City of Wanneroo

Neerabup Industrial Area Structure Plan
Local Water Management Strategy

July 2021

Executive summary

The Neerabup Industrial Area (NIA) is an industrial area of approximately 1,000 ha located in the suburb of Neerabup within the City of Wanneroo, 30 km north of the Perth CBD. It is planned to be the most significant new industrial estate in the Perth's North West Metropolitan Corridor.

This NIA Local Water Management Strategy (LWMS) has been developed to provide an integrated approach for management of stormwater runoff and water resources across the strategy area. The LWMS provides a coordinated approach to stormwater management to guide future industrial development and subdivision, and further identifies and describes water management design elements and management measures for future industrial development at the development, subdivision and lot scale.

The strategy area has well drained soils and no surface water features within its boundary. In its pre-development state all rainfall infiltrates to groundwater within the strategy area boundary. Groundwater is at considerable depth across the majority of the strategy area. Parts of the strategy area have potential karst risk and contamination risk and will need to be investigated and managed accordingly once development progresses. Further, the protection of sensitive environmental receptors is considered through appropriate management of stormwater across the various scales of development.

Planning has progressed in parts of the strategy area and the LWMS has incorporated information from these development areas where available to ensure a consistent and coherent approach to drainage planning and associated arterial flood management, and management of risks to sensitive environmental receptors that occur adjacent to the strategy area boundary.

The design criteria and management strategies in the LWMS have been developed with reference to contemporary water management guidance, with a key focus on water conservation and maintaining the site water balance through implementation of at source controls at all scales of development.

Key water conservation strategies include incorporation of measures to reduce the demand for scheme water at the lot and development scales. Within lots stormwater storage (rainwater tanks, underground storage) will reduce scheme water demand through provision of fit for purpose water sources for some non-potable demands, use of water efficient fixtures and fittings appropriate to the development type and implementation of waterwise landscaping practices.

Use of fit for purpose water to reduce scheme water demands is also a key water conservation measure at the development scale. Recycling of water and wastewater is a key strategy that shall be encouraged between altruistic industries through promotion of industrial ecology (water efficiency) and water reuse amongst complementary industry, with planning encouraging flexible lot sizes to cater to varying industry types.

Stormwater management across the strategy area is focussed on maintaining existing the existing water balance across the various scales of development (lot scale, development scale and arterial drainage). Lots are to retain, treat and infiltrate all stormwater generated within their lot boundary. Small event runoff from road catchments will be treated in appropriately sized bioretention areas, with infiltration of minor events provided in road and median swales in Industrial Connector roads. Swales and roads will provide conveyance of major events to flood storage basins located in topographical lows.

Stormwater quality across the development area will be maintained or improved through implementation of a treatment train of structural and non-structural best practices across all scales of development. Runoff from small events will be retained and treated as close to source as possible using bioretention elements within lots and road reserves. Land use planning will ensure that potentially polluting industry are located outside of areas that present a high risk of contamination to sensitive receptors.

Across the majority of the strategy area the finished contours have adequate clearance to groundwater levels based on predicted future groundwater levels.

Management of sensitive environmental receptors within and adjacent to the strategy area is based on a number of strategies including implementation of source control for stormwater across the development area and provision of separation distances and planning measures to manage the catchment and interface with sensitive receptors.

Due to the long time frames for development and potential risks to development and sensitive receptors, additional technical investigations will be required over parts of the strategy area to characterise site conditions in the period preceding development. Results from these investigations should be used to inform the preparation of, and reported within, the Urban Water Management Plans to support subdivision.

Acronyms

AEP	Annual Exceedance Probability
ARI	Average recurrence interval
ASP	Agreed Structure Plan
ASS	acid sulphate soil
BoM	Bureau of Meteorology
BMP	Best management practice
CEMP	Construction Environmental Management Plan
DBCA	Department of Biodiversity, Conservation and Attractions
DMP	Department of Mines and Petroleum
DNWMP	Drainage, Nutrient and Water Management Plan
DPLH	Department of Planning Lands and Heritage
DoW	Department of Water
DWER	Department of Water and Environmental Regulation
EY	Exceedance per Year
GDE	Groundwater dependent ecosystem
GL	Gigalitre
GPR	ground penetrating radar
GSWA	Geological Survey Western Australia
ha	Hectare
kL	Kilolitre
km	kilometre
LPP	Local Planning Policy
LWMS	Local Water Management Strategy
m	metre
mm	millimetre
mAHD	metres Australian Height Datum
MGL	maximum groundwater level
MRS	Metropolitan Region Scheme
NIA	Neerabup Industrial Area
POS	Public Open Space
PRAMS	Perth Region Aquifer Model
PSI	Preliminary site investigation
SPP	Statement of Planning Policy

TEC	Threatened Ecological Communities
TKN	Total Kjeldahl Nitrogen
UWMP	Urban Water Management Plan
WAPC	Western Australian Planning Commission
WDE	Water dependent ecosystem
WSUD	Water sensitive urban design
WQPN	Water Quality Protection Note
yr	Year

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1. Introduction

1.1 Background

The Neerabup Industrial Area (NIA) is an industrial area of approximately 1,000 ha located in the suburb of Neerabup within the City of Wanneroo, 30 km north of the Perth CBD. It is planned to be the most significant new industrial estate in the Perth's North West Metropolitan Corridor.

To the southeast of the NIA, there is significant current and future residential development within Banksia Grove. Residential estates along the coastal strip of the North West Corridor (including the suburbs of Clarkson, Merriwa, Kinross, Mindarie) are currently developing approximately 3 km to the west of the NIA. The East Wanneroo District Structure Plan (DPLH 2019), endorsed by the Western Australian Planning Commission in November 2020,identifies new residential and industrial areas to the east of the NIA.

A revised Structure Plan has been prepared for the NIA to provide contemporary planning and implementation framework for the NIA to complement the City's concept zoning plan for the area (Section 2.3).

The NIA area is currently in the early stages of industrial growth, with the plan area forecasted to reach full build-out within the next 40-45 years (GHD 2020a). Given the extended development timeframes across the NIA area, and fragmented land ownership, it is important that an integrated approach is adopted for management of stormwater runoff and water resources across the strategy area.

1.2 Purpose of this report

This Local Water Management Strategy (LWMS) is one of several supporting technical documents that have been prepared to support the revised Structure Plan for the NIA (the strategy area).

This document has been prepared on the basis of currently available information, input from other technical studies and key stakeholders to identify key issues, opportunities, strategies and management actions to guide total water cycle management across the strategy area.

The LWMS provides a coordinated approach to stormwater management to guide future industrial development and subdivision, and further identifies and describes water management design elements and management measures for future industrial development at the development, subdivision and lot scale.

An Urban Water Management Plan (UWMP) will be required to support future subdivision applications across the strategy area.

1.3 Planning context

This LWMS has been prepared in accordance with S*tate Planning Policy 2.9: Water Resources* (WAPC 2004) and *Better Urban Water Management* (WAPC 2008). The planning framework for land and water planning is illustrated in Figure 1-1.

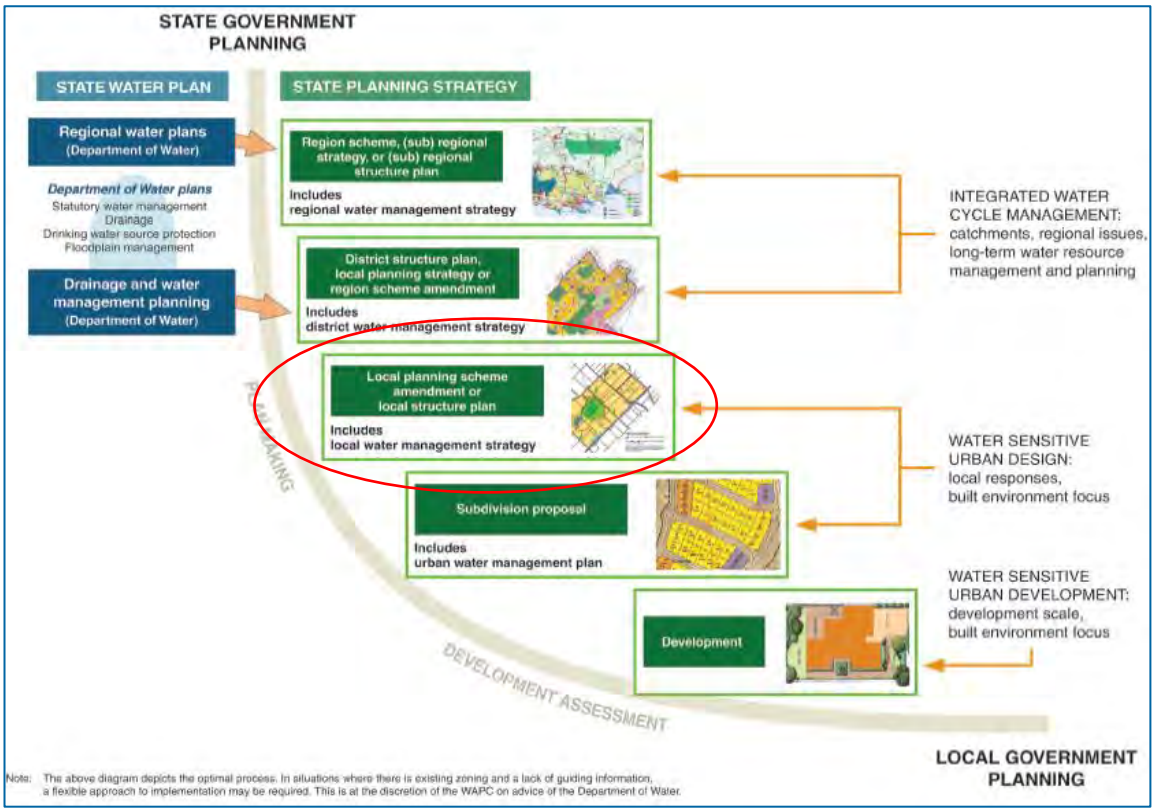

Figure 1-1 Framework for integrating water planning with land planning

1.3.1 Zoning

The NIA is predominantly zoned industrial under the Metropolitan Region Scheme (MRS), with a small portion in the north-east corner of the site zoned Public Purpose – Special Use which is to enable creation of a power station precinct.

Under the City of Wanneroo District Planning Scheme No 2 the majority of the NIA is zoned Industrial Development, with the central portion of the site zoned General Industrial and the north east corner reserved Public Purpose – Special Use, consistent with the MRS. The existing Structure Plan (ASP 17) identifies areas within the NIA as Business, General Industrial and Service Industrial, with a small portion identified as Open Space. A conservation reserve and a Bush Forever site (Site 295) are also identified.

A number of subdivision approvals have been issued by the Western Australian Planning Commission, over parts of the site.

1.3.2 NIA Master Plan

The NIA Master Plan, provides an updated planning strategy for the NIA,and was developed with regard to several supporting technical studies, and with consideration of site environmental conditions and service corridors and planning for adjacent areas.

The NIA Master Plan is presented in Figure 1-3.

1.3.3 Statement of Planning Policy 2.4 Basic Raw Materials

The NIA has been identified as a Priority Resource for sand and limestone resources for the Perth Metropolitan area and is identified in *Statement of Planning Policy 2.4 Basic Raw Materials* (SPP 2.4). In particular the central and western portion of the strategy area is identified as a limestone/lime sand resource and as a Priority Resource Location being known

for areas of high resource potential which should be held available for current and future extraction.

In accordance with SPP 2.4 staging of land uses should be sequenced following extraction of the basic raw materials.

1.3.4 Water management planning

This LWMS document has been developed with reference to several water management policies and planning guidance documents including (but not limited to):

- *Decision process for Stormwater Management in WA* (DWER 2017)
- *Waterwise Perth Action Plan* (DWER 2019)
- *State Water Plan* (DPC 2007)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006)
- *Stormwater Management Manual for Western Australia* (Department of Water 2004-2007)
- *North-West Sub-Regional Water Management Strategy* (Essential Environmental 2016)
- *Integrated Water Management Framework; East Wanneroo District Structure Plan* (referred to as East Wanneroo Integrated Water Management Framework) (RPS 2019)
- *Better Urban Water Management* (WAPC 2008)
- *North West Corridor Water Supply Strategy* (City of Wanneroo and Department of Water 2014)
- *Water Quality Protection Note 51: Industrial wastewater management and disposal* (DoW 2009b)
- *Water Quality Protection Note 52: Stormwater Management at Industrial Sites* (DoW 2010)

1.3.5 Local policy and technical specifications

The City of Wanneroo has several policies and technical specifications relevant to water management within the strategy area including:

- *Wanneroo Development Design Specification WD5; Stormwater Drainage Design* (City of Wanneroo 2019)
- City of Wanneroo Local Planning Policy 4.1: Wetlands
- City of Wanneroo Local Planning Policy 4.13: Caves and Karst Features
- City of Wanneroo Local Planning Policy 4.18: Earthworks and Sand Drift
- City of Wanneroo Local Planning Policy 4.3: Public Open Space
- City of Wanneroo Local Planning Policy 4.4: Urban Water Management
- City of Wanneroo standard drawings for Sump & Sump Outfall Details (TS03-4-2) and Sump Security (TS01-2-1)

Waterwise Council

The City of Wanneroo is a participant in the Waterwise Council Program, achieving Gold Status in 2020.

1.3.6 Planning process and approvals

This Local Water Management Strategy is intended to inform total water cycle management across the strategy area and provide a coordinated approach to stormwater management to guide future industrial development.

The water management strategies outlined in this Local Water Management Strategy are based on existing information available across the strategy area. Given the nature of existing extractive industries, fragmented land ownership and extended development timeframe more detailed studies will be required to support development for parts of the strategy area commensurate with the level of risk to water resource management.

1.4 Previous studies

1.4.1 Meridian Park

A large portion of the NIA industrial area is designated as Meridian Park, the location of which is identified in the plan in Appendix B.

Lot 22 Flynn Drive Neerabup, Drainage Nutrient and Water Management Plan

Lot 22 Flynn Drive Neerabup, Drainage, Nutrient and Water Plan (herein DNWMP) (Strategen 2008) was prepared as a condition of subdivision approval for the Meridian Park Industrial Estate, comprising parts of Lots 22 and 9004 Flynn Drive.

The DNWMP was prepared to provide guidance on total water cycle management for the industrial subdivision. The water management strategies identified in this document have been superseded by contemporary best practice stormwater management approaches and criteria that include small rainfall event management as detailed in this LWMS.

Meridian Park Design Requirements and Guidelines

The *Meridian Park Design Requirement and Guidelines* were developed by LandCorp and the City of Wanneroo (2010) to provide guiding principles for the estate, based on the vision to create a landmark industrial estate with a strong sense of place which demonstrates efficient use of land, water, energy and resources. The Design Requirements and Guidelines identify mandatory requirements for development within the estate.

Servicing Report, Neerabup Industrial Lot 9004 Flynn Drive

A preliminary servicing report prepared for Lot 9004 Flynn Drive (formerly Lot 22) Neerabup, to support industrial development of future stages (Cossill & Webley 2015). The report identified sufficient capacity of existing water reticulation, with applications to be made by the owner/builder at the time of construction. Sewer infrastructure comprises a tankering point (prior to grading out to the proposed pump station) with the balance connecting to existing sewer.

Road drainage grades to drainage Lot 8002, with temporary and permanent drainage infrastructure constructed in accordance with City of Wanneroo requirements.

1.4.2 Neerabup Industrial Area, Principle Landscape and Water Management Plan

The *Neerabup Industrial Area, Principle Landscape and Water Management Plan* was prepared by Blackwell & Associates (2009) to provide overarching guidance for management of landscape design, water conservation and stormwater and groundwater management across the NIA.

As noted for the Lot 22 Flynn DNWMP, contemporary best practice stormwater management approaches and criteria detailed in this LWMS supersede the stormwater management strategies in this document.

1.5 LWMS objectives

The overarching objective for water management of the NIA industrial estate is to achieve an integrated approach to total water cycle management and application of water sensitive urban design principles across the development area in accordance with the Local Planning Policy 4.4: Urban Water Management and current expectations of CoW. Key objectives include:

- Integration of water and land use planning early in the planning and development process.
- Achieve catchment specific environmental criteria.
- Achieve total water cycle management outcomes.
- Implement Water Sensitive Urban Design (WSUD) principles and best management practices for all planning proposals.
- Improve water quality within the City and ensure the protection and management of sensitive environments.
- Ensure all development connects to scheme water and reticulated sewerage.
- Assess the practical and appropriate level of risk related to the proposal in accordance with Schedule 1 of LPP 4.4.

Design criteria to achieve these objectives are outlined in Section 3.

1.6 Scope and limitations

This report: has been prepared by GHD for the City of Wanneroo and may only be used and relied on by the City of Wanneroo for the purpose agreed between GHD and the City of Wanneroo as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than the City of Wanneroo arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.7, 3, 5, 6, 7 and 8). GHD disclaims liability arising from any of the assumptions being incorrect.

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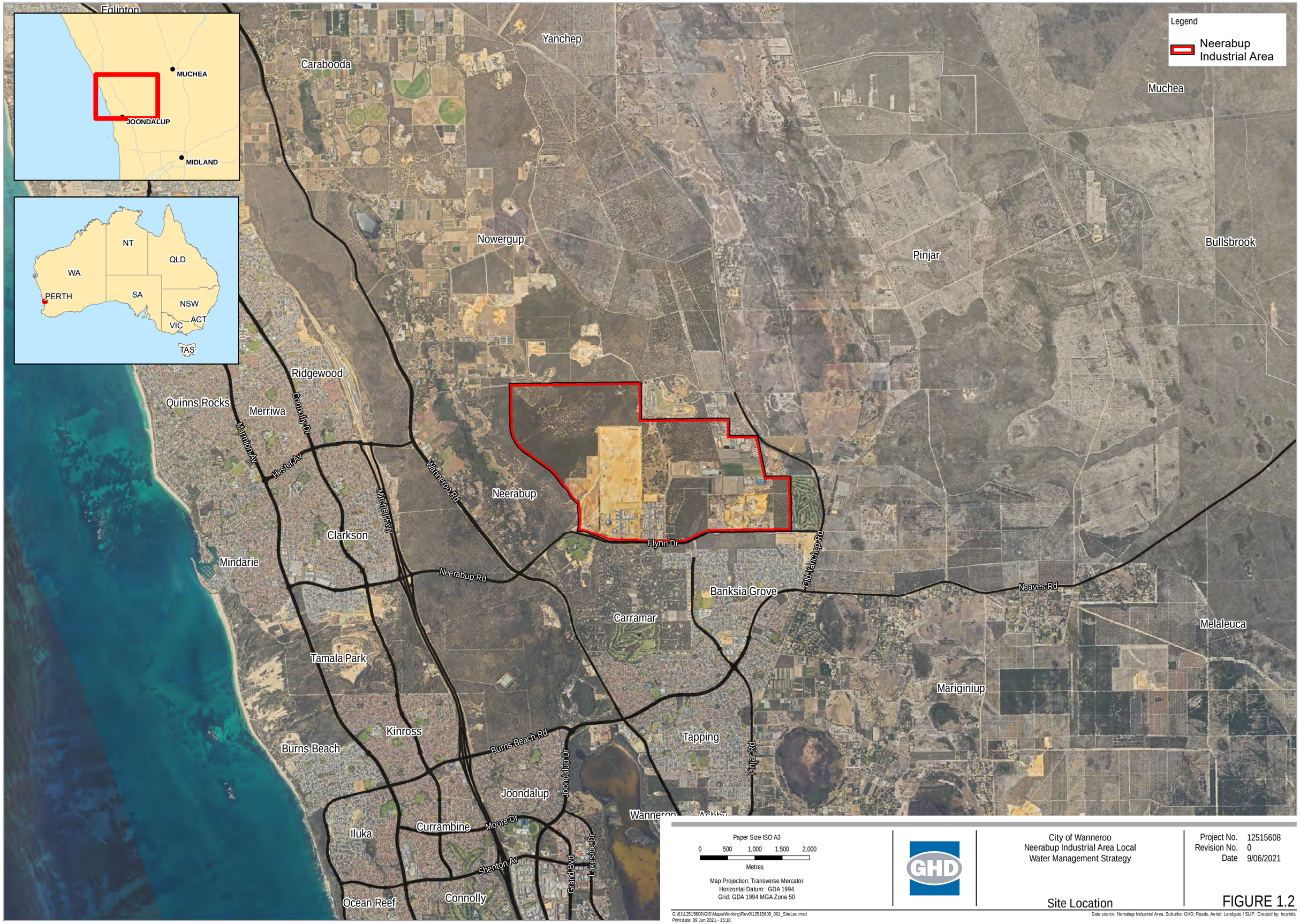


Paper Size ISO A3

0 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

City of Wanneroo
Neerabup Industrial Area Local Water Management Strategy

Site Location

Project No.	12515608
Revision No.	0
Date	9/06/2021

FIGURE 1.2

G:\61\12515608\GIS\Maps\Working\Rev0\12515608_001_SiteLoc.mxd
Print date: 09 Jun 2021 - 15:10

Data source: Nerrabup Industrial Area, Suburbs: GHD; Roads, Aerial: Landgate / SLIP. Created by: hcariola

DRAFT MASTERPLAN
NEERABUP INDUSTRIAL AREA

WATTLE AVE WEST
WATTLE AVE EAST
OLD YANCHEP ROAD
SUBJECT TO FUTURE PLANNING
TRANDOS ROAD
NEERABUP POWER STATION
ORCHID ROAD
FUTURE HWY
OLD YANCHEP ROAD
PEDERICK ROAD
PEDERICK ROAD
PEDERICK ROAD
PUMP STATION
GREENWICH PARADE
PINNACLE DRIVE
MATHER DRIVE
35m STREET
ZIATAS ROAD
OLD YANCHEP ROAD
FLYNN DRIVE
WANNEROO ROAD
FLYNN DRIVE
NEERABUP ROAD
800 m
400 m
200 m
N
0 500 m 1000 m 1500 m

LEGEND

- INDUSTRIAL ARTERIAL B (41.2-57m) 15,000-35,000 vpd 70km/h
- INDUSTRIAL CONNECTOR- (42m) >8000vpd
  CAPS ROAD SUBJECT TO FUTURE DETAILED PLANNING INVESTIGATION
- INDUSTRIAL CONNECTOR (40m) >8000vpd
- INDUSTRIAL CONNECTOR (35m) >8000vpd 60km/h
- EXISTING INDUSTRIAL ACCESS STREET(20-25m) 60km/h
- EXAMPLE INDUSTRIAL ACCESS STREET(20-25m) 60km/h
- INDICATIVE FUTURE RAIL LINE ALLIGNMENT SUBJECT TO REVIEW
- STRUCTURE PLAN AREA
- PROPOSED ROBOTICS (NARP) PRECINCT (INDICATIVE)
- EXISTING POS / DRAINAGE / CONSERVATION AREA
- OPEN SPACE / LANSCAPE BUFFER
- GENERAL INDUSTRIAL (GENERAL INDUSTRY)
- SERVICE INDUSTRIAL (LIGHT INDUSTRY)
- EXISTING INFRASTRUCTURE
- INDICATIVE EXISTING GAS PIPELINE ALIGNMENT
- INDICATIVE DRAINAGE BASIN
- SERVICE HUB (SERVICE COMMERCIAL ZONE)
- FURTHER INVESTIGATION REQUIRED FOR ROAD ALIGNMENT AND EXISTING POWER POLES
- PROPOSED ROUNDABOUT

NOTES: 1- PTA WILL CONSTRUCT AND FUND ANY GRADE SEPARATIONS OVER RAIL LINES WHERE A ROAD IS IN-SITU. WHERE THE ROAD IS CONSTRUCTED AFTER THE RAIL LINE, DEVELOPER IS REQUIRED TO FUND.
2- INDUSTRIAL ARTERIAL AND CONNECTOR ROADS TO FACILITATE MINIMUM RAV4 ACCESS.

Figure 1.3
NIA Master Plan

2. Proposed development

2.1 The strategy area

The strategy area has well drained soils and no surface water features within its boundary. In its pre-development state all rainfall infiltrates to groundwater within the strategy area boundary. Groundwater is at considerable depth across the majority of the strategy area.

Planning has progressed in parts of the strategy area and this document has incorporated information from these development areas where available to ensure a consistent and coherent approach to drainage planning and associated arterial flood management, and management of risks to sensitive environmental receptors that occur adjacent to the strategy area boundary.

2.2 Existing land use

The majority of the western and northern portion of the strategy area is currently undeveloped, with some areas retaining remnant vegetation and some lots subject to development approvals for extractive industry, resulting in clearing of vegetation. Existing light industrial development is primarily centred around the Mather Drive Industrial Area and Meridian Park Industrial Estate. Undeveloped lots occur throughout the remainder of the NIA, interspersed with existing land uses.

Existing land use is characterised by large scale natural resources extraction, transport and heavy industry through to a range of light industrial/showroom uses and agricultural activities.

The extractive industry within the NIA is associated with its 'Priority Resource' classification as part of SPP 2.4 (Section 1.3.3).

Based on the Landowners Intentions Surveys included in ASP 17 the intensive agricultural lots have previously included poultry farming, turf farms and market gardens (TBB *et al.* 2017).

The NIA Economic and Employment Strategy Report (GHD 2020a) identifies the following key land use planning floorspace types currently operate in the strategy area:

- Manufacturing, Processing and Fabrication,
- Storage and Distribution
- Utilities and Communications,
- Office and Business floorspace,
- Service Industry, and
- Primary and Rural (expected to diminish as more intensive industrial activities occur).

Existing public open space and amenity within the strategy area is limited, with existing drainage comprising sumps.

2.3 NIA development

2.3.1 Proposed land use

The NIA is expected to be an important future driver of employment within the City of Wanneroo, with around 1,000 hectares of predominantly general industrial land. Recognising environmental constraints including conservation and Bush Forever sites, around 600 hectares of this total area is believed to be developable as industrial employment lands.

The Economic and Employment Strategy report (GHD 2020a) identifies an industrial land use composition that includes a wide range of land use activities including:

- General Industrial: including manufacturing, processing and fabrication
- Storage and distribution
- Service Industrial: wide range of light industries, showrooms and warehouses, entertainment and recreational activities
- Offices
- Business: service uses such as banks, local shop, newsagent
- Shop and retail
- Other retail

2.3.2 Development timeframes

The Neerabup Industrial Area Economic and Employment Strategy Report (GHD 2020) identifies land development build out over a period of 50 years. This timeframe is based on discussion with key landholders including City of Wanneroo and Development WA, and in recognition of expected short term demand for industrial land and other drivers.

In accordance with SPP 2.4 staging of land uses should be sequenced following extraction of the basic raw materials (Section 1.3.3). Staging is proposed around provision of essential infrastructure and services to ensure cost-effective development to meet demand for industrial floorspace (GHD 2020).

2.3.3 Final Surface Contour Plan

The Final Surface Contour Plan (Appendix C) identifies the final surface levels which must be achieved prior to subdivision and/or development on-site.

The Final Surface Contour Plan (dated 7/06/2017) was refined by LandCorp in association with the Department of Mines and Petroleum (DMP), with consideration of the anticipated extent of sand and limestone extraction (Section 1.3.3).

3. Design criteria

Water management objectives, design criteria and strategies for the NIA industrial estate have been developed with reference to current water management policy and planning guidance (Section 1.3.4 and 1.3.5), site specific studies (Section 1.4) and key characteristics of the strategy area and its surrounds (Section 2 and 4).

The design and management objectives proposed are consistent with key guidance documents including the City of Wanneroo *Local Planning Policy 4.4: Urban Water Management, Decision process for stormwater management in Western Australia* (DWER 2017), *Better Urban Water Management* (WAPC 2008) and have been developed with regard to *Developing a Local Water Management Strategy* (DoW 2008a).

The design and management objectives are summarised in Table 3-1, which also identifies the section/s of this LWMS that summarise strategies to address the criteria and objectives.

Table 3-1 NIA design criteria and management objectives

Category	Design criteria and management objective	Section of LWMS
Water conservation and efficiency	Use fit-for-purpose water sources throughout the development.	Section 5
	No potable water use outside of buildings.	
	For in-building potable uses, achieve a total water consumption target of 110 kL/person/yr.	
	Implementation of waterwise practices across the estate including water harvesting (rainwater tanks plumbed to toilets and irrigation) and installation of water efficient fixtures and fittings.	
	Landscaping will follow waterwise guidelines, including hydrozoning principles with a reduced irrigation rate of 6,750 kL/yr (average rate across all irrigated areas).	
Stormwater quantity	Detain flows up to the 1% AEP within the boundary of each lot to maintain pre-development water balance.	Section 6.1
	Detain flows up to the 1% AEP within the development boundary to maintain pre-development water balance.	
	Provide unobstructed conveyance for the major event through the road network system to flood storage basins.	
	Protect people and property from flooding by constructing commercial and industrial building habitable floor levels with the following minimum clearances above the 1 % AEP flood level:	

	• road drainage systems: 0.3 metres • terminal retention or detention areas with no overflow relief: 0.5 metres • special facilities such as Western Power infrastructure and emergency services facilities: 1 metre	
	Minor roads are to be designed to remain passable in the 10% AEP event (or 10-yr ARI), and major roads to remain passable in the 1% AEP (or 100-yr ARI) event.	
Stormwater quality	Retain stormwater runoff from the minor rainfall event at-source as much as practical.	Section 6.2
	Size bioretention areas to at least 2% of the connected impervious area.	
	Use a combination of non-structural and structural controls in a treatment train to prevent, reduce and treat pollutants.	
	Compliance to *Water Quality Protection Note 52, Stormwater Management at Industrial Sites* (DoW, 2010)	
Groundwater management	Maintain or improve groundwater quality.	Section 7
	Treat first 15 mm of all stormwater runoff events before infiltration.	
	Establish development levels with acceptable clearance above post development groundwater levels.	

4. Site characteristics

4.1 Climate

Neerabup has a Mediterranean climate with hot dry summers and cool, wet winters. The Bureau of Meteorology (BoM) Perth Metro station (site number 009225) is the nearest weather station to the project area with continuous long-term data (27.5 km from project area). Climatic data from this station indicates the mean maximum temperature of the area ranges from 18.4°C in July to 31.6°C in February and the mean minimum temperature ranges from 7.9°C in July to 18.3°C in February. The mean annual rainfall is 733.2 mm with an average of 80.1 rain days per year (BoM 2019). Climate statistics are summarised in Figure 4-1.

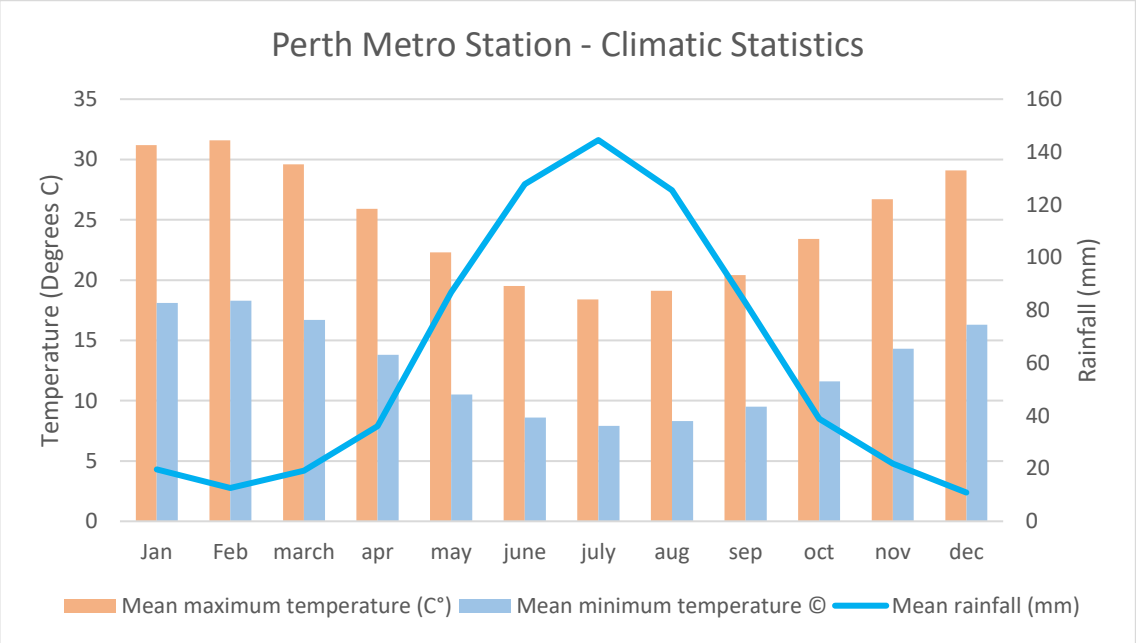


Figure 4-1 Mean climate statistics for Perth Metro (BoM 2019)

4.2 Geotechnical conditions

4.2.1 Landforms and topography

The existing pre-extraction landform of the NIA comprises undulating coastal Quindalup and Spearwood dunes. Natural surface elevation range from 44 m in the north-east of the Site near Trandos Road, with localised peaks ranging between 60 to 96 m Australian Height Datum (AHD) coinciding with dunal ridges (Figure 4-2).

The Final Surface Contour Plan for the NIA area depicts the final surface levels that must be achieved prior to subdivision and/or development of the site (Section 1.3.3, Appendix C).

4.2.2 Soils and geology

The NIA resides on the Swan Coastal Plain in the Costal Belt between the Indian Ocean and the Bassendean Dunes (GSWA 1978). The Coastal Belt is characterised by a belt of calcareous dunes and kankar overlying calcarenite and limestones, primarily Tamala Limestone. Figure 4-2 shows the surface geology of the NIA. The GSWA 250k Geology Map Series (Figure 4-3) identifies the NIA as coastal limestone (Qpck to the west and Qpcs to the east). To the west of the NIA lies an area of swamp and lacustrine deposits (Qrw) and further west still are areas of Safety Bay Sand (Qrs) adjacent to the coastline. Immediately adjacent to the east of the NIA lies the Bassendean Sand (Qpb) interspersed with areas of swamp and lacustrine deposits (Qrw).

Geotechnical investigations completed for lots within and adjacent to the NIA () typically identified uniform profile comprising deep sands with high permeability (5.9 to 37 m/day), with a summary overview of the various studies provided in Table 4-1 and location of investigation areas shown in Appendix D.

The Department of Water and Environment Regulation (DWER) have several deep groundwater monitoring bores predominantly distributed around the perimeter of the NIA. Lithology and stratigraphy logs are available for some of these bores in the Water Information Reporting database, and review of these logs identifies the site is underlain by sand through the majority of the profile (refer summary of logs in Appendix F, and bore locations in Figure 4-7).

4.2.3 Acid sulfate soils

Department of Water and Environmental and Regulation (DWER) Acid Sulphate Soil (ASS) risk mapping indicates no known risk of ASS at the site. The soils of Lake Neerabup and Lake Pinjar, located to the west and north-east respectively, are classified as a high to moderate risk of ASS (Figure 4-2).

No ASS were identified during site investigations of Lot 9100 Mather Drive (Perth Geotechnics 2019).

4.2.4 Karst

Karst risk in the NIA area is reviewed in Appendix D. This section provides a summary of the karst risk review.

The karst risk map provided in City of Wanneroo Local Planning Policy 4.13: Caves and Karstic Features (LPP 4.13) identifies zones of risk related to the presence of karst based on information provided by the Western Australian Speleological Group. The karst risk map (Figure 4-4) identifies the western boundary of the NIA as being in medium risk and being adjacent to high risk. The land to the north and east of the WA Limestone Quarry is considered low risk.

Figure 4-5 shows the contamination risk based on hydrogeological factors (Davidson 1995) which confirms the presence of potential high risk karstic areas lying adjacent to the western boundary of the NIA, and high risk areas along the eastern boundary due to shallow groundwater conditions.

Based on the available mapping the NIA is mapped as medium to low karst risk (west to east, Figure 4-4 and Figure 4-5).

In accordance with the Provision 2.5 of LPP 4.13 karst risk should be considered across the NIA, with particular focus in areas identified as medium karst risk in the western section of the NIA (as a minimum Lot 801(410) Flynn Drive (previously Lot 503), Appendix A). Detailed geotechnical investigations should be completed across all sites to assess karst risk. Geophysical survey using ground penetrating radar (GPR) should be considered following completion of resource extraction to maximise its effectiveness due to the limitations associated with GPR and the depth of potential karsts.

Table 4-1 Summary site geotechnical conditions

Geotechnical investigation	Lot reference	Overview of investigation	Key findings
Lots within NIA			
Preliminary Geotechnical Investigation Lot 22 Flynn Drive Neerabup (Golder 2007)	Lot 22 Flynn Drive (southern part of current Lot 9006, DevelopmentWA)	Preliminary geotechnical investigation of areas used as sand and limestone quarry. Site investigation comprising: - 21 Test Pits - 5 air cored boreholes to 7.5 to 10.5 m depth - 3 infiltration tests	Site investigations identified: - Typically homogenous sands (0.1 to 6m deep) overlying limestone, with a few exceptions where fill was encountered (TP16, TP01, BH02). - Groundwater not encountered during the investigation. - Infiltration testing identified values varying between 7 and 37 m/day. - Limestone may act as a confining layer and therefore shallow limestone may require special consideration during stormwater design.
Geotechnical and Hydrogeological Investigation; Neerabup Industrial Estate (Talis 2017)	Lot 9003 Lot 2001	Site investigation comprising: - 5 groundwater bores - 8 soil bores	Site investigations identified typically homogenous sands to depth for majority of groundwater and soil bores. Exceptions include: - Shallow clayey silt sand (4 to 6 mBGL) followed by moderately hard cemented limestone layer at depth of 7 mBGL (SB01, SB02) - Poorly cemented limestone at depth of 15 mBGL (GW03) - Layer of gravelly sand at depth of 4.5 mBGL (GW04).
Extractive industries License Application; Lot 503 Flynn Drive Neerabup (Phase 1 Area), (Peritas, 2019)	Lot 503 (current Lot 801 Flynn Drive, DevelopmentWA)	Desktop investigation	Desktop assessment to support extractive licence for sand and limestone with key summary information including: - Resource lies on a ridge of Tamala Limestone that extends north south. - Pillars of limestone are common, separated by deep yellow sand, and are the main landform of the ridge. - There is no evidence of karst features in the existing existing adjoining quarry east of Lot 503 or south of Flynn Drive. - Surface sand overlying a pale brown to off white, weakly to well cemented limestone comprised of fine to medium grained sand in a calcareous matrix.
Geotechnical site investigation report Lot 9100 (60) Mather Drive, Neerabup WA (Perth Geotechnics 2019)	Lot 9100 (60) Mather Drive	Site investigation comprising: - 34 Test Pits - 7 Guelph permeability tests - ASS sampling from 6 Test Pits	Site investigations identified: - Test Pits (typically to a depth of 3m) revealed generally homogenous soil profile conditions across the site comprising fine to coarse grained yellow orange sand. - No groundwater intercepted in Test Pits. - Saturated field hydraulic conductivity ranged between 5.9 and 7.4 m/day. - Inferred Potential ASS risk is low to medium.
Geotechnical Investigation; Meridian Park Stage 5A – Flynn Drive Neerabup WA (Structerre 2021)	Lot 9006	Site investigation comprising: - 5 Electric Friction Cone Penetrometer Tests (EFCPT) to 8m depth - 10 sample retrieval probe boreholes to 2.5m depth - 5 in-situ constant head permeameter tests.	The results of the EFCPT identified: - Natural sands consistent with mapped site conditions (sand derived from Tamala Limestone). - Fill encountered over parts of the site. - Results of desktop assessment and EFCPT results infer no evidence of potential Karst. - Groundwater not encountered in any boreholes. - Permeability tests ranged between 2.9 m/day and 5.9 m/day.
Lots adjacent NIA			
Former Pinjar Landfill; Groundwater Delineation Investigation (Coffey 2016)	Old Pinjar Tip site and motorcross site located to the east of Lot 1506	Site investigation to delineate potentially contaminated groundwater	Bore logs for six groundwater bores identified sand throughout the profile to depths of between 5.8 and 9.78 mBGL
Note: Lot reference refers to lot numbers identified in Appendix A, with locations shown in Appendix D.			

4.3 Contaminated sites

A search of the DWER Contaminated Sites Database identifies the former landfill site located at Lot 503 (1851) Old Yanchep Road, Pinjar, is classified as *Contaminated – restricted use* (Figure 4-2). The Basic Summary of Records Search Response for the site notes the following:

The groundwater impact is present as a leachate plume that extends at least 60 m west off-site and 270 m south-west off-site beneath 100 Pederick Road, Neerabup, which has been classified separately under the Act. With respect to the former landfill site the NIA ASP 17 (TBB et al. 2017) identifies the following:

> *There is an abandoned putrescible landfill site located immediately east of Pinjar Road below which a plume of leachate is spreading west towards the NIA (City of Wanneroo, pers. comm.). The landfill was previously operated by the City of Wanneroo and has been closed since the mid-eighties. Sampling of groundwater quality has been undertaken, and it is estimated that the leachate plume may extend as far west as Orchid Road (City of Wanneroo, pers. comm.). The presence of the plume should not prevent most industries from operating within the NIA, as the estate should be serviced with reticulated water, however it does present an issue of future liability for the future industries. This liability will need to be fully disclosed between the industries, landowners/developers and the City of Wanneroo.*

A groundwater delineation investigation was conducted by Coffey Environments Australia for the City of Wanneroo at the former Pinjar Landfill site (Coffey 2016). Results indicated heavy metals and nutrients present within the groundwater beneath the former landfill site and to the western boundary of the site were present in elevated concentrations. Monitoring locations down gradient of the source presented a half order decrease in the magnitude of the measurable concentrations of nutrients (total nitrogen and phosphorus). Given the down gradient concentrations, the Coffey report states that it would be unlikely that the nutrient rich water would extend beyond sample locations that are located down gradient (Coffey 2016).

Potentially affected land should be managed via a memorial on Certificates of Title (Coffey 2016). ASP 17 identifies land that may potentially be affected by the leachate plume from Pinjar Tip Site (refer ASP 17 Figure 5.1, TBB *et al.* 2017). ASP 17 further notes that potentially affected land shall have conditions imposed on any development approval and recommended on any subdivision application to ensure prospective purchasers of land or development are appropriately informed of the potential impacts of the plume.

Some current and historic intensive agricultural activities within the NIA have the potential to result in contamination from the use of fertilisers, pesticides and herbicides. Prior to a change in land use from the current activity a Preliminary Site Investigation (PSI) may be required to assess potential contamination (Section 8.3.3).

4.4 Environmentally sensitive areas

DWER mapping of environmentally sensitive areas is presented in Figure 4-6.

4.4.1 Threatened ecological communities

Floristic Community Type 20a, which is a Threatened Ecological Community, occurs within Lot 8001 which forms part of the Mather Reserve Conservation Area (Appendix A).

4.4.2 Bush Forever

Bush Forever Bush Forever sites were originally identified by the Government of Western Australia in 2000. They are a key component of the environmental infrastructure within the Perth

Metropolitan Area and are a key element in moving towards achieving an ecologically sustainable city.

Bush Forever sites are classified as Environmentally Sensitive Areas under Regulation 5 of the Environmental Protection (Clearing of Native Vegetation) Regulations 2004, with mapping of Bush Forever sites within and adjacent to the NIA is presented in Appendix E.

4.5 Aboriginal heritage

A search of the Department of Planning, Lands and Heritage Aboriginal Heritage Inquiry System did not identify any registered heritage sites within the strategy area. The search identified one 'Other Heritage Place' that occurs along the western boundary of the site (Lake Neerabup, ID 3693) (Figure 4-6).

A registered heritage site 'Orchestra Shell Cave' (Site 4404) intersects the Lake Neerabup site, and located approximately 400 m west of the north-west boundary of the strategy area.

4.6 Surface water

4.6.1 Wetlands

No wetlands occur within the strategy area. Geomorphic wetland mapping identifies two wetlands adjacent the strategy area boundary, Lake Neerabup to the west and Lake Pinjar to the north-east (Figure 4-7).

Lake Neerabup is identified as a resource enhancement category wetland. Lake Pinjar is identified as a mixture of Conservation and Multiple use category wetland. Both Lake Neerabup and Lake Pinjar are sumplands, which are seasonally waterlogged and contain water usually only during the winter months. The wetlands form part of a regionally significant north-south aligned wetlands that occur within the City of Wanneroo.

The nearby wetlands are largely protected within the Parks and Recreation reservation under the Metropolitan Region Scheme (MRS).

Davidson and Yu (2008) note that along the coastal limestone belt the maximum water level in some lakes is believed to be controlled by cavernous limestone that acts as spillways, however this has not been verified. Lake Neerabup was identified by Strategen to be maintained by groundwater flow and will be sensitive receptor to works effecting groundwater infiltration in the vicinity of the NIA (Strategen 2008).

Given the pervious nature of the soils and potential for karst along the western boundary of the NIA it is important that development is managed to ensure there are no impacts on these wetlands.

4.6.2 Water dependant ecosystems

Groundwater dependent ecosystems (GDE) are often associated with karstic environments as aquatic and terrestrial ecosystems can form from subterranean cave systems. Figure 4-8 shows the potential for both aquatic and terrestrial GDE's near the NIA. The figure shows a low potential for terrestrial GDE's based on vegetation across parts of the north west and south east of the NIA. There are no aquatic GDE's in the NIA boundary, with the closest being Lake Pinjar to the north east and Neerabup Lake to the west.

4.6.3 Surface water drainage

The NIA is located within the Swan Avon, Lower Swan Catchment within the Swan Coastal river basin. However, due to the high transmissivity of the soils there are no defined surface water drainage features.

4.6.4 Stormwater drainage

Parts of the NIA area have been developed as industrial land including the established Mather Drive Industrial Area and developing Meridian Park Industrial Estate.

Stormwater drainage within the existing Mather Drive Industrial Area comprises pits and pipes for road drainage with stormwater directed to drainage sumps. An overview of the drainage includes:

- There is some existing flooding within the Mather Drive industrial area, centred around Turnbull Road. Flooding issues likely a result of the development that has altered the local drainage, with the Turnbull Road sump (sited at the rear of a developed lot) not receiving intended road drainage, and parts of the existing V drain along Turnbull Road filled and replaced by carparking. The City of Wanneroo have installed additional soakwells in the Turnbull Road reserve to alleviate the flooding issue.
- The Mather Road Sump receives pit and pipe drainage from Warman Street. This sump has recently been expanded and is identified as a critical sump for the NIA with further opportunity to expand within the lot.
- An existing basin on Pederick Road occurs within DevelopmentWa land. Runoff from Pederick Road is directed to V drains in road reserve.

Parts of the Meridian Park Industrial Estate have also been progressively developed. Existing stormwater drainage within these areas comprises retention of on-lot drainage, and direction of stormwater runoff from road catchments and shared infrastructure to drainage basins. An existing drainage basin occurs at the corner of Axis Parade and Longitude Avenue. Temporary sumps occur outside of stage boundaries where the drainage will be directed to future basins.

Outside of the existing industrial areas the road runoff drains to road reserve where it is infiltrated at source. Existing basin locations are presented on Figure 6-1.

4.7 Groundwater

The NIA is located within the Gnangara Groundwater System, and locally within the Wanneroo groundwater subarea.

4.7.1 Groundwater flow

The predominant regional groundwater flow direction is generally considered to be westerly beneath the NIA, attributed to the high transmissivity of the soils and also the relatively steep gradient in Average Annual Maximum Groundwater Levels (AAMGLs) (Planwest *et al*., 1999).

Groundwater in proximity to Lake Pinjar may be locally influenced by the lake (Coffey 2016), with Talis (2017) reporting that Lake Pinjar acts as the local basin and controls local groundwater flow.

4.7.2 Groundwater levels

DWER Perth Groundwater Map indicates historical maximum groundwater levels (MGL) across NIA range from 45 mAHD in proximity to Lake Pinjar and the eastern boundary and 24 mAHD in the west of the Site near Lake Neerabup, in agreement with the westerly regional groundwater flow direction (Figure 4-7). The Water Information Reporting database identify several long term DWER groundwater monitoring bores distributed around the NIA (Figure 4-7). A summary table of the DWER groundwater bore construction, lithology, maximum groundwater levels and depth to groundwater from natural surface is provided in Appendix F. Appendix F also includes timeseries plots of the observed groundwater levels for these bores, which further demonstrate the decline in groundwater level since monitoring commenced. Stabilisation or minor upward

trend in groundwater level in a few bores is attributed to change in land use, including clearing of native vegetation for development (urban and industrial).

The proposed change in land use, including removal of vegetation and development of industrial land, is predicted to result in localised increase in groundwater recharge, and potential groundwater level rise (Peritas 2018). This is further discussed in Section 7.1.

4.7.3 Groundwater quality

DWER long term groundwater monitoring bores have limited groundwater quality data primarily comprising physico-chemical parameters and inorganic parameters including major cations and anions. The data is predominantly historic (1978-1995), with a single sample for limited parameters from bore 61610665 from 2016. A summary table of the range of values and count (number of samples) for the long term groundwater bores with groundwater quality data is provided in Appendix G. The historic data identify that the groundwater quality is typically neutral to marginally acidic, generally fresh and

Due to the depth to groundwater across the NIA local groundwater quality data is limited. Targeted groundwater investigation shave been completed for parts of the NIA, which have identified elevated concentrations of some parameters. These include:

- The Old Pinjar Landfill site to the north-east of the NIA. A groundwater delineation investigation of the former Pinjar Landfill site indicated elevated nutrients and metals beneath the former landfill site, however a significant decline in down-gradient bores towards the NIA boundary (Coffey 2016) (Section 4.3).
- Significantly elevated nitrate concentrations have reported in the Lake Neerabup area (maximum nitrate concentration of 280 mg/L), which have been attributed to the intensive irrigated horticultural area along the western boundary of the wetland (Yesertener 2010).

It is considered that in parts of the NIA the change in land use from horticulture to industrial, business and service has the potential to reduce leaching of nutrients and other agricultural chemicals (e.g. herbicides and pesticides) to sensitive groundwater and water dependent ecosystems.

4.7.4 Groundwater allocation

Groundwater allocation in Western Australia is regulated by DWER. For allocation purposes, aquifers are divided into specific groundwater areas and subareas. Each aquifer and groundwater subarea has a volume allocation for licencing purposes. In general, a licence to abstract (5C licence) will not be issued for areas that are fully allocated.

The NIA Is located within the Wanneroo groundwater area, with management of the groundwater resource in the area undertaken in accordance with:

- *Rights in Water and Irrigation Act 1914*
- *Gnangara groundwater areas allocation plan* (DoW 2009) (currently under revision)
- *Policy: Management of unused licence water entitlements* (DWER 2019)

The *Gnangara groundwater areas allocation plan* (DoW 2009a) is currently being revised including setting of new aquifer allocation limits to ensure sustainable groundwater supply and management of environmental values.

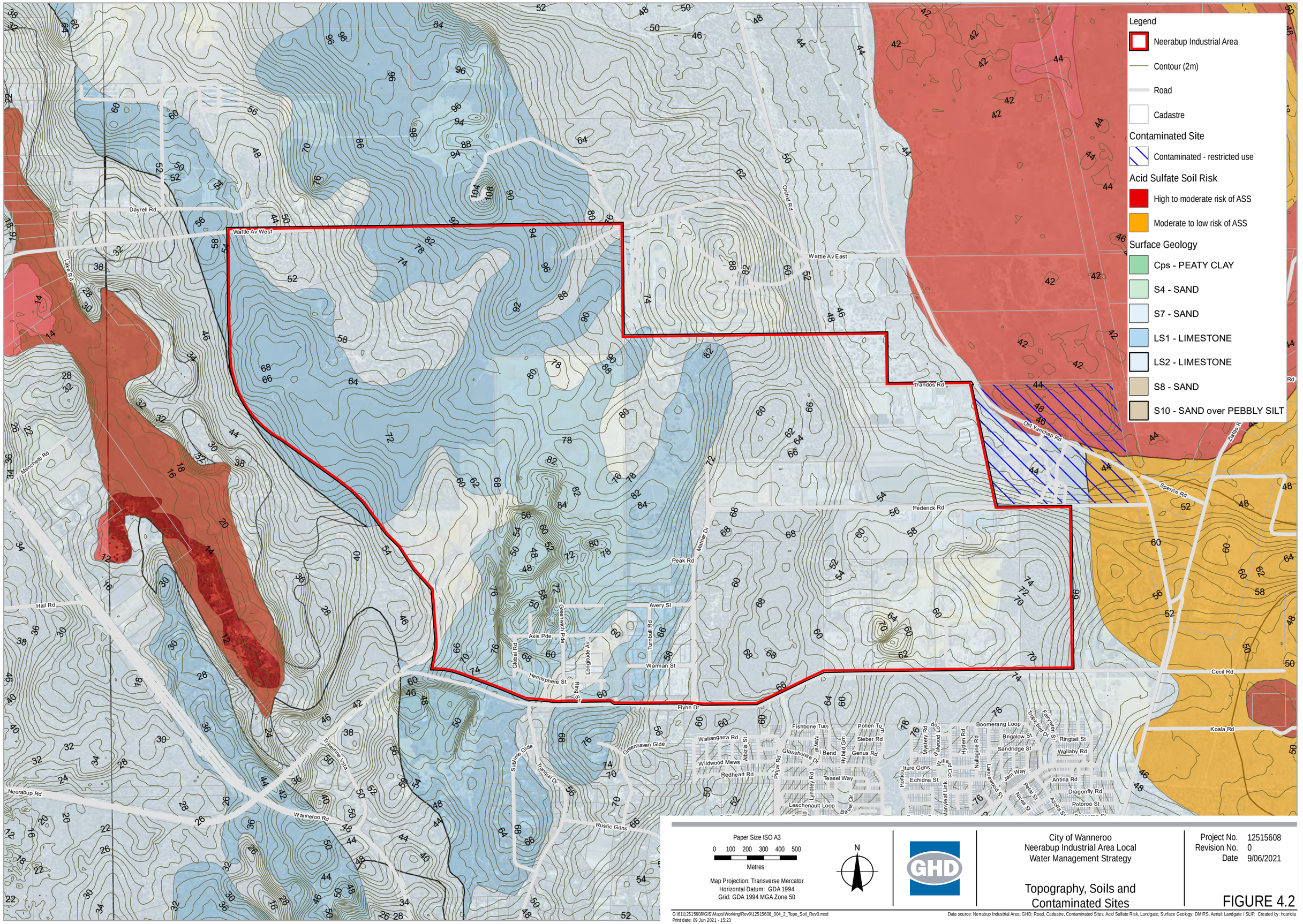
The DWER Water Register identifies that all aquifers within the Wanneroo groundwater area are fully allocated. Existing water licences in the NIA are shown in Figure 4-7 and summarised in Appendix H. All existing licenses are within the Superficial Swan aquifer, with large licensed

abstractions associated with existing horticulture and market gardens, the Neerabup Power Station and the Wesbeam manufacturing facility.

Groundwater allocation and trade/transfer of existing licenses is further discussed Section 5.2.2.

4.7.5 Public drinking water source areas

The Gnangara Underground Water Pollution Control Area, P1 area is located to the east and north-east of the NIA (Figure 4-7). The P1 area occurs in the vicinity of Lake Pinjar, and it is noted that there is potential for groundwater levels to be locally influenced by the lake (Section 4.7.1), and therefore land use planning should restrict potentially polluting industries in proximity to the lake, and with regard to identified contamination risk zones (Figure 4-5).


Legend
Neerabup Industrial Area
Contour (2m)
Road
Cadastre
Contaminated Site
Contaminated - restricted use
Acid Sulfate Soil Risk
High to moderate risk of ASS
Moderate to low risk of ASS
Surface Geology
Cps - PEATY CLAY
S4 - SAND
S7 - SAND
LS1 - LIMESTONE
LS2 - LIMESTONE
S8 - SAND
S10 - SAND over PEBBLY SILT
Dayrell Rd
Wattle Av West
Wattle Av East
Lake Rd
Menchetti Rd
Trandos Rd
Old Yanchep Rd
Spence Rd
Pederick Rd
Mather Dr
Orchid Rd
Peak Rd
Hall Rd
Avery St
Axis Pde
Global Rd
Greenwich Pde
Longitude Ave
Turnbull Rd
Warman St
Hemisphere St
Flynn Dr
Cecil Rd
Koala Rd
Neerabup Rd
Wanneroo Rd
Travertine Vista
Sublime Glde
Tranquil Dr
Greenhaven Glde
Rustic Gdns
Wallangarra Rd
Wildwood Mews
Redheart Rd
Leschenault Loop
Fishbone Turn
Pollen Turn
Sieber Rd
Genus Rd
Boomerang Loop
Brigalow St
Sandridge St
Ringtail St
Wallaby Rd
Antinna Rd
Dragonfly Rd
Potoroo St
Echidna St
Teasel Way
Paper Size ISO A3
0 100 200 300 400 500
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
City of Wanneroo
Neerabup Industrial Area Local
Water Management Strategy
Topography, Soils and Contaminated Sites
Project No. 12515608
Revision No. 0
Date 9/06/2021
FIGURE 4.2
G:\61\12515608\GIS\Maps\Working\Rev0\12515608_004_2_Topo_Soil_Rev0.mxd
Print date: 09 Jun 2021 - 15:23
Data source: Nerrabup Industrial Area: GHD; Road, Cadastre, Contaminated Sites, Acid Sulfate Risk, Landgate; Surface Geology: DMIRS; Aerial: Landgate / SLIP. Created by: hcariola

Legend

Neerabup Industrial Area

Qpb - Bassendean Sand: quartz sand

Qpck - Coastal Limestone: predominantly calcarenite and kankar

Qpcs - Costal Limestone: predominantly quartz sand

Qrw - Swamp and Lacustrine deposits: peat, peaty sand and clay

Qpck

Qrw

Qpck

Qpcs

Qrw

Qpcs

Qpb

Qrw

Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 50

N

GHD

City of Wanneroo
Neerabup Industrial Area
District Planning Study

Geology Map

Project No. 12515608
Revision No. 0
Date 21/01/2021

FIGURE 4.3

G:\61\12515608\GIS\Maps\Working\12515608_004_3_Geology_RevA.mxd
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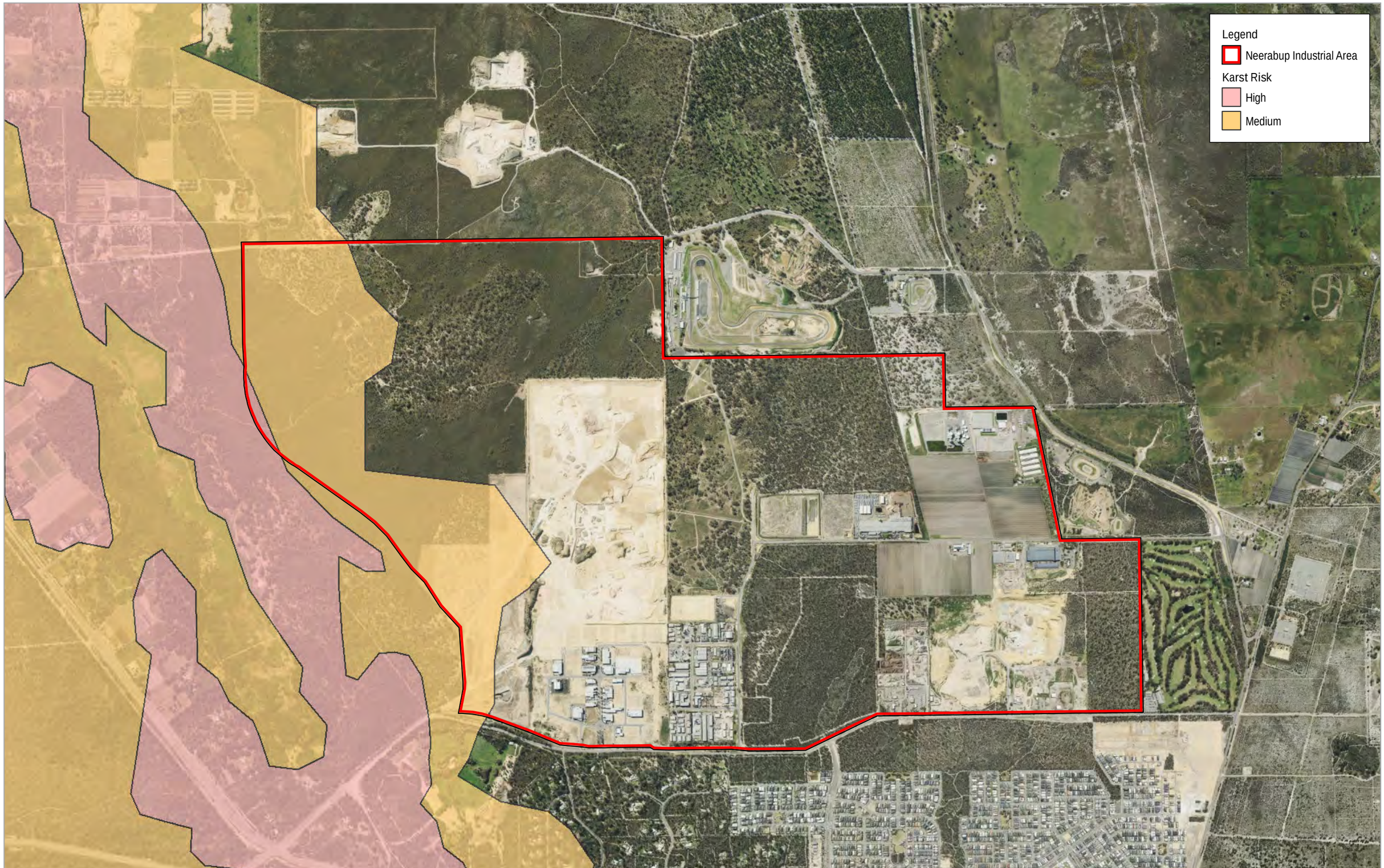
Data source: Nerrabup Industrial Area: GHD; Geology: DMIRS; Roads, Aerial: Landgate / SLIP. Created by: kaadams



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

City of Wanneroo
Neerabup Industrial Area
District Planning Study

Karst Risk Map

Project No. 12515608
Revision No. 0
Date 5/12/2019

FIGURE 4.4

G:\61\12515608\GIS\Maps\Working\12515608_004_4_Karst_RevA.mxd
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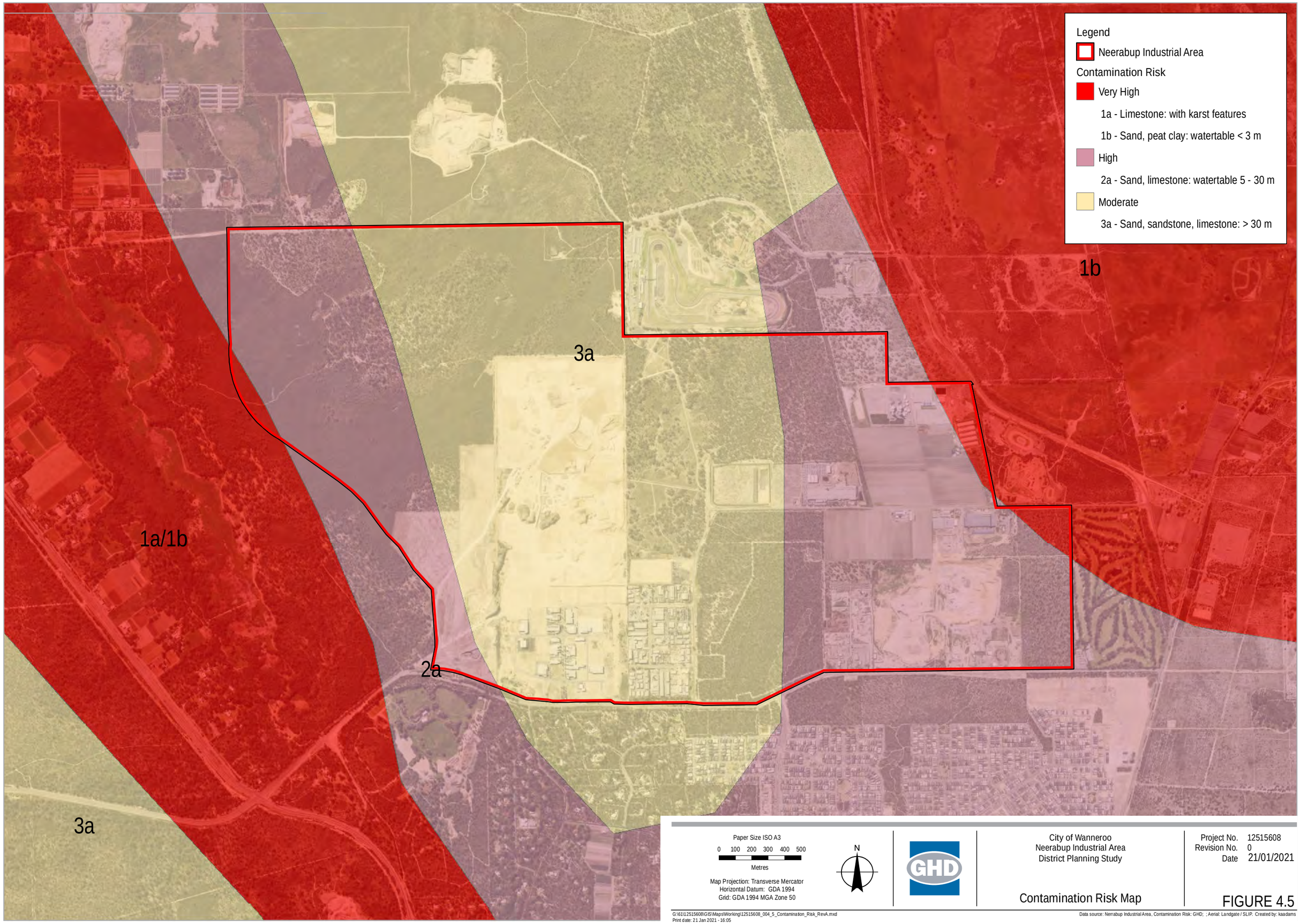
Data source: Nerrabup Industrial Area, Karst Risk: GHD; Aerial: Landgate / SLIP. Created by: kaadams



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

City of Wanneroo
Neerabup Industrial Area
District Planning Study

Contamination Risk Map

Project No. 12515608
Revision No. 0
Date 21/01/2021

FIGURE 4.5

G:\61\12515608\GIS\Maps\Working\12515608_004_5_Contamination_Risk_RevA.mxd
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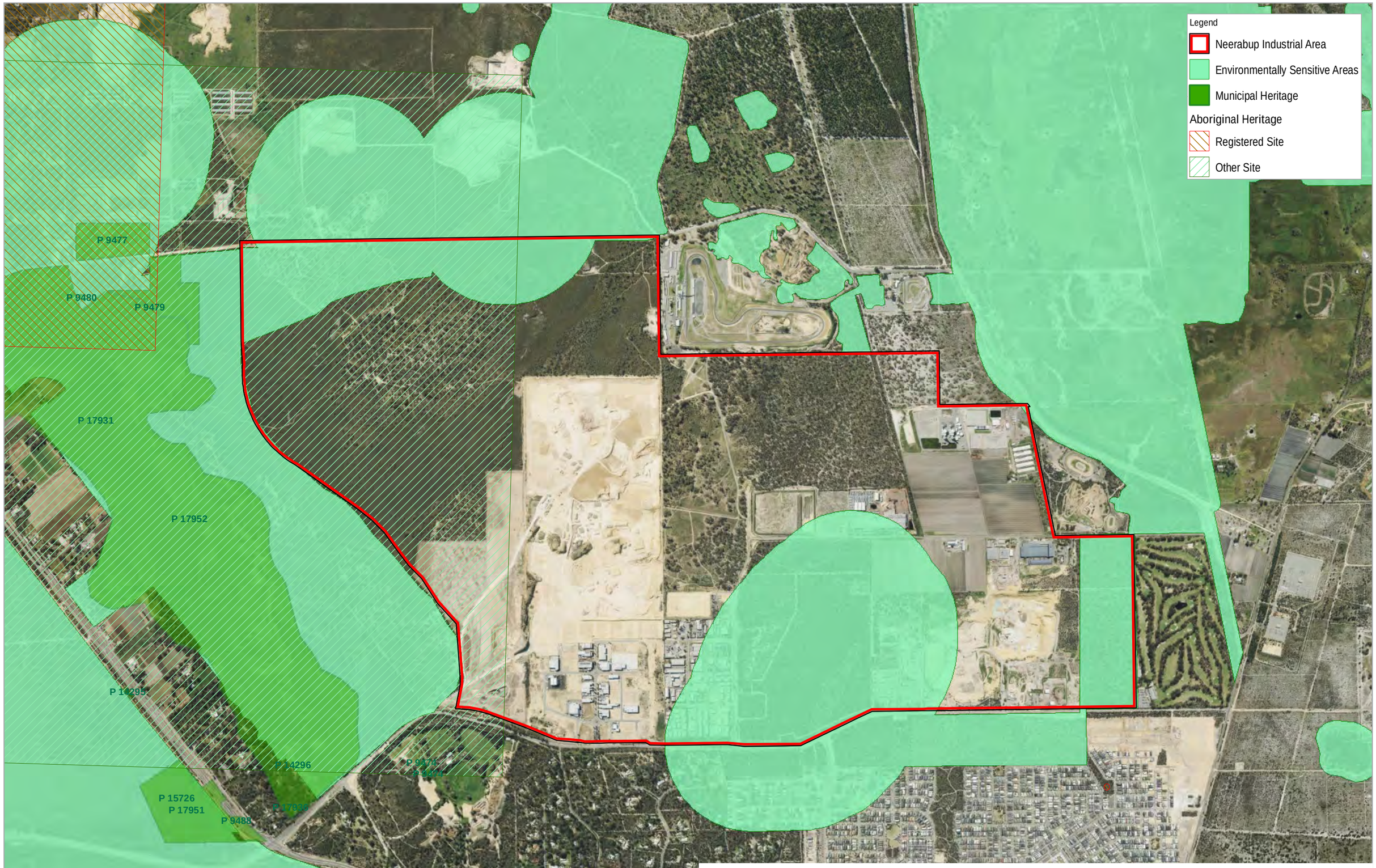

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Metres

Map Projection: Transverse Mercator
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Grid: GDA 1994 MGA Zone 50

N

GHD

City of Wanneroo
Neerabup Industrial Area Local
Water Management Strategy

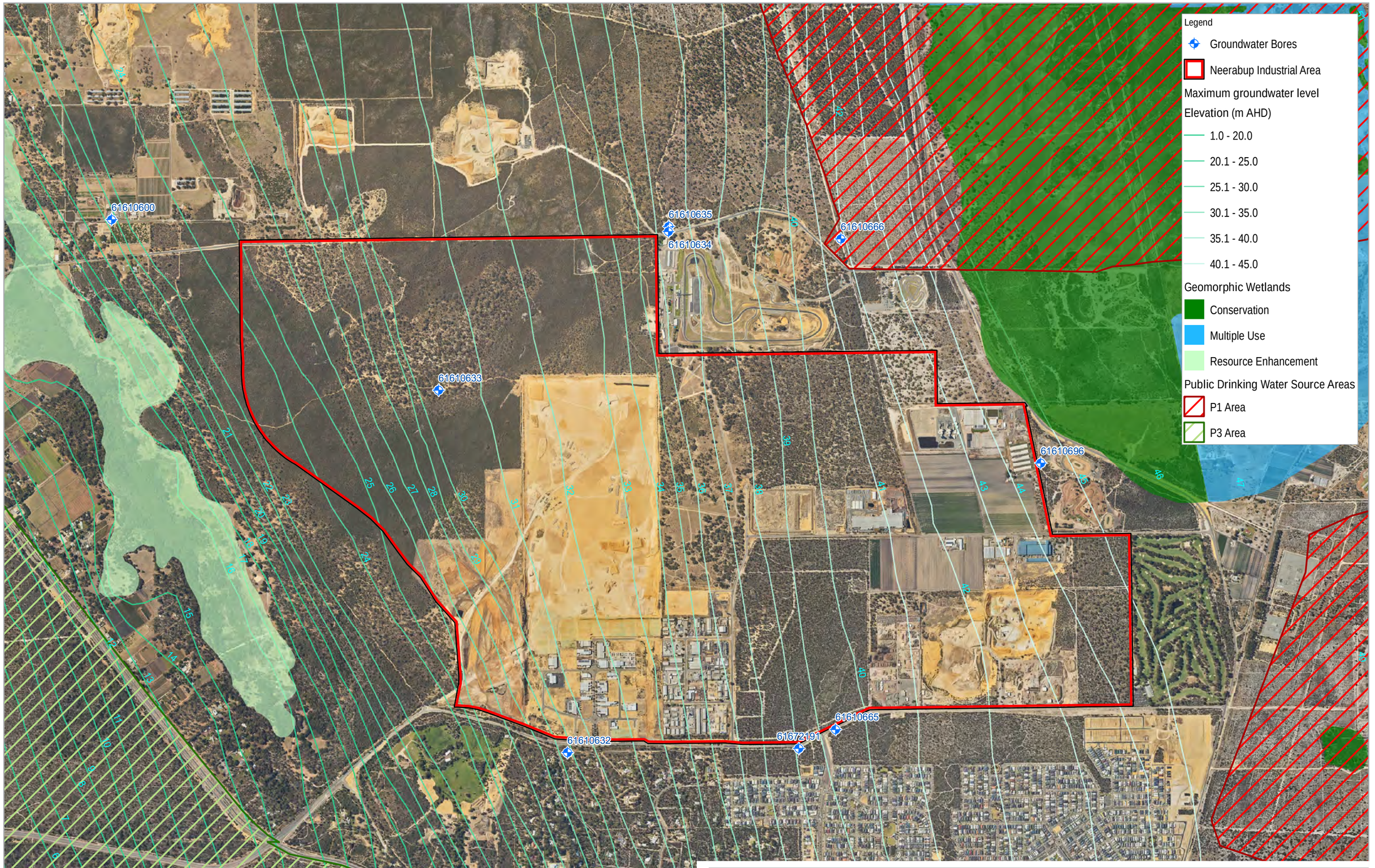
Environment and Heritage

Project No. 12515608
Revision No. 0
Date 22/01/2021

FIGURE 4.6

G:\61\12515608\GIS\Maps\Working\12515608_004_6_EnvHer.mxd
Print date: 22 Jan 2021 - 09:25

Data source: Nerrabup Industrial Area: GHD; Environmentally Sensitive Areas, Municipal Heritage, Aboriginal Heritage, Aerial: Landgate / SLIP. Created by: kaadams



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

City of Wanneroo
Neerabup Industrial Area Local
Water Management Strategy

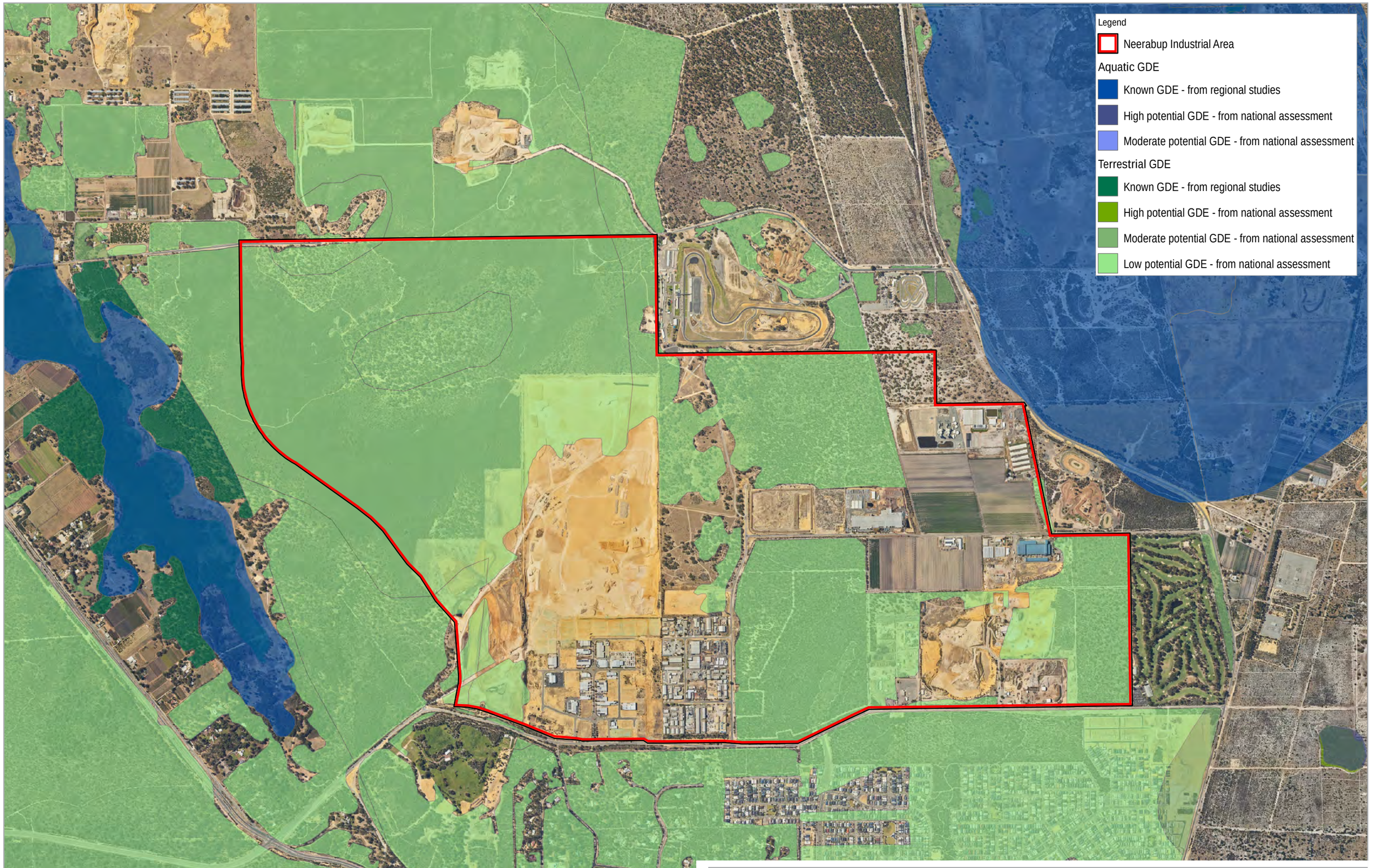
Project No. 12515608
Revision No. 0
Date 10/06/2021

Wetlands and Groundwater

FIGURE 4.7

G:\61\12515608\GIS\Maps\Working\Rev0\12515608_004_7_Wetlands_GW_Rev0.mxd
Print date: 10 Jun 2021 - 11:40

Data source: Nerrabup Industrial Area: GHD; Geomorphic Wetlands: Landgate; Maximum GW level, Public Drinking Water: DoW Aerial: Landgate / SLIP. Created by: hcariola



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

City of Wanneroo
Neerabup Industrial Area Local
Water Management Strategy

Project No. 12515608
Revision No. 0
Date 10/06/2021

Groundwater Dependent Ecosystems

FIGURE 4.8

G:\61\12515608\GIS\Maps\Working\Rev0\12515608_004_8_GDE_Rev0.mxd
Print date: 10 Jun 2021 - 12:02

Data source: Nerrabup Industrial Area: GHD; Aquatic GDE, Terrestrial GDE: Geoscience Australia; Aerial: Landgate / SLIP. Created by: hcariola

5. Water supply, conservation and management

5.1 Estimated water demand

5.1.1 Development area

The Lot 22 Flynn Drive DNWMP included a water demand analysis to determine water usage per lot and provide a basis for planning water supply strategies for the initial subdivision and early development stages (Strategen 2008).

This water demand assessment considers the revised range of industrial land uses identified for the NIA (Section 2.3.1), while acknowledging that water demands will largely be dependent on the types of industry that establish and may change over time as the estate matures.

Potential light industrial activities can have highly variable water demands. Existing industrial water demands within the NIA include the Wesbeam manufacturing plant which produces engineered wood products and has a current groundwater allocation of 150,000 kL/yr. Other existing industrial and commercial groundwater allocations are significantly lower.

Review of published information identified a range of industrial water demands values (have the potential to establish in the NIA over the long term.

) For the purposes of the NIA LWMS a mix of the Perth LIA High water use and Diversified Industrial Estate water demand have been adopted, reflecting the diverse nature of industrial land uses that have the potential to establish in the NIA over the long term.

The estimated annual water demands for the NIA are presented in Table 5-2 and were calculated using the following:

- Total land area based on the Moderate Growth development scenario from the Economic and Employment Strategy report (GHD 2020).
- 25% of the total land area developed is representative of Perth LIA High water use (3,000kL/ha/yr).
- 75% of the total land area developed is representative of the Diversified Industrial Estate with higher water use demands (25,000 kL/ha/yr) reflecting the potential for greater diversity in land use in some precincts of the NIA.

Review of the assumptions that support the Water Corporation H_2Options Water Balance tool identifies drinking and non-drinking water demands based on industry type (Table 5-3).

Based on the water demand estimate presented in Table 5-2, and using the drinking water and non-drinking water demand based on industry type (Table 5-3) the drinking water and non-drinking water estimate for the NIA at full build out (assumed 2070) is estimated as presented in Table 5-4.

Table 5-1 Industrial water demand estimates

Industrial estate type	Water demand estimate	Reference
Perth LIA Low water use	500 kL/ha/yr	Water Corporation (reported in JDA 2012)
Perth LIA High water use	3,000 kL/ha/yr	Water Corporation (reported in JDA 2012)
Diversified Industrial Estate	25,000 kL/ha/yr	Marsden Jacob Associates (2011)

Table 5-2 Estimated NIA water demand based on Moderate Growth

Year	Floorspace capacity (ha)	Perth LIA high water use demand (ML/yr)	Diversified water use demand (ML/yr)	**Total water use demand (ML/yr)**
2030	21.7	16	406	**422**
2040	46.5	35	872	**907**
2050	105.3	79	1974	**2053**
2060	244.1	183	4577	**4760**
2070	360.0	270	6750	**7020**

Table 5-3 Drinking and non-drinking water demand references

Industry type	Drinking water demand %	Non-drinking water demand %	Reference
General industrial	20 %	80 %	ABS Water Account 2020, Western Australia Total industry water supply
Light industrial	60 %	40 %	Water Corporation H_2Options Water Balance tool

Table 5-4 Estimated drinking and non-drinking water demands

Industry type	Drinking water demand ML	Non-drinking water demand ML
General industrial	1053	4212
Light industrial	1053	702
TOTAL (ML)	**2106**	**4914**

5.1.2 Public open space

As the NIA area is zoned for general industrial use amenity public open space (POS) areas will be limited to proposed service hub areas, subject to detailed design. For the remainder of the development area landscaped POS areas should incorporate native species, that require establishment irrigation only.

POS and landscaping across the NIA should be designed in accordance with City of Wanneroo Local Planning Policy 4.3: Public Open Space and industrial estate design guidelines, where applicable.

In the absence of concept landscape plans for the NIA the POS water demands should be in line with the *North West Corridor Water Supply Strategy* (City of Wanneroo and Department of Water 2014), which recommends an establishment irrigation rate of 6,750 kL/ha/year.

5.2 Fit for purpose water

The use of fit-for-purpose water sources will be encouraged across the strategy area to minimise the use of scheme water where it is not required.

5.2.1 Scheme water

Scheme water will be utilised for all potable water uses. Potable water may also be used for some non-potable uses within buildings where a non-potable water source is not available or is not viable. The in-building scheme water consumption target of 110 kL/person/year applies to the strategy area in accordance with the WaterWise Perth Action Plan (DWER 2019).

5.2.2 Groundwater

Groundwater abstraction is one of the easiest and most cost effective methods of providing an alternative to scheme water for industry feedwater and irrigation purposes. While it is noted that the groundwater aquifers in the Wanneroo Groundwater area are fully allocated, and DWER are currently revising allocation limits in the *Gnangara groundwater areas allocation plan* (DoW 2009a) (Section 4.7), there are several large licences associated with horticulture and market gardening that may become available following a change in land use.

Following a change in land use some existing licences may become available for redistribution, or alternatively developers and landholders may have the opportunity to transfer or trade allocations to provide an alternative fit for purpose water supply for proposed business and industry.

Groundwater quality (pH, salinity, alkalinity, hardness etc) may be important for industrial processes. The historic groundwater quality data for DWER long term bores is summarised in Appendix G, noting that there are limited samples for each bore and the date range is typically mid 1970's to mid 1990's. Review of the data identifies that groundwater quality across the majority of the site has neutral pH, is fresh (<1,500 uS/cm) and has low to moderate hardness ($CaCO_3$ <200 mg/L) and would require limited treatment for industrial water use. Some bores have elevated electrical conductivity and elevated hardness that may require some treatment prior to use.

Given the historic range of the data it is recommended that groundwater quality testing should be considered prior to consideration of use of superficial groundwater as a non-potable water source, and treatment or filtration requirements considered depending on the desired end use.

Groundwater contamination has been identified in part of the strategy area associated with the Pinjar Tip (Section 4.3). Development in areas affected or potentially affected by contamination should consider the results of further site investigations (Section 8.3.3, Section 8.4.2). Groundwater abstraction is not permitted in areas of known groundwater contamination.

Groundwater licences

Groundwater licences for the purposes of irrigation of landscaped areas and POS will be issued in accordance with the licensing schedule for the *North West Corridor Water Supply Strategy* (City of Wanneroo and Department of Water 2014).

Groundwater licence transfer and trade applications should be confirmed as development and water management planning progresses, with vendor and purchasers required to complete applications to transfer or trade water licences within the DWER *Water Online* customer portal.

Full details of groundwater licence transfer and detailed irrigation calculations for POS areas will be provided in future UWMPs.

5.2.3 Water harvesting

Rainwater harvesting is a key water conservation measure that will be implemented across all new development in the NIA to supplement scheme water requirements. Rainwater storage systems (e.g. rainwater tanks, underground storage systems) will provide multiple benefits including provision of water supply non-potable uses and stormwater detention for small event

runoff. Within the NIA rainwater harvesting may supply non-potable demands including indoor non-potable uses (e.g. toilet flushing), landscape irrigation and industrial demands (e.g. process water, washdown).

Should rainwater harvesting be implemented through estate design guidelines there is potential to reduce potable water use by up to 65% (LandCorp and City of Wanneroo 2010). Key rainwater harvesting design considerations drawn from the *Meridian Park Design Requirements and Guidelines* (LandCorp and City of Wanneroo 2010) include:

- Potential to achieve a 65% target reduction in potable water use if 90 kL/ha is plumbed into toilets and utilised by landscaped irrigation systems.
- The capacity of the rainwater tanks should be adjusted for individual developments based on lot sizes, and to accommodate specific end-user requirements and employee numbers.
- Overflow from rainwater tanks directed to designated landscaped areas.
- New development should aim to provide a minimum roof area equivalent of 50% of the total lot area to meet non-potable demands. Where there is insufficient roof area, non-potable water may be redirected from underground storage for fit for purpose non-potable uses, following water treatment if required (e.g. filtration).

5.2.4 Recycled water

Use of recycled water and wastewater as a non-potable water supply to reduce demands on potable water and groundwater resources has been successfully implemented in other areas (e.g. Kwinana Industrial Area) and provides a climate independent water source that is available year round (DoW 2016).

Industrial processes can produce highly variable wastewater discharges, both in terms of quality and quantity, and it is important that recycled water is treated to an appropriate level to be fit for purpose. The demand for process water is also highly variable in terms of quality and quantity.

Local wastewater recycling is a preferred option for meeting potential non-potable water supply shortfalls that may arise dependent on the types industrial development that establish in the area as the development matures.

Recycled water as a fit for purpose water source option within the NIA is likely more feasible within precincts with general industry (manufacturing, processing and fabrication), as opposed to commercial, light industrial or dry industry (such as storage and distribution).

Recycling of water and wastewater shall be encouraged between altruistic industries through promotion of industrial ecology (water efficiency) and water reuse amongst complementary industry throughout the strategy area. Planning for the NIA has encouraged flexible lot sizes within future subdivisions to cater to varying industry types (GHD 2020a) to aid this approach.

Implementation of recycled water to meet industrial water demands will be the responsibility of developers of subdivisions that propose higher water use industries. Recycled water may be provided from a decentralised source (i.e. networking between businesses) or centralised source (i.e. local wastewater treatment plant). Key considerations for recycled water include the requirement for additional infrastructure that will need to be funded by the water users. In the case of a centralised treatment plant the high construction cost will likely be prohibitive until there is sufficient demand from established industry. Other key considerations include the requirement for regulatory approval from Department of Health, Department of Water Environmental Regulation and potentially the Economic Regulation Authority.

5.2.5 Treated wastewater

Treated wastewater (TWW) is a potentially reliable, climate independent water source. Wastewater treatment plants (WWTP) in the north west corridor include Beenyup WWTP and Alkimos WWTP. Options for use of treated wastewater from WWTPs include:

- Managed aquifer recharge (MAR): whereby wastewater treated to a sufficient standard to prevent clogging is injected and stored in aquifers for subsequent abstraction and reuse at some distance from the point of recharge. This option relies on investment in wastewater treatment prior to infiltration, with further user investment in bore infrastructure to abstract TWW. Uncertainty in demand is not considered a constraint due to high demand for groundwater within the north west corridor, as well as alternate benefits such as aquifer replenishment.
- Direct wastewater recycling: whereby TWW is delivered directly through a distribution and reticulation pipe network (often referred to as a third pipe scheme). Direct wastewater recycling typically requires a higher level of treatment than MAR schemes due to the lack of natural attenuation in the aquifer. This option will require investment in third pipe infrastructure, and agreement and input of numerous stakeholders. Given the early stages of industrial growth within the NIA there is considerable uncertainty in future water demand from potential non-potable industries in the short term. Key constraints to this option include uncertainty in demand likely limiting significant investment in third pipe infrastructure, as well as approvals process and identification of a long term service provider to operate the scheme.

As with recycled water key considerations for these options relate to the requirement for additional infrastructure and uncertainty regarding development timeframe to reach demand requirements that would make the scheme cost effective. Further this option will require regulatory approval from Department of Health, Department of Water Environmental Regulation and potentially the Economic Regulation Authority.

5.3 Water conservation

Development of the NIA will lead to increasing demand for both potable and non-potable water to meet the requirements of new industry, business and commercial operations, as well as landscaping within the estate.

Key water conservation measures that will be employed across the estate to meet the design and management objectives summarised in Table 3-1 include:

- Harvesting of rainwater from all new buildings across the NIA.
- Landscaping will follow waterwise guidelines, including hydrozoning principles with a reduced irrigation rate of 6,750 kL/yr (average rate across all irrigated areas) in accordance *North West Corridor Water Supply Strategy* (City of Wanneroo and Department of Water 2014).
- Encourage industry to install water efficient industrial equipment and seek innovative designs that can be integrated into the built form.
- Recycling of water and wastewater shall be encouraged between altruistic industries, and flexible lot designs that enable colocation of like and complementary industries (e.g. co-location of high wastewater production industry with high water demand industry).
- POS areas throughout the estate may include irrigated turf provided a valid licence to take water issued by DWER has been approved, or an alternative water source has been secured.

In addition to the above the Water Corporation require that any business or industry that use more than 20,000 kL of water annually participate in the Water wise Business Program, including submission of a Water Efficiency Management Plan.

5.4 Water servicing

5.4.1 Potable water supply

Buildings within the NIA will be serviced by scheme water. Water Corporation mapping identifies an existing 250 mm diameter PVC distribution main extends into the estate along the western verge of Mather Drive. This is connected to a 200 mm diameter PVC main running west along the northern verge of Warman Street and connecting to Hemisphere Street, and further distributed throughout the existing NIA development area within 150 mm diameter PVC pipes.

It is understood that water pressure studies have been commissioned by the City of Wanneroo, to review the limitations and constraints of existing water supply to Lots 9003 and 9100.

Recent pressure studies completed by the Water Corporation confirm that the cut off level for water supply servicing in the NIA is 65 mAHD. The Water Corporation have further advised plans to install a booster pumping station on the corner of Flynn Drive and Mather Drive in 2028, to provide water pressure necessary to supply water to Lot 9003 after the ground is reduced to the Final Surface Contour Plan levels. The limit of this booster station is expected to be 80 mAHD or less.

In the long term the remainder of the NIA will be supplied by high level water tanks, however this is outside of Water Corporation's current planning and will be confirmed as development proceeds throughout the NIA (B. Coombes, pers. comm.) The tanks would likely be installed on high ground to the north-west of Barbagello Raceway.

5.4.2 Wastewater servicing

The NIA is proposed to be serviced by a gravity sewer system, which will ultimately gravitate to pump stations located at the west and east boundaries of the Site, and one existing pump station located on Redheart Road. The system will be designed in accordance with Water Corporation Sewer Design Guidelines and would cater for wastewater as permitted in their Industrial Waste Policy. Water Corporation mapping identifies sewer gravity pipes extend the full length of internal streets.

Temporary pump stations occur where the extraction and development do not occur sequentially, with sewage tankered from site in the short-term.

Gravity sewer services the existing developed areas of the NIA within Meridian Park. The gravity sewer currently flows to a temporary tankering point at the northern end of Horizon Terrace. This tankering arrangement will be removed when the Neerabup Pump Station 'L' is completed by the end of 2021. Pump Station 'L' is proposed near the intersection of Pederick Road and Altitude Drive. Water Corporation planning indicates that Pump Station 'L' will ultimately be graded out in the long term.

In a review of existing infrastructure Edge Consulting Engineers (2019) note that some parts of the NIA the sewer was constructed on a non-standard alignment with permission from the City of Wanneroo, which may impact siting of stormwater drainage and other estate infrastructure. The recent abovementioned study, commissioned by the City of Wanneroo, will also review the limitations and constraints of the existing sewer and waste management services for Lots 9003 and 9100.

Wastewater from industrial/commercial premises

Wastewater streams from future general and service industrial and commercial practices within the NIA will need to be identified and managed appropriately.

Trade waste may contain a range of environmentally hazardous materials that must not be discharged to the environment (refer to the Environmental Protection (Unauthorised Discharges) Regulations 2004 and Environmental Protection (Controlled Waste) Regulations 2004).

Wastewater from industrial land uses, such as process water or water from washdown areas, may require pre-treatment prior to being discharged to the reticulated sewer network in accordance with the Water Corporation Industrial Waste Policy and *Water Quality Protection Note 51: Industrial wastewater management and disposal* (DoW 2009b).

The treatment of waste from the industrial premise depends on the nature of the individual site. Advice on the acceptance criteria for trade waste is supplied via the Water Corporation business website.

6. Stormwater management strategy

Stormwater management of the NIA area will be managed consistent with DWER water sensitive urban design practices outlined in the *Decision process for Stormwater Management in WA* (DWER 2017) and S*tormwater Management Manual for Western Australia* (Department of Water 2004-2007), and in accordance with the City of Wanneroo's *Development Design Specification WD5: Stormwater drainage design* (City of Wanneroo 2019) and *Local Planning Policy 4.4: Urban Water Management*.

The stormwater management system has been designed with regard to the key principles, objectives and design criteria identified in Section 3.

6.1 Stormwater quantity management

The stormwater management strategy consists of three main components:

- Lot drainage
- Existing NIA area drainage
- New NIA area drainage

6.1.1 Lot drainage

Rainfall generated from industrial lots must be managed on site up to the major rainfall event (1% AEP) (City of Wanneroo 2019). Lots are also required to retain and treat runoff from small events within the lot boundary using bioretention areas sized for the 1 EY event.

Options for lot management of stormwater from buildings include rainwater harvesting to supplement non-potable water supply within lots, with rainwater tanks plumbed into toilets and landscaped irrigation systems. Overflows from rainwater tanks should be provided to landscaped biofiltration areas or on-site stormwater infiltration locations.

Lot management for stormwater runoff from carparks and other hardstand areas may be achieved through storage and/or infiltration options. Sub-surface storage tanks can be installed beneath car parks and hardstand areas, providing additional non-potable water that may be used within the lot for fit for purpose uses.

Source control and infiltration options that may be implemented within lots include:

- Maximise permeable surfaces to reduce stormwater runoff (e.g. gravel, permeable paving)
- Use of biofilters and tree-pits to treat and infiltrate stormwater at source
- Swales within car parking areas to direct stormwater runoff to landscaped areas and promote recharge of groundwater
- Soakwells may be required where car parking and hardstand areas are large

6.1.2 Existing NIA area drainage

Existing development within the NIA has occurred in accordance with a number of existing planning approvals. Drainage within these existing development areas was considered through the subdivision process.

The drainage infrastructure in the existing developed areas is assumed to be independent and will not impact future drainage infrastructure. Where existing pit and pipe networks discharge into temporary infiltration basins, future development will need to ensure connecting downstream drainage systems are suitably sized to manage these flows.

Opportunities to retrofit water sensitive urban design elements into the street drainage within the existing Mather Road Industrial Area should be considered. This is discussed further in Section 6.2.1.

6.1.3 New NIA area drainage

The stormwater drainage system within future NIA development areas is designed to mimic the existing pre-development surface water hydrology of the NIA, which is dominated by groundwater recharge.

Key aspects for management of stormwater include treating the small event runoff prior to infiltration, maximising infiltration at source for small and minor rainfall events and maximise use of overland flow paths wherever stormwater needs to be conveyed. Major events are conveyed to flood storage areas, with no direct discharge of stormwater to conservation areas and sensitive receptors.

Key strategies adopted for drainage in the new NIA are outlined as follows:

Small rainfall events (1 EY event)

- Lots to retain and treat runoff on-site using rainwater tanks and/or biofiltration areas (Section 6.1.1)
- Infiltrate impervious road catchment runoff up to the 1EY, 1 hour as close to the source as possible
- Road runoff managed within the road reserve, through treatment and infiltration via suitable bioretention elements

Minor rainfall events (greater than a small rainfall event up to the 10% AEP event)

- Lots to retain runoff using on-site infiltration areas (Section 6.1.1)
- Roads drain to bioretention elements within road reserve that contain and infiltrate all runoff

Major rainfall events (up to 1% AEP event)

- Lots to retain runoff on-site using on-site infiltration areas (Section 6.1.1)
- Road catchment flows exceeding the 10% AEP storage will be safely conveyed via roads, roadside swales, and pit and pipe network where required, to flood storage areas sized for the 1% AEP
- A minimum of 300 mm freeboard required between the flood level and the finished floor level of all buildings, and at least 500 mm above the flood level of adjacent land locked flood storage areas

6.1.4 Development drainage

Key components of the development drainage include:

- Runoff from the 1 EY event will be captured and retained within vegetated bioretention areas within road reserve. Bioretention areas will be sized to hold the 1 EY event.
- Tree pits sited within road reserve to capture and retain runoff from small events.
- Vegetated conveyance swales located within widened road verges or median along Industrial Connector roads. Vegetated conveyance swales distributed throughout the development area will assist with maintaining the site water balance through infiltration of small and minor rainfall events close to source, while providing safe conveyance to flood storage basins for major rainfall events. Assumed dimensions of vegetated conveyance

swales are a maximum depth of 0.5 m with batter slopes of 6H : 1V, and with slopes of between 1% and 4% to manage flow rates to prevent erosion in accordance with City of Wanneroo Development Design Specification WD5; Stormwater Drainage Design (2019).

- Piped drainage may be used where road verges are unable to accommodate vegetated swales.

6.1.5 Arterial drainage

Arterial drainage comprises flood storage basins located throughout the strategy area to receive stormwater runoff from road catchments in the major event. Flood storage basins have been located within the low points of the strategy area based on the Final Surface Contour Plan (Appendix C).

The road catchments were delineated using the Master Plan layout, the Final Surface Contour Plan and detail of the various road typologies proposed for the Master Plan.

Figure 6-1 shows the delineated basin catchment boundary, road type locations and indicative location of basin storage areas.

Contributing catchments

Flood storage area sizing was based on the proposed Master Plan road typologies and contributing road catchments. The equivalent pervious and impervious fractions of the various road types was estimated from the road cross-sections, which are summarised in Table 6-1.

Table 6-1 Road type and equivalent pervious / impervious fractions

Road Type	*% Pervious*	*% Impervious*
Industrial Connector (42 m)	*20*	*80*
Industrial Connector (40 m)	*20*	*80*
Industrial Connector (35 m)	*10*	*90*
Existing and Example Industrial Access Street (20 m – 25 m)	*15*	*85*

The road catchment area inside the basin catchment boundaries was calculated by measuring the total length of the road type then multiplying by the equivalent road width. Impervious and pervious catchment area was obtained by applying the impervious fraction shown in Table 6-1. Basin catchment areas and road catchment areas are summarised in Table 6-2.

Table 6-2 Basin and road catchment areas

Basin ID	Total catchment including lots (ha)	Road catchment area	
		Road impervious area (ha)	Road pervious area (ha)
Basin A	19.65	4.51	1.01
Basin B	247.83	36.97	7.16
Basin C	81.84	12.90	2.53
Basin D	54.66	8.29	1.59
Basin E	24.70	1.27	0.34
Basin F	128.66	22.06	4.29
Basin G	118.40	11.39	2.73
Basin H	10.52	1.80	0.32

Modelling parameters

The adopted parameters are summarised in Table 6-3.

Table 6-3 Modelling parameters

Basin Parameters	Adopted Value	Remarks
Hydraulic Conductivity (m/day)	5	5m/day (Conservative value based on 5.9m/day from Perth Geotechnics 2019)
Pervious IL (mm)	15	
Pervious CL (mm/hr)	3.1	ARR2019 value
Impervious IL (mm)	1	Value range from 0-1.5 for road surfaces, adopted value in between
Impervious CL (mm/hr)	0	Typical value for impervious surfaces

Flood storage basin sizing

DRAINS v2020.036 was used for the sizing of the basin. DRAINS is capable of modelling on-site detention basins with permeable surface such as the case of Neerabup basins.

The assumed dimension of the flood storage basin is a typical truncated pyramid with batter slopes of 6H : 1V. The summary of basin sizes using DRAINS is shown in Table 6-4.

Table 6-4 Summary of flood storage basin size

Basin name	Base Area (m^2)	Top Area (m^2)	Height (m)	Available Volume (m^3)	1% AEP Volume (m^3)	Freeboard (m)
Basin A	1,225	2,938	1.60	3,232	2,414	0.30
Basin B	14,400	19,044	1.50	25,000	19,374	0.30
Basin C	4,900	7,639	1.45	9,017	6,606	0.33
Basin D	2,500	4,789	1.60	5,733	4,414	0.30
Basin E	225	1,089	1.50	904	618	0.30
Basin F	7,225	11,236	1.75	16,025	12,439	0.33
Basin G	3,600	6,464	1.70	8,437	6,454	0.32
Basin H	625	1552	1.5	1,302	849	0.35
Note: Basin sizing based on the Master Plan road network, and assumed basin dimensions of 1 in 6 batter slopes.						

The following key points are noted:

- The basin sizing is based on the NIA Master Plan (dated November 2020) and Final Contour Plan (dated 2017). Revision to these may result in altered basin sizing.
- The flood storage basins sizes have 300 mm freeboard for 1% AEP event
- The basin height can be lowered by approximately 0.10 m if minor roads have more pervious areas (30%) and where swales are incorporated in road reserve. Basin volumes will also reduce if more pervious areas are provided for minor roads.
- Part of Lot 600 occurs within the Masterplan boundary however the City of Wanneroo have identified this as being outside the development extent.

Incorporation of flood storage basins into POS

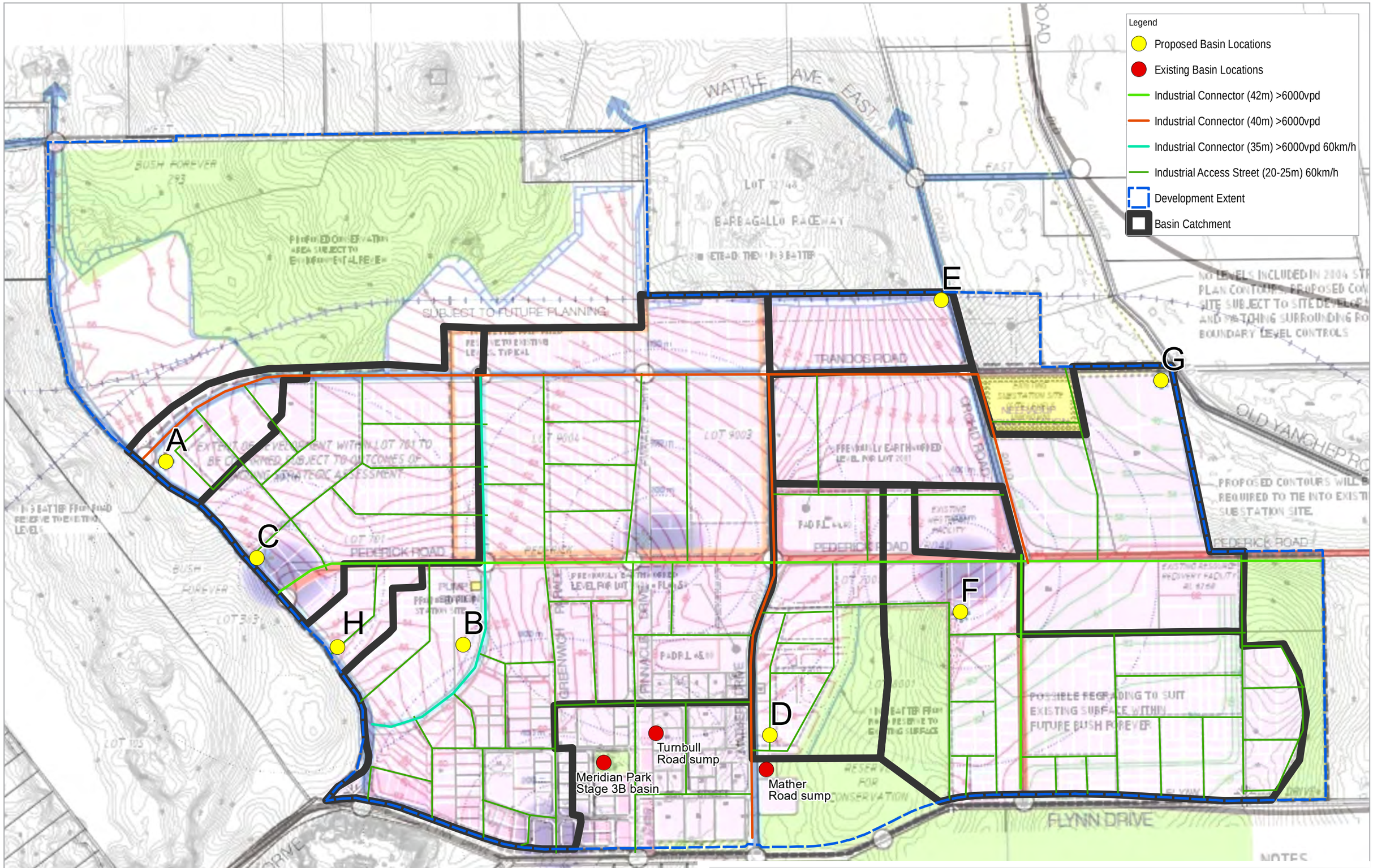
The layout of the Master Plan (Figure 1-3) aims to incorporate POS area adjacent to Service Hubs where possible, to provide multiple benefits including amenity and reduction in urban heat island effects. Where basins are incorporated into POS they should have a maximum 1.2 m flooded depth and 1 in 6 batter slopes in accordance with the *Development Design Specification WD5: Stormwater Drainage Design* (City of Wanneroo 2019) and City of Wanneroo *Local Planning Policy 4.3 Public Open Space* (City of Wanneroo 2016).

Siting of stormwater infrastructure in karst risk zones

Preliminary siting of storage basins has been undertaken with reference to the identified low points on the NIA Finished Surface Contour Plan (Appendix C), and completed prior to geotechnical investigations of the finished surface.

Mather (2013) notes that concentrated surface water discharge in areas of karst risk are a key mechanism for karst collapse on the Swan Coastal Plain, with recommendations relating to siting of infiltration locations (e.g. soakwells) with regard to buildings as well as development exclusion zones around basins.

Geotechnical investigations should be completed during the detailed design phase to ascertain the karst risk of the subdivision area (Section 8.3). Where karst risk is identified geotechnical engineers should advise on appropriate building design, stormwater management and other infrastructure considerations within these areas, including potential setbacks and exclusion zones. In particular basins located along the western boundary of the NIA are within an area of moderate karst risk (refer Section 4.2.4, Figure 4-4), and detailed geotechnical investigation of these locations is recommended.



Paper Size ISO A3

0 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

City of Wanneroo
Neerabup Industrial Area Local Water Management Strategy

Project No. 12515608
Revision No. 0
Date 10/06/2021

Stormwater Management Features

FIGURE 6-1

G:\61\12515608\GIS\Maps\Working\12515608_006_1_StormwaterManagementFeatures_Rev0.mxd
Print date: 25 Jan 2021 - 13:39

Data source: GHD: Proposed Basin Locations, Basin Catchment, Development Extent, Industrial Connectors - 20210122. Created by: kaadams

6.2 Stormwater quality

The key stormwater quality issues which may require management within the NIA development area are potential pollutants that may be generated from industrial and commercial areas including litter, nutrients, heavy metals, organic solvents, detergents and degreasers, oxygen demanding materials, paint and dye, pesticides, oil, fats and grease, hydrocarbons and other material as listed in Schedule 1 of the Environmental Protection (Unauthorised Discharges) Regulations 2004.

Stormwater quality within lot boundaries and road catchments throughout the NIA area will be managed through implementation of best practice water sensitive urban design principles. Treatment train approaches shall be developed to manage water quality including:

- Structural controls distributed within lots and road catchments to infiltrate and treat the 1EY event.
- Non-structural controls to reduce potential for nutrients and other contaminants in stormwater.

6.2.1 Structural controls

Structural controls are engineered devices implemented to manage runoff quality and quantity, to control, treat, or prevent stormwater pollution and/or reduce the volume of stormwater requiring management. Structural controls may be located at-source, in transit, or at end-of-catchment. They are ideally installed at or near the source of stormwater runoff, to protect receiving environments, including groundwater, waterways and wetlands (DoW 2004-2007).

Infiltration measures will not be promoted in areas of known or potential contamination, such as the leachate plume that extends beneath 100 Pederick Road, Neerabup (Section 4.3). Further investigations should be completed to assess potential contamination if required (Section 8.3.3).

Development scale

At the subdivision scale all structural controls will be constructed by the Developer. The City of Wanneroo (2019) identify a range of structures that can be used to mimic existing stormwater process via infiltration and improve management of small rainfall events including:

- Vegetated verge and median swales within the road reserve or abutting POS area (provided POS credits achieved)
- Underground storage tanks and infiltration cells
- Tree pits
- Bioretention systems
- Gross pollutant traps where additional treatment of high quantities of gross pollutants, hydrocarbons or other hazardous is required due to activities from within the catchment

It is noted that conditions within the site are ideal for vegetated swales due to the high infiltration rates of the sandy soils and adequate clearance to groundwater across the majority of the strategy area.

Where treatment structures are proposed for managing small rainfall events, proponents should consider the asset management requirements of proposed structures to enable the City to make informed decisions and plan for the long term management of these assets.

Opportunities to retrofit the above structures within the existing Mather Drive Industrial Area should be investigated. In particular opportunities exist to formalise street parking interspersed

with tree pits between cross-overs, as well as potential inclusion of flush kerbing and biofilters connected to existing pipe drainage within road reserves.

Lot scale

Lot scale structural controls will be the responsibility of the individual lot proponent or Developer to implement as part of the construction of the lot facilities. Industrial sites shall be required to demonstrate compliance to the *Water Quality Protection Note 52: Stormwater Management at Industrial Sites* (DoW 2010). Examples for lot scale structural controls are summarised in Table 6-5 and presented in Figure 6-2.

Table 6-5 Structural controls – lot scale

Structural control	Best management practice
Uncontaminated stormwater within lots	Rainwater tanks for water harvesting
	Infiltration measures: • Permeable pavements • Raingardens • Swales within carparks • Soakwells
Potentially contaminated stormwater within lots	Areas where stormwater may become contaminated should drain to treatment facilities for removal of solids and chemical residues and testing prior to disposal.
	Diversion banks, kerbing, surface grade changes, containment bunds and contained drains should be used to control stormwater runoff from large sites.
	Chemical storage and handling areas should be located within sealed secondary containment areas that allow maximum recovery of any spilt chemicals.
	Ensure washdown areas are appropriately bunded and of sufficient size to prevent over-spray.
	Drain internal hardstand areas to oil and grease trap or discharge to sewer system after appropriate treatment.
	Install in-line controls such as gross-pollutant traps (litter), oil and sand traps to discharge points, and equip drain inlets with shutoff valves to isolate contaminant spills.

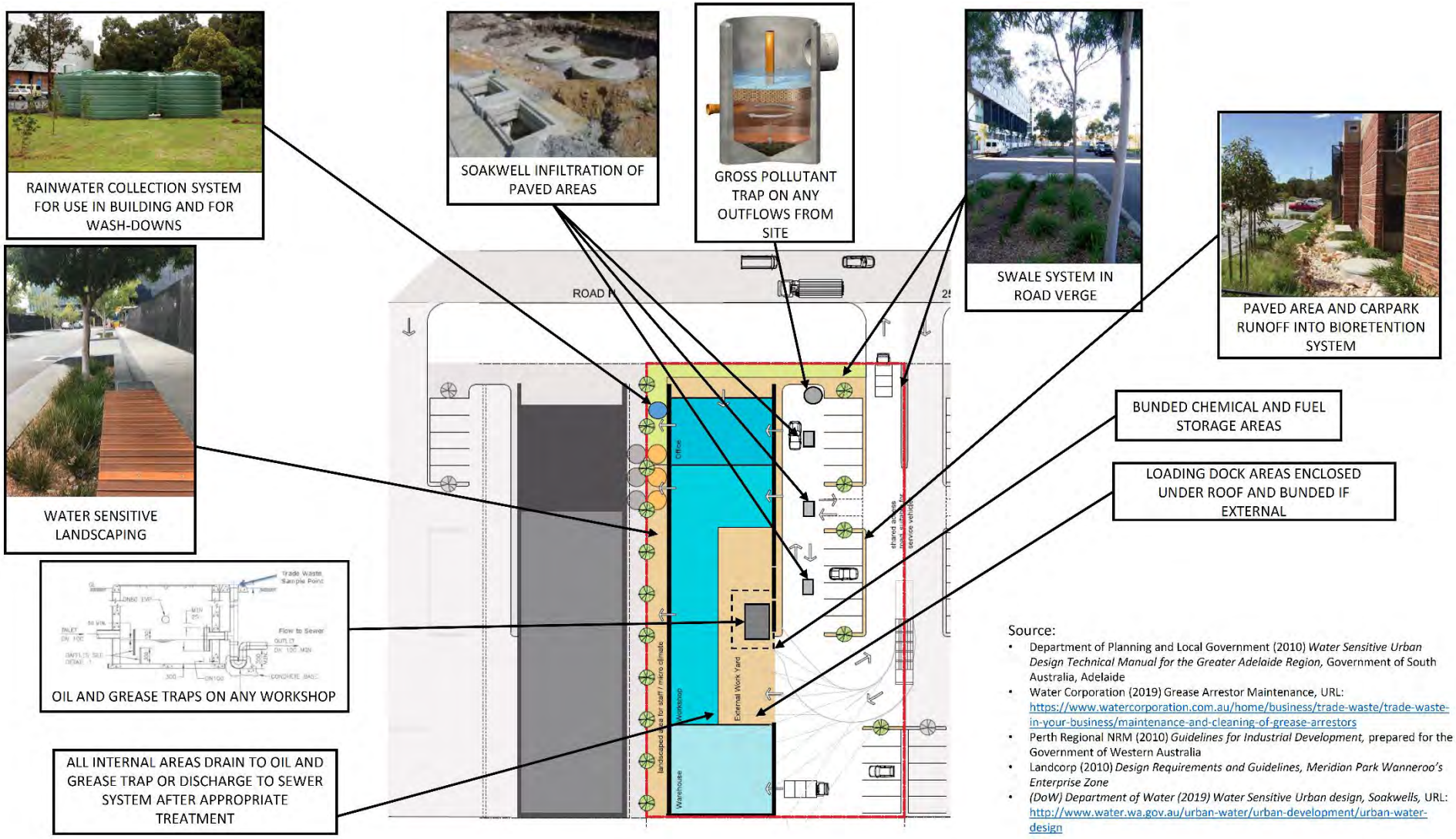


Figure 6-2 Example NIA lot scale structural controls

6.2.2 Non-structural controls

Non-structural stormwater controls are institutional and pollution-prevention practices designed to prevent or minimise pollutants from entering stormwater runoff and/or reduce the volume of stormwater requiring management. They do not involve fixed, permanent facilities and they usually work by changing behaviours through government regulation (e.g. planning and environmental laws), education and/or economic instruments (DoW 2004-2007). The proposed non-structural controls relevant to the lot and development scale are summarised in Table 6-6.

Table 6-6 Non-structural controls

Non-structural control	Best management practice
Planning and design	Grouping of similar types of industries to provide better control and regulation of stormwater management, and promotion of industrial ecology (water efficiency).
	Potentially polluting industry should not be located in areas identified as having a high potential for contamination risk (Figure 4-5).
	Industrial development in accordance with industry best practice and relevant development design guidelines: • Guidelines for Industrial Development (Perth Region NRM 2010) • Meridian Park Design Requirements and Guidelines (LandCorp and City of Wanneroo 2010)
Waterwise landscaping	Minimise water use, nutrient and pesticide application through planting of native endemic species and drought tolerant species, and minimising turf
	Landscaping will follow hydrozoning principles with a reduced irrigation rate of 6,750 kL/yr (average rate across all irrigated areas) in accordance with the *North West Corridor Water Supply Strategy* (City of Wanneroo and Department of Water 2014)
Education	Industry operators will be responsible for appropriate training and educations of employees, including preparation of Operation and Management Plans for the relevant industry
Maintenance	Maintenance of drainage infrastructure
	Street sweeping (development) and car park maintenance (lot) to reduce accumulation of litter, sediments and leaves
Regulatory controls	Regulatory measures to ensure appropriate stormwater management within industrial lots include: • Where proposed industrial development falls under the category of a prescribed premises in accordance with the *Environmental Protection Act 1986*, the developer/private landowner will be required to obtain a works approval from the DWER prior to construction. • For sites that are not prescribed premises operations should be managed to comply with the *Environmental Protection (Unauthorised Discharges) Regulations 2004*.

7. Groundwater management strategy

7.1 Predicted future groundwater level rise

As noted in Section 4.7, the change in land use is predicted to result in an increase in groundwater recharge across the NIA area, with a resultant change in water balance.

DWER has provided updated PRAMS model outputs that are being used to inform the revision of the Gnangara groundwater allocation plan. The PRAMS model outputs provided for the purpose of assessing change in groundwater levels across the NIA is median climate scenario, which provides a conservative estimate of future groundwater levels.

The median climate scenario considers future land use planning (urban and industrial), change in vegetation and management of licenced abstractions.

The PRAMS model shows that across the majority of the NIA area the groundwater levels in the Superficial aquifer are estimated to increase by 3-4 m from current levels.

Figure 7-1 presents the predicted depth to groundwater levels based on the NIA Final Surface Contour Plan (Appendix C) and the PRAMS modelled groundwater level surface for the median climate scenario. The predicted depth to groundwater identifies that the finished contours for the NIA will result in a depth to groundwater of greater than 5m across the strategy area.

Parts of the NIA do not show a predicted depth to groundwater. In the south these areas relate to the existing developed or earth worked parts of the NIA, with contours that align with the NIA Final Surface Contour Plan. Other areas in the north-west and along the southern boundary are proposed to be retained as natural surface with finished contours either regraded, battered or retained along their interface. A small area in the north-east has no assigned finished contours, however it is proposed that levels tie in to adjacent finished surfaces. Based on the predicted depth to groundwater in adjacent areas (Figure 7-1) these areas will also have a depth to groundwater of greater than 5m.

7.2 Clearance to groundwater

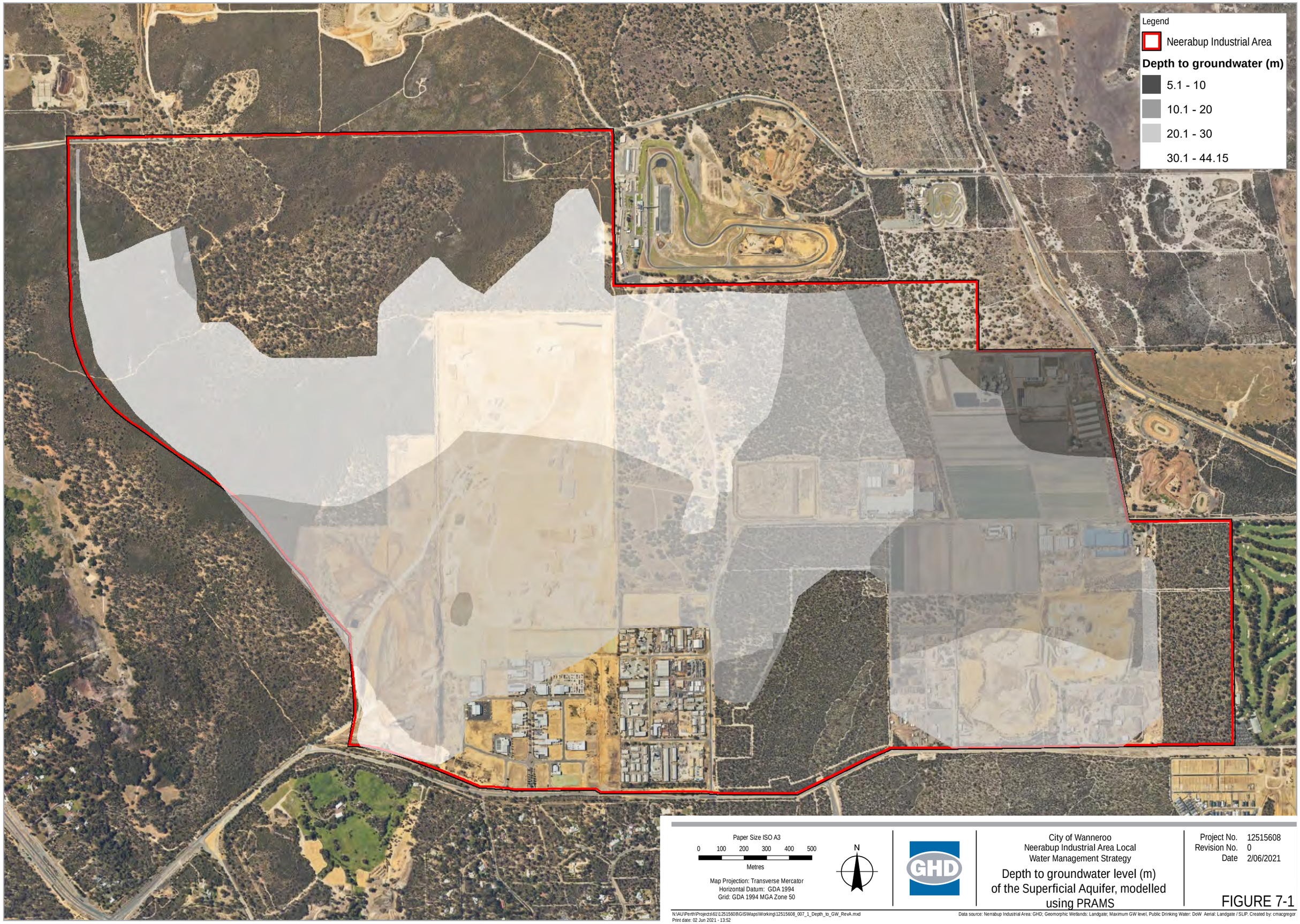
Given the predicted depth to groundwater (Figure 7-1), accounting for future development and change in groundwater allocation in the Wanneroo area, adequate clearance to groundwater is achieved and the NIA is considered a low risk in accordance with Schedule 1 of the LPP4.4.

7.3 Groundwater management

7.3.1 Groundwater level

Based on the clearance of more than 5 m from finished surface levels to predicted groundwater levels (Section **Error! Reference source not found.**) no groundwater level management is p roposed.

Should there be any further revision of the Final Surface Contour Plan (Appendix C, Rev F, dated 07/06/2017) then a review of the depth to groundwater and risk levels to development will need to undertaken, in liaison with City of Wanneroo and DWER. If proposed finished levels in the area in the north-east corner of the strategy area do not match surrounding road and lot boundary levels then fill may be required to obtain adequate separation, or alternate finished levels proposed prior to subdivision approval.



Paper Size ISO A3

0 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

City of Wanneroo
Neerabup Industrial Area Local
Water Management Strategy

Depth to groundwater level (m) of the Superficial Aquifer, modelled using PRAMS

Project No. 12515608
Revision No. 0
Date 2/06/2021

FIGURE 7-1

N:\AU\Perth\Projects\61\12515608\GIS\Maps\Working\12515608_007_1_Depth_to_GW_RevA.mxd
Print date: 02 Jun 2021 - 13:52

Data source: Nerrabup Industrial Area: GHD; Geomorphic Wetlands: Landgate; Maximum GW level, Public Drinking Water: DoW Aerial: Landgate / SLIP. Created by: cmacgregor

7.3.2 Groundwater quality

Infiltration of stormwater drainage within NIA development area is not expected to pose a significant risk to groundwater resources and associated water dependent ecosystems based on the stormwater quality measures proposed in Section 6.2. A key measure to protect groundwater quality is land use planning to ensure that potentially polluting industries are not located within the identified contamination risk zones (Figure 4-5).

Also, as noted in Section 4.7, the change in land use from horticulture to industrial, business and service has the potential to reduce leaching of nutrients and other agricultural chemicals (e.g. herbicides and pesticides) to groundwater and water dependent ecosystems.

Maximum groundwater levels across the majority of the NIA are below the estimated invert levels of the bioretention swales and flood storage basins. These structures inclusive of those stated in Section 6 will ensure the quality of the infiltrated stormwater.

7.4 Water dependent ecosystem management

The strategy area contains a Threatened Ecological Community within Mather Reserve (Section 4.4.1, Appendix A) and is bounded to the west and east by the regionally significant Lake Neerabup and Lake Pinjar wetlands (Section 4.6.1).

Key risks to the identified water dependent ecosystems and sensitive receptors are presented by the cumulative risks of vegetation clearing, change in land use, revision of the Gnangara groundwater allocation plan, as well as climate change. A primary risk from these cumulative impacts is an increase in groundwater outside of the range of natural variation of groundwater levels across the affected areas. However it is considered that the potential increase in groundwater levels should offset the significant decline in groundwater levels that have occurred for much of the Swan Coastal Plain, including Neerabup as evidenced by time series plots from the DWER long term groundwater monitoring bores (Appendix F).

Other risks from development include introduction of weeds and potential water quality impacts from potentially polluting industrial development. Management of these risks to sensitive environmental receptors within and adjacent to the strategy area will primarily be undertaken through implementation of the following key measures:

- Distributed source control measures at the development, street and lot scale will play a major role in maintaining and improving groundwater quality within the NIA (Section 6.2). This strategy aims to maintain the pre-development water balance and water quality across the development area, by infiltrating water close to source. No direct discharge to sensitive environmental receptors will occur with conveyance of major events to flood storage basins located outside of receptors and their buffers.
- Provision of adequate separation distance between proposed development and receptors. Separation distances will be dependent on the key risks of the proposed development to the environmental values of the receptor.
- Protection of groundwater quality within the probable groundwater catchments of key receptors using planning measures to prevent siting of heavy industry within areas identified as high Contamination Risk (Figure 4-5, Section 6.2.2).
- Inclusion of roads between the development area and conservation reserves to provide additional separation.
- Subdivision proposals for land parcels adjacent Lake Neerabup should include an overarching Landscape Master Plan to manage the interface with the Lake Neerabup Parks and Recreation reservation.

8. Subdivision and urban water management plans

8.1 Urban Water Management Plan

An Urban Water Management Plan (UWMP) is generally imposed as a condition of subdivision.

The Urban Water Management Plans should provide further detail of how the development design will achieve the principles and strategies for total water cycle management outlined in this Local Water Management Strategy, and should be consistent with the requirements outlined in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008b).

The UMWP should be developed in consultation with the City of Wanneroo, with advice from the DWER as required.

The UWMP should include detail of the following aspects of the subdivision:

- Design objectives consistent with this LWMS.
- Site characteristics including details of further site investigations if required and reporting of pre-development monitoring results.
- Details of subdivision and lot scale water conservation and water efficiency measures, including landscape irrigation demands and fit for purpose water supply options.
- Stormwater and groundwater management including detailed design of the subdivision drainage network and sizing of structural control measures.
- Detail of post-development monitoring program.
- Management and maintenance requirements during the construction and handover period.

8.2 Detailed design

Design assumptions of the stormwater drainage infrastructure will need to be confirmed during the development of Urban Water Management Plans for the site.

Design of the stormwater management system should be consistent with the design criteria in this LWMS. The detailed design should include modelling of the subdivision local road drainage network and sizing of subdivision flood storage basins, bioretention elements and other structural controls. Detail of the on-lot management of stormwater should be provided, including calculation of storage volumes and sizing of bioretention elements

8.3 Further site investigations

8.3.1 Karst investigation

Based on the location of the NIA in relation to the karst risk zones (low to medium risk, east to west) based on Figure 4-4 and Figure 4-5 further investigation should be considered prior to subdivision in the western section of the NIA (as a minimum Lot 801(410) Flynn Drive (previously Lot 503), Appendix A). If Provision 2.5 of the LPP 4.13 is to be followed, the entire NIA should be considered for further investigation. Initial geotechnical investigations should be considered prior to a geophysical survey once surface material has been removed.

A ground penetrating radar (GPR) assessment shall be completed following completion of resource extraction within those areas that occur within a medium karst risk zone.

Schedule 1 in the City of Wanneroo LPP 4.13 outlines the minimum requirements of Desktop Karst Surveys, Geotechnical Reports and Karstic Feature Management Plans which may be required prior to development application.

Where karst risk is identified geotechnical engineers should advise on appropriate building design, stormwater management and other infrastructure considerations within these areas, including potential setbacks and exclusion zones. In particular the siting of drainage basins within areas of karst risk (Figure 4-4) will require careful consideration.

Further, should karst be identified the proponent should liaise with the Environmental Protection Authority regarding appropriate management requirements to minimise potential impacts on communities of troglobiotic fauna and stygofauna within the affected area, in accordance with the *Environmental Protection Act 1986*.

8.3.2 Geotechnical conditions

Site specific geotechnical investigations should be completed where a flood storage basin or extensive swale system will be sited to verify the permeability of the soils. Soil permeability should be reported within the Urban Water Management Plan.

8.3.3 Potential contamination

Where a subdivision is proposed where a parcel of land was previously used for a potentially contaminating activity or may be impacted by a potentially contaminating activity (DER 2014) a Preliminary Site Investigation (PSI) may be required to assess potential contamination. Advice as to whether a PSI is required should be sought from DWER. Any PSI should be undertaken in accordance with current DWER guidance including:

- *Assessment and management of contaminated sites* (DER 2104)
- *National Environment Protection (Assessment of Site Contamination) Measure 1999* (as amended and in force on 16 May 2013 (the NEPM)

Pinjar Tip Leachate Plume

As noted in Section 4.3, land potentially affected by the leachate plume from Pinjar Tip shall have conditions imposed on any development approval, and recommended on any subdivision application to ensure prospective purchasers of land or development are appropriately informed of the potential impacts of the plume.

8.4 Monitoring program

8.4.1 Surface water monitoring

As no surface water features occur across the NIA pre-development, and all stormwater within the Site is proposed to be infiltrated to groundwater, no surface water monitoring is proposed.

8.4.2 Groundwater monitoring

Schedule 1 of the *draft LPP 4.4: Urban Water Management* (City of Wanneroo 2019) identifies development risk to receptors based on a range of site characteristics. Following the approach in the draft LPP the central part of the strategy area is classified as medium risk in due to the on-site infiltration of all stormwater to groundwater and presence of sensitive environmental receptors adjacent to the strategy area. The western extent and eastern extent of the strategy area are classified as high risk due to local groundwater flow in the direction of sensitive receptors (wetlands). The western boundary of the strategy area also has potential karst risk (Figure 4-4).

Pre and post development monitoring programs in areas identified as high risk should consider the key site conditions in developing the monitoring program.

Where land may be impacted by potentially contaminating activities the (Section 8.3.3) the groundwater monitoring program should consider the potential requirement for a Preliminary Site Investigation.

Pre-development monitoring

Pre-development groundwater monitoring should be completed for an 18-month period immediately preceding development as part of the site specific technical studies to support subdivision approval. Results from the pre-development groundwater monitoring should be reported in the Urban Water Management Plan.

The pre-development groundwater monitoring program is summarised in Table 8-1. A sufficient number of upgradient and down gradient bores should be installed to enable characterisation of local groundwater quality, groundwater levels and groundwater flow direction with reference to the subdivision, any land use within or in proximity to the development that may impact groundwater quality, and with regard to sensitive environmental receptors.

The pre-development groundwater monitoring program also includes additional parameters to consider in areas where more intensive or heavy industry is proposed. In accordance with design criteria to manage groundwater quality, heavy industry should be precluded from areas that are identified as having a high risk of contamination (Table 6-6, Figure 4-5).

Pre-development monitoring in areas affected by potentially contaminated activities should be informed through completion of a PSI (Section 8.3.3).

In areas potentially affected by the existing groundwater plume associated with the former Pinjar Landfill at Lot 503 (1851) Old Yanchep Road, Pinjar, should refer to the groundwater delineation completed by Coffey (2016) to inform pre-development monitoring and update the conceptual site model and potential risks.

Table 8-1 Pre-development groundwater monitoring program

Monitoring locations	Monitoring frequency	Parameters	Additional parameters
Upgradient bores Down gradient bores	Quarterly	In-situ: pH, Temp, Electrical conductivity, Dissolved Oxygen, Redox Laboratory analysis: Nutrients, dissolved metals (e.g. aluminium, arsenic, cadmium, chromium, copper, iron, mercury, nickel, lead, zinc), hydrocarbons (TRH and TPH)	Surfactants BTEX Oil and grease
Contingency plan: In the event that a monitored parameter exceeds nominated baseline water quality or agreed trigger values additional monitoring should be completed to determine the cause of the exceedance in consultation with the DWER and City of Wanneroo.			

Post-development monitoring

The post-development groundwater monitoring program for a subdivision should be detailed within the Urban Water Management Plan, based on guidance in *Water monitoring guidelines*

for better urban water management strategies and plans (DoW 2012), and consultation with City of Wanneroo and DWER. Monitoring should be commensurate with the risk to sensitive receptors from the proposed land use within the development.

8.5 Construction management

8.5.1 Construction Environmental Management Plan

Developers shall prepare a Construction Environmental Management Plan (CEMP) to provide guidance and management to construction contractors during construction of the NIA.

The CEMP should consider the management of stormwater during the construction phase in accordance with best practices identified in the *Stormwater Management Manual for Western Australia* (DoW, 2004-2007). Practices that should be implemented include:

- Mulching of cleared vegetation and stockpiling for use during progressive revegetation works
- Retention of topsoil for revegetation works
- Temporary bunding of stormwater infrastructure
- Designation of wash down areas located as far away as practicable from roads, stormwater management systems and water bodies.
- Prior to infiltration of stormwater, ensure adequate treatment has been conducted
- Use of recycled water or fit-for purpose water supplies for dust suppression
- Provision of litter and waste bins to contain waste during construction
- Manage silt and erosion
- Prior to infiltration of stormwater, ensure adequate treatment has been conducted
- Drainage systems should be maintained regularly, including cleaning of the pipe network, road reserves and removal of silt within bioretention areas

The CEMP should also include the following key aspects to minimise the potential for contamination events during construction:

- Spill response management plan
- Waste management plan

8.5.2 Temporary drainage measures

Where the staging of the NIA development area requires, temporary drainage measures may be employed at the extents of development that will tie into future development stages. These drainage structures are to comply with the City of Wanneroo's standard drawings for Sump & Sump Outfall Details and Sump Security, TS03-4-2 and TS01-2-1 respectively. These are to be maintained by the developer until the handover of the site.

8.6 Built form

The Neerabup Industrial Area Subdivision and Built Form report (GHD in prep) identifies the benefit of design guidelines in providing development guidelines for property developers and providing higher quality and more consistent built form outcomes. However, prescriptive design guidelines may restrict development options for some lots and development guidelines should recognise the need for flexibility for larger lot developments.

There are currently no design guidelines that are applicable across the NIA. In the absence of design guidelines proponents and developers can refer to the following guidance in order to facilitate more sustainable industrial development:

- *Meridian Park Design Requirements and* Guidelines (LandCorp and City of Wanneroo 2010)
- *Guidelines for Industrial Development* (Perth Region NRM 2010)

Proponents and developers should refer to the design criteria and management strategies within this LWMS for total water cycle management within lots, including water conservation measures, and management of stormwater quantity, stormwater quality and groundwater.

9. Implementation

Table 9-1 identifies the roles and responsibilities to be implemented by the various stakeholders undertaking subdivision and operating industry and commercial operations throughout the NIA.

Table 9-1 LWMS roles and responsibilities

Strategy element	Role	Responsibility	Requirement and period
Subdivision	Further site investigations if required (Section 8.3): - Pre-development groundwater monitoring - Karst - Preliminary site investigation - Geotechnical conditions	Developer	Investigations will be required to support subdivision / development application
	Subdivision proposals for land development adjacent Lake Neerabup should include an overarching Landscape Master Plan	Developer	Required to support subdivision application
Detailed design	Urban Water Management Plan	Developer	Prior to commencement of subdivision works
	Consider the following where relevant to the subdivision: - Sustainable development design - Subdivision guidelines and built form advice specific to the development of the NIA	Developers and proponents of lots within NIA	During the detailed design, subdivision and development of lots within the NIA
Water conservation	Implement subdivision and lot scale water conservation and water efficiency measures, including landscape irrigation demands and fit for purpose water supply options	Developers and proponents of lots within NIA	During development of subdivision and lots within the NIA
Waterwise practices	Implement subdivision and lot scale waterwise practices in accordance with the approved UMWP and/or subdivision guidelines	Developers and proponents of lots within NIA	During development of subdivision and lots within the NIA
	Design and construction of road catchment drainage	Developer	Design to be completed prior to

Strategy element	Role	Responsibility	Requirement and period
Stormwater quantity	infrastructure demonstrating compliance with this LWMS		commencement of subdivision works Constructed road drainage infrastructure to be handed over to the City of Wanneroo at practical completion
	Design and construction of lot drainage infrastructure demonstrating compliance with this LWMS	Proponents	Design to be completed prior to commencement of subdivision works
Construction management	Preparation of CEMP to guide contractors	Developer	Sediment and erosion management during construction
Temporary drainage measures	Design, construction and maintenance of temporary drainage structures	Developer during construction and maintenance period City of Wanneroo following practical completion	Design in accordance with City of Wanneroo standard drawings for Sump & Sump Outfall Details and Sump Security, TS03-4-2 and TS01-2-1 Developer responsible during construction and maintenance period City of Wanneroo following practical completion
Street sweeping	Completion of street sweeping to remove sediment and litter accumulation during construction phase	Developer during construction and maintenance period City of Wanneroo following practical completion	Street sweeping to be undertaken with a frequency agreed to within the UWMP

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Appendices

Appendix A – Land parcels and ownership within the NIA

City of Wanneroo (2019)

Razmoski Investments
Lot 1

Western Australian Planning Commission
Lot 502

Development WA
Lot 801

Development WA
Lot 9006

Lot 9003

City of Wanneroo
Lot 600

City of Wanneroo

Newgen Power
Lot 100

Trandos
Lot 9000

Trandos
Lot 1506

Development WA
Lot 2001

Dev WA
Lot 1001

Wesbeam
Lot 1000

Development WA
Lot 2001

Trandos
Lot 508

Mindarie Regional Council
Lot 801

Western Australian Planning Commission
Lot 800

City of Wanneroo
Lot 9100

Lot 8001
Reserve for Conservation

Alvito
Lot 5

Primewest
Lot 900

Borrello
Lot 901

Borrello
Lot 902

GDA

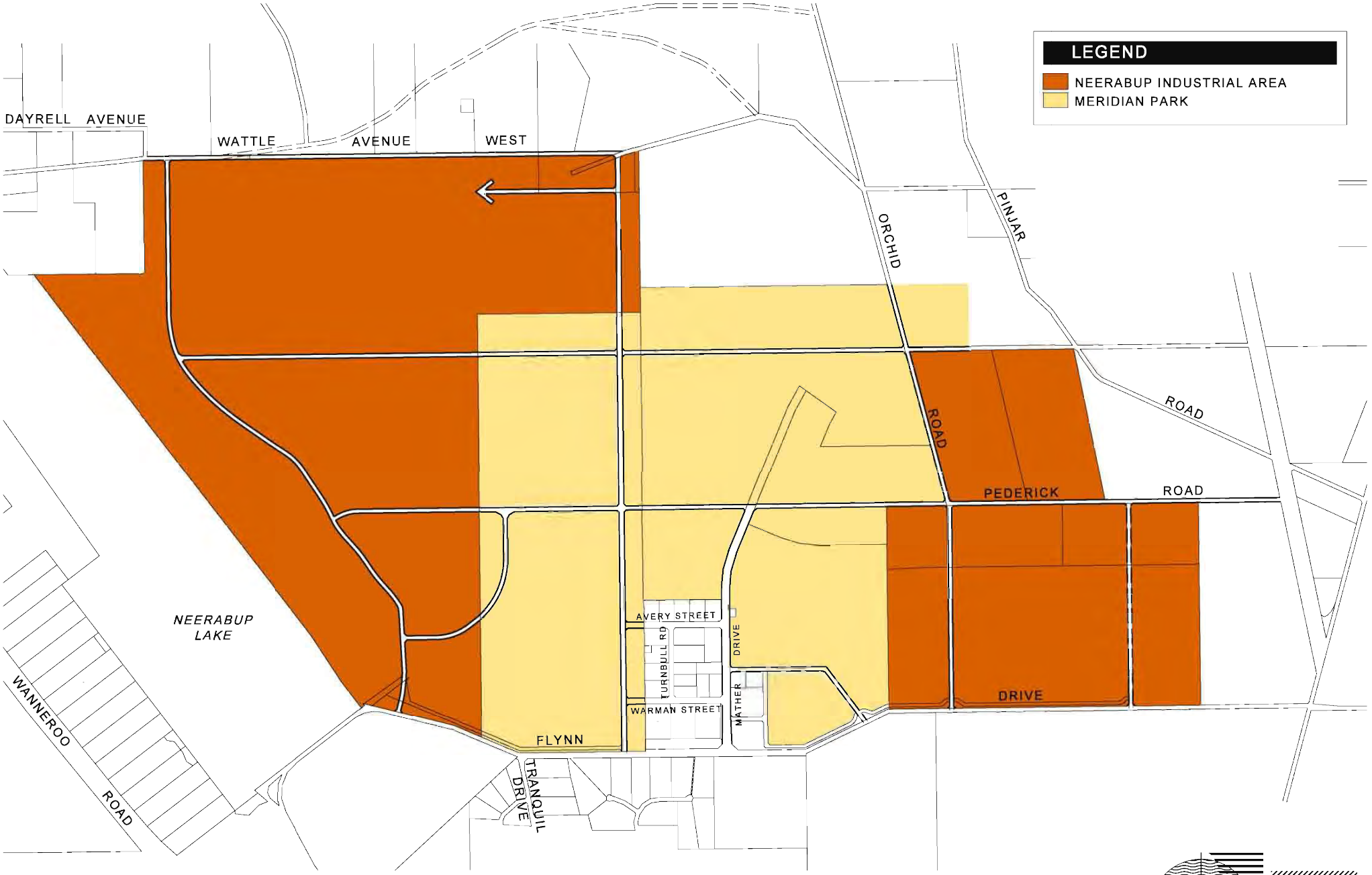
N

0 250 500 1,000 1,500 2,000
Metres

City of Wanneroo
Produced by Customer & Information Services
03/05/2019
KACE : 50477

Appendix B – Meridian Park

Source: ASP (TBB et al. 2017)



NEERABUP INDUSTRIAL AREA
MERIDIAN PARK

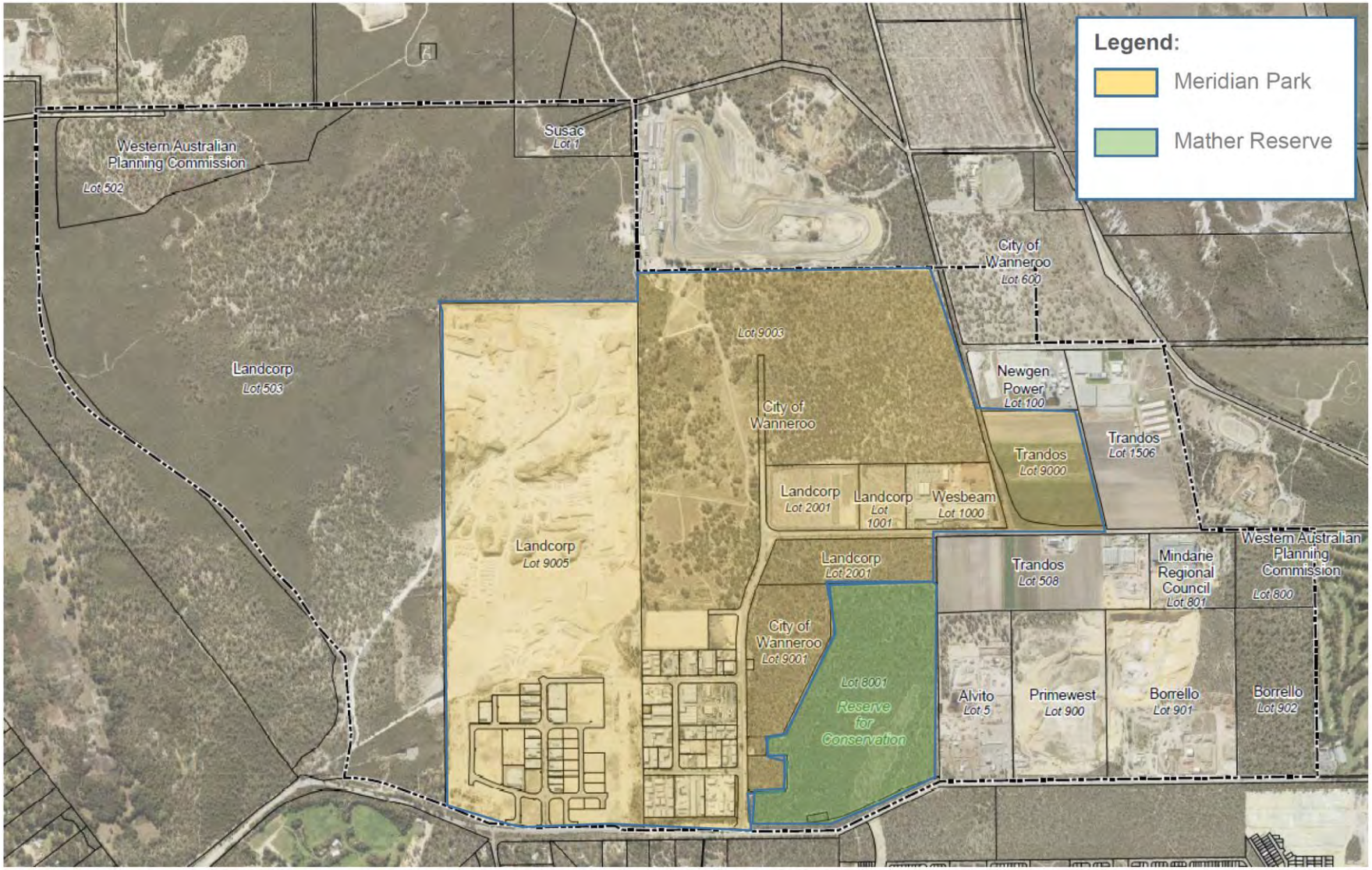
400m 200m 0m 200m 400m

NORTH

PLAN 6

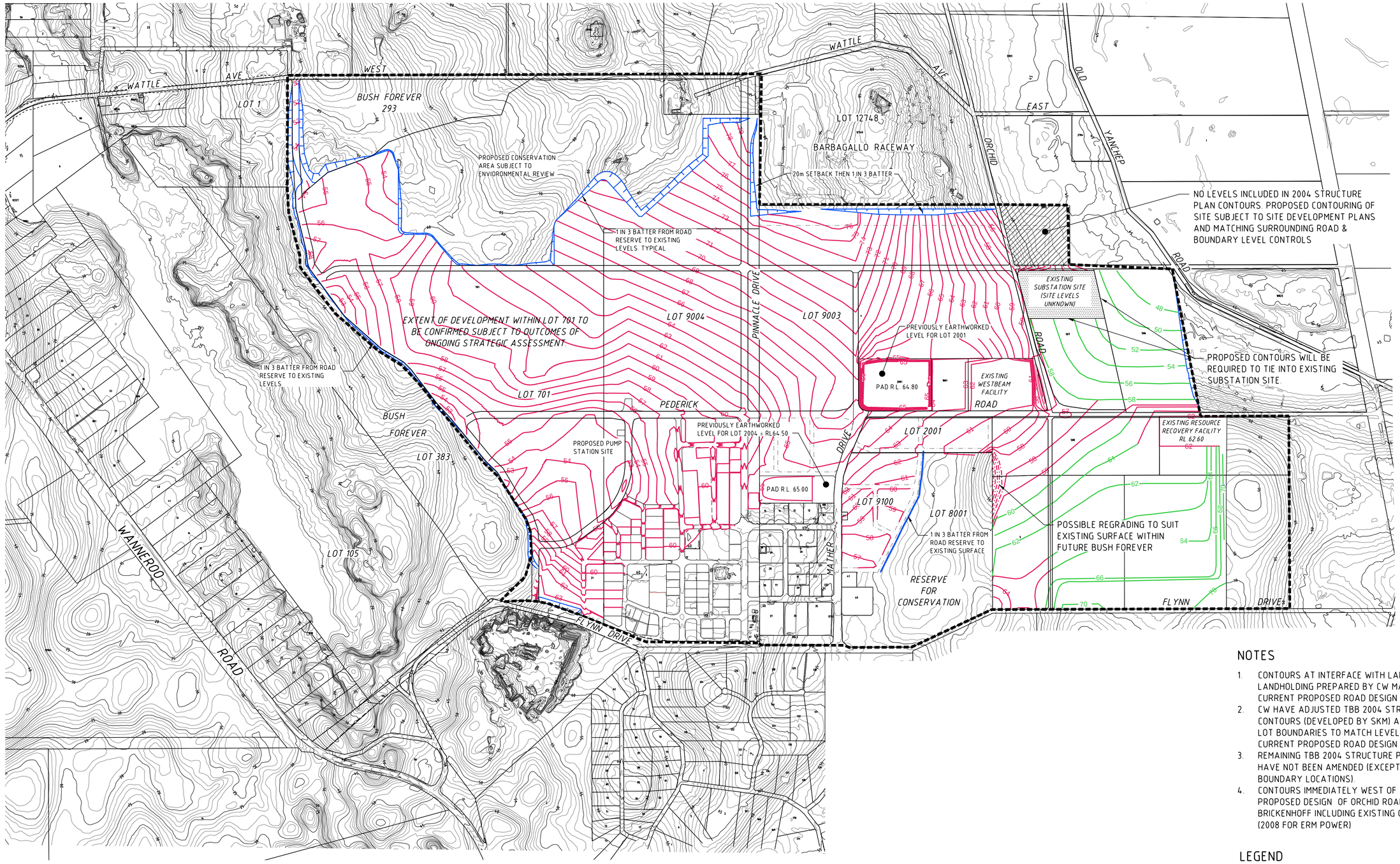
TAYLOR BURRELL BARNETT
Town Planning and Design
187 Roberts Road Subiaco
Western Australia 6008
Telephone: (08) 9382 2911
Facsimile: (08) 9382 4586
admin@tbbplanning.com.au

SINCLAIR KNIGHT MERZ


Legend:
Meridian Park
Mather Reserve
Western Australian Planning Commission
Lot 502
Susac
Lot 1
City of Wanneroo
Lot 600
Lot 9003
Landcorp
Lot 503
City of Wanneroo
Newgen Power
Lot 100
Trandos
Lot 1506
Trandos
Lot 9000
Landcorp
Lot 2001
Landcorp
Lot 1001
Wesbeam
Lot 1000
Landcorp
Lot 9005
Landcorp
Lot 2001
Trandos
Lot 508
Mindarie Regional Council
Lot 801
Western Australian Planning Commission
Lot 800
City of Wanneroo
Lot 9001
Lot 8001
Reserve for Conservation
Alvito
Lot 5
Primewest
Lot 900
Borrello
Lot 901
Borrello
Lot 902

Appendix C – NIA Final Surface Contour Plan

Rev F dated 7/06/2017



NOTES

1. CONTOURS AT INTERFACE WITH LANDCORP & CoW LANDHOLDING PREPARED BY CW MATCH EXISTING OR CURRENT PROPOSED ROAD DESIGN LEVELS.
2. CW HAVE ADJUSTED TBB 2004 STRUCTURE PLAN CONTOURS (DEVELOPED BY SKM) AT ROAD INTERFACE & LOT BOUNDARIES TO MATCH LEVELS ALONG EXISTING & CURRENT PROPOSED ROAD DESIGN LEVELS
3. REMAINING TBB 2004 STRUCTURE PLAN CONTOURS HAVE NOT BEEN AMENDED (EXCEPT AT SELECTED BOUNDARY LOCATIONS).
4. CONTOURS IMMEDIATELY WEST OF ORCHID RD TIE INTO PROPOSED DESIGN OF ORCHID ROAD BY PARSON BRICKENHOFF INCLUDING EXISTING O/H POWERLINES (2008 FOR ERM POWER)

LEGEND

- AMENDED 2015 STRUCTURE PLAN CONTOURS
- ORIGINAL 2004 STRUCTURE PLAN CONTOURS
- STRUCTURE PLAN BOUNDARY

1:10000 0m 200 400 600m

REV	DATE	DRN	CKD	APP	AMENDMENT
F	07.06.17	JBA	RP	R STANIFORTH	LOT 8001 RESERVE FOR CONSERVATION ADDED
E	14.12.15	JBA	RP	R STANIFORTH	ROAD LAYOUT REMOVED FOR CLARITY
D	09.11.15	JBA	RP	R STANIFORTH	BATTER AMENDED TO COLOUR WHEN PLOTTED
C	20.08.15	JBA	RGS	R STANIFORTH	CONTOURS REVISED TO SUIT EXISTING SUBSTATION & RESOURCE RECOVERY FACILITY
B	12.08.15	JV	RP	R STANIFORTH	CONTOURS REVISED ADJACENT TO LOT 1001 AND EXISTING WESTBEAM FACILITY
A	07.08.15	JBA	R.P.	R STANIFORTH	ISSUED FOR INFORMATION

This plan is not to be used for construction unless issued as revision 0 or higher

Cossill & Webley CONSULTING ENGINEERS
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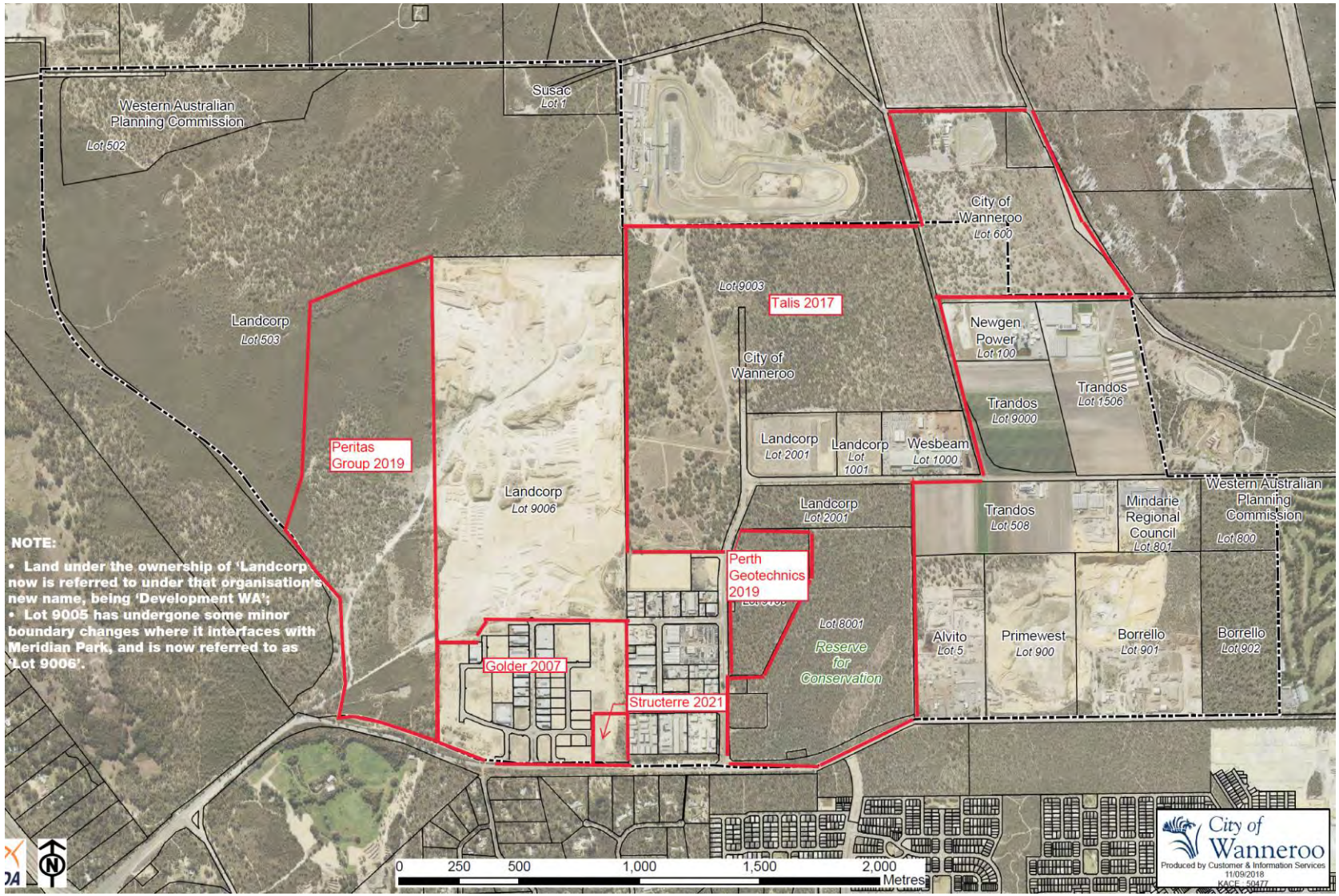
CLIENT: LANDCORP
APPROVED: ROLAND STANIFORTH
DESIGNED: JBA
SCALE: 1:10000

PROJECT: LOT 22 FLYNN DRIVE, NEERABUP
TITLE: ***Plan 2: Neerabup Industrial Area Final Surface Contour Plan (August 2015)***
WAPC No.
DRAWING No.: 5920-00-SK128
REVISION: F
ORIGINAL SIZE: A1

Appendix D – Geotechnical and hydrogeology conditions



D.1 Plan of location of Geotechnical Investigations across NIA (summarised in Table 4.1)

D.2 Karst risk review

This review summarises available information of know and potential karst risk in the Neerabup Industrial Area.

A karst risk map is provided in the Local Planning Policy 4.13: Caves and Karstic Features (City of Wanneroo, LPP 4.13). The map has zones of risk related to the presence of karsts ranging from low to high based on information provided by the Western Australian Speleological Group This risk map can be seen on Figure 4-4 where it shows the western boundary of the NIA as being in medium risk and being adjacent to high risk. The land to the north and east of the WA Limestone Quarry is considered low risk. Figure 4-5 shows the contamination risk based on hydrogeological factors (Davidson 1995) which confirms the presence of potential high risk karstic areas lying adjacent to the western boundary of the NIA, and high risk areas along the eastern boundary due to shallow groundwater conditions.

Peritas (2019) identified no signs of karstic features in existing excavations undertaken the existing quarry that occurs to the east of Lot 801(410) Flynn Drive (previously Lot 503). While Peritas (2019) identify low karst risk for Lot 801(410) on the basis of no evidence of karst features in the existing quarry to the east, it is considered that the karst risk is inconclusive and further karst investigations and risk assessment should be completed as excavation progresses.

The policy provisions 2.5 and 2.6 of the LPP 4.13 state: Provision 2.5 *"Where there are two or more different karst risk levels across a subject site, the highest risk level will apply."* and Provision 2.6 *"Where a property is located within 400 metres of a higher karst risk level, the higher risk level will be used when determining the requirements for karst assessment."*

Provision 2.5 indicates that the NIA as a whole should be assessed as an area of moderate karst risk due to the western portion of the NIA being in the moderate risk zone. Provision 2.6 indicates that if properties are to be developed along the western boundary of the NIA, within 400m of the high karst risk zone, they are to be assessed as high risk.

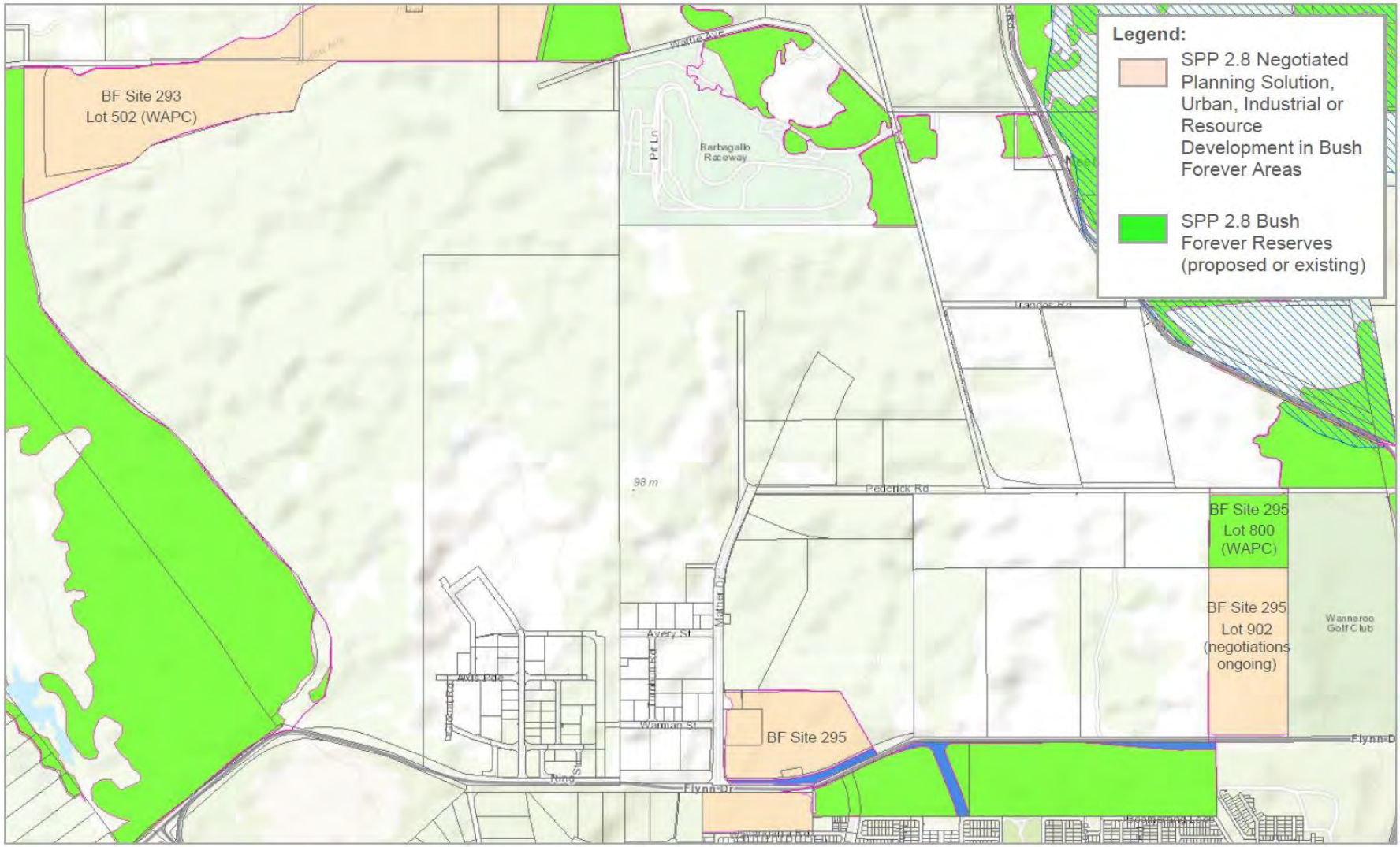
Table 1 in the City of Wanneroo document LPP 4.13 details the requirements of each phase of planning (Local Structure Plan, Subdivision and Development Application) depending on the karstic risk of the area. During the local structure planning stage it is stated a "Desktop Karst Survey" shall be prepared and included in the Local Structure Plan. The outcomes of this desktop assessment will determine whether a "Geotechnical Report" and/or "Karstic Features Management Plan" is required as a condition of subdivision (COW LPP 4.13).

Schedule 1 in the LPP 4.13 outlines the minimum requirements of Desktop Karst Surveys, Geotechnical Reports and Karstic Feature Management Plans which may be required prior to development application.

Based on the location of the NIA in relation to the karst risk zones (low to medium risk, east to west) based on Figure 4-4 and Figure 4-5 further investigation should be considered prior to subdivision in the western section of the NIA (as a minimum Lot 503). If Provision 2.5 of the LPP 4.13 is to be followed, the entire NIA should be considered for further investigation. Initial geotechnical investigations should be considered prior to a geophysical survey once surface material has been removed. A ground penetrating radar (GPR) assessment should be considered following completion of resource extraction to maximise its effectiveness due to the limitations associated with GPR and the depth of potential karsts.

Appendix E – Bush Forever

Source: PlanWA


Legend:
SPP 2.8 Negotiated Planning Solution, Urban, Industrial or Resource Development in Bush Forever Areas
SPP 2.8 Bush Forever Reserves (proposed or existing)
BF Site 293
Lot 502 (WAPC)
Barbagallo Raceway
Pit Ln
Wattle Ave
98 m
Pederick Rd
BF Site 295
Lot 800
(WAPC)
BF Site 295
Lot 902
(negotiations ongoing)
Wanneroo Golf Club
Avery St
Warman St
BF Site 295
Flynn Dr

Appendix F – DWER long term groundwater monitoring bores

Source: DWER Water Information Reporting

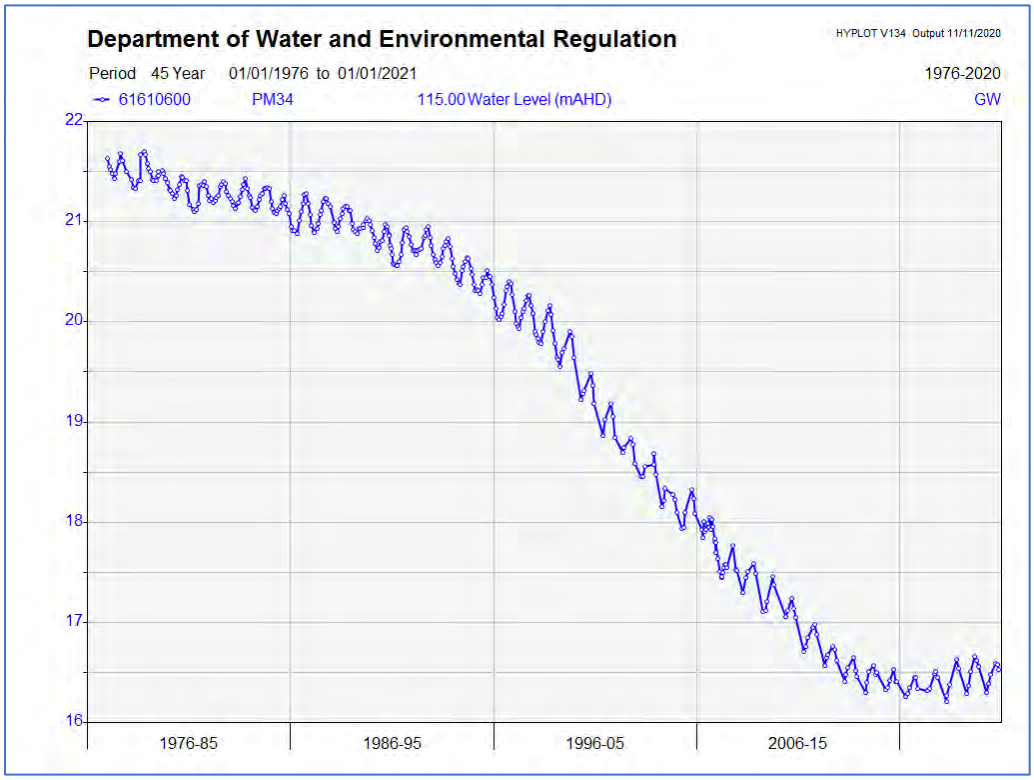
Refer to Figure 4-7 for DWER long term groundwater monitoring bore locations.

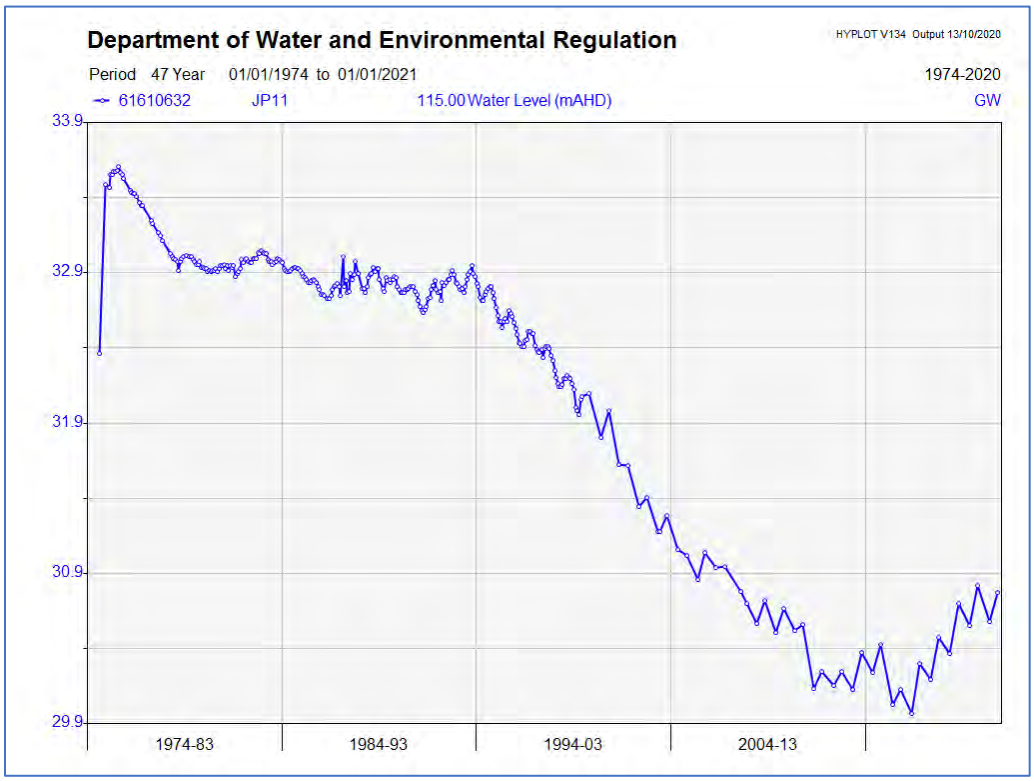
Table F.1 DWER long term groundwater monitoring bores summary table

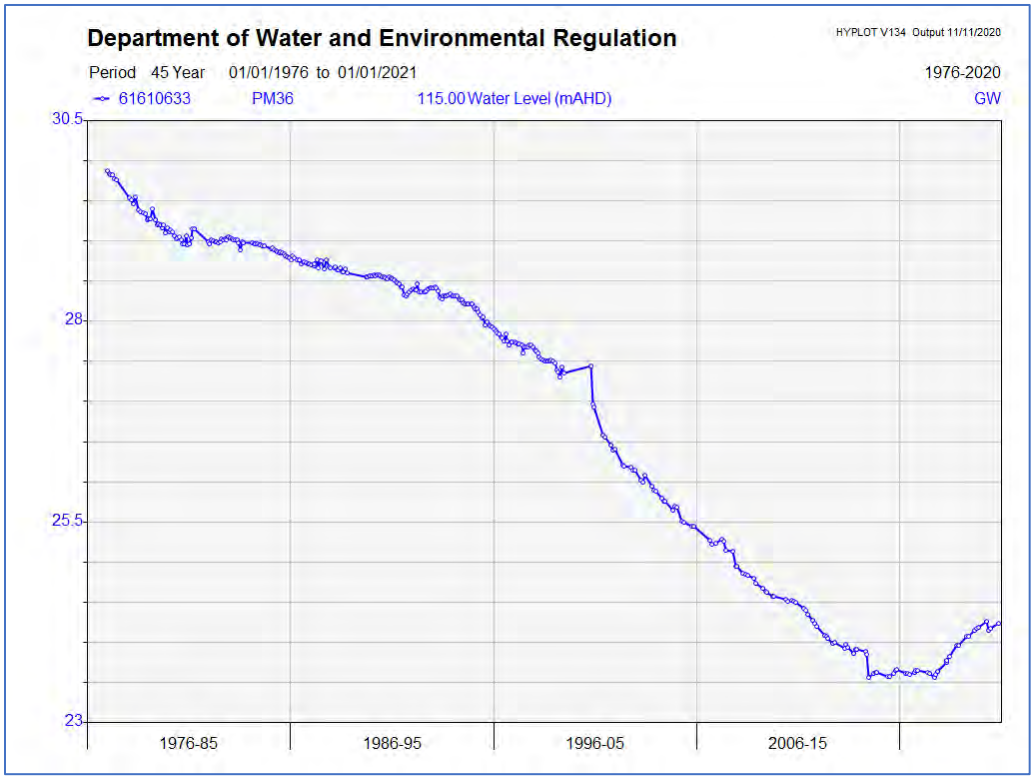
WIR Site reference	Bore ID	Location	Easting Northing	Ground level (mAHD)	Depth of drilling (mBGL)	Lithology			Groundwater monitoring date range	Historic maximum groundwater level (mAHD) (date)	Maximum groundwater level for period 2000-2020 (mAHD) (date)	Depth to maximum groundwater for period 2000-2020 (mBGL) #
						Substance	From (mBGL)	To (mBGL)				
61610600	PM34	North west of NIA, north of Wattle Ave West	381638 6496598	36.82	32.1	ND	ND	ND	29/12/1976-3/06/2021	21.7 (13/10/1978)	19.48 (12/10/2000)	17.34
61610632	JP11	Central southern boundary of NIA, in proximity to Flynn Drive	384269 6493522	60.18	78	Sand	0	78	5/08/1974-3/05/2021	33.6 (12/08/1975)	31.98 (20/10/2000)	28.2
61610633	PM36	Located centrally within NIA	383526.7 6495614.81	60.17	44.9	ND	ND	ND	30/12/1976-3/06/2021	29.87 (30/12/1976)	27.44 (20/10/2000)	32.73
61610634	JP13 (INV)	Central eastern northern boundary	384852 6496529	70.86	91	Sand	0	84.2	7/06/1973-20/05/2010	35.14 (12/10/1973)	31.83 (20/10/2000)^	39.03
						Clay	84.2	91				
61610635	JP13 (OBS)	Central eastern northern boundary	384854 6496559	70.32	69.00	ND	ND	ND	30/06/1973-15/07/2004	34.48 (30/06/1973)	31.78 (20/10/2000)^	38.54
61610666	P210	North-eastern corner of NIA	385846 6496487	53.04	71	ND	ND	ND	14/04/1975-10/06/1999	40.56 (2/10/1991)	ND	ND
61610665	WM4	Central eastern southern boundary	385815.44 6493657.36	64.21	39.6	ND	ND	ND	4/02/1975-7/11/2017	38.08 (24/04/1975)	36.37 (7/11/2017)	27.84

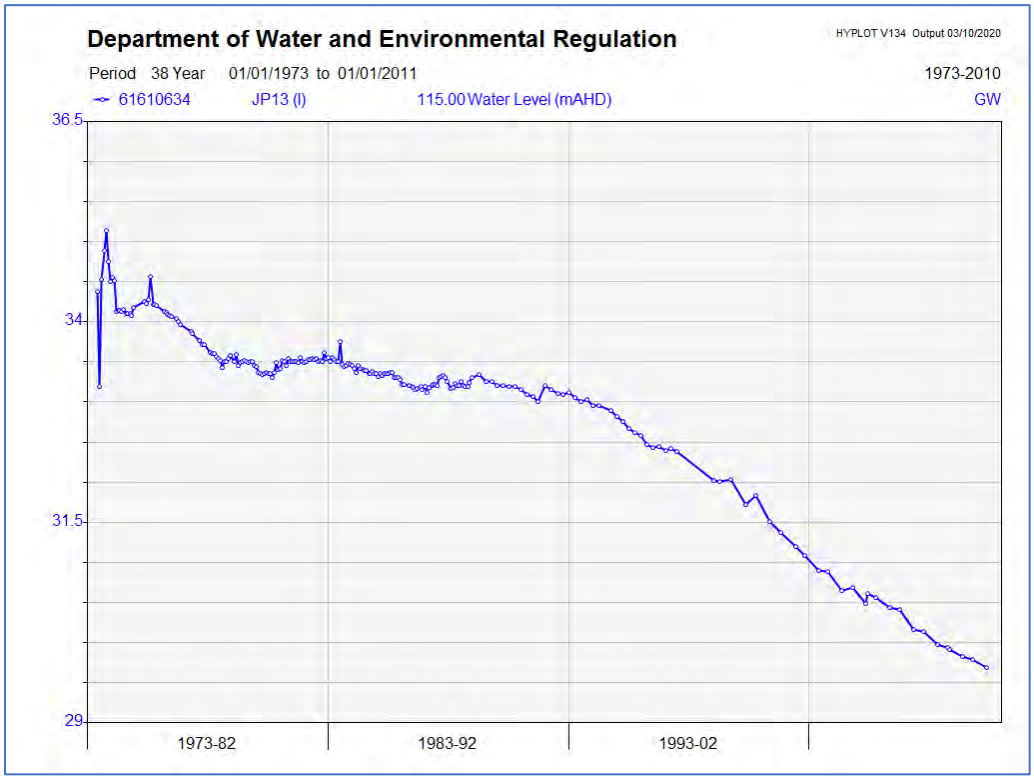
WIR Site reference	Bore ID	Location	Easting Northing	Ground level (mAHD)	Depth of drilling (mBGL)	Lithology			Groundwater monitoring date range	Historic maximum groundwater level (mAHD) (date)	Maximum groundwater level for period 2000-2020 (mAHD) (date)	Depth to maximum groundwater for period 2000-2020 (mBGL) #
						Substance	From (mBGL)	To (mBGL)				
61672191	WM4A (replacement for WM4)	Located along southern boundary within eastern extent	385603.56 6493546.93	58	42	Sand	0	42	12/04/2018-3/06/2021	Refer 61610665 (WM4)	Refer 61610665 (WM4)	Refer 61610665 (WM4)
61610696	GN19	Along central eastern boundary of NIA	386999 6495194	45.07	67.06	Sand	0	57.91	20/08/1965-3/06/2021	43.51 (25/11/1965)	41.63 (23/10/2018)	3.44[+]
						Claystone	57.91	65.53				
Note	# depth to natural surface level (not Final Surface Contour Plan)											
	ND – no data											
	^ date range does not extend to 2020											
	[+] Final Surface Contour Plan indicates finished level approx. 5 m higher than natural surface											

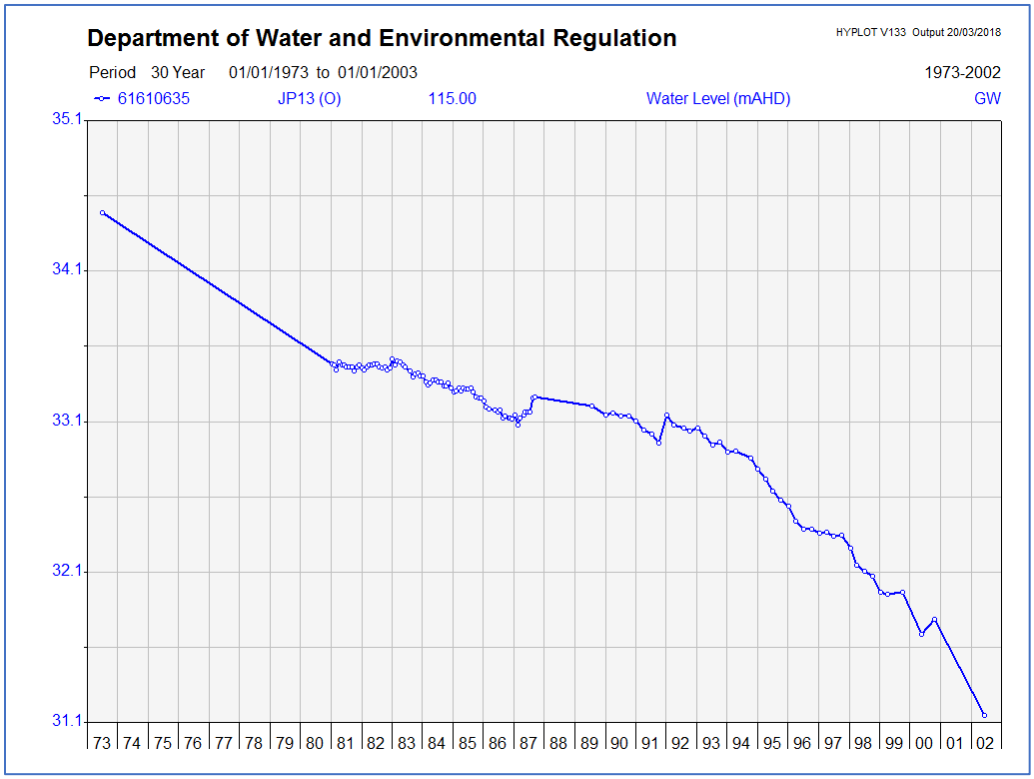
Figure F.1 DWER long term groundwater bores water level plots (mAHD)

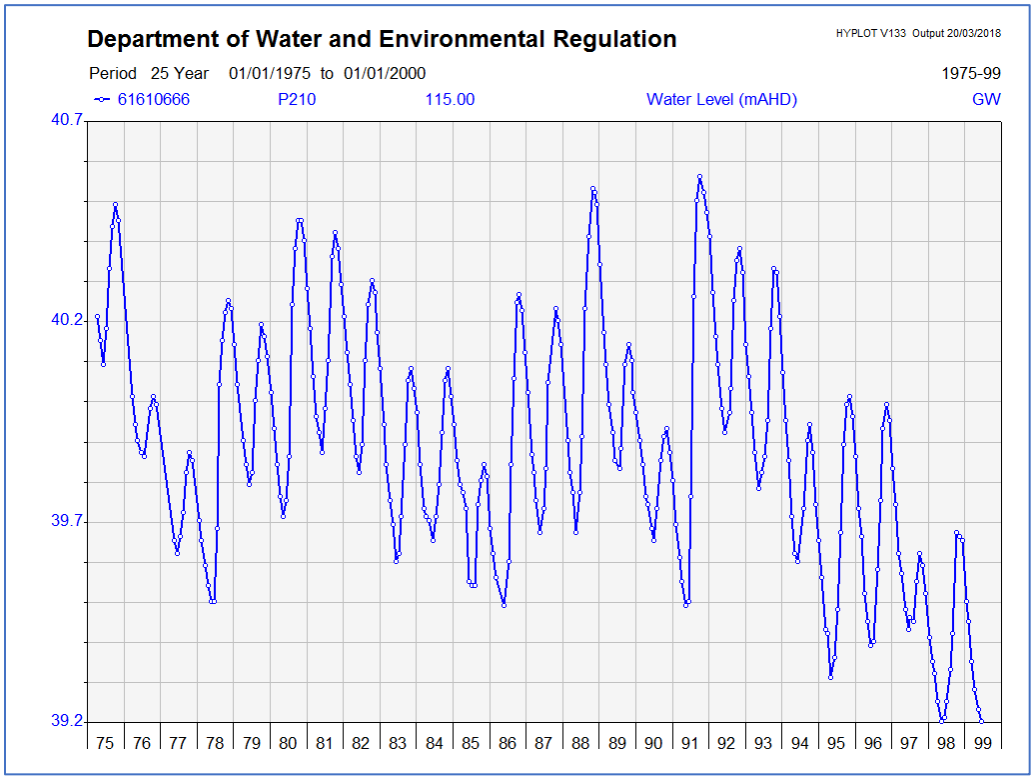


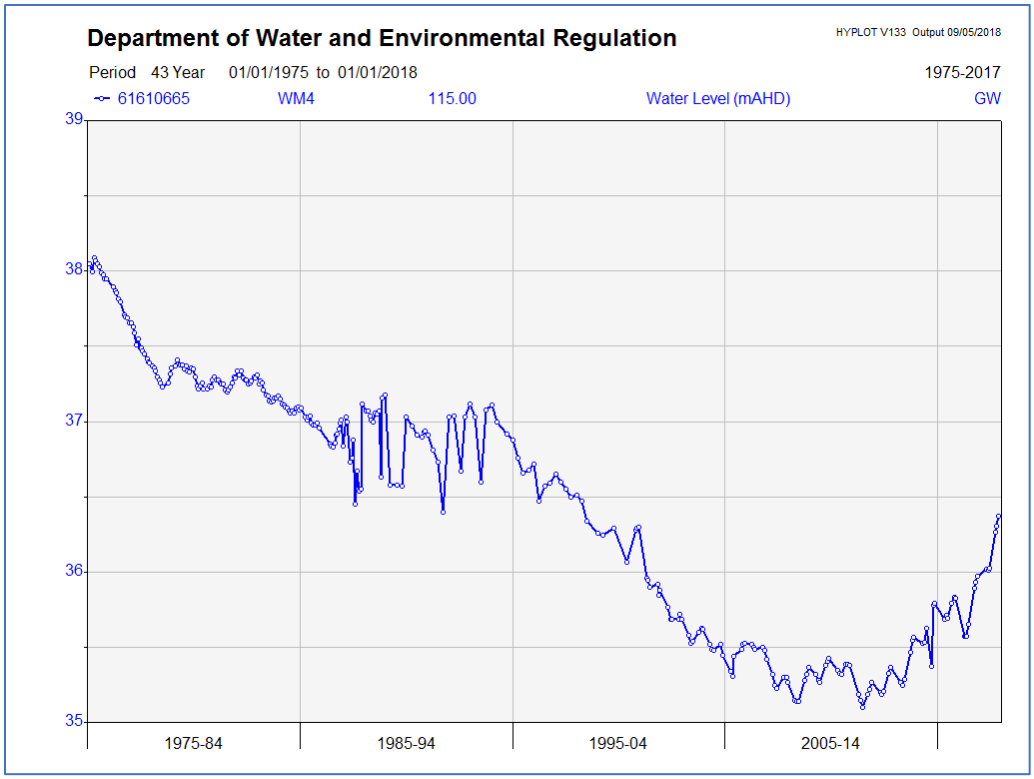


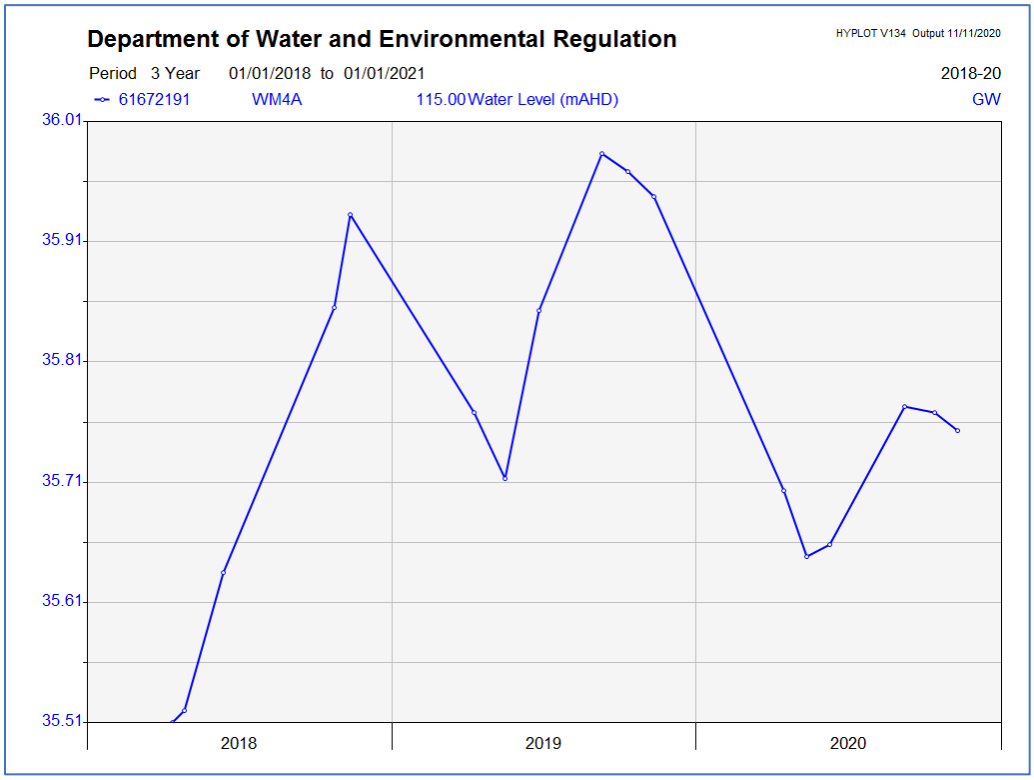

Department of Water and Environmental Regulation
HYPLOT V134 Output 11/11/2020
Period 45 Year 01/01/1976 to 01/01/2021
1976-2020
61610633 PM36 115.00 Water Level (mAHD) GW
30.5
28
25.5
23
1976-85
1986-95
1996-05
2006-15

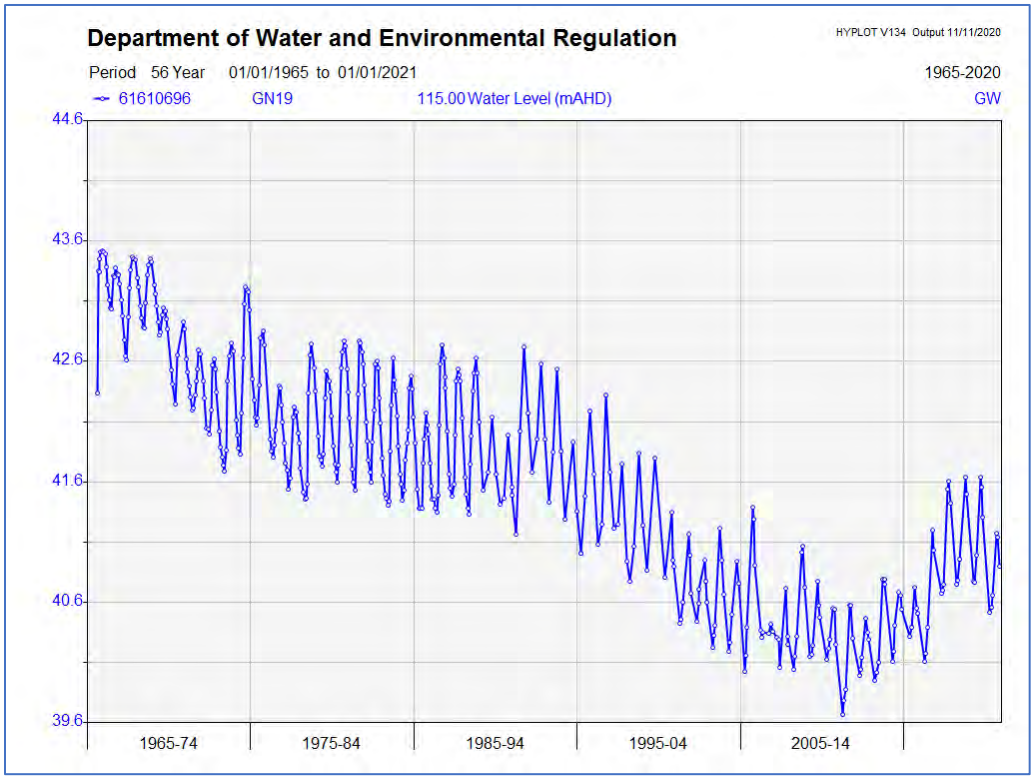

Department of Water and Environmental Regulation
HYPLOT V134 Output 03/10/2020
Period 38 Year 01/01/1973 to 01/01/2011
1973-2010
61610634 JP13 (I) 115.00 Water Level (mAHD) GW
36.5
34
31.5
29
1973-82
1983-92
1993-02


Department of Water and Environmental Regulation
HYPLOT V133 Output 20/03/2018
Period 30 Year 01/01/1973 to 01/01/2003
1973-2002
61610635 JP13 (O) 115.00 Water Level (mAHD) GW
35.1
34.1
33.1
32.1
31.1
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02


Department of Water and Environmental Regulation
HYPLOT V133 Output 20/03/2018
Period 25 Year 01/01/1975 to 01/01/2000
1975-99
61610666 P210 115.00 Water Level (mAHD) GW
40.7
40.2
39.7
39.2
75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99


Department of Water and Environmental Regulation
HYPLOT V133 Output 09/05/2018
Period 43 Year 01/01/1975 to 01/01/2018
1975-2017
61610665 WM4 115.00 Water Level (mAHD) GW
39
38
37
36
35
1975-84
1985-94
1995-04
2005-14


Department of Water and Environmental Regulation
HYPLOT V134 Output 11/11/2020
Period 3 Year 01/01/2018 to 01/01/2021
2018-20
61672191 WM4A 115.00 Water Level (mAHD) GW
36.01
35.91
35.81
35.71
35.61
35.51
2018
2019
2020


Department of Water and Environmental Regulation
HYPLOT V134 Output 11/11/2020
Period 56 Year 01/01/1965 to 01/01/2021
1965-2020
61610696 GN19 115.00 Water Level (mAHD) GW
44.6
43.6
42.6
41.6
40.6
39.6
1965-74
1975-84
1985-94
1995-04
2005-14

Appendix G –Historic groundwater quality

Source: DWER Water Information Reporting

Refer to Figure 4-7 for DWER long term groundwater monitoring bore locations.

Table G.1 DWER long term groundwater bores historic groundwater quality summary

Parameter	DWER long term monitoring bore					
	61610600	61610632	61610634	61610665	61610666	61610696
pH (no units)	6.7-8.2 (4)	5.9-6.3 (3)	6.6-6.7 (3)	5.4-6.8 (4)	6-6.5 (4)	6.1-7.3 (4)
Cond @ 25 deg C (uS/cm)	916-1320 (5)	420-4,200 (3)	752-761 (2)	259-302 (4)	1,480-1,550 (2)	496-771 (4)
Alkalinity (tot) (CaCO3) (mg/L)	102-178 (3)	25-32 (3)	90-122 (3)	11-19 (3)	56-60 (3)	54-157 (2)
Ca (sol) (mg/L)	90-148 (3)	6-8 (3)	22-24 (3)	2-3.4 (3)	18-21 (3)	8-165 (2)
Cl (sol) (mg/L)	122-157 (3)	140-105 (3)	166-175 (3)	55-89 (3)	406-410 (2)	128-133 (2)
Hardness (tot) (CaCO3) {Ca+Mg} (mg/L)	278-439 (3)	44-49 (3)	113-117 (3)	21-24 (2)	128-163 (3)	88-163 (2)
Mg (sol) (mg/L)	13-17 (3)	7 (3)	13-15 (3)	4-5 (3)	28 (2)	15-30 (2)
Na (sol) (mg/L)	70-87 (3)	59-62 (3)	105-107 (3)	40-48 (3)	220-228 (2)	71-82 (2)
SiO2 (sol react) (mg/L)	10-12 (3)	12-13 (3)	9-11 (3)	13-17 (2)	11-12 (2)	6-10 (2)
Note	Data shown as range (count of samples in brackets)					

Appendix H - Registered water allocations

Source: DWER Water Register

Table H.1 NIA licensed groundwater abstractions

Licence No.	Licence allocation (kL/yr)	Expiry date	Parties	Aquifer
60879	78000	22/4/2020	Western Australian Land Authority	Perth – Superficial Swan
160291	16500	9/12/2024	Borrello, F J	Perth – Superficial Swan
160290	1500	28/2/2026	Yennett Pty Ltd	Perth – Superficial Swan
160467	1500	18/11/2028	BGC (Australia) Pty Ltd	Perth – Superficial Swan
179096	1500	9/4/2024	Lindsay R C	Perth – Superficial Swan
172843	12000	10/6/2021	Holcim (Australia) Pty Ltd	Perth – Superficial Swan
183328	950	7/12/2026	Asphaltech Pty Ltd	Perth – Superficial Swan
160378	6250	31/5/2020	Boral Resources (WA) Ltd	Perth – Superficial Swan
94271	3150	3/8/2021	River Wind Pty Ltd	Perth – Superficial Swan
179117	30000	31/1/2027	Alvito Pty Ltd	Perth – Superficial Swan
151853	48000	26/4/2022	Borrello, F J	Perth – Superficial Swan
182623	5000	19/9/2026	Borrello, F J	Perth – Superficial Swan
159409	100000	15/7/2020	Mindarie Regional Council	Perth – Superficial Swan
99068	485650	14/9/2022	Trandros, N	Perth – Superficial Swan
104193	23500	4/7/2028	Trandos Hydroponic Growers Pty Ltd	Perth – Superficial Swan
202416	12000	10/2/2029	Fareast Assets Pty Ltd, Minalbi Pty Ltd	Perth – Superficial Swan
159473	150000	8/4/2020	Wesbeam Pty Ltd	Perth – Superficial Swan
164093	100000	18/5/2021	Newgen Power Neerabup Pty Ltd	Perth – Superficial Swan
182713	12000	31/1/2021	City of Wanneroo	Perth – Superficial Swan

Appendix I – Meridian Park plant species list

Source: Meridian Park Design Guidelines (LandCorp 2019)

Tree Species									
Species Name	**Common Name**	**Private Land**	**Carpark**	**Verge/ Median**	**Screening**	**Feature**	**Public Open Space**	**Potentially invasive**	**Comments**
Agonis flexuosa*	Peppermint	•			•		•		
Allocasuarina cunninghamiana	River Sheoak	•			•		•		
Angophora costata*	Smooth barked apple-myrtle	•	•						
Banksia littoralis	Swamp Banksia						•		Use in wet / dampland areas
Banksia menziesii*	Fire-Wood Banksia	•			•		•		
Banksia prionotes*	Acorn Banksia	•			•		•		
Brachychiton discolor x populneus						•			
Brachychiton gregorii	Desert Kurrajong					•			
Brachychiton populneo-acerifolius	Pink Kurrajong					•			
Casuarina obesa	Swamp Sheoak	•	•		•		•		
Delonix regia	Poinciana					•		•	
Eucalyptus botryoides	Bangalay	•	•				•		Use in high water table areas
Eucalyptus caesia*	Gungurru	•				•			Plant en masse
Eucalyptus calophylla 'Rosea'	Pink Marri	•					•		
Eucalyptus calophylla**	Marri	•					•		
Eucalyptus erythrocorys*	Illyarrie			•					Plant en masse
Eucalyptus ficifolia*	Red Flowering Gum	•	•	•		•	•		
Eucalyptus gomphocephala	Tuart						•		
Eucalyptus grandis	Rose Gum	•				•			
Eucalyptus leucoxylon**		•	•	•			•		
Eucalyptus maculata**	Spotted Gum		•	•		•		•	
Eucalyptus nicholii**	Willow Leaved Peppermint		•	•					
Eucalyptus platypus	Coastal Moort				•				
Eucalyptus sideroxylon	Pink Mugga Mugga		•	•		•			
Eucalyptus spathulata**	Swamp Mallet				•				
Eucalyptus stoatei	Scarlet Pear Gum								
Eucalyptus todtiana	Prickly Bark	•		•	•		•		
Ficus macrophylla	Moreton Bay Fig						•		
Ficus rubiginosa	Port Jackon Fig			•			•		Use only when there is a lot of space
Hymenosporum flavum	Queensland	•							
Magnolia grandiflora		•							
Melaleuca lanceolata**	Rottnest Tea Tree	•			•		•		
Melaleuca linariifolia**	Snow in Summer		•				•		
Melaleuca preissiana					•				Use in high water table areas
Melaleuca quinquenervia	Cajeput	•	•	•		•	•		
Melaleuca rhaphiophylla			•		•				
Metrosideros excelsa	Christmas bush	•			•	•			
Nuytsia floribunda*	WA Christmas Tree	•				•	•		
Podocarpus elatus	Plum Pine	•							
Tipuana tipu	Tipuana	•	•					•	

Shrubs									
Species Name	Common Name	Private Land	Carpark	Verge/ Median	Screening	Feature	Public Open Space	Potentially invasive	Comments
Acacia saligna**		•			•		•	•	
Adenanthos cygnorum	Woolybush	•			•		•		
Adenanthos cuneatus	Coastal Jug Flower	•	•	•			•		
Adenanthos meisneri					•				
Adenanthos sericeus	Coastal Woolybush				•				
Anigozanthos flavidus x pulcherrimus	Kangaroo Paw		•	•					Suitable for microclimate area
Anigozanthos flavidus x rufus	Kangaroo Paw		•	•					
Banksia ashbyii*		•					•		
Banksia baxteri*		•					•		
Banksia burdettii		•					•		
Banksia hookeriana*		•					•		
Banksia speciosa*	Ric-Rac Banksia	•					•		
Banksia victoriae*		•					•		
Beaufortia sparsa*	Swamp Bottlebrush	•			•				
Beaufortia squarrosa*	Sand Bottlebrush	•			•				
Callistemon 'Kings Park		•			•				
Callistemon citrinus	Crimson Bottlebrush	•			•				
Callistemon phoeniceus		•							
Calothamnus quadrifidus*	One-Sided Bottlebrush	•			•				
Chamelaucium uncinatum*	Geraldton Wax	•			•				
Darwinia citriodora**		•	•	•			•		
Dianella revoluta		•	•	•					
Dianella tasmanica		•		•					
Dianella utopia		•	•			•			
Dianella variegata	Varigated Dianella	•	•	•			•		
Eucalyptus macrocarpa*	Rose of the West	•		•		•	•		
Eucalyptus rodantha		•		•		•	•		
Eucalyptus tetragona		•					•		
Grevillea 'Ellendale Pool'		•		•					
Grevillea 'Honeygem'		•		•					
Grevillea 'Joe Mason'		•		•					
Grevillea bipinnatifida*		•			•				
Grevillea biternata		•	•	•					
Grevillea crithmifolia		•	•	•					
Grevillea obtusifolia		•			•				
Hakea laurina		•		•	•				Suitable for microclimate area
Hakea francisiana	Sea Urchin Hakea	•							
Hakea petiolaris		•			•				
Hypocalymma angustifolium	Swan River Myrtle	•	•			•	•		Suitable for microclimate area
Kunzea baxteri		•			•				
Kunzea pulchella					•				
Leucophyta brownii	Cushion Bush	•	•	•		•			
Macrozamia reidlei*		•							Suitable for microclimate area
Melaleuca coccinea*		•							
Melaleuca elliptica		•							
Melaleuca hypericifolia**		•					•		
Melaleuca nesophila**		•					•		
Murraya exotica	Orange Jessamine	•						•	Suitable for microclimate area
Philodendron xanadu		•							Suitable for microclimate area
Protea 'Duchess of Perth'		•	•	•	•	•			
Protea eximia	Broadleaf Sugarbush	•			•	•			
Protea magnifica	Queen Sugarbush	•	•		•	•			
Protea scolymocephala	Thistle Sugarbush	•	•	•	•	•			
Verticordia grandis	Scarlet Feather Flower					•			
Verticordia nitens	Christmas Morrison					•			
Xanthorrhoea preissii*	Grass Tree	•		•		•	•		

Groundcovers									
Species Name	**Common Name**	**Private Land**	**Carpark**	**Verge/ Median**	**Screening**	**Feature**	**Public Open Space**	**Potentially invasive**	**Comments**
Adenanthos cuneatus 'Coral Carpet'		•	•	•			•		
Convolvulus mauritanicus		•							
Eremophila glabra	Emu bush	•	•	•					
Gazania rigens		•		•				•	Not to be used within 500m of bush forever or 200m of dampland/remnant bushland
Grevillea crithmifolia 'Prostrata'		•	•	•			•		
Grevillea obtusifolia 'Prostrata'		•	•	•			•		
Grevillea 'Sea Spray'		•	•	•					
Grevillea thelemanniana*		•	•	•					
Hemiandra pungens*				•					
Hibbertia scandens			•	•					Suitable for microclimate area
Myoporum parvifolium					•				
Patersonia occidentalis*	Native Iris	•	•	•			•		

Climbers									
Species Name	**Common Name**	**Private Land**	**Carpark**	**Verge/ Median**	**Screening**	**Feature**	**Public Open Space**	**Potentially invasive**	**Comments**
Cissus rhombifolia "Ellen Danica'		•							Suitable for microclimate areas-shade planting only
Hardenbergia comptoniana	Native Wisteria	•	•	•			•		Suitable for microclimate area
Kennedia prostrata	Running Postman	•	•	•			•		
Trachelospermum jasminoides	Chinese Star-Jasmine	•						•	Suitable for microclimate area

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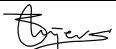
12515608-20662-150/https://projectsportal.ghd.com/sites/pp18_01/neerabupdistrictplan/ProjectDocs/LWMS/12515608-REP-1_Neerabup District Planning LWMS.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	M. Craft A. Stevenson K. Hunt	K. Hunt	On file	K. Petani	On file	5/12/2019
B	K. Hunt	B. Wijers	On file	K Petani	On file	25/01/2021
0	K. Hunt	B. Wijers		S Barlow		17/06/2021
1	K. Hunt	B. Wijers	On file	S Barlow		08/07/2021