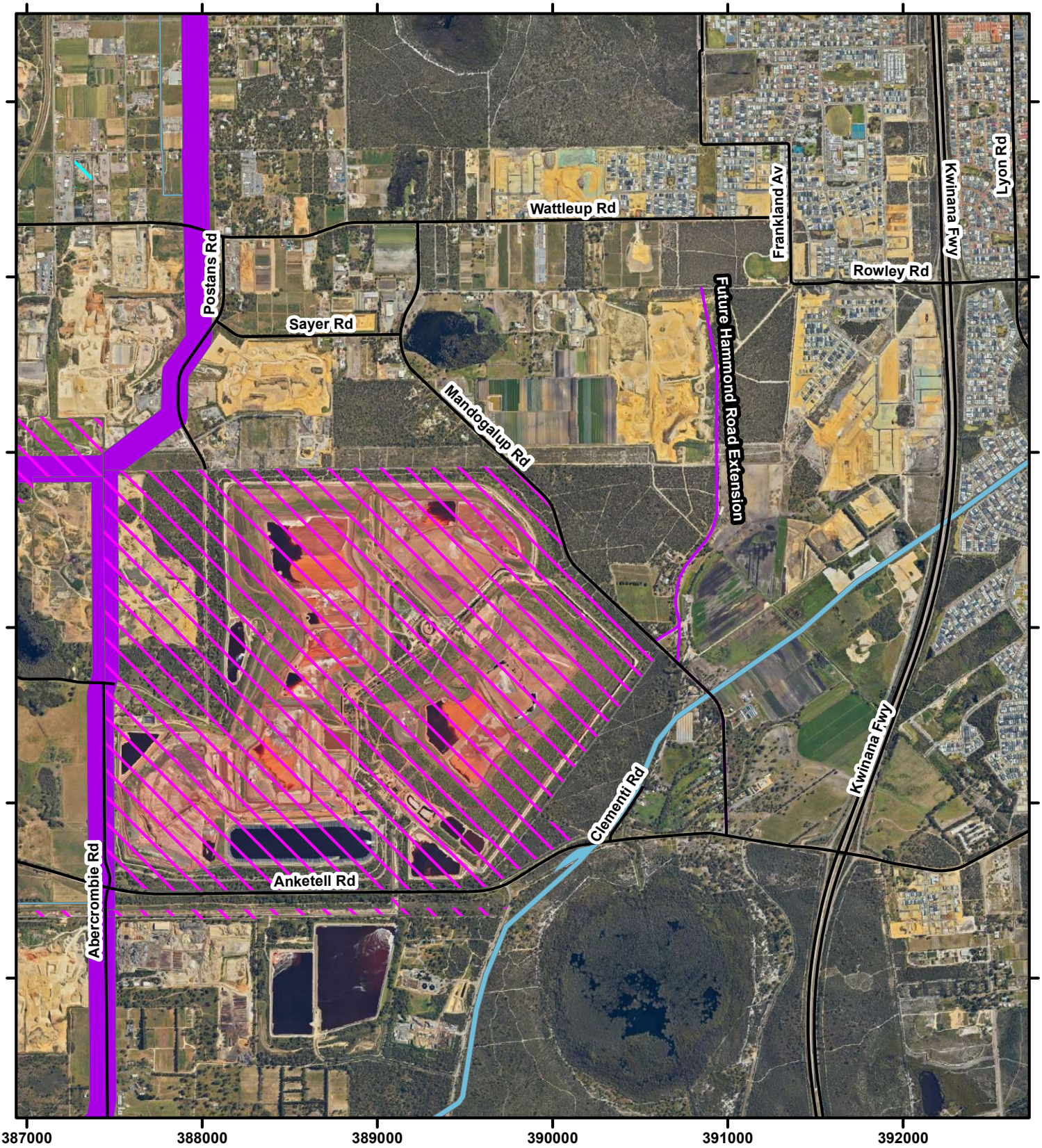
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Parks and Reserves.mxd

Hammond & Mandogalup Roads: Pipelines and Contaminated Sites



Legend

- Future Hammond Road Extension

Contaminated Sites

- Contaminated - remediation required
- Contaminated - restricted use

Pipelines

- Parmelia Pipeline
- Dampier to Bunbury Pipeline

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

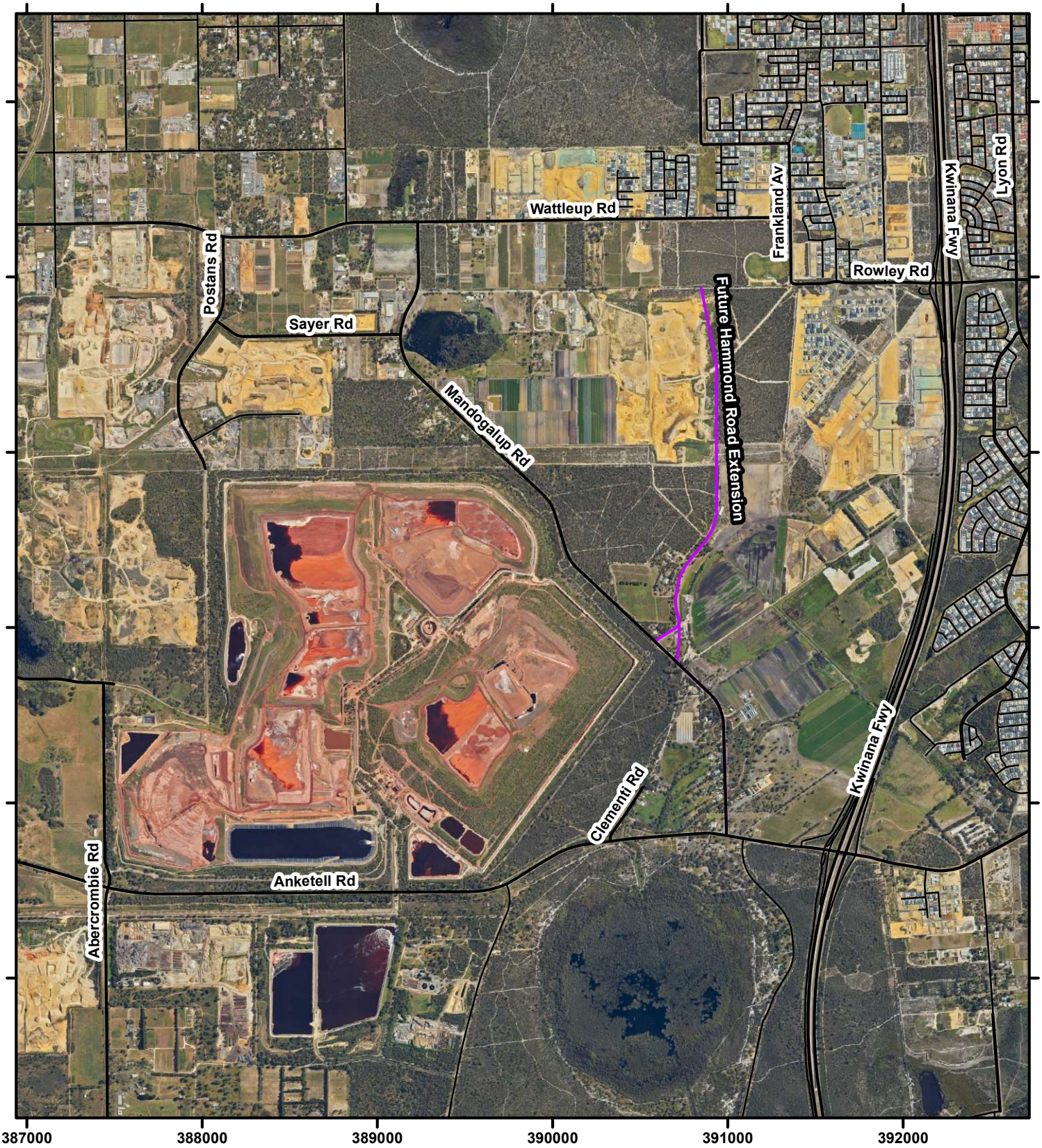
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Pipelines and Contaminated Sites.mxd

Hammond & Mandogalup Roads: Road Network



Legend

- Future Hammond Road Extension
- Road Network

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

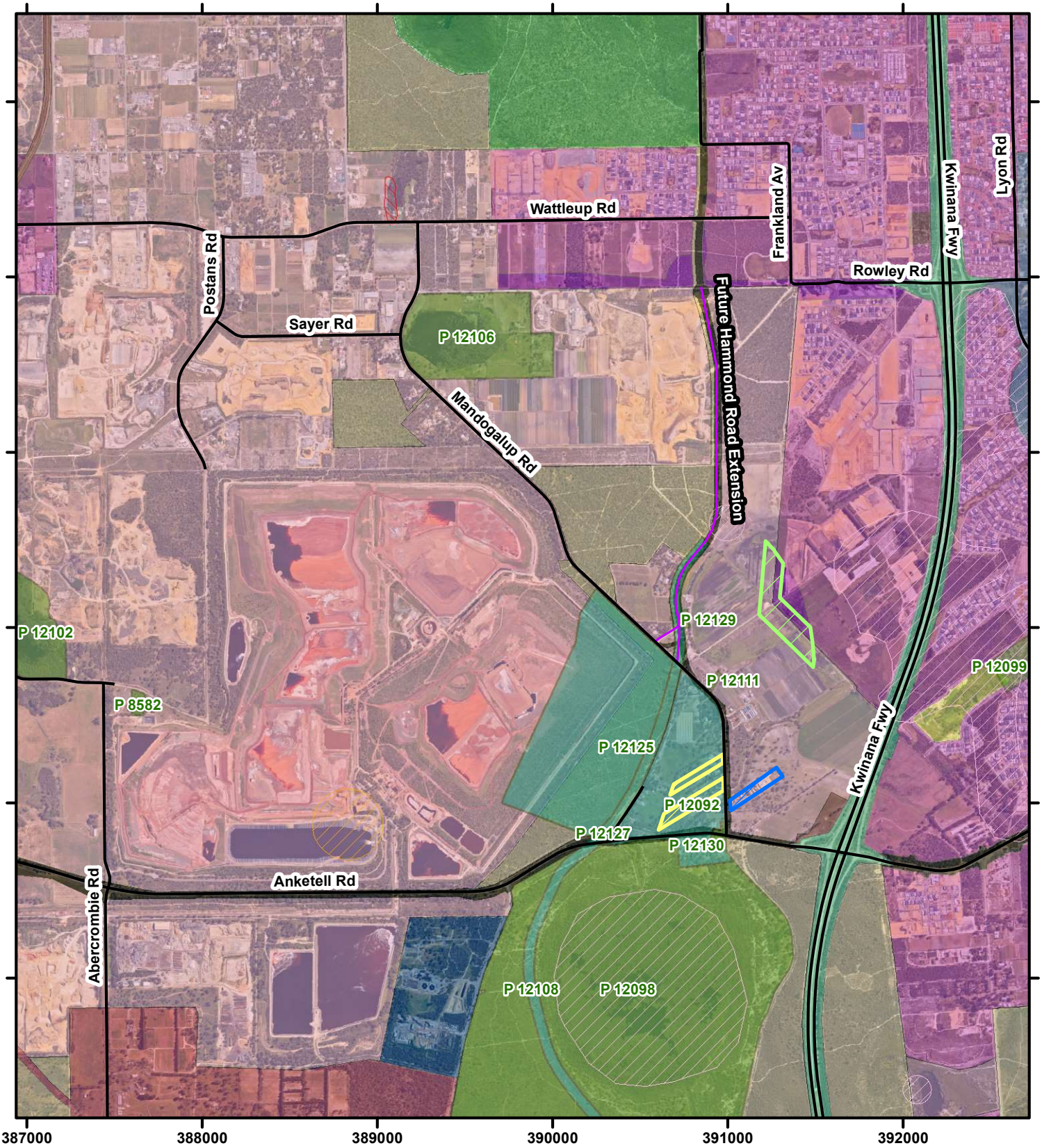
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Road Network.mxd

Hammond & Mandogalup Roads: Social



Legend

- Future Hammond Road Extension

Aboriginal Heritage Places
- Registered Site
- Lodged
- Stored Data / Not a Site

Municipal Inventory
- Precinct / Group
- Individual Place

Special Areas
- Heritage
- Heritage, Temple
- Infrastructure, Power Easement

Metropolitan Region Scheme Zones and Reserves
- Other regional roads
- Parks and recreation
- Parks and recreation - restricted public access
- Primary regional roads
- Public purposes - Water Authority of WA
- Public purposes - high school
- Public purposes - special uses
- Railways
- Rural
- Rural - water protection
- Urban
- Urban deferred

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Social.mxd

Hammond & Mandogalup Roads: Threatened Ecological Communities

Legend

- Future Hammond Road Extension
- Banksia Woodland
- Tuart Woodlands SCP

ACKNOWLEDGEMENT	BG&E
DRAWN AS	PROJECT P23078
REVIEWED	DATE 17/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

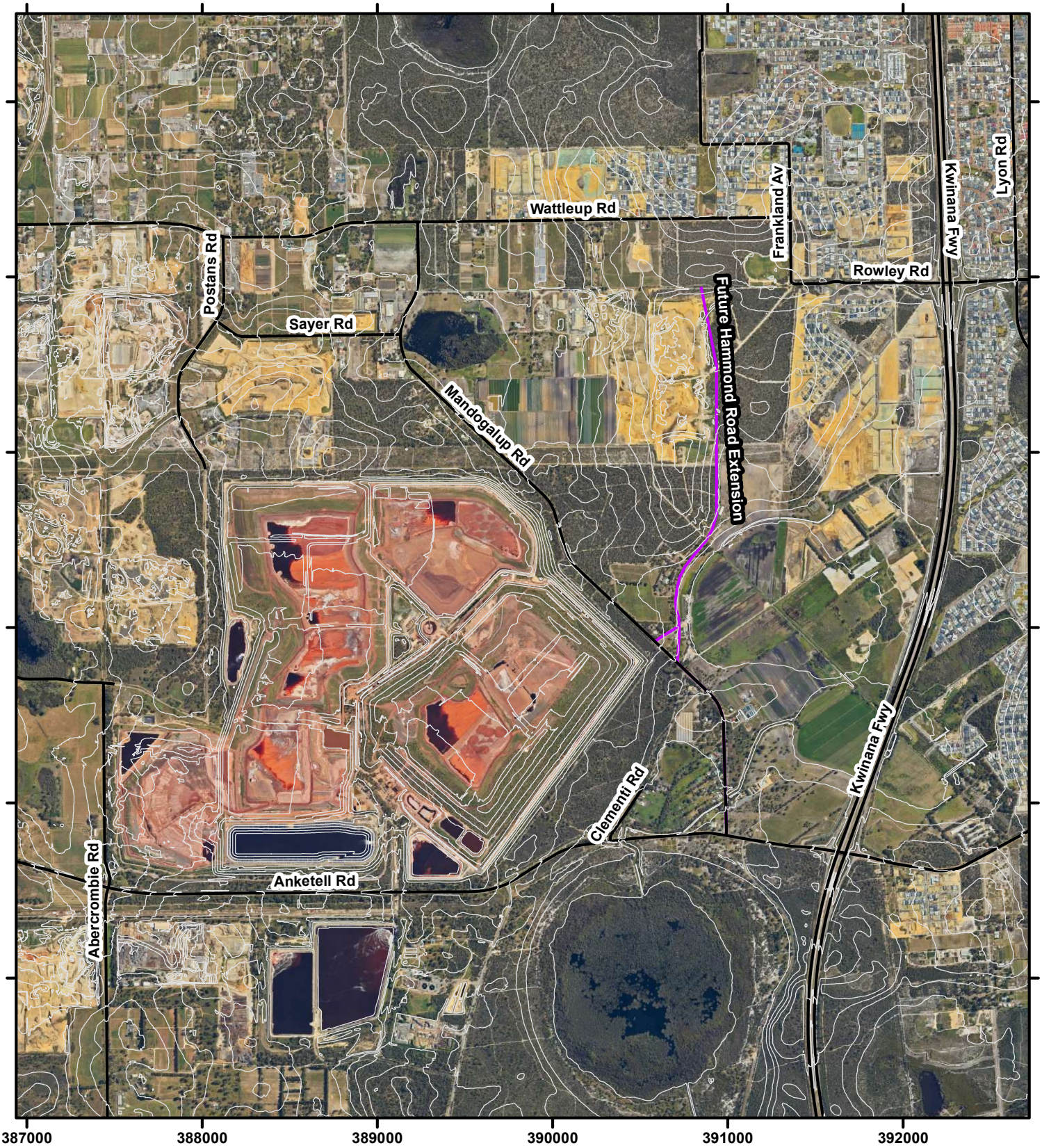
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Threatened Ecological Communities.mxd

Hammond & Mandogalup Roads: Topography



Legend

- 5m Contours
- Future Hammond Road Extension

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

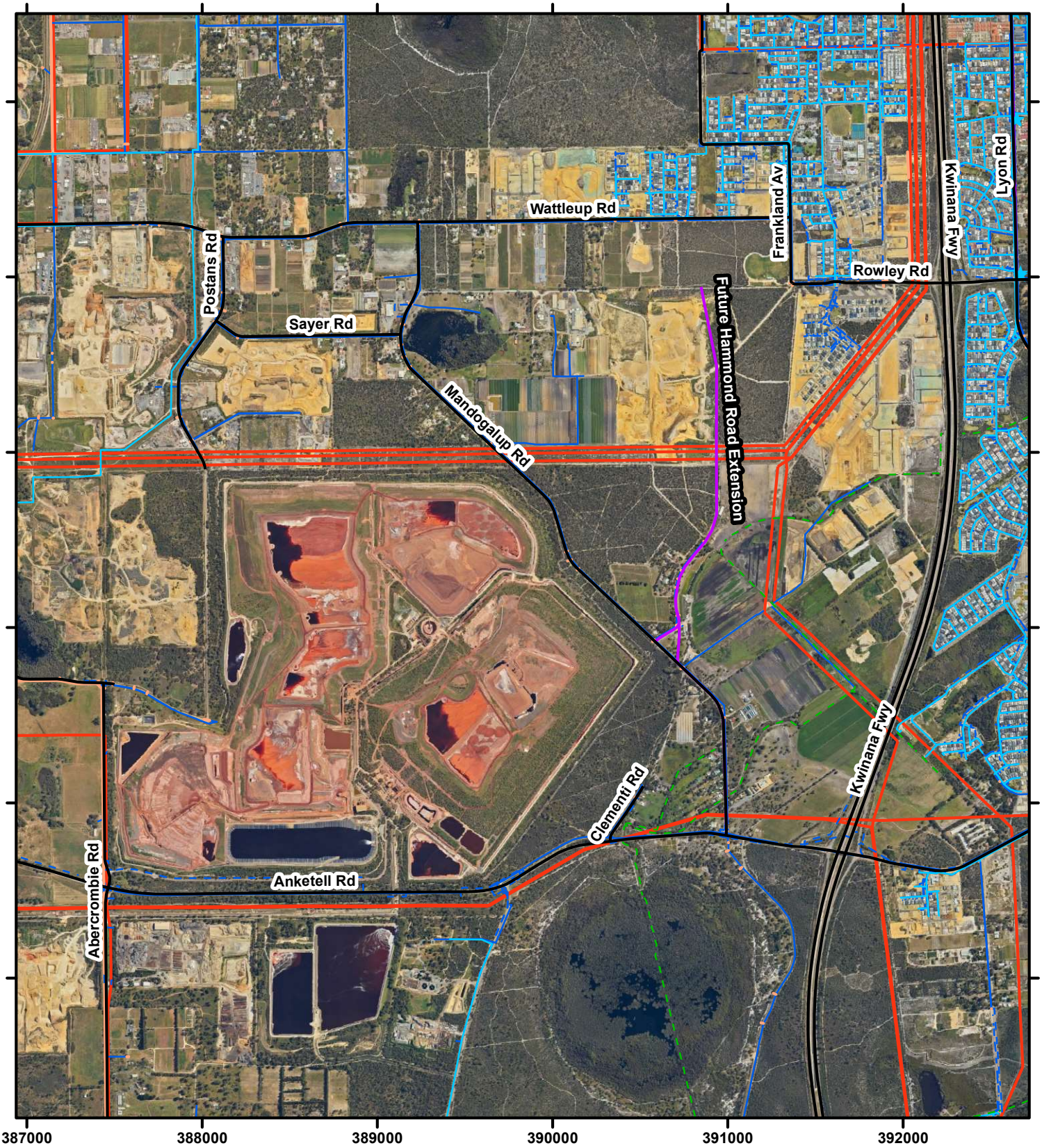
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Topography.mxd

Hammond & Mandogalup Roads: Utilities



Legend

- Future Hammond Road Extension
- Water Bore
- Drainage Open Channel
- Drinking Water; Unknown
- Raw Water
- Other Overhead Lines
- Distribution Underground Cables
- Distribution Overhead Powerlines
- Transmission Overhead Powerlines

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

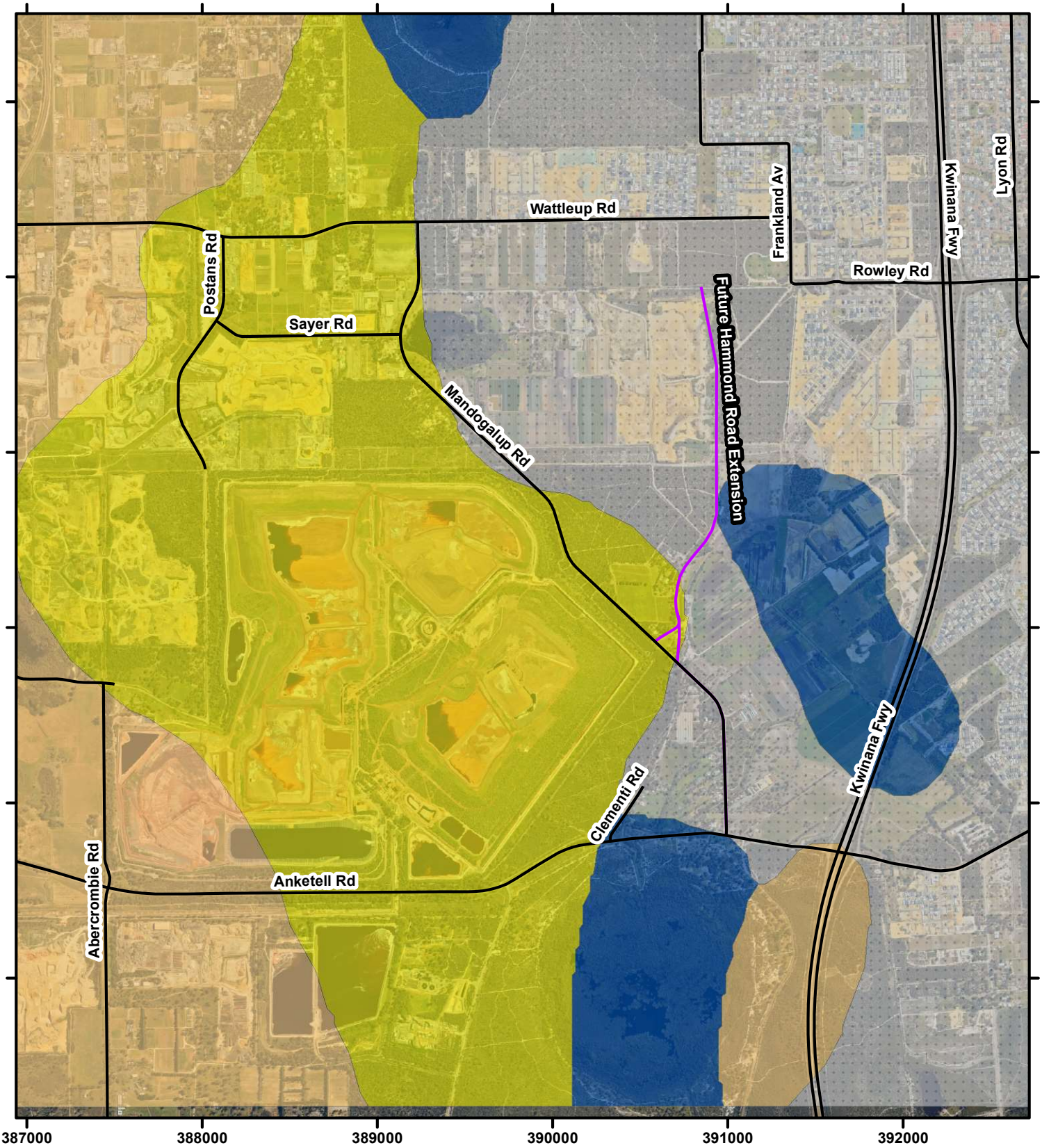
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Utilities.mxd

Hammond & Mandogalup Roads: Vegetation Complexes



Legend

- Future Hammond Road Extension

Vegetation Complexes

- Bassendean Complex-Central and South
- Karrakatta Complex-Central and South
- Cottesloe Complex-Central and South
- Herdsman Complex

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Vegetation Complexes.mxd

Hammond & Mandogalup Roads: Vegetation Condition

Legend

- Future Hammond Road Extension

Vegetation Condtion

- Completely degraded
- Degraded
- Degraded - good
- Good
- Good - very good
- Very Good

ACKNOWLEDGEMENT

BG&E

DRAWN AS	PROJECT P23078
REVIEWED	DATE 12/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,000 (at A4)

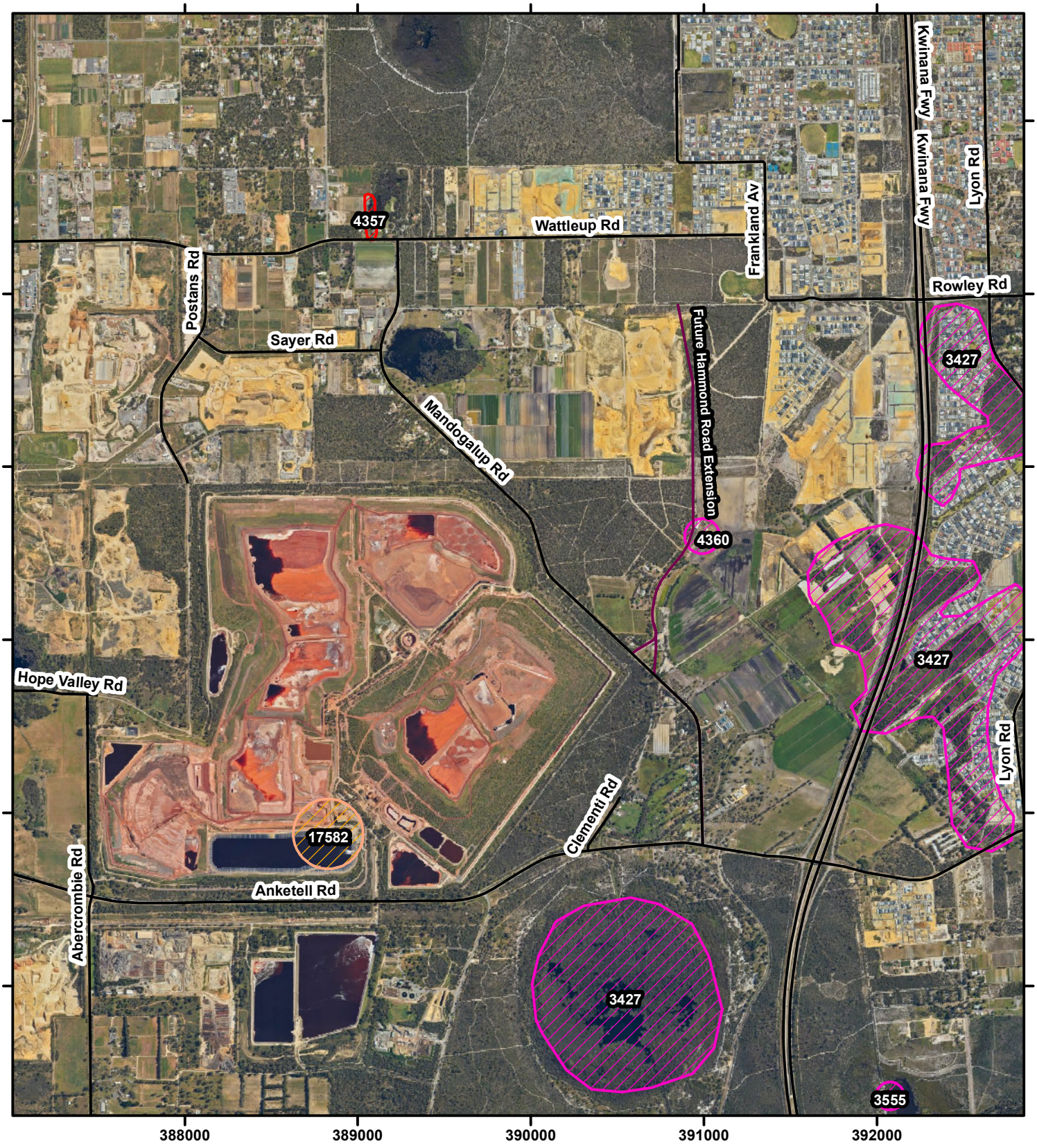
N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Vegetation Condition.mxd

Hammond & Mandogalup Roads: Aboriginal Heritage Places



Legend

Future Hammond Road Extension

Aboriginal Heritage Places

- Registered Site
- Lodged
- Stored Data / Not a Site

ACKNOWLEDGEMENT	BG&E
DRAWN AS	PROJECT P23078
REVIEWED	DATE 17/01/2024
APPROVED	DATUM GDA 1994 MGA Zone 50

1:30,316 (at A4)

N

0 0.25 0.5 1 Km

Disclaimer This map is current at the time of publication and has been prepared, in part, from unverified data and information (Data) supplied by other parties. Whilst BG&E takes due care in providing its services, BG&E accepts no liability for any loss or damage suffered which is caused by any inaccuracy in the design or drawing which has resulted from the use of any unverified, inaccurate or misleading Data supplied by other parties.

C:\Users\dmitry.zelenkin\bgeeng.com\Digital Engineering Group - Documents\01 Projects\P23078 HAMMOND & MANDOGALUP ROADS DPLH\GIS\Maps\Report Maps\Aboriginal Heritage Places.mxd

Appendix D – Calculations

PCSump Version 6.1: Licenced to BG&E Pty Limited

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

P23078 - Hammond & Mandogalup Road

Project Description:

Basin 1

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	36.6	1%	0.34	13.34	0.56	1,075	3,359	1
	2	1 hour	46.8	1%	0.43	13.43	0.47	1,395	3,461	1
	3	2 hour	61.0	1%	0.53	13.53	0.37	1,724	3,564	10
	4	3 hour	71.9	1%	0.59	13.59	0.31	1,960	3,637	1
	5	6 hour	95.9	1%	0.71	13.71	0.19	2,415	3,775	1
	6	9 hour	112.2	1%	0.79	13.79	0.11	2,687	3,856	1
	7	12 hour	124.0	1%	0.83	13.83	0.07	2,841	3,901	10
	8	24 hour	149.7	1%	0.85	13.85	0.05	2,947	3,932	5
	9	48 hour	165.7	1%	0.77	13.77	0.13	2,638	3,841	5
	10	72 hour	172.1	1%	0.69	13.69	0.21	2,320	3,746	3
	11	96 hour	179.6	1%	0.61	13.61	0.29	2,038	3,661	4
	12	120 hour	189.2	1%	0.58	13.58	0.32	1,907	3,621	5
	13	144 hour	201.0	1%	0.56	13.56	0.34	1,829	3,597	10
	14	168 hour	215.9	1%	0.54	13.54	0.36	1,761	3,576	1
Critical	***8***	***24 hour***	***149.7***	***1%***	***0.85***	***13.85***	***0.05***	***2,947***	***3,932***	***5***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

Climate Change Parameter Used: Adjustment to Design Rainfall of 6.9%

PCSump Version 6.1: Licenced to BG&E Pty Limited

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

P23078 - Hammond & Mandogalup Road

Project Description:

Basin 2a

Model Selection: **Deep Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	36.6	1%	0.4	16.60	0.80	1,333	3,607	8
	2	1 hour	46.8	1%	0.47	16.67	0.73	1,605	3,707	1
	3	2 hour	61.0	1%	0.56	16.76	0.64	1,924	3,823	3
	4	3 hour	71.9	1%	0.6	16.80	0.60	2,079	3,878	8
	5	6 hour	95.9	1%	0.64	16.84	0.56	2,251	3,938	5
	6	9 hour	112.2	1%	0.63	16.83	0.57	2,214	3,925	6
	7	12 hour	124.0	1%	0.61	16.81	0.59	2,114	3,890	9
	8	24 hour	149.7	1%	0.44	16.64	0.76	1,498	3,668	3
	9	48 hour	165.7	1%	0.26	16.46	0.94	852	3,423	8
	10	72 hour	172.1	1%	0.23	16.43	0.97	754	3,385	6
	11	96 hour	179.6	1%	0.15	16.35	1.05	473	3,274	1
	12	120 hour	189.2	1%	0.17	16.37	1.03	546	3,303	6
	13	144 hour	201.0	1%	0.17	16.37	1.03	540	3,301	10
	14	168 hour	215.9	1%	0.19	16.39	1.01	593	3,322	9
Critical	***5***	***6 hour***	***95.9***	***1%***	***0.64***	***16.84***	***0.56***	***2,251***	***3,938***	***5***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

Climate Change Parameter Used: Adjustment to Design Rainfall of 6.9%

PCSump Version 6.1: Licenced to BG&E Pty Limited

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

P23078 - Hammond & Mandogalup Road

Project Description:

Basin 2b

Model Selection: **Deep Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	36.6	1%	0.68	17.38	0.52	524	978	8
	2	1 hour	46.8	1%	0.8	17.50	0.40	640	1,053	2
	3	2 hour	61.0	1%	0.93	17.63	0.27	783	1,139	3
	4	3 hour	71.9	1%	0.99	17.69	0.21	862	1,186	6
	5	6 hour	95.9	1%	1.09	17.79	0.11	975	1,249	2
	6	9 hour	112.2	1%	1.12	17.82	0.08	1,022	1,276	6
	7	12 hour	124.0	1%	1.11	17.81	0.09	1,009	1,268	7
	8	24 hour	149.7	1%	0.95	17.65	0.25	809	1,154	9
	9	48 hour	165.7	1%	0.8	17.50	0.40	645	1,056	8
	10	72 hour	172.1	1%	0.7	17.40	0.50	545	992	10
	11	96 hour	179.6	1%	0.49	17.19	0.71	348	857	9
	12	120 hour	189.2	1%	0.6	17.30	0.60	450	929	7
	13	144 hour	201.0	1%	0.58	17.28	0.62	429	914	10
	14	168 hour	215.9	1%	0.62	17.32	0.58	470	942	10
Critical	***6***	***9 hour***	***112.2***	***1%***	***1.12***	***17.82***	***0.08***	***1,022***	***1,276***	***6***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

Climate Change Parameter Used: Adjustment to Design Rainfall of 6.9%

PCSump Version 6.1: Licenced to BG&E Pty Limited

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

P23078 - Hammond & Mandogalup Road

Project Description:

Basin 3a

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	36.6	1%	0.72	17.12	0.88	649	1,154	1
	2	1 hour	46.8	1%	0.88	17.28	0.72	843	1,272	10
	3	2 hour	61.0	1%	1.06	17.46	0.54	1,093	1,413	10
	4	3 hour	71.9	1%	1.16	17.56	0.44	1,230	1,487	1
	5	6 hour	95.9	1%	1.37	17.77	0.23	1,558	1,654	1
	6	9 hour	112.2	1%	1.46	17.86	0.14	1,709	1,726	1
	7	12 hour	124.0	1%	1.52	17.92	0.08	1,813	1,776	10
	8	24 hour	149.7	1%	1.59	17.99	0.01	1,938	1,834	7
	9	48 hour	165.7	1%	1.45	17.85	0.15	1,701	1,723	5
	10	72 hour	172.1	1%	1.33	17.73	0.27	1,492	1,621	3
	11	96 hour	179.6	1%	1.21	17.61	0.39	1,310	1,529	2
	12	120 hour	189.2	1%	1.17	17.57	0.43	1,251	1,498	5
	13	144 hour	201.0	1%	1.16	17.56	0.44	1,230	1,487	4
	14	168 hour	215.9	1%	1.13	17.53	0.47	1,185	1,463	1
Critical	***8***	***24 hour***	***149.7***	***1%***	***1.59***	***17.99***	***0.01***	***1,938***	***1,834***	***7***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

Climate Change Parameter Used: Adjustment to Design Rainfall of 6.9%

PCSump Version 6.1: Licenced to BG&E Pty Limited

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

P23078 - Hammond & Mandogalup Road

Project Description:

Basin 3b

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	36.6	1%	0.7	19.60	1.30	977	1,543	1
	2	1 hour	46.8	1%	0.88	19.78	1.12	1,260	1,608	5
	3	2 hour	61.0	1%	1.12	20.02	0.88	1,668	1,698	10
	4	3 hour	71.9	1%	1.27	20.17	0.73	1,915	1,751	1
	5	6 hour	95.9	1%	1.53	20.43	0.47	2,396	1,850	1
	6	9 hour	112.2	1%	1.68	20.58	0.32	2,662	1,903	1
	7	12 hour	124.0	1%	1.75	20.65	0.25	2,810	1,932	10
	8	24 hour	149.7	1%	1.85	20.75	0.15	2,993	1,968	7
	9	48 hour	165.7	1%	1.69	20.59	0.31	2,688	1,908	5
	10	72 hour	172.1	1%	1.51	20.41	0.49	2,345	1,840	3
	11	96 hour	179.6	1%	1.34	20.24	0.66	2,053	1,780	2
	12	120 hour	189.2	1%	1.31	20.21	0.69	1,988	1,766	5
	13	144 hour	201.0	1%	1.29	20.19	0.71	1,950	1,758	4
	14	168 hour	215.9	1%	1.24	20.14	0.76	1,866	1,740	1
Critical	***8***	***24 hour***	***149.7***	***1%***	***1.85***	***20.75***	***0.15***	***2,993***	***1,968***	***7***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

Climate Change Parameter Used: Adjustment to Design Rainfall of 6.9%

PCSump Version 6.1: Licenced to BG&E Pty Limited

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

P23078 - Hammond & Mandogalup Road

Project Description:

Basin 3c

Model Selection: **Deep Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	36.6	1%	0.92	31.22	0.88	1,416	1,787	8
	2	1 hour	46.8	1%	1.1	31.40	0.70	1,757	1,893	7
	3	2 hour	61.0	1%	1.33	31.63	0.47	2,191	2,014	3
	4	3 hour	71.9	1%	1.45	31.75	0.35	2,450	2,088	6
	5	6 hour	95.9	1%	1.68	31.98	0.12	2,944	2,225	2
	6	9 hour	112.2	1%	1.78	32.08	0.02	3,179	2,309	6
	7	12 hour	124.0	1%	1.76	32.06	0.04	3,132	2,291	7
	8	24 hour	149.7	1%	1.63	31.93	0.17	2,837	2,196	7
	9	48 hour	165.7	1%	1.17	31.47	0.63	1,879	1,925	9
	10	72 hour	172.1	1%	1.13	31.43	0.67	1,802	1,904	10
	11	96 hour	179.6	1%	0.78	31.08	1.02	1,170	1,710	10
	12	120 hour	189.2	1%	0.97	31.27	0.83	1,511	1,817	9
	13	144 hour	201.0	1%	1.1	31.40	0.70	1,741	1,888	6
	14	168 hour	215.9	1%	1	31.30	0.80	1,568	1,835	6
Critical	***6***	***9 hour***	***112.2***	***1%***	***1.78***	***32.08***	***0.02***	***3,179***	***2,309***	***6***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

Climate Change Parameter Used: Adjustment to Design Rainfall of 6.9%

At BG&E, we are united by a common purpose – we believe that truly great engineering takes curiosity, bravery and trust, and is the key to creating extraordinary built environments.

Our teams in Australia, New Zealand, South East Asia, the United Kingdom and the Middle East, design and deliver engineering solutions for clients in the Property, Transport, Ports and Marine, Water, Defence, Renewables and Resources sectors.

We collaborate with leading contractors, developers, architects, planners, financiers and government agencies, to create projects for today and future generations.

ABN 67 150 804 603

OPPORTUNITIES THROUGH EXCELLENCE

bgeeng.com

BG&E

DEPARTMENT of PLANNING, LANDS and HERITAGE

HAMMOND & MANDOGALUP ROADS

ROAD RESERVE REVIEW STUDY
DPLH401523

DETAILS SHOWN ON THIS PLAN ARE
PRELIMINARY ONLY STAGE CONSTRUCTION
AND ULTIMATE DEVELOPMENT MAY DIFFER
FROM DETAILS SHOWN

Perth *Office*
Level 19, Kings Square 1
556 Wellington St Perth WA 6000
P / +61 8 6364 3300 *E /* info@bgeeng.com
W / bgeeng.com

SCALE

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE
THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED : J WRIGHT		CHECKED : J WONG	
DRAWN : B WEST		APPROVED : S SIVANATHAN	
FILENAME DRG-18127-COVER-PAGE.dgn			
FILE REF :			

NORTH
AS ABOVE

SHEET SIZE
A1

ROAD RESERVE REVIEW STUDY DPLH401523
MRS-HAMMOND ROAD-COVER PAGE
HAMMOND ROAD

LOCAL AUTHORITY

URBAN TRANSPORT SYSTEMS DIRECTORATE

PLAN No.
1.8127

DRAWING No	DESCRIPTION
18127	COVER PAGE
18128	INDEX PAGE
18129	CONCEPT PLAN
18130	CARRIAGEWAY PATTERN AND PROFILE - CHA 0 TO CHA 1080
18131	CARRIAGEWAY PATTERN AND PROFILE - CHA 1080 TO CHA 2160
18132	CARRIAGEWAY PATTERN AND PROFILE - CHA 2160 TO CHA 3240
18133	LAND PROTECTION PLAN - CHA 0 TO CHA 1500
18134	LAND PROTECTION PLAN - CHA 1500 TO CHA 3240
18135	TYPICAL ROAD CROSS SECTIONS - SHEET 1
18136	TYPICAL ROAD CROSS SECTIONS - SHEET 2

DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN

Perth Office—
484 Murray St Perth WA 6000
P/+61 8 6364 3300
E/info@bgeeng.com
bgeeng.com—

BG&E

SCALE

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

GDA

Department of Planning, Lands and Heritage
GOVERNMENT OF WESTERN AUSTRALIA

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED J WRIGHT		CHECKED J WONG	
DRAWN B WEST		APPROVED S SIVANATHAN	

FILENAME DRG-18131-PLAN-PROFILE-1.dgn
FILE REF :

NORTH
AS ABOVE

SHEET SIZE
A1

ROAD RESERVE REVIEW STUDY DPLH401523

MRS-HAMMOND ROAD-DRAWING INDEX

HAMMOND ROAD

LOCAL AUTHORITY

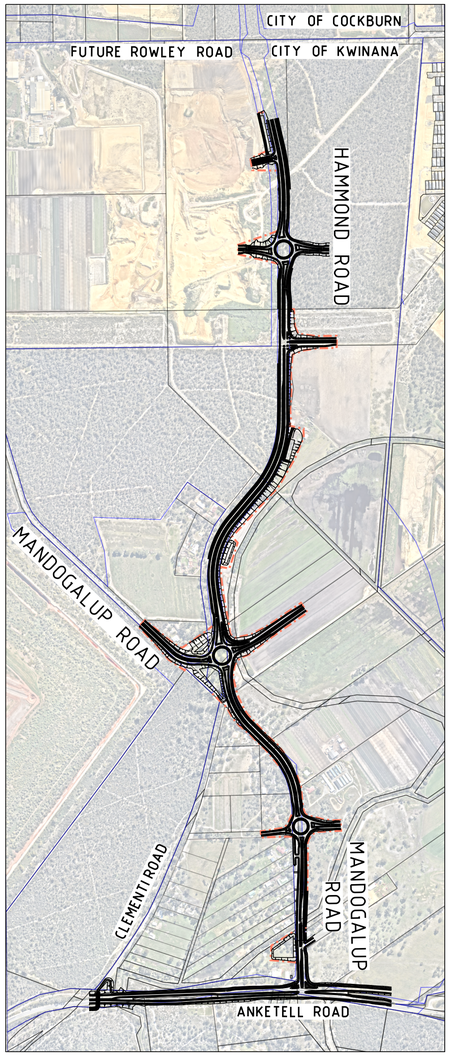
URBAN TRANSPORT SYSTEMS DIRECTORATE

PLAN No.
1.8128

LEGEND

EXISTING MRS
PROPOSED MRS
CADASTRAL BOUNDARY

NORTH



DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN

Perth *Office*
Level 19, Kings Square 1
556 Wellington St Perth WA 6000
P / +61 8 6364 3300 *E /* info@bgeeng.com
W / bgeeng.com

NOTE

1 FOR LAND PROTECTION PLAN SEE DRG No'S 1 8133 & 1 8134
2 FOR CARRIAGEWAY PATTERN AND PROFILE SEE DRAWING No'S 1 8130, 1 8131 & 1 8132
3 FOR TYPICAL CROSS SECTIONS SEE DRG No'S 1 8135 & 1 8136
4 DRAINAGE DESIGN SUBJECT TO DETAIL DESIGN
5 RAISED SAFETY PLATFORMS TO BE INVESTIGATED AT FUTURE DESIGN STAGES

SCALE HORIZONTAL 1:10000 200 100 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED J WRIGHT		CHECKED J WONG	
DRAWN B WEST		APPROVED S SIVANATHAN	

FILENAME DRG-1 8129-CONCEPT-PLAN dgn
FILE REF :

NORTH AS ABOVE

SHEET SIZE A1

ROAD RESERVE REVIEW STUDY DPLH401523

MRS-HAMMOND ROAD-CONCEPT PLANS

HAMMOND & MANDOGALUP ROADS

LOCAL AUTHORITY

URBAN TRANSPORT SYSTEMS DIRECTORATE

PLAN No. 1.8129

DRG-1.8129-CONCEPT-PLAN .dgn 31/05/2024 1:27:59 PM

NOTES

1 FOR CONCEPT PLAN SEE DRG No 18129

2 FOR LAND PROTECTION PLAN SEE DRG No'S 18133 & 18134

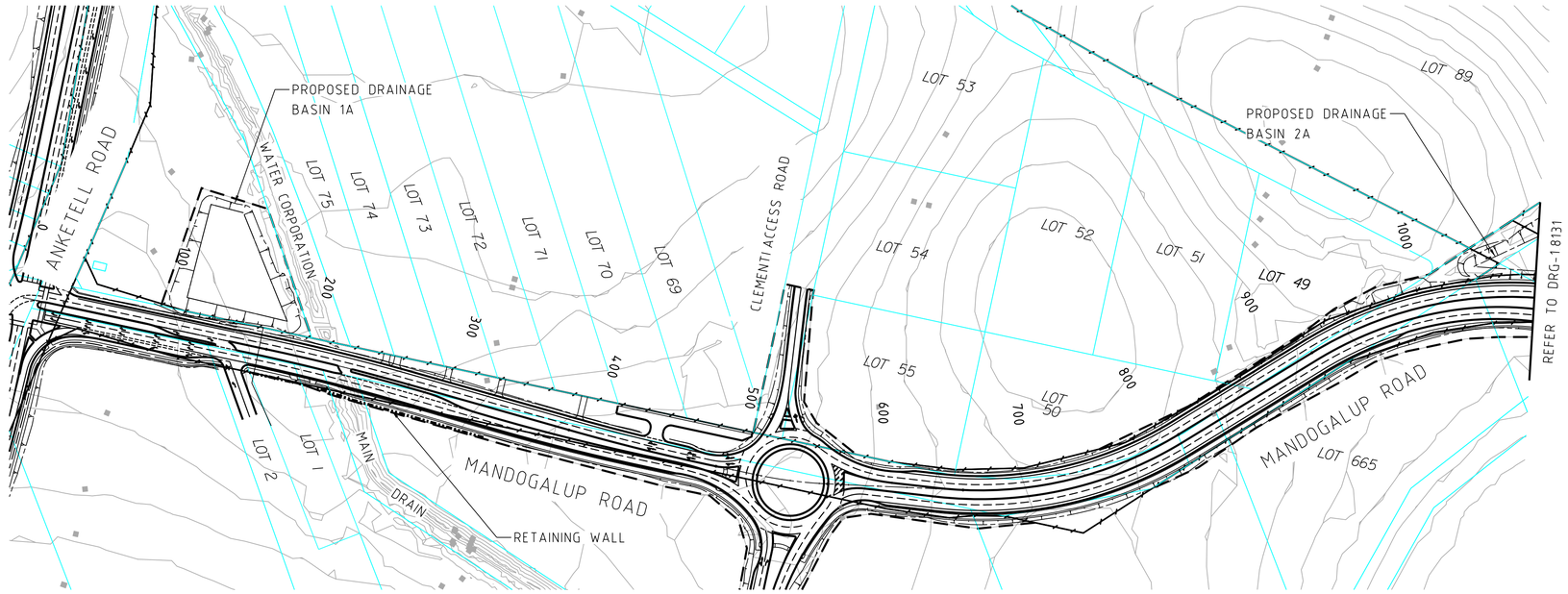
3 FOR TYPICAL CRCOSS SECTIONS SEE DRG No'S 18135 & 18136

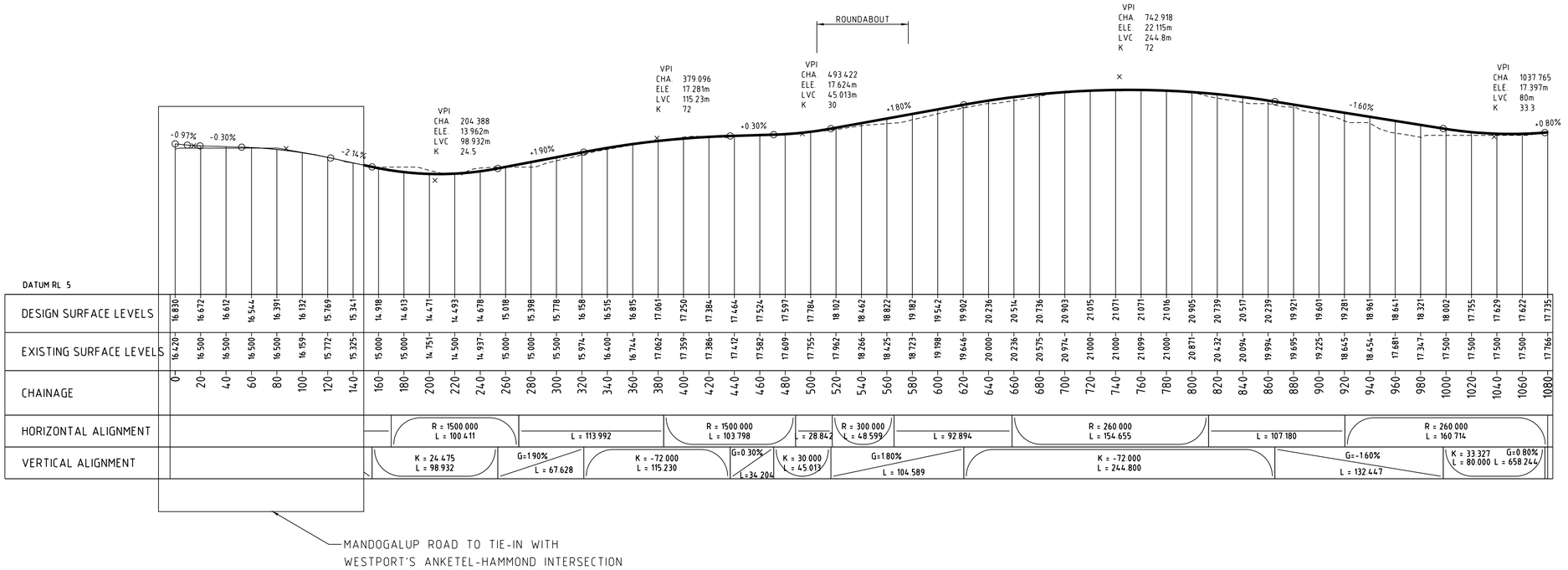
4 DRAINAGE DESIGN SUBJECT TO DETAIL DESIGN

5 GROUNDWATER LEVEL BASED ON PERTH GROUNDWATER ATLAS (DWER)

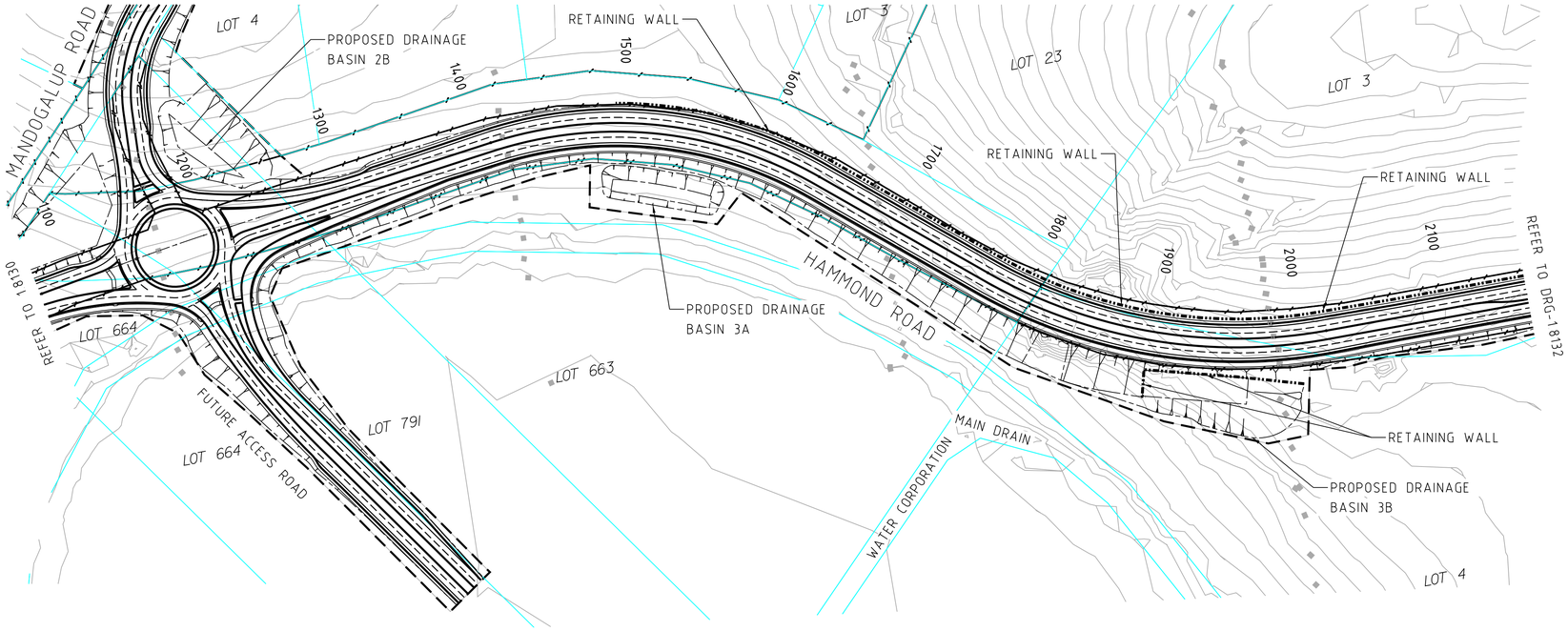
LEGEND

- CADASTRAL BOUNDARY
- EXISTING MRS
- PROPOSED LAND REQUIREMENT
- EXISTING CONTOUR
- RETAINING WALL





| | | |

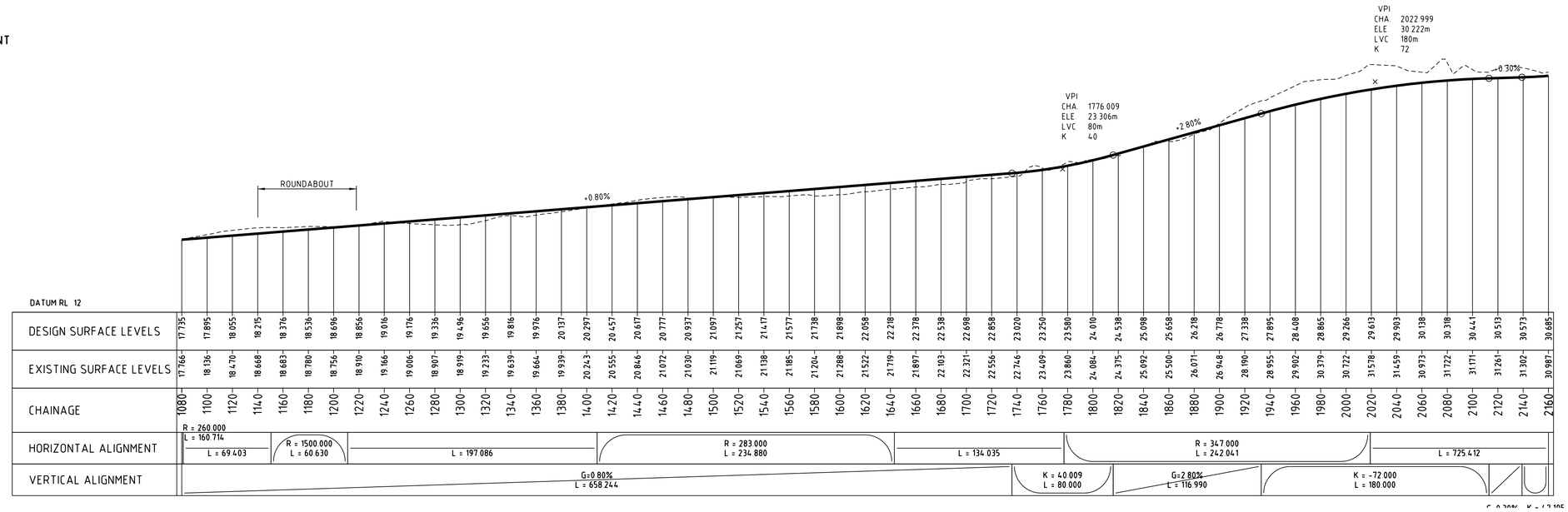


NOTES

1 FOR CONCEPT PLAN SEE DRG No 18129
2 FOR LAND PROTECTION PLAN SEE DRG No'S 18133 & 18134
3 FOR TYPICAL CRCOSS SECTIONS SEE DRG No'S 18135 & 18136
4 DRAINAGE DESIGN SUBJECT TO DETAIL DESIGN
5 GROUNDWATER LEVEL BASED ON PERTH GROUNDWATER ATLAS (DWER)

LEGEND

- CADASTRAL BOUNDARY
- EXISTING MRS
- PROPOSED LAND REQUIREMENT
- EXISTING CONTOUR
- RETAINING WALL



CHAINAGE	DESIGN SURFACE LEVELS	EXISTING SURFACE LEVELS
1080	17.735	17.766
1100	17.895	18.136
1120	18.055	18.470
1140	18.215	18.668
1160	18.376	18.683
1180	18.536	18.780
1200	18.696	18.756
1220	18.856	18.910
1240	19.016	19.166
1260	19.176	19.006
1280	19.336	18.907
1300	19.496	18.919
1320	19.656	19.233
1340	19.816	19.639
1360	19.976	19.664
1380	20.137	19.939
1400	20.297	20.243
1420	20.457	20.555
1440	20.617	20.846
1460	20.777	21.072
1480	20.937	21.030
1500	21.097	21.119
1520	21.257	21.069
1540	21.417	21.138
1560	21.577	21.185
1580	21.738	21.204
1600	21.898	21.288
1620	22.058	21.522
1640	22.218	21.719
1660	22.378	21.897
1680	22.538	22.103
1700	22.698	22.321
1720	22.858	22.556
1740	23.020	22.746
1760	23.250	23.409
1780	23.580	23.860
1800	24.010	24.084
1820	24.538	24.375
1840	25.098	25.092
1860	25.658	25.500
1880	26.218	26.071
1900	26.778	26.948
1920	27.338	28.190
1940	27.895	28.955
1960	28.408	29.902
1980	28.865	30.379
2000	29.266	30.722
2020	29.613	31.578
2040	29.903	31.459
2060	30.138	30.973
2080	30.318	31.722
2100	30.441	31.171
2120	30.513	31.261
2140	30.573	31.302
2160	30.685	30.987

DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN

Perth Office—
484 Murray St Perth WA 6000
P/+61 8 6364 3300
E/info@bgeeng.com
bgeeng.com—
BG &E

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

GDA

Department of Planning, Lands and Heritage
GOVERNMENT OF WESTERN AUSTRALIA

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED J WRIGHT		CHECKED J WONG	
DRAWN B WEST		APPROVED S SIVANATHAN	

FILENAME DRG-18131-PLAN-PROFILE-1.dgn
FILE REF :

NORTH AS ABOVE

SHEET SIZE A1

ROAD RESERVE REVIEW STUDY DPLH401523

MRS-HAMMOND ROAD-PLAN AND PROFILES

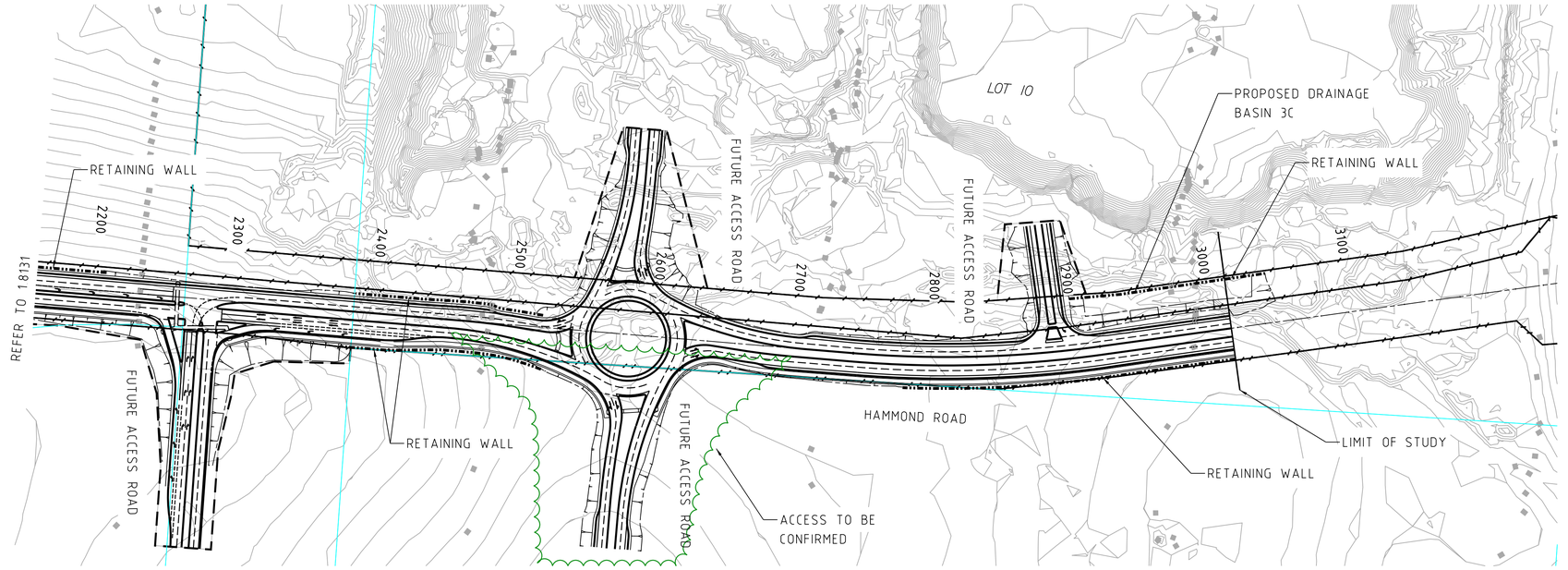
CARRIAGEWAY PATTERN AND PROFILE CH1080 to CH2160

LOCAL AUTHORITY

URBAN TRANSPORT SYSTEMS DIRECTORATE

PLAN No. 1.8131

SCALE HORIZONTAL 1:2000 VERTICAL 1:200

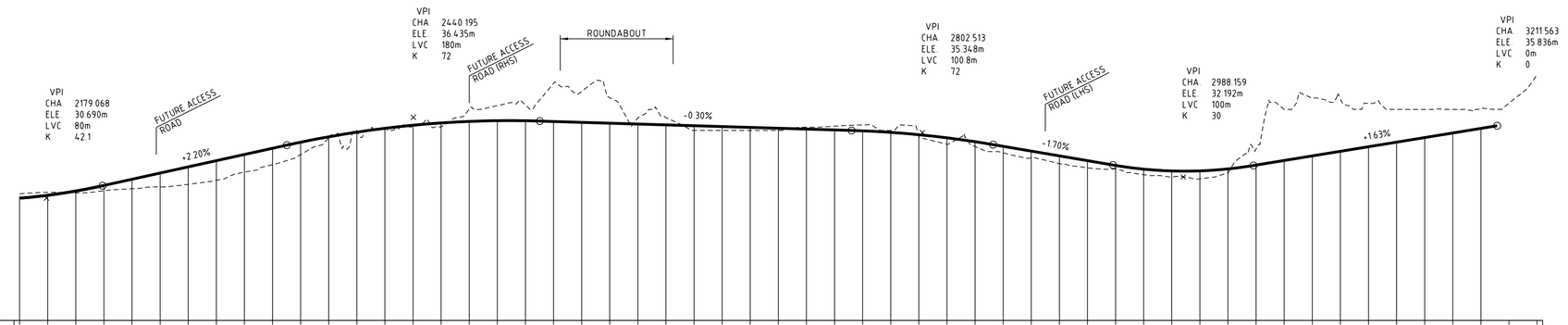


NOTES

1 FOR CONCEPT PLAN SEE DRG No 18129
2 FOR LAND PROTECTION PLAN SEE DRG No'S 18133 & 18134
3 FOR TYPICAL CRCOSS SECTIONS SEE DRG No'S 18135 & 18136
4 DRAINAGE DESIGN SUBJECT TO DETAIL DESIGN
5 GROUNDWATER LEVEL BASED ON PERTH GROUNDWATER ATLAS (DWER)

LEGEND

- CADASTRAL BOUNDARY
- EXISTING MRS
- PROPOSED LAND REQUIREMENT
- EXISTING CONTOUR
- RETAINING WALL



DATUM RL 22

| | | |

NOTE

1 DIMENSIONS ARE SUBJECT TO SURVEY
2 FOR CONCEPT PLAN SEE DRG No 18129
3 FOR CARRIAGEWAY PATTERN AND PROFILE SEE DRAWING No'S 18130, 18131 & 18132
4 FOR TYPICAL CROSS SECTIONS SEE DRG No 18135 & 18136
5 DRAINAGE INVESTIGATION SUBJECT TO DETAIL DESIGN

NORTH

LEGEND

CADASTRAL BOUNDARY
EXISTING MRS
PROPOSED LAND REQUIREMENT

CLEMENTI ROAD
MANDOGALUP ROAD
ANKETEL ROAD
HAMMOND ROAD
REFER TO 18134

LOT 501, LOT 89, LOT 4, LOT 23, LOT 22, LOT 53, LOT 52, LOT 51, LOT 49, LOT 54, LOT 664, LOT 75, LOT 74, LOT 73, LOT 72, LOT 71, LOT 70, LOT 69, LOT 55, LOT 50, LOT 665, LOT 791, LOT 663, LOT 1, LOT 2, LOT 666, LOT 667, LOT 668

DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN

Perth *Office*
Level 19, Kings Square 1
556 Wellington St Perth WA 6000
P / +61 8 6364 3300 *E /* info@bgeeng.com
W / bgeeng.com

SCALE HORIZONTAL 1:2000

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED J WRIGHT		CHECKED J WONG	
DRAWN B WEST		APPROVED S SIVANATHAN	
FILENAME DRG-18141-LAND-PROTECTION-PLAN-1.dgn			
FILE REF			

NORTH AS ABOVE

SHEET SIZE A1

ROAD RESERVE REVIEW STUDY DPLH401523

MRS-HAMMOND ROAD-LAND PROTECTION

LAND PROTECTION PLAN CH0000 to CH1500

LOCAL AUTHORITY

URBAN TRANSPORT SYSTEMS DIRECTORATE

PLAN No. 1.8133

DRG-1.8133-LAND-PROTECTION-PLAN-1.dgn 31/05/2024 4:35:44 PM

NOTE

1 DIMENSIONS ARE SUBJECT TO SURVEY
2 FOR CONCEPT PLAN SEE DRG No 18129
3 FOR CARRIAGEWAY PATTERN AND PROFILE SEE DRAWING No'S 18130, 18131 & 18132
4 FOR TYPICAL CROSS SECTIONS SEE DRG No 18135 & 18136
5 DRAINAGE INVESTIGATION SUBJECT TO DETAIL DESIGN

NORTH

REFER TO 18133

LOT 3

LOT 23

LOT 3

LOT 10

LOT 4

LOT 4

LOT 2

ACCESS TO BE CONFIRMED

DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN

LEGEND

CADASTRAL BOUNDARY

EXISTING MRS

PROPOSED LAND REQUIREMENT

SCALE HORIZONTAL 1:2000 0 20 40 60 80 100 120 140 160 180 200

Perth *Office*
Level 19, Kings Square 1
556 Wellington St Perth WA 6000
P / +61 8 6364 3300 *E /* info@bgeeng.com
W / bgeeng.com

BG&E

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED J WRIGHT		CHECKED J WONG	
DRAWN B WEST		APPROVED S SIVANATHAN	
FILENAME DRG-18142-LAND-PROTECTION-PLAN-2.dgn			
FILE REF :			

NORTH AS ABOVE

SHEET SIZE A1

ROAD RESERVE REVIEW STUDY DPLH401523

MRS-HAMMOND ROAD-LAND PROTECTION

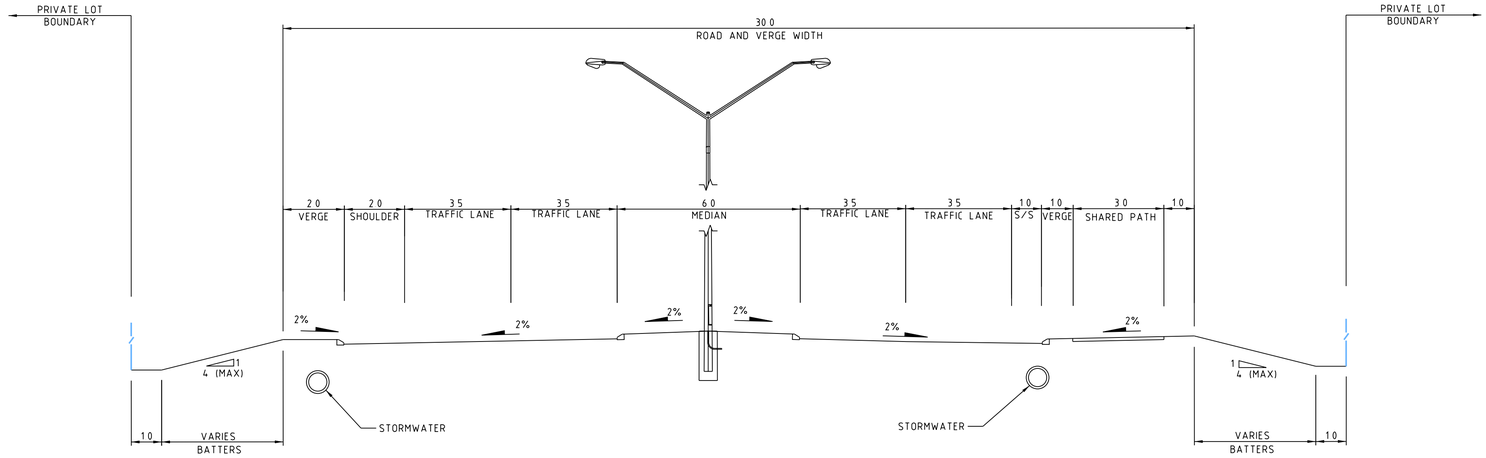
LAND PROTECTION PLAN CH1500 to CH3240

LOCAL AUTHORITY

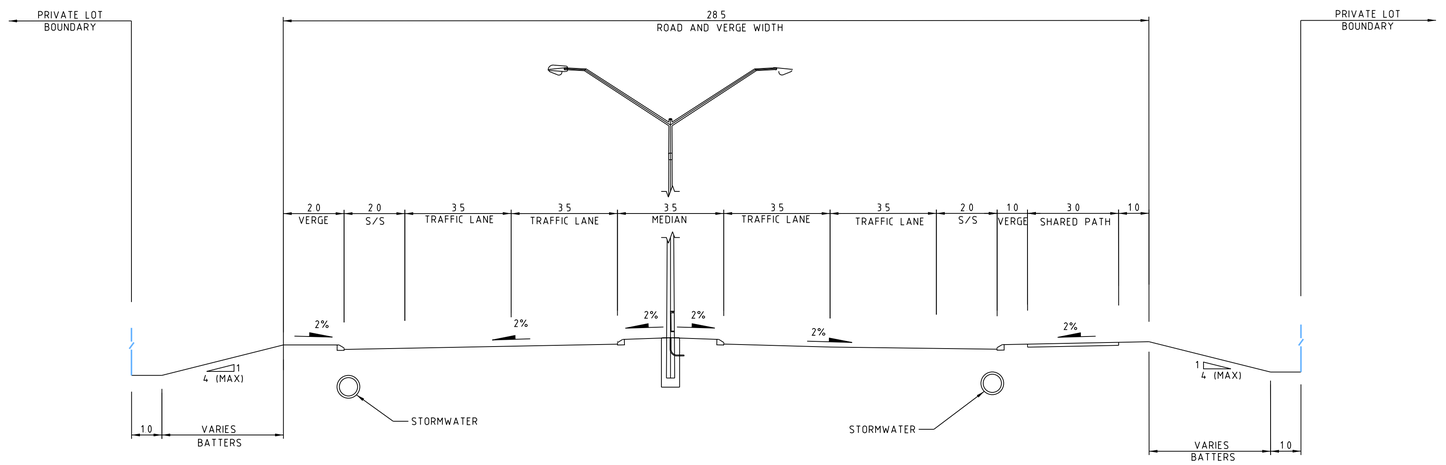
URBAN TRANSPORT SYSTEMS DIRECTORATE

PLAN No. 1.8134

NOTES
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.



MANDOGALUP ROAD (TYP)
ANKETELL ROAD TO CLEMENTI ACCESS ROAD
CH0 to CH600
1:100



MANDOGALUP ROAD (TYP)
CLEMENTI ACCESS ROAD TO NORKETT ROAD
CH600 to CH1300
1:100

DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN

Perth Office—
484 Murray St Perth WA 6000
P/+61 8 6364 3300
E/info@bgeeng.com
bgeeng.com—

BG&E

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

GDA

Department of Planning, Lands and Heritage
GOVERNMENT OF WESTERN AUSTRALIA

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED J WRIGHT		CHECKED J WONG	
DRAWN B WEST		APPROVED S SIVANATHAN	

FILENAME DRG-18131-PLAN-PROFILE-1.dgn
FILE REF

NORTH
AS ABOVE

SHEET SIZE
A1

ROAD RESERVE REVIEW STUDY DPLH401523
MRS-HAMMOND ROAD-TYPICAL CROSS SECTIONS
TYPICAL ROAD CROSS SECTIONS - SHEET 1

LOCAL AUTHORITY

URBAN TRANSPORT SYSTEMS DIRECTORATE

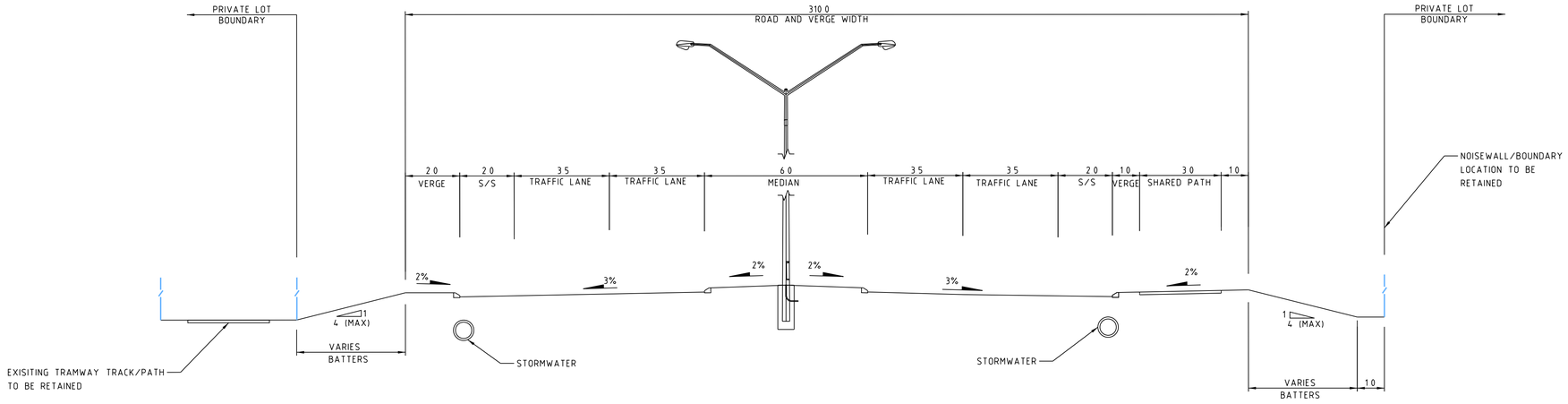
PLAN No.
1.8135

SCALE

typ1.dgn 31/05/2024 1:22:18 PM

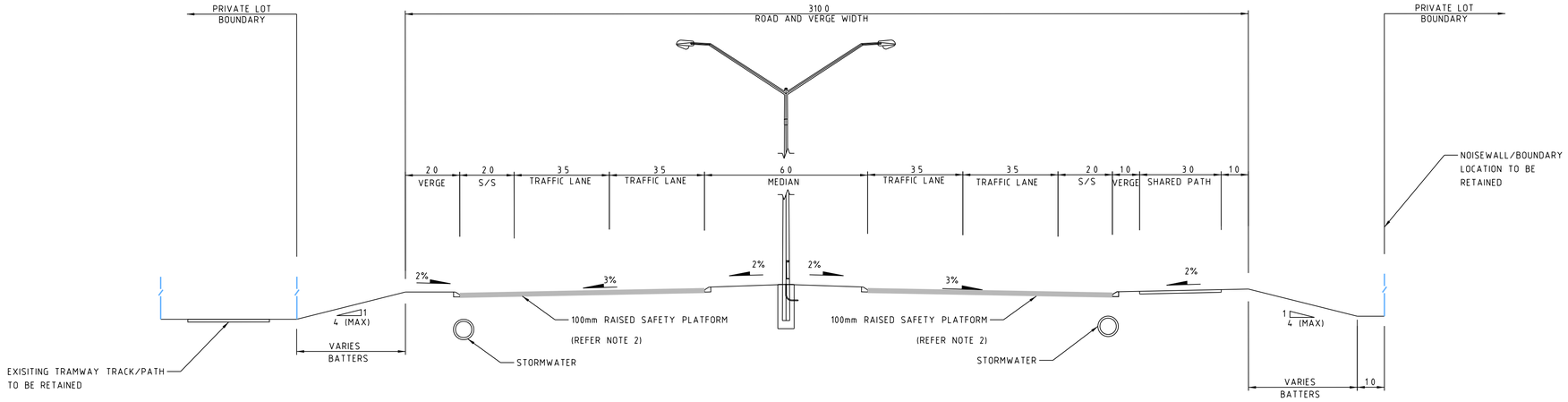
NOTES

1. DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE
2. RAISED SAFETY PLATFORM TO BE PROVIDED ON ALL ROUNDABOUT APPROACHES ON HAMMOND ROAD (APPROXIMATELY 25m BEFORE ROUNDABOUT) EXACT LOCATION TO BE CONFIRMED AT NEXT DESIGN STAGE



HAMMOND ROAD (TYP)

NORKETT ROAD TO ROWLEY ROAD
CH1300 to CH3000
1 100



HAMMOND ROAD

RAISED SAFETY PLATFORM
AT ROUNDABOUT APPROACHES
1 100

DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN

Perth Office—
484 Murray St Perth WA 6000
P/+61 8 6364 3300
E/info@bgeeng.com
bgeeng.com—

BG&E

BASE DATA SUPPLIED BY LI 430-2009-2
DATE OF AERIAL PHOTOGRAPHY

GDA

Department of Planning, Lands and Heritage
GOVERNMENT OF WESTERN AUSTRALIA

AMENDMENTS

IN THE ABSENCE OF THE APPROVED SIGNATURE THIS DRAWING SHALL BE TREATED AS PRELIMINARY

DESIGNED J WRIGHT		CHECKED J WONG	
DRAWN B WEST		APPROVED S SIVANATHAN	

FILENAME DRG-18131-PLAN-PROFILE-1.dgn
FILE REF

NORTH
AS ABOVE

SHEET SIZE
A1

ROAD RESERVE REVIEW STUDY DPLH401523

MRS-HAMMOND ROAD-TYPICAL CROSS SECTIONS

TYPICAL ROAD CROSS SECTIONS - SHEET 2

LOCAL AUTHORITY

URBAN TRANSPORT SYSTEMS DIRECTORATE

PLAN No.
1.8136

SCALE

typ2.dgn 31/05/2024 4:39:08 PM