Appendix 3

Local Water Management Strategy

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North Ellenbrook (West) Local Structure Plan 1

Local Water Management Report

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1. EXECUTIVE SUMMARY

This **Local Water Management Report [LWMR]** has been prepared to support the *North Ellenbrook (West) – Local Structure Plan Area 1* area which encompasses Lots 112, 114 & 1808 Chudalup Road, Bullsbrook.

The Structure Plan covers an area of approximately 111 ha and proposes urban development with a mix of residential lots (R20-R60) integrated with Regional Open Space (ROS), Public Open Space (POS) and a Private School.

This LWMR provides the framework for the application of total water cycle management to the urban development, consistent with the *North Ellenbrook (West) District Water Management Strategy* [DWMS] (JDA, 2022), Department of Water and Environmental Regulation's principles of Water Sensitive Urban Design as described in the *Stormwater Management Manual for Western Australia* (DWER, 2022) and *State Planning Policy 2.9 Water* (WAPC, 2025).

It identifies the hydrological characteristics of the site and demonstrates the proposed land use change can be supported with the application of an appropriate water management strategy.

A summary of the DWMS objectives and the LWMR design principles is presented in Table 1.

Table 1: Summary of LWMR Design Principles and Criteria

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Provide integration with planning processes and clarity for agencies involved with implementation • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation. • To maintain the total water cycle.		
Category	**DWMS Objectives**	**LWMR Criteria**
Water Conservation and Sustainability	• Ensure non-potable water supply systems are considered as part of an integrated water supply. • Household target water use of 100 kL/person/year. • Scheme water target use of 40-60 kL/person/year. • Use of waterwise landscaping practices both at development and lot scale.	• Consider alternative fit for purpose water sources where appropriate and cost-effective. • Aim to achieve the State Water Plan target for water use of 100 kL/person/yr. • Buildings to comply with water efficiency standards introduced into the building code. • POS irrigation water supply source from non-potable groundwater. • POS areas to be landscaped with at least 50% native plants.
Stormwater Management	• Maintenance of pre-development hydrological regime including outflow rates. • Safe conveyance and management of stormwater runoff in accordance with ARR 2019 (Ball et al., 2019) • At source detention of first 15 mm rainfall event. • On site detention of stormwater runoff up to 1% AEP storm event. • Water quality treatment systems and water sensitive urban design structures designed in accordance with *Stormwater Management Manual for Western Australia* (DoW, 2007) *Chapter 9 (Structural Controls)* and *Australian Runoff Quality* (Engineers Australia, 1997) • Non-structural measures to reduce applied nutrient loads.	• Stormwater runoff managed using the Small, Minor and Major approach as outlined in AR&R (2019). • Stormwater runoff from the 'small' event or first 15 mm of rainfall is treated by soakwells, tree pits, parklets or bio-retention areas to treat a minimum of 2% of connected impervious areas of road catchments. • Stormwater runoff from Minor and Major events (1% AEP) safely conveyed via pipe and overland flow to Flood Management Areas [FMA] within POS. • FMAs designed with peak outflow consistent with pre-development rates. • Use of non-structural controls to reduce applied nutrient loads. • Use of subsoil drainage to assist in managing perched water and facilitate adequate drainage of stormwater runoff.
Groundwater Management	• Ensure adequate separation (1.5 m) between building floor level and AAMGL. • Limit hydrological impact to Bush Forever and wetland sites. • Manage fertiliser and pesticide application in streetscapes and POS to reduce nutrient input.	• Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture with combination of fill and subsoil drainage where required. • Managing and minimising changes in groundwater levels and groundwater quality following development. • Maintain groundwater quality at pre-development levels, mean winter concentrations and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.
Water Quality	• Adopt nutrient load reduction design objectives for stormwater runoff. • Use of amended soils and ephemeral bioretention systems to treat stormwater.	• Treatment of stormwater runoff for 'small' event (15 mm rainfall) via infiltration through amended soils in tree pits, parklets and bio-retention areas prior to discharge.
Monitoring	• Pre- and post-development program to ensure water quality targets are met.	• Establishment of a post development Monitoring Program with criteria and contingency action.

2. INTRODUCTION

2.1 BACKGROUND

Avant Hydro has been appointed by Parcel Property to prepare this **Local Water Management Report [LWMR]** to support the *North Ellenbrook (West) – Local Structure Plan Area 1* [LSP1] (Rowe Group, 2026). The LSP1 covers approximately 111 ha and includes Lots 112, 114 & 1808 Chudalup Road, Bullsbrook, hereafter referred to as the 'Study Area' (Figure 1).

Land ownership of the Study Area is as follows:

- Lots 112 & 114 Chudalup Road - Ellenhoog Pty Ltd
- Lot 1808 Chudalup Road - Conoble Park Pty Ltd

The LSP1 area is Precinct 1 of the Northern Ellenbrook (West) District Structure Plan [DSP], Figure 1.

This LWMR outlines a conceptual water management strategy for stormwater, groundwater, water supply and water quality management, at a level of detail suitable for the purpose of the local planning scheme. This is consistent with the level of water management reporting required, and the general requirements for a LWMR as outlined in Table D.1 of SPP 2.9 (WAPC, 2025).

2.2 STATUTORY FRAMEWORK

2.2.1 Regional Planning

The Study Area is currently zoned *Rural* in the Metropolitan Region Scheme [MRS] and *General Rural* in the City of Swan Local Planning Scheme No. 17 (City of Swan, 2008).

An Urban Drainage and Water Management Strategy was developed by GHD and the then Department of Water [DoW] in 2007 to support the North East Corridor Structure Plan, inclusive of the Study Area, for use as a foundation for development of more detailed district and local structure plans and predates *Better Urban Water Management* (WAPC, 2008).

The Study Area is located within an area designated as *Urban Investigation* in the North-East Sub-Regional Planning Framework (DPLH, 2018) which aims to provide long-term growth to the Perth and Peel regions to cater to approximately 3.5 million people by 2050.

2.2.2 District Planning

A District Water Management Strategy (DWMS) was prepared by JDA in 2021/2022 for the 613 ha North Ellenbrook DSP area (Rowe Group, 2021) and approved by the Department of Water and Environmental Regulation [DWER]. The 111 ha Study Area represents Precinct 1 (of 4) of the *North Ellenbrook (West) DSP*, Figure 1.

The DWMS was consistent with DoW & GHD (2007) and detailed drainage strategies for local conditions, design criteria for water quantity and quality and implementation strategies and is further detailed in Section 2.3.5.

An amendment to rezone the North Ellenbrook DSP area from *'Rural'* to *'Urban'* under the MRS is currently under assessment.

2.2.3 Local Planning

The *North Ellenbrook (West) Area 1 – Gateway (South East) Local Structure Plan* (Rowe Group, 2026) proposes a mix of residential lots (R20-R60) integrated with Regional Open Space (ROS) and Public Open Space (POS) areas, and Private Clubs and Institutions, Figure 2 and Appendix A.

This LWMR is presented in support of this LSP and develops surface water and groundwater management strategies at a local scale and has been prepared in accordance with the requirements of the DWMS (JDA, 2022).

2.3 KEY DESIGN PRINCIPLE AND OBJECTIVES

The LWMR uses the following documents to define its content, key principles and objectives some of which are described in further detail below:

- *State Planning Policy 2.9: Water - Planning for Water Guidelines* (WAPC, 2025)
- *Local Water Quality Improvement Plan Ellen Brook Catchment* (SRT, 2009a);
- *Swan Canning Water Quality Improvement Plan* (SRT, 2009b);
- *Water Resource Considerations when Controlling Groundwater Levels in Urban Development* (DoW 2013)
- *Decision Process for Stormwater Management in Western Australia* (DWER, 2017a);
- *North Ellenbrook (West) 2D Groundwater & Surface Water Modelling* (JDA, 2021);
- *North Ellenbrook (West) District Water Management Strategy* (JDA, 2022); and
- *Stormwater Management Manual for Western Australia* (DWER, 2022a).

2.3.1 State Planning Policy 2.9 – Water - Planning for Water Guidelines (WAPC, 2025)

State Planning Policy 2.9 (WAPC, 2025) was developed to inform state government departments and local governments in the undertaking of their planning responsibilities for the use and development of land as it relates to water resources.

The objectives of the policy are to:

- Protect, conserve and enhance water resources that are identified as having significant economic, social, cultural and/or environmental values;
- Assist in ensuring the availability of suitable water resources to main essential requirements for human and other biological life with attention to maintaining or improving the quality and quantity of water resources; and
- Promote and assist in the management and sustainable use of water resources.

The state's water planning policy framework was reviewed by the Western Australian Planning Commission [WAPC] which resulted in a revision to the policy and guidelines with the aim to streamline and simplify the current planning framework and deliver greater clarity around how water-related provisions are implemented.

SPP 2.9 amalgamates and synthesises various State Planning Policies into a single planning document and replaces Better Urban Water Management (WAPC, 2008). The revised SPP 2.9 is used to further inform appropriate water management measures in this report.

2.3.2 Decision Process for Stormwater Management in Western Australia (DWER, 2017a)

The *Decision Process for Stormwater Management in Western Australia* (DWER, 2017a) was developed to provide an approach and outcome criteria for planning and designing stormwater management systems for urban developments and retrofitting of existing stormwater management systems. The document is the third edition and was originally published in 2005 then updated in 2009.

The purpose of the decision process is to:

- Design urban stormwater management systems that reduce risk to people and property from flooding to within acceptable levels;
- Design urban stormwater management systems that mimic natural hydrological process for the relevant stormwater catchment;
- Retain natural water bodies as the receiving environments for runoff of suitable quality from minor and major rainfall events;

- Retain and plant vegetation (preferably local native species), where possible, to reduce stormwater runoff volumes and peak flow rates, reduce urban temperatures, improve water quality, increase urban biodiversity and improve aesthetics and urban amenity;
- Implement stormwater management systems and site management, maintenance and other practices to prevent, reduce and treat pollutants' and
- Design urban stormwater management systems that achieve good urban amenity and provide multiple functions.

2.3.3 Stormwater Management Manual for Western Australia (DWER, 2022a)

The Water and Rivers Commission (Department of Water, DoW, 2006-2017; Department of Water and Environmental Regulation, DWER, 2017-present) released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998 to define and practically describe Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aimed to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

In consultation with a working team comprising industry and government representatives a major review of the manual was completed in 2007. The revised manual was officially launched in August 2007.

Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles

The manual was reviewed and updated in 2022 from the August 2007 version to ensure all information contained in the document was correct and up-to-date.

2.3.4 North Ellenbrook (West) District Water Management Strategy (JDA, 2022)

The *North Ellenbrook (West) District Water Management Strategy* [DWMS] was prepared by JDA on behalf of the Conoble Park Pty Ltd to support the *North Ellenbrook (West) District Structure Plan* (Rowe Group, 2021).

The aims of the DWMS were to:

- Identify the key water management elements of the DWMS area.

- Describe pre-development conditions of the DWMS area and its water resource management characteristics.
- Define land area requirements for conveyance of flood flows and protection of future urban development from peak flow events.
- Recommend management strategies for groundwater and drainage appropriate for local conditions that incorporates best practice WSUD measures.
- Present guiding principles and strategies for post-development management of water resources as recommended in DoW & GHD (2007).
- Recommend requirements and commitments for future actions including monitoring programs for water quantity and water quality pre-, during and post- development.

The DWMS was supported by a calibrated 2D groundwater-surface water interaction model (JDA, 2021).

3. PROPOSED DEVELOPMENT

Precinct 1 covers an area of 110.87 ha and is situated within the City of Swan, approximately 33 km north-east of the Perth CBD and 7 km north of the Ellenbrook town centre. The Study Area is bound by Chudalup Road to the north, Halden Road to the west, a rural residential lot to the south and Tonkin Highway to the east, Figure 1.

The *North Ellenbrook (West) Area 1 – Local Structure Plan 1* (Rowe Group, 2026) proposes a mix of residential lots (R20-R60) integrated with Regional Open Space (ROS) and Public Open Space (POS) areas with Private Clubs and Institutions and retains the existing waterways though the site, Figure 2.

Key elements of the Plan related to urban water management include:

- Infiltration of frequently occurring rainfall events ('small' event) from impervious lot and road reserves within planted Bio-Retention Areas [BRA] in POS areas.
- A pit and pipe system designed to convey minor event stormwater runoff from lots and roads to a down-gradient Flood Management Area [FMA]. Road carriageways will be used as an overland flow path to convey stormwater runoff from major event stormwater to the FMAs.
- Detention of stormwater for the minor and major rainfall events within a FMA, with a drainage outlet connection to existing waterway culverts to the east located under Tonkin Highway.
- Retention of existing trees and watercourses, where possible, within open spaces and multiple use corridors.
- Use of local native vegetation species in open spaces and streetscapes to reduce nutrient input and conserve water resources.

A breakdown of the land use within the Study Area is presented in Table 2 below.

Table 2: Land Use Breakdown

Land Use Description	Area (ha)
Residential Lots	27.92
Road Reserve	16.08
District Centre	18.51
Private School	10.05
Regional Open Space (ROS)	15.24
Public Open Space (POS)	10.09
Interchange / Flyover	12.89
Total	**110.87**

4. PRE-DEVELOPMENT ENVIRONMENT

4.1 Existing Land Use

The majority of the north-east of the Study Area has been cleared for pasture with homesteads located in the north-east and east. The remainder of the Study Area comprises of scattered trees and shrubland, Figure 1, with a minor watercourse flowing east through the centre of the Study Area and Sawpit Gully flowing similarly through the southern area of the Study Area.

4.2 Climate

The North Ellenbrook area, along with most of the Greater Perth Metropolitan Area, is characterised by a Mediterranean climate with warm dry summers and cool wet winters with rainfall predominantly occurring from May to September.

Rainfall data is provided by the nearby Bureau of Meteorology [BoM] *Pearce RAAF* rain gauge (Site ID: 009053), located 7 km north-east of the Study Area, Figure 3.

The rainfall record at the *Pearce RAAF* gauge dates from 1937, however, little data was recorded between 1946 and 1964. The average annual rainfall, 1965 to 2024, for Pearce RAAF was 645 mm, with a 30-year average of 621 mm, a 3% reduction. There has been a decreasing rainfall trend across south-west Western Australia since the 1970s (DoW, 2015b), however, no strong trend is evident at the Pearce RAAF rain gauge, either across the long- and short-term average annual rainfall nor the average monthly rainfall, Figure 3.

Average annual pan evaporation is estimated at 1,915 mm for the Study Area from pan evaporation data recorded at the Department of Primary Industries and Regional Development (DPIRD) Wanneroo weather station (2007-2024). This is slightly lower than estimated pan evaporation for the Study Area from Luke et al. (1987) of 1,990 mm. Average monthly pan evaporation is shown on Figure 3.

4.3 Topography

The pre-development topography (DoW, 2008) of the Study Area is shown on Figure 4 and shows the land generally grading to the east from over 54 mAHD to around 44 mAHD near the Tonkin Highway, Figure 4.

Drainage channels occur through the centre and south of the Study Area and are incised 0.3 to 0.5 m into the natural landscape.

The topography in Figure 4 predates construction of the Tonkin Highway extension east of the Study Area.

4.4 Surface Geology

Surface geology mapping by Gozzard (1982) is shown on Figure 5.

The Study Area is generally mapped as "S8" *Sand* or "S10" *Sand (S8) over Pebbly Silt*. "S8" soils are described in Gozzard (1982) as very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted and of aeolian origin. A section of "Cps" *Peaty Clay* intersects the Study Area in the south-east corner and is described as dark grey and black peaty clay with variable sand content and of lacustrine origin.

A geotechnical investigation of Parcel Property managed land which included LSP1, 2 and 3 was conducted by Structerre Consulting in August and September 2025 involving the excavation of 50 sample retrieval probe boreholes to maximum depths of 2.5m, BH01 to BH50; 50 sand penetrometer tests adjacent to each borehole, 15 in-situ percolation tests within the upper 1 m of the soil profile and 5 cone penetrometer tests to depths of 3.91 m. Of these, boreholes BH37 to BH50 were located within the Study Area. Locations of boreholes and permeability test locations are shown on Figure 5.

The average subsurface profile encountered comprised of topsoil to 0.2 m overlying natural sand in excess of 5 m in depth and generally aligned with regional mapping in Gozzard (1982). The sand within the Study Area is generally described in Structerre Consulting (2025) bore logs as pale grey, very loose, poorly graded and medium grained. No boreholes were located in the mapped peaty clays in the south-east of the Study Area, Figure 5. Groundwater was encountered generally at or near surface in most of the boreholes in the eastern half of the Study Area.

In-situ permeability testing by Structerre Consulting (2025) was conducted at 5 boreholes within the Study Area (BH39, BH42, BH45, BH47 and BH50) at depths of 0.65 to 0.9 m at all bores except BH47 which was tested at 0.45 to 0.7 m depth. Derived permeabilities ranged from 0.2 m/day at BH47 to 10.9 m/day at BH50 and were likely related to separation to the water table. The base of hole for the permeability tests in BH45 (0.8 m/day) and BH47 (0.2 m/day) was approximately at the water table and surrounding soils would have been saturated due to capillary fringe. The results at the other sites were 3.6 m/day at BH39; 5.9 m/day at BH42; and 10.9 m/day at BJ50, with the water table separation to the water table from base of hole at least 1.6 m in BH39 and BJ42 and 1.3 m in BH50.

Structerre Consulting (2025) considered the current ground conditions in the lower lying areas were not suitable for on-site disposal of stormwater runoff due to shallow groundwater but may be appropriate subject to suitable engineered design with the placement of free draining sand and appropriate drainage control systems.

A copy of the geotechnical investigation (Structerre Consulting, 2025) is attached in Appendix B.

4.5 Acid Sulphate Soils

The Study Area is generally classified as Class 1, having a moderate to low risk of Acid Sulphate Soils (ASS) occurring less than 3 m from surface but high to moderate risk of ASS beyond 3 m of natural soil surface (DWER, 2017b), Figure 5. A section in the south-east corner is classified as Class 2, having a high to moderate risk of ASS. occurring less than 3 m from natural surface, Figure 5, and aligns with mapped peaty clay (Section 4.4).

Investigation for potential Acid Sulphate Soils across the Study Area is recommended prior to subdivision.

4.6 Groundwater

4.6.1 Regional Hydrogeology

The hydrogeological formations under the Study Area can be grouped into four distinct aquifers, each being assigned the name of the major geological unit contributing to it. In descending order of depth from natural surface they are: Superficial Aquifer (unconfined); Mirrabooka Aquifer (semi-unconfined); Leederville Aquifer (confined) and Yarragadee Aquifer (confined). The hydrogeology of the Study Area has been inferred from Davidson (1987 & 1995) and DWER bore SV4A, located adjacent to bore L220C and described in Yesertener & Stevenson (2024).

Superficial Aquifer

The Superficial aquifer in the Study Area fronts part of the Gnangara Mound and flows in an eastern direction towards Ellen Brook. The superficial aquifer is unconfined and directly recharged from direct rainfall percolation, and below the Study Area extends to approximately -5 mAHD and an average saturated thickness of 50 m (Davidson, 1995). The aquifer consists of clayey sediments of the Guildford Formation with an average aquifer transmissivity of 400 to 600 m^2/day; salinity of < 500 mg/L TDS and estimated net rainfall recharge rate of 13.1% (Davidson, 1987 & 1995).

Mirrabooka Aquifer

The Mirrabooka aquifer is semi-confined and locally confined aquifer present along the eastern margin of the Swan Coastal Plain. It is confined below by the shales of the Osborne Formation and locally above by interbedded shale lenses and is hydraulically continuous with the overlying superficial aquifer (Davidson, 1987 & 1995). The average horizontal conductivity of the Mirrabooka aquifer is 1 m/day and salinity ranges from 130 to 350 mg/L TDS (Davidson, 1995). The Mirrabooka aquifer has a thickness within the vicinity of the Study Area of approximately 120 m (Yesertener & Stevenson, 2024).

Leederville Aquifer

The Leederville aquifer is found at the base of the Superficial aquifer and is approximately 350 m thick and flows southward beneath the Study Area (Davidsom, 1987; Yesertener & Stevenson, 2024). The Pinjar Member is found between -150 to -200 mAHD and overlies the Mariginiup Member and Wanneroo Member (Davidson, 1995). The aquifer is multi-layered and consists of discontinuous interbedded sandstones, siltsones and shales with average horizontal hydraulic conductivity in the sandstone beds of 10 m/day and in the siltstone and shale beds of 1 x 10^{-6} m/day and average transmissivity of 300 to 400 m^2/day (Davidson, 1995). The Leederville aquifer in the vicinity of the Study Area is brackish to saline, slightly acidic to slightly alkaline and has high concentrations of Iron and Phosphorus (Yesertener & Stevenson, 2024).

Yarragadee Aquifer

The Yarragadee aquifer is a multi-layered aquifer which underlies the entire Perth region and is more than 2000 m thick (Davidson, 1995). The top of the aquifer beneath the Study Area is at approximately -500 mAHD and is confined from the Leederville aquifer by the South Perth Shale (Davidson, 1995). The aquifer is interbedded in similar proportion to the Leederville aquifer and has similar average horizontal hydraulic conductivities in respective sandstones and siltstone/shale beds. The flow direction beneath the Study Area is generally south/south-east although the regional direction is south-westward (Davidson, 1995).

4.6.2 Groundwater Modelling

An integrated 2D groundwater and surface model was developed by JDA Consultant Hydrologists in liaison with the Department of Water and Environmental Regulation to support the North Ellenbrook (West) DSP/DWMS and is detailed in JDA (2021). The model was run as a 4 year simulation (2003 to 2006) and calibrated to 19 bores within the vicinity of the DSP Area which had sufficient quality and quantity of water level data and representative bore screening depths. A calibrated base case (S0) was run and compared to 3 scenarios (S1 to S3) under various climate change and land-use scenarios for the year 2030.

Scenario 3 represented a future median climate with an average 8.8% decrease in average rainfall, 0.7% increase in potential evapotranspiration and post-development land use with controlled groundwater levels and cut/fill of sand where needed. S3 resulted in 1.53 GL/year gross recharge to groundwater in the DSP area with groundwater level rise controlled by subsoil drainage with annual discharge of 0.24 GL/year or 7% of rainfall. The opposing influences of climate change and land use change modelled resulted in no change in aquifer storage over the simulation period compared to a 0.08 GL increase in the base case (S0).

4.6.3 Groundwater Levels

Pre-development groundwater monitoring was conducted by JDA for the DWMS area from July 2022 to October 2024. Six bores, WAR01 to WAR06, were drilled by Edrill Environmental and supervised by JDA on 27 July 2022 using hollow stem auger to approximately 3 m below the encountered groundwater level with bore depths ranging from 3.7 to 9.8 m below natural surface. Bores were screened in the lowest 3 m; gravel packed around the screen, backfilled with cuttings and sealed with bentonite. Of these bores, WAR06 is located within the south-east of the Study Area and WAR04 is located in the south-west within the Halden Road reserve, Figure 6.

A further four Department of Water and Environmental Regulation (DWER) bores (L220C, L230C, L240C & L250C) are located through the centre of the DWMS in the Warbrook Road reserve with L240C in the north-west corner and L250C in the north-east corner of the Study Area, respectively. Bores L220C and L240C were still monitored by DWER while monitoring of L230C ceased in 1999 and L250C in 2014.

Bore details are presented in Table 3 and locations shown in Figure 6. Bore lithological logs are included in the pre-development groundwater monitoring report (JDA, 2025) attached in Appendix C.

Table 3: Details of Groundwater Monitoring Bores

Bore ID	Coordinates[1]		Natural Surface (mAHD)	Total Depth (mbToC)	Top of Casing (mAHD)	Screened Interval (mbNS)	Water Level 30-Aug-22 (mAHD)	Estimated MGL (mAHD)	Installation Date
	Easting	Northing							
WAR01	400905	6489195	54.68	8.86	55.20	5.3-8.3	52.88	53.38	27 July 2022
WAR02	401263	6490721	60.05	10.42	60.63	6.8-9.8	52.93	53.43	27 July 2022
WAR03	402309	6491042	48.77	4.18	49.28	0.7-3.7	47.79	48.29	27 July 2022
WAR04	402369	6489096	52.35	4.22	52.91	0.7-3.7	48.40	48.90	27 July 2022
WAR05	403225	6491017	42.01	8.55	42.55	5-8	42.30[4]	42.01	27 July 2022
WAR06	403311	6489017	45.26	4.20	45.77	0.7-3.7	44.70	45.20	27 July 2022
L220C	400362	6489909	56.84	10.0	57.44	1-10	54.71	55.52[2]	1983/84
L230C	401367	6489949	54.22	10.0	54.58	2-10	51.73	52.23[3]	1983/84
L240C	402329	6490024	49.64	10.0	50.19	2-10	47.77	48.45[2]	1983/84
L250C	403399	6490139	42.91	10.0	43.39	0-10	42.39	42.89[3]	1983/84

Notes: bToC = metres below Top of Casing; BNS = metres below natural surface; mAHD = metres Australian Height Datum;
1. Coordinates in GDA 1994.; 2. MGL of DWER Bore (Table 4); 3. MGL calculated with +0.5 m adjustment; 4. Upward head in bore – AAMGL and MGL set at natural surface.

Quarterly manual still water measurements were conducted by JDA of the DWMS bores and the DWER bores from July 2022 to October 2024 with water level loggers installed in the DWMS bores over the same period. Manual groundwater measurements are shown on Figure 7 with logger data shown in JDA (2025).

Groundwater flow across the Study Area is generally west to south-east from 48.4 mAHD (WAR04) to 42.4 mAHD (L250C) towards Ellen Brook. The seasonal variation is on average 0.9 m (JDA, 2025).

Preliminary pre-development Average Annual Maximum Groundwater Levels (AAMGLs) were calculated in the DWMS (JDA, 2022) and contours were produced based on correlation to historical groundwater levels recorded at DWER bores within the vicinity of the DWMS area; shown on Figure 6 *left*.

A revised AAMGL has been prepared in this LWMR based on the results of the pre-development groundwater monitoring program. The highest manual recorded measurements were generally on the 30 August 2022 site visit (Table 3). The difference between these groundwater levels measured by JDA on 30 August 2022 and the bore AAMGLs presented in the DWMS was -0.16 m to 0.12 m with an average of -0.06 m.

It is therefore considered that groundwater levels measured on 30 August 2022 are representative of AAMGL, Tables 3 and 4.

Revised pre-development AAMGL contours across the DWMS area are shown on Figure 6 *left* and represents flow west/south-west to north-east, similar to the JDA (2022) AAMGLs. The Study Area AAMGL ranges from 48.6 mAHD (south-west) to 42.2 mAHD (north-east). Depth to AAMGL across the Study Area, Figure 6 *left*, is generally less than 1 m across the east of the Study Area; along watercourse alignments (Section 4.7.1) and mapped wetlands (Section 4.8); and rising to greater than 5 m in the south and western areas.

Maximum groundwater levels (MGLs) for the DWMS area have been estimated by applying an adjustment of +0.5 m to groundwater levels measured on 30 August 2022; being the average difference of the 4 long-term DWER bores to their AAMGLs (Table 4). Estimated MGLs for each bore are summarised in Table 3 with contours produced by Avant Hydro shown on Figure 6 *right*, which show a similar trend to the AAMGL contours. The estimated Study Area MGL ranges from 49 mAHD (south-west) to 42 mAHD (north-east). Depth to estimated MGL is at or near surface across the eastern half of the Study Area, Figure 6 *right*.

Table 4: Long-Term DWER Monitoring Bore Summary

Bore ID	Data Range	AAMGL (mAHD)	MGL (mAHD)	Adjustment (MGL -AAMGL)	MGL Date	Water level 30-Aug-22
L220C	1984-2018	54.78	55.52	0.74	16-Sep-1986	54.71
L230C	1984-1999	51.57	51.75	0.18	16-Sep-1986	51.73
L240C	1984-2018	47.65	48.45	0.80	16-Sep-1986	47.77
L250C	1984-2014	42.37	42.78	0.41	16-Aug-1984	42.39

4.6.4 Groundwater Quality

Pre-development groundwater quality monitoring of the DWMS bores was conducted by JDA quarterly from August 2022 to May 2024 with results summarised in JDA (2025). Groundwater samples were analysed for pH, Electrical Conductivity [EC], Total Dissolved Solids [TDS], nutrients and dissolved metals. Of the DWMS bores, WAR06 is located within the Study Area and WAR04 is located on Halden Road, the western Study Area boundary.

Mean groundwater quality results from JDA (2025) for WAR04 and WAR06 are summarised in Table 5 below.

Table 5: Mean Groundwater Quality Results – Study Area

Parameter	PQL	Guidance Value	WAR04	WAR06
Physico-chemical/Other				
pH *lab*	-	6.5-8[1]	4.2	4.9
EC (mS/cm) *lab*	1	0.12-0.3[1]	0.24	0.26
TDS (mg/L)	5	-	200	255
Nutrients (mg/L)				
NH_3_N	0.005	-	0.19	0.27
NO_x_N	0.005	0.15[1]	0.057	0.058
TKN	0.1	-	1.7	2.4
TN	0.01	1.2[1],1[2]	1.7	2.4
PO_4_P	0.005	0.04[1]	0.32	0.050
TP	0.05	0.065[1],0.1[2]	0.31	0.033
Dissolved Metals (mg/L)				
Aluminium, Al	0.01	-	1.5	0.77
Arsenic, As	0.001	≤0.0024[1]	<0.001	<0.001
Cadmium, Cd	0.0001	≤0.0002[1]	<0.0001	<0.0001
Chromium, Cr	0.001	≤0.001[1]	0.0012	0.0017
Copper, Cu	0.001	0.0014[1]	0.0015	0.0011
Iron, Fe	0.01	-	0.13	0.35
Lead, Pb	0.001	≤0.0034[1]	0.0011	<0.001
Manganese, Mn	0.005	1.9[1]	0.0015	0.015
Mercury, Hg	0.00005	0.006[1]	<0.00005	<0.00005
Zinc, Zn	0.001	0.08[1]	0.0035	0.021

Notes:
PQL = Practical Quantification Limit; defined at the lowest concentration at which an analyte can be detected in a sample with a reasonable degree of accuracy and precision.
1. ANZECC & ARMCANZ (2000) trigger values for slightly disturbed lowland river ecosystems. Exceedances in blue.
2. Swan Canning Water Quality Improvement Plan (SRT, 2009) nitrogen and phosphorus targets. Exceedances in purple.

A summary of the pre-development monitoring results for bores WAR04 and WAR06 is as follows:

- Groundwater at relevant bores was acidic to slightly acidic, range of 3.8 to 5.6, and fresh, TDS of 160 to 390 mg/L. pH was fairly constant at WAR04 over the monitoring period but at WAR04 was more acidic in August and November samples than January and April samples. The groundwater pH within the Study Area and wider DWMS area is similar to historical regional data in Davidson (1987) where pH ranged from 4.1 to 6.6.
- Total Nitrogen (TN) concentrations at WAR04 ranged from 1.1 to 2.2 mg/L with mean of 1.7 mg/L and at WAR06 from 0.87 to 4.5 mg/L with mean of 2.4 mg/L and were generally well above both the ANZECC & ARMCANZ (2000) trigger value of 1.2 mg/L and SRT (2009) target of 1 mg/L. Most of the TN in groundwater sampled at these bores was in the form of organic-bound nitrogen (TKN) and ammonia (NH_3_N) with nitrogen oxides (NO_x_N) concentrations generally below the PQL.
- Total Phosphorus (TP) concentrations at WAR04 ranged from 1.1 to 2.2 mg/L with mean of 1.7 mg/L and were all above both the ANZECC & ARMCANZ (2000) trigger value of 0.065 mg/L and SRT (2009) target of 0.1 mg/L. TP concentrations at WAR06 were ranged from <0.01 mg/L (PQL) to 0.092 mg/L with mean of 0.033 mg/L and were all below both the ANZECC & ARMCANZ (2000) trigger value and SRT (2009) target except for the August 2022 sample (0.092 mg/L). Phosphate concentrations (PO_4_P) were similar to TP.
- All dissolved Arsenic, Cadmium and Mercury concentrations were below the PQL and Lead concentrations were below or similar to the PQL. Chromium concentrations in both bores were generally marginally above the ANZECC & ARMCANZ (2000) trigger value.

4.6.5 Groundwater Resources for Irrigation

The Department of Water and Environmental Regulation manages the groundwater of the State under the *Rights in Water and Irrigation Act 1914* (RIWI Act). The Study Area is located within the North Swan sub-area of the Swan Groundwater Management Area for the superficial and Mirrabooka aquifers and within the Swan Confined sub-area for the Leederville aquifer. The North Swan sub-area comprises areas bound by state forest (west), Aveley and The Vines (south), Orange Avenue / Almeria Parade / Ellenbrook Road (east) and Chudalup Road (north).

The Swan Groundwater Management Area forms part of the Gnangara Groundwater Allocation Plan area. A new groundwater allocation plan (DWER, 2022) was released in June 2022 to replace the previous allocation plan (DoW, 2009). The new plan changed the allocation limits for North Swan in the superficial aquifer from 2,000,000 kL/year in DoW (2009) to 2,239,000 kL/year, a 12% increase, and in the Mirrabooka aquifer from 300,000 kL/year to 116,000 kL/year, a 61% reduction.

The DWER groundwater allocation limit and water allocations from the Swan sub-area are shown in Table 6 based on a Resource Allocation Report from DWER as at 21 August 2025.

Table 6: DWER Groundwater Resource Allocation and Limit, August 2025

GW Sub -Area	Aquifer	Allocation Limit Licensable component, (kL/yr)	Allocated (kL/yr)	Additionally Requested (kL/yr)	% Allocated, committed & requested
North Swan	Superficial Swan	2,239,000	2,412,676	0	108
North Swan	Mirrabooka	116,000	128,700	0	111
Neaves	Superficial Swan	2,908,000	3,009,925	0	104
Swan Confined	Leederville	4,746,000	5,568,434	0	117

A water source is required for the irrigation of streetscapes and establishment and ongoing irrigation of vegetated and turfed areas within POS in the Study Area. All groundwater aquifers beneath the Study Area are fully allocated.

Existing groundwater licences are held within the Study Area by Ellenhoog Pty Ltd at Lot 114 Chudalup Road for 47,000 kL/year (GWL1844771) and part of Conoble Park Pty Ltd's groundwater licence GWL182065 of 57,000 kL/year which includes Lot 1808 Chudalup Road. Both groundwater licences permit abstraction of groundwater from the superficial aquifer although the Conoble Park Ltd licence whilst including the Study Area is listed as part of the Neaves sub-area.

These groundwater licences are sufficient to provide a non-potable water source for irrigation areas within the Study Area. Amendments to these licences are required to reflect changes to uses and entitlements.

4.6.6 Public Drinking Water Source Areas

The Study Area is not located within a Public Drinking Water Source Area (PDWSA) or within a groundwater production bore wellhead protection zone.

Approximately 1.5 km west is the Gnangara Underground Water Pollution Control Area which is upgradient from the Study Area.

4.7 Surface Water

4.7.1 Existing Surface Hydrology

The Study Area is located within the Ellen Brook Catchment which is a natural ephemeral waterway that discharges east to the Swan River. DWER's 1% AEP floodplain mapping of the Ellen Brook indicates it does not extend upstream into the Study Area.

There are numerous small intermittent waterways within the Ellen Brook catchment area that are incised into the local sediments with <1 m depth. The LSP1 area is relatively flat and low lying with waterways that have shallow flow paths within cleared paddocks. They are generally in a degraded condition with only minor pockets of thin strips of riparian vegetation, and mainly assist in relieving prolonged flooding and waterlogging of the paddocks (JDA, 2022).

Within the Study Area, Sawpit Gully and an unnamed tributary (referred to from here as 'LSP1 Waterway') traverse the site from west to east and flow through the culverts at Tonkin Highway to the Ellen Brook (Figure 8).

Sawpit Gully has a relatively well defined channel and is fringed with established riparian vegetation that is associated with Multiple Use Geomorphic Wetland classification within the LSP1 area. The upstream section of Sawpit Gully is classified as Resource Enhancement. Surface water monitoring of Sawpit Gully performed by JDA (2025) indicates a minor winter baseflow component and is described further in Section 4.7.3.

The LSP1 Waterway is located north of Sawpit Gully and can be described in eastern and western sections. The eastern section has a shallow channel (<0.5 m) and is situated within an area of established vegetation. The surface geology of this section is characterised as Bassendean Sand and has separation to winter groundwater levels. The western section of this waterway has no fringing vegetation, is of a degraded nature and functions as a rural open drain in a lower lying cleared paddock.

4.7.2 Pre-Development 2D Flood Modelling

Regional surface drainage catchments for the North East Corridor were defined in GB Hill & Partners (1995) and DoW & GHD (2007). A drainage strategy and a two-dimensional hydrology study (using TUFLOW) was also prepared by BG&E (2018) for the Northlink Stage 3 section of the Perth-Darwin National Highway alongside the Study Area.

Details of the 6 BG&E (2018) catchments across the North Ellenbrook DWMS area are shown on Figure 8 and summarised in Table 7. Of these, catchments CT1862, CT1923 and CT1965 intersect the Study Area, Figure 8.

Table 7: Drainage Catchments (BG&E, 2018)

Catchment	Area (ha)	Length (km)	% Cleared
CT1657	177	2.70	50
CT1724	745	6.21	25
CT1805	70	2.00	90
CT1862	126	2.10	60
CT1923	215	3.50	15
CT1965	1190	12.00	60

Further 2D flood modelling was conducted by GHD (2025) for the design of the Tonkin Hwy North Ellenbrook Interchange (H017) as part of their Project Case 15% Design Report. It noted that the BG&E assessment was based on techniques that are generally no longer in use, including the now superseded 1987 version of *Australian Rainfall and Runoff* and resulted in excessively high runoff. The GHD model appears to be a Rain-on-Grid model conducted in Tuflow) and used a revised pre-development rainfall-runoff loss model based on previous assessments undertaken by DWER and in consultation with Main Roads Western Australia [MRWA]. The report does not provide values for the catchment roughness coefficient (Manning's Number), which is one of the parameters used in runoff generation. It also only provides flows at culvert locations for various design scenarios along the Tonkin Highway, and does not provide any catchment flows upstream of the highway for the pre-development condition.

Avant Hydro have therefore constructed a DHI MIKE21FM 2D hydraulic model to simulate pre-development catchment flow conditions across the LSP1 area. BoM (2016) design rainfalls were adjusted to 2030 (current and near-future climate mid-point) based on climate change factors for the Study Area from the ARR Data Hub. The rainfall-runoff loss model and pre-burst rainfall were consistent with GHD (2025), as that was based on previous DWER assessments. A Manning's roughness coefficient of 0.1 was used for the vegetated areas, 0.05 for creeklines and 0.06 for the cleared pasture areas. The 2D flood modelling technical note (Avant Hydro, 2026) is attached as Appendix D.

The Avant Hydro (2026) 2D model was used to simulate the 1% AEP and 20% AEP events for durations of 3 to 12 hours.

In the 20% AEP, the 3 hour duration event was critical with flow depths in Sawpit Gully generally less than 0.5 m and in LSP1 Waterway less than 0.3 m. In the 1% AEP, the 12 hour duration was critical for Sawpit Gully and 3 hour critical for LSP1 Waterway. Flow depth in Sawpit Gully was generally less than 0.7 m, with some areas of shallower flooding over a greater width. There is some overflow of discharge to the creek to the north (LSP1 Waterway). Flow in the LSP1 Waterway was fairly channelised for most of the western, upstream areas, with spreading of flows in the east of the Study Area as the topography flattens out. Flow in this channel is generally less than 0.4 m. Modelling results in Avant Hydro (2026) show flood extents generally similar to 'existing' (pre-development) results in GHD (2025) in areas upstream of Tonkin Highway.

The Avant Hydro model also shows a lower peak flow in Sawpit Gully compared to the GHD model (12.2 m^3/s at XS1, compared to ~25 m^3/s at location L158). As the two models use the same rainfall and runoff loss model (based on previous DWER information), the differences in runoff would be due to different Manning's roughness coefficient, and possibly model grid size. GHD (2025) does not state either the grid size or the roughness coefficient values. The roughness coefficient will have a larger impact on flow rates. To achieve a similar flow rate to the Avant Hydro model, the GHD model would require a roughness coefficient significantly lower than the 0.1 value used by Avant Hydro.

Flood extent and depth mapping from Avant Hydro (2026) for the 1% AEP 12 hour duration is shown on Figure 8. Peak flows at cross sections on LSP1 Waterway and Sawpit Gully are shown on Figure 9 and summarised in Table 8.

Table 8: Cross-Section Peak Flows (Avant Hydro, 2026)

Cross Section	1% AEP	20% AEP
XS1	12.19 (12hr)	2.74 (3hr)
XS2	4.72 (3hr)	1.95 (3hr)
XS3	3.74 (3hr)	1.54 (3hr)

Flood modelling in Avant Hydro (2026) also shows a waterway from the future LSP2 area ('central LSP2 Waterway') north of Chudalup Road, breaking out and flowing south-east over Chudalup Road and through the north-east corner of the Study Area, Figure 9. With future development and filling of the LSP2 area, this breakout will no longer occur and flow will be contained within the designated POS corridor through LSP2. In the interim, these flows will need to be conveyed within the Chudalup Road reserve eastward to the existing culverts at the corner of Chudalup Road and Raphael Road (culverts CT18.46 & CT18.62 on Figure 8).

4.7.3 Pre-Development Surface Water Level Monitoring

Pre-development surface water monitoring was conducted by JDA in-line with groundwater monitoring from August 2022 to October 2024 at 5 sites, RAP01 to RAP05, with results summarised in JDA (2025). Of these sites, RAP05 is located within the Study Area at the downstream (eastern) outlet location of Sawpit Gully, Figure 8, adjacent to the Tonkin Highway culvert. No site was established by JDA at an upstream location of Sawpit Gully due to site access restrictions. DWMS surface water site locations are shown on Figure 8 and summarised in Table 9 below.

Table 9: DWMS Surface Water Sites (JDA, 2025)

Site ID	Site Description	GDA 1994 Zone 50 Coordinates		Top of Casing (maNS)	Logger Installed (Y/N)
		Easting	Northing		
RAP01	U/S of Warton Road culvert	402156	6489915	1.29	Y
RAP02	Della South Road, mapped watercourse location	401267	6491227	-	N (observation only)
RAP03	U/S of Chitty Road culvert	402810	6491054	1.42	Y
RAP04	U/S of Raphael Road culvert	403454	6490499	-	N (sample only)
RAP05	U/S of Tonkin Hwy culvert	403417	6488919	1.86	Y

Note: maNS = metres above natural surface

Water level data loggers were installed at surface water sites RAP01, RAP03 and RAP05 with instantaneous maximum surface water depths recorded at these sites presented in Table 10. Water depths are relative to stream bed levels at the site locations.

Table 10: Peak Surface Water Depths – 2022 to 2024 (JDA, 2025)

Site ID	Instantaneous Peak Groundwater Level					
	2022		2023		2024	
	Date Recorded	Water Depth (m)	Date Recorded	Water Depth (m)	Date Recorded	Water Depth (m)
RAP01	13 September	0.15	N/A	Dry[1]	N/A	Dry[1]
RAP03	17 August	0.44	N/A[2]	N/A[2]	25 August[3]	0.29[3]
RAP05	17 August	0.47	13 September	0.38	03 October	0.39

Notes: 1. Only noise recorded on logger, no water observed in 2023 and 2024 during site visits.
2. Logger not operational over winter – 2023 peak not recorded.
3. Logger not operational September & October 2024.

Surface water depths at RAP05 at the eastern Study Area boundary peaked at 0.47 m in 2022; 0.38 m in 2023 and 0.39 m in 2024 (JDA, 2025). The site had ponded or flowing water at 0.3 m to 0.4 m depth from late-July to early-October in each monitoring year and was representative of groundwater baseflow.

4.7.4 Pre-Development Surface Water Quality Monitoring

Water sampling was attempted of surface water sites on 11 occasions by JDA as part of the JDA (2025) DWMS pre-development monitoring in 2022 to 2024. On these occasions, site RAP05 within the Study Area was dry or had ponded water (no flow) on 10 occasions with sampling occurring only on 06 October 2022. At the other sites, RAP03 was sampled on 30 August and 06 October 2022 and RAP04 on 06 October 2022. Surface water quality results from JDA (2025) are summarised in Table 11 below.

A summary of surface water of the DWMS area from JDA (2025) is as follows:

- Surface water pH in samples at RAP03 and RAP04 were acidic, 4.2 to 5.2, and slightly acidic in the RAP05 sample, 6.8. The pH of the RAP03 and RAP05 samples are similar to groundwater pH and may suggest groundwater is the major inflow component into these sites. The pH in the RAP05 sample is more alkaline than groundwater pH in adjacent bore WAR06 and may suggest stormwater inflow from the adjacent Tonkin Highway is the major contributor to the site.
- Surface water EC ranged from 0.38 to 0.75 mS/cm and suggests the surface water is fresh, similar to groundwater.
- Total Nitrogen (TN) concentrations in sampled surface water was above the SRT (2009) trigger value of 1 mg/L, similar to groundwater and ranged from 1.7 to 6.7 mg/L. Nitrogen was nearly all organic-bound (TKN) with ammonia and nitrogen oxide concentrations generally at or below the PQL
- The Total Phosphorus (TP) concentrations were below the PQL of 0.05 mg/L except in the RAP04 sample (1.2 mg/L). The TP in this sample is elevated compared to groundwater TP at up-gradient bore WAR03 and may reflect higher nutrient loading from the adjacent rural residential lots.
- Dissolved metal concentrations were generally similar to or less than PQL. Aluminium and Zinc concentrations were higher than in groundwater while Iron concentrations were similar to groundwater.

Alkalinity was only analysed in the 30 August 2022 samples with concentrations in the RAP03 sample less than 5 mg/L (PQL) and 14 mg/L in the RAP05 sample due to bicarbonate, also 14 mg/L.

Table 11: Surface Water Quality Results (JDA, 2025)

	Guideline Value	PQL	RAP03		RAP04	RAP05
			30-Aug-22	06-Oct-22	30-Aug-22	06-Oct-22
Physio-chemical						
pH (lab)	6.5-8[1]	-	4.2	4.5	5.2	6.8
EC (mS/cm) (lab)	0.12-0.3[1]	0.002	0.75	0.50	0.38	0.57
TSS (mg/L)		5	<5	<5	73	<5
Nutrients (mg/L)						
TN	1.2[1],1.0[2]	0.1	3	2.8	6.8	1.7
TKN	-	0.1	3.1	2.8	6.9	1.7
NO_x-N	0.15[1]	0.005	<0.1	<0.1	<0.1	<0.05
NH_3-N	-	0.005	<0.005	0.0052	0.012	<0.005
TP	0.065[1]	0.05	<0.05	<0.05	1.2	<0.05
PO_4-P	0.04[1]	0.005	0.018	0.016	0.96	0.007
Total Metals (mg/L)						
Aluminium, Al		0.01	1.6	1.3	0.92	0.9
Arsenic, As	0.0024[1]	0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, Cd	0.0002[1]	0.0001	<0.0001	<0.0001	<0.001	<0.0001
Chromium, Cr	0.001[1]	0.001	0.0021	0.0018	0.0024	0.0018
Copper, Cu	0.0014[1]	0.001	<0.001	<0.001	0.0021	<0.001
Iron, Fe	-	0.01	0.73	0.95	1.6	0.38
Lead, Pb	0.0034[1]	0.001	<0.001	<0.001	<0.001	<0.001
Manganese, Mn	1.9[1]	0.001	0.0051	0.0022	0.016	0.0084
Mercury, Hg	0.006[1]	0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Zinc, Zn	0.08[1]	0.001	0.006	0.003	0.028	0.052
Major Ions (mg/L)						
Calcium, Ca^{2+}	-	0.5	11	7.4	12	19
Magnesium, Mg^{2+}	-	0.001	0.0051	0.0022	0.016	0.0084
Potassium, K^+	-	0.5	3.7	2.5	4.7	2.2
Sodium, Na^+	-	0.5	100	68	49	78
Chloride, Cl^-	-	1	210	150	96	150
Sulphate, SO_4^{2-}	-	1	20	4.3	4.5	22
Alkalinity (mg/L)						
Bicarbonate, HCO_3	-	5	<5	-	14	-
Carbonate, CO_2^{3-}	-	5	<5	-	<5	-
Hydroxide, OH^-	-	5	<5	-	<5	-
Total Alkalinity	-	5	<5	-	14	-
Hardness	-	3	86	52	61	81

Notes: 1. ANZECC & ARMCANZ (2000) trigger values for slightly disturbed lowland river ecosystems. Exceedances in blue.
2. Swan Canning Water Quality Improvement Plan (SRT,2009) nitrogen and phosphorus targets. Exceedances in purple.

4.8 Wetlands and Vegetation

Geomorphic Wetland mapping of the Swan Coastal Plain (DBCA, 2025), Figure 11, shows the eastern section of the Study Area mapped as Multiple Use palusplain (UFI 15732). Multiple Use wetlands do not preclude development.

A lineal Resource Enhancement wetland is mapped in DBCA (2025) along a 1.5 km section of Sawpit Gully (UFI 13387), external to Study Area.

4.9 Contaminated Sites

A search of DWER's publicly available Contaminated Sites Database (accessed 13 August 2025) showed no contaminated sites within a 5 km buffer of the Study Area.

The publicly available database only identifies 3 of the 7 contaminated sites classifications: *Contaminated – restricted use; Contaminated – remediation required*; *and Remediated for restricted use*. The remaining classifications are *Report not substantiated*; *Possibly contaminated – investigation required*, *Not contaminated – unrestricted use;* and *Decontaminated*.

5. WATER SUSTAINABILITY

5.1 Water Supply

Engineering Servicing Report (TABEC, 2026) indicates Water Corporation have commenced a water services alignment study for the North Ellenbrook area.

An existing DN250 water reticulation pipe is located within Chudalup Road just north of the Study Area. Water Corporation have advised that this existing pipe system with no additional upgrades has sufficient capacity to service the initial stages of urban residential development in the proposed LSP1 area and provides adequate fire flow.

5.1.1 Residential Lots

Potable water supply to individual lots would be achieved by the construction of a network of DN100 to DN200 throughout the internal road network.

In order to minimise any potential impact on the groundwater resource the development will aim to:

- Utilise scheme water as the main water supply for residents.
- Appropriately manage bore use through structure planning and community education.

5.1.2 Public Open Spaces

Use of a non-potable groundwater water supply, such as groundwater abstraction from the superficial aquifer, is the preferred approach to meet POS irrigation requirements.

Current groundwater licences within LSP1 held by the existing two landowners (proponents) include:

- 47,000 kL/year - Lot 114 Chudalup Road, Licensee: Ellenhoog Pty Ltd (GWL1844771)
- 57,000 kL/year - Lot 1808 Chudalup Road, Licensee: Conoble Park Pty Ltd (GWL182065)

Concept landscape plan by LD Total (2026) indicates a preliminary long term irrigation requirement of 54,587 kL/yr. This is comprised of irrigation of 2.13 ha POS, 6,312 kL/yr for lake evaporation and 33,911 kL/yr for a private school. Estimated irrigation volume for establishment period (2 year) is 64,029 kL/yr. This is based on an irrigation application rate of 6,750 kL/ha/year consistent with the DWMS (JDA, 2022). The concept Landscape Master Plan is presented in Appendix E and is subject to refinement as part of detail design.

The existing 104,000 kL/yr licence allocation held by the proponent is sufficient to meet the long-term estimated LSP1 POS irrigation requirement of 54,587 kL/yr. Updates to the licensed activity of these licences for urban development and a detailed landscape plan outlining the irrigation water requirements will be presented in a future SDWMR.

5.2 Wastewater Management

Engineering Servicing Report (TABEC, 2026) indicates there is presently no wastewater infrastructure in immediate proximity to the proposed development area. Water Corporation have acknowledged a short-term (interim) servicing strategy for the North Ellenbrook area that incorporates interim pump stations and sewer mains are required.

Under this strategy, LSP1 can be serviced with sewer reticulation which gravitates to an interim pump station within the North Ellenbrook West DSP area and ultimately into the existing Barrambie Way Pump Station in Ellenbrook. Further detail on the interim and ultimate strategy is presented in the Engineering Servicing Report (TABEC, 2026).

5.3 Water Use Efficiency Measures

The revised State Planning Policy 2.9 regarding water resources (WAPC, 2025) requires new developments to employ a total water cycle approach to the consideration of water resources. Water Conservation initiatives are vital in reducing water demand and can reduce strain or delay timing of potable water supply infrastructure.

Water Conservation initiatives are vital in reducing water demand and can reduce strain or delay timing of potable water supply infrastructure.

The Water Conservation Strategy for the development is detailed below.

- Use of water-wise practices at the lot scale, including water efficient fixtures and fittings (WELD rated taps, showerheads, toilets, appliances, rainwater tanks);
- Initiatives to encourage waterwise landscaping of residential lots including use of native plant species, hydrozoning, mulching, soil amendments, water retention products and installation of appropriate irrigation fixtures; and
- Buildings constructed to current 7-star building standards as per the current National Construction Code [NCC].
- POS will incorporate retained trees and plantings of low water use-vegetation. Mulches and ground covers will be used to increase the efficiency of irrigation and conserve water. Where appropriate, native species will be used in drainage and other landscaped areas. The irrigation system will be designed to water wise principles.

Conservation measures aim to reduce scheme water consumption in the development area within the constraints of the site.

6. STORMWATER MANAGEMENT

6.1 Design Overview

Local stormwater management is proposed to be consistent with current water sensitive design practices and to meet key objectives and criteria as detailed in Table 1 and the stormwater design approach presented in the DWMS (JDA, 2022).

Existing waterways (Sawpit Gully and LSP1 Waterway) will be retained and integrated into POS. Stormwater runoff from the development area will be managed offline to these waterways.

Stormwater quality treatment and improvement measures include infiltration at source or as high up in the catchment where possible through the use of tree pits, flush kerbing, parklets and Bio-Retention Areas (BRA). These measures are designed to treat runoff from frequently occurring rainfall events and are described further in Section 8.

Flood Management Areas (FMA) are used to control stormwater runoff from larger and more extreme rainfall events. They are situated in drainage catchment low-points and typically comprise a large area of turf and/or garden within the POS area. The FMA located west of the District Centre will be constructed as an open waterbody, with assessment against DoW (2007) checklist for constructed lakes presented in (Appendix F). FMAs have a dual use function for both public recreation as well as drainage management. They manage stormwater runoff from the 20% AEP up to the 1% AEP rainfall events and discharge into existing waterways with outflow controlled to pre-development rates.

Stormwater management for the development is designed according to small, minor and major rainfall events as outlined in Australia Rainfall & Runoff (2019). Key points of the drainage strategy are outlined below.

6.2 Stormwater Management Strategy

6.2.1 Small Event Management

Small event management concentrates on the treatment and retention of stormwater runoff from the first 15 mm of rainfall (approximately 1 EY 1 hour event) from impervious lot areas using soakwells and from roads in bio-retention areas (BRAs). Runoff from the first 15 mm of rainfall can mobilise pollutants such as soluble materials, fine dusts and silts, oils, grease and other non-volatile hydrocarbons from impervious areas (DWER, 2017).

- Residential Lots retain and infiltrate the first 15 mm of rainfall from connected impervious areas. This can be achieved by means of systems such as soakwells and/or other underground storage units.
- Smaller size lots (<300 m^2) are to have a high level overflow connection from the soakwell or underground storage unit to a lot connection pit at the front of the lot, prior to discharge into the road drainage system. Soakwells or underground storage unit in these lots are to be interconnected within the lot.
- Stormwater runoff from roads from the first 15 mm of rainfall will be managed by a BRA within the POS. Flush kerbing around POS, tree pits, parklets etc will also provide further at-source treatment within the upstream catchments if deemed suitable at further detail engineering design stage in the SDWMR.
- BRAs will be underlain with amended soils and planted with suitable plant species, consistent with *Vegetation Guidelines for Biofilters in South-West Western Australia* (Monash University, 2014). BRAs also have subsoil drainage to convey treated stormwater to downstream areas. Further details are provided in Section 8.

6.2.2 Minor Drainage

The minor drainage system is defined as a system of swales, pipes, culverts, kerbs, gutters etc. designed to convey runoff generated by low frequency storms, typically less than the 20% AEP from lots and roads to FMAs.

- Stormwater runoff generated from residential lots in excess of underground storage devices (e.g. soakwells or cells etc.) flow overland via front of lot or overflow lot connection into the road drainage system.

- Stormwater runoff from roads in excess of the small event treatment structures (BRAs etc.) are conveyed primarily by the road pipe/swale network sized for the 20% AEP to FMAs in POS areas.
- FMAs discharge into an adjacent waterways at the 20% AEP pre-development rate via an outlet pipe.

6.2.3 Major Drainage

The major drainage system is defined as the overland flow arrangement of roads and swales planned to provide safe passage of stormwater runoff from extreme rainfall events from the 20% AEP up to the 1% AEP to the FMAs.

- Stormwater runoff generated from residential lots in excess of underground storage devices (e.g. soakwells or cells etc.) flow overland via front of lot or overflow lot connection into the road drainage system.
- Road reserves provide stormwater conveyance during major storm events. Once the minor drainage system is at capacity (20% AEP), excess stormwater bypasses these structures and flows overland within the road carriageway. Roads will grade towards, and convey flow to the downstream FMAs.
- FMAs discharge into an adjacent waterways at the 1% AEP pre-development rate via an outlet pipe.
- Minimum habitable building floor levels set 500 mm (0.5 m) above the 1% AEP water level in adjacent watercourses and 300 mm (0.3 m) above the 1% AEP top water level of BRA/FMA.

6.2.4 Sawpit Gully

Sawpit Gully flows along the southern boundary of the Study Area and will mainly be retained in its existing alignment and condition where possible. The waterway is affected in this area by works associated with the adjacent Tonkin Highway Interchange.

As part of LSP1, the western interchange ramp of the Tonkin Highway is proposed across this waterway. Based on pre-development modelling (described in Section 4.7.2) the peak 1% AEP flow through this location is 12.19 m^3/s, based on 8.5 m flow width and 1.0 m water depth. Appropriately sized drainage infrastructure will need to allow this flow to pass unrestricted, and be presented during detail engineering design at subdivision in the future SDWMR.

GHD (2025) provides further information on Sawpit Gully flows and levels through the Tonkin Highway culverts for various design scenarios associated with the interchange design.

6.2.5 LSP1 Waterway

The western section of LSP1 Waterway will be retained in existing condition with established riparian vegetation within the area designated as Regional Open Space. This vegetated area will interface with landscaped POS.

The eastern section of the LSP1 Waterway currently exists as an open rural drain in the cleared paddock area between the western vegetated area and the Tonkin Highway. This section of the waterway will be realigned into a landscaped conveyance swale within the District Centre to maintain its stormwater conveyance function and provide additional water quality improvement and treatment.

Based on pre-development modelling (described in Section 4.7.2) the peak 1% AEP flow through the District Centre area is 4.72 m^3/s, based on 4.8 m flow width and 0.6 m water depth. Swale dimensions to convey this flow through the District Centre area is approximately 5 m base width, 1 in 4 side slopes with 0.6 m depth of water. Details of this design is to be presented during detail engineering design at subdivision in the future SDWMR.

6.2.6 Central LSP2 Waterway

A breakout of the central LSP2 Waterway flows south-east over Chudalup Road and through the north-east corner of the Study Area during a 1% AEP rainfall event, Figure 9. This breakout will ultimately no longer occur with development and filling of Precinct 2 to the north but as an interim, these flows will need to be conveyed within the Chudalup Road reserve eastward to the existing culverts at the corner of Chudalup Road and Raphael Road.

6.3 Drainage Design Criteria

The proposed stormwater drainage system is be designed in accordance to the City of Swan's *"Handbook of Stormwater Drainage Design"* (2002) and *"Development Design Specification D5 - Stormwater Drainage Design"* (2012).

GHD (2025) modelled the North Ellenbrook catchments as part of the 15% Design report. The ARR DataHub loss model info was used by GHD as a starting point, with a modified model for the eastern cleared areas based on previous assessments undertaken by DWER. These values were then modified based on 8 scenarios with GHD (2025) adopting Scenario 5 in consultation with MRWA. The flood modelling incorporated design rainfalls adjusted for climate change. Allowable pre-development peak flows for the Study Area have been calculated pro-rata from the combined Tonkin Hwy peak discharge rates from each BG&E (2018) catchment for 2030 SSP5-8.5 design rainfalls.

Allowable peak discharges for each post-development catchment (Section 6.4.1) are summarised in Table 12 below.

Table 12: Allowable Peak Discharges

Catch ID	Catch Area (ha)	BG&E (2018)		LWMR Catchment Area in BG&E (2018) Discharge Catchments		GHD (2025) Peak Flows (m^3/s)		Pro-Rata Allowable (m^3/s)	
		Discharge Catchment	Area (ha)	(ha)	(%)	10% AEP	1% AEP	10% AEP	1% AEP
cI	22.15	CT1862	124.8	20.75	16.6	0.84	1.20	0.139	0.199
cO	5.48	CT1923	215.7	3.20	1.48	4.23	5.50	0.063	0.081
cS	13.42	CT1862	124.8	13.42	10.8	0.84	1.20	0.091	0.130
cT	17.85	CT1862	124.8	15.69	12.6	0.84	1.20	0.106	0.151
cU	16.38	CT1923	215.7	16.29	16.3	4.23	5.50	0.319	0.415
cV	1.90	CT1965	215.7	0.53	0.53	5.65	12.14	0.014	0.030
InterRamp	1.98	CT1965	215.7	1.98	0.92	5.65	12.14	0.052	0.112

6.4 Stormwater Modelling Parameters

The stormwater management system for the Study Area was modelled using the XP-SWMM hydraulic model to estimate maximum water level and peak outflow for the required FMAs and drainage structures.

The design storms modelled were according to the methodology in *Australian Rainfall & Runoff* (AR&R) (Ball et. Al. 2019). The rainfall temporal pattern was assumed to be spatially uniform across the catchment with storm durations from 1 hour to 72 hours. BoM (2016) design rainfalls have been adjusted to current and near-term 2030 based on SSP5-8.5 climate change factors for the Study Area as shown on the Australian Rainfall and Runoff [ARR] Data Hub.

6.4.1 Post Development Catchments

The Study Area has been divided into 7 surface water drainage catchments for hydraulic modelling based on proposed development levels in earthworks concept plan (Appendix G) and discharge locations as shown in Figure 12. Indicative breakdown of land use areas in each drainage catchment are presented in Table 13.

For this LWMR, catchment cI is an interim drainage catchment only as there is additional contributing catchment area proposed external to LSP1.

Land use breakdown presented for the District Centre (cU and cV) and Private School (cS) catchments are based on conservative assumptions, as the internal land use design of these areas is subject to further detail planning design. The land use for these areas will be refined in future detail design and presented in SDWMR.

All other catchment areas are indicative only and subject to refinement during further detail subdivision.

Table 13: Post Development Land Use For Hydraulic Modelling

Catchments (ha)	cI	cO	cS	cT	cU	cV	Inter Ramp	Total
Residential Lots (>300 m^2)	14.04	2.57	-	7.11	-	-	-	23.72
Residential Lots (<300 m^2)	-	-	-	4.20	-	-	-	4.20
Road	9.92	3.01	-	6.33	-	-	1.80	21.06
POS / Drainage	0.80	-	-	1.89	-	-	-	2.69
District Centre	-	-	-	0.24	16.37	1.90	-	18.51
Private School	-	-	10.05	-	-	-	-	10.05
Total Area (ha)	**24.76**	**5.58**	**10.05**	**19.77**	**16.37**	**1.90**	**1.80**	**80.23**

6.4.2 Loss Model

Rainfall runoff parameters applied to each of the various land uses in the Study Area are presented in Table 14.

Note that the loss model presented for the District Centre (cU and cV) and Private School (cS) catchments are based on conservative assumptions, as the internal land use design of these areas is subject to further detail planning design. The loss model for these areas will be refined in future detail design and presented in SDWMR.

Table 14: Runoff Parameters For Hydraulic Modelling

Land Use	Initial Loss (mm)	Proportional Loss (%)
Residential Lots (>300 m^2)	15	80
Residential Lots (<300 m^2)	15	20
Road	1.5	20
POS	-	90
District Centre	15	20
Private School	-	50

6.4.3 Tailwater Conditions

GHD (2025) modelled various design scenarios of the Tonkin Highway Interchange and Warbrook Overpass to assess the impact of the proposed culvert design on the flood extent and depth of the existing watercourses. In the Ultimate Case scenario, it assumes both the interchange and overpass are constructed and the North Ellenbrook West area is filled simulating a raised development area.

The modelled 1% AEP water level at the upstream end of the Tonkin Highway culverts for the 2030 (SSP5-8.5) Design scenario were adopted as the tailwater condition for the FMAs (cS, cT, cU, cV and Inter Ramp) located closest to Tonkin Highway (Table 18 of GHD, 2025).

6.5 Stormwater Modelling Results

6.5.1 Small Event (15 mm)

Stormwater runoff from the first 15 mm of rainfall generated from the impervious residential and road catchment areas is managed by BRAs. For the purposes of this reporting, volumes have been conservatively estimated assuming no treatment structures in the upper catchment (i.e. tree pits, rain garden, parklets etc).

Indicative locations of BRAs for Catchments cO, cT and the Inter Ramp areas are presented in Figure 13. No BRA details are provided for the following catchments, noting that detail design of the BRA for these catchments will be provided

as part of the future SDWMR and may incorporate multiple BRAs or treatment structures (e.g. tree pits, median swales, etc.) within their catchments areas:

- Catchment cI – This is only an interim temporary drainage basin.
- Catchment cS (Private School) – Impervious area is subject to further detail internal planning design.
- Catchment cU & cV (District Centre) – Impervious area is subject to further detail internal planning design.

Details of the BRA for the Catchments cO, cT and the Inter Ramp areas are presented in Table 15. It demonstrates the base area provided of each BRA meets the water sensitive urban design criteria that the base area must be more than 2% of the equivalent contributing impervious catchment area.

BRA volumes, levels, location and shape of drainage areas shown are indicative only, and subject to further refinement and detail design to be provided in the SDWMR.

Table 15: Small Event Management - Bio-retention areas

	BRA cO	BRA cT	Inter Ramp
Catchment Details			
Impervious Catchment Area (ha)	2.32	4.96	1.80
2% of Impervious Catchment Area (m^2)	465	993	360
Bio-Retention Base Area Provided (m^2)	931	1,985	1,170*
Storage Details			
BRA Invert (mAHD)	46.70	43.30	46.60
BRA Base Area (m^2)	931	1,985	1,170
Design Storage Depth (m)	0.30	0.30	0.30
Side Slope (1 in x)	0	0	0
Small Event Management			
Rainfall (mm)	15	15	15
Runoff Volume (m^3)	349	744	270
Water Depth (m)	0.30	0.30	0.30
Top Water Level (mAHD)	46.90	43.60	46.90
Top Water Area (m^2)	931	1,985	1,170
Stored Volume (m^3)	349	744	270

*Inter Ramp BRA base same as FMA base area

6.5.2 Minor & Major Event

For the Minor and Major rainfall events, XP-SWMM modelling results for the FMAs are presented in Table 16 and in Figure 13 for the Minor (20% AEP) event and Figure 14 for the Major (1% AEP) event.

FMAs are designed with base invert a minimum 0.3 m above AAMGL and have 1:6 side slopes (except for cO which has outlet set at AAMGL). Outflow from FMAs are controlled to pre-development rates via a low flow outlet pipe set at basin invert, ensuring no ponded water within the FMA. Basin and outlet pipe inverts are set above, and therefore not impacted, by the 1% AEP top water level modelled by GHD (2025) as part of the Tonkin Highway culvert design scenario.

Table 16: Minor & Major Event Management – Flood Management Areas

	cI FMA (Temp)	cO FMA	cS FMA	cT FMA	cU FMA	cV FMA	Inter Ramp
FMA Details							
AAMGL (mAHD)	45.2*	46.1	43.0*	43.0*	45.0*	45.7*	46.3
Invert Level (mAHD)	45.5	46.1[A]	43.3	43.3	45.3	46.0	46.6
Base Area (m^2)	7,810	2,800	3,610	6,740	6,410	1,170	1,170
Side Slopes [l:w]	1:6	1:6	1:6	1:6	1:6	1:6	1:6
Outlet Pipe Size (mm) at Invert	-	Ø225	Ø300	Ø300	Ø525	Ø225	Ø150
1% AEP							
Peak Water Level (mAHD)	46.46	46.72	44.30	44.30	46.20	46.47	47.50
Critical Duration (hours)	12	9	12	12	9	6	9
Peak Depth (m)	0.96	0.62	1.00	1.00	0.90	0.47	0.90
Peak Water Level Area (m^2)	10,200	3,500	5,300	8,900	8,500	1,600	1,900
Peak Water Storage Volume (m^3)	8,600	1,900	4,400	7,800	6,700	645	1,400
Peak Outflow Rate (m^3/s)	-	0.066	0.113	0.113	0.38	0.048	0.033
Pre-development Outflow Rate (m^3/s)	0.199	0.081	0.130	0.151	0.415	0.030	0.112
THNEI 1% AEP TWL (mAHD)[B]	-	-	43.04	43.04	44.60	45.40	45.40
10% AEP							
Peak Water Level (mAHD)	45.90	46.36	43.83	43.81	45.72	46.25	47.09
Critical Duration (hours)	9	9	6	12	9	3	9
Peak Depth (m)	0.40	0.26	0.53	0.51	0.42	0.25	0.49
Peak Water Level Area (m^2)	8,800	3,100	4,500	7,800	7,400	1,400	1,600
Peak Water Storage Volume (m^3)	3,300	700	2,200	3,700	2,900	320	680
Peak Outflow Rate (m^3/s)	-	0.035	0.079	0.077	0.20	0.032	0.023
20% AEP							
Peak Water Level (mAHD)	45.78	46.30	43.74	43.71	45.66	46.21	47.01
Critical Duration (hours)	6	6	6	24	24	6	6
Peak Depth (m)	0.28	0.20	0.44	0.41	0.36	0.21	0.41
Peak Water Level Area (m^2)	8,500	3,000	4,300	7,600	7,200	1,400	1,500
Peak Water Storage Volume (m^3)	2,300	500	1,700	3,000	2,400	265	550
Peak Outflow Rate (m^3/s)	-	0.027	0.071	0.069	0.155	0.028	0.021

Notes: * – AAMGL is equivalent to existing natural surface.
A – Invert of cO FMA is equivalent to AAMGL as this FMA acts as a constructed waterbody.
B – Modelled 1% AEP TWL Design Scenario 2030 (SSP5-8.5) from Table 18 of GHD (2025).

A conceptual cross-section of the FMAs for the 1% and 20 % AEP is presented in Figure 15.

The LSP and Concept landscape plans (Appendix E) **LD TOTAL** demonstrate there is sufficient space allocated within the structure plan to integrate drainage area requirements within POS areas.

The volumes, levels, location and shape of FMAs shown are indicative only, particularly for the Private School (cS) and District Centre (cU and cV) as their internal designs and catchments are subject to further design. Final configuration of the FMAs will be refined during detailed earthworks, drainage and road design for the development and presented in the SDWMR during subdivision stage.

Landscaping treatment of areas including plant species and planting density will be determined in consultation with the City of Swan.

7. GROUNDWATER MANAGEMENT

7.1 Design Criteria

Groundwater management for the Study Area has been prepared in line with the design criteria presented in the *Stormwater Management Manual for Western Australia* (DWER, 2022a) and the DWMS (JDA, 2022):

- Protect infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture.
- Protect groundwater-dependent ecosystems from the impacts of urban runoff.
- Manage and minimise changes in groundwater levels and groundwater quality following development.
- Adopt nutrient load reduction design objectives for discharges to groundwater.

7.2 Managing Groundwater Levels

Groundwater management is generally required to ensure minimum separation of 1.5 m between finished lot level and AAMGL. This is generally achieved through the use of a combination of imported fill and/or subsoil drainage to limit or control groundwater rise post development.

For the Study Area, clean free-draining sand fill, where required, will be used to provide sufficient separation between finished lot levels and AAMGL/MGL (AAMGL is close to, or equivalent to MGL across the majority of the eastern portion of the site). Sand fill is to have a minimum hydraulic conductivity of 5 m/day to achieve the required separation to groundwater. If a lower hydraulic conductivity fill is used, there is risk of saturation of soil profile.

Subsoil drainage is proposed within road reserves and beneath drainage areas within the POS to promote infiltration and prevent waterlogging, and to protect infrastructure in the event of any future groundwater level rise.

Subsoil drainage is set at or above the pre-development AAMGL to maintain existing conditions, and is not set below to lower water levels.

Subsoil drainage outlet is set above the BRA invert to ensure a free draining outlet condition. An indicative subsoil layout for the Study Area is shown in engineering drawings in Appendix G.

To meet engineering design requirements, preliminary earthwork levels indicate Lots have minimum 2.0 m clearance to AAMGL, satisfying the minimum 1.5 m clearance Appendix G.

7.3 Groundwater Quality

Groundwater quality management will be achieved by infiltrating stormwater runoff treated via non-structural and structural management measures. Water collected by subsoil drainage will discharge into a BRA for treatment, prior to outflow to downstream receiving environment.

8. WATER QUALITY MANAGEMENT

The effective implementation of the structural and non-structural controls as part of the residential development will enhance water quality from the Study Area as a result of land use change.

Incorporation of various best management practices (non-structural and structural source controls) provides a complete treatment train for stormwater movement through the development for water sensitive urban design. It promotes management of water volumes (by infiltration) and nutrient movement (by treatment) higher in the drainage catchment, rather than downstream end of pipe solutions.

8.1 Non-Structural Source Controls

Non-structural source controls to reduce nutrient export from the Study Area will focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed:

- Local native plants make up a minimum 50% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements;
- Community education to inform correct landscaping and fertiliser application rates; and
- Maintenance practices such as street sweeping and pit eduction to remove sediment build-up, particularly during the development and construction phase. The UWMP will outline the schedule and cleaning requirements for street sweeping, which will be co-ordinated with the City of Swan.

8.2 Structural Source Controls

Structural source controls complement the non-structural source controls to provide a complete stormwater treatment train and may include flush kerbing, tree pits, parklets and bio-retention areas within POS.

The *Stormwater Management Manual for Western Australia* (DWER, 2022) outlines expected pollutant removal efficiencies for detention/retention structural control systems. While DWER (2022) does not provide expected pollutant removal efficiencies for all BMPs, application of a treatment train approach such as in this strategy by using a combination of non-structural and structural measures will achieve BMP outcomes for water quality, Table 17.

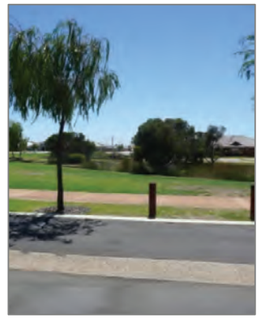
Table 17: BMP Water Quality Performance

Parameter	Structural Controls Nutrient Output Reduction[1]
	Detention/Retention Measures
Total Suspended Solids	65-99%
Total Phosphorus	40-80%
Total Nitrogen	50-70%
Gross Pollutants	> 90%

Note 1. Typical Performance Efficiencies via DWER (2022)

8.2.1 Flush Kerbing

Flush kerbing bordering road and POS areas allows stormwater runoff from the frequently occurring small rainfall events (15 mm) to flow directly into POS across grassed verge/areas, maximising infiltration at source. It also provides an opportunity to slow water movement through the development and provides a disconnect to the pipe system. Flush kerbing locations are to be cognisant of any existing vegetated areas, and is to be considered further during detail landscape and engineering design.





8.2.2 Tree Pits

Tree planting on lot frontages can incorporate porous rebated storage pits at the base to maximise infiltration of stormwater runoff from road areas during the frequently occurring small rainfall events. Runoff enters the tree pit via the road and bypasses to the next pit or pipe when full. Tree pits are typically 2 m in width and contain 0.2 m depth of water. Underlying soil media should have a minimum hydraulic conductivity of 5 m/day and have minimum 1.0 m clearance to estimated post-development groundwater level. Location of tree pits will be confirmed at the subdivision stage.





8.2.3 Parklets

Parklets located on corner verges have dual function of stormwater treatment and provision of public amenity. They are designed to capture and treat stormwater runoff from frequently occurring small rainfall events, similar to a rain garden. They will typically contain 0.2 m water depth and either be softscaped with planted vegetation, or be hardscaped with permeable paving. Underlying soil media should have a minimum hydraulic conductivity of 5 m/day and have minimum 1.0 m clearance to estimated post-development groundwater level.





8.2.4 Bio-Retention Areas (BRAs)

Bio-retention areas are designed to capture and infiltrate stormwater runoff from roads from the small rainfall event (15 mm). They are underlain with amended soil and planted with vegetation to provide water quality treatment. They are typically 0.3 m deep and are to provide a minimum treatment capacity of approximately 2% of the connected impervious area from road catchments.

Research conducted by the Facility of Advancing Water Bio-filtration (FAWB, 2009) indicates that the desired Ksat is in the range of 100 mm to 300 mm/hr (~ 2.5 to 7.5 m/day), to allow infiltration of stormwater while retaining sufficient moisture to support the vegetation. Clogging will occur in the first few years, however once the vegetation is established, the roots and associated biological activity will maintain the hydraulic conductivity of the soil media over time (FAWB, 2009).

Various BRA designs are outlined in FAWB (2009), which range from unlined infiltration systems to lined systems with submerged zones for additional water quality treatment. Whilst the minimum specifications for BRAs are presented in Table 18, the appropriate system design will be confirmed during detail design.

Table 18: Minimum Specifications for Bioretention Systems

Item	Specification
Amended soil media	• Minimum 300 mm thick. • Phosphorus Retention Index (PRI) >10. • Hydraulic Conductivity in the range of 2.5 and 7.5 m/day, once compacted. • Total clay and silt fraction <3% in total (w/w). • Organic matter content <5% (w/w). • Phosphorus content <100 mg/kg. • Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per the monitoring program.
Plant selection, planting density and distribution	• As per southwest vegetation guidelines (Monash University, 2014). • Plants selected should be suited to frequent inundations up to 0.5 m, which dries out in less than a day after rain ceases.

8.3 Nutrient Impacts of Land Use Change

The UNDO (Urban Nutrient Decision Outcomes) decision support tool (DoW, 2016) is a simple conceptual decision support model that evaluates nutrient reduction decisions for urban developments on the Swan Coastal Plain is south-west Western Australia.

The limitation of the UNDO model have been outlined in DoW (2016), including that UNDO:

- Does not set water quality targets;
- Is not a detailed design tool;
- Provides a steady state solution;
- Does not provide sub-annual solutions;
- Does not consider pre development nutrient loads; and
- Does not replace existing DWER policies and procedures.

UNDO has been used to help quantify the nutrient inputs and nutrient exports for the post-development scenario. The UNDO tool analyses inputs for Total Phosphorus (TP) and Total Nitrogen (TN) only, with calculations provided in Appendix H.

The Study Area pre-development in UNDO has been split into 2 subregions – low-lying paddocks where groundwater is near surface (< 1.5 m) and elevated, vegetated sand dunes which generally have greater than 3 to 4 m separation to groundwater.

The total estimated average pre-development nutrient loading from the Study Area is 657.8 kg/year TN (5.9 kg/ha/year) and 114.2 kg/year (1.02 kg/ha/year).

The proposed development of the Study Area without any WSUD results in a Nitrogen export load of 358.7 kg/year (3.2 kg/ha/year), a 54% reduction compared to pre-development, and a Phosphorus export load of 77.6 kg/year (0.69 kg/ha/year), a 32% reduction compared to pre-development. Implementation of the proposed structural and non-structural controls results in a total reduction of 71% for Nitrogen and a 61% reduction for Phosphorus, compared to pre-development. These estimates correspond to a reduced Nitrogen export rate of 1.7 kg/ha/year (down from 5.9 kg/ha/year) and a reduced Phosphorus export rate of 0.40 kg/ha/year (down from 1.02 kg/ha/year).

8.4 Disease Vector and Nuisance Insect Management

Structural stormwater management systems are designed to minimise the risk of chironomid midge and mosquito breeding. Infiltration, evapotranspiration or drawing down of water via subsoils underlying drainage areas to prevent pooling for longer than four days (96 hours) in late spring to early autumn will prevent completion of the larval stages of the mosquito life cycle (DWER, 2022a), as per requirement of the Department of Health.

9. IMPLEMENTATION

9.1 Roles and Responsibilities

Table 19 details the roles and responsibilities to undertake implementation of this strategy.

The operation and maintenance of the stormwater management system will initially be the responsibility of the developer but will ultimately be accepted by the Local Authority. Preparation of the future SDWMR will be the responsibility of the developer.

Table 19: Implementation Responsibilities

IMPLEMENTATION		RESPONSIBILITY	
LWMR Section	Action	Developer	City of Swan
9.2	Construction of stormwater and subsoil system	✓	
9.3	Stormwater system operation and maintenance - 12 months (period between Practical Completion Inspection and defects liability period) - Ongoing (from City acceptance of handover	✓	✓
9.4	Post-Development Monitoring	✓	
9.5	Preparation of a Subdivision & Development Water Management Report [SDWMR] to support subdivision	✓	

9.2 Construction Management

9.2.1 Dewatering

Dewatering will be required for some elements of subdivision construction including sewer installation. Given the depth of construction, dewatering will only be in the superficial aquifer.

Prior to commencement of any dewatering, the construction contractor may need to apply for and obtain from DWER a "Licence to Take Water". A licence is not required for dewatering if the pump rate does not exceed 10 L/s over a period of less than 30 days and the volume of water taken over the period does not exceed 25,000 kL.

Dewatering will be carried out in accordance with the licence conditions should a licence to take water be required. Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirement.

9.2.2 Acid Sulphate Soils

Figure 5 generally shows a moderate to low risk of ASS across most of the Study Area, however groundwater pH within the area is generally acidic.

An ASS assessment should be conducted prior to subdivision to support preparation of an ASS and Dewatering Management Plan for the Study Area.

ASS, if encountered, will be investigated and managed in accordance with the applicable DWER Acid Sulphate Guidelines for Identification and Investigation (DER, 2015a) and Treatment and Management (DER, 2015b) of Disturbed Acid Sulphate Soils. Specific methods for treatment and holding times for ASS are specified in these guidelines.

9.3 Stormwater System Operation and Maintenance

The stormwater and subsoil drainage system within the proposed development will require maintenance to ensure correct operation and minimise risk to the receiving watercourses including Sawpit Gully. It is considered the following operating and maintenance practices will be required periodically:

- Inspection and removal of debris, litter and sediments surrounding pipe inlets/outlets to prevent blockages.
- Inspection of drainage system outlets into the waterway area for erosion.
- Street sweeping to reduce particular build-up on road surface and gutters.
- Maintenance of planted areas including plant condition and weeds
- Cleaning of sediment build up and litter layer on the bottom of BRA's.
- Undertake education campaigns regarding source control practise to minimise pollution runoff into the stormwater drainage system.
- Assess function of subsoil drainage system.
- Detail post-development monitoring program for drainage structures (e.g. bio-retention/drainage areas).

The operating and maintenance schedule required is presented in Table 20.

Table 20: Maintenance Schedule for Drainage Infrastructure

Item	Maintenance Interval		
	Quarterly	Bi-annually	As required
Street Drainage			
Street sweeping to reduce particulate build-up	✓		
Removal of debris to prevent blockages	✓		
Inspection of sediment and rubbish in manholes	✓		
Planted Areas (BRAs/FMAs)			
Removal of debris from pipe inlets to prevent blockages	✓		
Inspect for erosion + sediment accumulation		✓	
Assess health of vegetation. Remove dead plants and replace where necessary.		✓	
Inspect for standing water 1 day after rainfall events			✓
Removal of sediment and leaf litter layer build up.			✓
Use of slow release/low Phosphorus fertilisers in turfed or planted areas.		✓	

9.4 Monitoring Program

The DWMS (JDA, 2022) outlined a post-development monitoring program to allow a quantitative assessment of hydrological impacts of development and the performance of water quality improvement drainage infrastructure.

The monitoring program is to operate over a 2-year period after completion of each stage. It will be periodically reviewed to ensure suitability and practicality and may need to be modified as data is collected.

A summary of the proposed monitoring program and reporting schedule is shown in Table 21. Monitoring data collected is for comparison to pre-development data (JDA, 2025) where possible. Post-development water quality trigger values are to be based on the 80th percentile of pre-development data, commensurate with monitoring and reporting guidelines in ANZECC & ARMCANZ (2000). Table 22 presents indicative monitoring criteria and contingency action which is to be refined and further detailed in the future SDWMR.

Groundwater monitoring for water level and quality is to occur from 4 sites across the Study Area (2 monitoring bores upstream and 2 monitoring bores downstream), consistent with pre-development monitoring locations where possible (L240C, L250C, WAR04 and WAR06) (Figure 16).

Surface water quality is to be measured at the outlet of three FMA's (cO, cT and cU) during winter months (June to October) when flowing. Water quality is to be analysed for nutrients (Nitrogen and Phosphorus) and assessed against pre-development water monitoring data and targets outlined in the *Swan Canning Water Quality Improvement Plan* (SRT, 2009). Table 22 presents indicative monitoring criteria and contingency action which is to be refined and further detailed in the future SDWMR.

The viability of surface water flow monitoring at the outlet of the two existing waterways (Sawpit Gully and unnamed tributary) due to elevated culverts above natural surface and extensive ponding at Tonkin Highway is to be assessed during subdivision and presented in the SDWMR.

All water quality sampling is to be conducted according to Australian Standards and water quality sample testing to be analysed by a NATA approved laboratory.

A summary report is to be prepared at the end of the 2 year monitoring period and submitted to the City of Swan for review.

Table 21: Monitoring Schedule and Reporting

Monitoring Type	Location	Parameter	Method	Timing
Groundwater Levels	Monitoring Bores L240C, L250C, WAR04 & WAR06	Water Level (m AHD)	Water level data logger or depth probe	Continuous or Monthly
Groundwater Quality	Monitoring Bores L240C, L250C, WAR04 & WAR06	Water quality in-situ: pH, EC, TDS, temp Lab: nutrients and selected metals	Pumped bore sample	Quarterly
Surface Water Quality	Outlet of 3 FMAs (cO, cT and cU)	In-situ: pH, EC, TSS, temp Lab: Nutrients (Nitrogen & Phosphorus)	Grab sample	Monthly when flowing (June to October)

Table 22: Contingency Planning

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action
Groundwater Level	Groundwater levels not to exceed estimated maximum groundwater level at bore.	After each monitoring occasion	1. Review design and operation of subsoil and stormwater drainage system. 2. Perform system maintenance if required. 3. Assess whether engineering solution required.
Groundwater Quality	Nutrient concentration not to exceed pre-development guideline trigger values (to be determined in SDWMR).	After each monitoring occasion	1. Identify and remove any point sources. 2. Consider reinforcement of Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising, cleaning) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system if required. 6. Consider initiation of community based projects.
Surface Water Quality	Nutrient concentrations not to exceed pre-development guideline trigger values (to be determined in SDWMR) or published .	After each monitoring occasion	1. Identify and remove any point sources. 2. Consider reinforcement of Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising, cleaning) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system if required. 6. Perform maintenance as required.

9.5 Future Water Management Reporting (Subdivision)

This LWMR outlines a water management strategy that meets the principles and objectives outlined in the DWMS (JDA, 2022). It demonstrates the proposed local structure plan can safely accommodate groundwater and surface water management requirements and address water quality protection with the appropriate application of water sensitive design.

To support the next subdivision planning stage, SPP 2.9 (WAPC, 2025) outlines the appropriate water management report as a *"Subdivision & Development Water Management Report"* [SDWMR]. This report is required to demonstrate in detail that all water matters within or impacting the site are appropriately managed. It is likely to be required as a condition of subdivision approval and prior to any subdivision activities.

The SDWMR builds on the water management strategy presented in this LWMR, and provides further detail on the following areas:

- Design of water quality treatment structures and flood storages as outlined in the *Stormwater Management Manual* (DWER, 2022);
- Refinement of catchment areas and the final configuration (storage side slopes, etc) and exact location of BRAs and FMAs, dependent on final earthworks, drainage and road design levels;
- Confirm BRA and FMA design for Private School and District Centre areas.
- Confirm conveyance swale design (inverts, width and flood depth) through the District Centre.
- Refine the groundwater management plan including contours, location and inverts of any proposed subsoil drainage;
- Confirm irrigation areas and volumes for Public Open Space;
- Investigation of potential ASS in the Study Area;
- Refine water quality monitoring program (if required) and confirm water quality trigger criteria.
- Confirm responsibilities and funding for implementing the requirements of the SDWMR.

The SDWMR is to be prepared consistent with the requirements outlined in Table E.1 of SPP 2.9 (WAPC, 2025).

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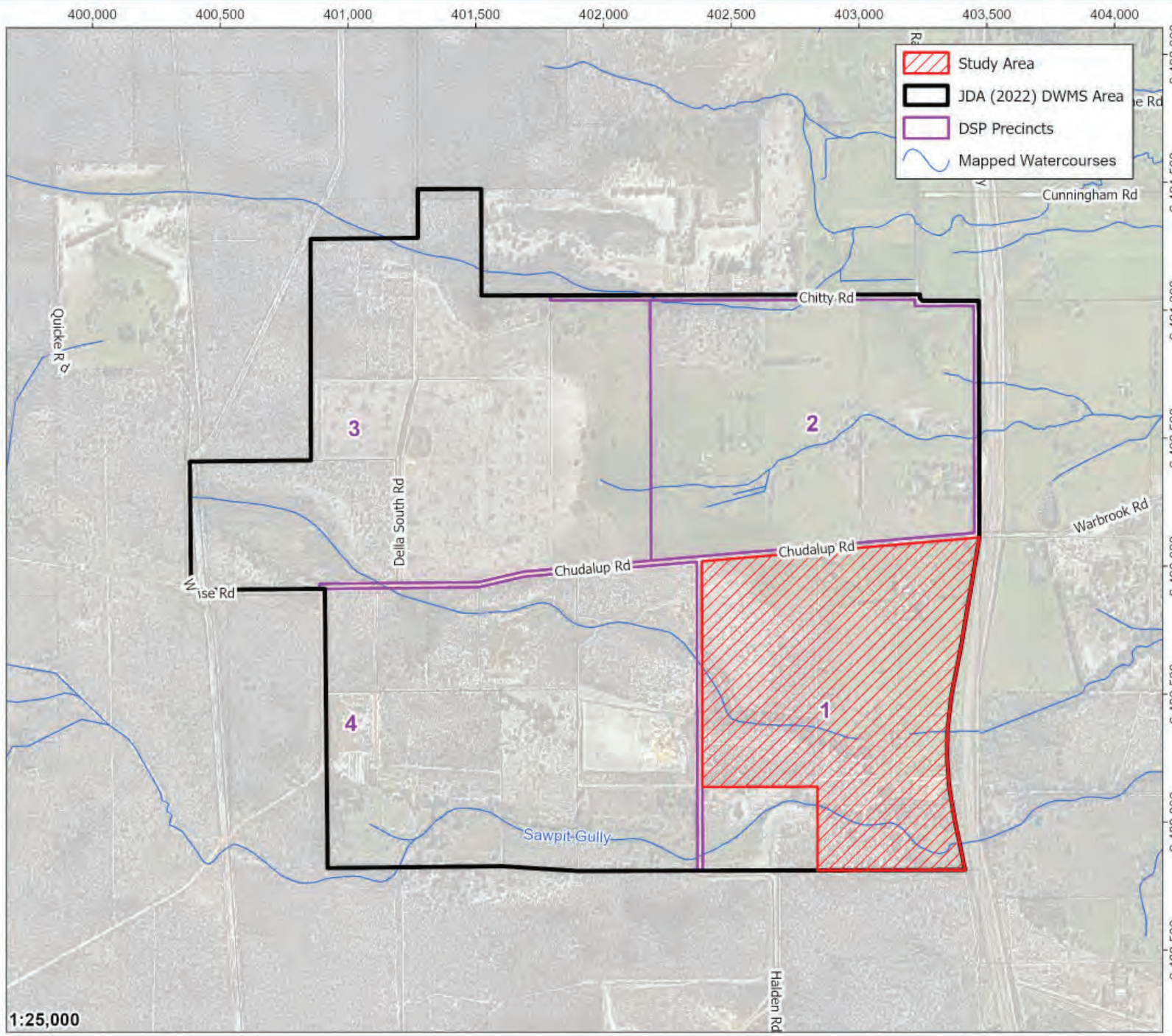
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FIGURES







Data Source: Street Express (2012); Nearmaps (2025) *05 July 2025.*

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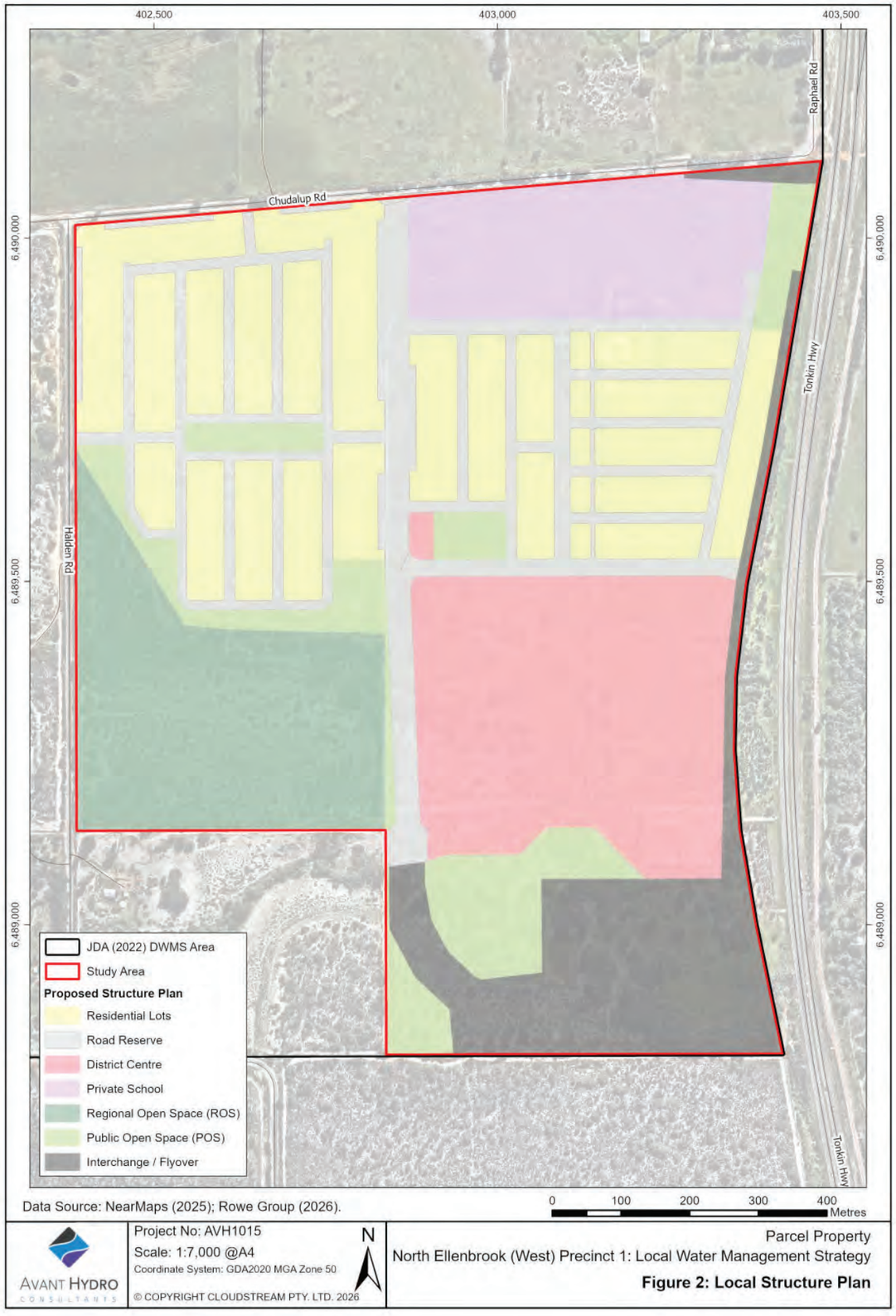
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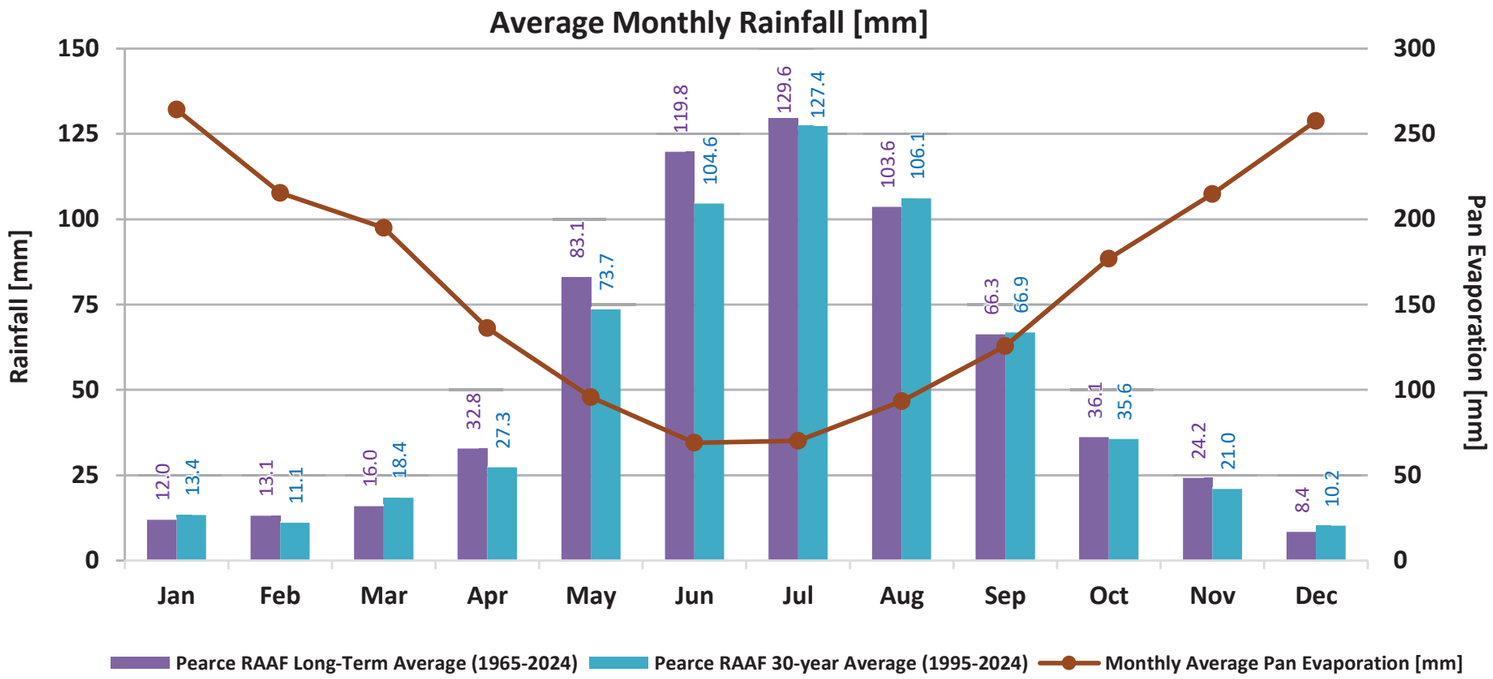
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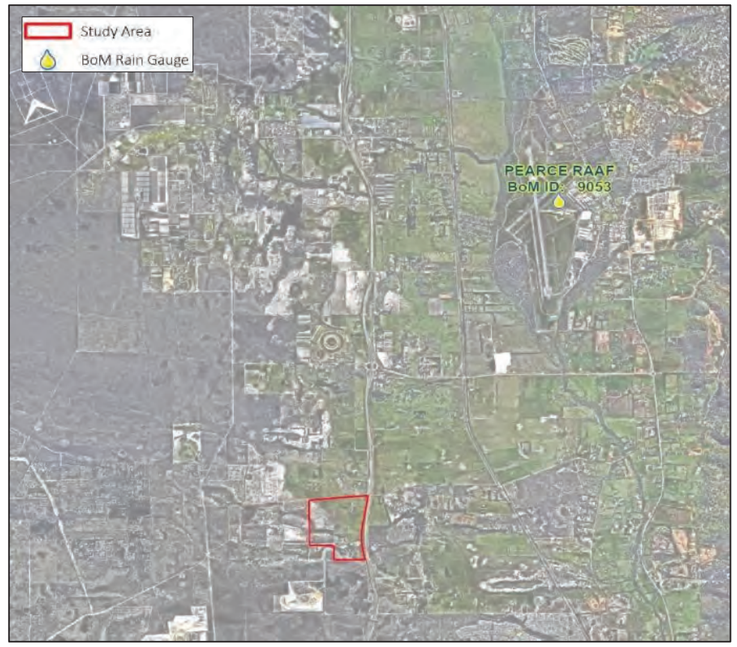
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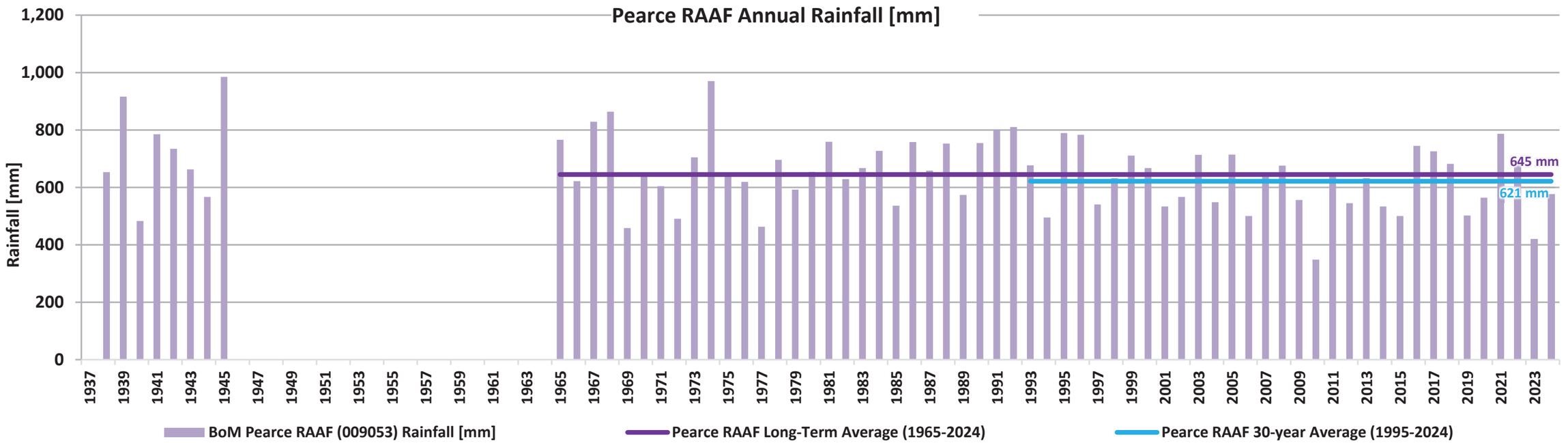
Figure 1: Location Plan



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Data Source: Bureau of Meteorology (2025) *Pearce RAAF (009053) Rainfall Gauging Stations;* DPIRD (2025) *Wanneroo weather station.*

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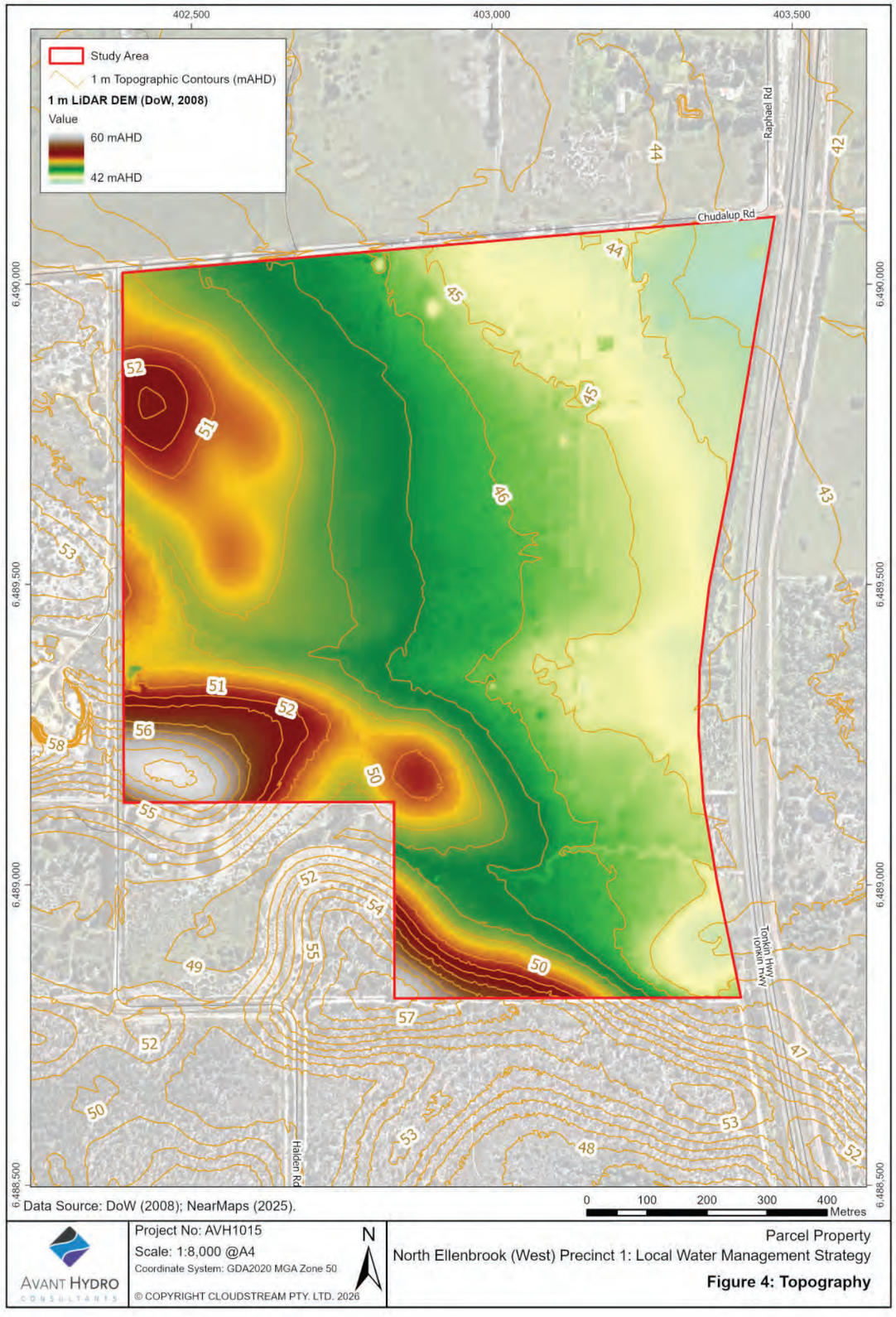
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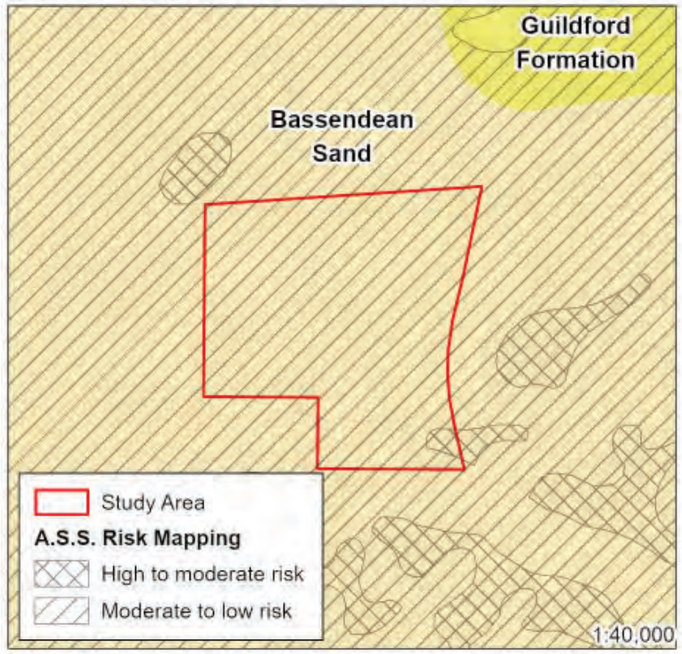
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Figure 3: Rainfall and Evapoation



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Lithological Classification

S8 Sand - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of aeolian origin.

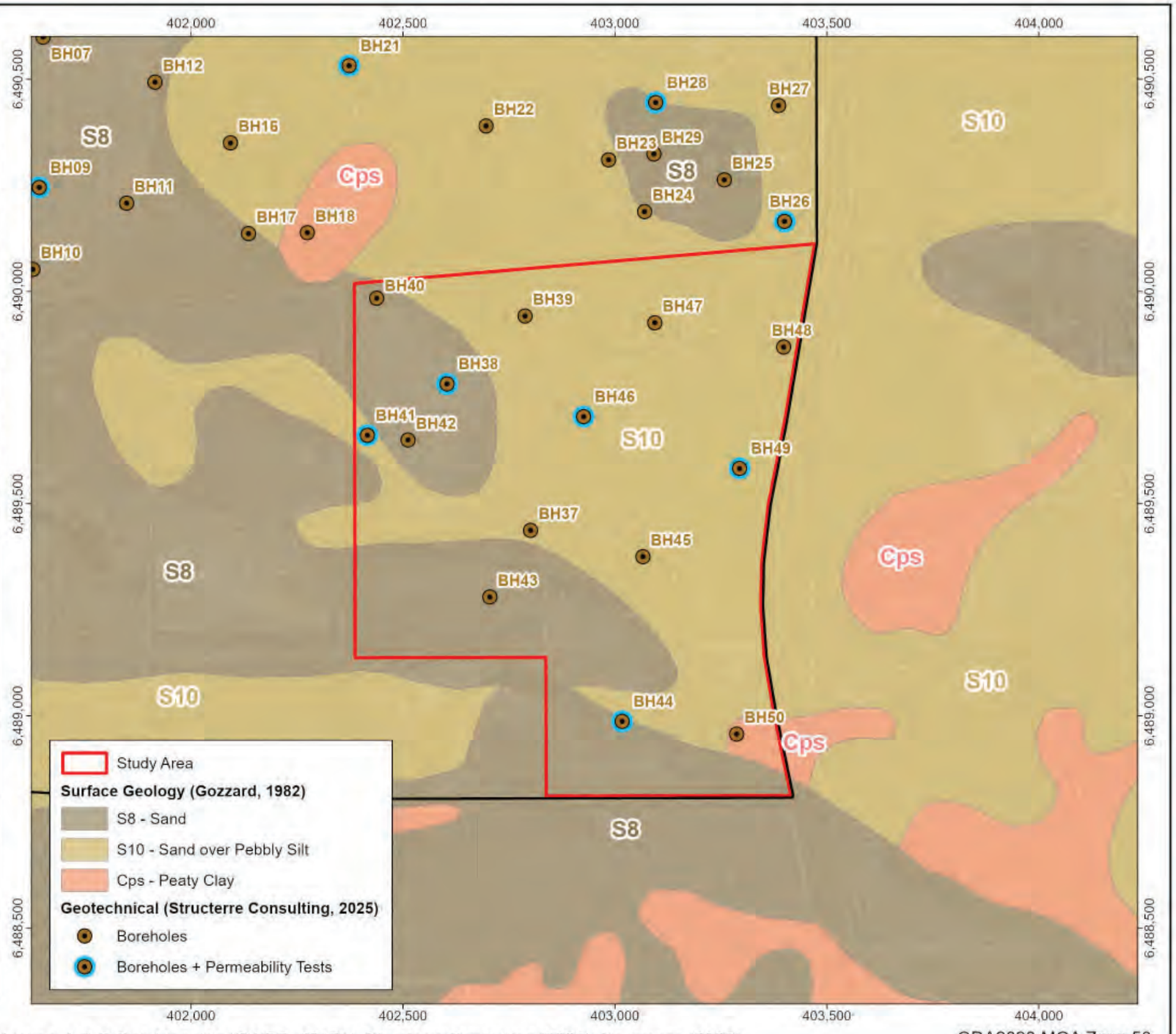
S10 Sand over Pebbly Silt - sand as S8 over gravelly silt.

Cps Peaty Clay - dark grey and black with variable sand content, of lacustrine origin.

Surface Geology

Bassendean Sand- Basal conglomerate overlain by dune quartz sand with heavy mineral concentrations

Guildford Formation
Alluvial sand and clay with shallow-marine and estuarine lenses and local basal conglomerate



Data Source: Gozzard (1982) Environmental Geology Series *Muchea*; A.S.S Risk Mapping (DWER, 2017b); Structerre Consulting (2025); Nearmaps (2025).

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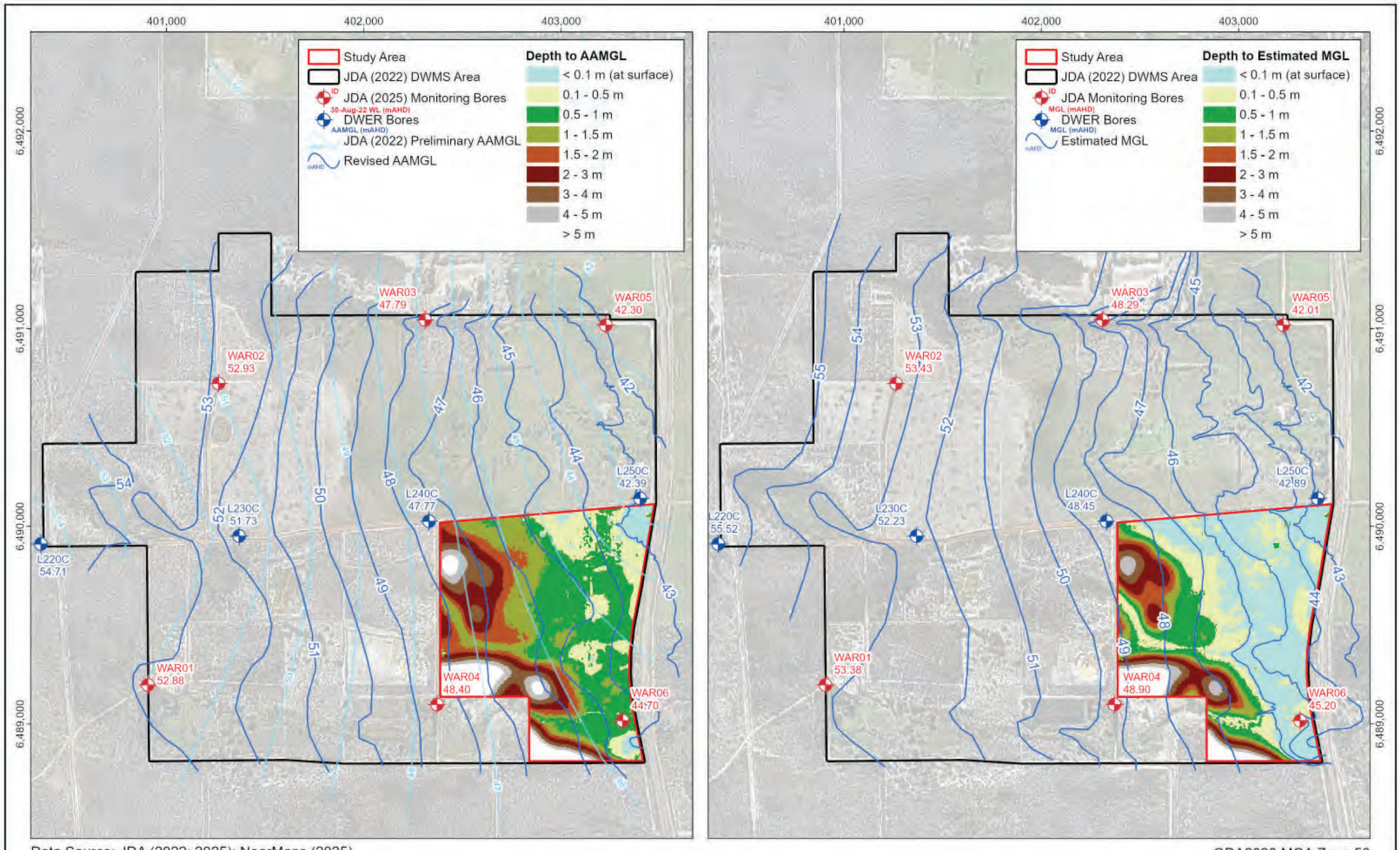
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Figure 5: Surface Geology, Geotechnical and A.S.S Mapping



Data Source: JDA (2022; 2025); NearMaps (2025).

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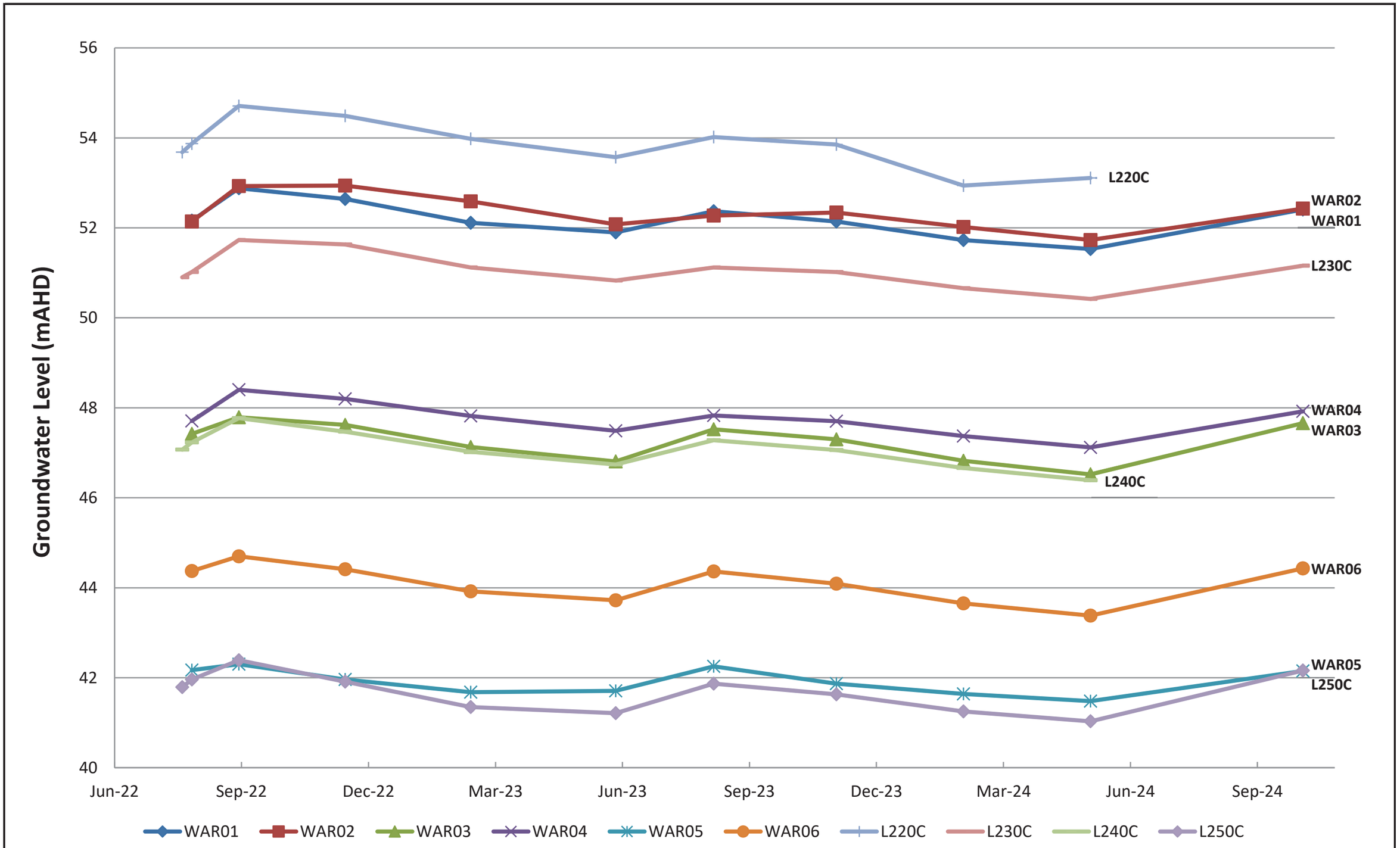
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Figure 6: Groundwater Monitoring Locations and Contours



Data Source: JDA (2025).

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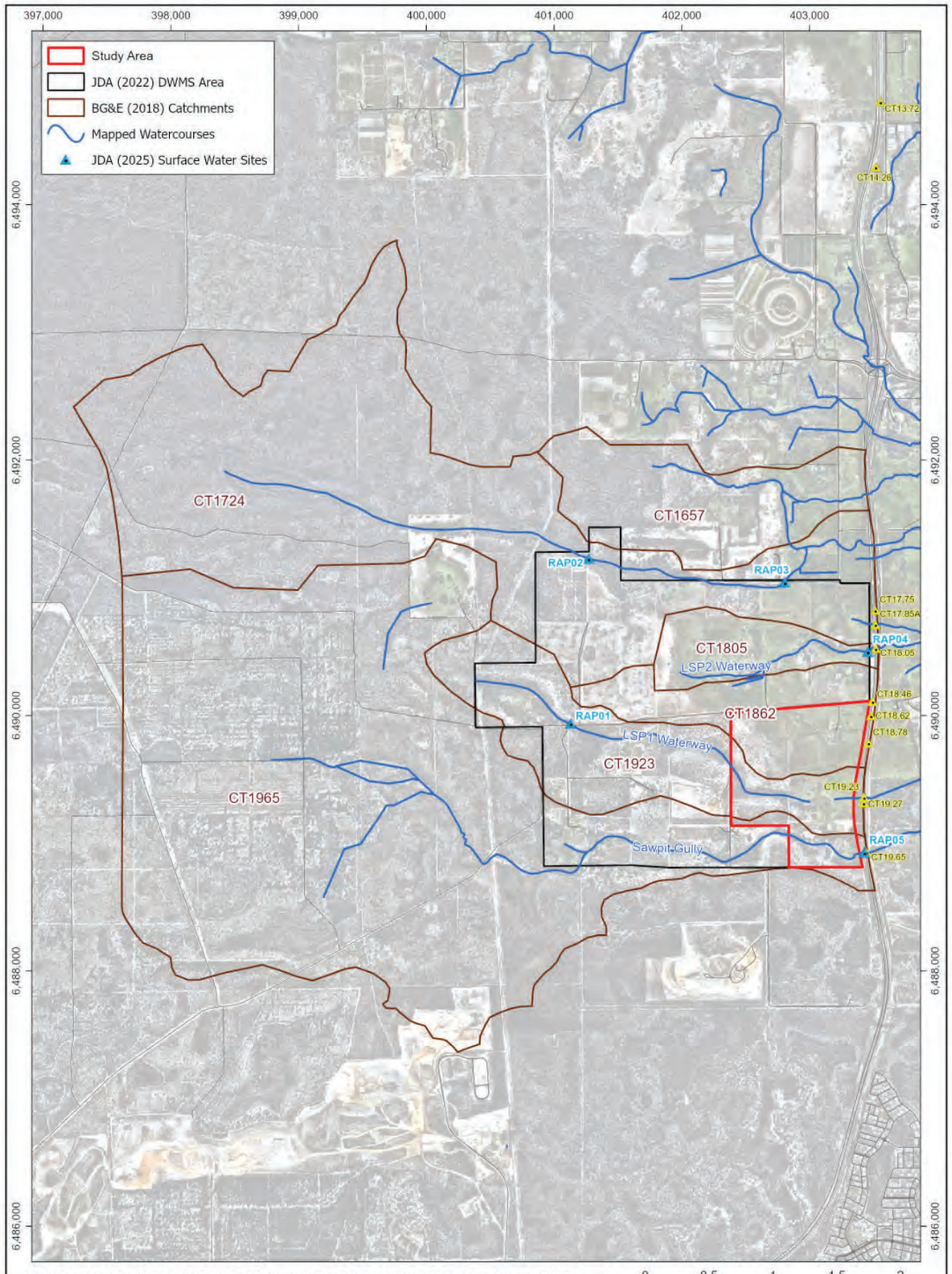
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Figure 7: Groundwater Levels - 2022 to 2024



Data Source: DoW (2008); BG&E (2018); DBCA (2025); JDA (2025); NearMaps (2025).

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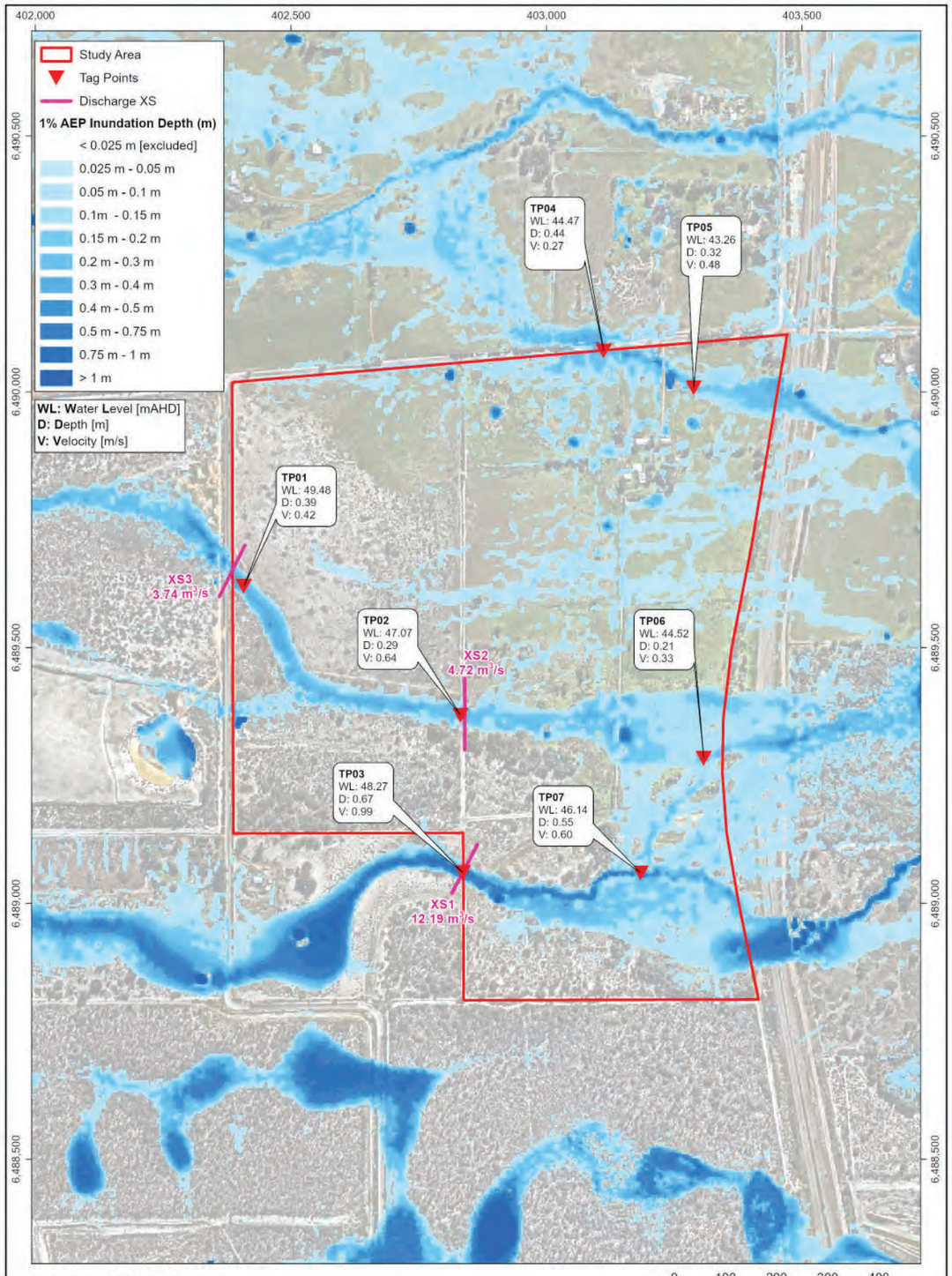
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Figure 8: Surface Hydrology



Data Source: Avant Hydro (2026).

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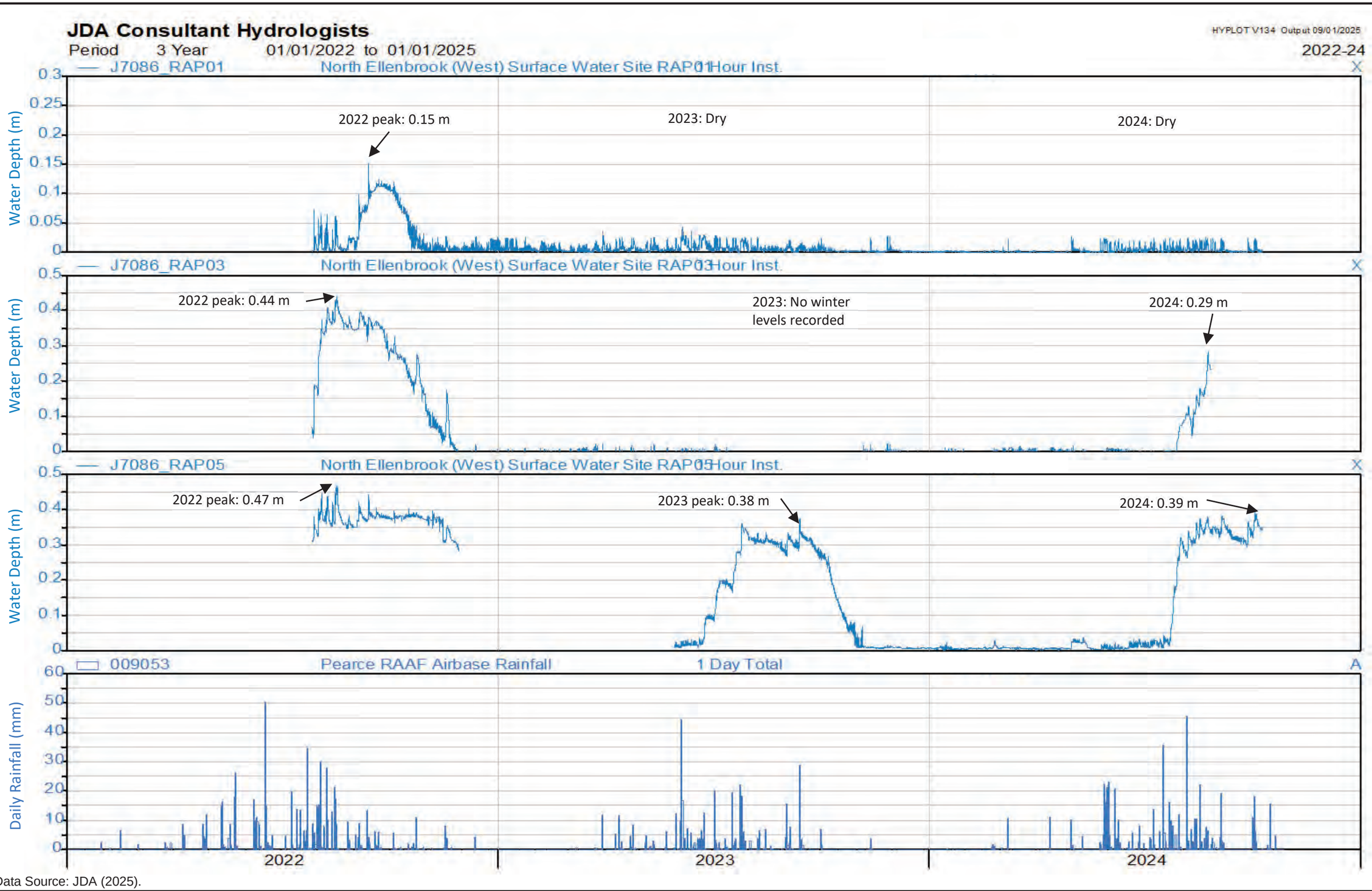
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Figure 9: Pre-Development 2D Flood Modelling



Data Source: JDA (2025).

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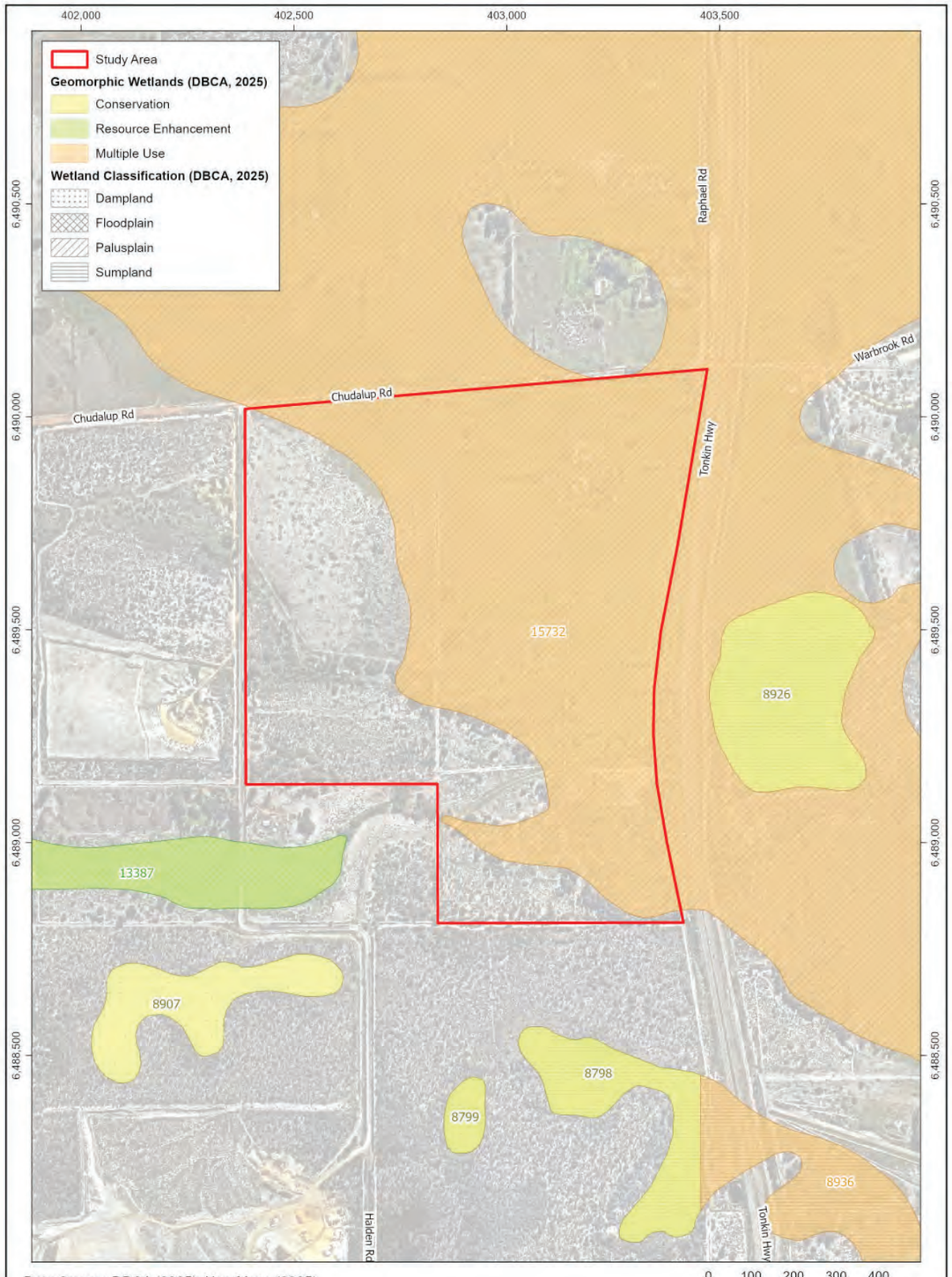
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Figure 10: Pre-Development Surface Water Monitoring Depths



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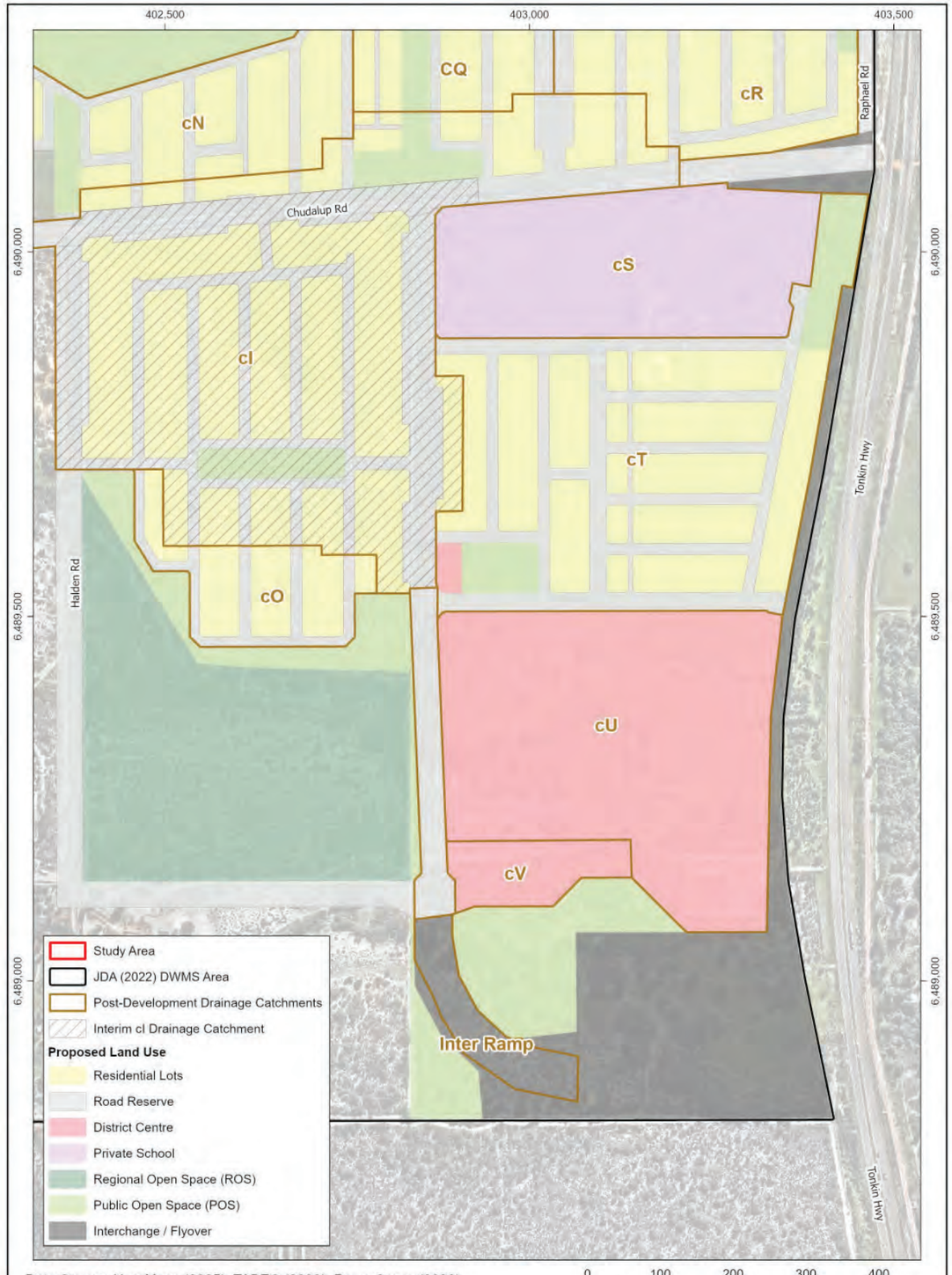
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Scale: 1:12,000 @A4
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Figure 11: Wetland Mapping



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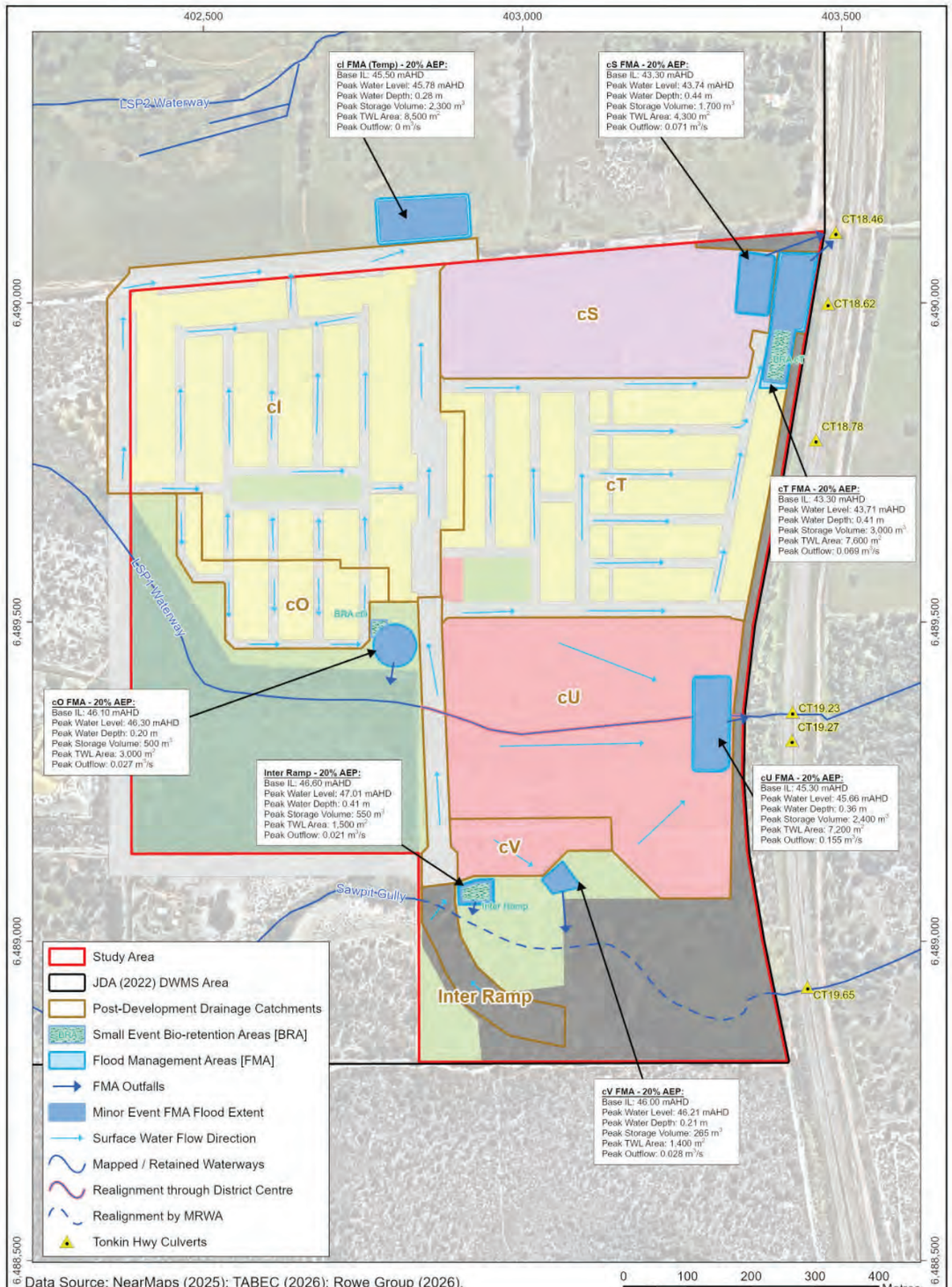
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Scale: 1:7,000 @A4
Coordinate System: GDA2020 MGA Zone 50

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Figure 12: Proposed Post-Development Catchments and Land Use



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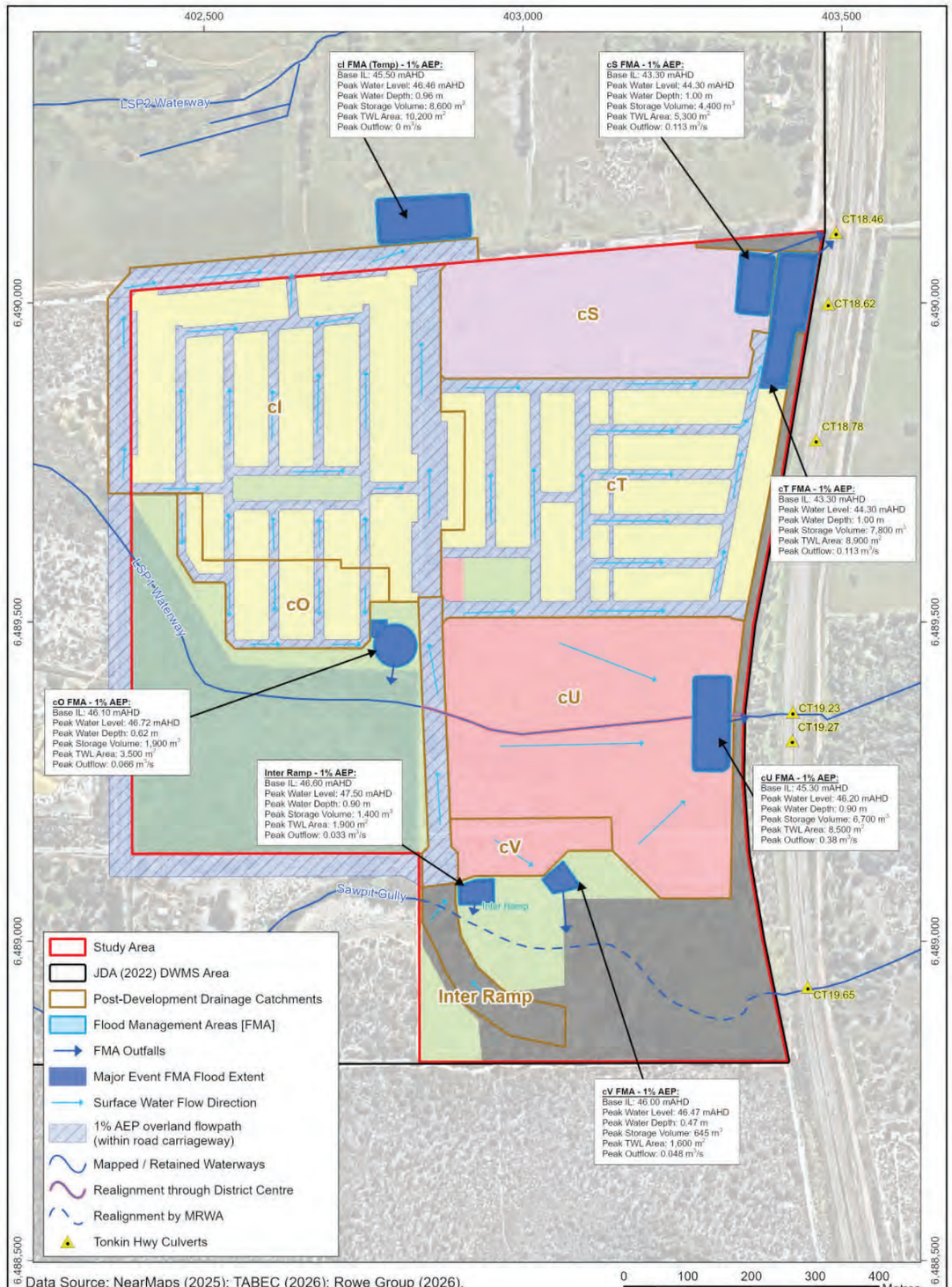
Project No: AVH1015
Scale: 1:8,000 @A4
Coordinate System: GDA2020 MGA Zone 50

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Figure 13: Small (First 15 mm) and Minor (20% AEP) Stormwater Event Plans



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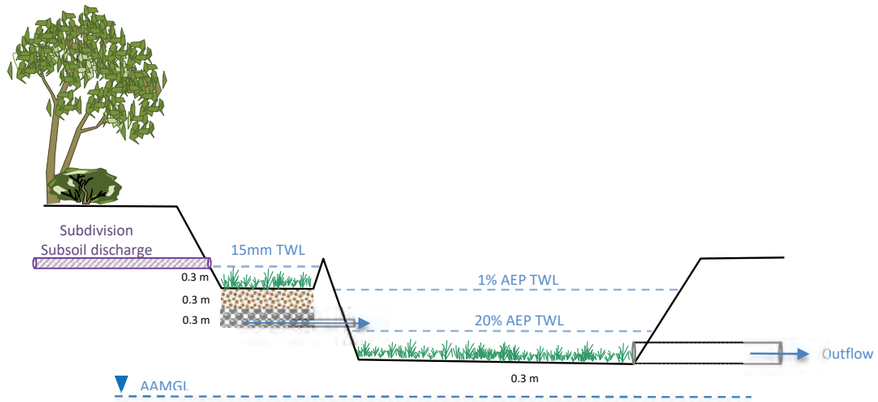
Project No: AVH1015
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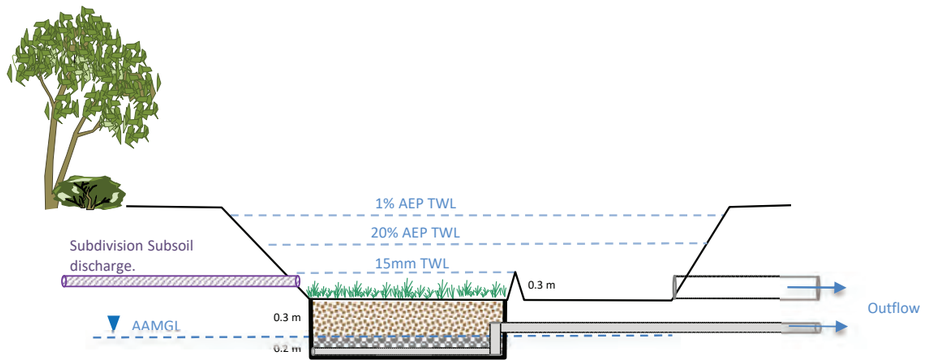
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Figure 14: Major (1% AEP) Stormwater Event Plan

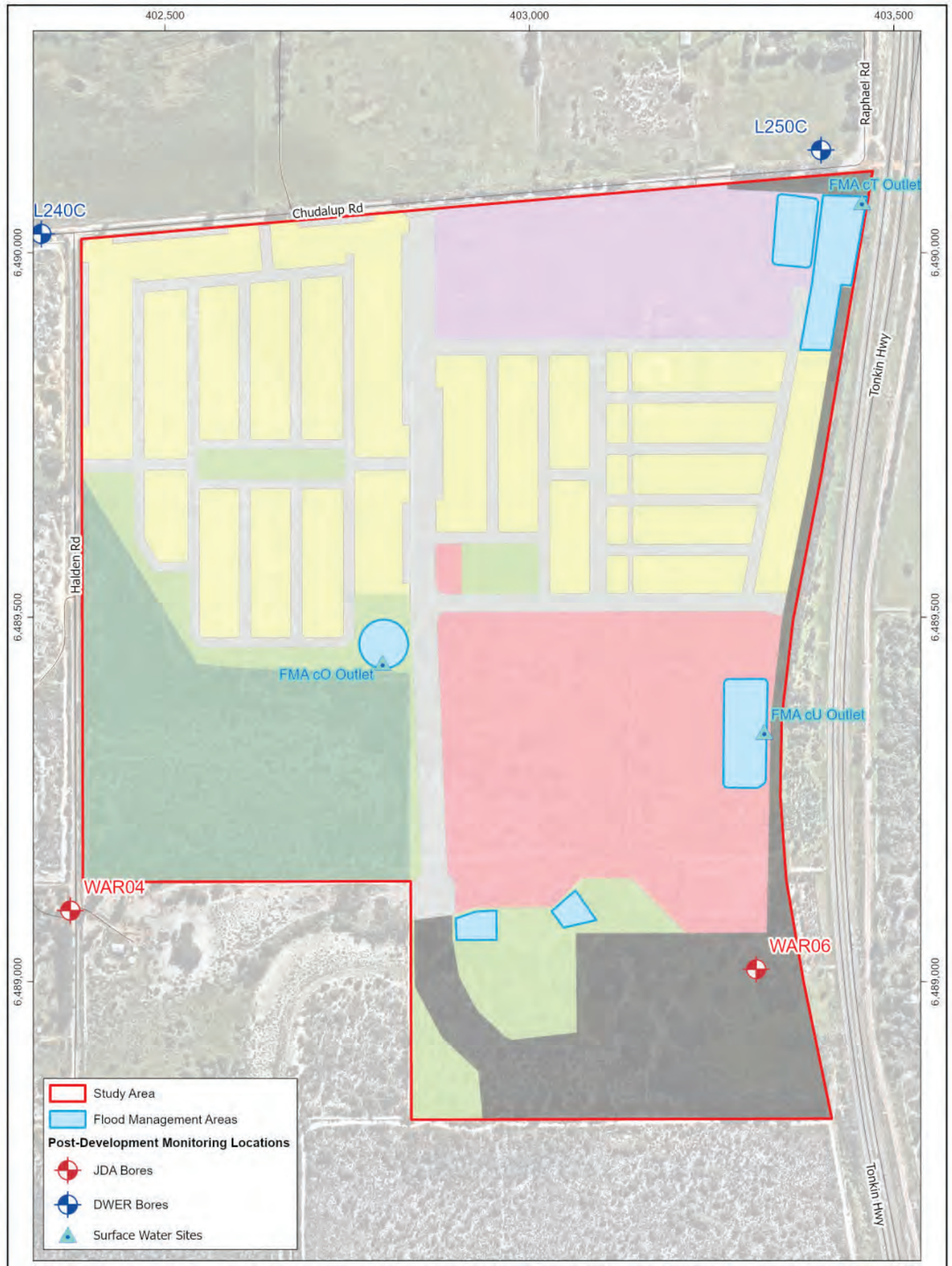


FMA with Bio-Retention Area



FMA with Submerged Bio-Retention Area

AVANT HYDRO CONSULTANTS	Project No. AVH1015	Parcel Property North Ellenbrook (West) Precinct 1: Local Water Management Strategy
	© COPYRIGHT CLOUDSTREAM PTY. LTD. 2026	**Figure 15: FMA Cross Section**



AVANT HYDRO CONSULTANTS	Project No: AVH1015 Scale: 1:7,000 @A4 Coordinate System: GDA2020 MGA Zone 50 © COPYRIGHT CLOUDSTREAM PTY. LTD. 2026	N Parcel Property North Ellenbrook (West) Precinct 1: Local Water Management Strategy **Figure 16: Post-Development Monitoring Locations**

APPENDICES

North Ellenbrook (West) LSP 1: Local Water Management Report

APPENDIX A

Local Structure Plan (Rowe Group, 2026)



PLAN 1 - LOCAL STRUCTURE PLAN - AREA 1 - GATEWAY SOUTH EAST

LOTS 112, 114 & 1808 CHUDALUP ROAD
NORTH ELLENBROOK WEST

DRAFT

N

0 150 m
SCALE @ A3: 1:6000

2270-LSP-01-D

DRAWN: VR
DATE CREATED: 2026.02.09
PROJECTION: PCG2020
CADASTRE: LANDGATE

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ROWE GROUP DESIGN

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APPENDIX B

Geotechnical Report (Structerre Consulting , 2025)

Geotechnical Investigation



Job No: J491896Rev1

Conoble Park Pty Ltd

North Ellenbrook (West) - Halden Road, Bullsbrook WA

Friday 31 October 2025

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Appendix A – Site Plans

Appendix B – Site Plans

Appendix C – Borelogs & Test Pit Logs

Appendix D – Laboratory Test Results

Appendix E – EFCPT Results

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1. Project Details

1.1 Introduction

At the request of Conoble Park Pty Ltd, Structerre Consulting (Structerre) have conducted a Geotechnical Investigation at North Ellenbrook (West) - Halden Road, Bullsbrook WA. The purpose of the investigation was to provide the following for residential subdivision purposes:

- Desk top study including a summary of geology, groundwater, site history (obtained from historical photographs) and potential presence of Acid Sulphate Soils (ASS)
- Summary of encountered ground and groundwater conditions, including borehole logs and indicative mapping of sand resources
- Site Classification in accordance with AS2870-2011 Residential slabs and footings
- Recommendations for stormwater drainage design, including in-situ soil permeability
- Earthquake site factor in accordance with AS1170.4
- Site preparation requirements (earthworks), including site traffic, excavation, reuse of materials and batter slopes, compaction requirements, expected shrinkage and bulking factors, and sub-surface settlement of fill during compaction
- Recommendations on earthworks and site preparation requirements including use of existing materials as fill or for use in public open space, recommendations on imported materials, compaction methods, testing, expected shrinkage and bulking factors, plasticity, sub-surface settlement during compaction of fill and future settlement, dewatering requirement, if necessary
- Preliminary pavement design parameter, indicative California Bearing Ratio (CBR) values determined from penetrometer results and ground conditions encountered
- Earth pressure coefficients for granular backfill for retaining wall design.

This report details the scope of the geotechnical investigation, present and interpretation of ground conditions and material properties across the site, provides geotechnical design parameters for the design of the proposed infrastructure, and evaluates the suitability of materials for use in earthworks. Interpretation of site conditions is based on the subsurface lithology revealed during the investigation programme, visual assessment of the in-situ materials and the results of in situ field tests.

Terms of reference for this investigation were presented in a Structerre Consulting proposal reference Q115142 (dated 12 August 2025), which was submitted to and accepted by The Developer.

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1.2 Site Description & Proposed Development

The site is located at North Ellenbrook (West) - Halden Road, Bullsbrook WA City of Swan. Halden Road and Della South Road lie to the west of the site, Tonkin Highway to the east, Chitty Road to the north and farmland to the south. Warbrook Road/Chudalup Road cuts through the site running east to west.

The site is undulating and slopes up towards the northwestern section. At the time of the field investigation existing buildings occupied Lots 114, 801, 802 and 1167 the remainder of the property was vacant. The property was covered in vegetation with small to large sized trees and was used a farmland. Sawpit Gully also runs along the southern boundary. At the time of the investigation water ponding was also noted on the surface on the low-lying areas (as marked on the attached site plan in Appendix A) of the site.

We understand that the site is to be developed for a residential subdivision, comprising public open space, residential and commercial buildings, with associated road networks.

1.3 Field Investigation – Scope of Works

The field investigation was carried out on 25 to 28 August and 18 & 19 September 2025 and comprised:

- Five (5) x Electric Friction Cone Penetrometer Tests (CPT) to a depth of 3.91m for material assessment and soil profiling
- Fifty (50) x Sample Retrieval Probe boreholes to a maximum depth of 2.5m over the site for material assessment and soil profiling
- Fifteen (15) x In-situ percolation tests to determine the permeability of the materials within the upper 1.0m; and
- Fifty (50) x Perth Sand Penetrometer Tests (PSP) tests in accordance with AS 1289.6.3.3 (1997) to a depth of up to 1.0m for evaluation of relative densities of the upper layers, and

The CPT and BH test locations are presented on the site plan, enclosed within Appendix A.

Suitably qualified geotechnical personnel from Structerre supervised the fieldwork and all fieldwork, interpretation and terminology used in this report are in accordance with the guidelines presented in AS1726-2017 Geotechnical Site Investigations.

2. Desk Study

2.1 Geological Setting

The Perth sheet 1: 50,000 Environmental Geology Series (Part Sheets 2034 III and 2134 III, 1986) prepared by the Geological Survey of Western Australia indicates that the following geological layers underlie the site:

- SAND (S10) – white to pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, subangular to subrounded, minor heavy minerals of eolian origin (Thin Bassendean Sand over Guildford Formation Qpb/Qpa),

2.2 Ground Surface & Groundwater Level

The Perth Groundwater Atlas (Waters & Rivers Commission) indicates the ground surface levels at this site was approximately between 42.0m to 62.0m Australian Height Datum (AHD).

The 2019 groundwater level at the site was approximately 52.0m AHD and the historical maximum was indicated to be approximately 43.5m AHD. It should be noted that the groundwater levels can vary significantly due to seasonal variation and the data from the recorded maximum levels should be used only as a guide.

2.3 Acid Sulphate Soils

Information from publicly available Landgate website indicates that the majority of the site lies within a zone of moderate to low risk with some small (localised) areas of the site lie within the high to moderate risk (as per the attached ASS site plan in Appendix A) of ASS occurring within 3m of natural surface.

2.4 Site History

Historical aerial photographs dating back to 1965 are publicly available through Landgate Map Viewer were assessed and a summary is presented in Table 1.

Table 1 - Historical Site Information

Date	Description
1965	The site is farmland
1974	Dams constructed on Lots 114, 801 and 1767
1977	Buildings constructed on Lots 114, 801 and 1767
1979	Buildings constructed on Lot 802
2025	Site remains relatively unchanged to the current day

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3. Results of the Investigation

3.1 Subsurface Soil Profile

The subsurface soil profile presented below was determined from the ground conditions encountered within the boreholes and through the interpretation of the CPT and PSP test results:

Table 2 – Subsurface Soil Profile

Test Location	Material Description / Depth (m)			
(BH)	Topsoil	Silty Sand	Sand	Comments
1	0.1	-	2.5	
2	0.1	-	2.5	
3	0.1	-	2.5	
4	0.1	-	2.5	
5	0.1	-	2.5	
6	0.1	-	2.5	
7	0.1	-	2.5	
8	0.1	-	2.5	
9	0.1	-	2.5	
10	0.1	-	2.5	
11	0.1	-	2.5	
12	0.1	-	2.5	
13	0.1	-	2.5	Iron staining @ 2.1m, water @ 2.0m
14	0.1	-	2.5	Iron staining @ 2.0m, water @ 1.3m
15	0.2	-	2.5	Water @ 1.5m
16	0.2	-	2.5	Water @ 1.2m
17	0.2	-	2.5	Iron staining @ 2.0m
18	0.2	-	2.5	Iron staining @ 1.8
19	0.2	-	2.5	Water @ 2.0m
20	0.2	0.2 -0.5	2.5	Water @ 0.3m
21	0.2	-	2.5	Water @ 2.0m
22	0.2	0.2 - 0.4	2.5	Water @ 0.4m
23	0.2	-	2.5	Water @ 2.0m
24	0.1	-	2.5	Water @ 0.2m
25	0.1	-	2.5	Water @ 0.7m
26	0.1	-	2.5	Water @ 0.5m
27	0.1	-	2.5	Water @ 0.2m
28	0.1	-	2.5	Water @ 1.0m
29	0.1	-	2.5	
30	0.2	1.9 – 2.5	2.5	Water @ 0.4m, Iron staining @ 1.9m
31	0.2	1.7 – 2.5	2.5	Water @ 0.6m, Iron staining @ 1.7m
32	0.1	-	2.5	Water @ 0.3m
33	0.1	0.1 – 1.0	2.5	Water @ 0.1m

34	0.2	-	2.5	Water @ 0.3m
35	0.2	-	2.5	Water @ 0.1m
36	0.2	-	2.5	Water @ 0.5m
37	0.2	-	2.5	Iron staining @ 2.4m
38	0.2	-	2.5	
39	0.1	-	2.5	
40	0.2	-	2.5	Water @ 2.0m
41	0.2	-	2.5	
42	0.1	-	2.5	
43	0.1	-	2.5	Water @ 2.1m
44	0.1	-	2.5	Water @ 1.0m
45	0.3	-	2.5	Water @ 0.1m
46	0.2	-	2.5	Water @ 0.9m, Iron staining @ 2.3m
47	0.2	-	2.5	Water @ 0.1m
48	0.1	-	2.5	Water @ 0.2m
49	0.1	-	2.5	Water @ 0.2m
50	0.1	-	2.5	Water @ 2.2m, Iron staining @ 2.3m
CPT1	-	-	3.91	Refusal @ 3.91
CPT2	-	-	2.85	Refusal @ 2.85
CPT3	-	-	3.15	Refusal @ 3.15
CPT4	-	-	3.69	Refusal @ 3.69
CPT5	-	-	3.42	Refusal @ 3.42

The field results from the borehole testing are consistent with the Environmental Geology Map. It is important to note that there may be pockets of fill on site that are deeper than that encountered by the investigation boreholes. The subsurface soil conditions encountered are presented in the bore logs, within Appendix C.

3.2 Groundwater

Perched groundwater was encountered on or near the surface in the low-lying areas (as shown on the attached site plan in Appendix A).

Groundwater was also encountered in a number of boreholes as indicated in the table above (Table 2).

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3.3 Percolation Testing

Percolation testing of the in-situ soils was undertaken in fifteen (15) locations. Results of the testing are summarised below:

Table 2 - In Situ Percolation Test Results

Test Location	Testing Depth (m)	Soil Type	Permeability (m/day)
BH 02	0.65 – 0.9	SAND	5.1
BH06	0.65 – 0.9	SAND	13.4
BH09	0.75 – 1.0	SAND	5.0
BH14	0.65 – 0.9	SAND	3.1
BH16	0.75 – 1.0	SAND	1.3
BH22	0.65 – 0.9	SAND	1.1
BH27	0.25 – 0.5	SAND	1.3
BH29	0.65 – 0.9	SAND	5.5
BH31	0.65 – 0.9	SAND	1.1
BH34	0.65 – 0.9	SAND	0.7
BH39	0.65 – 0.9	SAND	3.6
BH42	0.65 – 0.9	SAND	5.9
BH45	0.65 – 0.9	SAND	0.8
BH47	0.45 – 0.7	SAND	0.2
BH50	0.65 – 0.9	SAND	10.9

The insitu sands underlying the topsoils encountered onsite would be considered generally permeable, however onsite percolation results may have been inhibited (reduced) due to the saturation of the site and encountered water levels at the time of testing.

3.4 Laboratory Test Results

Selected soil samples were tested for Particle Size Distribution (PSD) and Organic Content Testing (OC). Atterberg limits tests were not undertaken due to the non-cohesive nature of the soils. Results of the testing are presented in Appendix D and summarised below.

3.4.1 Organic Content Testing

Results for organic tests of representative selected samples are summarised below:

Table 3 - Organic Content Test Results

Test Hole	Depth (m)	Average Organic Contect (%)
BH03	0.0 – 0.2	1.8
BH06	0.0 – 0.2	1.1
BH21	0.0 – 0.2	2.0
BH27	0.0 – 0.2	20.1
BH29	0.0 – 0.2	1.7
BH31	0.0 – 0.2	2.1
BH38	0.0 – 0.2	1.2
BH50	0.1 – 0.2	4.4

Based on the above results screening and blending at a ratio of 1:1 would clean sand would be required to achieve suitable structural fill (i.e. <2% organics). Excessive organic content result was recorded at BH27 which would be considered localised in section and could be removed from any blending process and used for landscaping purposes or in non-structural areas. Further assessment during earthworks should be undertaken at this location to define extent.

3.4.2 Particle Size Distribution

Table 5 – Particle Size Distribution Test Results

Test Hole	Depth (m)	Soil Description	%Fines
BH01	0.7 – 1.1	SAND trace silt	1
BH14	1.0 – 1.4	SAND trace silt	2
BH17	1.0 – 1.4	SAND trace silt	1
BH29	1.0 – 1.4	SAND trace silt	2
BH31	1.0 – 1.4	SAND trace silt	2
BH48	1.0 – 1.4	SAND trace silt	3
BH50	1.0 – 1.4	SAND trace silt	1

Test results indicate that the samples tested are poorly graded SAND (SP).

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4. Geotechnical Construction Considerations

4.1 Site Classification

AS 2870-2011 Residential Slabs and Footings provides guidance on site classification for residential slabs and footing design based on the expected ground surface movement and depth of expected moisture changes.

The site in its current (undeveloped) condition is classified as Class “P” due to the general topsoils/organic materials and loose sand materials encountered across the site.

Based on results of this investigation the site can be classified as a Class “A” provided that all unsuitable materials are removed and replaced with engineer-controlled sand fill materials in accordance with earthwork recommendations outlined in Section 4.3 in this report.

4.2 Seismic Site Subsoil Class

The seismic subsoil site class has been assessed in accordance with AS 1170.4-2007, using the results of this investigation and published information.

Table 4 - Summary of Seismic Parameters

Hazard Factor	Site Sub-soil Class
0.10	Class Ce -shallow soil site

4.3 Earthworks

All earthworks shall be undertaken in accordance with AS 3798-2007 Guidelines on Earthworks for Commercial and Residential Developments and are to include but not limited to the following:

4.3.1 Earthworks Equipment

It is considered that standard sized earthmoving equipment would be appropriate for the proposed development.

The ground surface was generally competent and should not pose significant issues to either excavation or site traffic movements. Near surface materials may become saturated during the wetter months of the year, which may impede site movements.

4.3.2 Clearing and Topsoil Stripping

All surface vegetation (i.e. grass and bushes) to be stripped and removed off site. Trees should be grubbed, stockpiled and mulched for use in landscaping areas within the proposed subdivision. Loose ground resulting from the removal of vegetation (i.e. trees) should be profiled, compacted and in filled with suitably compacted fill.

Based on the investigation the topsoil is approximately 0.2m thick. The encountered topsoil may be used as is in landscape areas but is not suitable for use as structural fill.

Alternatively, screening and blending of topsoil may provide suitable structural fill provided vegetation, roots and stumps are removed. Should this be engaged, it is recommended to blend topsoil with clean sand in ratio to provide an organic content of <2% by mass. Typically, a suitable blended material is achieved by blend ratio (clean sand/topsoil) of 1:1. Any blended material should not be placed in the upper 0.6m fill profile, however where drainage is a consideration placement should be at depth. Additionally, it is recommended monitoring of the screening and blending process be conducted by an Engineer experienced in earthworks, which would include the following:

- Sampling of the topsoil sources to determine organic content
- Site visit, supervision and testing to determine the appropriate blending process
- Ongoing monitoring and testing of the blending process at a frequency of 1 visit per 2000m^3.

The organic content of the underlying soils (i.e. <2%), is typical of poorer sub-soils. Subject to inspection and testing, it is considered that these materials can be left in situ and blended with the initial layer of clean sand fill. Further assessment is recommended at BH27 location to assess extent of richer topsoils prior to reuse as blended fill.

4.3.3 Uncontrolled Fill

Uncontrolled fill was not encountered during the investigation. However, should it be identified during earthworks, it is recommended that screening and blending be undertaken before reusing as structural fill provided it is uncontaminated, dry, non-reactive and free from organics (i.e. <2%) and deleterious materials.

Should cohesive (i.e. reactive) uncontrolled fills be encountered, these materials can be processed, as above, and reused at -1.5m below finished levels.

4.3.4 Proof Compaction

The near surface sand materials can be proof compacted by utilising the following methodology:

- Apply a minimum of 4 passes with a self-propelled, smooth drum vibratory roller (operating in high amplitude mode) allowing a minimum of 20% overlap. The surface should then be given an additional minimum of 4 passes with the vibrating roller operating in low amplitude. Areas that deform excessively under rolling should be removed and replaced with clean sand. On completion of vibratory rolling, the roller should be operated in static mode, applying a minimum of 2 passes over the site.

After excavation / stripping and proof compaction, it is recommended the base is to be inspected and approved by a representative from this office prior to backfilling. At this stage it can be assessed whether any further materials need to be removed or whether further compaction of the base is required.

The compaction requirements are set out below, as per AS3798:2007

Table 5 - Compaction Requirements

Item	Application	Minimum relative compaction %	
		Minimum density ratio (Standard Compaction Effort) (Cohesive soils)	Minimum density index (Cohesionless soils)
1	Residential - lot, fill, house, sites	95	70
2	Commercial – fills to support minor loadings, including floor loading of up to 20kPa and isolated pad or strip footings to 100kPa	98	75
3	Fill to support pavements General Fill Subgrade (to a depth of 0.3m)	 95 98	 70 75

4.3.5 Cohesionless Sand Structural Fill

The SAND encountered on site is deemed to have suitable geotechnical engineering properties and can be utilised as structural fill.

However, it should be noted that the in-situ sand materials have a variable silt content at depth (ranging from SAND trace fines to SAND with silt), which may reduce the permeability characteristics when placed and compacted as engineered fill. Therefore, it is recommended that any silty SAND exposed be blended with clean SAND and the permeability characteristics verified during the earthworks. The silty sand was encountered at BH's 20, 22, 30, 31, and 33, with the Iron staining (silt) generally at ground water (fluctuation) levels and is included in Table 2 of this report.

Within fill areas, the ground level should be built up to design levels. Generally, the sand materials should be placed in layers not exceeding 300mm loose thickness and compacted to achieve the criteria stated in Table 7.

It is recommended that a Perth Sand Penetrometer (PSP) / Density correlation be undertaken to confirm the PSP requirements. However, the following criteria can be used as a guide:

- A minimum of 8 PSP blows over the interval 150 – 450mm, 9 PSP blows over the interval 450 – 750mm and 11 PSP blows over the interval 750 – 1050mm.

4.4 Temporary and Permanent Slopes

The following temporary and permanent excavation batters are considered suitable for non-surcharged (i.e. no surcharge within 4.0 m of crest), dry, cohesionless sand slopes of less than 2.0m in height, in accordance with the Building Code of Australia (BCA) Table 3.1.1.1.

Table 6 - Slope Gradients

	Temporary	Permanent
Cut	1V : 2H	1V : 2.5H
Fill	1V : 2H	1V : 2.5H

Slopes greater than 2.0m or if steeper slopes are required should be analysed on a case-by-case basis.

4.5 Sand Extraction

Sand was encountered on site to the target exploration depth and representative samples were collected and submitted for Particle Size Distribution. The encountered SAND can be described as being typically poorly graded sand with a fines content varying from 1% to 5%.

The SAND with fines content of less than or equal to 5%, would be described as being structural free draining sand. The SAND with fines content of more than 5% can be used as fill at depth (i.e. more than -1.5m depth) or blended with the clean sands to provide suitable free draining materials. The SAND material encountered on site would be described as being trafficable with 4WD vehicles and as being 'easy to dig'.

4.6 Drainage

The existing ground conditions in the lower lying areas are not considered suitable for on-site disposal of stormwater runoff through the use of soakwells due to the depth to groundwater encountered.

On site drainage through the use of soakwells may be appropriate subject to suitable engineered design with the placement of free draining sand to provide suitable freeboard from groundwater levels and appropriate drainage control systems.

It is recommended that The Client confirm the permeability rates following the completion of the (filling) earthworks.

4.7 Indicative California Bearing Ratio (CBR)

The indicative California Bearing Ratio (CBR) value of the subgrade material (following earthworks) can be estimated from the site investigation results and would be appropriate for preliminary design purposes. The indicative design CBR value is shown in table 9:

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Table 9 - Indicative CBR Values

Material	Indicative CBR (%)	Compaction
SAND (In-situ or Imported Fill)	12	95% of MMDD*

* Implies the maximum dry density ratio using Modified compaction in accordance with AS 1289 5.2.1-2003.

For detailed design of the pavements, it is recommended that the CBR values be verified with laboratory Soaked CBR testing on the anticipated subgrade material.

4.8 Retaining Walls

Retaining walls proposed to be installed at the site will likely support sandy soils. Where imported granular backfill is to be used in conjunction with retaining walls, the geotechnical properties will vary depending upon the nature of the granular materials imported.

For cohesion-less free draining sand, the following parameters can be used as a guide for design purposes:

- Angle of internal friction, Ø = 33^0
- Coefficient of active earth pressure Ka = 0.29
- Coefficient of passive earth pressure Kp = 3.39
- At rest coefficient of earth pressure K0 = 0.46
- Bulk density 18 kN/m^3

Retaining structures should be designed in accordance with AS 4678-2002 Earth Retaining Structures. Where significant eccentric and/or horizontal loading is applied, further assessment will be required. Additionally, handheld compaction equipment is utilised within 2.0m of the walls, to reduce the potential increase in lateral pressure on the retaining wall.

Retaining wall design should ensure adequate drainage to the rear of the wall. It is recommended that the drainage comprises free draining sand and weepholes that are interconnected with a suitable sized perforated drainage pipe.

Experience indicates that excavation immediately in front of retaining walls (i.e. due to service installation) may cause movement to the wall to occur. This can lead to cracking of adjoining structures and needs to be accounted for in the design and construction sequencing of the new works.

4.9 Acid Sulphate Soils

If more than 100m^3 of soil is to be removed from below the water table and/or dewatering is required, in accordance with Department of Environmental Regulation (DER) guidelines an ASS Management Plan will be required.

5. Conclusions

A site investigation was carried out at the proposed commercial development site to assess the geotechnical conditions. Parameter and design recommendations are incorporated in the body of the report. The following conclusions have been drawn from the site investigation:

- The site is considered suitable for the proposed subdivisional development.
- The average subsurface soil profile encountered comprised topsoil to 0.2m overlying Natural sand to in excess of 5.0m in depth.
- Groundwater / perched water was encountered at a number of boreholes (as indicated in Table 2) below ground level.
- The site can be reclassified as Class "A" in accordance with AS 2870-2011 provided the recommended earthworks are undertaken.
- It is considered that the current site conditions are not suitable for on-site drainage (low-lying areas), however can be reassigned to suitable, subject to engineered design, including lifting of surface levels with free draining sand to provide suitable separation from groundwater and groundwater management controls.
- In general, small to medium sized earthworks equipment are considered suitable for the proposed development.
- Site movement and excavations should not pose a significant issue. Wet ground in the low-lying areas will be encountered in the winter months, and this should be allowed for during earthworks.
- Recommended earthworks include stripping of topsoil and any unsuitable materials, proof compaction of the base, excavation of loose materials (where necessary), placement fill and compaction of final level.
- The underlying sand materials are considered structural suitable for reuse as structural fill.
- A CBR value is 12% is recommended for the existing subgrade and imported sand fill.
- At this stage it is considered that an ASS Investigation and Management Plan will be required.

FSGWAG_GTIDEV-SAND v1.0 25/3/2025
Friday 31 October 2025

6. Limitation of Field Investigations

This report has been prepared in accordance with generally accepted consulting practice for The Client using information supplied at the time and for the project specific requirements as understood by Structerre. To the best of our knowledge the information contained in this report is accurate at the date of issue, however it should be emphasised that any changes to ground conditions and/or the proposed structures may invalidate the recommendations given herein.

The conclusions and recommendations in this report are based on the site conditions revealed through selective point sampling, representing the conditions of the site in total, although the area investigated represents only a small portion of the site. The actual characteristics may vary significantly between successive test locations and sample intervals other than where observations, explorations and investigations have been made.

The materials and their geotechnical properties presented in this report may not represent the full range of materials and strengths that actually exist on site and the recommendations should be regarded as preliminary in nature. Allowances should be made for variability in ground conditions and any consequent impact on the development. Structerre accepts no responsibility and shall not be liable for any consequence of variations in ground conditions.

If ground conditions encountered during construction are different to that described in this report, this office should be notified immediately.

We trust this meets with your requirements. Should you require any additional information, or clarification of the above, please contact the undersigned.

For and behalf of Structerre Consulting.

Signature
David Harding
Geotechnical Supervisor

(08) 9205 4500
wageotechengineering@structerre.com.au

Signature
Mel Castle
Geotechnical Manager

31 October 2025

WA | QLD | NSW | VIC
www.structerre.com.au

7. References

Department of Water – Perth Groundwater Atlas

Geological Survey of Western Australia 1:50,000 Environmental Geology Series

AS 1170.4-2007 Structural design actions – Earthquake actions in Australia

AS 1289 Methods of testing soils for engineering purposes

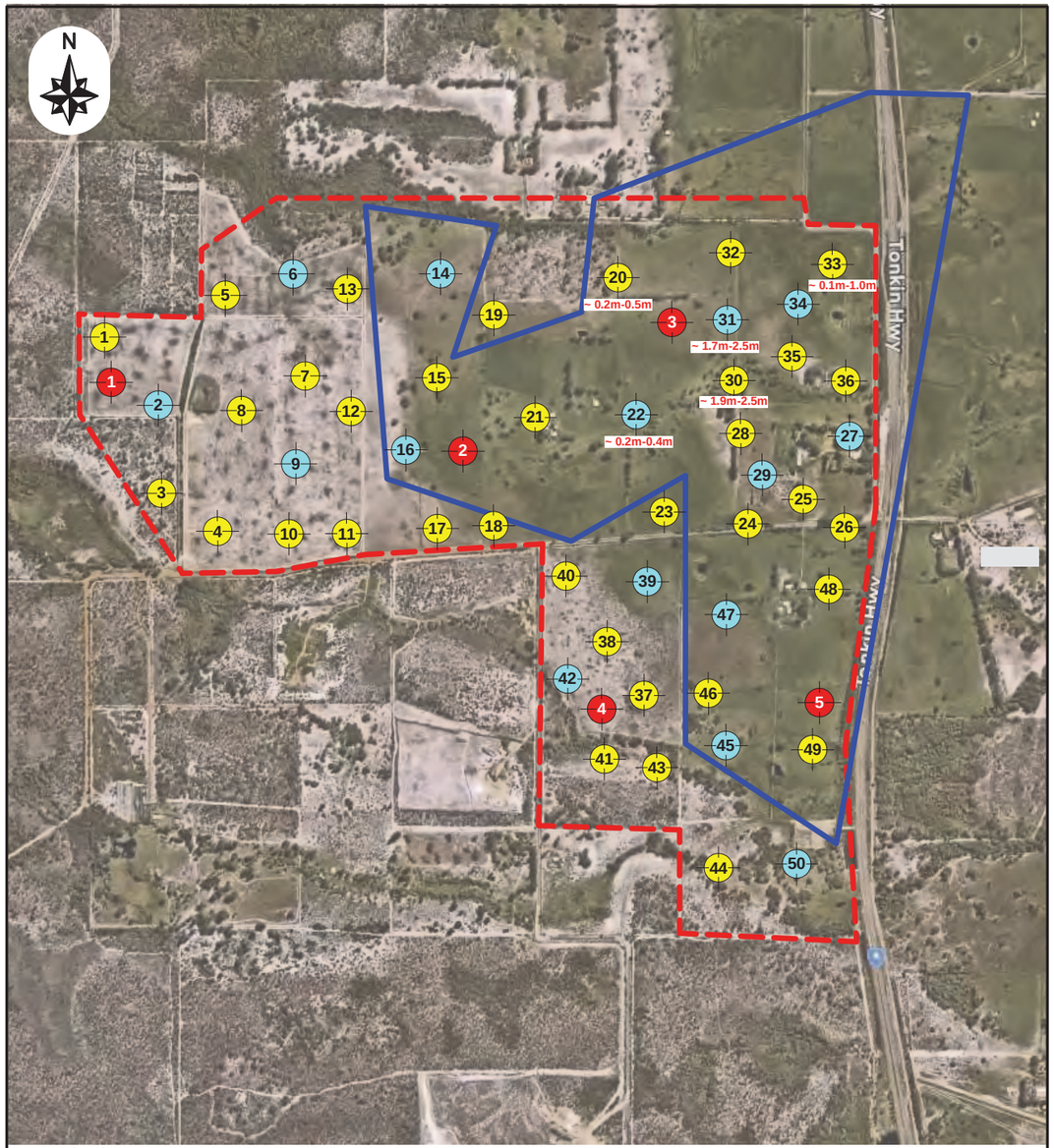
AS 1726-2017 Geotechnical site investigation

AS 2870-2011 Residential slabs and footings

AS 3798-2007 Guidelines on earthworks for commercial and residential developments

Appendix A – Site Plan

WA | QLD | NSW | VIC
www.structerre.com.au



Note: Showing approximate test locations only

LEGEND

- Borehole
- Borehole and Percolation Test
- Site Boundary
- Electric Friction Cone Penetrometer Test
- Area of Surface Water
- ~ m Depth/Thickness of Silty Sand

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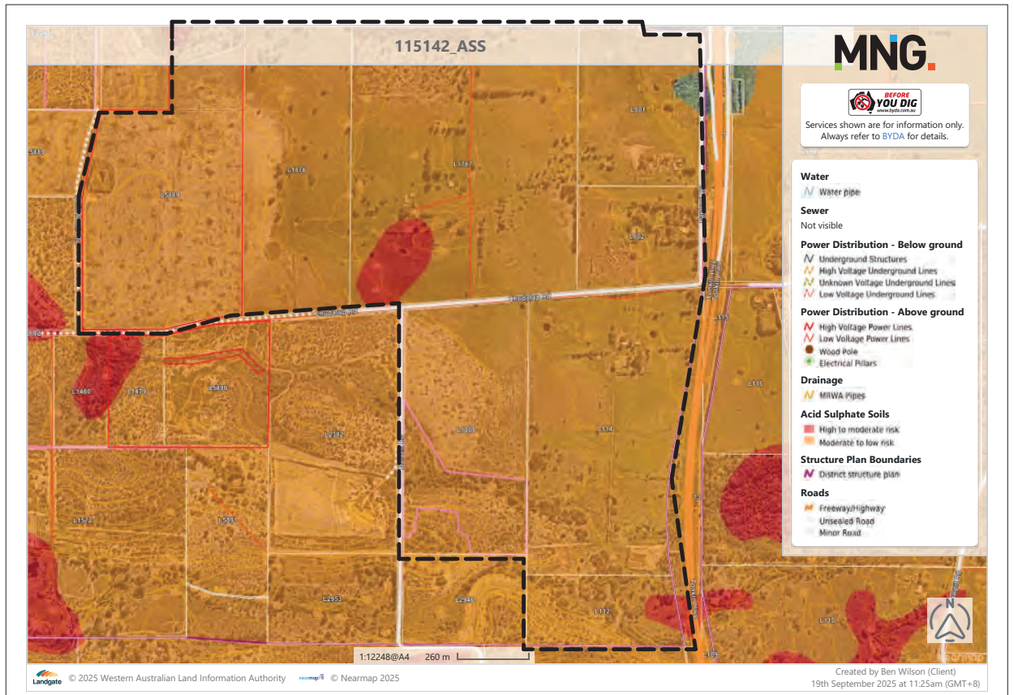
Zemla Pty Ltd (ABN 71 349 772 837) ATF the Young Purich and Higham Unit Trust trading as Structerre Consulting

1 ERINDALE ROAD, BALCATTA, WA 6021
TEL 9205 4500 FAX 9205 4501 EMAIL: wageotecheng@structerre.com.au

PROJECT:	North Ellenbrook (West) - Halden Road, Bullsbrook
PROJECT #:	D369796
CLIENT:	**Conoble Park Pty Ltd**
JOB #:	J491896
SCALE:	NTS
TITLE:	Geotechnical Investigation Site Plan
DATE:	30 Oct '25
DRAWN BY:	MAI
CHECKED BY:	DH

DOC: GE:3.001

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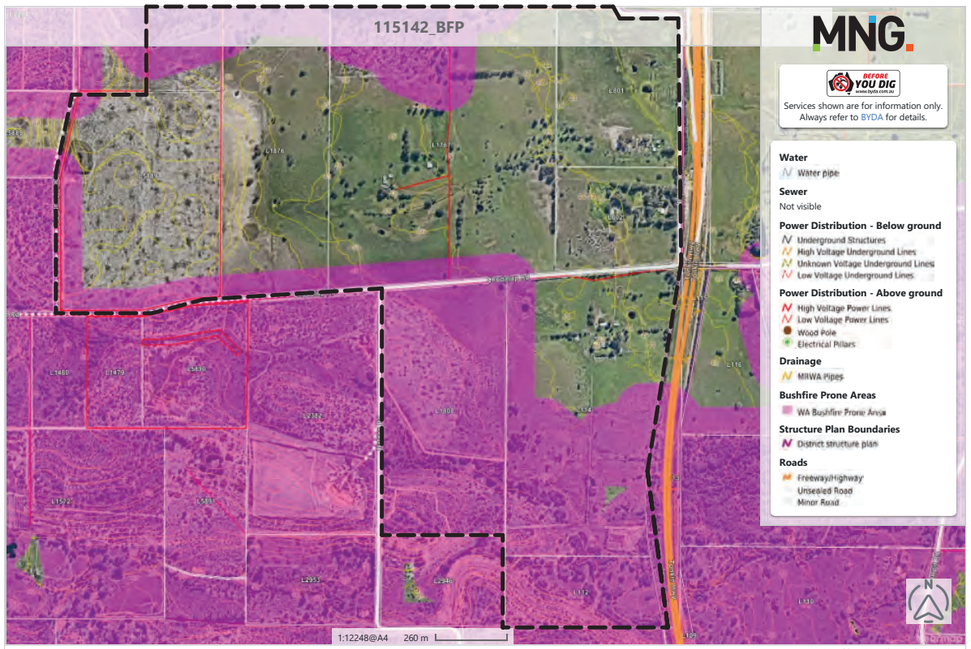
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PROJECT:	North Ellenbrook (West) - Halden Road, Bullsbrook
PROJECT #:	D369796
CLIENT:	**Conoble Park Pty Ltd**
JOB #:	J491896
SCALE:	NTS
TITLE:	Geotechnical - Acid Sulphate Soils
DATE:	25 Aug '25
DRAWN BY:	MM
CHECKED BY:	DH

DOC: GE:3.001

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PROJECT: North Ellenbrook (West) - Halden Road, Bullsbrook

PROJECT #: D369796

CLIENT: **Conoble Park Pty Ltd**

JOB #: J491896

SCALE: NTS

TITLE: Geotechnical - Bushfire Prone Areas

DATE: 25 Aug '25

DRAWN BY: MM

CHECKED BY: DH

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DOC: GE:3.001

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Appendix B – Site Photos



PHOTO 1 - Facing east from BH1 location



PHOTO 2 - Facing north from BH11 location



PHOTO 3 - Facing south from BH14 location



PHOTO 4 - Facing west from BH23 location

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PROJECT: North Ellenbrook (West) - Halden Road, Bullsbrook

PROJECT #: D369796

JOB #: J491896

CLIENT: **Conoble Park Pty Ltd**

SCALE: NTS

TITLE: Site Photographs

DATE: 25 Aug '25

DRAWN BY: MM

CHECKED BY: DH

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PROJECT: North Ellenbrook (West) - Halden Road, Bullsbrook

PROJECT #: D369796

JOB #: J491896

CLIENT: **Conoble Park Pty Ltd**

SCALE: NTS

TITLE: Site Photographs

DATE: 25 Aug '25

DRAWN BY: MM

CHECKED BY: DH

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PHOTO 5 - Facing east from BH45 location



PHOTO 6 - Facing north from BH50 location

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PROJECT:	North Ellenbrook (West) - Halden Road, Bullsbrook
PROJECT #: D369796	CLIENT: **Conoble Park Pty Ltd**
JOB #: J491896	
SCALE: NTS	TITLE: Site Photographs
DATE: 25 Aug '25	DRAWN BY: MM / CHECKED BY: DH

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Appendix C – Borelogs & Borelog Terminology

STRUCterre consulting engineers

Residential Geotechnical Commercial & Infrastructure

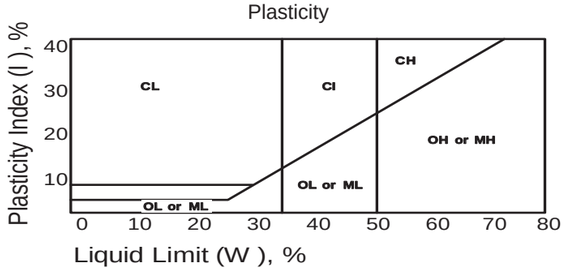
Inspect & Investigate Energy Assessment Environmental

BOREHOLOG TERMINOLOGY

Particle Size Distribution

Major Division	Subdivision	Size
Boulders		>200mm
Cobbles		200 - 63mm
Gravel	Coarse	63 - 20mm
	Medium	20- 6mm
	Fine	6 - 2.36mm
Sand	Coarse	2.36 - 0.6mm
	Medium	0.6 - 0.2mm
	Fine	0.2 - 0.075mm

Plasticity



Consistency of Cohesive Soils

Term	Undrained Strength Su (kPa)	Field Guide
Very Soft	< 12	Exudes between the fingers when squeezed in hand
Soft	12 - 25	Can be moulded by light finger pressure
Firm	25 - 50	Can be moulded by strong finger pressure
Stiff	50 - 100	Cannot be moulded by Fingers. Can be indented by thumb.
Very Stiff	100 - 200	Can be indented by thumb nail
Hard	> 200	Can be indented with difficulty by thumb nail.
Friable	-	Crumbles or powders when scraped by thumbnail

Consistency/Density of Non-Cohesive Soils

Term	Density Index (%)	SPT "N" Value Comparison
Very Loose	< 15	0 - 4
Loose	15 - 35	4 - 10
Medium Dense	35 - 65	10 - 30
Dense	65 - 85	30 - 50
Very Dense	> 85	> 50

Moisture Content

D	Dry
M	Moist
W	Wet
S	Saturated

Minor Components

Term	Assessment Guide	Proportion of Minor Component In:
Trace	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component	Coarse grained soils: < 5 % Fine grained soils: <15%
With	Presence easily detected by feel or eye, soil properties little different to general properties of primary component	Coarse grained soils: 5 - 12 % Fine grained soils: 15 - 30%

Soil Legend

FILL	CLAY	GRAVEL	CONCRETE
TOPSOIL	SILT	LIMESTONE	COMBINATIONS
PEAT	SAND	BEDROCK	eg: Clay, Silty, Sandy

USCS

GW	Well graded gravel	SC	Clayey sand	OL	Organic low plasticity silt
GP	Poorly graded gravel	SM	Silty sand	ML	Low plasticity silt
SW	Well graded sand			MH	High plasticity silt
SP	Poorly graded sand			OH	Organic high plasticity silt

CL	Low plasticity clay
CI	Intermediate plasticity clay
CH	High plasticity clay
PT	Peat

DOC:GE:3.003

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Borehole Record: BH01

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401012.27
Northing: 6490545.98
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, p		VL-L	0 5 10 15 20 25 30		
	1							2 2 3 3 4 5		
	2									
					BH01 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

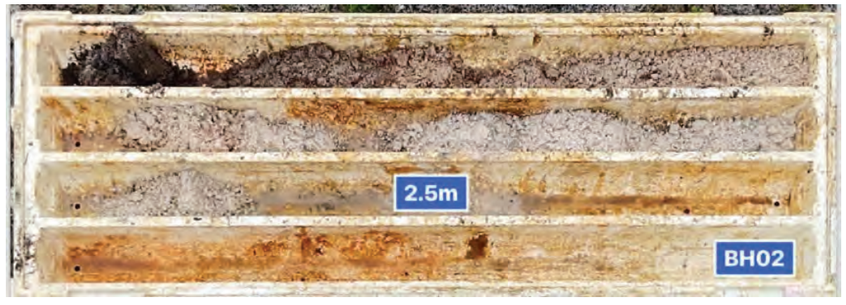
Borehole Record: BH02

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401164.30
Northing: 6490443.97
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	1	Non-soil / Natural		TS / SP	Topsoil. Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	1, 2, 2, 2, 4, 4	5.1	
	2				BH02 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH03

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401168.42
Northing: 6490211.23
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	1	Non-soil / Natural		TS / SP	Topsoil. Sand (SP): very loose to loose, poorly graded, fine to medium grained, pale grey.		VL-L	1, 3, 4		
	2				BH03 Terminated at 2.5 m					



Depth: 2.5 m

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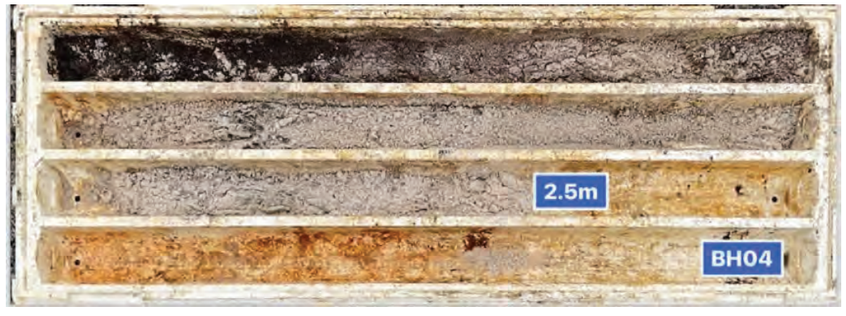
Borehole Record: BH04

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401274.66
Northing: 6490049.82
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	1 2	Non-soil Natural		TS SP	Topsoil. Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	1, 2, 2, 2, 4, 4		
					BH04 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH05

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401300.22
Northing: 6490583.62
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	1 2	Non-soil Natural		TS SP	Topsoil. Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	1, 2, 2, 2, 4, 4		
					BH05 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH06

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401639.35
Northing: 6490850.35
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	0	Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, p		VL-L	1 2 3 3 3 4	13.4	
	1									
	2									
					BH06 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH07

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401651.90
Northing: 6490599.55
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	0	Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	2 2 3 3 4 5		
	1									
	2									
					BH07 Terminated at 2.5 m					



Depth: 2.5 m

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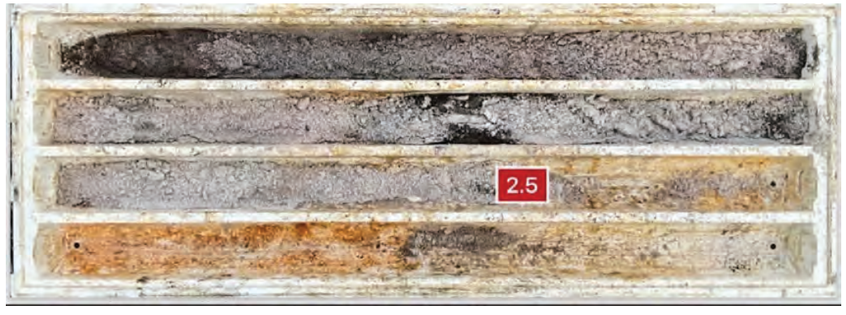
Borehole Record: BH08

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401389.86
Northing: 6490301.58
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	0	Non-soil / Natural		TS / SP	Topsoil. Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	2 2 2 2 2 3 2		
	1									
	2									
					BH08 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH09

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401642.28
Northing: 6490245.63
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	0	Non-soil / Natural		TS / SP	Topsoil. Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	1 2 2 2 2	5.1	
	1									
	2									
					BH09 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH10

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401627.77
Northing: 6490052.50
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	1	Non-soil Natural		TS SP	Topsoil. Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	2, 2, 2, 2, 3, 4		
	2				BH10 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH11

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401848.78
Northing: 6490208.87
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	1	Non-soil Natural		TS SP	Topsoil. Sand (SP): very loose to loose, poorly graded, medium grained, pale grey.		VL-L	2, 2, 2, 3, 3, 4		
	2				BH11 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH12

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401915.25
Northing: 6490493.42
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	0	Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey		VL	1, 1, 2, 1, 2		
	1									
	2									
					BH12 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH13

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 401910.71
Northing: 6490815.57
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
	0	Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, p		VL-L	1, 1, 2, 1, 3, 2		
	1									
GWL	2			SP	Sand (SP): medium dense, poorly graded, medium grained, pale brown, moist.	M	MD			
					BH13 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH14

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402095.71
Northing: 6490893.55
Elevation: Not Surveyed
Inclination:

Date Drilled: 25/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey		VL		3.2	
GWL	1									
	2			SP	Sand (SP): medium dense, poorly graded, medium grained, pale brown, moist.	M	MD			
					BH14 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH15

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402115.23
Northing: 6490683.74
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist to wet.	W-M	VL			
GWL	1									
	2									
					BH15 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH16

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402093.46
Northing: 6490350.81
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, pale grey, moist to wet.	W-M	VL-L	2 3 2 1 2 2	1.3	
	2				BH16 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH17

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402133.07
Northing: 6490132.15
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2		
	2				BH17 Terminated at 2.5 m					



Depth: 2.5 m

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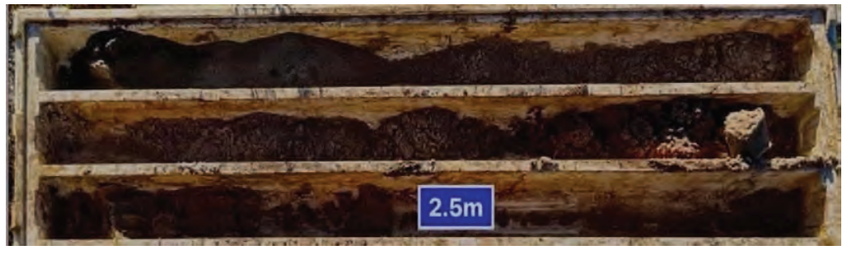
Borehole Record: BH18

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402133.07
Northing: 6490132.15
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 1 2 2 2		
	2									
					BH18 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH19

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402200.03
Northing: 6490801.20
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2		
GWL	2									
					BH19 Terminated at 2.5 m					



Depth: 2.5 m

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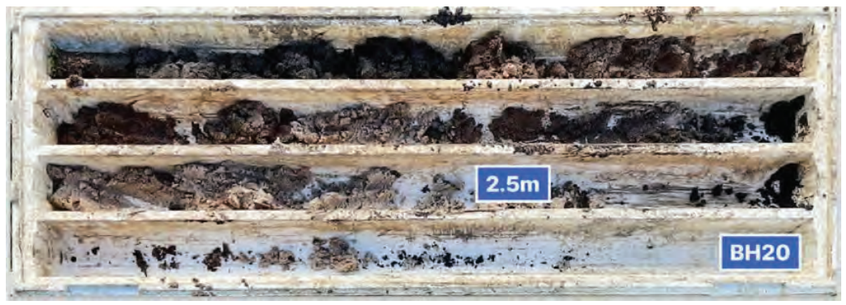
Borehole Record: BH20

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402655.56
Northing: 6490988.25
Elevation: Not Surveyed
Inclination:

Date Drilled: 28/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL		Natural		SM	Silty Sand (SM): very loose, poorly graded, medium grained, pale grey, wet.	W	VL	1 2 1 1 2 2		
	1			SP	Sand (SP): very loose, poorly graded, medium grained, pale brown, wet.	W	VL			
	2									
					BH20 Terminated at 2.5 m					



Depth: 2.5 m

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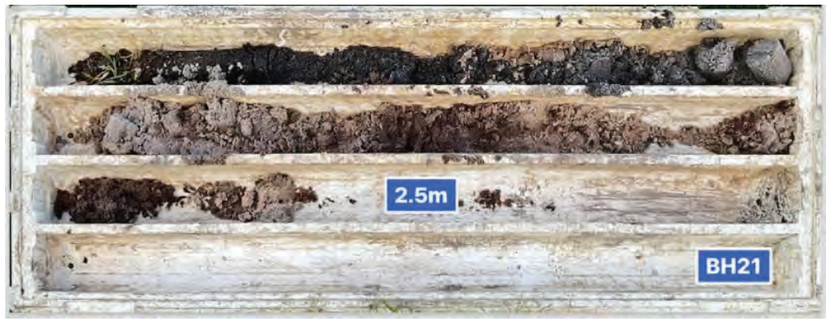
Borehole Record: BH21

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402373.72
Northing: 6490532.70
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2		
GWL	2									
					BH21 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH22

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402696.76
Northing: 6490390.94
Elevation: Not Surveyed
Inclination:

Date Drilled: 28/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
		Natural		SM	Silty Sand (SM): very loose, poorly graded, medium grained, pale grey, wet.	W	VL	1 1 2 1 1 2 2		
GWL	1			SP	Sand (SP): very loose, poorly graded, medium grained, pale brown, wet.	W	VL		1.2	
	2									
					BH22 Terminated at 2.5 m					



Depth: 2.5 m

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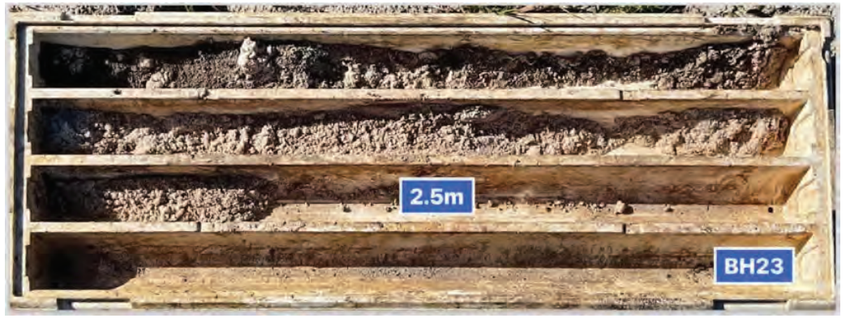
Borehole Record: BH23

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402985.91
Northing: 6490310.56
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2 2		
GWL	2									
					BH23 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH24

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403070.97
Northing: 6490188.05
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
GWL	0	Non-soil		TS	Topsoil.					
		Natural		SM	Silty Sand (SM): very loose to loose, poorly graded, medium grained, pale grey, wet.	W	VL-L	2, 1, 4, 3, 4, 3		
	1									
	2									
					BH24 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH25

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403258.90
Northing: 6490263.24
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR 324
Drill Supplier Example supplier
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
GWL	0	Non-soil		TS	Topsoil.					
		Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, pale grey, moist.	M	VL-L	2, 1, 3, 3, 3, 4		
	1									
	2									
					BH25 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH26

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403400.23
Northing: 6490165.20
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	0 5 10 15 20 25 30		
	2				BH26 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH27

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403386.44
Northing: 6490438.60
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SM	Silty Sand (SM): very loose, poorly graded, medium grained, pale grey, moist to wet.	W-M	VL	0 5 10 15 20 25 30	1.2	
	2				BH27 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH28

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403096.32
Northing: 6490445.71
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SM	Silty Sand (SM): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	1 2 1 2 1 2		
	2				BH28 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH29

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403092.78
Northing: 6490324.41
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, pale grey, moist to wet.	W-M	VL-L	2 1 2 3 4 4	5.5	
	2				BH29 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH30

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403083.85
Northing: 6490650.56
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey	W		2 1 2 1 2 2		
	2			SM	Silty Sand (SM): loose, poorly graded, medium grained, dark grey, trace fine gravel, wet.	W	L			
					BH30 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH31

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403148.57
Northing: 6490828.00
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey	W		2 1 2 2 2 1	1.1	
	2			SM	Silty Sand (SM): loose, poorly graded, medium grained, brown, trace fine gravel, wet.	W	L			
					BH31 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH32

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403061.42
Northing: 6490973.83
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, wet.	W	VL	2		
	2									
					BH32 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH33

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403295.06
Northing: 6490961.61
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SM	Silty Sand (SM): very loose to loose, poorly graded, medium grained, pale grey, wet.	W	VL-L	2		
	2			SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, wet.	W	VL			
					BH33 Terminated at 2.5 m					



This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH34

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403387.54
Northing: 6490735.22
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2	0.6	
	2				BH34 Terminated at 2.5 m					



Depth: 2.5 m

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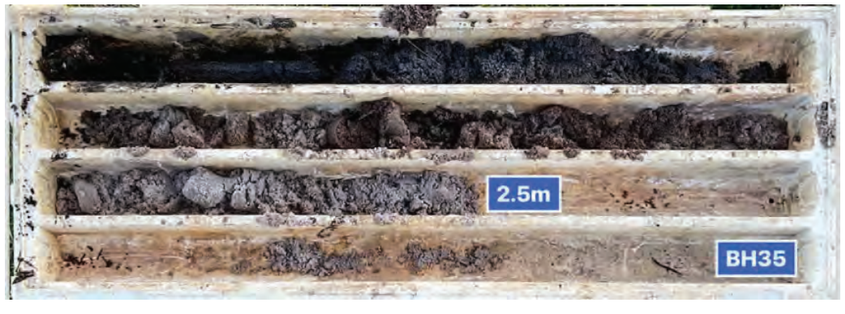
Borehole Record: BH35

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403296.98
Northing: 6490754.29
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 1 2 1		
	2				BH35 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH36

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403371.24
Northing: 6490701.13
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2 2		
	2									
					BH36 Terminated at 2.5 m					



This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

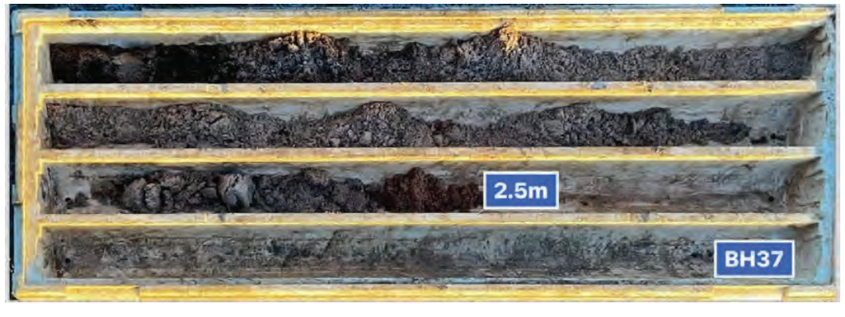
Borehole Record: BH37

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402801.74
Northing: 6489437.08
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2 2		
	2									
					BH37 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

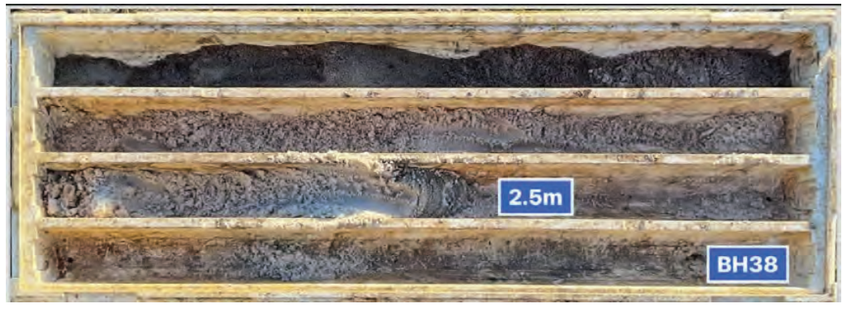
Borehole Record: BH38

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402604.48
Northing: 6489782.38
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	1, 2, 2, 2, 2		
	2				BH38 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH39

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402788.95
Northing: 6489942.90
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, grey, moist to wet.	W-M	VL-L	2, 3, 2, 3, 2, 3	3.6	
	2				BH39 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH40

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402438.70
Northing: 6489984.20
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1 2	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	2 2 2 2 2 2 2		
					BH40 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

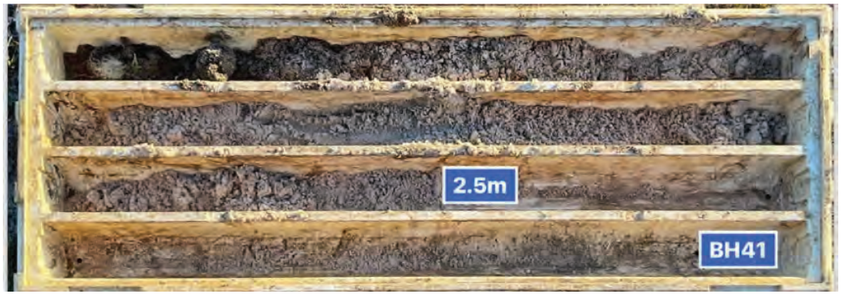
Borehole Record: BH41

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402416.53
Northing: 6489661.79
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1 2	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist.	M	VL	1 2 2 2		
					BH41 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH42

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402512.84
Northing: 6489650.65
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, moist to wet.	W-M	VL	2 2 2 2 2 3	5.8	
	2									
					BH42 Terminated at 2.5 m					



Depth: 2.5 m

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Borehole Record: BH43

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402705.41
Northing: 6489280.19
Elevation: Not Surveyed
Inclination:

Date Drilled: 18/09/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose to loose, poorly graded, medium grained, pale grey, moist.	M	VL-L	2 2 2 2 2 3		
GWL	2									
					BH43 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH44

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403017.43
Northing: 6488987.51
Elevation: Not Surveyed
Inclination:

Date Drilled: 28/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, wet.	W	VL	0 1 1 1 2		
	2				BH44 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH45

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403066.60
Northing: 6489375.33
Elevation: Not Surveyed
Inclination:

Date Drilled: 28/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
GWL		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP): very loose to medium dense, poorly graded, medium grained, brown, wet.	W	VL-MD	2 2 3 3 2 1	0.7	
	2				BH45 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH46

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 402926.12
Northing: 6489705.58
Elevation: Not Surveyed
Inclination:

Date Drilled: 28/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, wet.	W	VL			
	2				BH46 Terminated at 2.5 m					

PSP: 0 5 10 15 20 25 30



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH47

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403094.71
Northing: 6489926.33
Elevation: Not Surveyed
Inclination:

Date Drilled: 28/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, wet.	W	VL		0.2	
	2				BH47 Terminated at 2.5 m					

PSP: 0 5 10 15 20 25 30



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH48

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403398.23
Northing: 6489869.04
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): very loose, poorly graded, medium grained, pale grey, wet.	W	VL	2 2 2 2 2 2		
	2									
					BH48 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH49

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403294.20
Northing: 6489583.14
Elevation: Not Surveyed
Inclination:

Date Drilled: 26/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
GWL	1	Natural		SP	Sand (SP): loose, poorly graded, medium grained, pale grey, wet.	W	L			
	2									
					BH49 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

Borehole Record: BH50

Project: North Ellenbrook (West)
Location: Halden Rd, Bullsbrook WA 6084, Australia
Loc Comment:
Job No: D369796 J491896

Position: Easting: 403287.86
Northing: 6488957.91
Elevation: Not Surveyed
Inclination:

Date Drilled: 28/08/2025
Drill Rig SRP - 1HUR
Drill Supplier Structerre Consulting
Logged/Checked: Ankush Rabadia/Tony Broadway

Water	Depth (m)	Soil Origin	Graphic Log	USCS	Material Description	Moisture	Consistency	PSP (0 5 10 15 20 25 30)	Percolation (m/day)	Samples
		Non-soil		TS	Topsoil.					
	1	Natural		SP	Sand (SP) very loose, poorly graded, medium grained, pale grey, wet.	W	VL	1, 2, 1, 1, 2, 2	10.8	
GWL	2			SP	Sand (SP): very loose, poorly graded, medium grained, pale brown, wet.	W	VL			
					BH50 Terminated at 2.5 m					



Depth: 2.5 m

This report must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

STRUCterre consulting

Appendix D – Laboratory Test Results

WA | QLD | NSW | VIC
www.structerre.com.au

Malaga Laboratory
44 Crocker Drive, Malaga, WA 6090
Post: PO Box 792, Balcatta WA 6914
Ph : (08) 9205 4500
Email: wageotechlab@structerre.com.au
Website: www.structerre.com.au
ABN: 71 349 772 837 / ACN: 008 966 283

Material Test Report

Report Number: ASM:W25-04933
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd

Client Address: L1, 301 Vincent Street Leederville WA 6007

Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK

Project No: D369796

Approved Signatory: Jacob Pritchard

Accredited for compliance with ISO/IEC 17025

Material Details

Test Location	Topsoil Material Assessment	**TRN**	-
Soil Description	Sand	**Proposed Use**	Fill
Specification	N/A	**Sampling Method**	Sample submitted by client
Depth of Test	0 - 200	**Depth of Layer**	

Sample Details

Sample ID	25S-11754	25S-11755	25S-11756	25S-11757
Field Sample ID	BH3	BH06	BH21	BH27
Date Sampled	22/09/2025	22/09/2025	22/09/2025	22/09/2025

Other Test Results

Description	Method	Results				Limits
Ash Content (%)	ASTM D 2974	98.2	98.9	98.0	79.9	
Organic Content (%)		1.8	1.1	2.0	20.1	
Furnace Temperature (°C)		440	440	440	440	
Moisture Content (%)		0	0	0	1	
Moisture contents are proportioned by		oven-dried mass	oven-dried mass	oven-dried mass	oven-dried mass	
Moisture Content Method (A or B)		A	A	A	A	
Ash Content Method (C or D)		C	C	C	C	
Date Tested		23/09/2025	23/09/2025	23/09/2025	23/09/2025	

Comments

N/A

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Malaga Laboratory
44 Crocker Drive, Malaga, WA 6090
Post: PO Box 792, Balcatta WA 6914
Ph : (08) 9205 4500
Email: wageotechlab@structerre.com.au
Website: www.structerre.com.au
ABN: 71 349 772 837 / ACN: 008 966 283

Material Test Report

Report Number: ASM:W25-04933
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd

Client Address: L1, 301 Vincent Street Leederville WA 6007

Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK

Project No: D369796

Approved Signatory: Jacob Pritchard

Accredited for compliance with ISO/IEC 17025

Material Details

Test Location	Topsoil Material Assessment	**TRN**	-
Soil Description	Cement Stabilised Sandy Gravel	**Proposed Use**	Fill
Specification	N/A	**Sampling Method**	Sample submitted by client
Depth of Test	0 - 200	**Depth of Layer**	

Sample Details

Sample ID	25S-11758	25S-11759	25S-11760	25S-11761
Field Sample ID	BH29	BH31	BH38	BH50
Date Sampled	22/09/2025	22/09/2025	22/09/2025	22/09/2025

Other Test Results

Description	Method	Results				Limits
Ash Content (%)	ASTM D 2974	98.3	97.9	98.8	95.6	
Organic Content (%)		1.7	2.1	1.2	4.4	
Furnace Temperature (°C)		440	440	440	440	
Moisture Content (%)		0	0	0	0	
Moisture contents are proportioned by		oven-dried mass	oven-dried mass	oven-dried mass	oven-dried mass	
Moisture Content Method (A or B)		A	A	A	A	
Ash Content Method (C or D)		C	C	C	C	
Date Tested		23/09/2025	23/09/2025	23/09/2025	23/09/2025	

Comments

N/A

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Malaga Laboratory
44 Crocker Drive, Malaga, WA 6090
Post: PO Box 792, Balcatta WA 6914
Ph : (08) 9205 4500
Email: wageotechlab@structerre.com.au
Website: www.structerre.com.au
ABN: 71 349 772 837 / ACN: 008 966 283

Material Test Report

Report Number: MAT:25S-11747
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd
Client Address: L1, 301 Vincent Street Leederville WA 6007
Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK
Project No: D369796

Accreditation Number 18742

Approved Signatory: Jonty Sargent

Accredited for compliance with ISO/IEC 17025

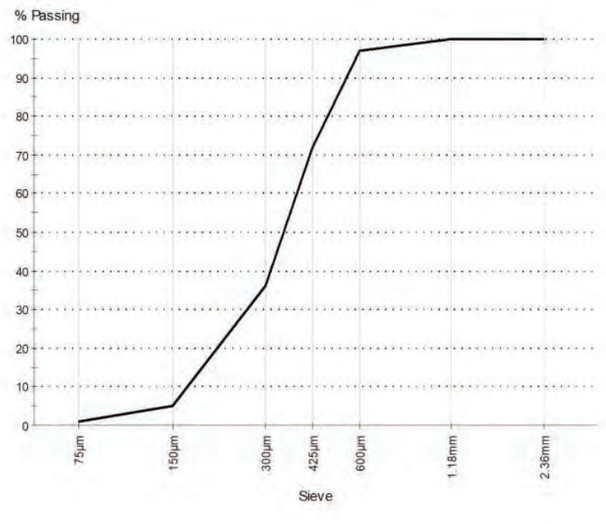
Sample Details

Sample ID	Material Assessment
Field Sample ID	BH01
Date Tested	23/09/2025
Date Sampled	22/09/2025
Soil Description	SAND trace silt
Proposed Use	Fill
Depth of Test	700 - 1100
Depth of Layer	
Sampling Method	Sample submitted by client
TRN	-
Work Order ID	W25-04932

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 23/09/2025

Note: Sample Washed

Sieve Size	% Passing	Limits
2.36mm	100	
1.18mm	100	
600µm	97	
425µm	72	
300µm	36	
150µm	5	
75µm	1	

Comments

N/A

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Material Test Report

Report Number: MAT:25S-11748
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd
Client Address: L1, 301 Vincent Street Leederville WA 6007
Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK
Project No: D369796

Accreditation Number 18742

Approved Signatory: Jonty Sargent

Accredited for compliance with ISO/IEC 17025

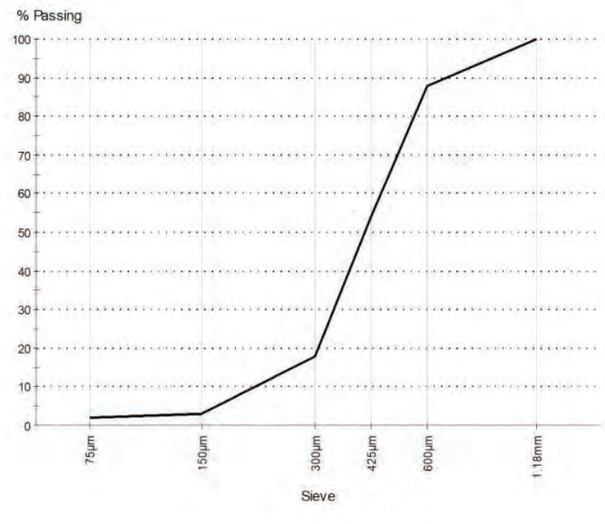
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Date Sampled	22/09/2025
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Depth of Layer	
Sampling Method	Sample submitted by client
TRN	-
Work Order ID	W25-04932

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 23/09/2025

Note: Sample Washed

Sieve Size	% Passing	Limits
1.18mm	100	
600µm	88	
425µm	54	
300µm	18	
150µm	3	
75µm	2	

Comments

N/A

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Material Test Report

Report Number: MAT:25S-11749
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd

Client Address: L1, 301 Vincent Street Leederville WA 6007

Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK

Project No: D369796

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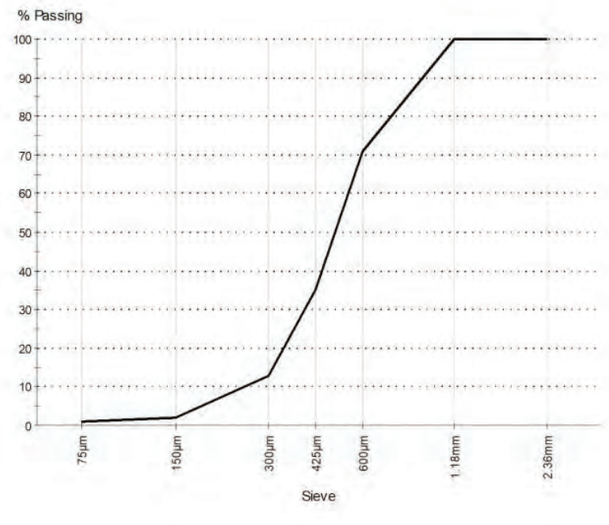
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Field Sample ID	BH17
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Date Sampled	22/09/2025
Soil Description	SAND trace silt
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Depth of Test	1000 - 1400
Depth of Layer	
Sampling Method	Sample submitted by client
TRN	-
Work Order ID	W25-04932

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 23/09/2025

Note: Sample Washed

Sieve Size	% Passing	Limits
2.36mm	100	
1.18mm	100	
600µm	71	
425µm	35	
300µm	13	
150µm	2	
75µm	1	

Comments

N/A

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Material Test Report

Report Number: MAT:25S-11750
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd

Client Address: L1, 301 Vincent Street Leederville WA 6007

Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK

Project No: D369796

Accreditation Number 18742

Approved Signatory: Jonty Sargent

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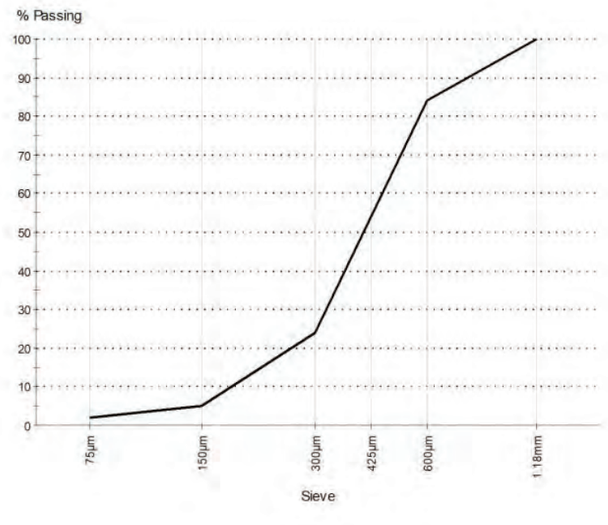
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Date Sampled	22/09/2025
Soil Description	SAND trace silt
Proposed Use	Fill
Depth of Test	1000 - 1400
Depth of Layer	
Sampling Method	Sample submitted by client
TRN	-
Work Order ID	W25-04932

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 23/09/2025

Note: Sample Washed

Sieve Size	% Passing	Limits
1.18mm	100	
600µm	84	
425µm	54	
300µm	24	
150µm	5	
75µm	2	

Comments

N/A

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Material Test Report

Report Number: MAT:25S-11751
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd
Client Address: L1, 301 Vincent Street Leederville WA 6007
Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK
Project No: D369796

Accreditation Number 18742

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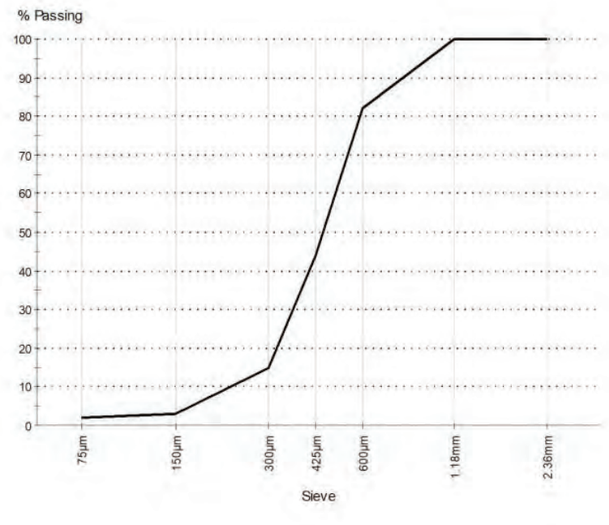
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Field Sample ID	BH31
Date Tested	23/09/2025
Date Sampled	22/09/2025
Soil Description	SAND trace silt
Proposed Use	Fill
Depth of Test	1000 - 1400
Depth of Layer	
Sampling Method	Sample submitted by client
TRN	-
Work Order ID	W25-04932

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 23/09/2025

Note: Sample Washed

Sieve Size	% Passing	Limits
2.36mm	100	
1.18mm	100	
600µm	82	
425µm	44	
300µm	15	
150µm	3	
75µm	2	

Comments

N/A

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Material Test Report

Report Number: MAT:25S-11752
Date of Issue24/09/2025
Issue Number: 1

Client: Conoble Park Pty Ltd
Client Address: L1, 301 Vincent Street Leederville WA 6007
Project: NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK
Project No: D369796

Accreditation Number 18742

Approved Signatory: Jonty Sargent

Accredited for compliance with ISO/IEC 17025

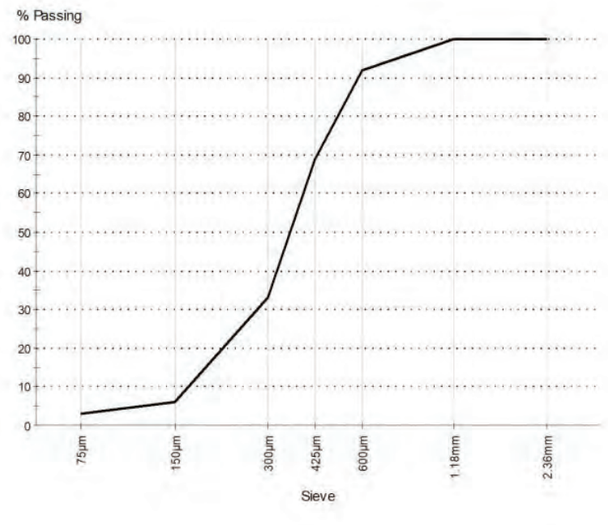
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Field Sample ID	BH48
Date Tested	23/09/2025
Date Sampled	22/09/2025
Soil Description	SAND trace silt
Proposed Use	Fill
Depth of Test	1000 - 1400
Depth of Layer	
Sampling Method	Sample submitted by client
TRN	-
Work Order ID	W25-04932

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 23/09/2025

Note: Sample Washed

Sieve Size	% Passing	Limits
2.36mm	100	
1.18mm	100	
600µm	92	
425µm	69	
300µm	33	
150µm	6	
75µm	3	

Comments

N/A

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Material Test Report

Report Number: MAT:25S-11753
Date of Issue24/09/2025
Issue Number: 1

Accreditation Number 18742

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Client:	Conoble Park Pty Ltd
Client Address:	L1, 301 Vincent Street Leederville WA 6007
Project:	NORTH ELLENBROOK (WEST) - HALDEN RD BULLSBROOK
Project No:	D369796

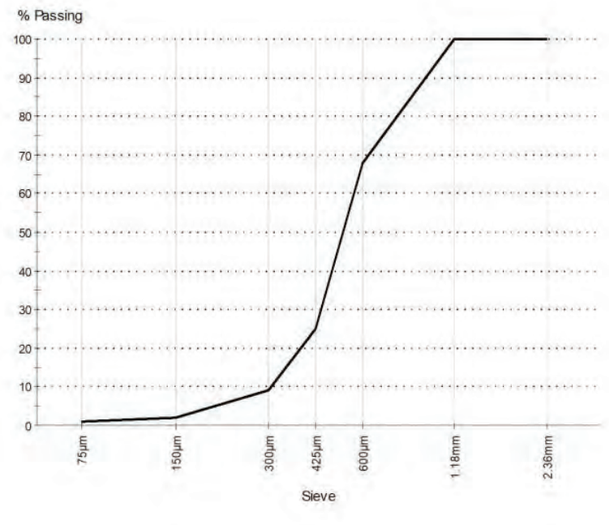
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Field Sample ID	BH50
Date Tested	23/09/2025
Date Sampled	22/09/2025
Soil Description	SAND trace silt
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Depth of Test	1000 - 1400
Depth of Layer	
Sampling Method	Sample submitted by client
TRN	-
Work Order ID	W25-04932

Other Test Results

Description	Method	Result	Limits

Particle Size Distribution



Method: AS 1289.3.6.1
Drying by: Oven
Date Tested: 23/09/2025

Note: Sample Washed

Sieve Size	% Passing	Limits
2.36mm	100	
1.18mm	100	
600µm	68	
425µm	25	
300µm	9	
150µm	2	
75µm	1	

Comments

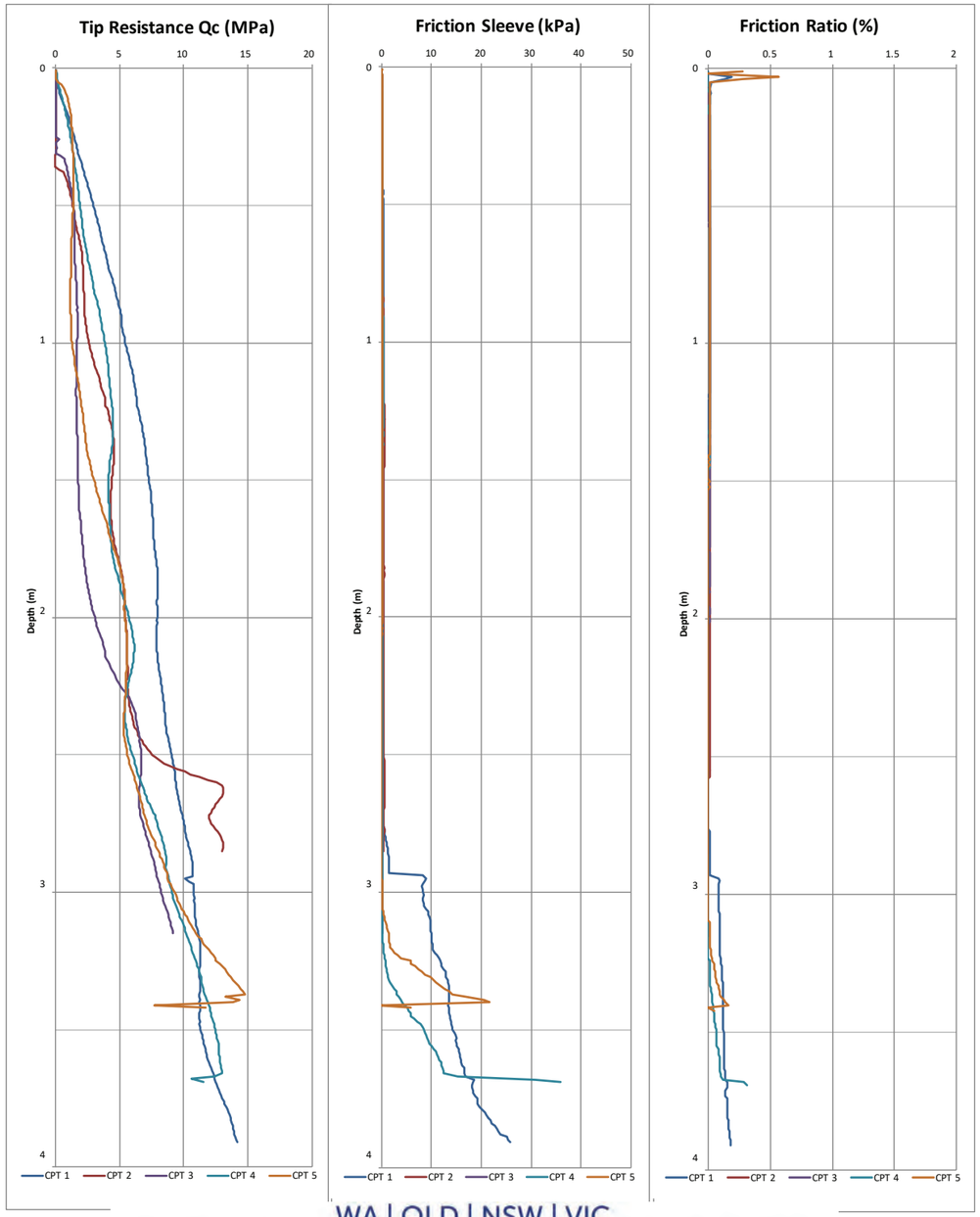
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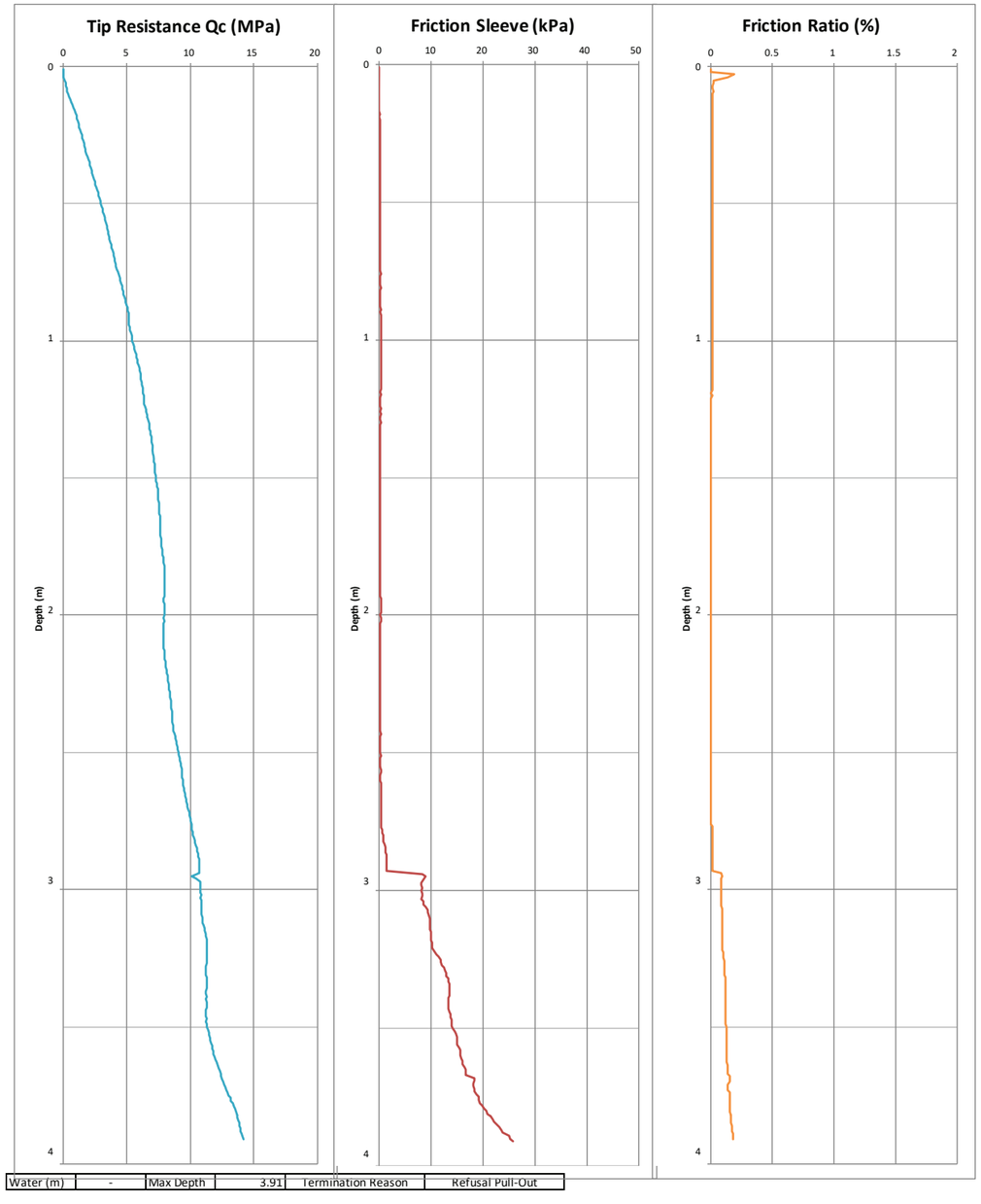
Appendix E – EFCPT Results

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Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT All	Test Date:	19/9/2025	Tested By:	TOB

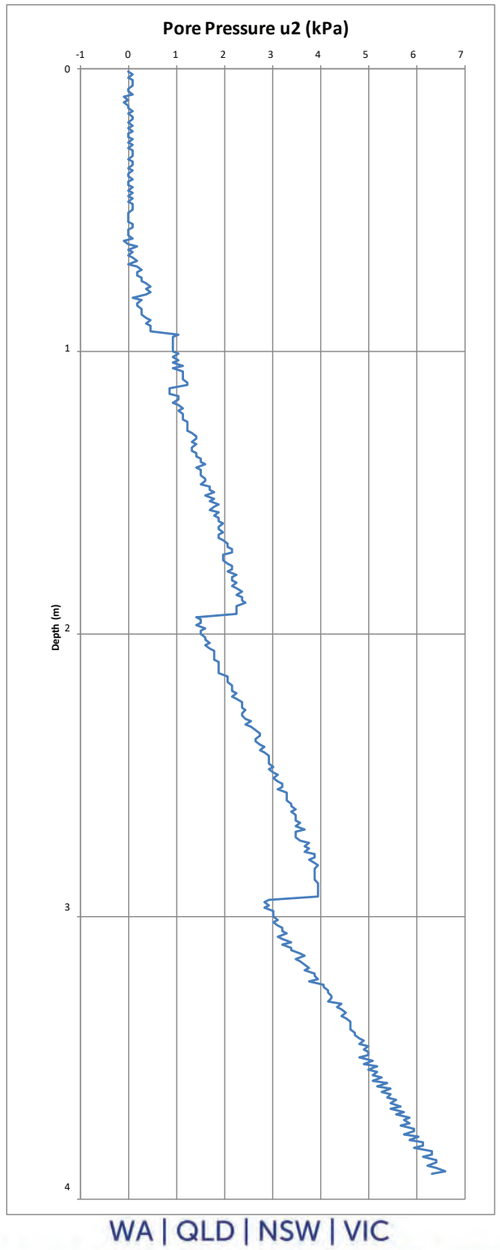


Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT1	Test Date:	19/9/2025	Tested By:	TOB



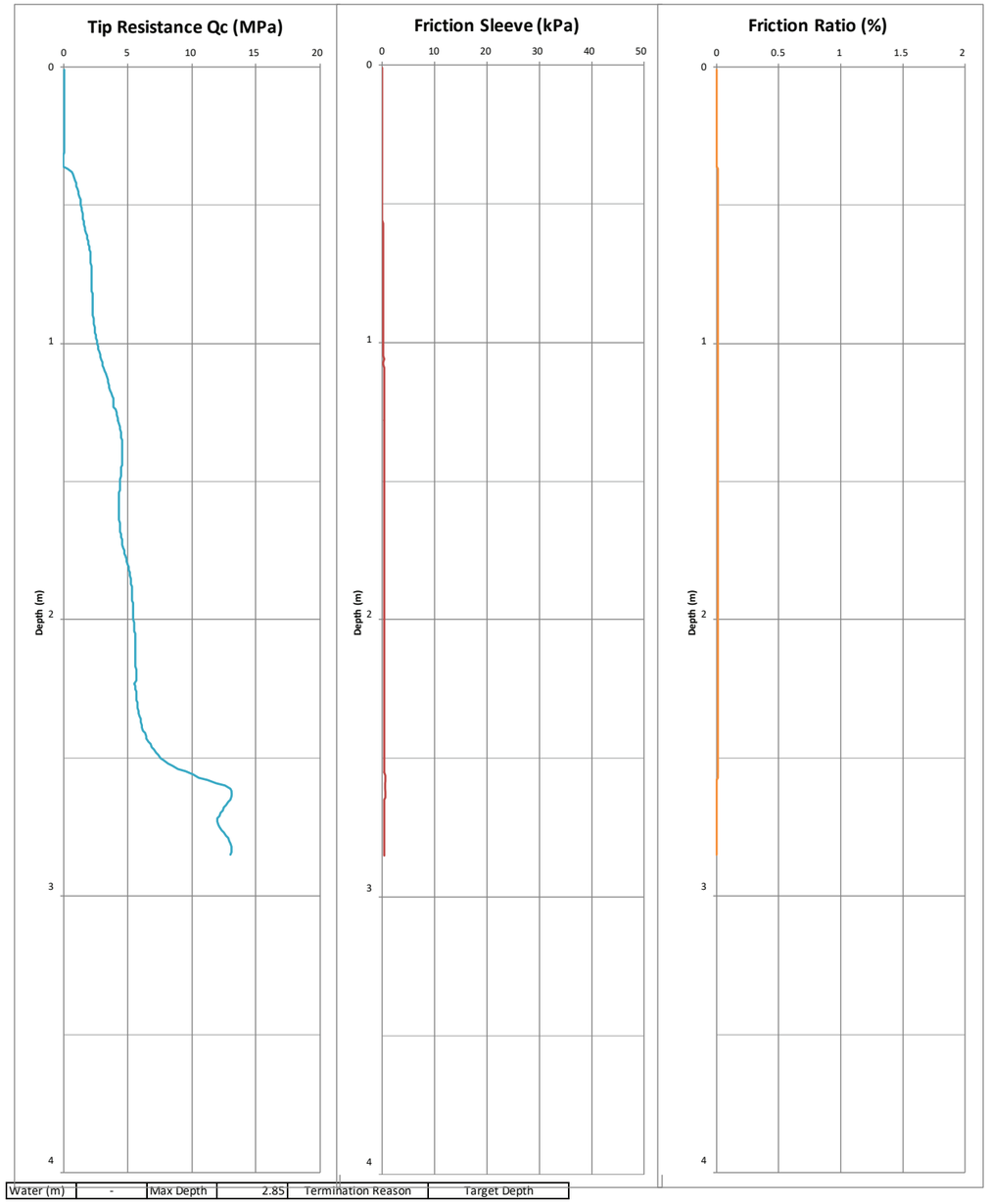
Water (m)	-	Max Depth	3.91	Termination Reason	Refusal Pull-Out

Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT1	Test Date:	19/9/2025	Tested By:	TOB



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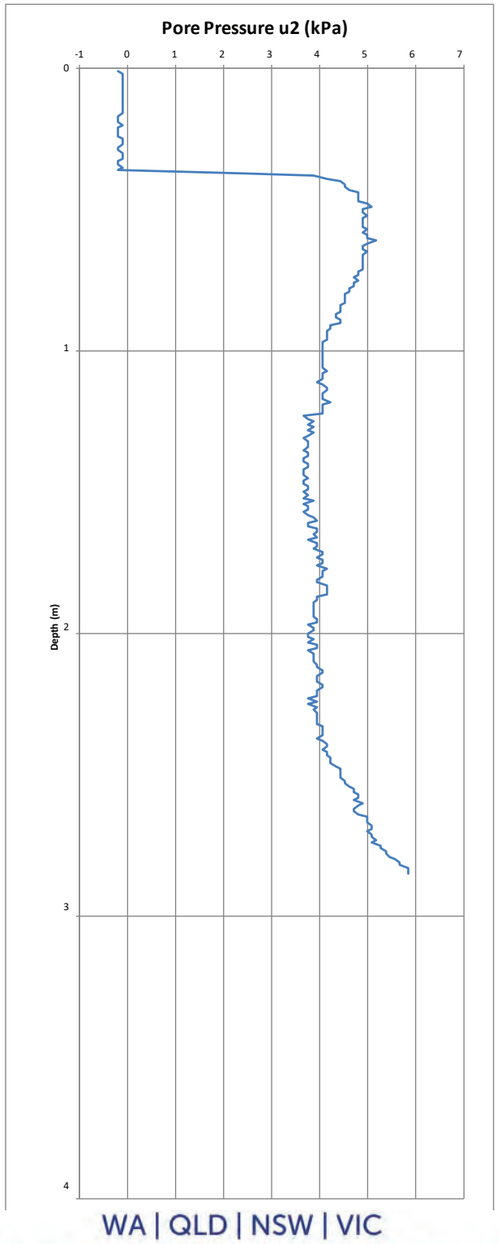
Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT2	Test Date:	19/9/2025	Tested By:	TOB



Water (m)	-	Max Depth	2.85	Termination Reason	Target Depth

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Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT2	Test Date:	19/9/2025	Tested By:	TOB



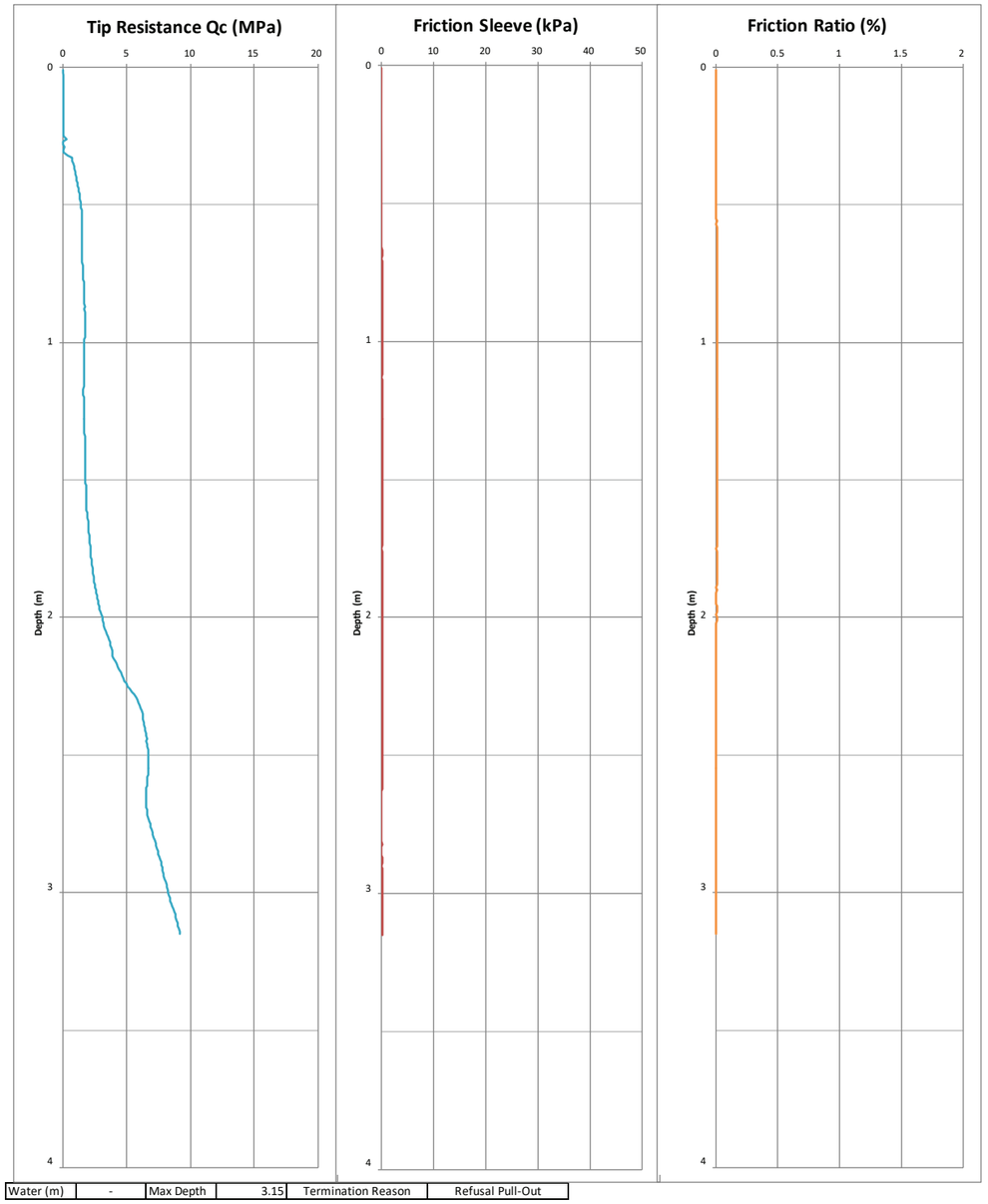
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Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT3	Test Date:	19/9/2025	Tested By:	TOB



Water (m)	-	Max Depth	3.15	Termination Reason	Refusal Pull-Out

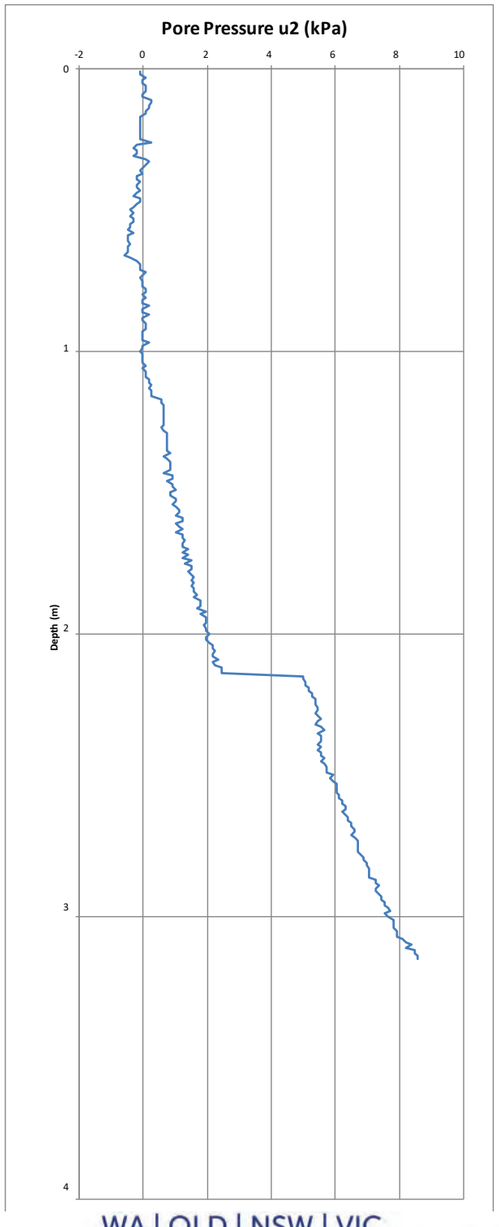
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Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT3	Test Date:	19/9/2025	Tested By:	TOB



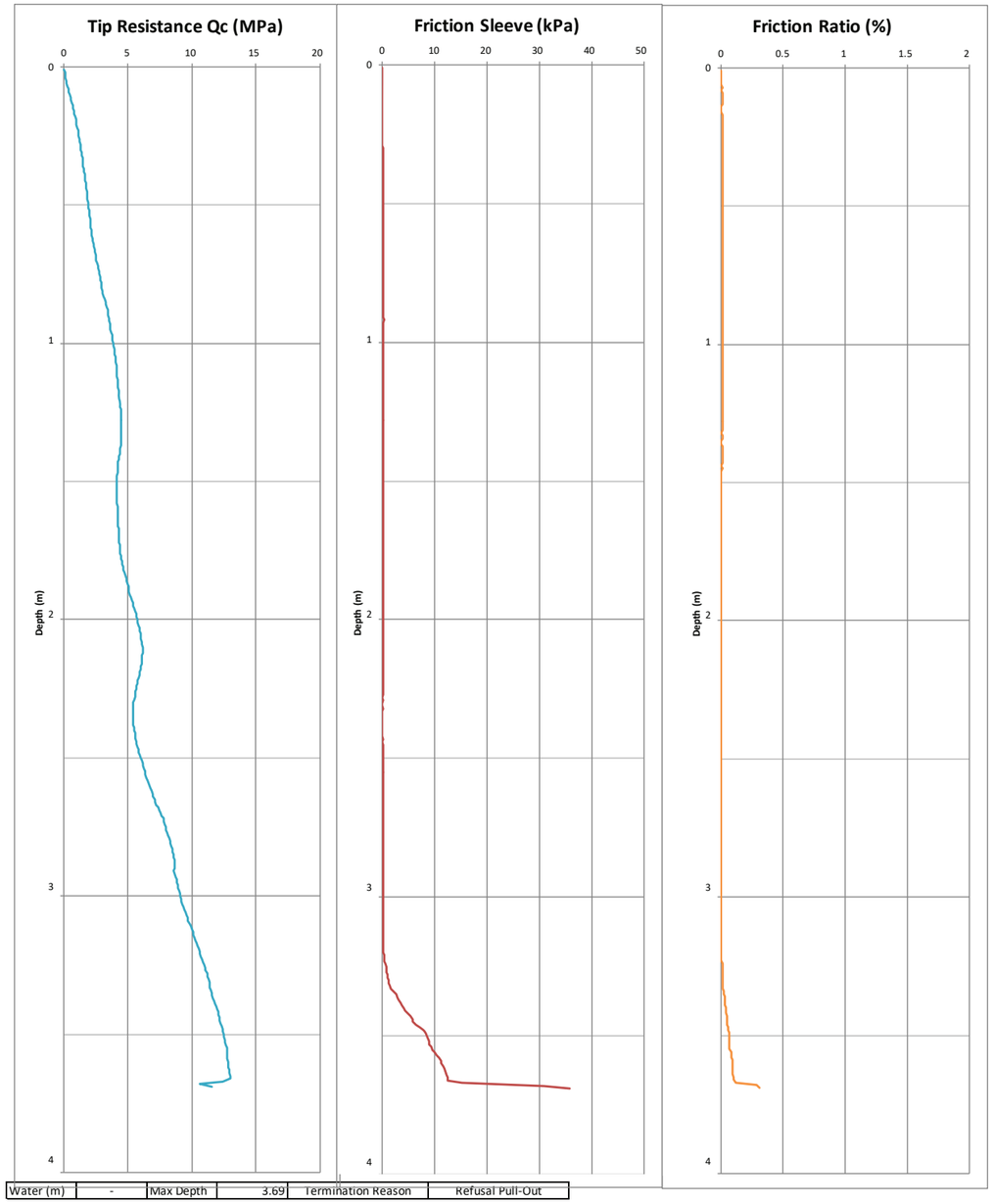
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Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT4	Test Date:	19/9/2025	Tested By:	TOB



Water (m)	-	Max Depth	3.69	Termination Reason	Refusal Pull-Out

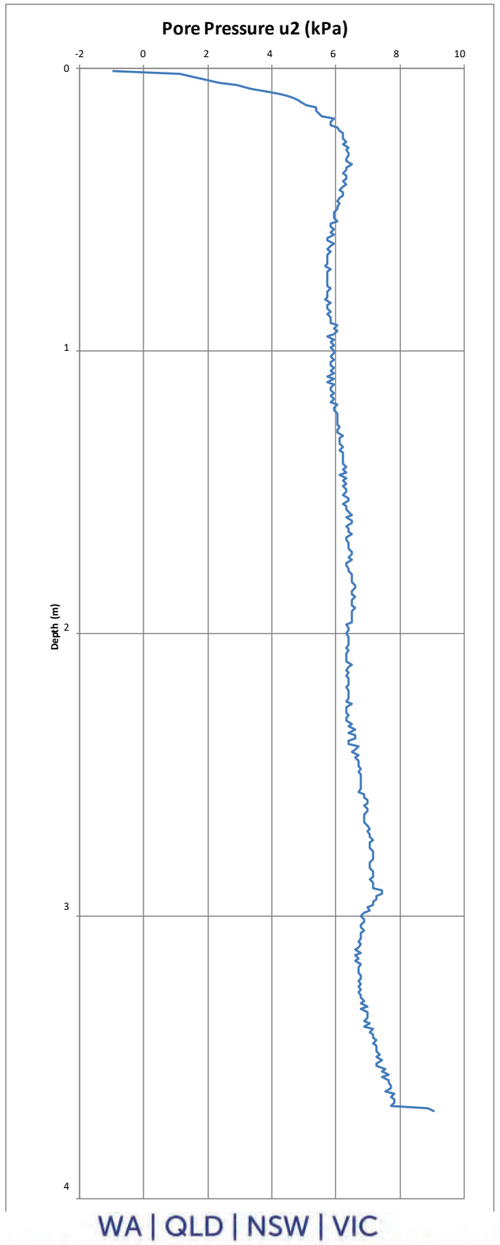
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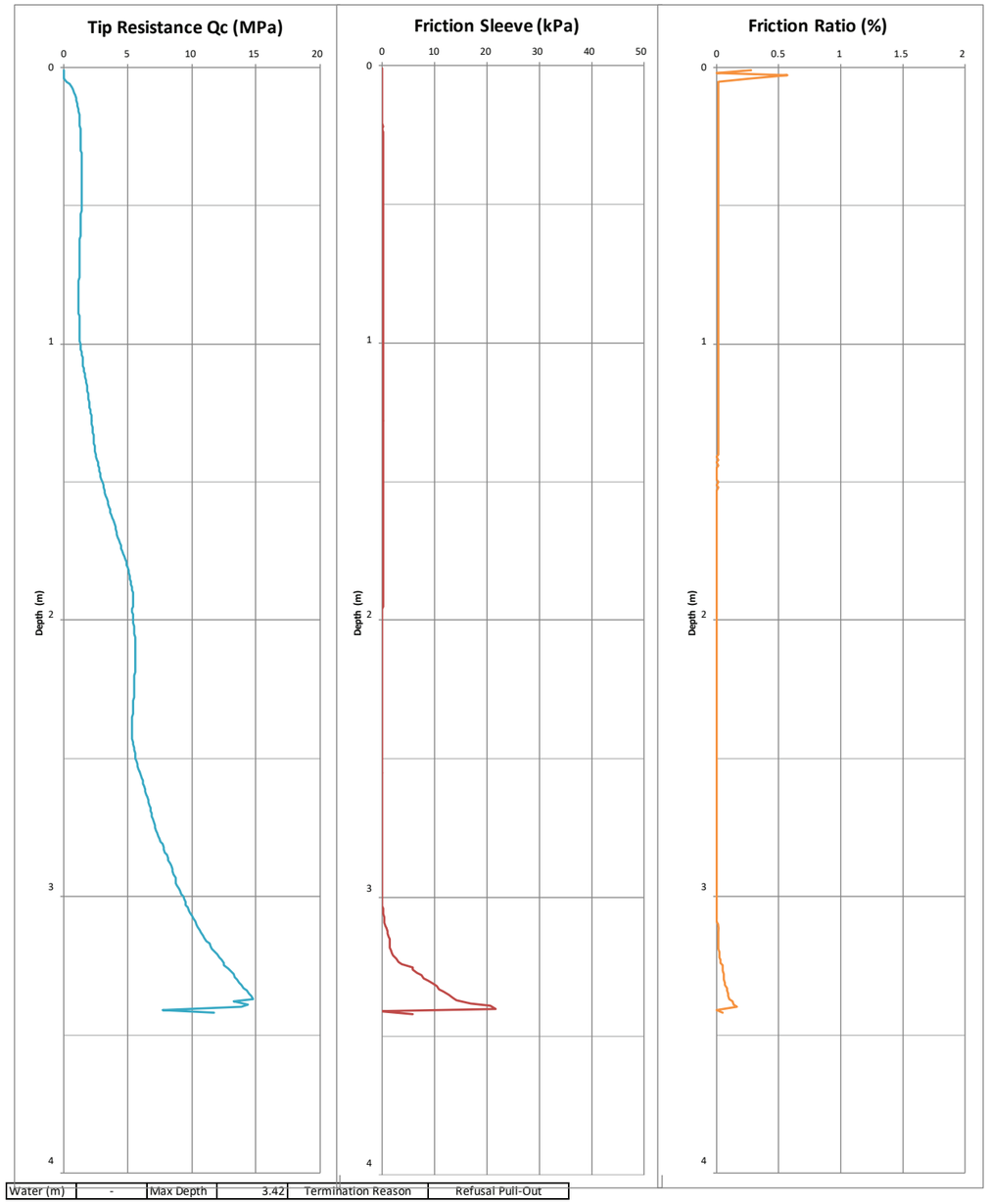
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Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT4	Test Date:	19/9/2025	Tested By:	TOB



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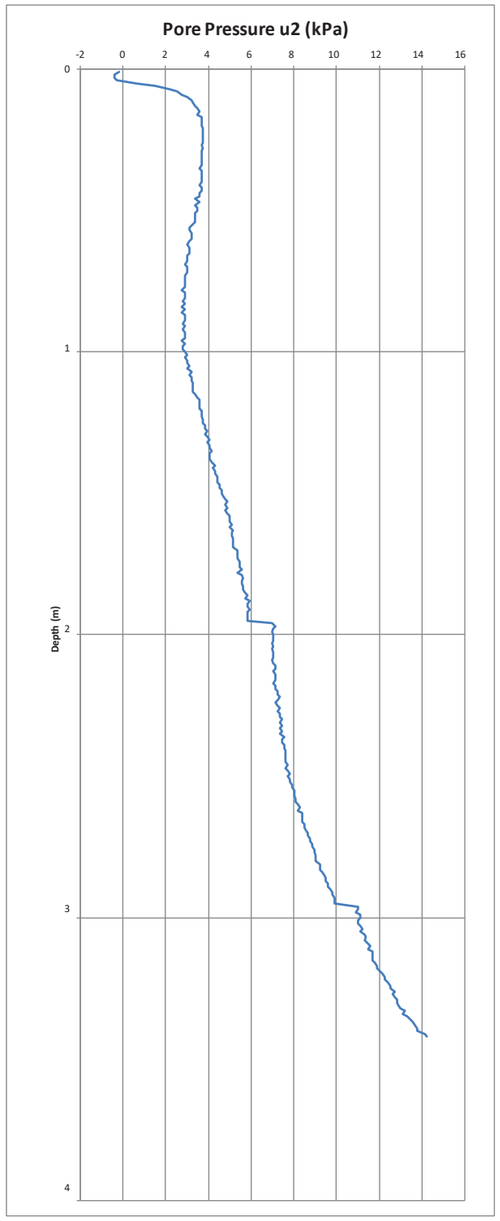
Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT5	Test Date:	19/9/2025	Tested By:	TOB



Water (m)	-	Max Depth	3.42	Termination Reason	Refusal Pull-Out

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Client:	Conoble Park Pty Ltd			Project:	D369796 / J491896
Project:	Halden Rd, Bullsbrook			GPS:	
Probe No:	CPT5	Test Date:	19/9/2025	Tested By:	TOB



APPENDIX C

Pre-Development Monitoring Report (JDA, 2025)

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Prepared for:

CONOBLE PARK PTY LTD

North Ellenbrook (West) DSP Area, Bullsbrook Pre-Development Monitoring

Summary Report



March 2025

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J7086a	07 March 2025

	Name	Signature	Date
Author	Michael Ioannidis		07 March 2025
Checked by	Matthew Yan		07 March 2025
Approved by	Jim Davies		07 March 2025

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1. INTRODUCTION

1.1 Background

The North Ellenbrook (West) District Structure Plan (DSP) area, herein referenced as the Study Area, is located within the City of Swan, approximately 29 km north-east of the Perth CBD and 7 km north-east of Ellenbrook Central and is generally bound by native bushland to the west and south, Tonkin Highway to the east and Chitty Road to the north, Figure 1.

The North Ellenbrook West District Structure Plan was assessed as a planning investigation area in the *North East Sub-regional Planning Framework* (DLPH, 2018) and intends to provide approximately 4,000 to 4,500 dwellings to accommodate a future population of up to 13,500 people. A District Water Management Plan (DWMS) (JDA, 2022) was prepared for the District Structure Plan area and endorsed by the Department of Water and Environmental Regulation (DWER).

Better Urban Water Management (WAPC, 2008) recommends at least 18 months (or 2 winters) of pre-development monitoring is required to support a district structure plan and/or a local structure plan. JDA was appointed by Conoble Park Pty Ltd to conduct pre-development monitoring across the DSP area from July 2022 to October 2024, with monitoring predominantly conducted across winter 2022 and 2023. The results of this monitoring are summarised in this report fulfilling the pre-development monitoring requirements for the Study Area as described in WAPC (2008).

1.2 DWMS Pre-Development Monitoring Requirements

The intent of pre-development monitoring is to establish baseline conditions across the Study Area and to set site-specific trigger values.

Pre-development monitoring requirements were detailed in the DWMS and have been reproduced in Table 1. The pre-development monitoring implemented for the Study Area (Section 2) is consistent with the requirements in the DWMS.

TABLE 1: DWMS PRE-DEVELOPMENT MONITORING REQUIREMENTS (JDA, 2022)

Monitoring Type	Number of Sites	Frequency & Timing	Parameter
Groundwater Levels	Sufficient coverage to spatially represent the site	Water level data loggers for two years prior to the approval of the Local Structure Plan	Continuous Water Level
Groundwater Quality	Sufficient coverage to spatially represent the site	Quarterly water sampling	In-situ: pH, EC, TDS, temp Lab: nutrients, selected metals and cations & anions
Surface Water Quality	Selected water courses upstream and downstream boundary of Study Area	Quarterly water sampling	In-situ: pH, EC, TSS, temp Lab: nutrients, selected metals and cations & anions
Surface Water Flow	Selected water courses upstream and downstream boundary of Study Area	Water level data loggers and rating curves based on discharge measurements using Velocity Area Method for two years prior to approval of the Local Structure Plan	Continuous Flow Rate

1.3 Water Quality Objectives

The ANZECC & ARMCANZ (2000) freshwater guideline values for slightly disturbed wetland ecosystems and *Swan Canning Water Quality Improvement Plan* (SRT,2009) nitrogen and phosphorus targets have been used in this report as a benchmark for assessment of groundwater quality within the Study Area. This approach is consistent with the DWMS (JDA, 2022). It should be noted that while ANZECC & ARMCANZ (2000) and SRT (2009) guideline values are valuable as benchmark values, they are not based on groundwater quality specific to the Study Area and thus are intended for general comparison purposes only. Trigger values for future post-development monitoring should be set at the LWMS/UWMP stage of development based on site specific data.

2. MONITORING LOCATIONS AND PROCEDURE

2.1 Rainfall

The closest Bureau of Meteorology [BoM] rainfall gauging station to the Study Area is Pearce RAAF (009053), 6.5 km north-east of the Study Area. The site has approximately 67 years of rainfall data - from 1938 to 1945 and 1965 to 2024.

To compare the site hydrology with the macroclimate of the area, long-term and 30-year short-term average annual and monthly rainfall were calculated from rainfall recorded at the Bureau of Meteorology's Pearce RAAF rainfall gauging station.

TABLE 2: RAINFALL GAUGING STATION

	GDA 1994 Zone 50 Coordinates	
	Easting (m)	Northing (m)
BoM Pearce RAAF Rain Gauge	406994	6496067

2.2 Groundwater

2.2.1 Monitoring Locations

Six groundwater bores, WAR01 to WAR06, were drilled within the Study Area on 27 July 2022 by Edrill Environmental and supervised by JDA for pre-development monitoring. Bores were drilled using hollow stem auger to approximately 3 m below the encountered groundwater level, with bore depths ranging from 3.7 m to 9.8 m. Bores were screened in the lowest 3 m; gravel packed around the screen and backfilled with cuttings in the remainder of the hole and sealed with bentonite. Lithological logs are attached in Appendix A and show sand in all bores to the target depths. Coffee rock layers were encountered at bore WAR04 at depths of 5 to 6 m (weakly cemented) and 7 to 8 m (target depth) (hard cemented).

Bores WAR01 and WAR03 to WAR05 were installed within the road reserve for which permission was granted by the City of Swan (Yoon-Kah Wong, July 2022). Groundwater level and quality monitoring was conducted at Study Area bores across the monitoring period.

Department of Water and Environmental Regulation (DWER) bores (L220C, L230C, L240C & L250C) are located through the centre of the Study Area in the Warbrook Road reserve. Bores L220C and L240C are still monitored by DWER while monitoring of L230C ceased in 1999 and L250C in 2014. JDA received permission from DWER to access and monitor groundwater levels in these bores during the monitoring period.

Bore details are provided in Table 3 and locations shown in Figure 1.

TABLE 3: GROUNDWATER MONITORING BORES

Bore ID	GDA 1994 Zone 50 Coordinates		Ground Level (mAHD)	Top of Casing (mAHD)	Total Depth (mbToC)	Screened Interval (mBGL)
	Easting	Northing				
WAR01	400905	6489195	54.68	55.2	8.86	5.3-8.3
WAR02	401263	6490721	60.05	60.63	10.42	6.8-9.8
WAR03	402309	6491042	48.77	49.28	4.18	0.7-3.7
WAR04	402369	6489096	52.35	52.91	4.22	0.7-3.7
WAR05	403225	6491017	42.01	42.55	8.55	5-8
WAR06	403311	6489017	45.26	45.77	4.20	0.7-3.7
L220C	400362	6489909	56.84	57.44	10.0	1-10
L230C	401367	6489949	54.22	54.58	10.0	2-10
L240C	402329	6490024	49.64	50.19	10.0	2-10
L250C	403399	6490139	42.91	43.39	10.0	0-10

2.2.2 Sampling Frequency and Methods

Static groundwater levels in monitoring bores WAR01 to WAR06 were recorded at three hour intervals by Odyssey capacitance water level loggers and verified on-site by manual still water level measurements using an electrical depth probe. Quarterly manual still water level measurements were measured at DWER bores using an electrical depth probe.

The HYDSTRA data management system was used to store, process and analyse water level data recorded by the Odyssey capacitance loggers.

2.2.3 Groundwater Quality Parameters

The following groundwater quality parameters were analysed by a NATA-accredited laboratory from pumped samples at the Study Area, WAR01 to WAR06.

Physico-chemical:

- pH
- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)

Dissolved Nutrient concentrations:

- Total Nitrogen (TN)
- Total Kjeldahl Nitrogen (TKN)
- Nitrogen in Nitrogen Oxides (NO_x-N)
- Nitrogen in Ammonia (NH_3-N)
- Total Phosphorus (TP)
- Phosphate or Filterable Reactive Phosphorus (PO_4-P or FRP)

Dissolved Metal concentrations:

- Aluminium (Al)
- Arsenic (As)
- Cadmium (Cd)
- Chromium (Cr)
- Copper (Cu)
- Iron (Fe)
- Lead (Pb)
- Manganese (Mn)
- Mercury (Hg)
- Selenium (Se)
- Zinc (Zn)

Major Anion and Cation concentrations:

- Sodium (Na^{+})
- Potassium (K^{+})
- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Chlorine (Cl^{-})
- Sulphate (SO_4^{2-})

All sampling was conducted in accordance with the guidelines set out by the Australian/New Zealand Standard (AS/NZS) 5667.11: 1998 “Water Quality - Sampling Part 11: Guidance on sampling of groundwater”.

2.3 Surface Water

2.3.1 Monitoring Locations

5 surface water sites, RAP01 to RAP05, were monitored within the Study Area, Figure 1.

Sites RAP01 and RAP02 were located at upstream inflow locations into the Study Area, Figure 1. Site RAP01 was located in a discharge channel from a wetland, just upstream of a Warbrook Road culvert. The site was installed within a slight dip of the channel, about 0.1 m below the outflow culvert invert. Site RAP02 was at the location of a mapped watercourse on Della South Road however no channel was discernible immediately upstream or downstream of the road. Visual flow observations only were conducted of the site over the monitoring period. JDA did not have permission to access most lots along the southern Study Area boundary and therefore were unable to install a site at the inflow point of the southern watercourse, only the outflow (site RAP05).

Sites RAP03 to RAP05 were located at downstream outflow locations from the Study Area, Figure 1. Site RAP03 was located upstream of a partially collapsed culvert across Chitty Road. Site RAP04 was located upstream of a Raphael Road culvert. This culvert was mostly buried by vegetation and a logger was not installed due to potential inference from vegetation, although the site was sampled during quarterly site visits when flowing. Site RAP05 was located at the outflow of the southern watercourse, upstream of the Tonkin Highway culvert.

Plates of the surface water sites are attached in Appendix B.

Surface water site details are provided in Table 4 and locations shown in Figure 1.

TABLE 4: SURFACE WATER SITES

Site ID	Site Description	GDA 1994 Zone 50 Coordinates		Top of Casing (maNS)	Logger Installed (Y/N)
		Easting	Northing		
RAP01	U/S of Warton Road culvert	402156	6489915	1.29	Y
RAP02	Della South Road, mapped watercourse location	401267	6491227	-	N (observation only)
RAP03	U/S of Chitty Road culvert	402810	6491054	1.42	Y
RAP04	U/S of Raphael Road culvert	403454	6490499	-	N (sample only)
RAP05	U/S of Tonkin Hwy culvert	403417	6488919	1.86	Y

Note: maNS = metres above natural surface

2.3.2 Sampling Frequency and Methods

Static water levels were measured in logged sites during site visits. Levels were recorded at 15 mins intervals across winter/spring and 30 mins in summer months using Odyssey capacitance water level loggers. Logged water levels verified on-site by manual still water level measurements using an electrical depth probe.

The HYDSTRA data management system was used to store, process and analyse water level data recorded by the Odyssey capacitance loggers.

2.3.3 Surface Water Quality Parameters

The following surface water quality parameters were analysed by a NATA-accredited laboratory from grab samples at surface water sites, if flowing:

Physico-chemical:

- pH
- Electrical Conductivity (EC)
- Total Suspended Solids (TSS)

Nutrient concentrations:

- Total Nitrogen (TN)
- Total Kjeldahl Nitrogen (TKN)
- Nitrogen in Nitrogen Oxides (NO_x-N)
- Nitrogen in Ammonia (NH_3-N)
- Total Phosphorus (TP)
- Phosphate or Filterable Reactive Phosphorus (PO_4-P or FRP)

Heavy Metal concentrations:

- Aluminium (Al)
- Arsenic (As)
- Cadmium (Cd)

- Chromium (Cr)
- Copper (Cu)
- Iron (Fe)
- Lead (Pb)
- Manganese (Mn)
- Mercury (Hg)
- Selenium (Se)
- Zinc (Zn)

Major Anion and Cation concentrations:

- Sodium (Na^{+})
- Potassium (K^{+})
- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Chlorine (Cl^{-})
- Sulphate (SO_4^{2-})

3. MONITORING RESULTS AND ANALYSIS

3.1 Climate

The Bullsbrook area is characterised by a Mediterranean climate with warm dry summers and cool wet winters. The Study Area has on average 58 precipitation days per year, which occur predominately between the months of May to and September. Rainfall data is provided by the nearby Bureau of Meteorology Pearce RAAF rain gauge (Site ID: 009053), located 6 km north-east of the Study Area, Figure 2.

The rainfall record at the Pearce RAAF gauge dates from 1937, however, little data was recorded between 1946 and 1964. The long-term average annual rainfall, 1965 to 2021, for Pearce RAAF was 649 mm, with a short-term 30-year average of 625 mm, a 4% reduction. Long-term and short-term average annual and monthly rainfall recorded at BoM's Pearce RAAF rain gauge are shown on Figure 2. There has been a decreasing rainfall trend across south-west Western Australia since the 1970s (DoW, 2015), however, no such trend is evident at the Pearce RAAF rain gauge, either across the long- and short-term average annual rainfall nor the average monthly rainfall, Figure 2.

Detailed monthly rainfall for 2022 to 2024 from BoM's Pearce RAAF station is provided in Table 5 below, in comparison with the long-term and short-term monthly averages.

TABLE 5: MONTHLY RAINFALL – 2022 TO 2024 AND LONG- AND SHORT-TERM AVERAGES

Month	BoM Pearce RAAF (009053)				
	2022 Rainfall (mm)	2023 Rainfall (mm)	2024 Rainfall (mm)	Long-term Average 1965-2021 (mm)	Short-term Average 1992-2021 (mm)
January	2.6	0.0	0.2	12.6	13.8
February	7.4	0.0	3.8	13.6	14.2
March	7.6	13.4	11.0	16.2	18.4
April	41.8	35.4	11.2	33.0	25.6
May	93.8	21.6	85.2	83.9	78.1
June	132.2	134.4	88.4	119.9	105.1
July	123.0	111.6	116.8	130.2	125.7
August	191.0	22.2	150.8	102.7	108.0
September	56.8	66.4	29.8	67.1	68.7
October	25.2	8.6	60.4	36.4	34.5
November	14.0	6.4	13.2	24.9	23.2
December	4.2	0.0	4.2	8.7	10.1
Total	**699.6**	**420.0**	**575.0**	**649.2**	**625.2**

Annual rainfall recorded in 2022 was 699.6 mm, slightly above both the long-term and short-term average annual rainfall and in 2023 & 2024 was 420 mm and 575 mm, respectively, and below both the short-term and long-term averages, Figure 2 and Table 5.

Monthly rainfall in 2022 was generally above average in May, June and August and at or below average in the other months, Table 5. In 2023, rainfall was just above average in April and June; at average in September and well below average in the other months, particularly May and August. In 2024, rainfall was at or below average across much of the year except in May and July.

Winter rainfall in both 2022 and 2023 accounted for 64% of total annual rainfall, slightly higher than the long-term and short-term average of 54%, Table 5. Rainfall in 2024 was predominantly in winter and accounted for 62% of total rainfall.

In summary, 2022 was a slightly above average rainfall year whilst 2023 and 2024 were dry years. The 2023 annual rainfall was the second lowest rainfall year on record at BoM's Pearce RAAF station after 2010 (348.2 mm), Figure 2.

Average annual pan evaporation is estimated at 1,850 mm for the Study Area from pan evaporation data recorded at the Department of Primary Industries and Regional Development (DPIRD) Wanneroo weather station (2007-2021). This is slightly lower than the estimated pan evaporation for the Study Area from Luke et al. (1987) of 1,990 mm. Pan evaporation at the Wanneroo weather station in 2022 was 1,871 mmm, similar to the 2007-2021 average; in 2023 was 1,973 mm and 2024 was 2,023 mm, above the 2007-2021 average and similar to estimate from Luke et al. (1987).

3.2 Groundwater Levels

Recorded groundwater fluctuations logged at WAR01 to WAR06 are presented on Figures 3 and 4 with manually recorded measurements summarised on Table 6 and peak instantaneous groundwater levels at logged bores in 2022 to 2024 summarised on Table 7. Daily mean groundwater data is summarised in Appendix C.

TABLE 6: MANUALLY RECORDED GROUNDWATER LEVELS – 2022 TO 2024

Bore ID	Groundwater Level (mAHD)										
	20-Jul-22	27-Jul-22	30-Aug-22	15-Nov-22	14-Feb-23	30-May-23	09-Aug-23	06-Nov-23	06-Feb-24	08-May-24	09-Oct-24
Study Area Bores											
WAR01	*NYC*	52.16	52.88	52.64	52.11	51.90	52.37	52.14	51.73	51.53	52.41
WAR02	*NYC*	52.14	52.93	52.94	52.59	52.08	52.27	52.34	52.02	51.73	52.43
WAR03	*NYC*	47.42	47.79	47.62	47.13	46.81	47.52	47.30	46.82	46.52	47.66
WAR04	*NYC*	47.705	48.4	48.2	47.82	47.49	47.83	47.7	47.37	47.12	47.92
WAR05	*NYC*	42.17	42.3	41.96	41.68	41.71	42.25	41.87	41.64	41.48	42.15
WAR06	*NYC*	44.37	44.7	44.41	43.92	43.72	44.36	44.09	43.65	43.38	44.43
DWER Bores											
L220C	53.68	53.87	54.71	54.49	53.98	53.57	54.02	53.85	52.94	53.11	*NM*
L230C	50.90	51.02	51.73	51.63	51.12	50.83	51.12	51.02	50.66	50.42	51.16
L240C	47.07	47.23	47.77	47.47	47.02	46.74	47.28	47.06	46.66	46.39	*NM*
L250C	41.79	41.96	42.39	41.91	41.35	41.21	41.87	41.63	41.25	41.03	42.16

Notes: NM – Not Measured; NYC – Not Yet Constructed

TABLE 7: MAXIMUM RECORDED GROUNDWATER LEVELS – 2022 TO 2024

Bore	Instantaneous Peak Groundwater Level					
	2022		2023		2024	
	Date Recorded	Water Level (mAHD)	Date Recorded	Water Level (mAHD)	Date Recorded	Water Level (mAHD)
WAR01	18-24 September	52.94	14-Sept to 05-Oct	52.41	09 October[1]	52.42[1]
WAR02	04 October	53.01	10 October	52.41	07 October	52.44
WAR03	18 August	47.88	11-23 August	47.53	03-09 October	47.66
WAR04	19 September	48.44	21-22 September	47.87	06-09 October	47.92
WAR05[2]	-	42.31	-	42.31	-	42.31
WAR06	17 August	44.81	01 August	44.42	05 October	44.54

Notes: 1. Logger not operational. Peak water level is period is given as manual water measurement (Table 6)
2. Groundwater levels in bore WAR05 peaked in 2022-2024 above natural surface at bore (42.01 mAHD) and the top of the logger (42.31 mAHD; upward head in casing).

Results of interest on Figures 3 and 4 and Tables 6 and 7 include:

- Groundwater levels generally peaked across the Study Area in mid-September to early-October in 2022, 2023 and 2024 except for bores WAR03 and WAR06 which peaked in August 2002 and 2023 and bore WAR05 which was at natural surface across all of winter, Table 7. Groundwater levels overall were highest in the western-most bore L220C and lowest in the eastern-most bores WAR05 and L250C, Figure 3, and suggest a general west to east groundwater flow direction towards Ellen Brook, consistent with regional mapping in DoE (2004) and preliminary AAMGL contours in JDA (2022) (Figure 1).
- Peak groundwater levels in bores WAR01 to WAR06 in 2022 ranged from 44.81 mAHD to 53.01 mAHD at WAR02; in 2023 from 44.42 mAHD to 52.41 mAHD; and in 2024 from 44.54 mAHD to 52.44 mAHD, Figure 4 and Table 7. Peak groundwater levels in 2023 were generally 0.35 m to 0.6 m lower than 2022, consistent with a dry rainfall year and although slightly wetter in 2024, peak groundwater levels were similar to 2023.
- Groundwater levels in 2022 peaked close to ground level at WAR05 (0.3 m separation) and WAR06 (0.45 m separation), consistent with wetland mapping (JDA, 2022). Separation to the 2022 peak groundwater level varied in the remaining bores from 0.89 m at WAR03 to 7.04 m at WAR02.
- The seasonal variation in the monitoring period ranged from 0.7 m (WAR05) to 1.12 m (WAR05) with an average of 0.89 m.
- Peak groundwater levels in 2022 in bores WAR01 to WAR05 were on average 1.1 m higher than JDA (2022) preliminary AAMGLs, Figure 1. The smallest differences were in bores WAR04 and WAR05 where the 2022 peak groundwater levels were 0.77 m and 0.55 m respectively lower than JDA (2022) preliminary AAMGL contours. The largest difference was in bore WAR02 which peaked 2 m higher in 2022 to the preliminary AAMGL. Bore WAR06 was the only bore which peaked lower in 2022 than the JDA (2022) AAMGL by 0.84 m. The preliminary AAMGL contours in JDA (2022) are to be revised at the local planning stage of development based on the additional groundwater level data detailed in this report.

3.3 Groundwater Quality

Quarterly groundwater sampling was conducted from August 2022 to May 2024 at Study Area monitoring bores WAR01 to WAR06. Groundwater quality results including overall mean and median values are summarised in Tables 8 and 9 with laboratory analysis certificates attached in Appendix D. Tables 8 and 9 also contain ANZECC & ARMCANZ (2000) guidelines values and SRT (2009) trigger values.

Results of interest in Tables 8 to 9 include:

- pH across the Study Area is acidic and ranges from 3.5 to 6 with an average of 4.6 and is well below the ANZECC & ARMCANZ (2000) guideline range of 6.5 to 8 (slightly acidic to slightly alkaline).
- Groundwater is generally fresh with EC ranging from 0.22 to 0.58 mS/cm and TDS from 110 to 530 mg/L in all bores except WAR03 which is fresh to marginally brackish with EC from 0.27 to 1.90 mS/cm and TDS from 300 to 1,500 mg/L. Groundwater was generally above the ANZECC & ARMCANZ (2000) guideline range of 0.12 to 0.3 (fresh) in bores WAR01 and WAR03.
- Total Nitrogen (TN) concentrations across the Study Area are nearly all above both the SRT (2009) trigger value of 1 mg/L and ANZECC & ARMCANZ (2000) guideline value of 1.2 mg/L and ranged from 0.87 mg/L to 4.5 mg/L with average of 2.4 mg/L.
- Four species of nitrogen were analysed: Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Nitrogen in Ammonia (NH_3_N) and Nitrogen Oxides (NO_x_N). TN accounts for all organic and inorganic nitrogen in

dissolved and particulate forms. Most of the TN in groundwater is in the form of organic-bound nitrogen (TKN). Concentrations of nitrogen oxides (NO_x_N) were mostly below the practical quantifiable limit (PQL; 0.01/0.05 mg/L) except at bore WAR02 with NO_x_N concentrations ranging from 0.36 to 1.2 mg/L.

- The Total Phosphorus (TP) concentrations ranged from < 0.01 mg/L, the PQL, to 0.62 mg/L and were below the ANZECC & ARMCANZ (2000) guideline value of 0.065 mg/L and the SRT (2009) trigger value of 0.1 mg/L at WAR01, WAR02 and WAR06 but generally above at bores WAR03 to WAR05 and no spatial trend is apparent. The phosphate (PO_4_P) concentration was generally below the PQL in bores WAR01, WAR02 and WAR06 and above the ANZECC & ARMCANZ (2000) guideline value of 0.04 mg/L in bores WAR03 to WAR05 with PO_4_P concentrations in these bores similar to the TP concentration.
- The physico-chemical and nutrient analytical results for the Study Area are similar to monitoring conducted in surrounding areas with elevated nutrients associated with historical and current agricultural land use and flushing of natural nutrients in the soil from clearing.
- Dissolved concentrations of Arsenic, Copper and Lead and Manganese rarely exceeded their PQLs and concentrations of Cadmium and Mercury in all samples were below their PQL. Aluminium and Chromium concentrations were mostly above their PQL and averaged 1.5 mg/L and 0.0037 mg/L, respectively. Iron concentrations were generally highest at bore WAR01 and averaged 1.6 mg/L across the Study Area and Zinc concentrations were generally low and averaged 0.0034 mg/L.

TABLE 8: GROUNDWATER QUALITY SUMMARY - PHYSICO-CHEMICAL AND NUTRIENTS

Bore	Date	pH	Conductivity mS/cm	TDS mg/L	TN mg/L	TKN mg/L	NO_x-N mg/L	NH_3_N mg/L	TP mg/L	PO_4_P mg/L
ANZECC & ARMCANZ (2000)	-	6.5-8	0.12-0.3	-	1.2	-	0.15	-	0.065	0.04
SRT (2009)	-	-	-	-	1.0	-	-	-	0.1	-
WAR01	30-Aug-22	4.8	0.58	530	2.8	2.9	<0.1	0.41	<0.05	0.016
	15-Nov-22	4.8	0.48	480	3.1	3.1	<0.05	0.35	<0.05	<0.05
	14-Feb-23	4.6	0.44	400	2.4	2.4	<0.05	0.4	0.05	<0.05
	30-May-23	4.4	0.47	390	2.5	2.5	<0.25	0.37	0.024	<0.05
	09-Aug-23	4.6	0.49	270	2.6	2.7	<0.005	0.39	<0.01	0.022
	06-Nov-23	4.6	0.46	-	1.9	2	<0.05	0.32	0.023	0.022
	06-Feb-24	4.5	0.54	400	2.7	2.8	<0.10	0.41	0.016	<0.05
	08-May-24	4.6	0.51	440	2.8	2.9	<0.05	0.30	0.018	<0.05
WAR02	30-Aug-22	5.4	0.25	210	2.2	1	1.2	0.073	<0.05	<0.005
	15-Nov-22	3.9	0.26	190	2.9	1.8	1.1	0.058	<0.05	<0.005
	14-Feb-23	3.7	0.29	190	1.6	1.2	0.42	0.083	<0.05	<0.05
	30-May-23	3.6	0.31	190	1.2	0.83	0.40	0.082	<0.01	<0.05
	09-Aug-23	3.7	0.28	170	2.1	1.4	0.66	0.073	<0.01	<0.005
	06-Nov-23	3.7	0.29	-	1.8	0.88	0.87	0.058	<0.01	<0.005
	06-Feb-24	3.6	0.29	190	2.4	1.8	0.60	0.27	<0.01	0.028
	08-May-24	3.5	0.30	140	1.9	1.5	0.36	<0.050	<0.01	<0.05
WAR03	30-Aug-22	5.3	1.90	1,500	3.4	3.4	<0.05	0.12	0.16	0.16
	15-Nov-22	6	0.72	740	4.2	4.2	<0.05	0.091	0.1	0.073
	14-Feb-23	4.7	1.20	970	2.4	2.4	<0.05	0.19	0.095	0.061
	30-May-23	4.6	1.10	800	1.9	1.9	<0.050	0.12	0.048	0.050
	09-Aug-23	4.7	1.30	1,100	3.7	3.7	<0.005	0.04	0.043	0.067
	06-Nov-23	5	0.79	-	3.7	3.8	<0.05	0.038	0.066	0.081
	06-Feb-24	5.1	0.27	300	2.0	2.0	<0.10	<0.10	0.040	0.074
	08-May-24	4.5	0.72	440	1.6	1.6	<0.0050	0.23	<0.010	0.015
WAR04	30-Aug-22	4.4	0.27	270	1.8	1.7	0.15	0.21	0.38	0.35
	15-Nov-22	4.3	0.22	220	2.2	2.2	<0.05	0.17	0.62	0.58
	14-Feb-23	4.3	0.22	210	1.3	1.3	<0.05	0.16	0.41	0.35
	30-May-23	4.2	0.23	180	1.1	1.1	<0.050	0.15	0.25	0.31
	09-Aug-23	4.2	0.24	160	1.9	1.9	<0.005	0.17	0.22	0.24
	06-Nov-23	4.1	0.26	-	1.2	1.2	<0.05	0.17	0.18	0.21
	06-Feb-24	4.1	0.25	190	2.0	2.0	<0.050	0.35	0.16	0.24
	08-May-23	4.1	0.22	160	2.0	2.0	<0.050	0.12	0.23	0.29
WAR05	30-Aug-22	5.3	0.17	230	2.3	2.3	<0.05	0.5	0.26	0.25
	15-Nov-22	5.4	0.16	220	2.8	2.9	<0.05	0.37	0.23	0.23
	14-Feb-23	5.2	0.15	230	2.3	2.4	<0.05	0.45	0.18	0.15
	30-May-23	5.0	0.14	220	2.6	2.6	<0.10	0.52	0.49	0.59
	09-Aug-23	5.4	0.16	110	2.6	2.6	<0.005	0.43	0.22	0.24
	06-Nov-23	5.3	0.16	-	2.2	2.2	<0.05	0.41	0.21	0.22
	06-Feb-24	5.2	0.15	240	3.2	3.2	<0.10	0.44	0.19	0.27
	08-May-24	5.0	0.13	190	3.3	3.3	<0.050	0.42	0.48	0.60
WAR06	30-Aug-22	3.8	0.34	390	3.4	3.4	<0.005	0.16	0.092	0.087
	15-Nov-22	4.3	0.21	340	4.5	4.5	<0.05	0.25	0.06	<0.05
	14-Feb-23	5.5	0.23	230	1.7	1.7	<0.05	0.26	<0.05	<0.05
	30-May-23	5.5	0.21	180	0.87	0.87	<0.050	0.24	<0.010	<0.05
	09-Aug-23	4.1	0.35	250	3.1	3.1	<0.005	0.25	0.018	0.045
	06-Nov-23	5.1	0.29	-	2.1	2.1	<0.05	0.33	0.015	0.02
	06-Feb-24	5.6	0.23	230	2.2	2.0	0.20	0.47	<0.01	<0.05
	08-May-24	5.5	0.21	160	1.8	1.8	<0.050	0.21	0.011	<0.05
All Bores	Samples	48	48	42	48	48	48	48	48	48
	Minimum	3.5	0.13	110	0.87	0.83	<0.005	<0.05	<0.01	<0.01
	Maximum	6	1.9	1,500	4.5	4.5	1.2	0.52	0.62	0.60
	Median	4.6	0.27	230	2.3	2.2	<0.05	0.24	0.05	0.05
	Average	4.6	0.41	348	2.4	2.3	0.17	0.24	0.12	0.14

Notes: 1. ANZECC & ARMCANZ (2000) trigger values for slightly disturbed lowland river ecosystems. Exceedances in orange.
2. Swan Canning Water Quality Improvement Plan (SRT,2009) nitrogen and phosphorus targets. Exceedances in red.

TABLE 9: GROUNDWATER QUALITY SUMMARY - DISSOLVED METALS

Bore	Date	Al mg/L	As mg/L	Cd mg/L	Cr mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Mn mg/L	Hg mg/L	Zn mg/L
ANZECC & ARMCANZ (2000)	-	-	0.0024	0.0002	0.001	0.0014	-	0.0034	1.9	0.006	0.08
SRT (2009)	-	-	-	-	-	-	-	-	-	-	-
WAR01	30-Aug-22	1.8	0.0026	<0.0001	0.018	<0.001	10	<0.001	0.0028	<0.00005	0.0025
	15-Nov-22	2	0.0022	<0.0001	0.019	<0.001	11	<0.001	0.0016	<0.00005	0.0014
	14-Feb-23	1.5	0.0017	<0.0001	0.013	<0.001	6.8	<0.001	0.0013	<0.00005	0.0013
	30-May-23	2.4	0.0026	<0.0001	0.019	<0.001	8.5	<0.001	0.0017	<0.00005	0.0037
	09-Aug-23	1.4	0.0019	<0.0001	0.014	<0.001	7	<0.001	0.0018	<0.00005	<0.001
	06-Nov-23	1.4	0.0018	<0.0001	0.012	0.0024	7.5	<0.001	0.0017	<0.00005	0.002
	06-Feb-24	1.2	0.0015	<0.0001	0.011	<0.001	5.9	<0.001	0.0010	<0.00005	0.0028
	08-May-24	1.8	0.0021	<0.0001	0.015	<0.001	5.9	<0.001	0.0010	<0.00005	0.0018
WAR02	30-Aug-22	0.81	<0.001	<0.0001	0.0011	0.0016	0.1	0.0024	0.0014	<0.00005	0.018
	15-Nov-22	1.1	<0.001	<0.0001	0.0012	0.0014	0.12	0.0019	<0.001	<0.00005	0.0066
	14-Feb-23	1.3	<0.001	<0.0001	0.0014	<0.001	0.1	<0.001	<0.001	<0.00005	0.0063
	30-May-23	1.2	<0.001	<0.0001	<0.001	<0.001	0.086	<0.001	<0.0010	<0.00005	0.0034
	09-Aug-23	1.1	<0.001	<0.0001	<0.001	<0.001	0.069	<0.001	<0.001	<0.00005	0.001
	06-Nov-23	1.3	<0.001	<0.0001	<0.001	<0.001	0.065	<0.001	<0.001	<0.00005	0.0042
	06-Feb-24	1.4	<0.001	<0.0001	<0.001	<0.001	0.055	<0.001	<0.0010	<0.00005	0.0023
	08-May-24	1.1	<0.001	<0.0001	<0.001	<0.001	0.055	<0.001	<0.0010	<0.00005	0.0038
WAR03	30-Aug-22	1.5	<0.001	<0.0001	0.0028	<0.001	2	<0.001	0.12	<0.00005	0.02
	15-Nov-22	2.1	<0.001	<0.0001	0.0018	<0.001	1.7	<0.001	0.03	<0.00005	0.0026
	14-Feb-23	2.4	<0.001	<0.0001	0.0018	<0.001	1.1	<0.001	0.0077	<0.00005	0.0016
	30-May-23	2.7	<0.001	<0.0001	0.0013	<0.001	0.89	<0.001	0.0079	<0.00005	0.0016
	09-Aug-23	3	<0.001	<0.0001	0.0024	<0.001	0.54	0.0012	0.0068	<0.00005	0.0022
	06-Nov-23	5.2	<0.001	<0.0001	0.0036	<0.001	0.81	<0.001	0.0071	<0.00005	0.0029
	06-Feb-24	2.2	<0.001	<0.0001	0.0016	<0.001	0.29	<0.001	0.0025	<0.00005	0.0036
	08-May-24	0.88	<0.001	<0.0001	<0.001	<0.001	0.76	<0.001	0.0090	<0.00005	0.0072
WAR04	30-Aug-22	2.2	<0.001	<0.0001	0.0017	0.0014	0.32	<0.001	0.0032	<0.00005	0.0039
	15-Nov-22	2	<0.001	<0.0001	0.0014	0.002	0.14	<0.001	0.0014	<0.00005	0.005
	14-Feb-23	1.5	<0.001	<0.0001	0.0013	<0.001	0.1	<0.001	0.0014	<0.00005	0.0032
	30-May-23	1.4	<0.001	<0.0001	0.0011	0.0014	0.094	<0.001	0.0011	<0.00005	0.0023
	09-Aug-23	1.5	<0.001	<0.0001	0.0012	0.0023	0.09	0.0015	0.0011	<0.00005	0.0045
	06-Nov-23	1.3	<0.001	<0.0001	<0.001	0.0015	0.11	<0.001	0.0014	<0.00005	0.0029
	06-Feb-24	1.3	<0.001	<0.0001	0.0011	0.0011	0.12	<0.001	0.0013	<0.00005	0.0027
	08-May-23	0.96	<0.001	<0.0001	<0.001	0.0013	0.080	<0.001	0.0011	<0.00005	0.0035
WAR05	30-Aug-22	0.99	<0.001	<0.0001	0.0014	<0.001	0.3	<0.001	0.0023	<0.00005	0.0013
	15-Nov-22	1	<0.001	<0.0001	0.001	<0.001	0.39	<0.001	0.0032	<0.00005	0.0014
	14-Feb-23	1.1	<0.001	<0.0001	0.0011	<0.001	0.3	<0.001	0.0024	<0.00005	0.0022
	30-May-23	1.1	<0.001	<0.0001	<0.001	<0.001	0.34	<0.001	0.0019	<0.00005	0.0017
	09-Aug-23	1	<0.001	<0.0001	<0.001	<0.001	0.33	<0.001	0.0032	<0.00005	0.0019
	06-Nov-23	1.1	<0.001	<0.0001	<0.001	<0.001	0.38	<0.001	0.004	<0.00005	0.0037
	06-Feb-24	1.3	<0.001	<0.0001	<0.001	<0.001	0.30	<0.001	0.0017	<0.00005	0.0011
	08-May-24	1.1	<0.001	<0.0001	<0.001	<0.001	0.32	<0.001	0.0017	<0.00005	0.0013
WAR06	30-Aug-22	0.95	<0.001	<0.0001	0.0019	0.0016	0.62	<0.001	0.034	<0.00005	0.0042
	15-Nov-22	1.1	<0.001	<0.0001	0.0021	<0.001	0.94	<0.001	0.0085	<0.00005	0.0029
	14-Feb-23	0.68	<0.001	<0.0001	0.0018	<0.001	0.19	<0.001	<0.001	<0.00005	0.0013
	30-May-23	0.57	<0.001	<0.0001	0.0013	<0.001	0.10	<0.001	<0.0010	<0.00005	0.0011
	09-Aug-23	0.75	<0.001	<0.0001	0.0016	<0.001	0.46	<0.001	0.0032	<0.00005	0.0015
	06-Nov-23	0.82	<0.001	<0.0001	0.0012	<0.001	0.19	<0.001	<0.001	<0.00005	0.0027
	06-Feb-24	0.66	<0.001	<0.0001	0.0017	<0.001	0.14	<0.001	<0.0010	<0.00005	<0.001
	08-May-24	0.62	<0.001	<0.0001	0.0016	<0.001	0.13	<0.001	<0.0010	<0.00005	0.0017
All Bores	Samples	48	48	48	48	48	48	48	48	48	48
	Minimum	0.57	<0.001	<0.0001	<0.001	<0.001	0.055	<0.001	<0.001	<0.00005	<0.001
	Maximum	5.2	0.0026	<0.0001	0.19	0.0024	11	0.0024	0.12	<0.00005	0.02
	Median	1.3	<0.001	<0.0001	0.0014	<0.001	0.31	<0.001	0.0017	<0.00005	0.0026
	Average	1.5	0.0012	<0.0001	0.0037	0.0011	1.6	0.0011	0.0062	<0.00005	0.0034

Notes: 1. ANZECC & ARMCANZ (2000) 95% trigger values for slightly to moderately disturbed freshwater systems. Exceedances in orange.

3.4 Surface Water Flow and Depths

Surface water sites, RAP01 to RAP05, were visited by JDA on 11 occasions over the monitoring period with a summary of water flow observations detailed in Table 10.

Sites RAP01 and RAP02 (up-stream) were dry across the monitoring period. Site RAP03 had very low flow in Aug-22 and Oct-22; RAP04 had low flow in Aug-22 and RAP05 had low flow in Oct-22, else the sites were dry.

TABLE 10: SURFACE WATER FLOW OBSERVATIONS

Site	30 Aug 2022	06 Oct 2022	15 Nov 2022	29 Nov 2022	14 Feb 2023	30 May 2023	09 Aug 2023	06 Nov 2023	06 Feb 2024	08 May 2024	09 Oct 2024
RAP01	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*
RAP02	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*
RAP03	*1-2 L/s*	*0.5 L/s*	*Culvert Dry*	*Dry*	*Dry*	*Dry*	*Ponded -Blocked*	*Dry*	*Dry*	*Dry*	*Ponded*
RAP04	*Low flow*	*Ponded*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*	*Dry*
RAP05	*Ponded*	*Low flow*	*No Flow*	*No Flow*	*Dry*	*Dry*	*Ponded*	*Dry*	*Dry*	*Dry*	*Ponded*

Data loggers were installed at surface water sites RAP01, RAP03 and RAP05. Instantaneous maximum surface water depths recorded at these sites are presented in Table 11 and shown on Figure 5. Water depths are relative to stream bed levels at the site locations.

TABLE 11: PEAK SURFACE WATER DEPTHS – 2022 TO 2024

Site ID	Instantaneous Peak Groundwater Level					
	2022		2023		2024	
	Date Recorded	Water Depth (m)	Date Recorded	Water Depth (m)	Date Recorded	Water Depth (m)
RAP01	13 September	0.15	N/A	Dry[1]	N/A	Dry[1]
RAP03	17 August	0.44	N/A[2]	N/A[2]	25 August[3]	0.29[3]
RAP05	17 August	0.47	13 September	0.38	03 October	0.39

Notes: 1. Only noise recorded on logger, no water observed in 2023 and 2024 during site visits.
2. Logger not operational over winter – 2023 peak not recorded.
3. Logger not operational September & October 2024.

Results of interest in Table 11 and Figure 5 include:

- Site RAP01 had a peak water depth of 0.15 m on 13 September 2022 as a result of approximately 15 mm rainfall but was dry from late-October 2022 to the end of monitoring in October 2024. The site is located within a slight depression in the channel and water depths recorded across winter 2022 generally reflect ponded water at the site location and not flow.
- Site RAP03 had a peak water depth of 0.44 m on 17 August 2022 as a result of 30 mm rainfall and an additional 40 mm in the preceding three days. The peak water depth of 0.29 m on 25 August 2024 resulted from approximately 13 mm rainfall at BoM RAAF Pearce but may have been more intense over the Study Area. No data was recorded across winter 2023 nor September & October 2024 and the peak water depth in 2024 may have risen higher than detailed in Table 11. Surface water depths recorded at RAP03 likely represent both groundwater baseflow and surface water inflow. The site is located up-gradient of a collapsed culvert and may have influenced the magnitude of the depths recorded at the site.
- Site RAP05 had a peak water depth of 0.47 m on 17 August 2022, 0.38 m on 13 September 2023 and 0.39 m on 03 October 2024. The site is located up-gradient of a culvert across Tonkin Highway and had ponded or flowing water at 0.3 to 0.4 m from late-July to early-October each monitoring year. Depths are largely

reflective of groundwater inflow with groundwater generally at surface at the site location. No data was recorded across late-November 2022 to early-June 2023 due to logger failure.

3.5 Surface Water Quality

Flow observations summarised in Section 3.4 and Table 10 show flow was only observed by JDA at site RAP03 to RAP05 on 30 August 2022 and 06 October 2022. Sites RAP03 and RAP04 were sampled on 30 August 2022 and RAP03 and RAP05 on 06 October 2022 with results summarised in Table 12 and Laboratory Reports attached in Appendix D.

TABLE 12: SURFACE WATER QUALITY RESULTS

	Guideline Value	PQL	RAP03		RAP04	RAP05
			30-Aug-22	06-Oct-22	30-Aug-22	06-Oct-22
Physio-chemical						
pH (lab)	6.5-8[1]	-	4.2	4.5	5.2	6.8
EC (mS/cm) (lab)	0.12-0.3[1]	0.002	0.75	0.50	0.38	0.57
TSS (mg/L)		5	<5	<5	73	<5
Nutrients (mg/L)						
TN	1.2[1],1.0[2]	0.1	3	2.8	6.8	1.7
TKN	-	0.1	3.1	2.8	6.9	1.7
NO_x-N	0.15[1]	0.005	<0.1	<0.1	<0.1	<0.05
NH_3-N	-	0.005	<0.005	0.0052	0.012	<0.005
TP	0.065[1]	0.05	<0.05	<0.05	1.2	<0.05
PO_4-P	0.04[1]	0.005	0.018	0.016	0.96	0.007
Total Metals (mg/L)						
Aluminium, Al		0.01	1.6	1.3	0.92	0.9
Arsenic, As	0.0024[1]	0.001	<0.001	<0.001	<0.001	<0.001
Cadmium, Cd	0.0002[1]	0.0001	<0.0001	<0.0001	<0.001	<0.0001
Chromium, Cr	0.001[1]	0.001	0.0021	0.0018	0.0024	0.0018
Copper, Cu	0.0014[1]	0.001	<0.001	<0.001	0.0021	<0.001
Iron, Fe	-	0.01	0.73	0.95	1.6	0.38
Lead, Pb	0.0034[1]	0.001	<0.001	<0.001	<0.001	<0.001
Manganese, Mn	1.9[1]	0.001	0.0051	0.0022	0.016	0.0084
Mercury, Hg	0.006[1]	0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Zinc, Zn	0.08[1]	0.001	0.006	0.003	0.028	0.052
Major Ions (mg/L)						
Calcium, Ca^{2+}	-	0.5	11	7.4	12	19
Magnesium, Mg^{2+}	-	0.001	0.0051	0.0022	0.016	0.0084
Potassium, K^+	-	0.5	3.7	2.5	4.7	2.2
Sodium, Na^+	-	0.5	100	68	49	78
Chloride, Cl^-	-	1	210	150	96	150
Sulphate, SO_4^{2-}	-	1	20	4.3	4.5	22
Alkalinity (mg/L)						
Bicarbonate, HCO_3	-	5	<5	-	14	-
Carbonate, CO_2^{3-}	-	5	<5	-	<5	-
Hydroxide, OH^-	-	5	<5	-	<5	-
Total Alkalinity	-	5	<5	-	14	-
Hardness	-	3	86	52	61	81

Notes: 1. ANZECC & ARMCANZ (2000) trigger values for slightly disturbed lowland river ecosystems. Exceedances in orange.
2. Swan Canning Water Quality Improvement Plan (SRT,2009) nitrogen and phosphorus targets. Exceedances in red.

Results of interest in Table 12 include:

- pH in samples at RAP03 and RAP04 were acidic, 4.2 to 5.2, and slightly acidic in the RAP05 sample, 6.8. The pH of the RAP03 and RAP05 samples are similar to groundwater pH and may suggest groundwater is the major inflow component into these sites. The pH in the RAP05 sample is more alkaline than groundwater pH in adjacent bore WAR06 and may suggest stormwater inflow from the adjacent Tonkin Highway is the major contributor to the site.
- Surface water EC ranged from 0.38 to 0.75 mS/cm and suggests the surface water is fresh, similar to groundwater.
- Total Nitrogen (TN) concentrations in sampled surface water was above the SRT (2009) trigger value of 1 mg/L, similar to groundwater and ranged from 1.7 to 6.7 mg/L. Nitrogen was nearly all organic-bound (TKN) with ammonia and nitrogen oxide concentrations generally at or below the PQL.
- The Total Phosphorus (TP) concentrations were below the PQL of 0.05 mg/L except in the RAP04 sample (1.2 mg/L). The TP in this sample is elevated compared to groundwater TP at up-gradient bore WAR03 and may reflect higher nutrient loading from the adjacent rural residential lots.
- Dissolved metal concentrations were generally similar to or less than PQL. Aluminium and Zinc concentrations were higher than in groundwater while Iron concentrations were similar to groundwater.
- Alkalinity was only analysed in the 30 August 2022 samples with concentrations in the RAP03 sample less than 5 mg/L (PQL) and 14 mg/L in the RAP05 sample due to bicarbonate, also 14 mg/L.

4. CONCLUSIONS

The report summarises pre-development monitoring completed by JDA across the North Ellenbrook (West) DSP Area from July 2022 to October 2024 representing a minimum of 2 winters per the requirements of the DWMS (JDA, 2022) and WAPC (2008).

JDA concludes:

- The annual rainfall in 2022 of 699.6 mm at the Pearce RAAF station was slightly above both the long-term and short-term average annual rainfall of 649 mm and 625 mm, respectively. Annual rainfall in 2023 was 420 mm and 575 mm, respectively, and below both the long-term and short-term average annual rainfall.
- In the monitoring period, 2022 was a slightly above average rainfall year and 2023 and 2024 dry years.
- Groundwater flow direction is generally west to east across the Study Area towards Ellen Brook, consistent with DoE (2004 and JDA (2022). Groundwater levels generally peaked across the Study Area in the period mid-September to early-October except for bores WAR03 and WAR06 which peaked in August in 2022 and 2023 and bore WAR05 which is at natural surface all winter.
- The seasonal variation in the monitoring period ranged from 0.7 m to 1.12 m with an average of 0.89 m.
- Peak groundwater levels in 2022 were on average 1.1 m higher than the preliminary AAMGL contours presented in the DWMS (JDA, 2022). AAMGL mapping should be revised at the local planning stage of development based on the additional groundwater level data detailed in this report.
- Groundwater across the Study Area is generally acidic and classified as fresh in salinity.
- Total Nitrogen concentrations were generally above both the SRT (2009) trigger value and ANZECC and ARMANZ (2000) guidance value and averaged 2.4 mg/L across the Study Area. Nitrogen was mostly in the form of organic-bound nitrogen and concentrations of oxides of nitrogen are mostly below the practical quantifiable limit (PQL).
- Total Phosphorus concentrations were below the SRT (2009) trigger value and ANZECC & ARMCANZ (2000) guideline value at WAR01, WAR02 and WAR06 but generally above both values bores WAR03 to WAR05 and were similar to reactive phosphate concentrations. The median TP concentration across the Study Area was 0.05 mg/L.
- Groundwater quality results were similar to monitoring conducted in surrounding areas, particularly the elevated nutrients associated with historical and current agricultural land use and flushing of natural nutrients in the soil.
- Surface water sites were generally observed by JDA either having either ponded water or as dry across the monitoring period except in August and October 2022 site visits.
- Logged surface water depths at selected sites are likely to have been influenced by local conditions with site RAP01 dry for much of the monitoring period and RAP03 and RAP05 having water depths ranging from 0.29 m to 0.47 m.
- Surface water sampled was generally fresh and acidic, similar to groundwater, and suggests groundwater inflow may be significant contributor to surface water flow at these sites. The exception was RA05 which had slightly more alkaline pH than surrounding groundwater and may incorporate stormwater runoff from the adjacent Tonkin Highway.

- Surface water TN concentrations were similar to groundwater at all sites. Surface water TP concentrations were blow PQL except at RAP04 which may have elevated TP concentrations due to activities in adjacent rural residential lots.

5. REFERENCES

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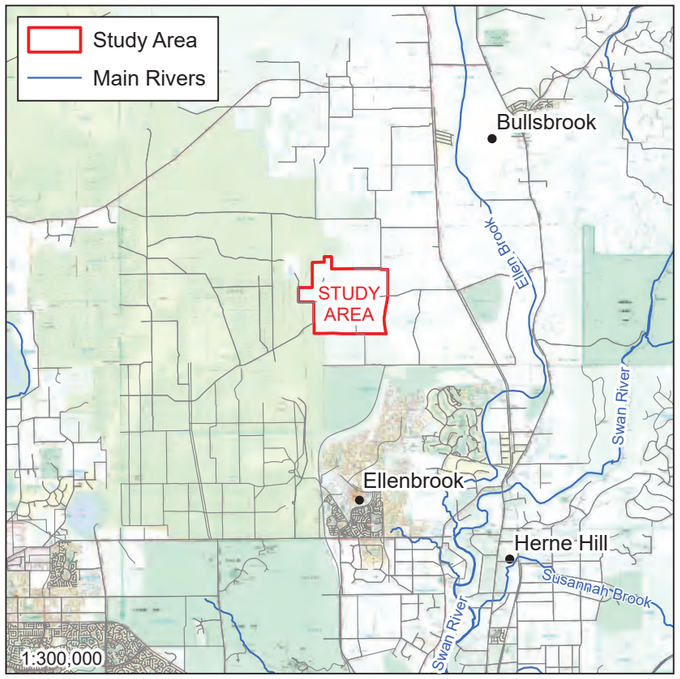
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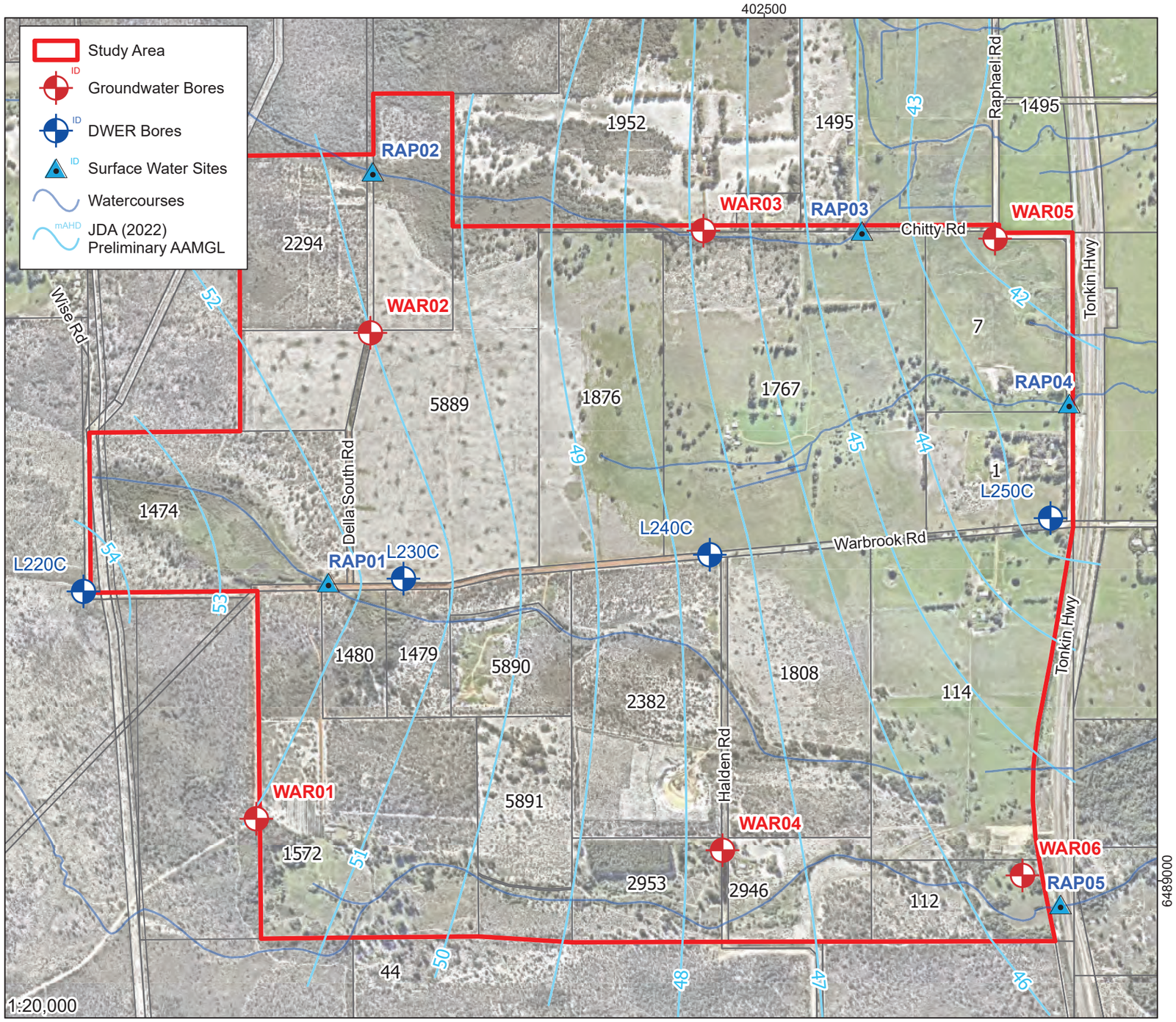
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FIGURES







Data Source: Nearmap (2024), Street Express (2012)

Coordinate System: GDA 94, Zone 50

Job No. J7086

Scale: 1:20,000 @A4

0 250 500 1,000 Metres

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North Ellenbrook (West) DSP Area, Bullsbrook: Pre-Development Monitoring

Figure 1: Location Plan and Monitoring Locations