Stream Environment and Water

Anketell Road Upgrade Wetland Assessment

MARCH, 2025

MAIN ROADS WESTERN AUSTRALIA

Stream Environment and Water Pty Ltd

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Contents

1 INTRODUCTION

1.1 Project Background

Main Roads Western Australia (Main Roads) is proposing to upgrade Anketell Road. The Proposal includes approximately seven kilometres (km) of new road construction along Anketell Road, between Leath Road, Kwinana to Treeby Road, Wandi/Anketell in the City of Kwinana, Western Australia.

The Proposal will involve the construction of an efficient freight corridor using Anketell Road, connecting Kwinana Freeway with the future freight terminal for a land backed port within the Kwinana Industrial Area (KIA). The Proposal includes:

- A new urban expressway standard, dual carriageway
- Grade separated interchanges at numerous locations
- Grade separation over rail
- New local roads and existing road modifications
- A shared path along the length of the Proposal
- Drainage basins of varying size
- Utility relocations and other road infrastructure and furniture.

Construction of the Proposal is likely to adopt a mix of earthwork batters (fill and cut) with landscaping and retaining walls. The Proposal will also likely require the crossing and potential realignment of a Water Corporation open drain (Peel Main Drain).

Main Roads intends to submit a revised Referral Supporting Document in March 2025 and have asked Stream Environment and Water (Stream) to assess the risks to wetlands and surface water from the proposal by charactering the existing environment and considering direct and indirect impacts from the proposal within the Anketell Road upgrade referral boundary (referred to as the Development Envelope or DE).

There are several wetland areas identified in the geomorphic wetlands dataset within and surrounding the proposal area, with management categories including Multiple Use (MU), Resource Enhancement (RE) and Conservation Category Wetland (CCW) (DBCA 2023). Of note is the North Spectacles conservation CCW approximately 100m south of the DE and the Mandogalup Swamp South CCW 10m to the northeast. An assessment of the environmental values of wetland areas within and surrounding the DE is required to inform the potential impacts to wetlands resulting from changes to the hydrology and drainage as a result of the roadworks.

1.2 Site Location and Details

The proposal is located on the Swan Coastal Plain, in the City of Kwinana (Figure 1). Some aspects of the wetland and hydrological desktop assessment also included assessment of information within 250 m radius of the DE (referred to as the survey area) and within a 5 km radius of the survey area (desktop study area).

1.3 Scope and Objectives

Main Roads contracted Stream Environment & Water Pty Ltd (Stream) to carry out an assessment of wetland and hydrological values of the survey area and conduct an assessment of the risks and potential impacts to those values as a result of the proposal.

The scope of work included:

Wetland Assessment

- A desktop review of wetland and associated ecological values of the survey area, with approximate 5 km buffer area (study area) to provide context.
- A field survey to ground truth and compliment the results of the desktop assessment to characterise the features, attributes, functions, values and condition of the wetlands and watercourses intersecting the survey area.
- Evaluation of each wetland within the survey area following the evaluation procedure detailed in DBCA (2017a) to verify the current management classification of each wetland and to assist in the identification of wetland geomorphology, wetland processes, and ecological values.

Hydrological Assessment

In parallel to the desktop ecological values assessment a review of available hydrological data and information will be conducted to describe and characterise current groundwater and surface water regimes of the survey area. This included:

- Review of the outputs of the FSG Preliminary Groundwater Assessment Report (FSG 2024)
- Review of surface water level, flow and water quality information pertaining to the Peel Main Drain.
- Description and characterisation of wetlands/surface water that are likely to be supported/linked to hydrology. i.e. groundwater/surface water dependent.

Assessment of Risks and Impacts

- Assessment of the proposal's potential impacts on surface water and wetlands considering direct and indirect impacts (due to excavation, dewatering and groundwater abstraction) to wetlands within the survey area.
- Review of surface water design information and Drainage Management Strategy in consideration of risks and management of impacts.

Reporting

- Preparation of a technical report with suitable maps to summarise methods and results of the assessment.

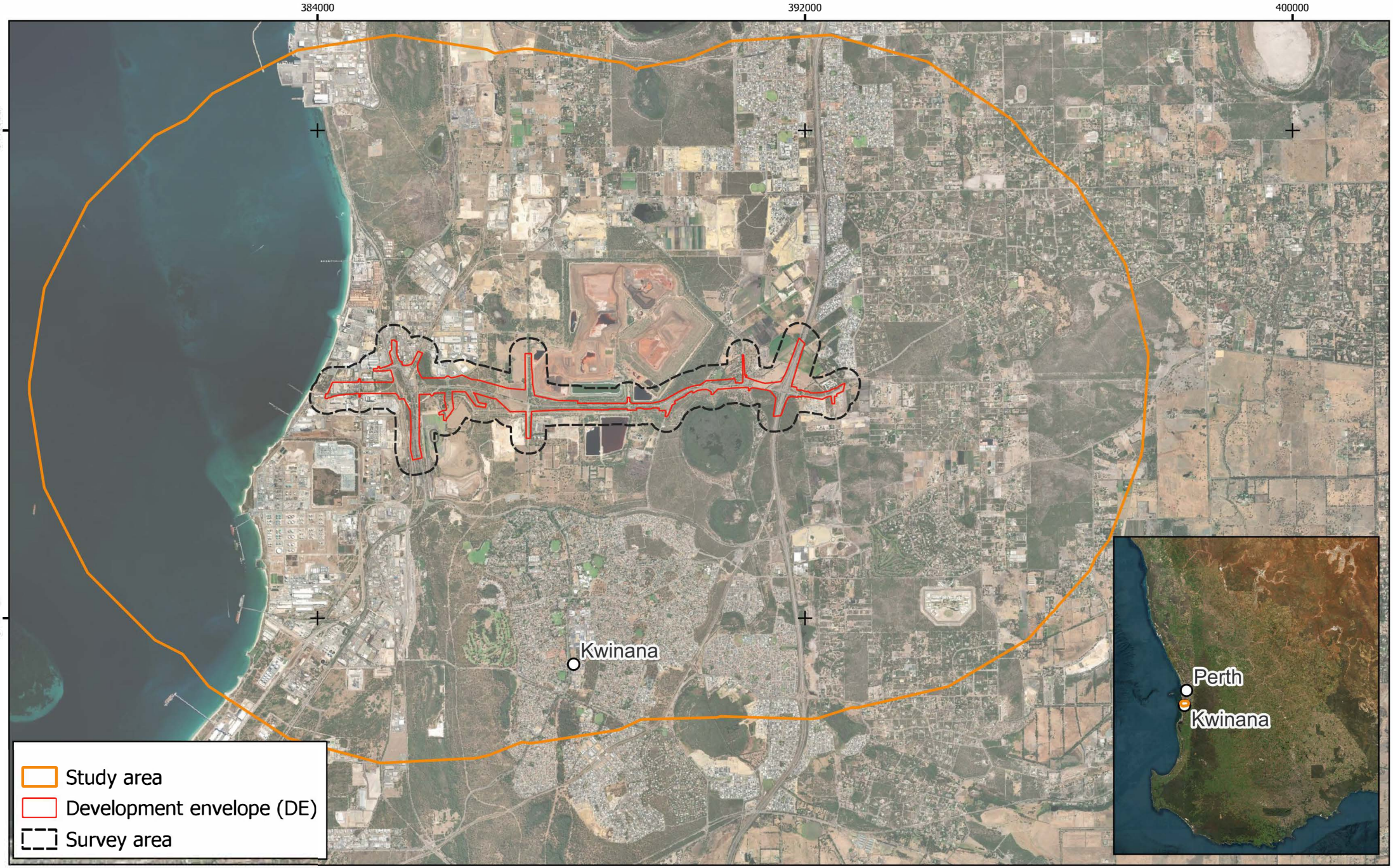

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Figure 1
Location of the DE, survey area and study area

Anketell Road Upgrade Wetland Assessment

N

0 2.5 5 km

Base map © ESRI and its data suppliers. Landgate (2020)
CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 31/01/25 Author: CS

2 METHODOLOGY

2.1 Wetland Assessment

The wetland assessment primarily followed the methodology detailed in *A methodology for the evaluation of wetlands on the Swan Coastal Plain, Western Australia* (DBCA 2017a). Where appropriate the methodology was supplemented by additional information and also included consideration of:

- Environmental Factor Guideline, Inland Waters (EPA 2018)
- Methodology: Rapid Indicator Assessment of Western Australian Inland Aquatic Ecosystems (DEC 2008)
- Wetland identification and delineation: information for mapping and land use planning on the Swan Coastal Plain (DBCA 2017b)
- Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016).

The assessment included desktop and field components and was completed for wetlands within the survey area.

2.2 Desktop ecological values assessment

A desktop assessment was conducted to identify relevant ecological values within the survey area, focusing on wetlands and waterways and other ecosystems sensitive to changes in hydrology. The desktop review included review of information available from relevant datasets/sources within the desktop study area. The following sources and datasets were included:

- Geomorphic wetlands of the Swan Coastal Plain and Consanguineous wetland suites (DBCA-019 and DBCA-020) (DBCA 2023, DBCA 2017c)
- Directory of important wetlands in Australia (DBCA-045) (DBCA 2018)
- Ramsar sites (DBCA-010) (DBCA 2017d)
- Bureau of Meteorology (BoM) Groundwater Dependent Ecosystems Atlas (BoM 2024a)
- Water information reporting database (DWER) (DWER 2024a)
- Bush Forever (DEP 2000)
- Healthy rivers south west website and data (rivers.dwer.wa.gov.au) (DWER 2024b)
- Threatened/Priority Flora and Ecological Communities for the Survey area (provided by Main Roads)

The information collected during the desktop assessment was used to identify and describe the key ecological features and complete relevant sections of the *Wetland evaluation desktop and site assessment form* (Appendix C of DBCA 2017a).

The results of recently completed *Anketell Road Upgrade Consolidated Biological Report* was utilised in the desktop assessment to identify ecological values such as significant communities, flora and fauna (Biota 2025)

2.3 Hydrology Review

In parallel to the desktop ecological values assessment, available hydrological data and information was reviewed. This included available groundwater level, surface water flow and water quality monitoring results. The hydrological review utilised existing information to describe and characterise

current groundwater and surface water regimes across the survey area and of key ecological features within the survey area (and in vicinity of the Proposal).

Key hydrological features, including waterways and groundwater systems were described including:

- Catchment boundaries for surface water features
- Groundwater levels within the survey area and direction of flow (focusing on shallow aquifers)
- Potential areas of groundwater surface water interaction
- Groundwater and surface water chemistry.

The following documents and data were reviewed for the purposes of the hydrology review, including water quality:

- Cockburn groundwater area water management plan (DoW 2007)
- Cockburn groundwater allocation plan methods report (DWER 2018)
- Geotechnical report MRWA Westport Project – Anketell Rd and Thomas Rd, Kwinana to Oakford, Preliminary Geotechnical Investigation 2022 (Golder 2022, 2024)
- Jandakot drainage and water management plan, Peel Main Drain (DoW 2009)
- Lower Serpentine hydrological studies, conceptual model report. Water Science technical series report 45 (Marillier *et al.* 2012)
- Inferring groundwater dynamics in a coastal aquifer near wastewater infiltration ponds and shallow wetlands (Kwinana, Western Australia) using combined hydrochemical, isotopic and statistical approaches (Bekele *et al.* 2019)
- Water Information Reporting (DWER 2024a)
- Water quality improvement plan for the rivers and estuary of the Peel Harvey system (EPA 2008a).
- FSG Preliminary Groundwater Assessment Report outputs (FSG 2024)

2.4 Site Visit

A targeted field visit was conducted on Wednesday 13th March 2024 to ground truth and compliment the results of the desktop survey. The field visit collected information to characterise the features, attributes, functions, values and condition of the wetlands and watercourses intersecting the survey area (identified in the desktop assessment).

Site locations were recorded using handheld GPS and data collected using standard field sheets.

The target areas were those with potential high conservation values and representative of wetlands intersecting the survey area and/or where the collection of site specific data was possible and could add value to the assessment

2.5 Hydro-Ecological Interaction

Information from the ecological values assessment and hydrological review has been used describe and characterise how wetlands and surface water features are likely to be supported/linked to hydrology. i.e. groundwater/surface water dependent.

2.6 Assessment of Risks and Impacts

An assessment of the proposal's potential impacts on surface water and wetlands was carried out with consideration to key values identified in the wetland assessment. The focus of the impact assessment was high value wetlands (conservation category) and areas considered "at risk" i.e. those wetlands

that are likely to be affected by changes in hydrology resulting from activities associated with the Proposal.

Assessment included consideration of the following components:

- Describing the construction activities that have the potential to impact surface water and wetlands.
- Conducting a risk assessment of construction activities on the hydrological processes and ecological values of wetlands and waterways of the survey area.
- A summary of the potential direct and indirect impacts to wetlands and surface water.

2.7 Survey Limitations

Due to time constraints, the assessment primarily relied on existing datasets and information. Some targeted one off data was collected during the site visit, however, hydrological assessments of this type rely on time series data and therefore existing information was utilised for this assessment. Wetland assessments should typically occur after significant rainfall. This was not possible due to the timing of the assessment.

3 REGIONAL SETTING

3.1 Climate

Perth has a mediterranean climate with hot dry summers and mild wet winters. The Anketell Road survey area is in the City of Kwinana. Jandakot Aero (climate station 9172) is the nearest meteorological station to the survey area with a long-term record. Annual average rainfall recorded at the station is 813 mm (1972 – 2023) with most rain falling between May to August.

Rainfall was below average in the months preceding the current wetland assessment (July to December 2023) and, despite above average rainfall in June, overall annual rainfall in 2023 was below average at 595 mm.

Climate statistics for Jandakot Aero show a temperature range from an average maximum of 31.6°C in the hottest month of February, to an average minimum of 18.1°C in July (climate station 9172) (BoM 2024b).

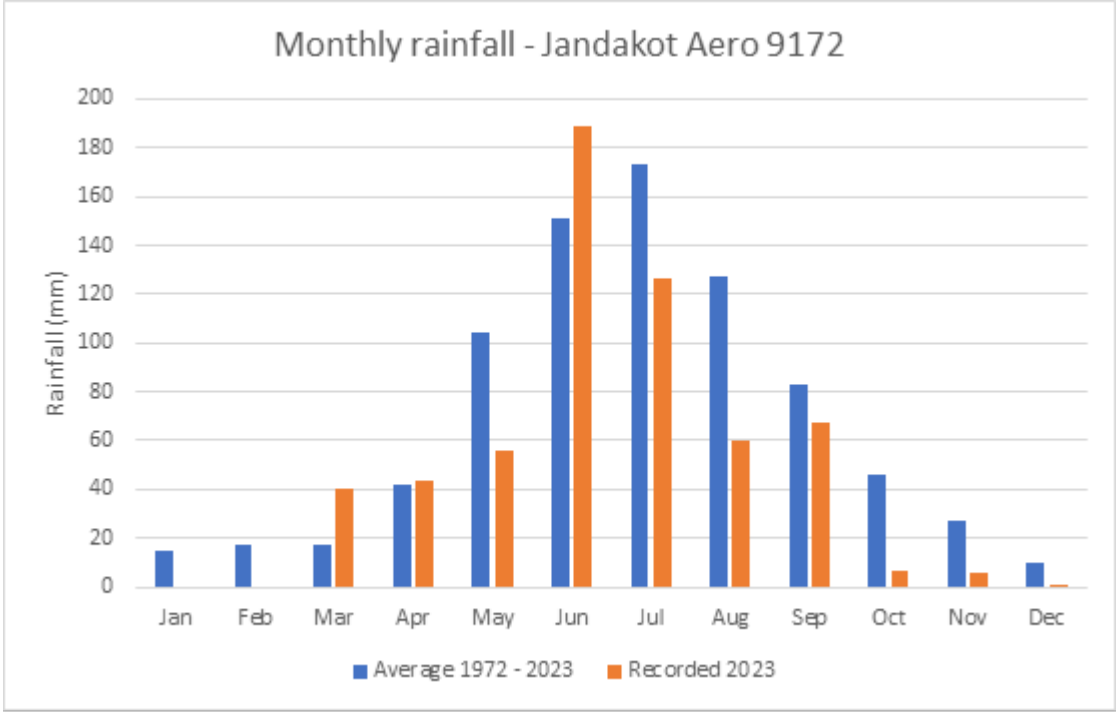

Figure 2: Rainfall averages of Jandakot Aero Station 9172

3.2 Topography

The study area is located on the Swan Coastal Plain (SCP) and extends from the coast to approximately 13 km inland. The topography of the study area is characterised by gentle undulating dune systems that occur as ridges and swales that generally run parallel to the present coastline. The survey area extends across the following three geomorphic units present in this part of the SCP (west to east) (DoW 2007, Marillier *et al.* 2012, Golder 2022):

- Quindalup Dune System (Riseley Road to Rockingham Road)
- Spearwood Dune System (Rockingham Road to Mandogalup Road)
- Bassendean Dune System (Mandogalup Road to Nicholson Road)

Topographically, elevation of the Quindalup dunes is 0 - 5 m AHD, the Spearwood dunes between 15 – 50 m AHD and Bassendean dunes about 15 – 35 m AHD (Marillier *et al.* 2012). Surface elevation along the survey area ranges between 7 and 42 m AHD (Golder 2022). Within the study area, Mandogalup Swamp, the Spectacles Wetlands and Bollard Bullrush Swamp are located on the western edge of the Jandakot Mound, and range in elevation from 15 m AHD, 10 m AHD and 5 m AHD respectively (Figure 3).

Within the study area the local topography is modified due to industrial, agricultural and urban development.

3.3 Geomorphology and Soils

The Quindalup Dune System is composed of Safety Bay Sands, present as a narrow coastal belt of low, generally unstable dunes over limestone. Tamala Limestone, overlain by Tamala Sand, is the geological formation of the Spearwood Dune System (Dow 2007, Golder 2022). At the interface between Tamala Limestone and Bassendean Sand to the east, a chain of wetlands run north-south consisting of alluvial, estuarine and swamp deposits. The Bassendean Dune System is composed of Bassendean Sand that overlies the relatively impermeable Guildford Clay (DoW 2007; Marillier *et al.* 2012). The sand ridges are excessively drained while the swales are seasonally inundated basins with minimal natural drainage (Semeniuk 1988).

There are eleven geological units (surface geology) within the study area (DMIRS 1986). Five units intersect the survey area, four are predominantly sand and limestone (S7, S8, S13and LS1) (Table 1). The lacustrine unit Ms5 (sand silt) is swamp deposits associated with the chain of wetlands at the interface between the Spearwood and Bassendean Dune Systems (Figure 4).

Table 1: Surface geology (1:50,000) of the survey area (250m buffer zone)

Code	Description
S7	SAND - pale yellowish brown, medium to coarse-grained sub-angular quartz, trace of feldspar, moderately sorted, of residual origin.
LS1	LIMESTONE - pale yellowish brown, fine to coarse-grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of eolian origin.
Ms5	SANDY SILT - dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content, of lacustrine origin.
S8	SAND - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin.
S13	CALCAREOUS SAND - white, medium-grained, rounded quartz and shell debris, well sorted, of eolian origin.

3.4 Regional Geology and Hydrogeology

The survey area is located on the Perth Basin, an extensive trough of sedimentary rocks that extend 1000 km north-south and to 12 000 m below ground level (mbgl). Within the Perth Basin geological formations with varying lithologies form distinct aquifers.

In the location of the survey area groundwater occurs in five regional aquifers, in order of shallowest to deepest these are the Superficial, Leederville (upper and lower), Yarragadee and Cattamarra aquifers (Marillier *et al.* 2012). The Superficial Aquifer is the most relevant to the current wetland assessment. The Jandakot Mound is a significant hydrogeological feature of the Superficial Aquifer in the area.

The Superficial Aquifer is unconfined and consists of sand, silt, clay and limestone derived from Tamala Limestone, Bassendean Sand and Guildford Clay. Beneath the survey area, the superficial formations range in thickness between 30 m to 65 m (DWER 2018a) and the saturated thickness ranges between 20 m and 40 m (Golder 2022). The Tamala Limestone forms a highly transmissive karst aquifer with irregular limestone outcropping. The Bassendean Sand is highly permeable and also forms an extensive component of the Superficial Aquifer on the SCP that extends into the survey area (Figure 5).

On the SCP, recharge to the Superficial Aquifer is mainly by direct infiltration of rainfall into sandy sediments such as Bassendean Sands. Recharge to the Superficial Aquifer may also occur via upward leakage from the Leederville Aquifer where upward head gradients occur. This recharge mechanism is mainly restricted to the eastern side of the SCP near the Darling Scarp. Regional groundwater flow on the SCP is generally in a westerly direction from the Darling Scarp toward the ocean, with other flow deviations caused by rivers, wetlands and drains. In the location of the study area the Jandakot Mound influences groundwater to flow radially east and west as part of a regional groundwater flow system (Golder 2022; Marillier *et al.* 2012).

Groundwater discharge from the Superficial Aquifer is primarily via evaporative losses as well as to rivers, coastal lakes, wetlands, artificial drains and as outflow to the ocean (DoW 2007).

The deeper Leederville and Yarragadee aquifers do not outcrop in the study area. The Kardinya Shale Member of the Osborne Formation acts as a confining aquiclude between the Leederville and superficial formations. The South Perth Shale forms a major confining bed between the Leederville and deeper Yarragadee aquifer (DoW 2007, Marillier *et al.* 2012).

3.5 Regional Hydrology

The study area is in the most northwestern extent of the Murray River basin and extends across the Coastal, Bartram Road and Peel Estuary-Serpentine River catchments (Figure 6). The sub catchments of Lake Coogee and Peel Main Drain intersect the survey area and Berriga Main Drain sub catchment intersects the study area to the east (DWER 2018b) (Table 2).

Table 2: Catchments and sub catchments of the Study area

Basin	Catchment	Sub catchment
Murray River Basin	Coastal	-
	Bartram Road	Lake Coogee
	Peel Estuary-Serpentine River	Peel Main Drain
		Berriga Main Drain

Historically within the study area and neighbouring parts of the SCP construction of agricultural drains, draining of wetlands and river straightening began around 1960 to manage rising water tables as a result of extensive clearing in the late 1800 (Marillier *et al.* 2012). The Peel Main Drain is one of the largest artificial drainage systems in the area and is the only surface hydrological feature, in addition to wetlands, within the study area.

Peel Main Drain is constructed entirely on the Swan Coastal Plain, beginning in the northeast of the study area at Banjup Lake. The drain runs south intersecting several wetlands including The Spectacles (north and south) and Bollard Bullrush Swamp within the study area before discharging to the Serpentine River and ultimately to the Peel Inlet. Peel Main Drain is a highly modified system designed

to remove excess water quickly from residential and agricultural land. Just over half of the 125km^2 catchment is cleared (59%). Land use across the catchment includes residential (rural and urban), industrial, horticulture, agriculture (beef and sheep), cropping and equestrian properties (DWER 2021).

The catchment of Berriga Main Drain and a minor tributary intersects the eastern boundary of the study area. This drain connects to Peel Main Drain close to the confluence with the Serpentine River. Berriga Main Drain begins east at Wungong Brook near the base of the Darling Scarp and runs south intercepting flow diverted into drains from watercourses off the Darling Scarp, including Beenyup Brook, Cardup Brook, Manjedal Brook and Medulla Brook (DWER 2018b).

3.6 Geomorphic Wetland Mapping

The Geomorphic Wetlands Swan Coastal Plain (DBCA-019) (GWSCP) dataset (DBCA 2023) represents the most comprehensive record of wetland mapping, classification and evaluation work on the SCP (DBCA 2017a). The dataset displays the location, boundary, geomorphic type and management category of wetlands on the SCP and is based on mapping by Hill *et al.*. (1996a, b) and V and C Semeniuk Research group (1998).

Wetlands in the GWSCP dataset are assigned into one of three management categories: CCW, RE and MU wetlands based on their attributes, functions and values. These categories, their descriptions and objectives are outlined in Table 3 (from DBCA 2007, EPA 2008b).

CCWs are wetlands retaining the highest level of attributes and functions and generally have intact wetland vegetation and may provide habitat for conservation significant flora and fauna.

Wetlands within the GWSCP dataset are grouped into consanguineous wetland suites which are natural wetland assemblages based on their similarities. There are 62 consanguineous suites on the Swan Coastal Plain (DBCA 2017c).

The consanguineous wetland suites and geomorphic wetlands within the survey and study area are discussed in Section 4.1.1 and Section 4.1.2.

Table 3: Wetland Management Categories and Objectives (DBCA 2007, EPA 2008b)

Management Category	General Description	Objective
CCW	Wetlands which support a high level of attributes and functions	To preserve and protect their existing conservation values through various mechanisms including: -reservations in national parks, Crown Reserves and State owned land -wetland covenanting by landowners No development or clearing is considered appropriate. These are the most valuable wetlands and any activity that may lead to further loss or degradation is appropriate.
RE	Wetlands which may have been modified or degraded, but sill support substantial attributes and functions	To manage, restore and protect towards improving their conservation value and hydrological/hydrogeological regiome. These wetlands have the potential to be restored or rehabilitated to Conservation category focussing on wetland functions, structure and biodiversity value.

Management Category	General Description	Objective
MU	Wetlands which still support few remaining attributes and functions	The use, development and management of these wetlands should be considered in the context of ecologically sustainable development and best management practice catchment planning. Their role in managing the natural hydrological and hydrogeological regime of the general area should be maintained.

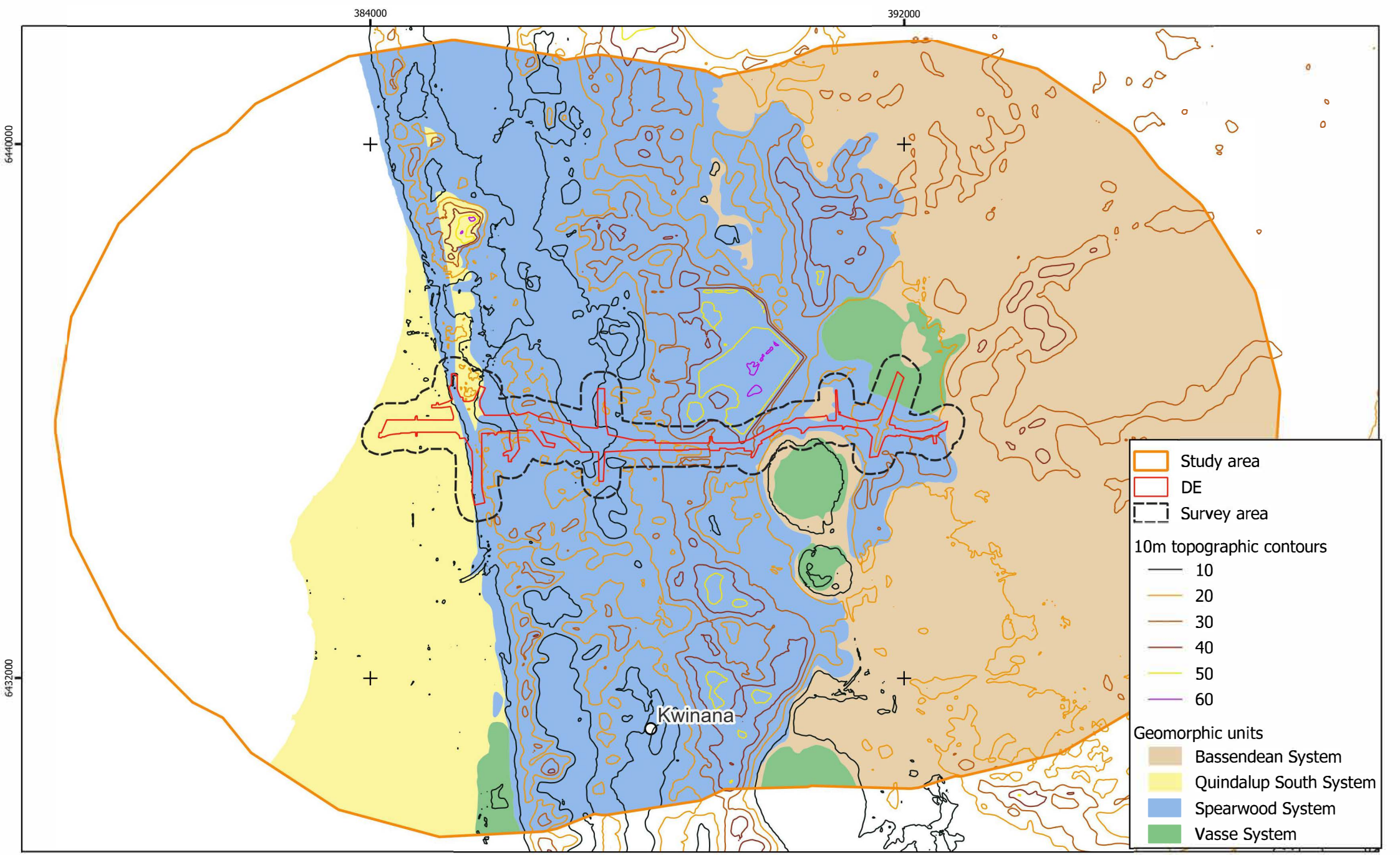

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Figure 3
Topography of the study area

Anketell Road Upgrade Wetland Assessment

N

0 2.5 5 km

Base map © ESRI and its data suppliers. Landgate (2020)
CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 31/01/25 Author: CS

Figure 4: Surface geology of the study area

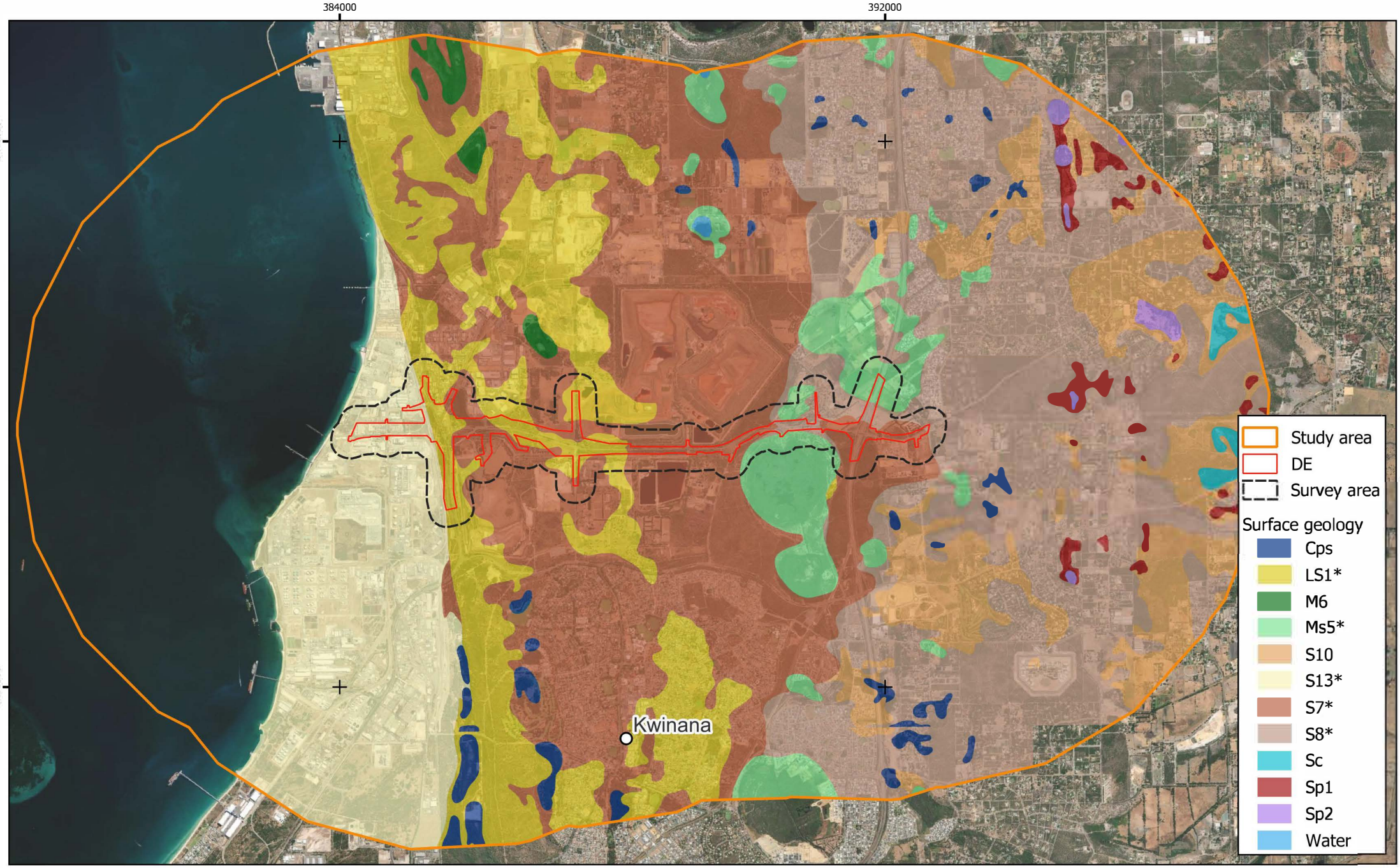

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Figure 4
Surface geology within the study area

Anketell Road Upgrade Wetland Assessment

N

0 2.5 5 km

Base map © ESRI and its data suppliers. Landgate (2020)
CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 31/01/25 Author: CS

ROCKINGHAM ROAD | ARMSTRONG ROAD | ABERCROMBIE ROAD | MANDOALUP ROAD | KWINANA FREEWAY | TREEBY ROAD | LYON ROAD | NICHOLSON ROAD | SPEARS DRIVE | KARGOTICH ROAD

WEST — EAST

STUDY AREA - WETLAND ASSESSMENT

THOMAS ROAD

SURVEY AREA - WETLAND ASSESSMENT

APPROXIMATE GROUND SURFACE

ELEVATION (m AHD)

DISTANCE (m)

TAMALA SAND

FILL

BASSENDEAN SAND (GNANGARA DUNE)

BASSENDEAN SAND

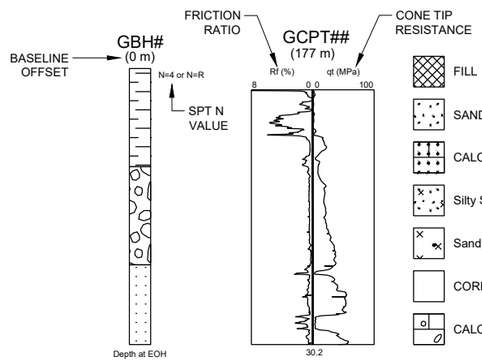
TAMALA LIMESTONE

GUILDFORD FORMATION

OSBORNE FORMATION

GCPT01A (-116 m) | GBH01 (-116 m) | GCPT02A (-25 m) | GBH03 (-91 m) | GCPT03 (-96 m) | GBH04 (-55 m) | GCPT04 (-56 m) | GBH05 (17 m) | GCPT05 (18 m) | GBH06 (28 m) | GCPT06 (27 m) | GCPT07 (-22 m) | GBH07 (-23 m) | GCPT08 (-75 m) | GBH08 (-79 m) | GBH09 (-9 m) | GCPT09 (-10 m) | GBH10 (10 m) | GCPT10 (9 m) | GCPT11 (-128 m) | GBH11 (-126 m) | GCPT13 (21 m) | GCPT12 (19 m) | GBH12 (19 m)

LEGEND



- FILL
- SAND
- CALCARENITE
- Silty SAND
- Sandy SILT
- CORE LOSS
- CALCIRUDITE
- SANDSTONE
- TOPSOIL
- Clayey SAND
- Sandy CLAY
- PERTH GROUNDWATER ATLAS LEVEL (1997)
- GROUNDWATER LEVEL (DECEMBER 2021)
- FILL
- BASSENDEAN SAND (GNANGARA DUNE)
- BASSENDEAN SAND
- TAMALA SAND
- TAMALA LIMESTONE
- GUILDFORD FORMATION
- OSBORNE FORMATION

NOTES

1. SOME TEST LOCATIONS ARE MOVED LATERALLY FOR CLARITY. WHERE LATERALLY MOVED, ACTUAL POSITION IS SHOWN BY ARROWS.
2. MATERIAL BOUNDARIES SHOWN ARE CONJECTURAL AND ARE BASED ON GEOLOGICAL INTERPRETATION.
3. GROUND LEVEL SOURCED FROM SLIP LANDGATE GROUND CONTOUR DATA.

1:400 V: 0 — 10 — 20 METRES

1:50,000 H: 0 — 1,000 — 2,000 METRES

CLIENT: MAIN ROADS WA

CONSULTANT: WSP GOLDER

YYYY-MM-DD	2022-03-01
DESIGNED	SZ
PREPARED	JRP
REVIEWED	DAB
APPROVED	DAB

PROJECT: MRWA WESTPORT PRELIMINARY GI ANKETELL ROAD - THOMAS ROAD

TITLE: **GEOLOGICAL MODEL**

PROJECT NO.	CONTROL	REV.	FIGURE
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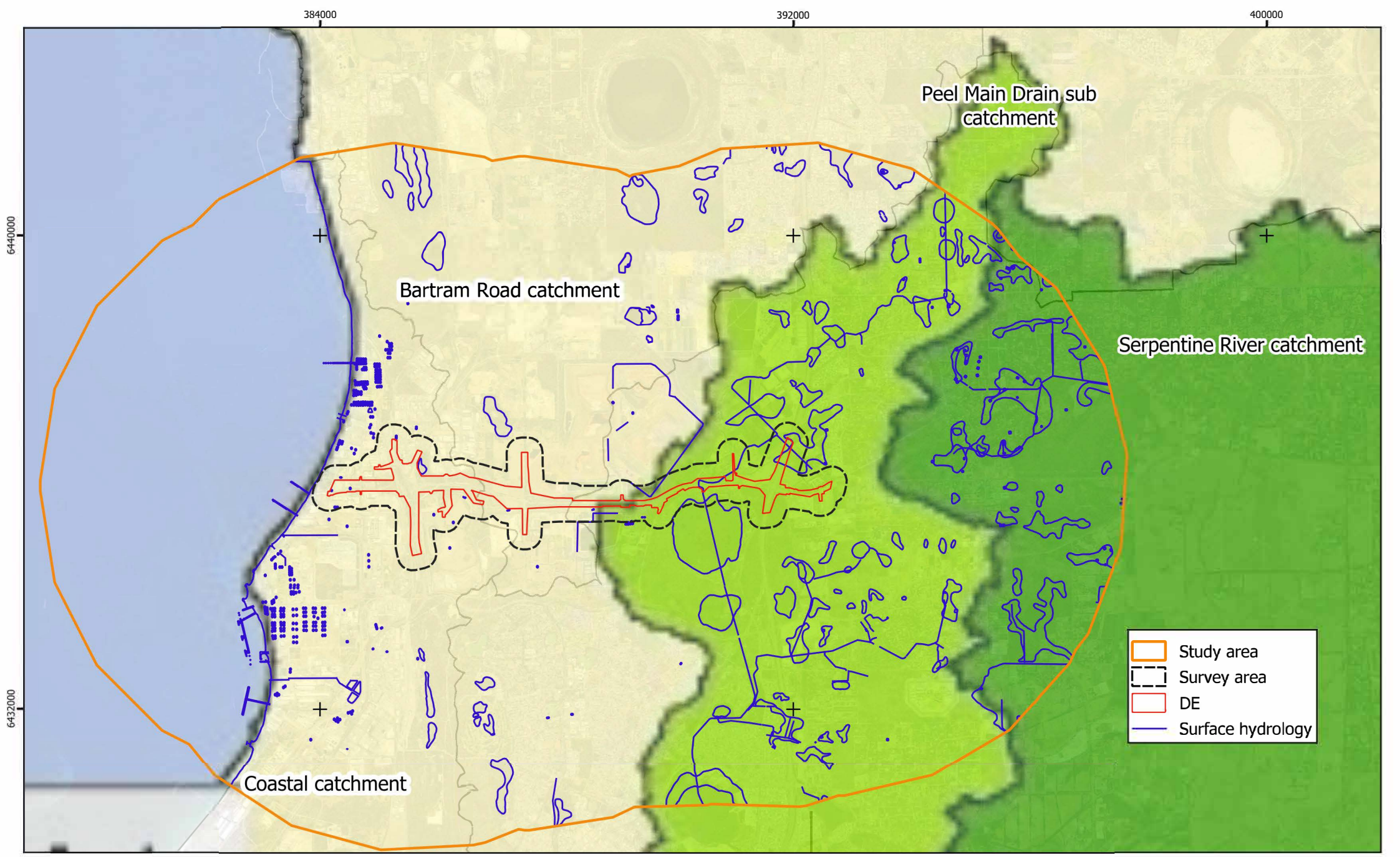

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Figure 6
Regional hydrology

Anketell Road Upgrade Wetland Assessment

N

0 2.5 5 km

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4 WETLAND ASSESSMENT

4.1 Desktop assessment

The information collected during the desktop assessment was used to identify and describe the key ecological features and conduct a wetland evaluation of the survey area (Section 4.3). Details of the desktop assessment are provided in Appendix C and a brief summary is outlined below.

The GWSCP dataset identified two hundred and twelve individual wetlands of which seven occur within the survey area. Two CCW, three MU and two RE wetlands are within the survey area, two of which (both MU dampland wetlands) intersect the DE (Table 4, Figure 7).

Table 4: Geomorphic wetlands in the survey area and 250m buffer area

Wetland UFI No.	Wetland Name	Landform	Wetland Type	Management Category	Consanguineous Suite	Total Wetland area (ha)	Area in survey area (ha)	Area in DE (ha)
6379	Unknown	Basin	Dampland	RE	Stakehill	2.12	2.12	-
6381	Unknown	Basin	Dampland	MU	Stakehill	1.49	0.12	-
6539	Spectacles North	Basin	Sumpland	CCW	Bibra	132.10	9.41	-
6538	Unknown	Basin	Dampland	MU	Bibra	20.09	20.09	4.70
12981	Mandogalup Swamp South	Basin	Dampland	CCW	Jandakot	3.42	3.42	-
6380	Unknown	Basin	Dampland	RE	Stakehill	2.01	0.34	-
6530	Mandogalup Swamp South	Basin	Dampland	MU	Jandakot	215.39	46.57	6.87

Key findings from the desktop assessment are summarised below (further details are provided in Appendix C Desktop Assessment and Appendix D Site forms):

- Two DIWA (Directory of Important Wetlands in Australia) wetlands occur within the desktop study area, Spectacles Swamp and Gibbs Road Swamp System. The Spectacles Swamp occurs just over 100m to the south of the DE.
- No Ramsar wetlands occur within the 5km study area or survey area.
- Bush forever site 269 is associated with the Spectacles Wetland occurring within 250m of the survey area.
- Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain Threatened ecological community (TEC) (and State PEC) intersects wetlands 6379, 6381, 6539,6538 in the survey area and 6538 in the DE.
- Banksia woodlands of the Swan Coastal Plain TEC intersects wetland 6539 in the survey area
- Northern Spearwood shrublands and woodlands (FCT 24) intersects wetlands 6539 and 6381 in the survey area

- The Communities of Tumulus Springs (Organic Mounds SCP) has been considered in this wetland assessment due to its potential occurrence in wetland 6530 (DBCA database only, not confirmed or mapped by Biota 2025). NB. The TEC occurs within the buffer area only and does not occur within the DE or survey area.
- No threatened or priority flora listed under the EPBC Act or BC Act were located within wetlands within the survey area during multi season targeted surveys (Biota 2025).
- Dampland habitat occurs in several wetlands (6379,6539, 6538, 12981,6380) and potentially provides habitat for Quenda (P4). Open areas associated with wetlands potentially provide habitat for Glossy Ibis and bird of prey, and Eucalyptus and Banksia woodlands provide foraging habitat for Black Cockatoos.

4.2 Field Assessment

A site visit on the 13th March 2024 was conducted to ground truth and compliment the results of the desktop survey and assist with wetland evaluation. It was not possible for the wetland assessment to be conducted at the appropriate time of year (after significant rainfall) to be able to assess inundation, waterlogging and soil moisture. However, other features such as geomorphology, vegetation condition and ecological values could be observed. Of the seven wetlands within the survey area, two had limited access (6538, 12981) so were assessed from a nearby road. Three wetlands were completely inaccessible and could not be assessed from any reasonable distance (6381,6380, 6530). The location of assessment sites are shown in Figure 7.

4.3 Wetland Evaluation and Characterisation

Following the evaluation procedure detailed in DBCA (2017a), preliminary wetland evaluations were completed using the results of the desktop and site assessments for seven wetlands (Table 5).

The preliminary assessment confirmed wetland 6539 and wetland 12981 supported CCW values. The assessment indicated wetland 6379, currently classified as RE, also supports wetland values equivalent to CCW classification. Four wetlands were identified as requiring secondary evaluations which were completed using desktop information and ‘over the fence’ observations as these wetlands were not accessible during the site visit.

The key wetland values for each of the seven wetlands evaluated and the outcomes from the assessment are provided in Table 5 and the following section.

Further details of the data collected for each wetland during the site assessments (including photos) are provided in Appendix D.

Table 5: Preliminary evaluations and outcomes for wetlands within 250m of the Survey area

No.	Criteria	Wetland 6379	Wetland 6381	Wetland 6539	Wetland 6538	Wetland 12981	Wetland 6530	Wetland 6380
	Current management Category	RE	MU	CCW	MU	CCW	MU	RE
1	The wetland is currently recognised as internationally or nationally significant for natural values e.g. Ramsar listed, Govt endorsed Ramsar candidate site, DIWA site, National Heritage list or other	N	N	Y	N	N	N	N
2	Wetland spatially dominated by vegetation in good or better condition & identified as significant for its natural values	Y	N	Y	N	N	N	N
3	The wetland supports a breeding, roosting or refuge site or critical feeding site for populations of significant/threatened or priority fauna	Y	N	Y	N	Y	N	N
4	Wetland spatially dominated by vegetation in good or better condition and supports occurrence of a TEC*, confirmed occurrence of PEC (P1 or 2) or confirmed occurrence of declared rare (threatened) flora species.	Y	N	Y	N	N	N	N
5	≥ 90% of the wetland supports vegetation in a good or better condition	Y	N	Y	N	Y	N	N
6	Wetland spatially dominated by vegetation in good or better condition and is known to support significant (international, national, state) scientific values including geoheritage and geoconservation	N	N	Y	N	N	N	N
7	Wetland is spatially dominated by vegetation in good or better condition and meets one of: - <10% of wetlands of same type assigned Conservation category on SCP (by area) - <10% of all wetlands in consanguineous suite are CCW (by area) - <10% of wetlands of same type in consanguineous suite are CCW	N	N	N	N	N	N	N

	Wetland 6379	Wetland 6381	Wetland 6539	Wetland 6538	Wetland 12981	Wetland 6530	Wetland 6380
- best representative of type within consanguineous suite							
Outcome	Recommended CCW (no site assessment required)	MU pending secondary assessment	Confirmed CCW (no site assessment required)	MU pending secondary assessment	Confirmed CCW (no site assessment required)	MU pending secondary assessment	RE pending secondary assessment

*Wetland 6538 and 6381 have a very minor area of mapped Tuart TEC (<0.06ha (tuart canopy buffer area only), and<0.15ha respectively) based on mapping by Biota (2025).

Wetland UFI6379

Wetland 6379, or Conway Road Swamp (mapped as RE Dampland) is located 50m east of Conway Road, Hope Valley, and 29m east and 100m north of the survey area. The field assessment was conducted at one site (Site 1). The assessment was also informed by the previous vegetation mapping (Biota 2025).

The wetland contains intact native vegetation (*Melalueca preissiana* woodland with fringing *Eucalyptus gomphocephala* occasional *Eucalyptus marginata and Banksia spp.* woodland) (Biota 2025) predominantly in good or better condition. The wetland is surrounded native vegetation that extends to the south and east. Vegetation occurring within the wetland includes the listed TEC/PEC Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community (mapped by Biota 2025).

The *Melaleuca* spp. low open woodland, was considered potential habitat for the Quenda (P4) as well as foraging and potential breeding habitat (suitable DBH trees) for Carnaby's (EN) and Forest Red-tailed Black Cockatoos (VU). Further details of the wetland values are provided in the desktop assessment and Appendix C.

Wetland 6379 met the preliminary evaluation criteria for Conservation management category. This wetland, currently assigned as 'Resource Enhancement', meets criteria to be classified as 'Conservation' category based on the elevated ecological function, provision of habitat for threatened communities and species, wetland function and its location within a known ecological linkage.

Wetland UFI6381

Wetland 6381 (mapped as MU Dampland) is located 270m east of Investigator Drive, Hope Valley and approximately 240m north of the survey area. This wetland was unable to be accessed and the assessment was informed by the desktop assessment.

The wetland has been mapped as predominantly cleared (Biota 2025) and aerial photographs show some scattered trees and regrowth. The wetland is surrounded by cleared areas to the east and some native vegetation to the west. Within the 250m buffer area the western and southern edge of Wetland 6381 intersects both mapped Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain TEC and State Priority 3 PEC Spearwood shrublands and woodlands. This small area (0.14ha and <0.01ha respectively) of TEC and PEC would be unlikely to add hydrological function or ecological value to this wetland.

Wetland 6381 failed to meet the preliminary evaluation criteria for 'Conservation' management category. The wetland was not accessible (during the site visit) and a detailed site assessment for secondary evaluation was not completed. However, based on aerial photos and review of desktop information this wetland classification as 'Multiple Use' is considered appropriate.

Wetland UFI6539 Spectacles North Wetland

Wetland 6539 or the Spectacles North Wetland (mapped as CCW Sumpland) is located approximately 500m southwest of the Anketell Road and Kwinana Freeway intersection and 100m south of the survey area at its closest point. The wetland is considered a representative example of a wooded swamp of the SCP, contains intact native vegetation in a very good to excellent condition, is listed as part of Bush Forever site 260 and Directory of Important Wetlands (WA090) and is part of an ecological linkage. Spectacles Swamp is fed by groundwater and inflow from the Peel Main Drain originating 8-10 km north-east and continuing through to the Serpentine River. There is substantial flow in the Peel

Main Drain in the winter months resulting near-permanent presence of standing water in the wetland. Maximum water depths of around 1.2 m occur in September. The wetland is dry or nearly so in summer-autumn.

The wetland is known to support flora, fauna and communities of ecological significance as well as providing a high level of hydrological function. The Spectacles Wetland supports breeding waterbirds and is the only known breeding area for spoonbills in the metropolitan area. The values of this wetland are described in more detail in Appendix C. Stream visited two locations at Spectacles North. Site 2 (lookout over water body) and Site 3 (where the Peel Main Drain meets the wetland).

Wetland 6539 met the preliminary evaluation criteria for Conservation management category based on its nationally significant values, intact and very good condition vegetation and its role as a habitat and refuge for fauna. This wetland is considered to have high value attributes, functions and values which is considered rare in a largely cleared and highly modified landscape.

Wetland UFI6538

Wetland 6538 (mapped as MU Dampland) is located on and northwest of the Mandoglup Road and Anketell Road intersection. Approximately 4.70ha of this wetland occurs within the DE and 2.09ha within the survey area. Anketell and Mandogulup Road traverse the wetland. A site assessment was conducted at Site 4, however most of the wetland was unable to be accessed and the assessment was informed by the desktop assessment and observations made from nearby roads. This wetland would still provide some hydrological function however is highly modified due to mixed land uses. The wetland was cleared or in a degraded condition with only small patches of scattered trees. Biota (2025) mapped a small area of Dampland habitat and15 suitable DBH trees (tuarts) for Black Cockatoos Within the survey area wetland 6538 (MU Dampland) contains a very small area of mapped Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community. The wetland in this area to be dominated by roads and cleared areas and the very small area of TEC is within the tuart canopy buffer area only and would be unlikely to add hydrological function or ecological value to this substantially modified wetland.

Wetland 6538 failed to meet the preliminary evaluation criteria for Conservation management category. Insufficient site access was available to undertake a detailed site assessment for secondary evaluation. However, based on aerial photos, a review from nearby roads and desktop information this wetland is considered Multiple Use. The geomorphic wetland boundary could be modified to exclude paved areas that no longer retain any ecological or hydrological function. The remaining areas are still likely to have a has a role in contributing to the management hydrological and hydrogeological regime and function.

Wetland UFI712981 Mandogalup Swamp South

Wetland 12981, Mandogalup Swamp South (mapped as CCW Dampland) is located between Kwinana Freeway and Darling Chase, Wandi, approximately 10m north of the survey area. A site assessment was informed by the desktop assessment and observations made from nearby road (Site 5). The wetland contains intact native vegetation (*Kunzea* tall shrubland to tall open scrub and *Melaleuca preissiana* low woodland over *Astartea*) in good condition (Biota 2025). This dampland provides potential for Quenda (P4) and foraging habitat for birds of prey (Biota 2025). Further details of the wetland values are provided in Appendix C.

Wetland 12981 met the preliminary evaluation criteria for Conservation management category based on the good condition intact native vegetation and habitat for the Quenda.

Wetland UFI6380

Wetland 6380 (mapped as RE Dampland) is located 240m west of Abercrombie Road and 450m north of Anketell Road, Hope Valley, approximately 280m north of the survey area. This wetland was inaccessible and the assessment was informed by the desktop assessment and aerial photos.

The wetland has been mapped as a mix of *Kunzea* tall shrubland to tall open scrub in Degraded condition and cleared (Biota 2025). The wetland is predominately surrounded by cleared areas. Fauna habitat descriptions (Dampland, Biota 2025) indicated potential habitat for Quenda (P4), Glossy Ibis and birds of prey.

Wetland 6380 failed to meet the preliminary evaluation criteria for Conservation management category. Insufficient site access was available to undertake a detailed site assessment for secondary evaluation. However, based on aerial photos and review of desktop information this wetland is likely to retain its RE status due to retaining habitat features, potential refuge for fauna and retaining hydrological function and attributes. Although this wetland exhibits a disturbed and cleared northern edge, due to the small size and geomorphology of the wetland this wetland was evaluated as one geomorphic unit. The cleared areas still provide natural hydrological functions and may support birds such as the Glossy Ibis.

Wetland UFI6530 Mandogalup Swamp South

Wetland 6530, Mandogalup Swamp South (mapped as MU Dampland) is located on and northwest of the Mandoglup Road and Anketell Road intersection. Approximately 6.87ha of this wetland occurs within the DE and 46.57ha within the survey area. Kwinana Freeway traverses the wetland. This wetland is extensive and occurs over multiple land uses and so the assessment was informed by the desktop assessment and observations made from nearby roads (Site 5). This wetland may still provide some hydrological function in areas outside of the Freeway. It is, however, highly modified due to clearing and mixed land use. Within the survey area the wetland was cleared or with a few scattered trees and planted areas in close proximity to the freeway in a completely degraded condition.

The Communities of Tumulus Springs (Organic Mounds SCP) is mapped as occurring within wetland 6530 (DBCA database only, not confirmed or mapped by Biota 2025). The TEC does not however occur within the DE or survey area.

Wetland 6530 failed to meet the preliminary evaluation criteria for Conservation management category. Insufficient site access was available to undertake a detailed site assessment for secondary evaluation. Based on aerial photos and review of desktop information this wetland is likely to retain its MU status. The geomorphic wetland boundary could be modified to exclude paved areas that no longer retain any ecological or hydrological function. In addition, if a detailed flora and vegetation survey of the wetland 6530 confirmed the occurrence of Organic Mounds SCP TEC, then this portion of the wetland could potentially be re-evaluated (potentially becoming an RE or CCW wetland in an otherwise modified and degraded landscape).

4.4 Summary of wetland classification and mapping

Table 6 summarises the outcomes of the wetland evaluation. Following the desktop assessment of seven geomorphic wetlands and subsequent field assessment, it is recommended that wetland 6379 has its management category amended. Geomorphic wetland UFI 6379, whilst currently classified as 'Resource Enhancement' retains values representative of a 'Conservation' category based on the elevated ecological function, vegetation values, and its location within a known ecological linkage. As

a consequence of the assessment this wetland is treated as a CCW wetland in the risk and impact assessment (Section 7).

While Geomorphic wetland UFI 6530 retains its MU status, the potential occurrence of TEC (Mound springs SCP) within a small area of this wetland will be considered in the risk assessment due to its ecological value and likely susceptibility to changes in hydrology.

Table 6: Summary of wetland classification and mapping

Wetland UFI No.	Wetland Name	Current Management Category	Key outcomes
6379	Unknown	RE	Based on the elevated ecological function, vegetation values, and its location within a known ecological linkage wetland retains values representative of a CWW
6381	Unknown	MU	Current management category is appropriate*.
6539	Spectacles North	CCW	Current management category is appropriate.
6538	Unknown	MU	Current management category is appropriate**.
12981	Mandogalup Swamp South	CCW	Current management category is appropriate**.
6380	Unknown	RE	Current management category is appropriate*.
6530	Mandogalup Swamp South	MU	Current management category is appropriate***.

*Detailed site investigations not possible due to access constraints

**Partial site investigation due to limited access

*** Detailed site investigations not possible due to access constraints. Potential occurrence of TEC within wetland boundary.

Figure 7
Wetlands of the survey area

Anketell Road Upgrade Wetland Assessment

Stream Environment and Water
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Base map © ESRI and its data
CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 29/01/2025 Author: JW

5 HYDROLOGY ASSESSMENT

5.1 Groundwater

5.1.1 Recharge and groundwater flow

The Jandakot Mound is present in the eastern portion of the study area and is a major regional recharge zone of the Superficial Aquifer in the area. High rainfall recharge rates are due to deep sandy sediments of Bassendean Sand and large unsaturated thickness of the Mound (Marillier *et al.* 2012).

Surface geology (Table 7) shows the survey area occurs mostly on sandy soils and limestone and that units S7, LS1, S8 and S13 are potential areas of recharge from direct infiltration of rainfall.

Groundwater flows radially out from Jandakot Mound (Golder 2022; Marillier *et al.* 2012). Minimum groundwater level contours (2004) (BoM 2024c) indicate a westerly groundwater flow direction across the study area demonstrated by a progressive decrease in water level from east to west. Minimum groundwater level at Jandakot Regional Park in the east of the study area is 24 mAHD and decreases to 1 mAHD near Abercrombie Road in the west, near the coast.

5.1.2 Groundwater level

Golder Associates (2022) completed a preliminary geotechnical investigation within the current survey area which includes groundwater level monitoring. Golder conducted initial monitoring in December 2021, with subsequent monitoring from May 2023 to March 2024 (Golder 2022; Golder 2024). Hydrographs for Golder GBH monitoring bores that are relevant to the current assessment are presented in Figure 8. Locations of groundwater monitoring bores are shown in Figure 9.

The following observations are based on the groundwater level monitoring conducted by Golder (2024) over the past 12 months, providing details of recent groundwater level trends[1] within the survey area:

- Notable variation in groundwater level across the survey area, ranging from lower than 1 mAHD (in the west) to 20 mAHD (in the east). These levels reflect a similar trend (of decline in the groundwater surface spatially from east to west) to that presented in the 2004 minimum groundwater contours (BoM 2024).
- GBH01, GBH03 and GBH04 screened in the Tamala limestone recorded groundwater levels ≤1 mAHD, change in water level (max and min over the monitoring period) of between 0.3 and 0.4 m and a decline in minimum water level of approximately 0.2 m.
- GBH05, GBH06, GBH07 (in the vicinity of the Spectacles Wetland) screened in Bassendean Sand recorded groundwater levels between 10.8 mAHD to 12.9 mAHD, change in water level (max and min over the monitoring period) ranged between 0.4m to 0.85 m and with no change in minimum water level.
- GBH08 and GBH09 (at the eastern end of the survey area) screened in Bassendean Sand recorded groundwater levels between 18.8 to 20.3 mAHD and change in water level (max and min over the monitoring period) was approximately 0.5 m. GBH09 had no change in minimum water level and GBH08 had a slight increase of 0.17 m.
- Groundwater level recorded in December 2021 is about 0.2 m higher than levels recorded in November 2023 in all bores, except GBH08 (0.2 m lower) and GBH09 (the same level).

GBH03 monitoring bore is 300 m east (at slightly higher elevation) of Wetland 6379 UFI, a wetland covered by the current assessment. The hydrograph shows a seasonal fluctuation in response to

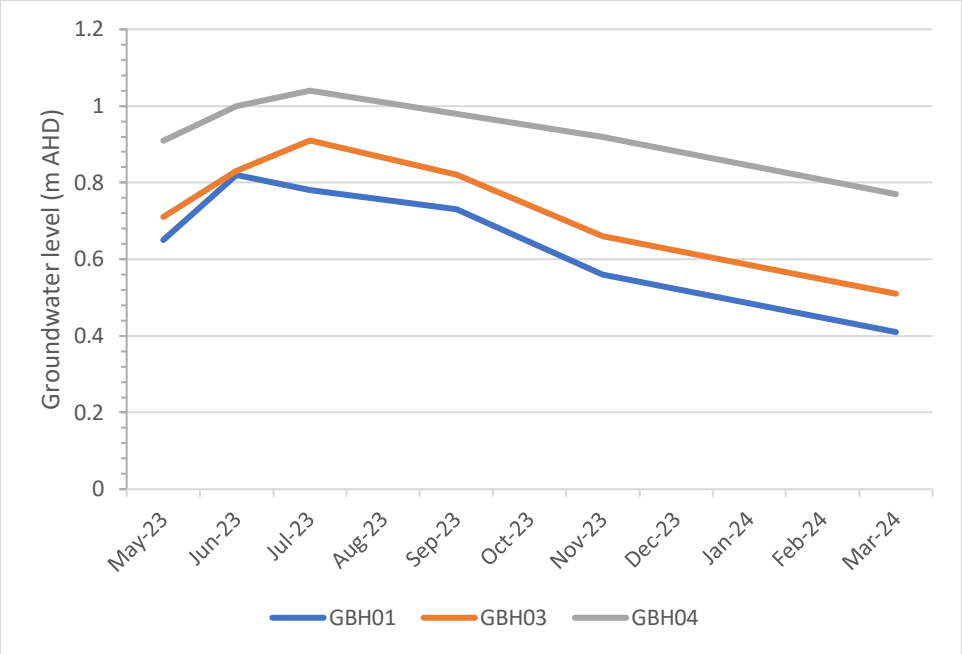
[1] Given the short duration of monitoring for these bores trends may not capture full seasonal variation.

rainfall and a decline in minimum groundwater level of 0.2 m from 0.7 mAHD in May 2023 to 0.5 mAHD in March 2024.

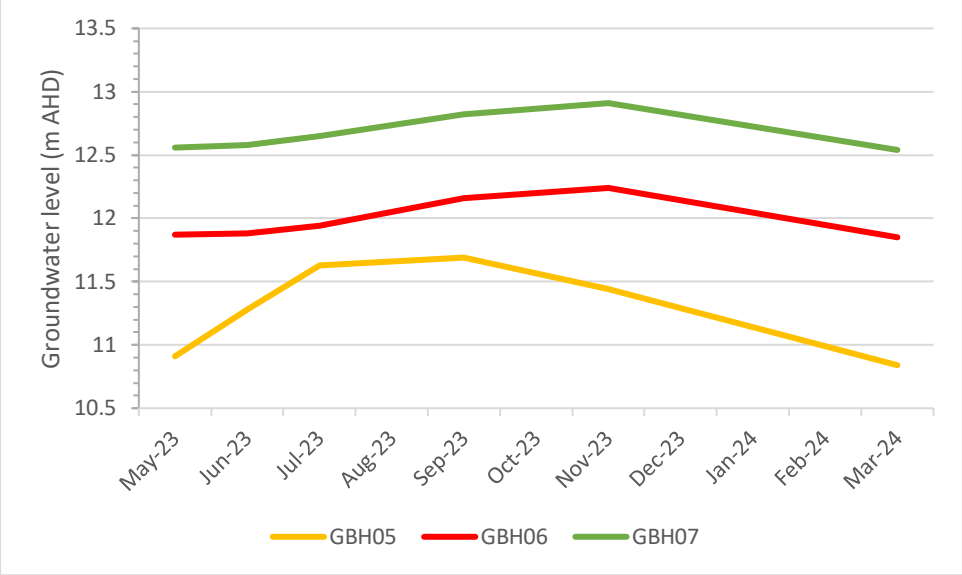
GBH05 is on the north side of Anketell Road and about 400 m north (and 5 mAHD higher elevation) of the Spectacles Wetland. The hydrograph shows a seasonal fluctuation in response to rainfall and no change in minimum groundwater level from May 2023 to March 2024.

Table 7: Groundwater level monitoring data conducted by Golder within the survey area (Golder 2024)

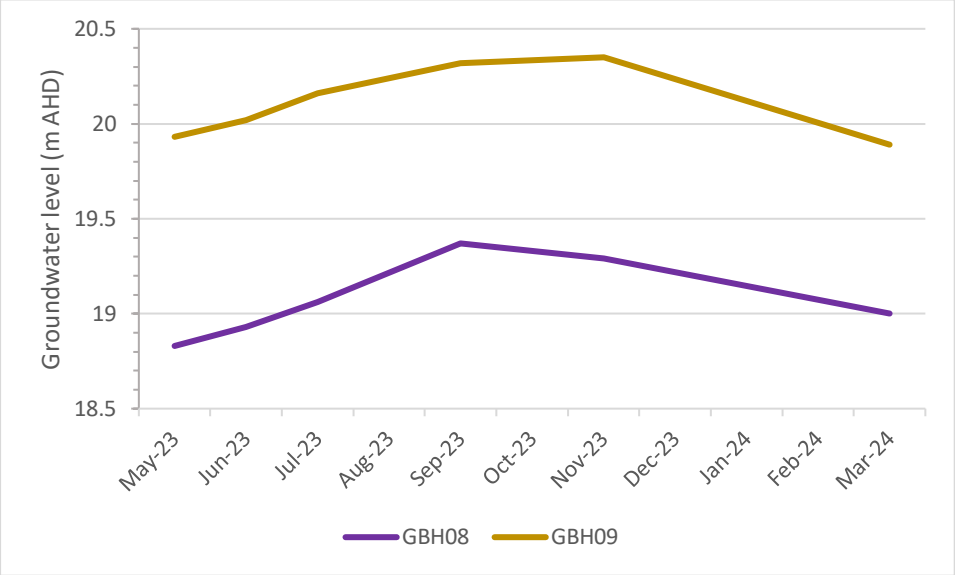
Well ID	Screened geology	Depth to groundwater (mbgl)	Groundwater level (m AHD)			
		March 2024	March 2024	May 2023	Nov 2023	Dec 2021
GBH01	Limestone	16.77	0.41	0.65	0.56	0.76
GBH03	Limestone	10.28	0.51	0.71	0.66	0.86
GBH04	Limestone	8.38	0.77	0.91	0.92	1.16
GBH05	Bassendean Sand	5.64	10.84	10.91	11.44	11.64
GBH06	Bassendean Sand	11.11	11.85	11.87	12.24	12.47
GBH07	Bassendean Sand	12.48	12.54	12.56	12.91	13.04
GBH08	Bassendean Sand	13.87	19.00	18.83	19.29	19.07
GBH09	Bassendean Sand	9.38	19.89	19.93	20.35	20.35



(a) Screened in Limestone



(b) Screened in Bassendean Sand



(c) Screened in Bassendean Sand

Figure 8: Hydrographs of the Golder GBH monitoring bores (Golder 2024)

To characterise long-term groundwater level trends within the survey area six monitoring bores (operated by DWER) were also assessed, hydrographs are presented in Figure 10.

Monitoring bores 61410068 and 61410084 are located in Tamala Limestone. Bore 61410068 has a seasonal variation of approximately 0.4 m with recorded water level maximum of 1.842 m AHD and minimum 0.542 m AHD. Bore 61410084 shows a seasonal variation between 0.5 m and 1.0 m, with monitoring suggesting a potential increase in seasonal variation since 2016 of approximately 1.2 m. The recorded water level maximum (bore 614100840 is 12.616 m and minimum 10.516 m AHD. Overall, groundwater levels in both monitoring bores appear to be relatively stable over the monitoring period (for which data was available) which extends from 1977 to 2023.

Hydrographs from DWER monitoring bores located in Bassendean Sand have been reviewed for groundwater trends in the eastern portion of the study area and in the vicinity of Spectacles North Wetland.

Bore 61410118, located to the east of the study area, shows an overall declining groundwater trend. Monitoring suggests a step decline occurred in 2006/2007 which is supported by the Golder (2022) assessment. Between 1974 and 2016 water levels declined by approximately 2.5 m. From 2016 to present, water levels have recovered by approximately 0.8 m. Seasonal variation is about 1.0 m and recorded water level maximum is 24.7 m AHD and minimum is 20.3 m AHD.

Bore 61410705 declined ~1.5 m between 1995 and 2016, with a recovery of about 0.5 m since 2016 to present. Seasonal variation in this bore is approximately 0.5 m and the recorded water level maximum is 21.1 m AHD and minimum 18.6 m AHD.

Bores 61419851 and 61419711 are located on the western and eastern sides of the Spectacles North wetland respectively. Both bores are used to inform the Spectacles monitoring program conducted by DWER. Bore 61419851 shows an increasing trend in groundwater level of around 0.8 m from 1995 to 2008 followed by a decrease of the same magnitude to present. Seasonal fluctuation is around 0.6 m and the recorded maximum is 10.4 m AHD and minimum is 8.79 m AHD. Bore 61419711 shows a trend of decline and recovery (somewhat similar to bore 61410705), declining approximately 2 m AHD between 1994 to 2015 and recovering about 1.6 m AHD to present. Seasonal fluctuation in bore 61419711 is approximately 1.2 m and the recorded maximum is 18.7 m AHD and minimum is 15.8 m AHD. Figure 8 shows groundwater level hydrographs from long term DWER monitoring bores in (or near) the survey area.

Table 8: Groundwater level data from DWER monitoring bores within the survey area and study area

Well ID *	Screened geology	Groundwater level mAHD		
		Maximum	Minimum	Average seasonal variation
61410068 - T130 (I)	Tamala Limestone	1.84	0.54	0.4 m
61410084 – T140(0)	Tamala Limestone	12.61	10.51	1.0 m
61419851 SP1_1A	Bassendean Sand/Swamp deposits	10.40	8.79 (9.073)	0.6 m
61419711	Bassendean Sand	18.76	15.89	1.2 m
61410705	Bassendean Sand	21.17	18.68	0.5 m
61410118	Bassendean Sand	12.54	12.56	1.0 m

* Well ID in bold indicates bores in survey area.

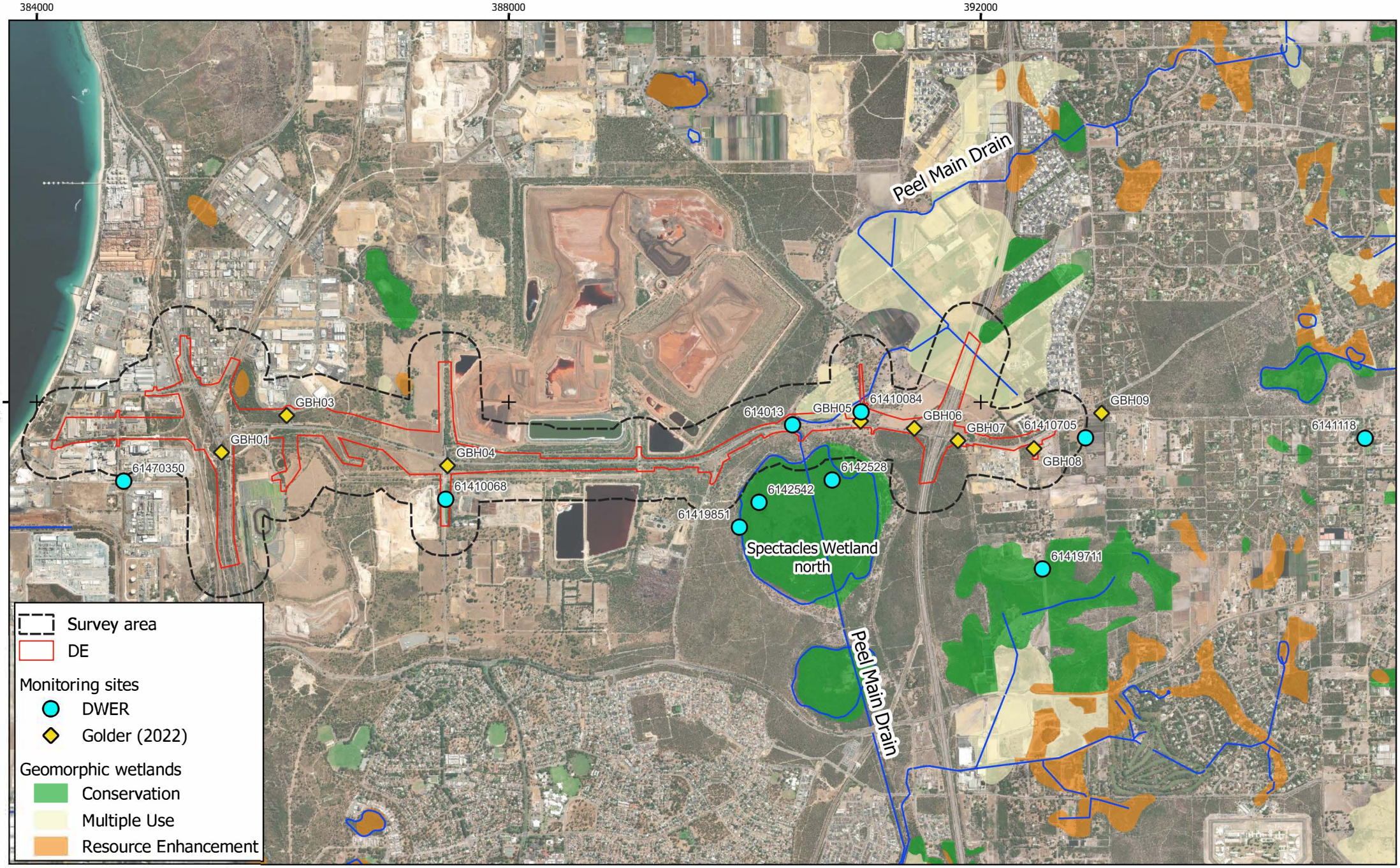


Figure 9
Groundwater and surface water monitoring site locations

Anketell Road Upgrade Wetland Assessment

Stream Environment and Water
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N

0 1 2 km

Base map © ESRI and its data suppliers. Landgate (2020)

CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 31/01/25 Author: CS

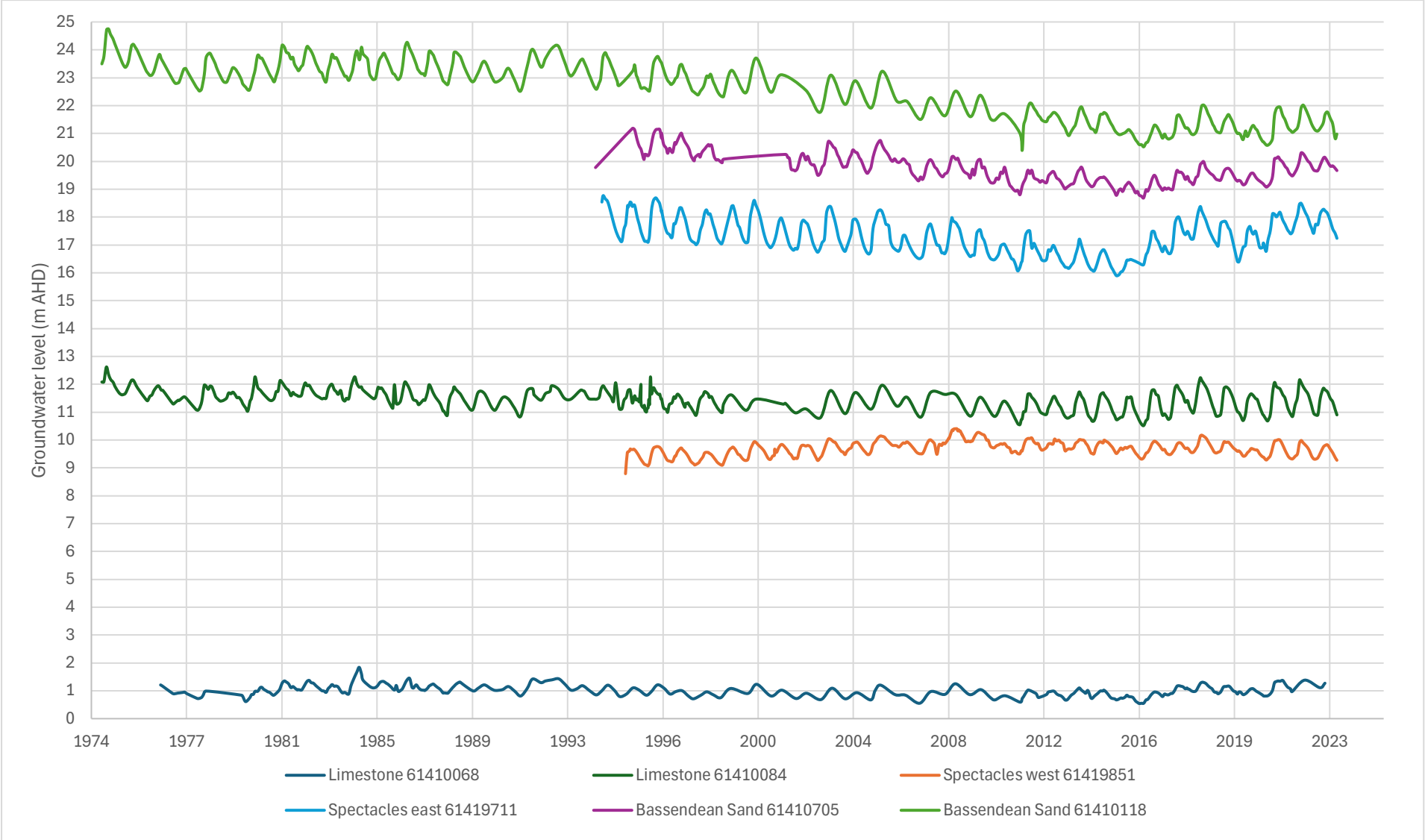

Figure 10: DWER monitoring bores hydrographs

5.1.3 Groundwater chemistry

Groundwater quality and the potential for contamination needs to be considered given the historical and current land uses of the area. The existing land use to the west of the Kwinana Freeway is currently mostly industrial. There are contaminated sites within the project area development envelope (discussed below). Recent publicly available hydrochemistry data is limited from within the survey area, meaning characterisation of groundwater quality at this stage is limited.

Three sites previously monitored by DWER (sites ref #61410068, 61419851 and 61470350) for water quality provide non continuous data for groundwater quality within the survey area.

Golder (2022) analysed groundwater samples obtained in December 2021 for water aggressivity (on steel and concrete structures) from nine monitoring bores within the current survey area. Parameters analysed relevant to the current study were pH and Total Dissolved Solids (TDS), discussed below.

There are no ANZECC trigger values for water quality parameters in groundwater. However, due to the absence of groundwater refence condition data, and the close proximity of several groundwater dependant wetlands with above ground ecosystems and surface water expression, the groundwater physical parameters and nutrients were compared to the ANZECC 2000 guidelines for southwest Australia slightly disturbed wetlands and metals were compared to ANZECC 2000 guidelines for slightly-moderately disturbed systems (ANZECC and ARMCANZ 2000).

Physical parameters

Golder monitoring in December 2021 and DWER long term data recorded groundwater from slightly acidic to slightly basic with a pH range from 5.78 pH units to 9.4 pH. Golder data was above the lower limit pH trigger value of 7.0 pH units and five bores (GBH01, GBH04, GBH05, GBH06, GBH08) recorded pH higher than the upper limit trigger value of 8.5 pH units for slightly disturbed ecosystems. Groundwater was neutral to slightly basic and stable in DWER monitoring bore 61410068 (2005 – 2018) with a pH range from 7.2 pH to 8 pH units. Groundwater was slightly acidic to slightly basic from bore 61419851 located in the Spectacles wetland, with a pH range from 5.78 pH units to 8.7 pH units and average of 6.9 pH units (1995 – 2009) which is marginally below the lower limit pH trigger value.

Golder data from December 2021 recorded TDS between 24 mg/L to 376 mg/L in a random distribution from GBH01 to GBH09. Water quality data from DWER bores 61470350 and 61410068 between 2018 to 2023 recorded average TDS of 1052 mg/L and 366 mg/L respectively. Groundwater from bore 61419851 recorded an average TDS of 1447 mg/L (1995 – 2009). These results correspond with Statewide groundwater salinity mapping (DWER-026) which indicates that groundwater within the survey area ranges in TDS between 0 – 1000 mg/L.

Dissolved oxygen (DO) in groundwater was low (as is typical for groundwater) from bore 61419851 (1995 – 2009) with a maximum of 2.2 mg/L and minimum of 0.1 mg/L and 61410068 (three readings 2005, 2010, 2018) recording 0.14 to 0.7 mg/L.

Nutrients

Limited data on groundwater nutrients is available from bores relevant to the survey area. Monitoring of water quality from bore 61419851 provides data from between 1995 and 2009. During that monitoring period oxides of nitrogen (NOx) in bore 61419851 was below the ANZECC trigger value (0.1mg/L). Total Nitrogen (TN) concentrations exceeded the trigger value (1.5 mg/L) on all sampling occasions, with average 7.7mg/L. Total Phosphorus (TP) concentrations exceeded the trigger value of 0.06mg/L on all sampling occasions, with average 0.35 mg/L.

Within the survey area, secondary treated wastewater is infiltrated at Kwinana Wastewater Treatment Plant. Water Corporation report that TN and TP from this source is approximately 2.5 times and 10 times respectively the level of native groundwater (Metis 2024).

Acid sulphate soil

Based on Golder (2022) assessment, actual acid sulfate soil (AASS) was not detected within the survey area. 90% of samples suggested low potential acid sulfate soil (PASS) risk rating and the remaining 10% high PASS risk rating. Golder (2022) concluded that AASS and PASS materials may be present in the Bassendean Sand within the survey area.

The acid sulfate soil risk map, Swan Coastal Plain (DWER-055) (DWER 2017) maps areas of 'High to Moderate ASS Disturbance Risk (<3 m from surface)' near the proposed road alignment at wetland sites The Spectacles and Mandogalup Swamp.

Metal and other contaminants

Three DWER bores 61419851, 61470350 and 61410068 monitored metals between 1995 to 2018, providing non continuous (and sporadic) data. Eight metals monitored over that period have trigger values: aluminium, cadmium, copper, lead, manganese, mercury, nickel and zinc. Site 614170350 has data from a one off event in 2018 with records for metals all below the trigger values. The following summarises when the trigger values were exceeded:

- The concentration of Aluminium exceeded the trigger value (0.055mg/L) at site 61419851 on all but on monitoring event 1995 – 2009.
- The concentration of Lead and Mercury exceeded the trigger values (0.0034mg/L and 0.00006mg/L) on one occasion at site 61410068.
- The concentration of Zinc exceeded the trigger value (0.008mg/L) at site 61419851 on all but on monitoring event 1995 – 2009 and on one occasion at site 61410068.

Alcoa Kwinana Refinery Residual area (Alcoa Refinery) intersects the survey area and is registered as a contaminated site on the Contaminated Sites Database (DWER-059) (DWER 2024c).

5.2 Surface Water

5.2.1 Surface Hydrology

Surface water only exists in the study area as wetlands and The Peel Main Drain, an artificial drainage line. Wetlands of the survey area and DE are characterised in Section 4.0. The surface hydrology of the Peel Main Drain is described below.

Peel Main Drain

Peel Main Drain is the main surface water feature, apart from wetlands, intersecting the survey area.

Peel Main drain is an artificial, highly modified system constructed to drain wetlands on the southern SCP. The Drain and local sub drains were originally constructed to assist in controlling regional winter groundwater levels (DoW 2009) to enable agricultural use of the land. It is approximately 32 km in length and runs from Banjup Lake (in the northeast of the study area) in a southerly direction discharging to the Serpentine River, intersecting several wetlands along its length (DWER 2021). The drain intersects the survey area after passing through Mandogalup Swamp South. It is then diverted under Anketell Road (survey area) between Mandongalup Road and Clementi Road, entering the Spectacles Wetland, before continuing south and exiting the survey area through Bollard Bulrush

Swamp on the southern boundary. The Peel Main Drain ultimately discharges to the Serpentine River, that then discharges to the Peel -Yalgorup system, a Ramsar site.

The Peel Main Drain catchment area upstream of the survey area is approximately 26 km^2 and largely consists of sand to sandy silt soils associated with Bassendean and Spearwood Dunes and wetland areas (soil units S8, S7, Ms5). At Mandogalup Swamp the drain elevation is 25 mAHD dropping to 4 mAHD over 15 km (outside of the study area). Streamflow in the drain is predominantly from surface rainfall runoff generated in areas of clayey surface geology. The northern reach of the drain has sections (where clay is not present) which intercepts groundwater during winter, that flows west from Jandakot Mound (DoW 2009, Marillier et al. 2012). The Peel Main Drain contributes approximately 48% of the water entering the Spectacles Wetlands (the remainder is from groundwater (DoW 2009))

The Hope Valley gauging station (614013) recorded flow in Peel Main Drain entering the Spectacles Wetland between 1985 – 2001. Average annual flow over that period was 1.6 GL (Marillier *et al.* 2012) with flow seasonal, generally ceasing in December or January and recommencing in April or May (DoW 2009).

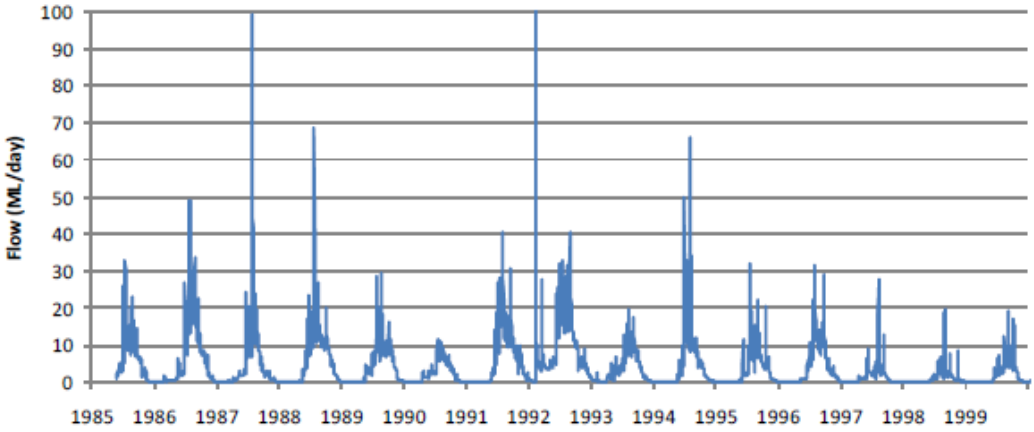

Figure 11: Flow (ML/day) 1985 - 2001 Hope Valley gauging station – Peel Main Drain 614013 (Marillier *et al.* 2012)

The Water Corporation modelled flow in the Peel Main Drain at Anketell Road, with predicted flow rates of 1.15m^3/s and 1.59m^3/s for the 10 year ARI (10% Annual Exceedance Probability (AEP) and 100 year ARI (1% AEP) respectively (DoW 2009).

5.2.2 Surface water chemistry

The most recent available water quality monitoring data is from Golder and associates (2021). This data has been used to characterise the basic surface water chemistry of the Peel Main Drain and Spectacles wetland, including physical parameters (such as pH and dissolved oxygen) and those that might be found in road runoff (predominately sediments, heavy metals, oil and grease/hydrocarbons, inorganic constituents and nutrients). Additional information where relevant has been included from other sources. Results from this monitoring are discussed below in comparison to the ANZECC and ARMCANZ (2000) guidelines for southwest Australia slightly to moderately disturbed wetlands. .

5.2.2.1 Peel Main Drain

Golder monitored one site on the Peel Main Drain just upstream (PMDUP) and one site downstream (PMDOWN) of Spectacles wetland in the months of August, September and November 2021.

Physical parameters

Surface water pH at PMDUP and PMDOWN was neutral, average 7.2 pH. One record (6.97 pH at PMDUP) was below the lower ANZECC trigger value of 7.0 pH. No records were above the 8.5 pH ANZECC upper limit.

Electrical conductivity (EC) indicated fresh water to slightly brackish with surface water readings between 0.911 mS/cm to 1.8 mS/cm. Two surface water readings were just outside the ANZECC trigger value for EC of 0.3 – 1.5 mS/cm. These were at PMDOWN.

Dissolved oxygen was variable ranging from 0.88 (PMDOWN in September) to 7.6mg/L (PMDUP in November) with an average of 3.74mg/L.

Nutrients

The Peel Main Drain is considered a major source of nutrients to the Spectacles Wetland (DoW 2009). Shams (1997) estimated that the loading of total nitrogen in the Spectacles was estimated to be 12 tonnes/year (58% from the Peel main drain and 42% from groundwater) while loading total phosphorus was 1.7 tonnes/year (80% from the Peel main drain and 20% from groundwater) (DoW 2009).

All TN concentrations recorded within the Peel Main Drain were above ANZECC guideline of 1.5mg/L, with an average concentration of 3.7 mg/L. Average TN concentrations were higher downstream (4.8mg/L at PMDOWN) of the Spectacles wetland than upstream (2.5mg/L at PMDUP).

All TP concentrations recorded within the Peel Main Drain were above ANZECC guideline of 0.06mg/L with an average concentration of 0.81mg/L. Average TP concentrations were higher downstream (1.06mg/L TP at PMDOWN) of the Spectacles wetland than upstream (0.56mg/L TP at PMDUP).

Metals

Sampling undertaken by Golder in 2021 recorded elevated levels for Aluminium (>ANZECC guideline of 0.055mg/L) and Copper (> ANZECC guideline of 0.0014mg/L (PMDUP only)). Elevated Iron (>DoH Non-Potable Groundwater Use NPUG) was also evident.

5.2.2.2 Spectacles North Wetland

Golder monitored seven surface water quality sites (SpecSW1-SW7) in the months of August, September and November 2021 and January 2022. Unless otherwise referenced the data summary below is from this monitoring period.

Physical parameters

Surface water of the Spectacles was neutral, average 7.74 pH. Two records (8.6pH at SpecSW7 and 8.6 at SpecSW5 in January 2022) were alkaline and above the ANZECC trigger value of 8.5pH.

Electrical conductivity (EC) indicated fresh water to slightly brackish, with surface water readings between 1.28 mS/cm to 5.47mS/cm. Most surface water readings were outside the ANZECC trigger value for EC of 0.3 – 1.5 mS/cm. Higher surface water readings (>3.0 mS/cm) are often measured in

summer due to evaporative loss (ANZECC and ARMCANZ 2000). The average EC reading for all sites sampled was 2.29 mS/cm.

Dissolved oxygen was variable ranging from 0.0mg/L (SpecSW1 in November 2021 and SpecSW2 in January 2022) to 16.44mg/L (SpecSW7 in January 2022) with an average of 4.56mg/L.

Nutrients

All TN concentration records within the Spectacles were above ANZECC guideline of 1.5mg/L, with an average concentration of 5.7 mg/L. TN concentrations ranged from 2.5mg/L (SpecSW1 November 2021) to 21.4mg/L (SpecSW2 in January 2022).

All TP concentration records within the Spectacles were above ANZECC guideline of 0.06mg/L with an average concentration of 1.1mg/L. TP concentrations ranged from 0.52mg/L (SpecSW1 November 2021) to 2.7mg/L (SpecSW2 in January 2022).

Metals

Sampling undertaken by Golder in 2021 recorded elevated levels for Aluminium (>ANZECC guideline of 0.055mg/L) at all sites. Copper was below the ANZECC guideline of 0.0014mg/L with the exception of a SpecSW1 in July and September 2021. Elevated Iron (>DoH Non-Potable Groundwater Use NPUG) was also evident at all sites.

5.2.2.3 Summary

The snapshot of water quality above (spring/summer 2021) indicates that the Peel Main Drain and Spectacles wetlands are characterised by fresh to slightly brackish waters with generally neutral pH and variable dissolved oxygen concentrations. Nitrogen and phosphorous concentrations are high and well above ANZECC guideline values, however this is expected given the history of agricultural and industrial use within the catchment. Most metals are within ANZECC guideline values.

6 GROUND/SURFACE WATER INTERACTION

The ecological values assessment identified five hydrological features which intersect the survey area and support moderate to high wetland attributes and functions. The five features are:

- The Spectacles North wetland (CCW UFI 6539) located 100m south of the DE
- Mandogalup Swamp South (CCW UFI12981) located 10m north of the DE
- Wetland UFI6379 (with CCW attributes and values) located 30m east of the DE
- Resource Enhancement wetland (UFI6380) located 285m east of the DE
- The Peel Main Drain intersects the DE and directly drains into the Spectacles North wetland

How these wetlands and surface water features are likely to be supported/linked to hydrological processes and functions. (i.e. groundwater/surface water interactions) is described below. Previous studies of groundwater dependent ecosystems in the area as well as groundwater level contours and surface topography were used to describe the potential groundwater and surface water interactions of the five high value hydrological features.

An additional three MU wetlands which occur within the survey area (two within the DE) are considered to have few remaining important attributes and functions and are not addressed further.

The Spectacles Wetland North and Mandogalup Swamp South are groundwater throughflow wetlands with water level controlled by groundwater flowing west from Jandakot Mound, resulting in surface water expression of groundwater at the wetland, typically in winter (Bekele *et al.* 2019, Marillier *et al.* 2012). On the up-gradient (east) side of Spectacles wetland, groundwater contours decrease 5mAHD over 300m, demonstrating high hydraulic gradient and water level higher or equal to the topographic surface of the wetland (10 m elevation). This results in surface water expression of groundwater as it moves west through the low lying wetland to higher topography and lower aquifer hydraulic gradient on the down-gradient (west) side of the wetland (Marillier *et al.* 2012).

The Spectacles Wetland experiences high rates of evapotranspiration with a maximum water depth usually less than one meter (Bekele *et al.* 2019). Previous studies indicate that wastewater infiltrated to the Superficial aquifer 500 m west of the wetland creates a small groundwater mound which maintains water level in the wetland (Bekele *et al.* 2019). Additionally, inflow and outflow from Peel Main Drain influences water level along with minor contributions from rainfall on the wetland surface (Marillier *et al.* 2012, DoW 2009).

In the survey area, flow in Peel Main Drain is derived from surface runoff of rainfall (in excess of infiltration), and groundwater discharge in winter. The drain is an ephemeral system drying in summer, with peak stream flow generally between July and September (Marillier *et al.* 2012, DoW 2009).

Resource Enhancement wetland 6379 and 6380 occur in low lying depressions (<10 mAHD surface elevation) within Spearwood Dunes and Tamala limestone. Monitoring in March 2024 indicated groundwater level near these wetlands was 8 – 10 m below surface level, corresponding with the minimum groundwater contour 0 - 1 mAHD (Golder 2024). Based on Golder's geological cross section (Figure 5), it is unlikely, or rare that surface expression of groundwater occurs at these wetlands, even in winter when maximum groundwater contours indicate 1 – 2 mAHD and 2 -3 mAHD beneath the wetlands respectively or between 7 to 9 m below ground surface. Vegetation in the wetlands (noting 6379 is in Good or better condition) is likely to be phreatophytic, dependent on the subsurface presence of groundwater.

7 RISK AND IMPACT ASSESSMENT

7.1 Activities

The proposed upgrade to Anketell Road has potential to result in impacts to high value wetlands identified through this assessment during construction and operation. Potential impacts to hydrological values during construction include potential impacts associated with:

- Dewatering – lowering of the water table to allow construction of footings etc
- Abstraction of groundwater for construction supplies
- Uncontrolled runoff from the construction area resulting in erosion and/or sedimentation
- Spills and/or contaminated runoff resulting from construction activities
- Realignment of a section of the Peel Main Drainand existing culvert to be extended or replaced.

Following completion of construction, during the operation phase of the proposal, potential impacts may include:

- Changes to recharge and runoff associated with permanent increased area of hard surface and drainage away from the site
- Changes to local surface water runoff resulting from changes in drainage
- Spill and/or contaminated runoff resulting from traffic.

7.2 Potential impacts and management

7.2.1 Dewatering

Dewatering has the potential to result in impacts to local groundwater levels and groundwater flow. This can in turn result in impacts to dependent ecosystems including wetlands directly through changes in hydrological regimes i.e. lowering groundwater levels reducing groundwater inflow and/or reducing groundwater availability to vegetation. Dewatering can also result in changes to groundwater chemistry including those resulting from oxidation of ASS.

Main Roads have indicated dewatering for construction will likely be required east of the freeway (near Treeby Road) to allow construction of a dive structure and associated stormwater collection tank and sump pump. MRWA indicate that dewatering for this activity in this location would require groundwater level to be lowered by 1.9 m (in the dry season) for a duration of 3 months. Based on these parameters FSG (2024) developed a groundwater model and ran potential dewatering scenarios to determine construction dewatering rates, extent of groundwater level drawdown and potential risk to hydrological values. Stream (2025) used the modelling outputs to assess the risk of impact from dewatering to groundwater dependent ecosystems, including wetlands. Details of the assessment, including the modelling scenarios and assessment methodology are provided in Appendix F.

The assessment focused on assessing two dry season dewatering scenarios (considered to pose the highest potential risk to GDEs), a dry season dewatering scenario with no recharge and a dry season scenario with recharge (i.e. infiltration of recovered water via a trench located approximately 220 m north east of the dewatering point).

Overall, the risk of impact to wetlands from dewatering under both scenarios was assessed as low. A section of one MU wetland (part of Mandogalup Swamp) is within the extent of modelled drawdown. The overall risk of impact to the wetland was scored as moderate (under no recharge scenario). This risk rating is considered conservative given the assessment identified this wetland does not support

significant ecological values, retains isolated trees only (mapped by Biota (2025) as isolated trees over cleared/pasture) and historical change in groundwater level is negligible. With recharge of dewatering to the aquifer as modelled in the second scenario, the extent of predicted drawdown is reduced and as a consequence, the potential risk to this wetland was reduced to low.

Recharge of dewatering outputs via an infiltration trench, also avoids potential risk to the Tumulus Spring TEC located approximately 700 m to the north of the dewatering location. Groundwater flow modelling indicates flow paths in the vicinity of the spring are not impacted under the dewatering scenario when recharge is incorporated (FSG 2024) and modelled drawdown contours do not extend out to the Tumulus Spring TEC. Based on the modelling outcomes, no impacts to the TEC are expected to result from dewatering associated with the proposal.

In addition, potential impacts associated with dewatering can be managed by:

- Ensuring that the duration of dewatering is minimised.
- Monitoring of the extent and magnitude of groundwater drawdown, including monitoring of groundwater prior to and during dewatering activities.
- Establishing exclusions zones around high value wetlands (discussed below).

7.2.2 Abstraction

Abstraction of groundwater can result in localised groundwater drawdown which occurs when groundwater is abstracted from an aquifer at a rate faster than it can be replenished, forming a cone of depression (in groundwater level).

The high hydraulic conductivity and transmissivity of Tamala Limestone and, to a lesser extent, Bassendean Sand within the survey area means a fast rate of lateral groundwater flow to the abstraction sites, potentially reducing groundwater level at sensitive wetlands. Change in groundwater level has the potential to impact high value wetlands identified in the assessment through alteration of hydrological regimes, reduced water availability and impacts to groundwater chemistry.

Substantial abstraction can also result in changes to groundwater flow (independent of potential change resulting from reduced or increased recharge). As presented by Bekele *et al* (2019), the groundwater mound created by infiltration of secondary treated wastewater at KWWTP influences groundwater flow west of the Spectacles Wetland and maintains water level at the wetland. Changes to the volume and/or location of abstraction bores that currently interact with this mound could potentially alter the groundwater flow dynamics between the KWWTP and Spectacles Wetland.

The estimated total water demand during the earthworks period of the project is approximately 430,000 kL (Metis 2024) over an approximate two-year timeframe, consisting of 308,000 kL during construction and 122,000 kL for dust suppression (FSG 2024). MRWA advise that the current approach to meet this water requirement is partially (50%) through abstraction of 215,000 kL of groundwater within the development envelope, with the remaining 50% to be obtained from alternative and existing water sources.

FSG (2025) modelled the groundwater level drawdown and extent of several abstraction scenarios. The risk of impact of groundwater abstraction on Groundwater Dependent Ecosystems (GDEs), including wetlands was assessed by Stream (2025) using the model outputs (Appendix F).

Exclusion Zones

Proposed abstraction bore locations, used in FSG modelling, have been positioned outside exclusion zones developed by Stream previously (Appendix G), reducing the potential likelihood of impact to high value groundwater dependent wetlands.

The exclusion zones were calculated using a drawdown estimate based on the estimated water requirement and known aquifer parameters for Tamala Limestone and Bassendean Sand. Details of the calculations are provided in Appendix G.

The results indicate at 180 days of groundwater abstraction the following drawdown and radius is expected:

- In Tamala Limestone: just over 10cm drawdown at 400 m radius and dropping below 10 cm beyond 400 m radius
- In Bassendean Sand: 42 cm drawdown at 400 m radius, dropping to 16cm at 600 m radius

Figure 12 shows wetlands with relevant (based on distribution of Tamala Limestones and Bassendean Sands) exclusion zones of 400 m in Tamala Limestone and 600 m in Bassendean Sands applied, and the proposed locations of abstraction bores (production bores 1, 2 and 3). NB. Figure 12 shows exclusion zones applied only to wetlands identified as high value in this assessment.

Abstraction Scenarios

The assessment of risk of impact to GDEs including wetlands focused on abstraction scenario 3 which represent the current water requirements and suggested approach by MRWA (outlined above). Scenario 3 for supply of construction water modelled 50% (215 000 kL) and 100% of dust suppression (270 000 kL) from three production bores. Scenario 3 also modelled 210 days for dust suppression only (270 000 kL) from three proposed production bores. The two stages are referred to as Scenario 3a (production and dust suppression) and Scenario 3b (dust suppression only) respectively.

The risk of impact to wetlands from both abstraction scenarios was assessed as very low. For each scenario the total drawdown area (i.e. the extent of modelled drawdown) for each production bore was used to identify GDEs potentially at risk (of impact from drawdown), and then risk to GDEs (including wetlands) was assessed. No wetlands occur within the modelled drawdown area for production bores 2 and 3 under Scenario 3a and not wetlands occur within any of the total drawdown areas under Scenario 3b.

Part of MU wetland UFI6530 (part of Mandogalup Swamp) occurs within the total drawdown area (intersects the 0.1m drawdown contour) under Scenario 3a at production bore 1, located east of the Freeway. The risk assessment concluded that the risk of impact to this wetland was low given:

- The wetland supports low level ecological values; retains isolated trees only over cleared/pasture (as mapped by Biota 2025).
- Historical change in groundwater level is negligible (meaning the susceptibility of this wetland to impacts is considered low).
- The drawdown of 0.1 m predicted for this wetland is less than the drawdown of >0.5 m identified as likely to pose a high risk to wetlands (as identified by Froend and Loomes 2004).

In addition, given the relatively short timeframes for water abstraction under the production scenarios assessed, the potential risk to wetlands is considered further reduced and groundwater would be expected to recover following cessation of abstraction.

7.2.3 Uncontrolled runoff during construction

Uncontrolled runoff from the proposal area during construction has the potential to result in erosion, sedimentation and impacts to water quality if not appropriately managed. This could result in impacts to downstream surface water features.

The risk of such impacts is considered low during construction as there are no surface water features (streams, waterways) that intersect the survey area aside from the Peel Main Drain and risks can be minimised by:

- Undertaking construction works around the Peel Main Drain periods of no flow to mitigate any risks to water quality within the drain or downstream at the Spectacles North wetland.
- Implementing appropriate construction management measures such as silt curtains (if required), erosion control and monitoring and hydrocarbon storage management during construction.

7.2.4 Spills and contamination during construction

There is a potential risk of accidental spills (such as fuel) during the construction phase of the project from vehicles and construction equipment. These spills are unlikely to be significant and can be readily managed in a construction environment through implementation of measures such as reduction of site vehicle speed lessening chance of major spill; management restrictions on use of hydrocarbons and refuelling adjacent to waterways and use of physical barriers. The Peel Main Drain does not flow year round. As construction will occur during low/no flow periods it is considered that any accidental spills would be localised.

7.2.5 Changes to recharge and runoff

Construction of additional road and other hard surfaces associated with the proposal has the potential to alter hydrological regimes by reducing infiltration of rainfall (and recharge to groundwater) and/or increasing runoff from rainfall events into surface water features. This can potentially result in impacts to hydrological values, including wetlands within and adjacent to the survey area. However, the change in recharge is expected to be very small in comparison to overall local recharge area and any potential changes will be partially mitigated by the implementation of the drainage strategy for the proposal detailed below.

The Anketell Road West Drainage Strategy (BG & E 2024) provides details on the proposed approach to drainage for the proposal. Runoff management objectives of the drainage strategy are as follows:

- Minimise impact on wetlands, groundwater dependent ecosystems and adjacent receptors
- Maintain the hydrology of the project area
- Minimise impact on surface water and groundwater
- Provide for water sensitive urban design
- Minimise clearing of vegetation
- Minimise impact on existing utilities.

The strategy proposes use of permeable base pits (leaky pits) and infiltration basins to provide for infiltration of small frequent rainfall events, major flood events and removal of target pollutants resulting in recharge of the groundwater as close to source as possible and maintaining the existing hydrology regime and water quality. This approach is particularly suited to the current proposal given the majority of soils in the survey area are highly transmissive sands with high infiltration rates.

Leaky pits consist of a standard road drainage pit with a hole in the base slab that allows for some infiltration of the runoff entering the pit. Leaky pits help maintain the existing hydrological flow regime by infiltrating runoff as close to source as possible. These systems may be used where the drainage system is kerbed, and pits are above groundwater level.

Infiltration basins operate by capturing runoff within a constructed depression or an aggregate-filled trench, allowing water to infiltrate. The local geology and soil permeability and generally good groundwater separation within the proposal area will facilitate efficient infiltration of runoff. These basins are effective solutions for managing stormwater runoff and flood management. During major events, the infiltration basins will create some localised mounding of groundwater at the basin locations, however, these are expected to be temporary with the mounding dissipating following the runoff infiltration (BG & E 2024).

With the highly transmissive sands of the proposal area and implementation of an appropriate drainage design as proposed, the potential risk associated with impact from changes to recharge and runoff is likely to be low.

7.2.6 The Peel Main Drain

The Peel Main Drain is an artificial constructed drain that, despite holding limited ecological values itself, is important in maintaining the hydrological regime of the Spectacles Wetland. The project will require a section of the Peel Main Drain to be realigned in the vicinity of Anketell Road and for the existing culvert to be extended or replaced. To avoid impacts to the hydrology of the Peel Main Drain (and the Spectacles Wetland):

- Existing culvert size and invert levels will be replicated to maintain the existing performance.
- The drain realignment section will not add any additional length to the drain.
- The section of realigned channel will replicate the existing channel size and characteristics.

It is not anticipated that the current capacity of the drain will be impacted by the proposal. The drain and culvert are Water Corporation assets, and proposed changes to their infrastructure require their approval, which typically involves any changes being incorporated into their hydrologic/hydraulic model to ensure that it does not negatively impact the drainage system (BG & E 2024). By minimising the impact to flow into the drain, impacts to the current water quality will also be negligible.

Road runoff will not be directed into the Peel Main Drain. In order to manage small frequent rainfall events, rainfall runoff from the road will be directed into roadside into leaky pits and infiltration basins (described above) to maximise on site infiltration, consistent with the current hydrology of the site

7.2.7 Spill and/or contaminated runoff

Spills during the operation phase of the project due to large vehicle accidents will be managed through standard emergency response procedures by Main Roads and relevant authorities.

The main potential contaminants in road run off are sediments, hydrocarbons , inorganic constituents (i.e. metals and minerals) and nutrients:

- Sediment originates from the erosion of nearby land, the wear and tear of road surfaces and particles released by vehicles.
- Inorganic constituents such as heavy metals primarily originate from fuel combustion and vehicles, and atmospheric deposition. As metals are largely insoluble they adhere to sediments.
- Hydrocarbons enter road runoff from vehicle leaks, spills, and atmospheric deposition.

- While nutrients may occur in road runoff, largely from atmospheric deposition or spills, the contribution of nutrients to catchment waterways is considered low due to the already high load of nutrients from the catchment.

Based on the main constituents likely to occur in highway road runoff, the highway drainage system should target the removal of sediments/TSS, heavy metals and hydrocarbons/oils/grease.

The Drainage Management Strategy focussed primarily on the maintenance of hydrological regime to ensure minimal impacts to significant wetlands and Groundwater dependant ecosystems. However, the use of infiltration basins and leaky pits also effectively removes the target pollutants (BG & E 2024). Leaky pits are effective at trapping suspended solids (sediment) and the associated heavy metals and organic compounds that are bound to the sediment. Leaky pits will have some retention of hydrocarbons within the soil under the pit however without exposure to sunlight biodegradation of hydrocarbons is limited. Similarly, infiltration basins are effective at removing litter, total suspended solids (sediment) and heavy metals from stormwater flows through retention and filtration of the runoff through the soil. Hydrocarbons will bond to the upper layer of soil of infiltration basins and will biodegrade over time.

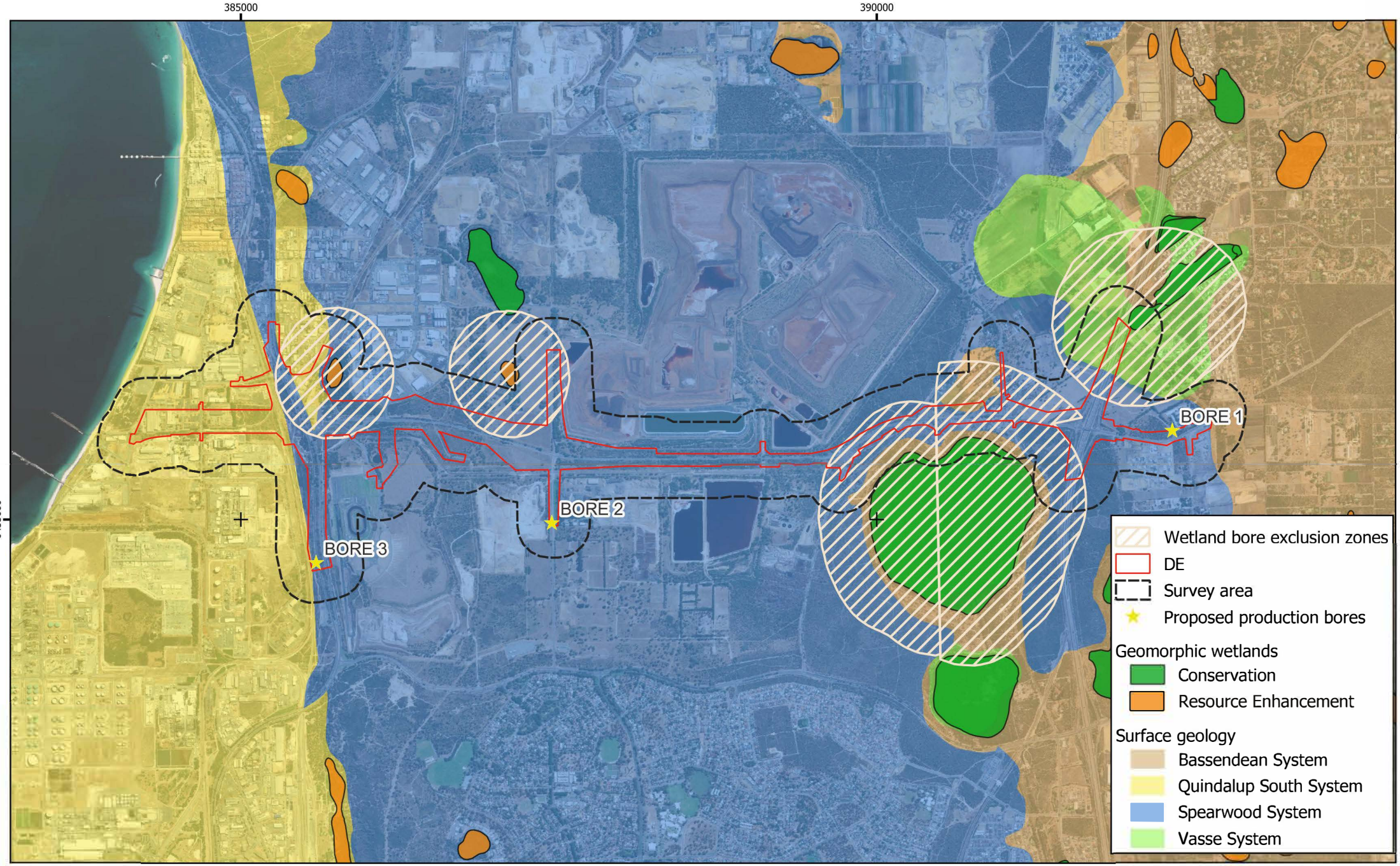

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Figure 12
Proposed exclusion zones on high value wetlands

Anketell Road Upgrade Wetland Assessment

N

0 1 2 km

Base map © ESRI and its data suppliers. Landgate (2020)
CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 31/01/25 Author: CS

8 CONCLUSION

The Anketell upgrade proposal is located in a highly modified area where surface hydrological features have been modified by clearing, infrastructure, agriculture and industry. The water quality of wetlands and waterways of the area have been compromised by historical land use. However, several wetlands in close proximity to the Development Envelope were identified and retain hydrological values:

- The Spectacles North wetland (CCW UFI 6539) located 100m south of the DE
- Mandogalup Swamp South (CCW UFI12981) located 10m north of the DE
- Wetland UFI6379 (RE but retains CCW values) located 30m east of the DE
- Resource Enhancement wetland (UFI6380) located 285m east of the DE

In addition, the Peel Main Drain intersects the DE and directly drains into the Spectacles North wetland. The Peel Main Drain is also considered an important surface water feature because of its interaction with the Spectacles Wetland and eventual connection with the Peel -Yalgorup system, a Ramsar site, via the Serpentine River.

Located approximately 600 m north of the DE, at it's closest point, an occurrence of Communities of Tumulus Springs (Organic Mounds SCP) TEC is an additional significant ecological community potentially impacted by the proposal. The occurrence is reported within a section of wetland 6530 (DBCA database only, not confirmed or mapped by Biota 2025). The spring has the potential to be impacted by changes in hydrology and supports a flora and fauna assemblage reliant on a permanent supply of freshwater.

The proposed upgrade to Anketell Road has the potential to impact hydrological values during the construction and operation phases. During construction, activities such as dewatering, groundwater abstraction, uncontrolled runoff, and spills have the potential to impact nearby water resources and ecosystems as listed above. These activities can lead to erosion, sedimentation, contamination and localised groundwater drawdown, posing risks to aquatic ecosystems and water quality. Once construction is completed, changes to recharge and runoff patterns due to increased hard surfaces, altered drainage systems, and potential spills from traffic also have potential to impact hydrological values in the area.

However, by considering the identified hydrological values in the design and implementing appropriate management during construction and operation of the proposal, it is possible to minimise the risks to these values. The following measures will reduce the risk of impact to hydrological values:

- Implementation of the Anketell Drainage Management Strategy which aims to maintain existing hydrological regimes, including not restricting or altering the capacity of the Peel Main Drain and minimise impacts to wetlands and the Peel Main Drain. The strategy will achieve these aims through the use of permeable base pits (leaky pits) and infiltration basins to provide for infiltration of small frequent rainfall events, major flood events and removal of target pollutants. The drainage design will result in recharge of the groundwater as close to source as possible and maintaining the existing hydrology regime and water quality.
- Implementation of standard construction management to manage risks associated with erosion, sedimentation and/or spills during construction.
- Locating production bores for water supply during construction outside of exclusion zones developed by Stream, reducing the potential likelihood of impact to high value groundwater dependent wetlands.

- Dewatering required to facilitate construction of the proposal is minimal and risks of impacts (to GDEs) from dewatering can be reduced by infiltration of dewater back into the aquifer.
- Monitoring of the extent and magnitude of groundwater drawdown, including monitoring of groundwater prior to and during dewatering activities.

With implementation of these measures, risks to hydrological values is manageable and the risk of impact is low. The assessment of risk to hydrological values concluded that:

- Drawdown extent associated with dewatering and water production scenarios is small and bore placement (under production scenarios) means drawdown (as modelled) generally occurs where the depth the groundwater is relatively deep, reducing the risk of impact to wetlands.
- Given the relatively short timeframes for water abstraction under the dewatering and production scenarios assessed, the potential risk to wetlands is considered further reduced and groundwater would be expected to recover following cessation of abstraction.
- GDE Risk analysis by Stream (2025) found both production scenarios were considered to pose a low risk to wetlands and with infiltration (via trench as modelled) risk to wetlands and the Tumulus Spring (TEC) (occurring to the north of the dewatering location) from dewatering was also considered low.
- Changes in recharge and runoff associated with the proposal are expected to be small in the context of current recharge catchments and mitigated further by drainage design which will allow on site infiltration and mitigate any change to recharge.
- Risks of impacts to hydrological values during construction associated with erosion, sedimentation and/or spills are relatively low and can be managed through implementation of standard construction controls.

9 REFERENCES

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Appendix A Categories and definitions for threatened and priority ecological communities

State Threatened and Priority Ecological Community Categories

Category	Description
Threatened	
Presumed totally Destroyed (PD)	An ecological community that has been adequately searched for but for which no representative occurrences have been located.
Critically Endangered (CR)	An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
Endangered (EN)	An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
Vulnerable (VU)	An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium (within approximately 50 years) to long-term future.
Priority	
Priority 1 (P1) – Poorly known	Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist.
Priority 2 (P2) – Poorly known	Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). At least some occurrences are not believed to be under immediate threat (within approximately 10 years) of destruction or degradation.
Priority 3 (P3) – Poorly known	Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent

	threat(within approximately 10 years), or; made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range
Priority 4 (P4) – Adequately known	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.
Priority 5 (P5) – Conservation dependent	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

EPBC Act conservation categories for threatened ecological communities

Category	Description
Critically Endangered (CR)	An ecological community that is facing an extremely high risk of extinction in the wild in the immediate future (indicative timeframe being the next 10 years)
Endangered (EN)	An ecological community that 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 (VU)	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 Categories and definitions for threatened and priority flora species

CONSERVATION CODES FOR WESTERN AUSTRALIAN FLORA

T: Threatened Flora - Specially protected under the BC Act, listed under Schedules 1, 2 and 3 of the Wildlife Conservation (Rare Flora) Notice 2018 (which may also be referred to as Declared Rare Flora). Taxa which have been adequately searched for and are deemed to be, in the wild, either rare, at risk of extinction, or otherwise in need of special protection, and have been gazetted as such. The assessment of the conservation status of these species is based on their national extent. Ranking: CR · Schedule 1 - taxa that are extant and considered likely to become extinct or rare, as critically endangered flora, and therefore in need of special protection. EN · Schedule 2 - taxa that are extant and considered likely to become extinct or rare, as endangered flora, and therefore in need of special protection. VU · Schedule 3 - taxa that are extant and considered likely to become extinct or rare, as vulnerable flora, and therefore in need of special protection.
EX: Presumed extinct Flora - Specially protected under the BC Act, listed under Schedule 4 of the Wildlife Conservation (Rare Flora) Notice (which may also be referred to as Declared Rare Flora). Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such. Threatened flora are ranked according to their level of threat using IUCN Red List categories and criteria. EX · Schedule 4 - taxa that are presumed to be extinct in the wild and therefore in need of special protection.
Priority Flora
Taxa that may be threatened or near threatened, but are data deficient or have not yet been adequately surveyed to be listed under the Wildlife Conservation (Rare Flora) Notice, are added to the Priority Flora List 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 flora. Taxa that are adequately known and are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened list for other than taxonomic reasons, are placed in Priority 4. These taxa require regular monitoring.
1: Priority One: 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 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 Two: 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, 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 Three: Poorly-known species
Species that are known from several locations, and the species do 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 Four: 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 do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.
(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

EPBC Act conservation categories (follow IUCN Red List categories)

Category	**Description**
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.
Extinct in the wild (EW)	A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence indicates that it is considered to be (according to specified criteria) facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when it is considered (according to specified criteria) to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence indicates that it is considered (according to specified criteria) to be facing a high risk of extinction in the wild.
Conservation dependent (CD)	A taxon is conservation dependent if, at a particular time, it is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered.

Appendix C Desktop Wetland Assessment

Consanguineous wetland suites

The desktop search area contains wetlands from six consanguineous suites; Coogee, Bibra, Keysbrook, Jandakot, Becher and Stakehill. Four of the six consanguineous suites overlay the survey area (Bibra, Jandakot, Becher and Stakehill), however only wetlands from three consanguineous suites occur within the survey area (Table C1, Figure C1).

Table C1 Wetland consanguineous suites within the study area

Consanguineous Suite	Summary description	Within Survey area
Coogee	Lakes & sumplands. Carbonate mud overlying limestone	No
Bibra	Lakes & sumplands in a north-south oriented chain. Mud, peat, or peaty sand overlying Bassendean Sand	Yes
Keysbrook	Palusplains, floodplains, creeks of the Pinjarra Plain. Clay overlying lateritic clay & sand	No
Jandakot	Damplands & sumplands. Peat or peaty sand or humic sand overlying quartz sand	Yes
Becher	Sumplands & damplands. Humic sand or peak & thin carbonate mud overlying Safety Bay sand	Yes*
Stakehill	Lakes & sumplands. Carbonate mud & peat over-lying yellow sand	Yes

* Overlays but no wetlands within this part of the Survey area

Geomorphic wetland mapping

The desktop search area includes 212 individual wetlands as identified in the GWSCP dataset. Two CCW, three MU and two RE wetlands are within 250m of the survey area, two of which (both MU dampland wetlands) intersect the survey area (Table C2, Figure C2).

Table C2 Geomorphic Wetlands in the survey area and 250m buffer area

Wetland UFI No.	Wetland Name	Landform	Wetland Type	Management Category	Consanguineous Suite	Total Wetland area (ha)	Area in Survey area (ha)	Area in DE (ha)
6379	Unknown	Basin	Dampland	RE	Stakehill	2.12	2.12	-
6381	Unknown	Basin	Dampland	MU	Stakehill	1.49	0.12	-
6539	Spectacles North	Basin	Sumpland	CCW	Bibra	132.10	9.41	-

6538	Unknown	Basin	Dampland	MU	Bibra	20.09	20.09	4.70
12981	Mandogal up Swamp South	Basin	Dampland	CCW	Jandakot	3.42	3.42	-
6380	Unknown	Basin	Dampland	RE	Stakehill	2.01	0.34	-
6530	Mandogal up Swamp South	Basin	Dampland	MU	Jandakot	215.39	46.57	6.87

Directory of Important Wetlands

The Directory of Important Wetlands in Australia (DIWA) (Environment Australia 2001) identifies wetlands assessed as meeting criteria for national importance. and provides information about these wetlands such as their hydrological, ecological, social and cultural values.

Two DIWA wetlands occur within the desktop study area, Spectacles Swamp and Gibbs Road Swamp System. The closest DIWA wetland is the Spectacles Swamp that occur just over 100m to the south of the survey area (within the 250m buffer area). The southwestern part of the Gibbs Road Swamp System occurs approximately 4.9km to the northeast of the survey area. Information from DCCEW(2024) regarding these wetlands is outlined below.

Spectacles Swamp (WA090)

Spectacles Swamp comprises 'Big Eye Spectacle' (113.1 ha) and Small Eye Spectacle (28.4 ha). Both spectacles are round sumplands, joined to each other and nearby wetlands by a deep (artificial) drain. The Swamp is considered a representative example of a wooded swamp of the SCP and consists of a low open-forest dominated by Flooded Gum (*Eucalyptus rudis*) with a low closed-forest of *Melaleuca rhaphiophylla* interspersed with shrubs of *M. teretifolia*, and the sedgeland by *Typha orientalis* and *Baumea articulata* (EPA/WAWA 1990).

Spectacles Swamp is fed by groundwater and inflow from the Peel Main Drain originating 8-10 km north-east and continuing through to the Serpentine River. There is substantial flow in the winter months. Water within the wetland is seasonal however near-permanent due to the Peel Main Drain. Maximum water depths of around 1.2 m occur in September. The wetland is dry or nearly so in summer-autumn.

Spectacles Swamp has important wetland functions, improving the quality of water draining (via the Peel Main Drain) from the Jandakot rural and housing area into the Serpentine River and Peel Inlet by filtering out pollutants (Lavery and Summers 1992) and providing habitat for fauna such as Quenda, Western Brush Wallaby and Lined Skink. The Swamp supports breeding waterbirds and is the only known breeding area for spoonbills in the metropolitan area. The vegetation of Spectacles Swamp has been identified as regionally significant bushland (Bush forever site 269) and part of ecological linkages.

Scientific surveys have been conducted at the Swamp and educational/heritage features include an Aboriginal Heritage Trail, the Biara Boardwalk Trail and bird hide. The wetland is also on the City of Kwinana heritage list and part of Beelair Regional Park.

Gibbs Road Swamp (WA078)

The Gibbs Road Swamp System comprises eight wooded swamps on the east slope of the Jandakot groundwater mound. Whilst the swamps support significant ecological values, the closest wetland is located over 4.5km from the survey area and will not be impacted by the proposal.

Ramsar Wetlands of International Importance

Wetlands considered as internationally important can be nominated under the Ramsar Convention (an intergovernmental treaty that aims to conserve remaining wetlands through maintaining their ecological character) (DCCEW 2024). No Ramsar wetlands occur within the 5km study area. Forrestdale and Thomsons Lake' (Australian Ramsar Site 35) are jointly listed as a Wetland of International Importance under the Ramsar Convention, and are located approximately 8km north of the survey area.

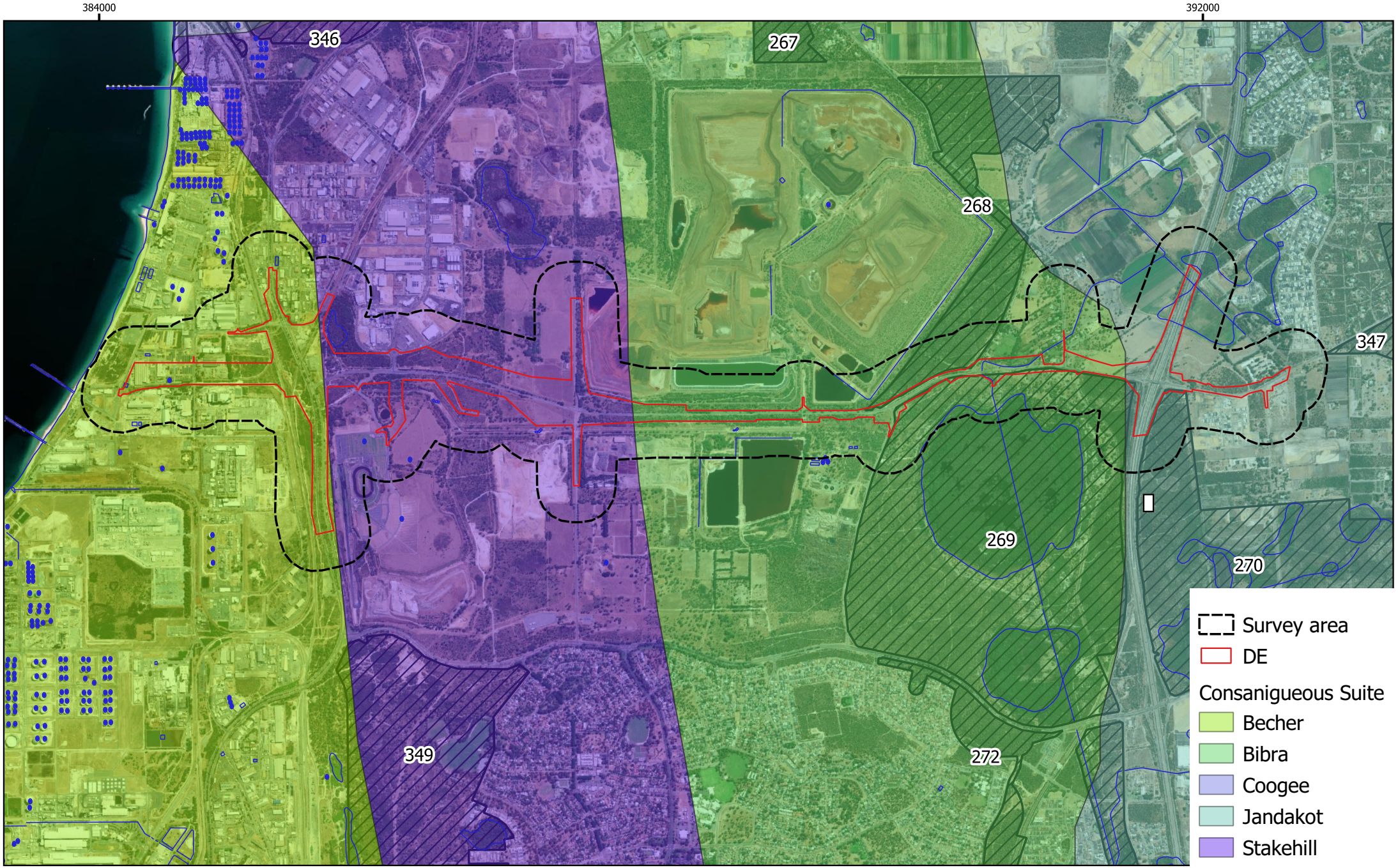

Figure C1
Consanguineous wetland suites

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Anketell Road upgrade wetland assessment

Base map © ESRI and its data
CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 29/01/2025 Author: JW

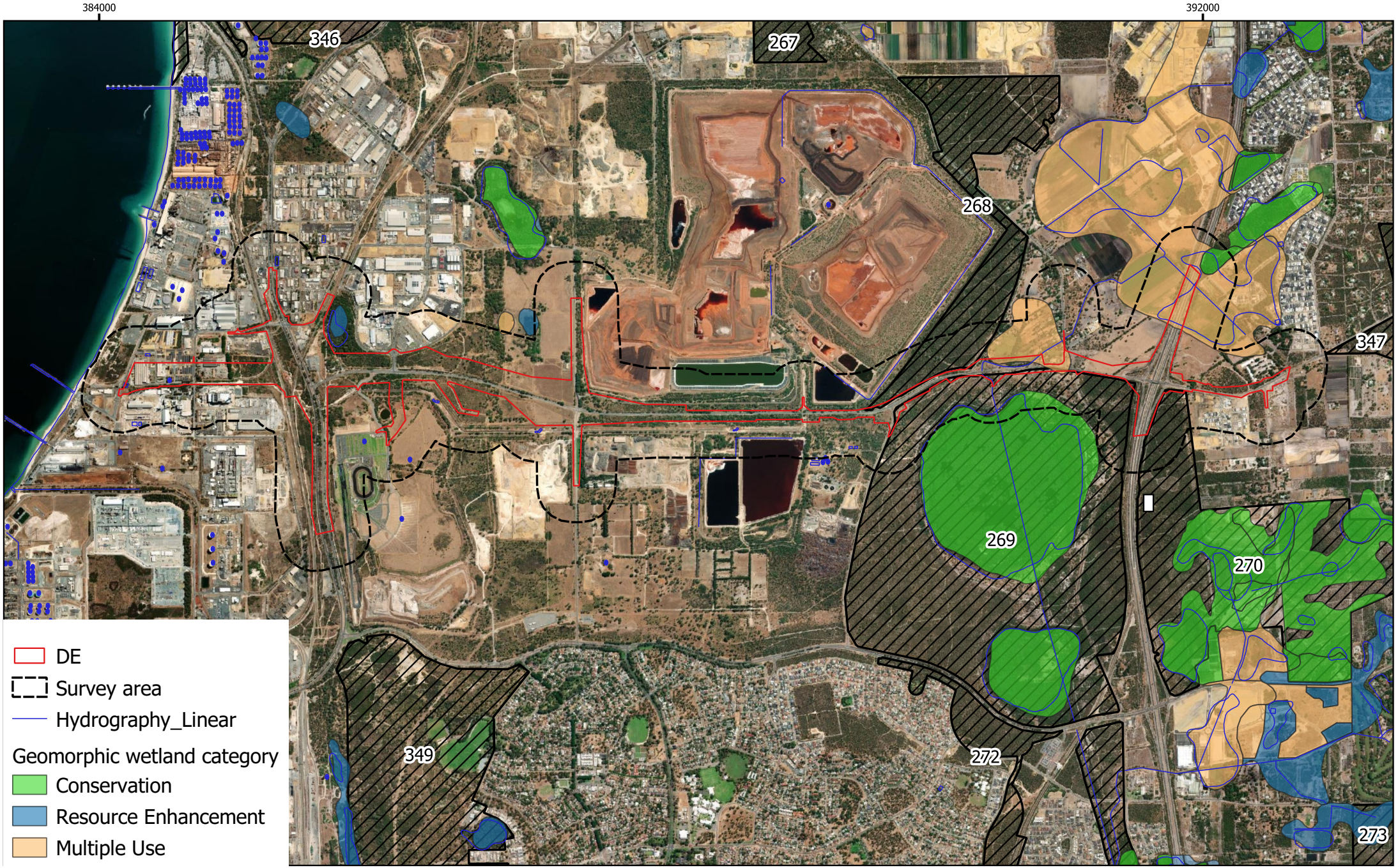

Figure C2
Geomorphic wetlands

Base map © ESRI and its data
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Project ref: 230903
Date: 29/01/2025 Author: JW

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Bush Forever and other conservation areas

Fifteen Bush Forever sites occur within the desktop search area (Figure C3), eleven of which intersect wetlands and/or waterways. Two sites occur both within the survey area, and the DE (Table C3).

Table C3 Bushforever sites within the Study area that intersect wetlands/waterways

Bush forever Site No.	Name	Occurs within survey area	Occurs within DE
347	Wandi Nature Reserve and Adjacent Bushland, , Wandi/Oakford	-	-
346	Brownman Swamp, Mt Brown Lake and Adjacent Bushland, Henderson/ Naval Base	-	-
348	Modong Nature Reserve and Adjacent Bushland, , Oakford	-	-
349	Leda and Adjacent Bushland, Leda	-	-
492	Lyon Road Bushland, Banjup	-	-
270	**Sandy Lake and Adjacent Bushland, Anketell**	**Yes**	**Yes**
272	Sicklemore Road Bushland, Parmelia/ Casuarina	-	-
392	Harry Waring Marsupial Reserve, Wattleup	-	-
269	**The Spectacles**	**Yes**	**Yes**
273	Casuarina Prison Bushland	-	-
393	Wattleup Lake and Adjacent Bushland, Wattleup/ Mandogalup	-	-

Bush forever site 269 is associated with the Spectacles Wetland occurring within 250m of the survey area. The Bush forever site 269 248.44ha bushland is endorsed for conservation purposes within Beelair Regional Park.

Bush forever site 270 is associated with the Sandy Lake wetland system – which occurs 700m to the southeast of the survey area. This 72.11ha bushland is endorsed for conservation purposes within Jandakot regional Park

Waterway assessment sites

No Department of Water and Environmental Regulation (DWER) healthy rivers waterway assessment sites are located within the desktop search area. The closest relevant site is located on the Serpentine Downstream Peel Main Drain (AWRC Reference 6144122). This site is located approximately 20km to the south of the survey area in association with the Peel Main Drain and the Serpentine River (DWER 2020). The findings of the assessment of these sites is yet to be published by DWER on the Healthy Rivers website (dwer.wa.gov.au).

Threatened ecological communities

Ecological communities are protected under the State BC Act and Federal Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). A community is listed as a TEC if the community is presumed to be totally destroyed or at risk of becoming totally destroyed (see Appendix A for details and conservation categories).

Where communities are considered rare but not (currently) threatened or there is insufficient information available for the community to be considered a TEC, communities can be listed as priority ecological communities (PECs) (definitions of priority classes are provided in Appendix A).

Biota (2025) reports the results of consolidated biological surveys for the DE with a 500m contextual area. TECs and PECs that intersect wetlands and/or waterways are listed in Table 7 (Table C4, Figure C4).

Table C4: TECs/PECs within the Survey area that intersect wetlands of the Survey area

TEC/PEC	Conservation Status	Wetland UFI /waterway intersects survey area	Wetland UFI /waterway intersects DE
Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community	Federal TEC (Critically Endangered) State PEC (Priority 3)	6379, 6381, 6539, 6538*	6538
Banksia woodlands of the Swan Coastal Plain ecological community	Federal TEC (Endangered)	6539 Peel Main Drain	None
Northern Spearwood shrublands and woodlands (FCT 24)	PEC (Priority 3)	6539, 6381**	None

*<0.06ha in a highly degraded and modified condition

** <0.15ha mapped in context area only (extrapolated information) and in a degraded condition

The Communities of Tumulus Springs (Organic Mounds SCP) has been considered in this wetland assessment due to its potential occurrence in wetland 6530 (DBCA database only, not confirmed or mapped by Biota 2025).The TEC does not however occur within the DE or survey area (only the buffer area).

Threatened and Priority flora

All native flora in Western Australia is protected under the EP Act by virtue of the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA). Specific flora species may be afforded special protection under the BC Act for flora taxa declared as 'Threatened Flora'. In addition, DBCA also classifies flora under four Priority codes (policy based) where they are under consideration for future listing as Threatened flora but there is insufficient information, or they are not currently threatened but could become so if circumstances change (Appendix B).

Flora species can also be listed under the EPBC Act as Threatened species and are classed as either extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependant (Appendix B). Any actions likely to have significant impact on species (or communities) listed under

the EPBC Act require referral for assessment and approval from the Federal Minister for the Environment.

Biota (2024), identified five Priority flora species within the DE; *Poranthera moorokatta* (Priority 2), *Hibbertia leptotheca* (Priority 3), *Pimelea calcicole* (Priority 3), *Calothamnus quadrifidus subsp. teretifolius* (P4) and *Eucalyptus foecunda* subsp. *foecunda* (Priority 4). A further two Priority species recorded only within the Biota (2024) contextual area ; *Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459) (Priority 3) and *Caladenia speciosa* (Priority 4).

No threatened or priority flora listed under the EPBC Act or BC Act were located within wetlands within the DE or the survey area.

Figure C3
Bushforever Sites

N

0 1 2 km

Base map © ESRI and its data
CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 29/01/2025 Author: JW

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Anketell Road upgrade wetland assessment

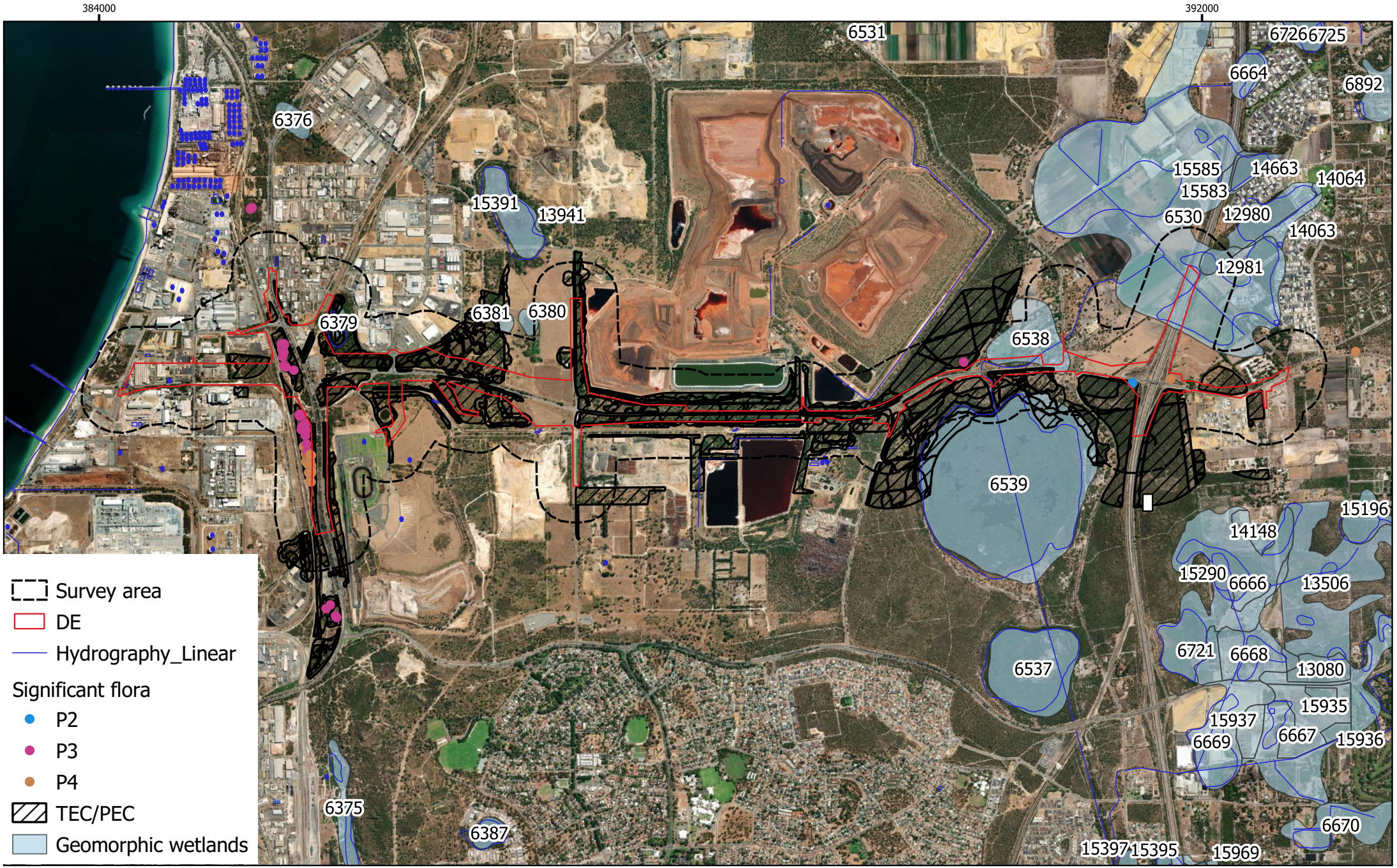

Figure C4
Significant communities and species intersecting the DE and Survey area

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Anketell Road upgrade wetland assessment

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CRS: GDA2020/MGA zone 50
Project ref: 230903
Date: 29/01/2054 Author: JW

Conservation significant fauna and habitats

Results of desktop and fauna surveys (Biota 2025) reported four significant fauna species recorded within the DE:

- *Isoodon fusciventer,* Southern Brown Bandicoot, Quenda (P4)
- *Zanda latirostris*, Carnaby's Black Cockatoo (EN)
- *Lerista lineata*, Perth Lined Slider (P3)
- *Calyptorhynchus banksia naso*, Forest Red–tailed Black Cockatoo (VU)

An additional four fauna species are considered likely to occur; *Falco peregrinus* Peregrine Falcon (OS), *Neelaps calonotos* Black–striped Snake (P3), *Synemon gratiosa* Graceful Sunmoth (P4)and *Idiosoma sigillatum* Swan Coastal Plain Shield–backed Trapdoor Spider(P3) and four may occur in the Survey area; *Plegadis falcinellus* Glossy Ibis (MA, MI), *Zanda baudinii* Baudin's Black Cockatoo (EN*), Dasyurus geoffroii* Chuditch (VU) and *Notamacropus Irma* Western Brush Wallaby(P4). No individuals with the potential to represent SREs were found within the DE.

Nine broad fauna habitats were mapped within the DE and a 500m contextual area by Biota (2024). A summary of the habitats that occur in wetlands relevant to this assessment and their potential value to conservation significant fauna is summarised in Table C5. Note that suitable DBH trees for Black Cockatoos were not surveyed outside of the DE. Fifteen DBH trees were recorded within Wetland 6538 (this wetland overlapped the DE).

Table C5 Fauna Habitats that intersect Wetlands of the Survey area (adapted from Biota 2025)

Fauna Habitat	Values	Wetlands of the Survey area (UFI)
EW - *Eucalyptus* Woodland/Forest	Habitat for Quenda Black cockatoo (Carnaby's Cockatoo and Forest Red Tailed Black Cockatoo) foraging tree species. Sandy soils may provide habitat for fossorial species.	6379, 6381
JBW - *Jarrah/Banksia* Woodland	Habitat for Quenda, Chuditch (transitory only)and Western Brush Wallaby (transitory only) and Black Cockatoo species(Carnaby's Cockatoo and Forest Red Tailed Black Cockatoo). Habitat for Perth Lined Slider	6539
PL - Emergent Flooded Gum and Marri, planted eucalypts	Potential foraging habitat for black cockatoo species(Carnaby's Cockatoo and Forest Red Tailed Black Cockatoo).	12981, 6530*
DL - Damplands	Habitat for Quenda and in open areas, Glossy Ibis. Foraging habitat for birds of prey.	6379, 6539, 6538*, 12981, 6380
CM - Modified Areas	Pastures provide potential habitat for Glossy Ibis. Foraging habitat for birds of prey.	6530*
CL – Degraded/Cleared	Habitat for small fossorial species may be present in sandier areas. Foraging habitat for birds of prey.	6381, 6539, 6538*, 12981, 6380, 6530*

***These wetlands occur within the Survey area**

Appendix D Assessment Details for Individual Wetland Sites

WETLAND 6379

Date	6/3/2024		
Easting	385623		
Northing	66436135		
Location/property address	Approximately 50m east of Conway Road, Hope Valley		
Wetland details			
Name	Unknown	Consanguineous suite	Stakehill
UFI	6379	Wetland type	Dampland
Wetland area	2.12 ha	Management category	Resource Enhancement
Area evaluated Area of wetland within Development Envelope (DE)	Entire wetland considered in evaluation 0 ha within DE 2.12ha within 250m buffer	Assessed as a portion of a wetland with varying areas of value	No
PRELIMINARY DESKTOP QUESTIONS			
Land uses		**Conservation significance, international, national or regional significance**	
Current ownership	City of Kwinana	Ramsar	No
Current land use	Managed Reserve	Conservation reserve (system 6)	No
Past land use		Bush Forever	No
Surrounding land use	Urban, Rural,	Conservation estate	No
Existing management	City of Kwinana?	Other	No
Fire history/regime	>5 years		
Does the wetland retain the values for which it was originally registered or listed, describe		NA	
Scientific value			
Scientific, geoheritage or geoconservation values		None known	
Fauna			
Species	Significance	Observations	Source of information
Carnaby's Black Cockatoo (CBC) (*Calyptorhynchus latirostris)*	Endangered BC Act, EPBC Act	Foraging habitat Suitable DBH trees	Biota (2025) Site Visit (this report)
Forest Red-tailed Black Cockatoo (FRTBC) (*C. banksii naso*)	Vulnerable BC Act, EPBC Act		
Quenda, *Isoodon fusciventer*	Priority 4	Suitable habitat. The Quenda was recorded in similar habitat type nearby.	

Flora				
Vegetation condition (Refer to Appendix E for ranking)	Area (ha)*	Total area % within the wetland*	Total % 50 metres surrounding the wetland	Source of information
Very Good			>90%	Biota 2025 Aerial Photos *A site visit in 2024 observed parts of the wetland to be in Good-Very Good Condition.
Good	2.12 ha*	100%		
Degraded				
Completely degraded				
Cleared				

Is the wetland vegetation predominantly in good condition		Yes	
Vegetation complex (Heddle et al., 1980)		Cottesloe Complex Central and South (52)	
% remaining vegetation complex		33.51%	
Threatened ecological communities	Significance	Observation	Source of information
Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community	Critically Endangered, EPBC Act State PEC (P3)		Biota 2025
Threatened and Priority flora	Significance	Population measure and Observation	Source of information
Outside of Biological Survey area. None known to occur (database search)			Biota 2025 DBCA Threatened and Priority Flora Database
Representativeness			
% area wetlands with same classification assigned Conservation mgt category on SCP		29.3%	
% area wetlands in same suite assigned Conservation mgt category		86.1%	
% area wetlands with same classification and suite assigned Conservation mgt category		35.2%	
Is the wetland rare:		No	
Photographs			

*Estimate only

WETLAND 6381

Date	6/3/2024		
Easting	386931		
Northing	6436083		
Location/property address	270m east of Investigator Drive, Hope Valley		
Wetland details			
Name	Unknown	Consanguineous suite	Stakehill
UFI	6381	Wetland type	Dampland
Wetland area	1.49 ha	Management category	Multiple Use

Area evaluated Area of wetland within Development Envelope (DE)	Entire wetland considered in evaluation 0 ha within DE 0.12ha within 250m buffer.		Assessed as a portion of a wetland with varying areas of value	No
PRELIMINARY DESKTOP QUESTIONS				
Land uses			**Conservation significance, international, national or regional significance**	
Current ownership	City of Kwinana		Ramsar	No
Current land use	Managed Reserve and Rural property		Conservation reserve (system 6)	No
Past land use	Rural		Bush Forever	No
Surrounding land use	Urban, Rural,		Conservation estate	No
Existing management	City of Kwinana/Private property		Other	No
Fire history/regime	Unknown			
Does the wetland retain the values for which it was originally registered or listed, describe			NA	
Scientific value				
Scientific, geoheritage or geoconservation values			None known	
Fauna				
Species	Significance		Observations	Source of information
Fauna habitat mapped as Cleared-degraded areas. May provide limited fauna habitat				Fauna habitat mapping (context only (Biota 2025))
Flora				
Vegetation condition (Refer to Appendix E for ranking)	Area (ha)*	Total area % within the wetland*	Total % 50 metres surrounding the wetland	Source of information
Very Good			<50%	Biota 20252025 (extrapolated vegetation condition mapping) Aerial Photos
Good				
Degraded				
Completely degraded	0.01 ha	<1%		
Cleared	1.11 ha	99.1%		
Is the wetland vegetation predominantly in good condition			No	
Vegetation complex (Heddle et al., 1980)			Cottesloe Complex Central and South (52)	
% remaining vegetation complex			33.51%	
Threatened ecological communities	Significance		Observation	Source of information
Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community	Critically Endangered, EPBC Act State PEC (P3)		Note <0.15ha mapped in context area only (extrapolated information) and in a degraded condition	Biota 2025 Stream review of aerial photos
Threatened and Priority flora	Significance		Population measure and Observation	Source of information
Outside of Biological Survey area. None known to occur (database search)				DBCA threatened and priority flora database
Representativeness				

% area wetlands with same classification assigned Conservation mgt category on SCP	29.3%
% area wetlands in same suite assigned Conservation mgt category	86.1%
% area wetlands with same classification and suite assigned Conservation mgt category	35.2%
Is the wetland rare:	No
Photographs	

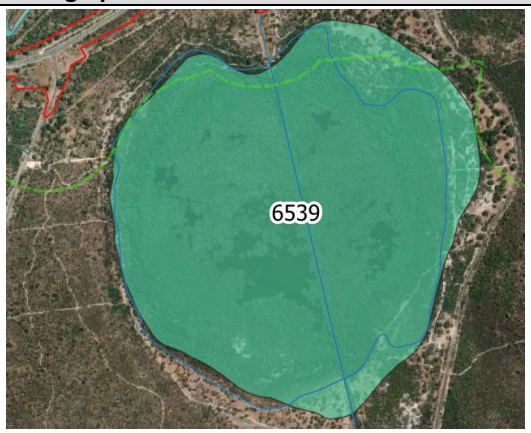
*Estimate only

WETLAND 6539

Date	6/3/2024		
Easting	390508		
Northing	6435474		
Location/property address	Located approximately 500m southwest of the Anketell Road and Kwinana Freeway intersection		
Wetland details			
Name	Spectacles North	Consanguineous suite	Bibra
UFI	6539	Wetland type	Sumpland
Wetland area	132.10 ha	Management category	CCW
Area evaluated Area of wetland within Development Envelope (DE)	Entire wetland considered in evaluation 0 ha within DE 9.41ha within 250m buffer.	Assessed as a portion of a wetland with varying areas of value	No
PRELIMINARY DESKTOP QUESTIONS			
Land uses		**Conservation significance, international, national or regional significance**	
Current ownership	Alcoa/City of Kwinana	Ramsar	No

Current land use	Conservation Reserve		Conservation reserve (system 6)	No
Past land use	Conservation Reserve		Bush Forever	Yes (269)
Surrounding land use	Urban, Rural,		Conservation estate	No
Existing management	Conservation Park		Other	DIWA (WA090)
Fire history/regime	>5yrs			
Does the wetland retain the values for which it was originally registered or listed, describe			YES	
Scientific value				
Scientific, geoheritage or geoconservation values			Yes. Scientific surveys have been conducted at the Swamp and educational/heritage features include an Aboriginal Heritage Trail, the Biara Boardwalk Trail and bird hide. The wetland is also on the City of Kwinana heritage list and part of Beelair Regional Park.	
Fauna				
Species	Significance		Observations	Source of information
Fauna habitat mapped as Damplands within 250m buffer. Indicated as habitat for Quenda (P4), Glossy Ibis and birds of prey.				Fauna habitat mapping (context only (Biota 2025)
Provides habitat for fauna such as Quenda (P4), Western Brush Wallaby (P4) and Lined Skink. The Swamp supports breeding waterbirds (including Blue-billed duck (P4)) and is the only known breeding area for spoonbills in the metropolitan area.				DIWA (2024) DBCA database
Flora				
Vegetation condition (Refer to Appendix E for ranking)	Area (ha)*	Total area % within the wetland*	Total % 50 metres surrounding the wetland	Source of information
Very Good - Excellent	122.1	92.5%	>80%	Biota 2025 (extrapolated vegetation condition mapping) for part area. Stream review of aerial photos
Degraded - Good	8	6%		
Completely degraded	2	1.5%		
Cleared				
Is the wetland vegetation predominantly in good condition			Yes	
Vegetation complex (Heddle et al., 1980)			Herdsman Complex (53) Karrakatta Complex – Central and South (49)	
% remaining vegetation complex			48.29% (53) and 30.14% (49)	
Threatened ecological communities	Significance		Observation	Source of information
Banksia woodlands of the Swan Coastal Plain ecological community	Federal TEC (Endangered)		Extrapolated context area mapping only	Biota 2025
Threatened and Priority flora	Significance		Population measure and Observation	Source of information
Dodonaea hackettiana	(P4)		3 Observed (estimate)	DBCA TPFL Database
Representativeness				
% area wetlands with same classification assigned Conservation mgt category on SCP			40.1%	

% area wetlands in same suite assigned Conservation mgt category	65.9%
% area wetlands with same classification and suite assigned Conservation mgt category	65.8%
Is the wetland rare:	Yes
Photographs	



*Estimate only

WETLAND 6538

Date	6/3/2024		
Easting	390767		
Northing	6436011		
Location/property address	Located on and northwest of the Mandoglup Road and Anketell Road intersection		
Wetland details			
Name	Unknown	Consanguineous suite	Bibra
UFI	6538	Wetland type	Dampland
Wetland area	20.09ha	Management category	MU
Area evaluated Area of wetland within Development Envelope (DE)	Entire wetland considered in evaluation 4.70 ha within DE 20.09ha within 250m buffer.	Assessed as a portion of a wetland with varying areas of value	No
PRELIMINARY DESKTOP QUESTIONS			
Land uses		**Conservation significance, international, national or regional significance**	
Current ownership	Mixed	Ramsar	No
Current land use	Mixed use	Conservation reserve (system 6)	No
Past land use		Bush Forever	No
Surrounding land use	Urban, Rural,	Conservation estate	No
Existing management		Other	
Fire history/regime	>5 years		
Does the wetland retain the values for which it was originally registered or listed, describe		NA	
Scientific value			
Scientific, geoheritage or geoconservation values		No	

Fauna				
Species	Significance		Observations	Source of information
Fauna habitat mapped as predominantly Cleared with small area of Dampland habitat and15 suitable DBH trees (tuarts) for Black Cockatoos				Fauna habitat mapping (Biota 2025Biota 20252025)
Flora				
Vegetation condition (Refer to Appendix E for ranking)	Area (ha)	Total area % within the wetland	Total % 50 metres surrounding the wetland	Source of information
Very Good - Excellent			<10%	Biota 2025 Stream review of aerial photos
Good				
Degraded				
Completely degraded	Approx 2ha	10%		
Cleared	Approx 20ha	90%		
Is the wetland vegetation predominantly in good condition			No	
Vegetation complex (Heddle et al., 1980)			Bassendean Complex – Central and/South (44) Herdsman Complex (53)	
% remaining vegetation complex			37.21 % (44) and 48.29% (53)	
Threatened ecological communities	Significance		Observation	Source of information
Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community	Critically Endangered, EPBC Act State PEC (P3)		A review of aerial photography shows the wetland in this area to be dominated by roads and cleared areas and the small area of mapped TEC (<0.06ha) would be unlikely to add hydrological function or ecological value to this substantially modified wetland	Biota 2025 (mapping) Stream review of aerial photos
Threatened and Priority flora	Significance		Population measure and Observation	Source of information
None recorded within Survey area. Unlikely to occur in remaining wetland area due to cleared area and poor remaining vegetation condition.				Biota (2025)
Representativeness				
% area wetlands with same classification assigned Conservation mgt category on SCP			43.9%	
% area wetlands in same suite assigned Conservation mgt category			65.9%	
% area wetlands with same classification and suite assigned Conservation mgt category			87.0%	
Is the wetland rare:			No	
Photographs				

*Estimate only

WETLAND 12981

Date	6/3/2024		
Easting	392055		
Northing	6436599		
Location/property address	Located between Kwinana Freeway and Darling Chase, Wandi		
Wetland details			
Name	Mandogalup Swamp South	Consanguineous suite	Jandakot
UFI	12981	Wetland type	Dampland
Wetland area	3.42ha	Management category	CCW
Area evaluated Area of wetland within Development Envelope (DE)	Wetland within buffer area considered in evaluation 0 ha within DE 3.42ha within 250m buffer.	Assessed as a portion of a wetland with varying areas of value	No
PRELIMINARY DESKTOP QUESTIONS			
Land uses		**Conservation significance, international, national or regional significance**	
Current ownership	WAPC	Ramsar	No
Current land use	Managed Reserve	Conservation reserve (system 6)	No
Past land use		Bush Forever	No
Surrounding land use	Urban, Rural,	Conservation estate	No
Existing management	WAPC	Other	No
Fire history/regime	>5 years		
Does the wetland retain the values for which it was originally registered or listed, describe		NA	
Scientific value			
Scientific, geoheritage or geoconservation values		None known	
Fauna			
Species	Significance	Observations	Source of information
Fauna habitat mapped as Damplands within 250m buffer. Indicated as habitat for Quenda (P4), Glossy Ibis and birds of prey.			Fauna habitat mapping (context only (Biota 2025)
Quenda, *Isoodon fusciventer*	Priority 4	2014 (count 7)	DBCA database

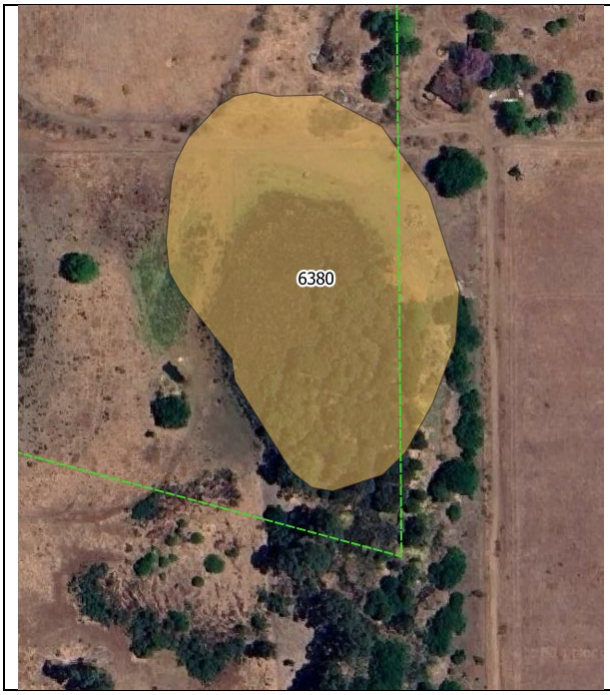
Flora				
Vegetation condition (Refer to Appendix E for ranking)	Area (ha)*	Total area % within the wetland*	Total % 50 metres surrounding the wetland	Source of information
Very Good			Approx 50%	Biota 2025 (extrapolated vegetation condition mapping) Stream review of aerial photos
Good	3.42ha (buffer area only)	>90%		
Degraded				
Completely degraded				
Cleared				
Is the wetland vegetation predominantly in good condition			Yes	
Vegetation complex (Heddle et al., 1980)			Bassendean Complex – Central and/South (44) Herdsman Complex (53)	
% remaining vegetation complex			37.21 % (44) and 48.29 (53)	
Threatened ecological communities	Significance		Observation	Source of information
Banksia Woodlands of the Swan Coastal Plain ecological community	EN (commonwealth) and P3 (State)		Within TEC buffers. However considered unlikely to occur as Biota (2025) extrapolated contextual area mapped as *Kunzea* tall shrubland to tall open scrub and *Melaleuca preissiana* low woodland over *Astartea.*	DBCA TEC/PEC database.
Communities of Tumulus Springs (Organic Mounds SCP)	EN (commonwealth) and CE (State)			DBCA TEC/PEC database
Threatened and Priority flora	Significance		Population measure and Observation	Source of information
Outside of Biological Survey area. None known to occur (database search)				DBCA threatened and priority flora database
Representativeness				
% area wetlands with same classification assigned Conservation mgt category on SCP			29.3%	
% area wetlands in same suite assigned Conservation mgt category			21.7%	
% area wetlands with same classification and suite assigned Conservation mgt category			38.2%	
Is the wetland rare:				
Photographs				

*Estimate only

WETLAND 6380

Date	6/3/2024		
Easting	387165		
Northing	6436599		
Location/property address	Approx 240m west of Abercrombie Road and 450m north of Anketell Road, Hope Valley		
Wetland details			
Name	Unknown	Consanguineous suite	Stakehill
UFI	6380	Wetland type	Dampland
Wetland area	2.01 ha	Management category	Resource Enhancement
Area evaluated Area of wetland within Development Envelope (DE)	Entire wetland considered in evaluation 0 ha within DE 0.34 ha within 250m buffer	Assessed as a portion of a wetland with varying areas of value	No
PRELIMINARY DESKTOP QUESTIONS			
Land uses		**Conservation significance, international, national or regional significance**	
Current ownership	Private	Ramsar	No
Current land use	Rural	Conservation reserve (system 6)	No
Past land use		Bush Forever	No
Surrounding land use	Urban, Rural,	Conservation estate	No
Existing management	Private	Other	No
Fire history/regime	>5 years?		
Does the wetland retain the values for which it was originally registered or listed, describe		NA	
Scientific value			
Scientific, geoheritage or geoconservation values		None known	
Fauna			
Species	Significance	Observations	Source of information
Part of wetland the fauna habitat mapped as Damplands (remaining area cleared). Indicated as potential habitat for Quenda (P4), Glossy Ibis and birds of prey.			Fauna habitat mapping (context only (Biota 2025)
Flora			
Vegetation condition (Refer to Appendix E for ranking)	Area (ha)*	Total area % within the wetland*	Total % 50 metres surrounding the wetland	Source of information

Very Good			<20%	Biota 2025 Mapping
Good				
Degraded	Approx 0.908ha	45%		
Completely degraded				
Cleared	Approx 1.097ha	55%		
Is the wetland vegetation predominantly in good condition			Yes	
Vegetation complex (Heddle et al., 1980)			Cottesloe Complex Central and South (52)	
% remaining vegetation complex			33.51%	
Threatened ecological communities	Significance		Observation	Source of information
Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community	Critically Endangered, EPBC Act State PEC (P3)		Within TEC buffer area. However considered unlikely to occur as Biota (2025) extrapolated contextual area mapped as *Kunzea* tall shrubland to tall open scrub.	DBCA database
Threatened and Priority flora	Significance		Population measure and Observation	Source of information
Outside of Biological Survey area. None known to occur (database search)				DBCA threatened and priority flora database
Representativeness				
% area wetlands with same classification assigned Conservation mgt category on SCP			26.6%	
% area wetlands in same suite assigned Conservation mgt category			86.1%	
% area wetlands with same classification and suite assigned Conservation mgt category			35.2%	
Is the wetland rare:			No	
Photographs				



*Estimate only

WETLAND 6530

Date	6/3/2024		
Easting	390857		
Northing	6436532		
Location/property address	Intersects northeast end of Survey area, over Kwinana Freeway, Wandi		
Wetland details			
Name	Unknown	Consanguineous suite	Jandakot
UFI	6530	Wetland type	Dampland
Wetland area	215.39 ha	Management category	Multiple Use
Area evaluated Area of wetland within Development Envelope (DE)	Entire wetland 6.87 ha within DE 46.57 ha within 250m buffer	Assessed as a portion of a wetland with varying areas of value	No
PRELIMINARY DESKTOP QUESTIONS			
Land uses		**Conservation significance, international, national or regional significance**	
Current ownership	Variable, large area	Ramsar	No
Current land use	Managed Reserve	Conservation reserve (system 6)	No
Past land use		Bush Forever	No
Surrounding land use	Urban, Rural,	Conservation estate	No
Existing management	City of Kwinana	Other	No
Fire history/regime	>5 years?		
Does the wetland retain the values for which it was originally registered or listed, describe		NA	
Scientific value			
Scientific, geoheritage or geoconservation values		None known	
Fauna			

Species	Significance		Observations	Source of information
Cleared, planted and modified habitat				Fauna habitat mapping (Biota 2023a)
Flora				
Vegetation condition (Refer to Appendix E for ranking)	Area (ha)*	Total area % within the wetland*	Total % 50 metres surrounding the wetland	Source of information
Very Good			<20%	Biota 2025 Stream review of aerial Photos
Good	0.86ha in association with wetland 12981, potentially another 3ha in asscociation with Tumulus springs TEC	<5%		
Degraded				
Completely degraded	Unknown			
Cleared	Unknown			
Is the wetland vegetation predominantly in good condition			Yes	
Vegetation complex (Heddle et al., 1980)			Cottesloe Complex Central and South (52)	
% remaining vegetation complex			33.51%	
Threatened ecological communities	Significance		Observation	Source of information
Banksia Woodlands of Swan Coastal Plain; Communities of Tumulus Springs (Organic Mounds SCP)	EN (commonwealth) and P3 (State); EN (commonwealth) and CE (State)		Within TEC buffer areas. Biota (2025 mapped as *Eucalyptus marginata* (Bansia spp) over K*unzea* and *Acacia* (EB1 commnuhity). However contextual area only (not groundtruthed)	DBCA database Biota (2025)
Threatened and Priority flora	Significance		Population measure and Observation	Source of information
Predominately outside of Biological Survey area. None found or known to occur				DBCA threatened and priority flora database Biota 2025
Representativeness				
% area wetlands with same classification assigned Conservation mgt category on SCP			43.9%	
% area wetlands in same suite assigned Conservation mgt category			21.7%	
% area wetlands with same classification and suite assigned Conservation mgt category			38.2%	
Is the wetland rare:			No	
Photographs				


6719
14662
6724
6726
6664
15583
6530
14063
Mandogalup
6538

Appendix E Vegetation Condition Scale (EPA 2016)

Vegetation Condition	South West and Interzone Botanical Provinces	Eremaean and Northern Botanical Provinces
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.	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
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.	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
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.	More obvious signs of damage caused by human activity since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
Poor		Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
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.	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
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.	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

Adapted from Keighery and Trudgen 988

Appendix F Stream (2025) GDE Assessment

Stream Environment and Water

Memorandum

Date	12 March 2025	**Reference**	242138
To	John Morrell, Main Roads Western Australia		
CC			
From	Mike Braimbridge	**Email**	mike@streamew.com.au

Anketell Road characterisation and assessment of impacts on GDEs and groundwater users

1 Introduction

Main Roads Western Australia (Main Roads) is proposing to upgrade Anketell Road. The proposal includes approximately seven kilometres (km) of new road construction along Anketell Road, between Leath Road, Kwinana to Treeby Road, Wandi/Anketell in the City of Kwinana, Western Australia.

Stream Environment and Water (Stream) was commissioned by Main Roads to assess the risks to wetlands and surface water, considering direct and indirect impacts from the proposal. Stream submitted a draft Wetland Assessment to Main Roads in June 2024 (updated in 2025). Based on recent advice from the EPA, Main Roads have requested Stream assess the risks to groundwater dependent ecosystems (other than wetlands) and groundwater users from the proposal, summarised in this memo.

2 Scope of Work

The objective of this memo is to assess the risk of impact on Groundwater dependent ecosystems (GDEs) and groundwater users from potential groundwater drawdown associated with dewatering and groundwater abstraction for the proposal. The key components of the assessment scope were:

- Identify and characterise GDEs and groundwater users potentially impacted by groundwater drawdown associated with the proposal.
- Assess the risk and potential impacts on GDEs and groundwater users of modelled groundwater drawdown from abstraction and dewatering activities.

3 Methodology

3.1 Assessment of risk to GDEs

The assessment uses a methodology based on that developed by Froend and Loomes (2004) to assess the risks to GDEs from groundwater abstraction on the Swan Coastal Plain. The methodology has been adapted from the original Froend and Loomes (2004) approach incorporating outcomes of previous consultation with DWER for completion of ecological water requirements for the Peel Integrated Water Initiative, and described in Braimbridge *et al.* (2018).

The methodology uses a semi quantitative approach to rate the risk of impact to GDEs. The assessment considers the type and conservation value of the ecosystem, the current depth to groundwater and historical change to rate the susceptibility of ecosystems (Figure 1). A risk of impact from a predicted drawdown (obtained from a numerical groundwater model) is also assigned to each GDE. A score is assigned at each step and the overall risk of impact determined based on the total score. The method and steps to complete the assessment are outlined below.

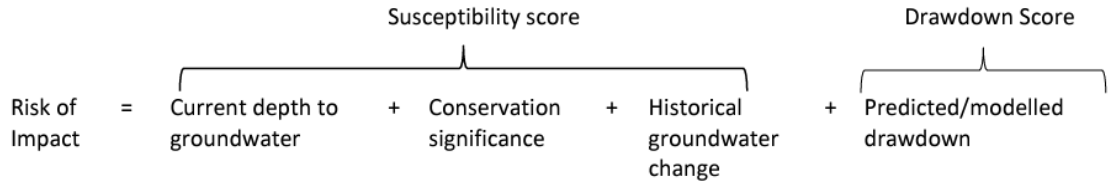
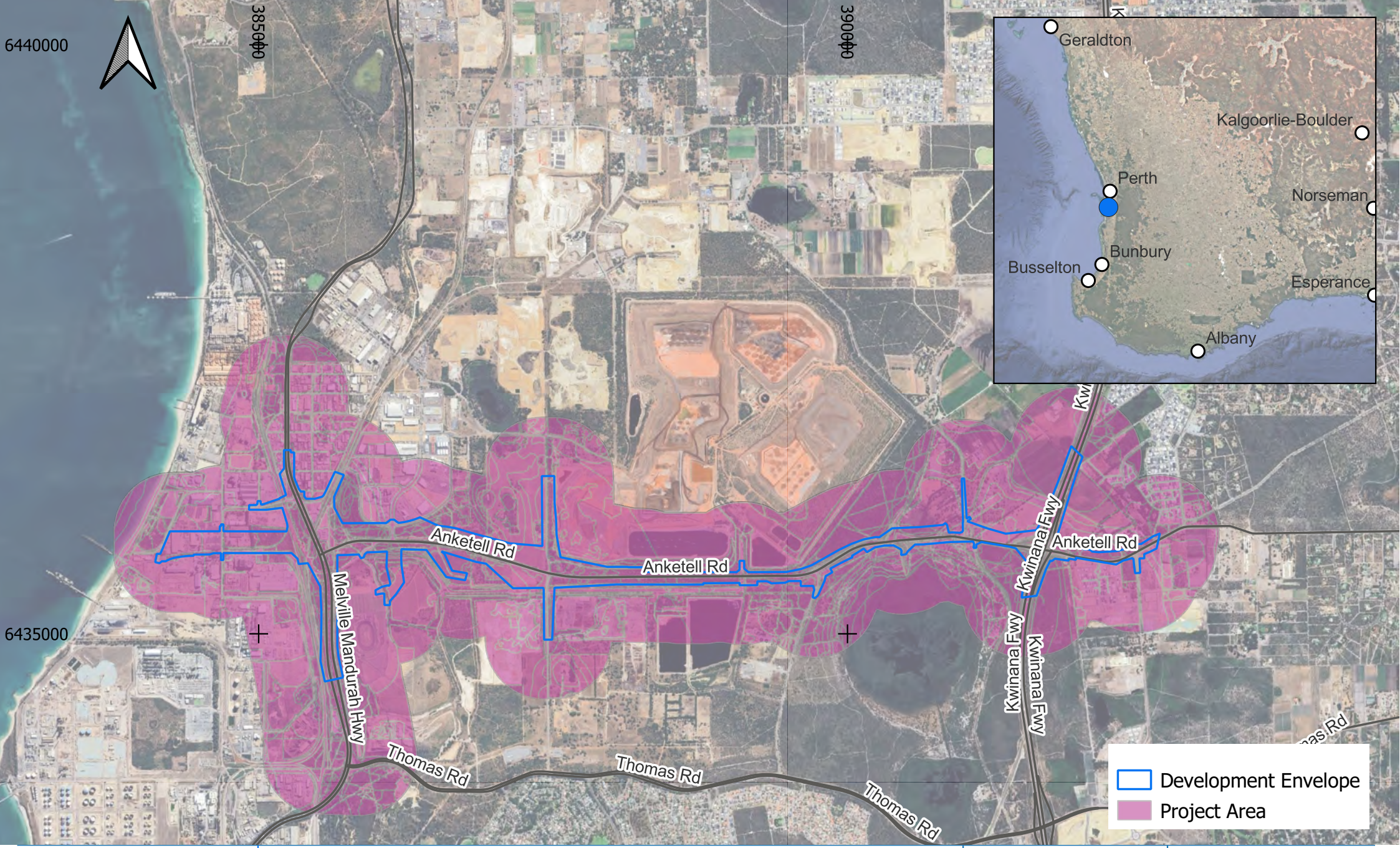


Figure 1: Calculation for risk of impact from modelled drawdown

Information sources

This risk assessment was completed using existing information focusing on ecosystems within the contextual boundary defined for vegetation mapping in Biota (2025). The mapping covers an area of approximately 1700 ha, the extent of which is the Project Area for this risk assessment (Figure 2). The assessment utilised information from the draft wetland assessment (Stream 2025) and groundwater information and predicted groundwater surfaces for dewatering and water abstraction scenarios modelled by FSG (2025) to support the proposal. Further information on datasets used to support each step of the risk assessment are detailed below.



0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 2: Risk assessment location

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Step 1: Identify potential GDEs and current depth to groundwater

Potential GDEs were identified based on vegetation mapping completed by Biota (2025), Geomorphic Wetlands of the Swan Coastal Plain dataset (see wetland assessment, Stream 2025) and current depth to groundwater (based on groundwater surface developed by FSG 2025). GDEs were categorised by ecosystem type as either wetland, phreatophytic vegetation or non-GDE. Vegetation units that represent predominantly native vegetation were considered as potential GDEs.

Ecosystems were identified as potentially groundwater dependent where the current maximum depth to groundwater was less than 10 m. Previous studies on the Swan Coastal Plain have identified 10 m as an approximate maximum depth where groundwater dependence of vegetation is likely (e.g., Antao 2015, Froend *et al*. 2004). Groundwater may still provide a water source to deep rooted vegetation, however dependence on groundwater is considered low or opportunistic beyond 10 m.

Potential GDEs were scored based on the ecosystem type and current depth to groundwater (DTGW) categories (Table 1) using the maximum depth to groundwater value for each feature. Ecosystems with a shallower depth to groundwater score higher because they are considered to have a greater dependency on groundwater and therefore a higher susceptibility to impact from groundwater drawdown. Consistent with the application of the scoring method elsewhere, wetlands were scored higher, indicating a higher susceptibility or sensitivity to drawdown than groundwater dependent vegetation at the same depth to groundwater.

Table 1: Current depth to groundwater (DTGW) categories and scoring (adapted from Froend and Loomes 2004)

Score	DTGW Category	Current DTGW Description
0	>10 m	Watertable estimated to be >10.5 m
1	6 – 10 m	Watertable estimated to be 6 – 10.5 m DTGW
2	3 – 6 m	Watertable estimated to be 3 - 6 m DTGW
3	0 – 3 m (vegetation)	Watertable estimated to be 0 -3 m DTGW, vegetation site
4	<3 m (wetland)	Watertable estimated to be < 3 m DTGW, wetland site

Step 2: Assess ecological value/conservation significance of GDEs

The ecological value and conservation significance of GDEs within the project area was assessed using the following spatial datasets:

- Threatened/Priority flora, fauna and ecological communities (Biota 2025)
- Bush Forever (DEP 2000)
- Vegetation Complex mapping (Native Vegetation Extent DPIRD-005 (DPIRD 2020)
- Geomorphic Wetlands of the Swan Coastal Plain DBCA-019 (DBCA 2023)
- Directory of important wetlands in Australia (DBCA-045) (DBCA 2018)
- Ramsar sites (DBCA-010) (DBCA 2017)

The ecological value of potential GDE features were scored as low, moderate (locally significant) or high (regionally, nationally or internationally significant), based on the categories in Table 2.

This scoring system acknowledges that the consequence and risk of impact of groundwater drawdown is greater for high value ecological features, however, not that these features are necessarily more susceptible to impacts.

Table 2: Ecological value score

Score	Category	GDE values
1	Low	Assessed as having no recognised values and moderately to severely impacted from surrounding land uses, where values are: - Multiple use wetland - Remnant vegetation consisting of a vegetation complex with greater than 30% pre-clearing extent remaining intact and located on private land
2	Locally significant (moderate)	Assessed as having some recognised values and low to moderately impacted from surrounding land uses, where values are: - Resource enhancement wetland - Remnant vegetation consisting of a vegetation complex with less than 30% pre-clearing extent remaining intact
4	Regionally, Nationally or internationally significant (high)	Formally assessed international, national or regional environmental values with evidence of low to moderate impacts from surrounding land use, where values include: - Ramsar wetland - Directory of important wetlands in Australia - Conservation category wetlands - Native vegetation mapped as Bush Forever - Native vegetation supporting threatened and priority species or ecological communities

Step 3: Assess historical groundwater level change

Declines in groundwater over the previous 10 years may indicate an ecosystem is already under water stress and potentially more susceptible to risk of impact from additional declines in groundwater. To incorporate pre-existing hydrology the risk assessment included review of recent (last 15 years) groundwater levels in representative bores.

Historical change in groundwater was assessed based on a linear trend (line of best fit) calculated for seven superficial monitoring bores within the project area (see Section 4). This method uses all available data however reduces the potential influence of individual years (Braimbridge et al. 2018).

The calculated historical change in groundwater was scored based on Table 3.

Table 3: Historical change (10 years previous) in groundwater score

Rate of decline m/yr		DTGW Category and Score			
Lower Threshold (≥)	Upper threshold (<)	6-10 m	3-6 m	0-3 m Vegetation	0-3 m Wetland
	-1†	0	0	0	0
0	0.025	1	1	1	1
0.025	0.05	1	1	2	2
0.05	0.075	1	1	2	3
0.075	0.1	1	2	2	4
0.1	0.125	1	2	3	5
0.125	0.15	2	3	3	5
0.15	0.175	2	3	3	5
0.175	0.2	3	3	4	5
0.2	0.225	3	4	5	5
0.225	0.25	4	4	5	5
0.25	0.275	4	5	5	5
0.275	3	5	5	5	5

The selected monitoring bores are operated by DWER and provide long term superficial groundwater trends across the project area. GDEs were assigned a historical change calculated from the nearest bore.

Step 4: Rate GDE susceptibility to change in DGWL (Susceptibility score)

The susceptibility of identified GDEs was calculated by adding the scores from Step 1: depth to groundwater, Step 2: environmental value/conservation significance and Step 3: historical change in groundwater (Figure 1).

Step 5: Risk of modelled drawdown (Drawdown score)

The potential impact of construction activities on GDEs was assessed using drawdown predicted for proposed dewatering and abstraction scenarios. Details of the scenarios modelled by FSG (2025) are provided in the section 5.

Scoring for drawdown is based on the risk of impact resulting from change in depth to groundwater level described in Froend and Loomes (2004). The scoring applied in this assessment as outlined in Table 4, incorporates modifications arising from previous consultation with DWER, as described in Braimbridge *et al.* (2018).

The scoring outlined in Table 4 rates the risk of impact (from low 1to severe 5) associated with groundwater level drawdown for GDEs in each depth to groundwater category (determined in step 1).

Table 4: Risk of modelled groundwater drawdown score

Modelled drawdown		DTGW Category and Score			
Lower	Upper	6–10 m	3–6 m	0–3 m Vegetation	0–3 m Wetland
0	**0.09**	0	0	0	0
0.10	**0.24**	1	1	1	1
0.25	**0.49**	1	1	2	3
0.5	**0.74**	1	1	2	4
0.75	**0.99**	1	2	3	5
1	**1.24**	2	3	3	5
1.25	**1.49**	3	3	4	5
1.5	**1.74**	3	4	4	5
1.75	**1.99**	3	4	5	5
2	**2.24**	4	4	5	5
2.25	**2.5**	4	5	5	5
2.5	**2.74**	4	5	5	5
2.75	**3**	5	5	5	5

Step 6: Overall risk of impact

The susceptibility score is combined with the drawdown score to obtain an overall risk of impact. Based on the sum of susceptibility and drawdown, the risk to GDEs from a decline in groundwater level is then classed as either 'acceptable', 'manageable' or 'unacceptable' (Table 5).

Table 5: Sum of susceptibility and drawdown risk

Risk of Impact	Risk category	Score
Low	Acceptable	<10
Moderate	Manageable	10 - 13
High	Unacceptable	>13

3.2 Assessment of risk to existing groundwater users

A search of DWERs online Water Register was conducted for existing 5C groundwater licences in the Superficial aquifer within the project area. A 5C licence was captured where the property with a licence intersected the groundwater model boundary. Information obtained from the register and used for this assessment included:

- Total number of licences within the project area
- Groundwater area
- Allocated licenced volume
- Number of drawpoints associated with a licence

The potential risk of impact to existing groundwater users was assessed by overlaying projected drawdown for proposed dewatering and abstraction scenarios on drawpoint mapping in the Water Register. Details of the scenarios modelled by FSG (2025) are provided in the Section 5.

Existing groundwater users were considered potentially at risk of impact where they occurred within the predicted drawdown contours for the modelled scenarios. A nominal threshold of 1m drawdown was used to identify groundwater users with a potentially high level of risk (drawdown risk of 1m or greater was considered to have potential to draw groundwater levels below screened section of existing production bores).

4 Assessment Results - Susceptibility

The results of steps 1,2 and 3 of the assessment are presented for the overall project area. The results of the drawdown assessment and overall risk assessment are presented for each of the modelled scenarios assessed.

Step 1: Potential GDEs and depth to groundwater

The project area occurs in a highly modified landscape with a variety of land use including cleared semi-rural areas and industrial and residential developments.

Biota (2025) mapped vegetation over approximately 1773.49 ha and described 34 mapping units. Approximately 1033.02 ha (of the 1773.49 ha area) was described as modified or cleared under one of the following six units:

- Cleared (CL)
- Road and rail infrastructure (RR)
- Modified/planted Callistemon and Calothamnus on roadsides (R2)
- Beach (B)
- Ocean (O)
- Commercial/residential mixed land use (ML)[1].

These units (and area) do not represent native vegetation (not representative of potentially groundwater dependent ecosystems) and were excluded from further assessment.

A total of 324.84 ha of potential GDE was identified within the project area. This includes areas with some native vegetation intact (some of the mapping units included have cleared areas with native trees) and depth groundwater of <10m or shallower. Of the 324.84 ha, 67.99 ha is mapped as wetland and 256.86 ha as phreatophytic vegetation (Table 6) (Figure 3&4).

The project area also includes 338.85 ha of native vegetation with depth to groundwater >10m and identified as non-GDE.

[1] It is noted through this desktop assessment that some sections classified as ML contain isolated native trees.

In addition, a 76.77 ha section of vegetation mapping (including 32.54 ha was mapped as vegetated and the remainder as cleared/modified) was not assessed as it extended beyond the boundary of the groundwater model[2].

Table 6: Desktop assessment results for project area

	Depth to Groundwater and Category (Area, ha)					Total Area (ha)
GDE Type	**>10m (0)**	**6-10m (1)**	**3-6m (2)**	**0-3m veg (3)**	**0-3m wetland (4)**	
Vegetation						**256.86**
Non-TEC		49.51	49362	33.47		132.61
TEC/PEC		76.84	23.37	24.04		124.25
Wetland			**2.22**		**65.77**	**67.99**
CCW			1.23		55.12	55.12
RE					3.27	3.27
MU			0.99		8.61	9.60
Non-GDE – not assessed						
Vegetation DTGW >10 m (not GDE)	338.85					**338.85**
Other – not assessed						
Not mapped (outside of Biota 2025 survey extent)						**76.77**
Cleared/Modified	430.63	145.47	245.04	119.13	92.75	**1033.02**
Total						**1773.40**

Step 2: Environmental values

Phreatophytic Vegetation

Of the 256.86 ha identified as potential groundwater dependent vegetation:

- 124.25 ha was rated as high ecological value, 64.30 ha as moderate and 68.31 ha as low.
- High value areas included:
    - 53.31 ha identified as representative of either the Banksia Woodlands of the Swan Coastal Plain TEC or Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain (22.04 ha) by Biota (2025)
    - Occurrences of vegetation representative of the Northern Spearwood shrublands and woodlands Priority 3 PEC

[2] Note the groundwater model included the full extent of predicted drawdown associated with all of the potential scenarios and therefore this section of vegetation is beyond the potential zone of influence of groundwater abstraction and/or dewatering associated with the proposal.

    - Areas with flora species of conservation significance (Priority 3 and Priority 4), all of which occurred in GDE vegetation with DTGW of 6 – 10 m (majority of which also occurred in areas mapped as either the Northern Spearwood shrublands and woodlands Priority 3 PEC or the Banksia Woodlands of the Swan Coastal Plain TEC).
- 91.42 ha is classified as a vegetation complex with less than 30% remaining (some of which was rated as high value as it also coincided with TEC occurrences and/or priority flora occurrences) and 165.43 ha of a vegetation complex with greater than 30% remaining.

Wetland values

Of the 67.99 ha of wetland within the project area:

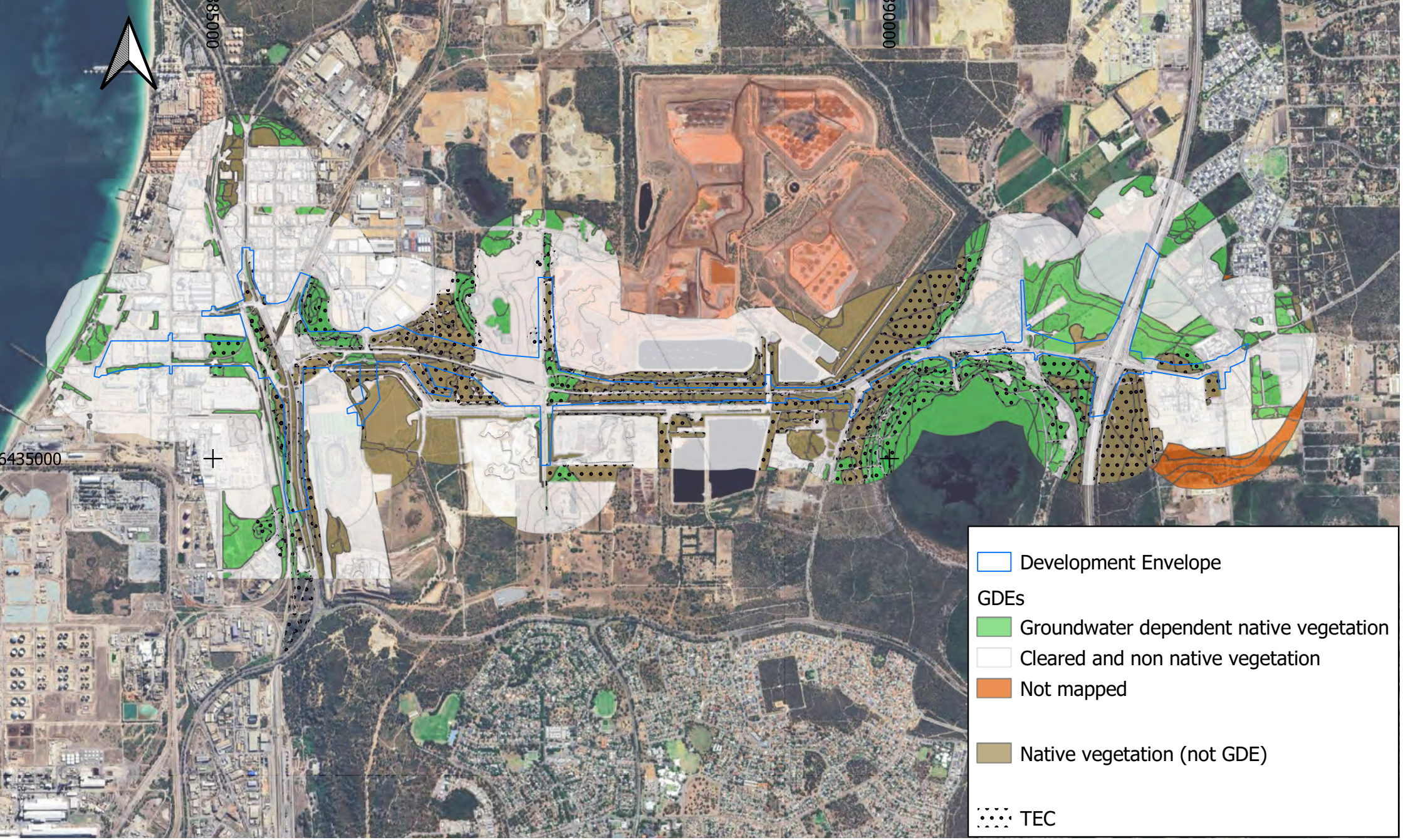
- 56.63 ha was rated as high ecological value, 7.27 ha as moderate and 4.08 ha as low (Based on scoring in Table 2). This included:
    - 55.12 ha was classified as Conservation Category wetland, 3.27 ha as Resource Enhancement wetland and 9.60 ha as Multiple Use wetland
    - 15.49 ha was identified within wetland boundaries as representative of either the Banksia Woodlands of the Swan Coastal Plain TEC (13.98 ha) or Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain (1.51 ha) by Biota (2025)
    - 16.04 ha of vegetation within wetlands was classified as a vegetation complex with less than 30% remaining, with 51.94 ha of a vegetation complex with greater than 30% remaining.
- No flora species of conservation significance occurred within wetland areas.

Tumulus Spring TEC

The Communities of Tumulus Springs (Organic Mounds SCP) is listed as a critically endangered ecological community under the BC Act 2016 and endangered under the EPBC Act. The TEC is mapped as occurring within geomorphic wetland UFI 6530 (DBCA database only, not confirmed or mapped by Biota 2025). The area of potential TEC occurs approximately 600m north of the DE (Figure 4).

The flora and fauna assemblages of the Organic Mounds SCP TEC are reliant on a permanent supply of freshwater and the maintenance of hydrological processes to the mounds (DBCA 2023). Typical and common native vascular plant species associated with the tumulus springs are the trees *Banksia littoralis* (swamp banksia), *Melaleuca preissiana* (moonah) and *Eucalyptus rudis* (flooded gum), and the shrubs *Taxandria linearifolia* (swamp peppermint), *Pteridium esculentum* (bracken fern), *Astartea scoparia* (common astartea) and *Cyclosorus interruptus* (swamp shield-fern) (DBCA 2023). The habitat of the mound springs is characterised by raised areas of peat that with a continuous discharge of groundwater supporting moist microhabitats and invertebrate fauna assemblages. This community is likely to provide a refuge for flora and fauna in a drying climate (DBCA 2023).

One of the key threats to this community is decline groundwater levels and quality (DBCA 2023). Changes in the level of the water table are very likely to influence the hydrology of these wetlands as they are likely to be almost entirely dependent on groundwater for water supply (Department of Conservation and Land Management 2006).



0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 3: Groundwater dependent vegetation and other native vegetation

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0 0.5 1 km

Projection: GDA 20 zone 50

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Figure 4: Wetlands within the project area.

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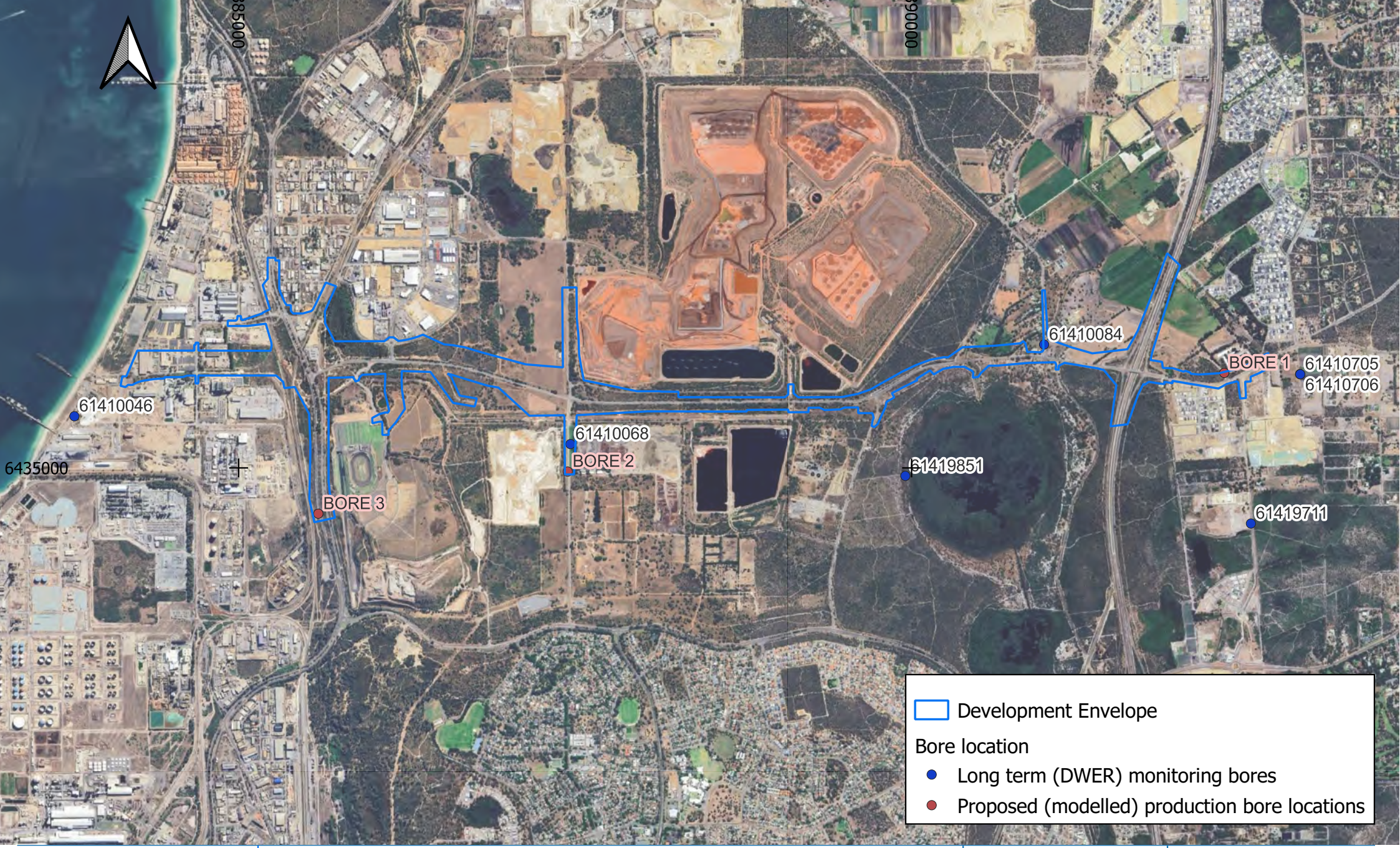
Step 3: Historical groundwater level trends

Historical groundwater level change was assessed using groundwater level data from seven long term monitoring bores operated by DWER (61410046, 61410068, 61410084, 61410705, 61410706, 61419711, 61419851) (Figure 5). Hydrographs for the 15 years 2009 to 2024 indicate there is a rising trend in groundwater level across the project area in six of the seven monitoring bores (Appendix A). Based on scoring in Table 3, groundwater levels over the majority of the project area were scored 0 for historical change.

One bore located on the west side of The Spectacles Wetland (61419851) shows a declining long-term trend of around 0.3 m from 2009 to 2024 (Appendix A). This decline over a 15 year period equates to a rate of 0.02 m per year and is therefore scored as 1 (based on scoring in Table 3). This bore is located 2.5 km west of the site for proposed dewatering and production bore 1 and 2.5 km east of proposed production bore 2 (Figure 5).



0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 5: Monitoring bores and proposed production bores

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5 Assessment results – drawdown and overall risk

For steps five and six the assessment focused on groundwater dependent vegetation and wetlands within the potential area of drawdown for four modelled dewatering and abstraction scenarios (FSG 2025).

The assessment was completed for two dewatering scenarios:

- Dewatering dry season without recharge - Construction dewatering (volume 180,000kL) during the dry season without infiltration of the abstracted groundwater back into the aquifer.
- Dewatering dry season with recharge - Construction dewatering (volume 210,000kL) during the dry season with infiltration (infiltration rate 16 L/s) of some of the abstracted groundwater back into the aquifer. Infiltration was modelled based on a trench located between the dewatering location and the Tumulus Spring TEC (to minimise the potential impacts on groundwater levels at the TEC.

For water supply during construction, the assessment was completed for one modelled scenario (with outputs assessed at two stages) with water obtained from 3 proposed production bores (location of bores shown in Figure 5):

- Scenario 3: 50% of the earthworks construction water demand (215,000 kL) and 100% of the additional water demand for dust suppression (270,000 kL) was obtained from 3 production bores (Figure 5).

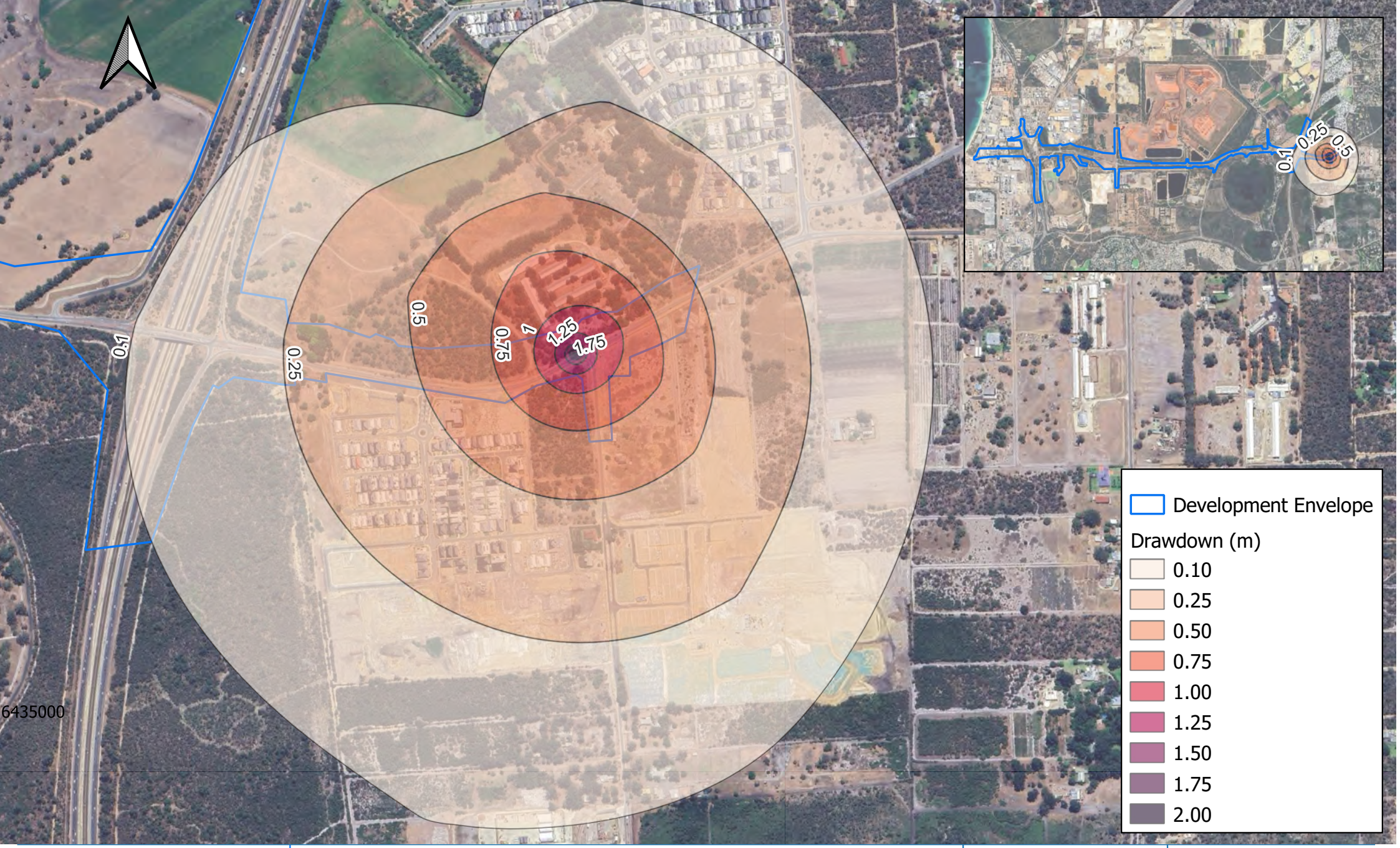
The assessment of impacts was completed at two points for scenario 3. Once after 413 days of abstraction for construction demand and dust suppression (Scenario 3a) and once after an additional 210 days of abstraction for dust suppression only (Scenario 3b).

Further details of the model construction, data used, scenarios assessed, rates of abstraction and additional scenarios modelled are provided in FSG (2025).

The potential risk of impact to GDEs (groundwater dependent vegetation and wetlands identified in the previous steps) was assessed within the predicted total area of drawdown as represented by the limit of the 0.1 m drawdown contour for each scenario (referred to as the total area of drawdown). The assessment results for each scenario are presented in the following sections.

5.1 Dewatering (no recharge) – dry season

The dewatering dry season scenario (with no recharge) results in drawdown (to a minimum modelled drawdown of 0.1 m) across approximately 183.4 ha (Figure 6). Drawdown at the dewatering point reaches a maximum depth of 1.9 m. This depth of drawdown is restricted to a 0.006 ha area (as represented by the 2 m drawdown contour) (Figure 6). The assessment of risk of impact considered the potential drawdown impacts on native vegetation and wetlands within the 183.4 ha total drawdown area (Table 7).



0 0.8 1.6 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 6: Drawdown contours - dewatering dry season no recharge scenario

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GDEs present

27.26 ha of potential GDEs were identified within the total drawdown area including:

- 22.26 ha of native vegetation (non-TEC)
- 2.27 ha of native vegetation identified as Banksia Woodlands of the Swan Coastal Plain TEC
- 2.73 ha of Wetlands (Multiple Use)
- 0.026 ha of the estimated extent of the Tumulus Spring TEC[3].

In addition, within the total drawdown area there is:

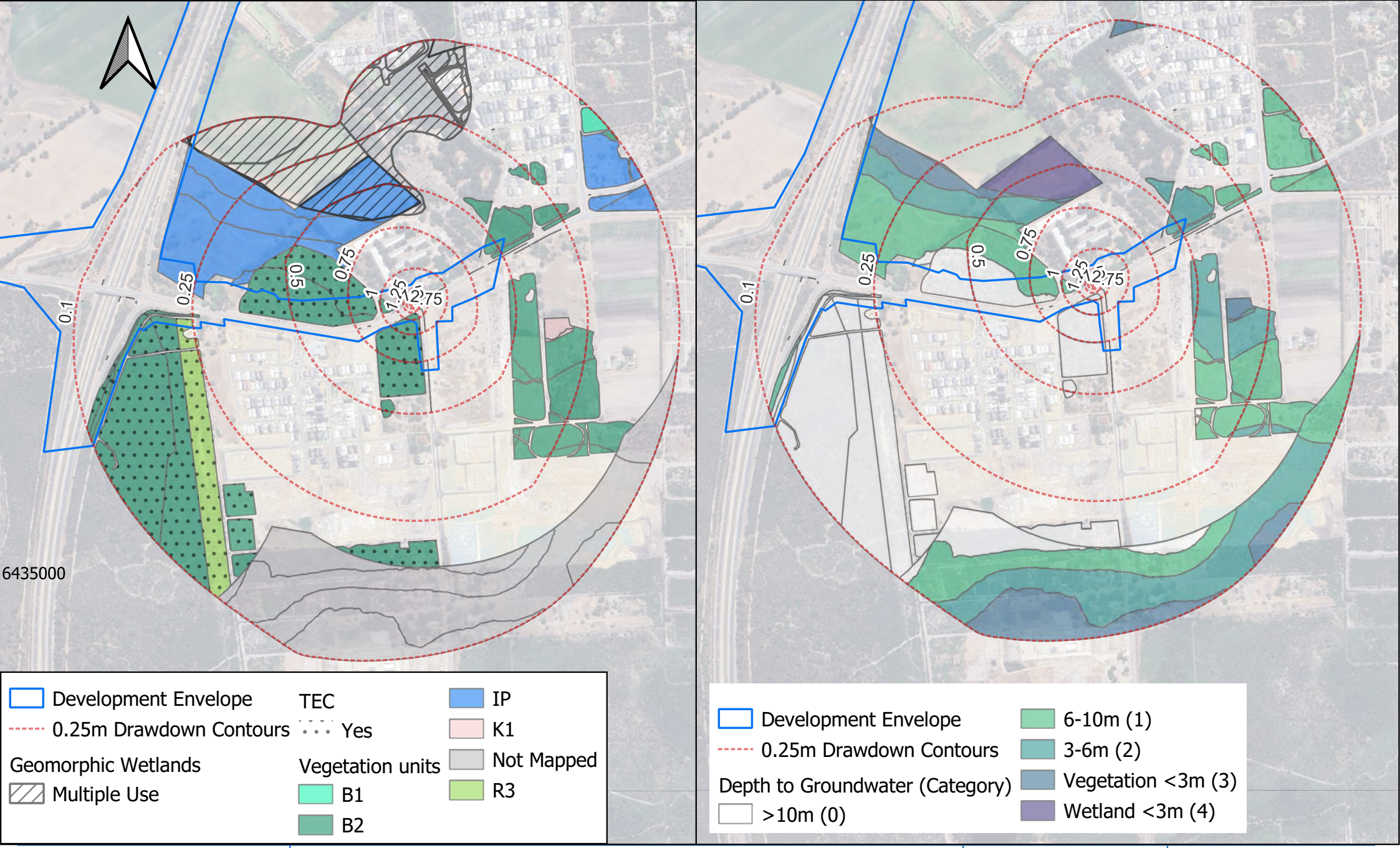
- 22.89 ha of native vegetation with a DTGW >10m (and not considered to be groundwater dependent)
- 24.62 ha outside of the extent of vegetation mapping by Biota (2025)
- 108.70 ha mapped as cleared, roads or mixed commercial/residential.

The majority of the total area of drawdown has relatively deep groundwater. Of the 24.53 ha of potentially groundwater dependent vegetation (TEC and non-TEC), 1.99 ha has DTGW <3 m, 7.45 ha 3-6 m and 15.12 ha 6-10 m DTGW. Almost all of the 2.73 ha of wetland has a DTGW <3 m (Figure 7).

Table 7: Summary of GDE and other areas within total dewatering drawdown area

	Depth to Groundwater and Category (Area, ha)					Total Area (ha)
GDE Type	**>10m (0)**	**6-10m (1)**	**3-6m (2)**	**0-3m veg (3)**	**0-3m wetland (4)**	
Vegetation		**15.12**	**7.42**	**1.99**		**24.53**
Non-TEC		12.86	7.42	1.99		22.26
TEC/PEC		2.27				2.27
Wetland			**0.04**		**2.69**	**2.73**
Non-GDE – not assessed						
Vegetation DTGW >10 m (not GDE)	22.89					**22.89**
Other – not assessed						
Not mapped (outside of Biota 2025 survey extent)	3.11	6.77	9.41	5.33		**24.62**
Cleared/Modified	45.35	24.73	20.31	5.19	13.12	**108.70**
Total						**183.47**

[3] This occurrence is located just outside of the limit of the Biota (2025) vegetation mapping.



0 0.8 1.6 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 7: Dewatering dry season drawdown contours with potential GDEs by (a) GDE Type and (b) Depth to groundwater category

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Risk of impact

The risk of impact to GDE's from dewatering under this scenario is generally low (Figure 8).

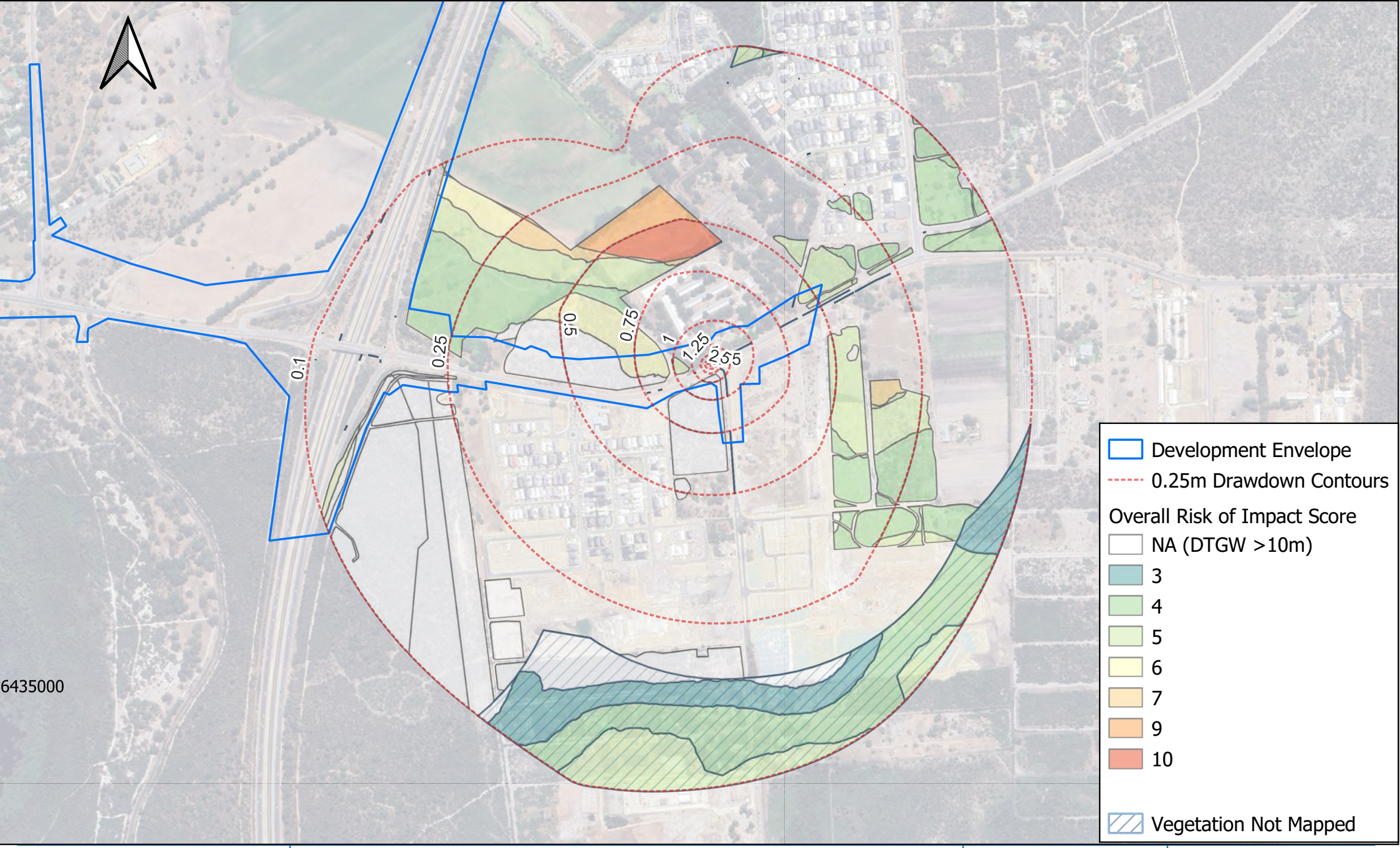
The highest risk of impact within the total area of drawdown is for a 1.37 ha section of MU wetland (part of Mandogalup Swamp). This wetland falls within the 0.5 m drawdown contour with groundwater at or near surface and scored a risk impact of 10. The overall risk of impact to this wetland was scored as moderate as:

- the wetland depth to groundwater is <3 m (DTGW score = 4)
- the wetland is classed as Multiple Use and does not support any significant ecological values (was mapped by Biota (2025) as isolated trees over paddock) (ecological value score = 2)
- historic change in groundwater is negligible (nearest bores had an increasing trend in groundwater) (Historical change value = 0)
- susceptibility score = 6
- the drawdown is classed as high risk (Drawdown score = 4)
- overall risk of impact (Susceptibility score (6) + Drawdown score (4) = 10 (moderate risk of impact 10-13).

The assessment of drawdown risk as high and the overall risk of impact as moderate is considered conservative for this wetland given the vegetation within the wetland is mapped as isolated trees over previously cleared or pasture (Biota 2025).

The Tumulus Spring TEC occurrence that intersects the 0.1m drawdown had an overall risk of 9, indicating a low risk of impact. Groundwater flow modelling indicates flow paths in the vicinity of the spring are very slightly altered under the dewatering scenario.

All of the remaining potential GDE areas within the total drawdown area were assessed as having an overall low risk of impact (<10 score). This is in part due to the relatively deep groundwater underlying the majority of native vegetation within the total drawdown area, reducing the potential risk of impacts from drawdown. In addition, the zone of high drawdown (where drawdown is equal to or greater than 1 m) is very small and includes only 0.34 ha of native vegetation (of which 0.27 ha has DTGW >10 m).



0 0.8 1.6 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 8: Dewatering dry season drawdown contours with overall risk of impact for GDEs

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5.2 Dewatering (with recharge) – dry season

The dewatering dry season scenario (with recharge) results in drawdown of up to 1.9 m (2 m contour) within a 0.004 ha area. Drawdown of to 0.1 m occurs across approximately 106.66 ha (Figure 9). The infiltration trench is located approximately 675 m north of the dewatering area and is modelled to result in increased groundwater levels over an approximately 2.38 ha area.

The assessment of potential risk of impact focused on the potential drawdown impacts on native vegetation and wetlands within the 106.66 ha total drawdown area (Table 8). That is, the area with increased groundwater levels from infiltration was not assessed.

GDEs present

19.75 ha of potential GDEs were identified within the total drawdown area including:

- 16.44 ha of native vegetation (non-TEC)
- 2.06 ha of native vegetation representative of the Banksia Woodlands of the Swan Coastal Plain TEC by Biota (2025)
- 1.26 ha of wetlands (Multiple Use).

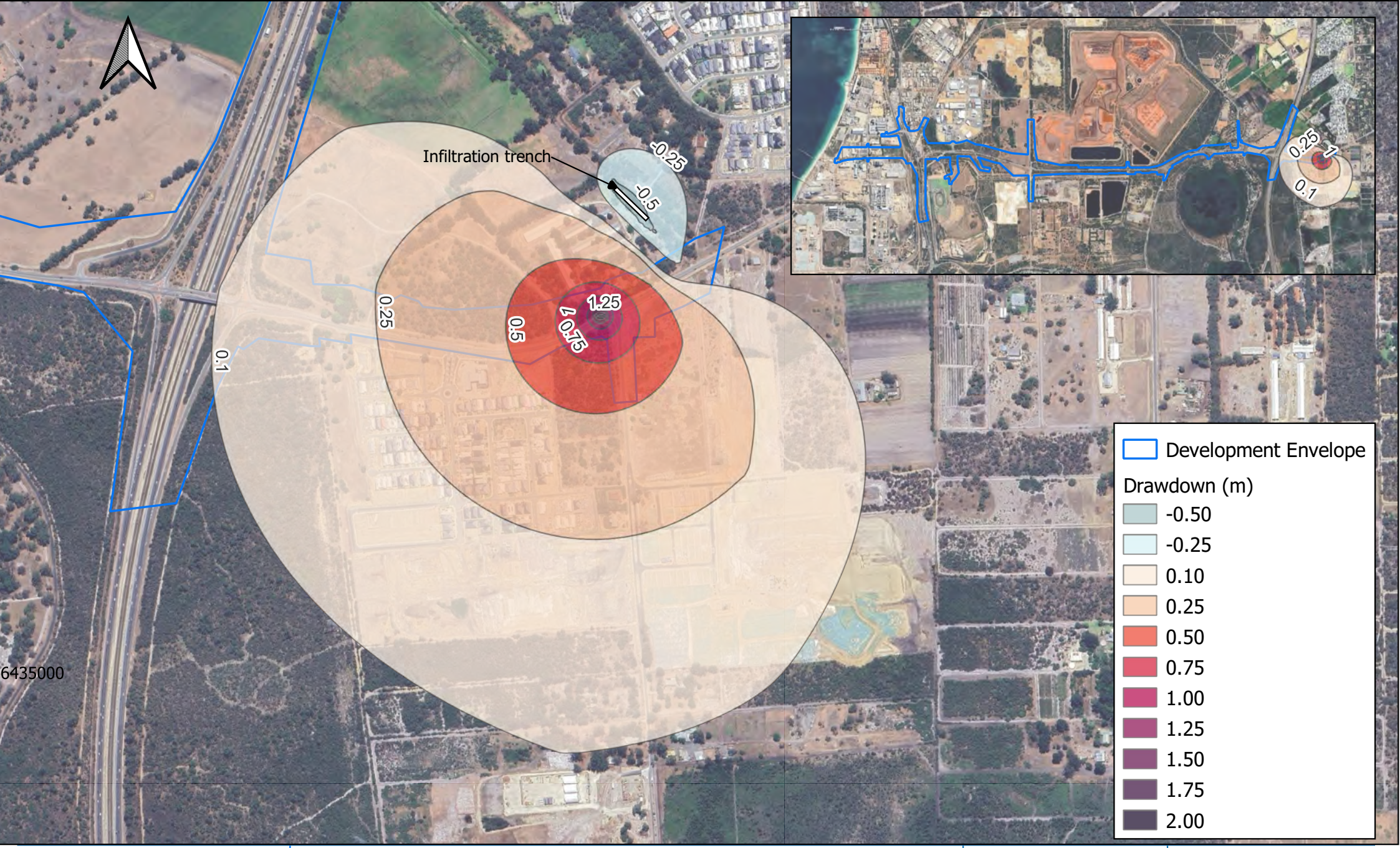
In addition, within the total drawdown area there is:

- 16.21 ha of native vegetation with a DTGW >10m (and not considered to be groundwater dependent)
- 58.84 ha mapped as cleared, roads or mixed commercial/residential
- 11.87 ha outside of the extent of vegetation mapping by Biota (2025).

The majority of the total area of drawdown has relatively deep groundwater. Of the 18.49 ha of potentially groundwater dependent vegetation (TEC and non-TEC), 1.62 ha has DTGW <3 m, 5.75 ha 3-6 m and 11.13 ha 6-10 m DTGW. Almost all (1.22 ha) of the 1.25 ha of wetland has a DTGW <3 m (Figure 10).

Table 8: Summary of GDE and other areas within total dewatering drawdown area

	Depth to Groundwater and Category (Area, ha)					Total Area (ha)
GDE Type	**>10m (0)**	**6-10m (1)**	**3-6m (2)**	**0-3m veg (3)**	**0-3m wetland (4)**	
Vegetation		**11.13**	**5.75**	**1.62**		**18.49**
Non-TEC		9.07	5.75	1.62		16.44
TEC/PEC		2.06				2.06
Wetland			**0.04**		**1.22**	**1.26**
Non-GDE – not assessed						
Vegetation DTGW >10 m (not GDE)	16.21					**16.21**
Other – not assessed						
Not mapped (outside Biota 2025 survey)	2.93	3.90	4.40	0.68		**11.87**
Cleared/Modified	42.43	7.90	6.49	0.22	1.79	**58.84**
Total						**106.67**



0 0.8 1.6 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 9: Drawdown contours - Dewatering dry season with recharge scenario

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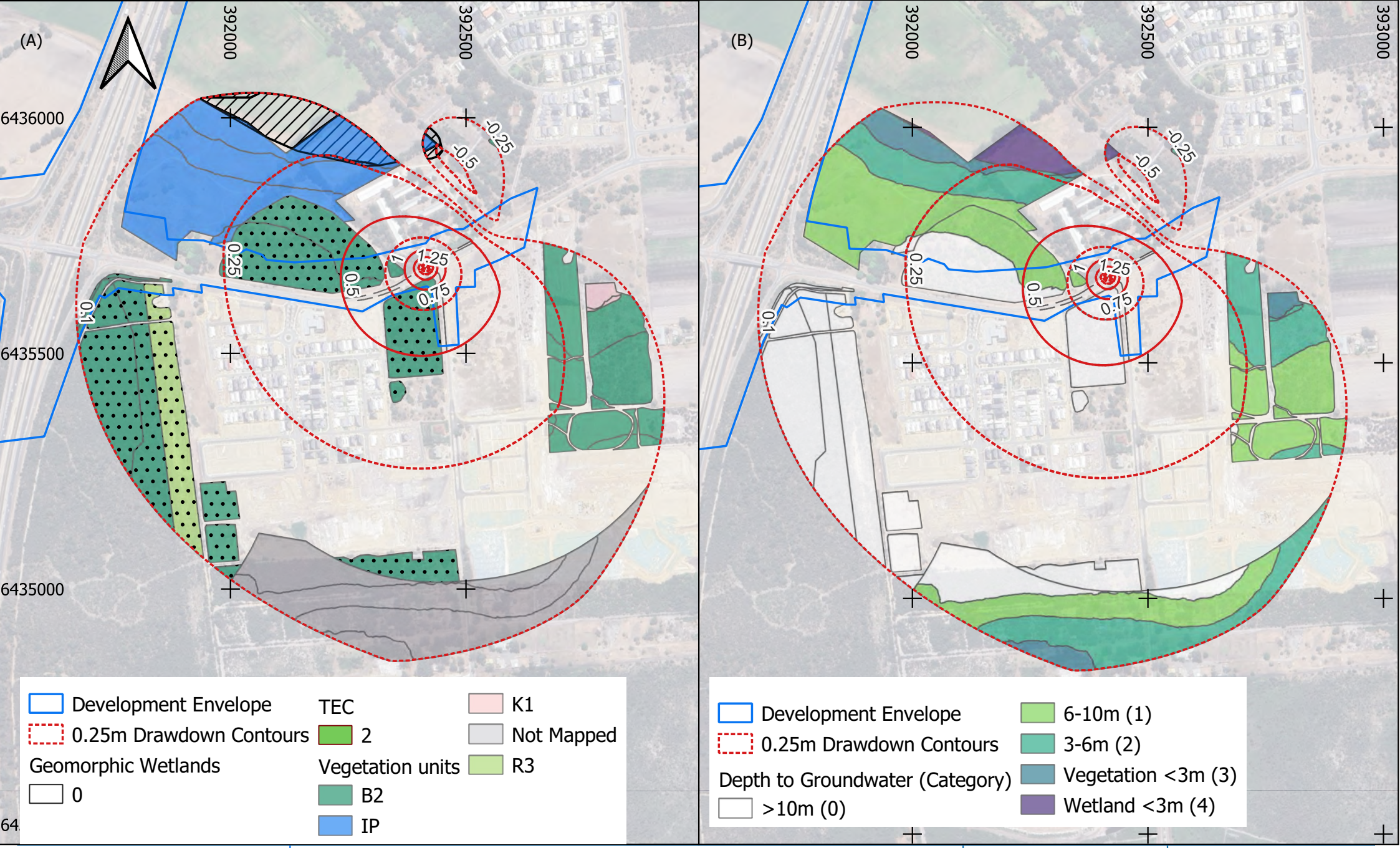

0 0.8 1.6 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 10: Dewatering dry season drawdown contours with potential GDEs by (a) GDE type and (b) Depth to groundwater category

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Risk of impact

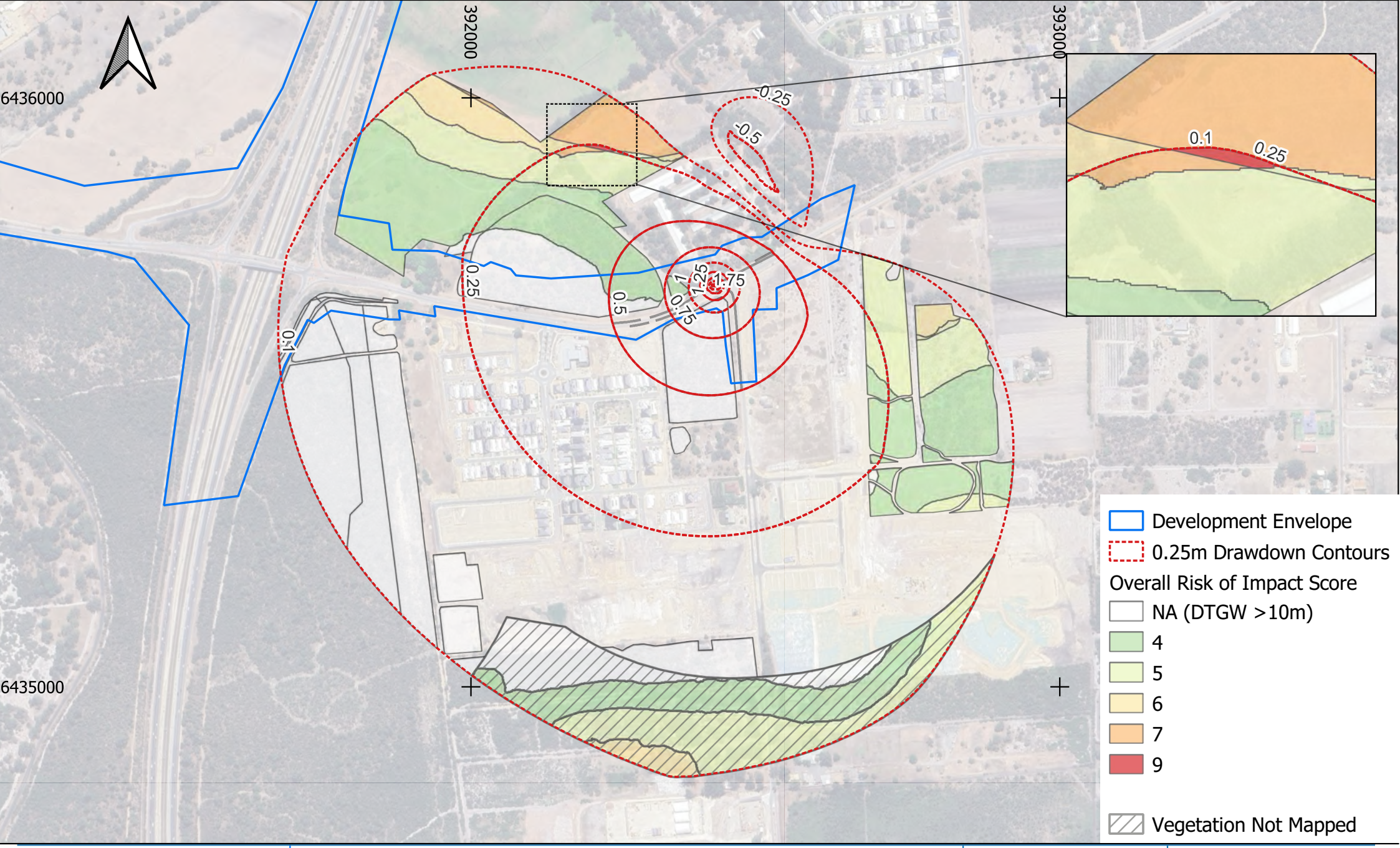
The risk of impact to GDEs from dewatering under this scenario is low. All of the potential GDE areas are identified as having a low risk of impact (<10 score) (Figure 11).

The total drawdown area includes four sections of Multiple Use wetland (part of Mandogalup Swamp) that retain isolated trees only (mapped as unit IP by Biota 2025). One of the four sections occurs within the 0.25 m drawdown area (and has depth to groundwater <3 m), which represents a moderate drawdown risk. The total risk of impact for this 0.03 ha section is scored as 9 which represents a low overall risk of impact. This is in part due to the low ecological values present within this wetland (i.e. Multiple Use, with vegetation that is not representative of TEC or providing habitat for significant flora or fauna) and no historical decline in groundwater. One other section of the wetland also occurs within the 0.25 m drawdown contour but has a depth to groundwater of 3-6 m and therefore has a reduced risk of impact (overall risk of impact of 5). The remaining two sections of wetland both occur within the predicted 0.1 m drawdown contour which presents a low risk of impact and score low overall risk of impact. NB Additional areas within the MU wetland were mapped as cleared (Biota 2025) and not assessed.

The drawdown contours under this scenario do not extend to the Tumulus Spring (TEC) occurrence to the north of the dewatering location and therefore no impact from dewatering is expected under this scenario. In addition, groundwater flow modelling indicates flow paths in the vicinity of the spring are not impacted under the dewatering scenario when recharge is incorporated.

The depth to groundwater underlying the majority (16.87 ha, 91%) of potentially groundwater dependent vegetation in the total drawdown area is relatively deep (3-10 m). Approximately 1.62 ha of the assessed area of vegetation has a depth to groundwater of 0-3 m, however this occurs within the 0.1 m and 0.25 m drawdown areas and the risk of impact resulting from this drawdown is considered low (Risk of impact score 6 for 0.1 m drawdown and 7 for 0.25 m drawdown). It is also noted that 1.3 ha of this vegetation (of the 1.6 ha with DTGW 0-3 m) is mapped as isolated trees in paddocks and is likely to retain limited ecological values (was not identified as supporting any threatened or priority flora, fauna or communities).

There are several areas of vegetation, including areas identified as Banksia Woodland TEC that occur within the total area of drawdown, however the majority of the TEC occurs where the depth to groundwater is >10 m and is therefore considered to have limited dependence on groundwater. The remaining areas have a DTGW of 6-10 m and are predicted to be subject to 0.1 to 0.25 m of drawdown which is considered low risk (the highest overall risk of impact for these areas was calculated to be 4).



0 1 2 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 11: Dewatering dry season drawdown contours with overall risk of impact for GDEs

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5.3 Construction water supply: Scenario 3a and 3b

Scenario 3 for supply of construction water modelled 50% (215 000 kL) and 100% of dust suppression (270 000 kL) from three production bores. Scenario 3 also modelled 210 days for dust suppression only (270 000 kL) from three proposed production bores. The two stages are referred to as Scenario 3a and Scenario 3b respectively.

The assessment of risk of impact focused on the potential drawdown impacts on native vegetation identified as groundwater dependent and wetlands within the total drawdown area of each bore and both abstraction scenarios (Table 9, Figure 12).

Table 9: Modelled groundwater drawdown and extent

Bore	Scenario	Maximum drawdown (m)	Extent (ha)	Extent of 0.1 m drawdown (ha)
1 (east)	3a	0.2	0.188	13.2
	3b	0.1	0.240	
2 (central)	3a	0.3	0.003	4.3
	3b	0.1	0.03	
3 (west)	3a	0.3	0.004	7.5
	3b	0.1	0.02	

5.3.1 Scenario 3a

Production Bore 1

Modelled abstraction at bore 1 results in drawdown up to 0.2 m within a 0.188 ha area. The maximum extent of modelled drawdown, out to the 0.1 m contour, occurs across 13.24 ha (total drawdown area) (Figure 12).

3.61 ha of potential GDEs were identified within the total drawdown area, including:

- 1.36 ha of native vegetation (non-TEC)
- 1.78 ha native vegetation identified as Banksia Woodlands of the Swan Coastal Plain TEC/PEC
- 0.47 ha of Wetlands (Multiple Use, non-TEC).

In addition, within the total drawdown area there is:

- 7.31 ha mapped as cleared, roads or mixed commercial/residential.
- 2.32 ha of native vegetation with DTGW >10 m (not considered GDE).

DTGW increases from north to south across the drawdown zone. Of the 3.14 ha of potentially groundwater dependent vegetation (TEC and non-TEC), 0.06 ha has DTGW <3 m, 0.85 ha has 3-6 m and 2.23 ha 6-10 m DTGW (Table 10). Almost all of the 0.47 ha of wetland has DTGW <3 m (Figure 13).

Production Bore 2

Modelled abstraction at bore 2 results in drawdown up to 0.3 m within a 0.003 ha area. The maximum extent of drawdown modelled, out to the 0.1 m contour, occurs across 4.31 ha (total drawdown area) (Figure 12).

A relatively small area of GDE native vegetation, 0.07 ha (DTGW 6 – 10 m), is the only GDE to intersects the total drawdown zone. It is part of a larger patch of native vegetation within the drawdown zone (0.69 ha DTGW >10 m) that is representative of Northern Spearwood shrublands and woodlands State Priority 3 PEC (Biota 2025) (Figure 13, Table 10).

Over half of the drawdown zone is mapped as cleared, roads or mixed commercial/residential (2.69 ha). The majority of the total area of drawdown had DTGW >10 m (3.86 ha), of which 1.54 ha is native vegetation.

Production Bore 3

Abstraction under Scenario 3a results in drawdown at bore 3 up to 0.3 m within a 0.004 ha area. The maximum extent of drawdown modelled, out to the 0.1 m contour, occurs across approximately 7.51 ha (total drawdown area) (Figure 12).

3.50 ha of potential GDEs were identified within the total drawdown area including:

- 1.92 ha native vegetation (non-TEC)
- 0.53 ha of native vegetation identified as Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain Federal TEC
- 1.06 ha native vegetation identified as Northern Spearwood shrublands and woodlands State Priority 3 PEC.

Additionally, within the total drawdown area there is:

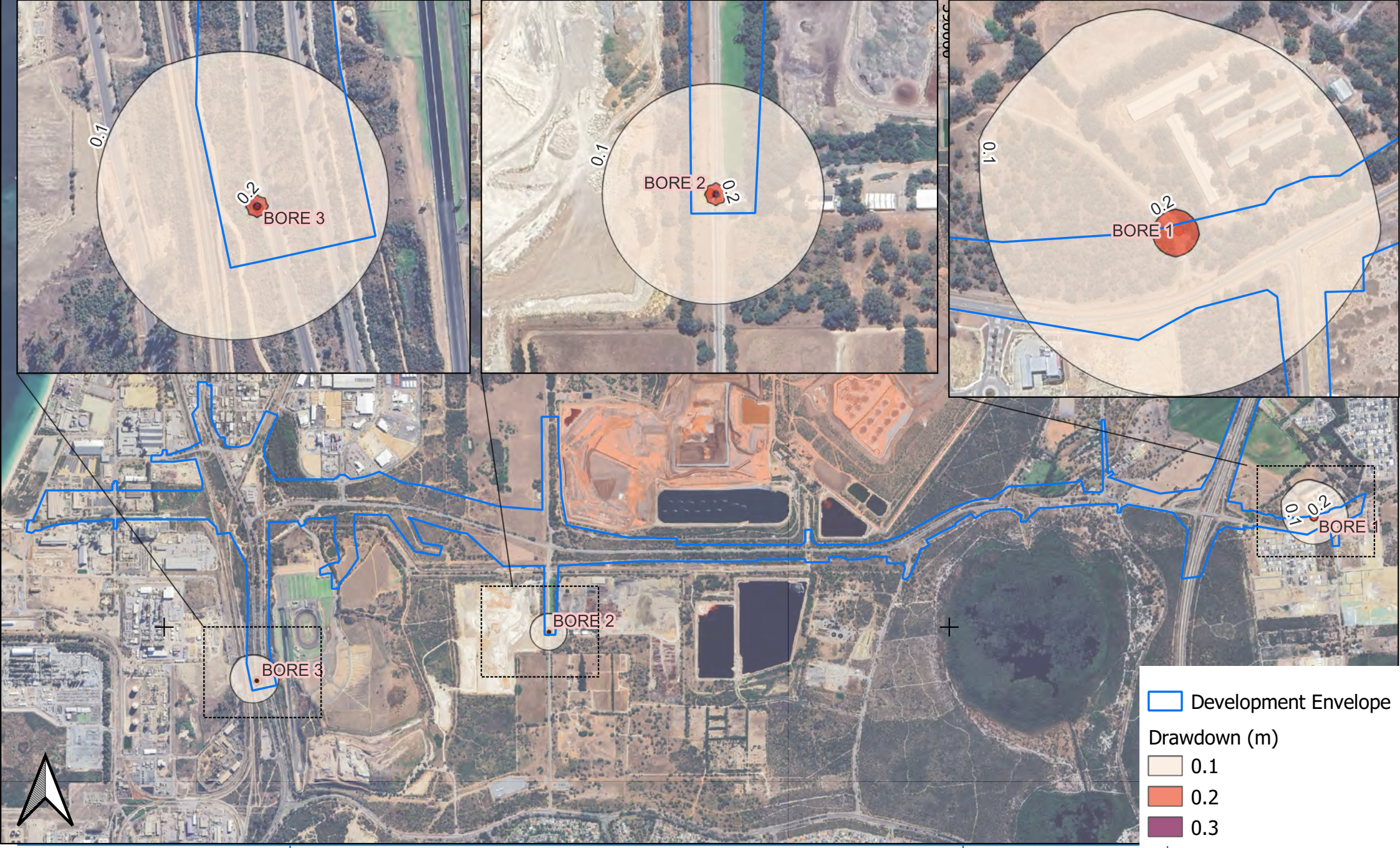
- 2.37 ha mapped as cleared, roads or mixed commercial/residential.
- 1.64 ha of native vegetation with DTGW >10 m (not considered to be groundwater dependent).

No wetlands were identified to occur within the total drawdown zone (<3 m DTGW).

DTGW becomes shallower from east to west across the drawdown zone. Of the 3.50 ha of potentially groundwater dependent vegetation (TEC and non-TEC), 0.13 ha has DTGW <3 m, 1.38 ha has 3-6 m and 2.0 ha has 6-10 m DTGW (Figure 13, Table 10).

Table 10: Summary of GDE and other areas within total drawdown area – Scenario 3a

GDE Type	Depth to Groundwater and Category (Area, ha)					Total Area (ha)
	>10m (0)	6-10m (1)	3-6m (2)	0-3m veg (3)	0-3m wetland (4)	
Production Bore1						
Vegetation		**2.23**	**0.85**	**0.06**		**3.14**
Non-TEC		0.45	0.85	0.06		1.36
TEC/PEC		1.78				1.78
Wetland (MU) (non-TEC)			**0.04**		**0.43**	**0.47**
Vegetation DTGW >10 m (not GDE)	2.32					**2.32**
Cleared/ Modified	7.31					**7.31**
Total						**13.24**
Production Bore 2						
Vegetation (TEC)		**0.07**				**0.07**
Not TEC						
TEC/PEC		0.07				0.07
Vegetation DTGW >10 m (not GDE)	1.54					**1.54**
Cleared/ Modified	2.69					**2.69**
Total						**4.3**
Production Bore 3						
Vegetation		**2.00**	**1.38**	**0.13**		**3.50**
Not TEC		0.93	0.87	0.11		1.92
TEC/PEC		1.06	0.51	0.02		1.59
Vegetation DTGW >10 m (not GDE)	1.64					**1.64**
Cleared/ Modified	0.49	0.92	0.59	0.37		**2.37**
Total						**7.51**



0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 12: Drawdown contours - production scenario 3a

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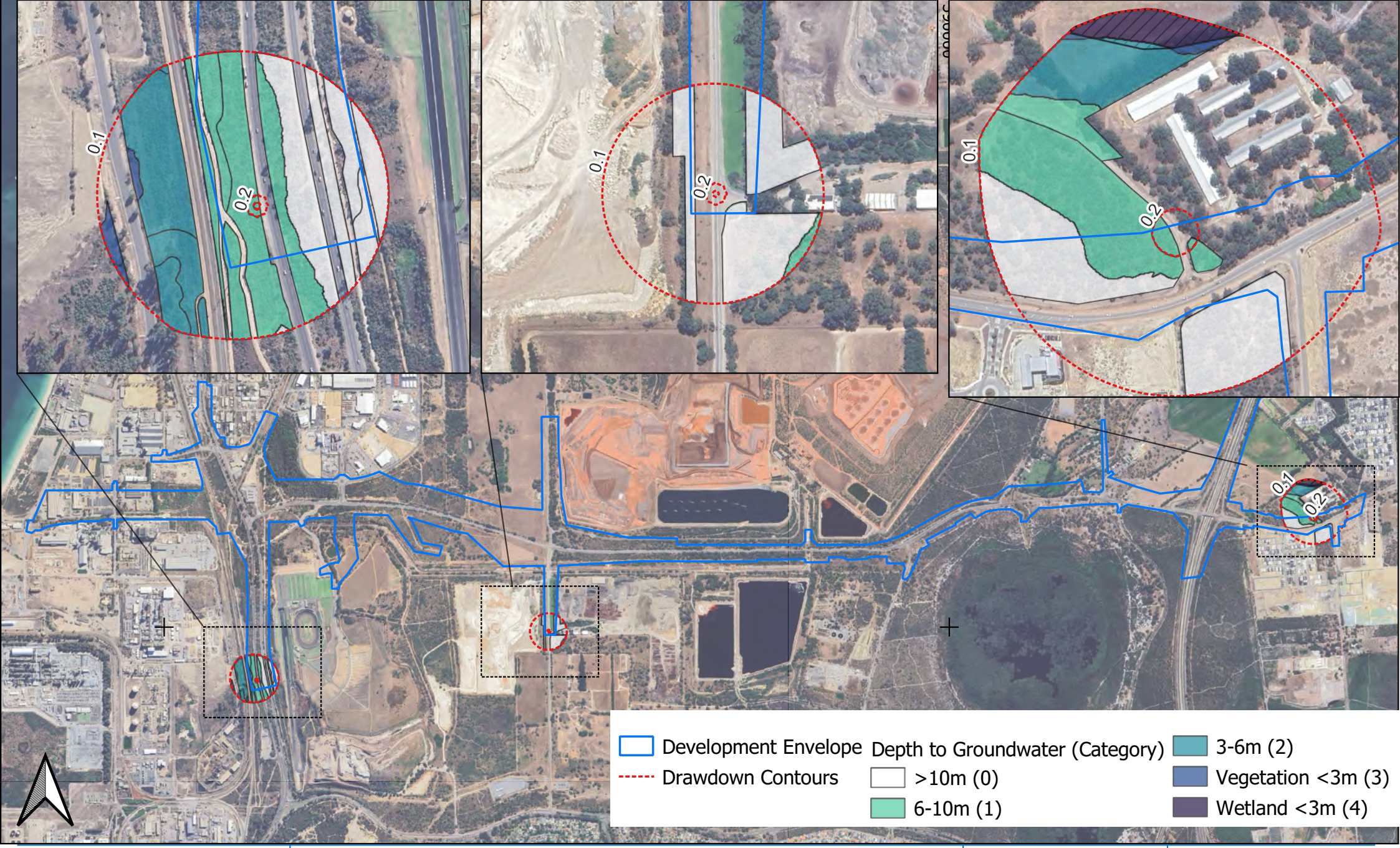

0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 13: Drawdown contours - production scenario 3a with GDEs by depth to groundwater category

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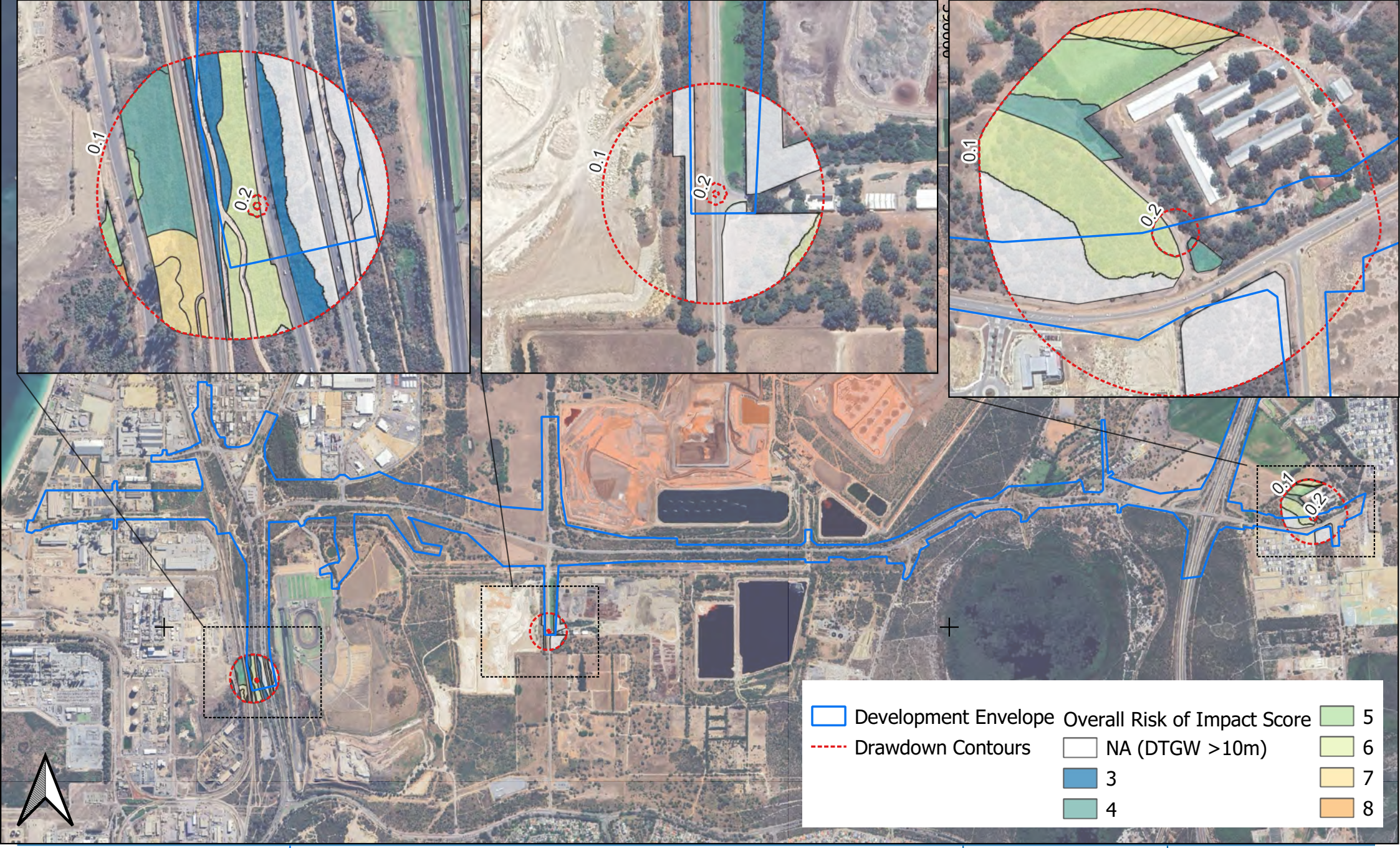
Risk of impact

The risk of impact to GDEs from this abstraction scenario is low (Figure 14). The total of 7.18 ha of potential GDE within the three drawdown zones are identified as having a low risk of impact (<10 score). The maximum drawdown of 0.2 m and 0.3 m is less than drawdown identified as likely to pose a high risk to GDEs i.e. drawdown >0.5 m for wetlands and >1.25 m for terrestrial vegetation (as identified by Froend and Loomes 2004).

The area of Tuart TEC (0.53 ha) within the 0.1 m drawdown contour of bore 3 had an overall risk impact of 7 to 8. The section is part of a larger Tuart TEC Patch (which extends outside of the total drawdown area of this bore) and occurs on shallow groundwater (0 – 3 m based on DTGW data). The overall risk of impact to this TEC is low considering drawdown of 0.1 m is classed as low risk for this type of GDE and historic change in groundwater level is negligible in this location.

Two sections of MU wetland 6530 occur in the 0.1m drawdown contour for production bore 1 and have risk of impact scores of 5 and 7 respectively. The risk of impact to this Multiple Use wetland is low, in due to:

- the wetland is classed as Multiple Use and supports limited ecological values (was mapped by Biota (2025) as isolated trees over paddock,
- historic change in groundwater is negligible (nearest bores had an increasing trend in groundwater),
- the 0.1m drawdown poses a low level of risk.



0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 14: Production scenario 3a drawdown contours with overall risk of impact for GDEs

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5.3.2 Scenario 3b

The model results for Scenario 3b indicate a reduced extent of drawdown compared to Scenario 3a as groundwater levels partially recover when the pumping rate is reduced part way through the scenario.

At the end of the scenario the maximum modelled drawdown is reduced to 0.1 m at each of the three bores and the maximum extent (total drawdown area) is approximately 0.24 ha (bore 1), 0.03 ha (bore 2) and 0.02 ha (bore 3) (Figure 15).

GDEs present and environmental values identified within the 0.1 m drawdown extent for the three production bores, under Scenario 3b, is outlined below:

- Total drawdown area under Scenario 3b at Production bore 1 is 0.24 ha. Within that extent 0.11 ha of GDE native vegetation (6 – 10 m DTGW) was identified, of which 0.09 ha is Banksia Woodlands of the Swan Coastal Plain TEC and PEC. The remaining 0.13 ha is mapped as cleared/mixed land use.
- At Production bore 2 the total drawdown area under Scenario 3b is 0.03 ha. No GDEs were identified within this extent, the entire drawdown zone is mapped as cleared and roads and rail infrastructure.
- Maximum extent of drawdown at Production bore 3 is 0.02 ha. Within that extent 0.013 ha of GDE native vegetation (6 – 10 m DTGW) was identified which is Northern Spearwood shrublands and woodlands State Priority 3 PEC. The remaining area is mapped cleared.

The risk of impact at the end of Scenario 3b, to all GDEs at bores 1 and 3 (where GDEs were identified), is low to negligible (Figure 16). The maximum drawdown of 0.1 m is considered low risk to wetlands and vegetation (as identified by Froend and Loomes 2004).

0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 15: Drawdown contours - production scenario 3b

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0 0.5 1 km

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 16: Production scenario 3b with overall risk of impact to GDEs

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5.4 Existing groundwater users

The online Water Register identified 36 current 5C groundwater licences issued within the Superficial aquifer across three groundwater areas intersecting the groundwater model boundary (Appendix B).

Based on the data provided on the Water Register i.e. the number and location of drawpoints displayed for a GW licence, and the risk threshold of 1 m or greater of groundwater drawdown, the risk to existing groundwater users was assessed as low for modelled scenarios of dewatering and abstraction (Figure 17).

No drawpoints (as displayed on the Water Register) intersect the maximum extent of drawdown (the 0.1 m drawdown contour) for modelled production scenarios Scenario 3a or Scenario 3b.

Assessment of the dewatering scenarios indicate a low level of risk to existing groundwater users considering all drawpoints occur outside of the 1 m drawdown risk threshold. No drawpoints occur from the maximum drawdown of 2 m to the 0.5 m contour in either scenario. Thirteen drawpoints occur between the 0.75 m and 0.1 m contour in the dewatering no recharge (dry season) scenario and ten drawpoints occur between the 0.5 m and 0.1 m contour in the dewatering with recharge (dry season) scenario.

0 100 200 m

Projection: GDA 20 zone 50

Source: Base map © ESRI and its data suppliers, DPIRD (2019). Landgate (2019)

Figure 17: Current SC groundwater licences with drawdown from {a) Scenario 3a {b) Scenario 3b

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6 Conclusion and Recommendations

Overall risk of impact to GDEs from dewatering and production scenarios is considered low.

Drawdown extent is small and bore placement means drawdown (as modelled) generally occurs where the depth the groundwater is relatively deep, reducing the risk of impact to GDEs, and/or environmental values associated with GDEs are limited. One section of multiple use wetland was scored with a moderate risk of impact under the dewatering scenario without recharge. With recharge the potential risk to this wetland was reduced to low.

Recharge of dewatering outputs via an infiltration trench, as modelled, appears to exclude any potential risk to the Tumulus Spring TEC occurring to the north of the dewatering location. Groundwater flow modelling indicates flow paths in the vicinity of the spring are not impacted under the dewatering scenario when recharge is incorporated. Modelled drawdown contours do not extend out to the Tumulus Spring TEC and therefore no impact to the TEC is expected.

Both production scenarios were considered to pose a low risk to GDEs. The modelled total drawdown area is very small and the degree of drawdown is low and poses a low risk of impact to GDEs.

In addition, given the relatively short timeframes for water abstraction under the dewatering and production scenarios assessed, the potential risk to GDEs is considered further reduced and groundwater models would be expected to recover following cessation of abstraction.

Similarly, the risk to existing groundwater users is low. The predicted drawdown from production bores under abstraction Scenario 3a and 3b do not intersect known bore locations of existing groundwater users.

7 References

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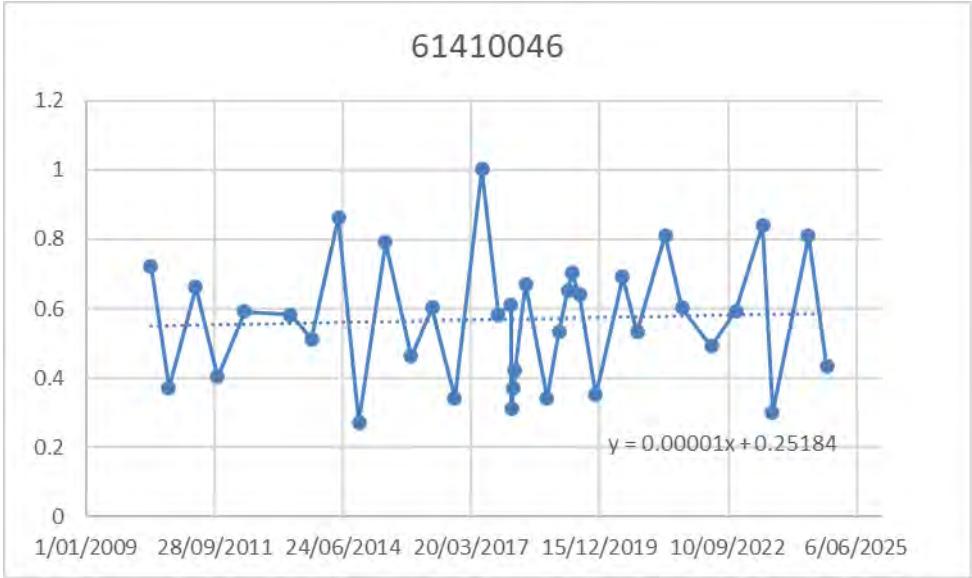
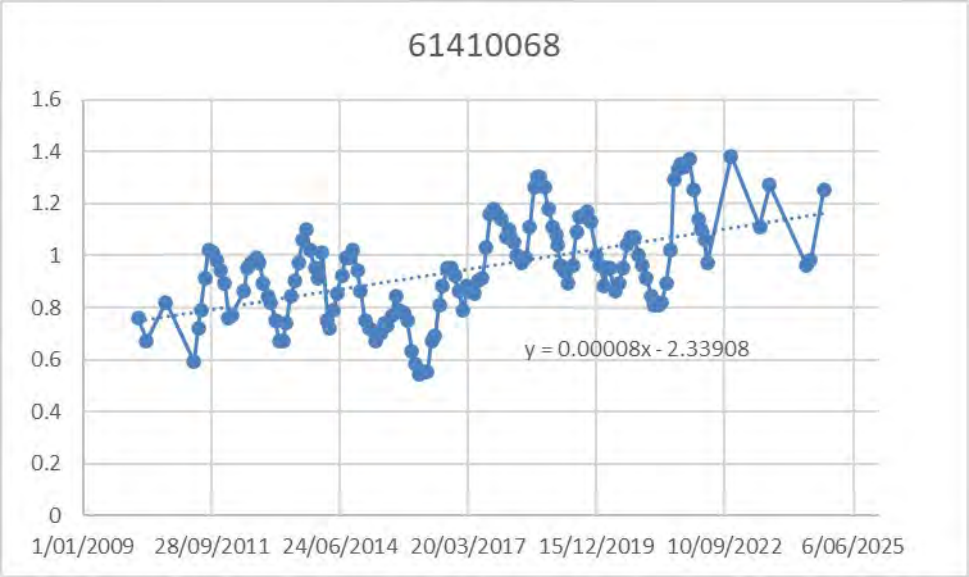
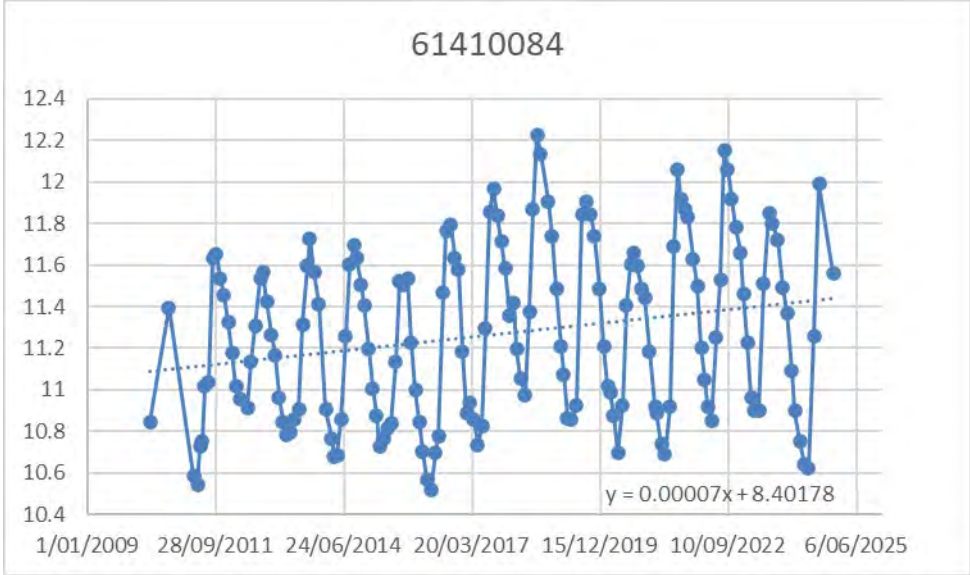
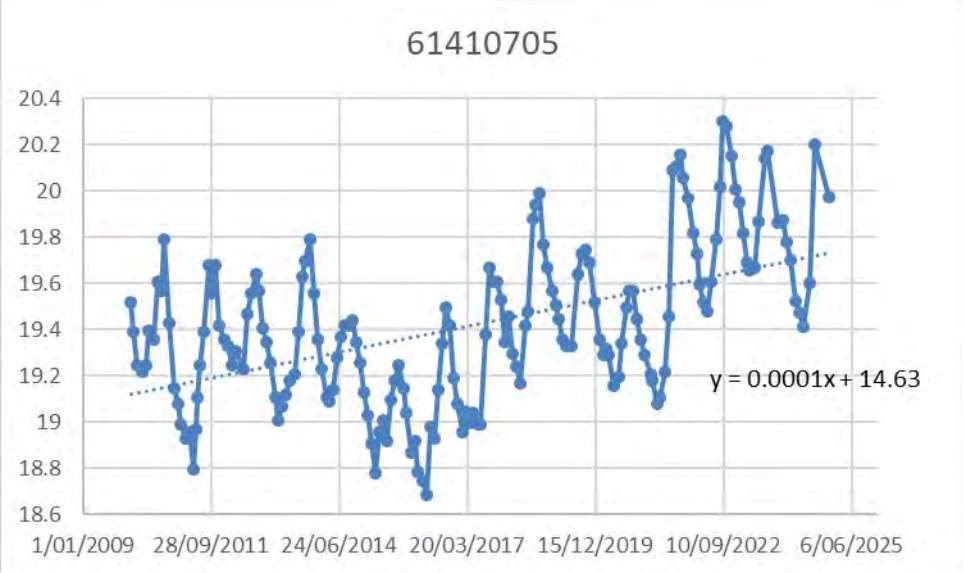
Appendix A: Long term groundwater monitoring






61410084
12.4
12.2
12
11.8
11.6
11.4
11.2
11
10.8
10.6
10.4
y = 0.00007x + 8.40178
1/01/2009
28/09/2011
24/06/2014
20/03/2017
15/12/2019
10/09/2022
6/06/2025


61410705
20.4
20.2
20
19.8
19.6
19.4
19.2
19
18.8
18.6
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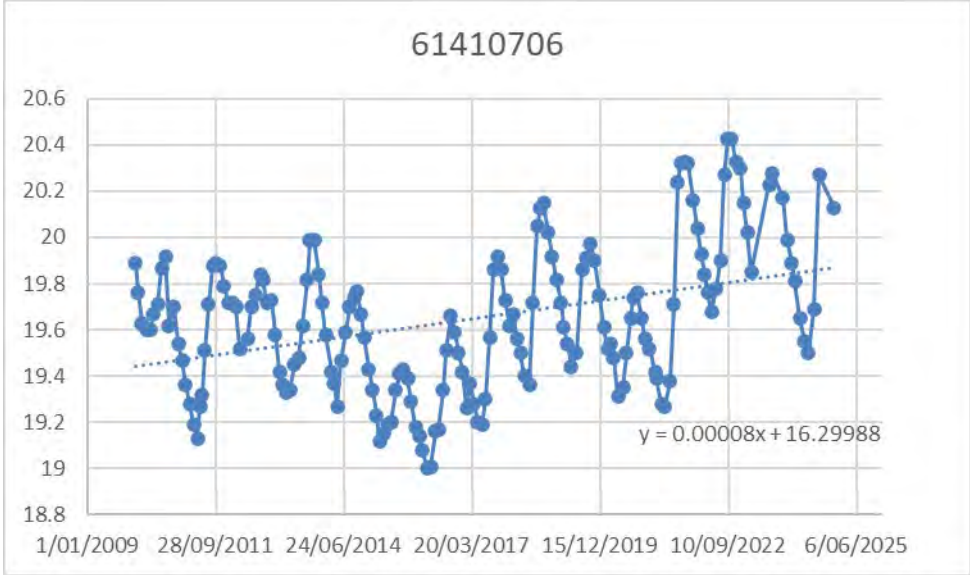
1/01/2009
28/09/2011
24/06/2014
20/03/2017
15/12/2019
10/09/2022
6/06/2025


61410706
20.6
20.4
20.2
20
19.8
19.6
19.4
19.2
19
18.8
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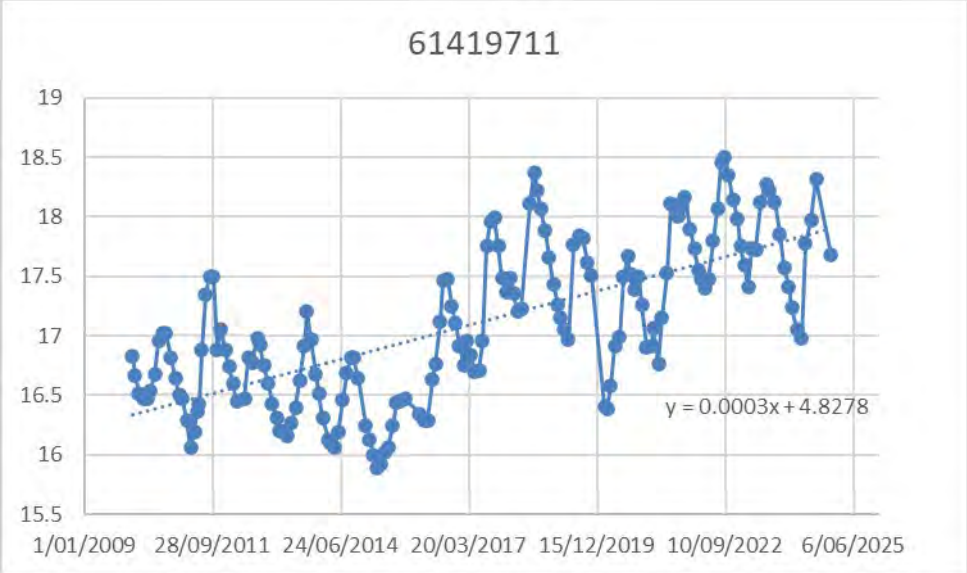
24/06/2014
20/03/2017
15/12/2019
10/09/2022
6/06/2025


61419711
19
18.5
18
17.5
17
16.5
16
15.5
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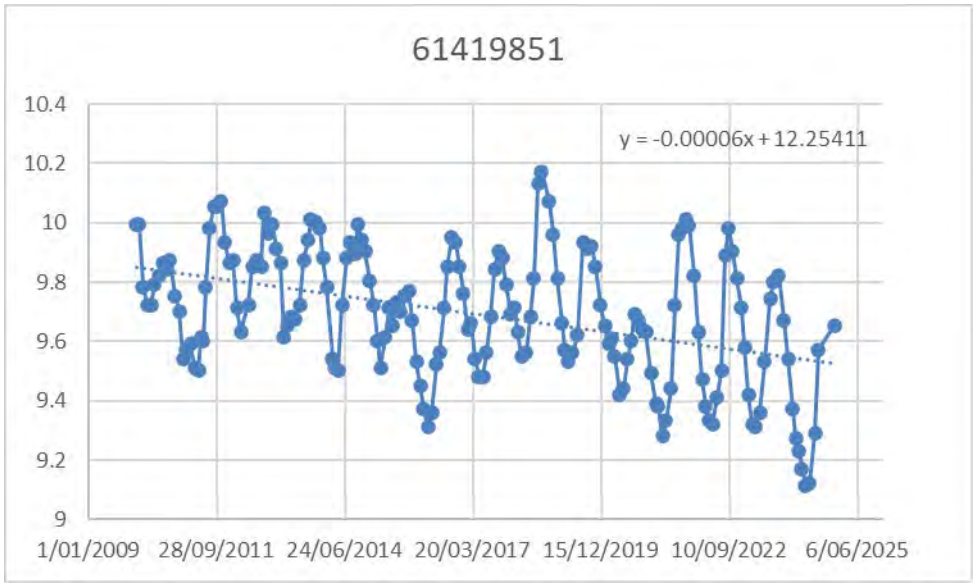
20/03/2017
15/12/2019
10/09/2022
6/06/2025


61419851
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10.4
10.2
10
9.8
9.6
9.4
9.2
9
1/01/2009
28/09/2011
24/06/2014
20/03/2017
15/12/2019
10/09/2022
6/06/2025

Appendix B: Existing groundwater users

Table 11: Current 5C groundwater licences within the model boundary

Licence Number	Licence Allocation	# of drawpoints
Serpentine Jandakot Mound 1 Perth - Superficial Swan		
48228	19950 KL	1
58529	9200 KL	2
101078	10350 KL	2
160839	8000 KL	1
179454	61150 KL	2
182060	14625 KL	1
202118	1875 KL	1
203006	15375 KL	1
208076	16800 KL	1
210876	20000 KL	1
106782	6750 KL	1
150481	17900 KL	2
156470	18650 KL	1
Jandakot, Mandogalup, Perth - Superficial Swan		
166922	724935 KL	3
169930	119650 KL	1
171301	9750 KL	1
177515	270800 KL	2
181321	300000 KL	2
200427	8400 KL	1
200440	15150 KL	1
202605	226285 KL	5
205255	18650 KL	1
Cockburn, Valley, Perth - Superficial Swan		
50465	97000 KL	2
54280	15000 KL	1
59069	26500 KL	3
73597	12000 KL	1
78096	300000 KL	1
109942	150000 KL	2

158359	3000 KL	1
159072	60850 KL	1
159085	5404000 KL	many
163607	40000 KL	1
175643	75000 KL	1
175930	129100 KL	1
181288	1500 KL	1
200502	35000 KL	1

Appendix G Drawdown from production bores

Drawdown from production bores

Localised groundwater drawdown occurs when groundwater is abstracted from an aquifer at a rate faster than it can be replenished, forming a cone of depression (in groundwater level), potentially reducing groundwater level at sensitive hydrological value/wetland sites. Impacts to wetlands and associated vegetation may occur as a result of reduced water availability and changes in groundwater chemistry.

To manage the potential risk to hydrological values from groundwater drawdown it is recommended that abstraction bores are not located near groundwater dependent wetlands or waterways.

To inform the selection of locations for potential production bores (with consideration of potential impacts to wetlands) exclusion zones or distances from identified high value groundwater dependent wetlands have been determined based on calculated aquifer drawdown using the Theis equation.

Inputs to the calculation were determined based on predicted water supply requirements, estimated pumping rates and aquifer properties for the Tamala Limestone and Bassendean Sand components of the Superficial Aquifer.

The total water requirement to construct the project over an estimated two-year timeframe is approximately 430,000 kL. The Water Source Report determined an average flow rate of 9.7 litres per second (over 24-hour period) is required from a production bore to obtain this volume, which is expected to be achieved in limestone with a flow rate of 13 litres per second observed at Abercrombie Road (WA Limestone quarry).

Aquifer parameters for Tamala Limestone and Bassendean Sand were based on published values for the area published in Davidson (1995) and estimated aquifer thickness was based on locally derived aquifer cross sections (Golder 2023). The values are summarised in Table G1 below.

Table G1: Aquifer parameters used to calculate cone of depression

Aquifer material	Hydraulic conductivity (K)	Estimated saturated thickness	Transmissivity (T) m^2/d	Storativity
Bassendean sands (fine to medium)	8.2	15	123	0.2
Tamala limestone/Calcarenite	100*	20	2000	0.2

* Davidson (1995) quotes a range in hydraulic conductivity of Tamala Limestone of between 100-1000. A conservative approach was applied in this case with the lower K value used in calculations.

The results indicate that at 180 days of groundwater abstraction the following drawdown and radius is expected:

- In Tamala Limestone: just over 10 cm drawdown at 400m radius and dropping below 10 cm beyond 400 m radius (figure G1)
- In Bassendean Sand: 42 cm drawdown at 400m radius, dropping to below 6 cm at 800 m radius (figure G2)

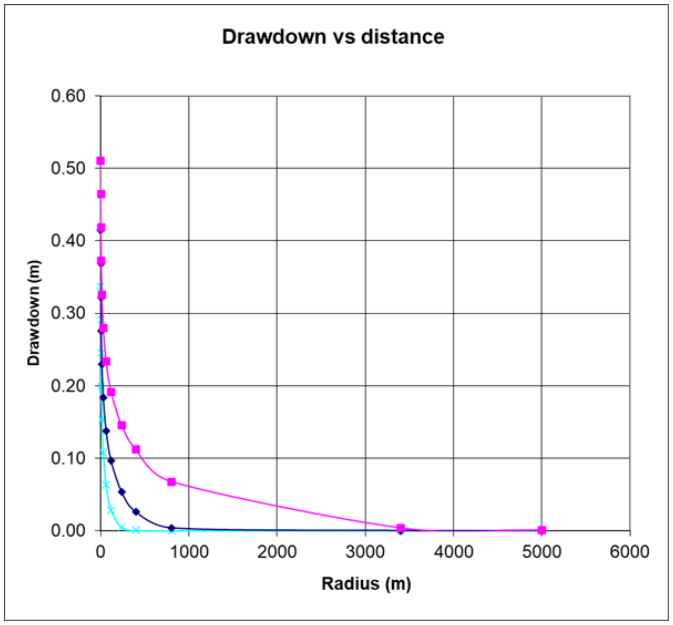

Figure G1: Drawdown in Tamala Limestone

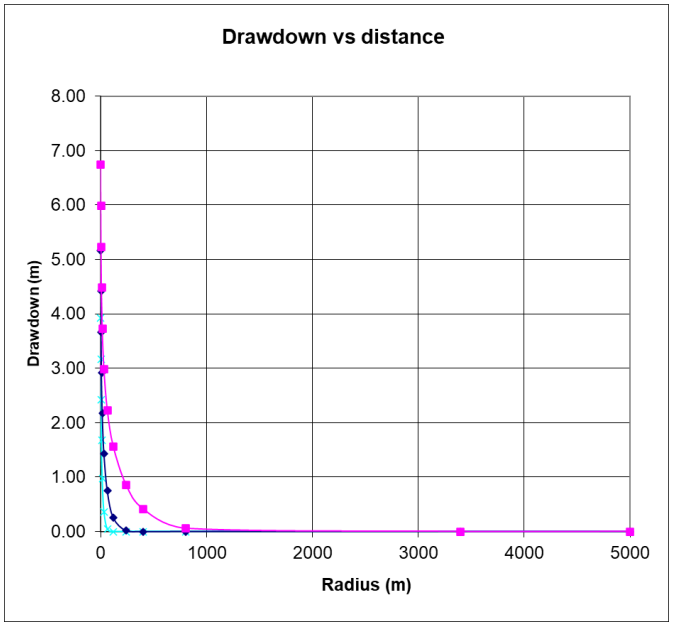

Figure G2: Drawdown in Bassendean Sand

Froend *et al.* (2004) provide risk of impact level of permissible change for wetland vegetation in terms of magnitude (m) and rate (m/year) by depth to groundwater/phreatophytic category summarised in Table G2.

For wetlands overlying Tamala Limestone the calculated drawdown of 10cm at 400m (and dropping below 10cm beyond 400m) is considered low risk in terms of magnitude and rate of permissible change in groundwater level. Bores should therefore be located 400m from the geomorphic wetland boundary.

Table G2: Risk of impact level of permissible change (adapted from Froend *et al.* 2004).

Phreatophytic category	Low	Moderate	High	Severe
0 -3m (wetland)		Magnitude of permissible change (m)		
	0-0.25	0.25-0.5	0.5-0.75	>0.75
		Rate of permissible change (m/year)		
	0-0.1	0.1-0.2	0.2-0.3	>0.3

For bores located in Bassendean Sands the calculated drawdown of 42cm at 400m is considered moderate risk and severe risk in terms of magnitude and rate respectively which unacceptable risk (for rate). At 600 m the drawdown is calculated to drop to 16 cm which is considered low risk in terms of magnitude and moderate in terms of rate. Bores should therefore be located 600m from the geomorphic wetland boundary.

References

Davidson WA (1995). Hydrogeology and Groundwater Resources of the Perth Region, Western Australia. Geological Survey of Western Australia Bulletin 142.

Froend R, Loomes R, Horwitz P, Bertuch M, Storey A and Bamford M (2004), Study of Ecological Water Requirements on the Gnangara and Jandakot Mounds under Section 46 of the Environmental Protection Act - Task 2: Determination of Ecological Water Requirements. Prepared for: The Water and Rivers Commission by Centre for Ecosystem Management, ECU.