Conoble Park Pty Ltd

North Ellenbrook (West)
District Water Management Strategy

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Consultant Hydrologists

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1. INTRODUCTION

1.1 Background

JDA Consultant Hydrologists has prepared this **District Water Management Strategy** (DWMS) on behalf of Conoble Park Pty Ltd, to guide water management over the land represented by the Ellenbrook North Landholders Group in the City of Swan (herein referred to as the Study Area) (See Figure 1).

This DWMS has been prepared to support the District Structure Plan (DSP), Rowe Group (2021).

The Study Area is approximately 613 ha in size and is situated within the City of Swan. It is located approximately 33 km northeast of the Perth Central Area and 15 km to the east of Wanneroo (Figure 1). The site currently comprises of areas of pasture and native vegetation, and contains several intermittent tributaries of the Ellen Brook - Swan River surface drainage catchment.

The preparation of this DWMS is consistent with the WAPC (2008) Better Urban Water Management and has been prepared in consultation with relevant government agencies. A copy of the DWMS Checklist (Department of Water, 2013) is contained as Appendix A to assist agency review of this document.

1.2 Town Planning Context

The site is currently zoned 'General Rural' under the Metropolitan Region Scheme (MRS) (Figure 2).

The recent North-East Sub-Regional Planning Framework (Department of Planning, Lands and Heritage, 2018) classifies the site as 'Urban Investigation' to accommodate part of the long-term growth of the Perth and Peel regions to approximately 3.5 million people by 2050.

1.3 Proposed Structure Plan

A District Structure Plan for the North Ellenbrook area prepared by Rowe Group (2021) is shown in Figure 2. The northern portion (LSP Area 2) is proposed to comprise of Light Industrial / Service Commercial with residential urban living in the remaining portions of the site (LSP Areas 1, 3 and 4). The area immediately north of the District Structure Plan is the Bullsbrook Freight and Industrial District Structure Plan Area.

The Master Plan Concept proposes mixed use with an industrial area in the north east, and suburban living integrated with the existing water courses and wetland areas maintained within public open space areas as shown in Figure 3.

1.4 Principles and Objectives

In addition to Better Urban Water Management (WAPC, 2008) this DWMS uses the following documents to define its key principles and objectives:

- *North East Corridor Urban Water Management Strategy (DoW & GHD, 2007)*
- *Drainage Management Strategy for North East Corridor (GB Hill & Partners, 1995)*
- *Local Water Quality Improvement Plan Ellen Brook Catchment (SRT, 2009a)*
- *Swan Canning Water Quality Improvement Plan (SRT, 2009b)*
- *Better Urban Water Management (WAPC, 2008)*
- *Decision Process for Stormwater Management in WA (DWER, 2017)*
- *State Planning Policy 2.9: Water Resources (WAPC, 2004)*
- *Stormwater Management Manual for WA (DoW, 2007)*

The DWMS ensures that the water management strategy proposed is consistent with the *North East Corridor Urban Water Management Strategy* (UWMS; DoW & GHD, 2007). The UWMS was produced as a Regional Drainage and Water Management Strategy and is used as the foundation for developing more detailed District and Local Structure Plans. In addition, the Department of Water and Environmental Regulation (DWER) has long-term groundwater datasets within and around the Study Area which can assist in supporting structure planning of the Study Area.

The aims of this DWMS are specifically to:

1. *Identify the key water management elements of the Study Area.*
2. *Describe pre-development conditions of the Study Area and its water resource management characteristics.*
3. *Define land area requirement for conveyance of flood flows and protection of future urban development from peak flow events.*
4. *Recommend management strategies for groundwater and drainage appropriate for local conditions that incorporates best practice water sensitive urban design (WSUD) measures.*
5. *Present guiding principles and strategies for post development management of the water resources as recommended in the North East Corridor UWMS.*
6. *Recommend requirements and commitments for future actions including monitoring programs for water quantity and water quality pre-, during and post- development.*

Table 1 provides a summary of the proposed principles and objectives for this DWMS.

Table 1: Summary of DWMS Design Objectives

Key Guiding Principles	
• Facilitate implementation of sustainable best practice 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. • Encourage environmentally responsible development.	
Category	**DWMS Objectives**
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 the 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.
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.
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.
Water Quality	• Adopt nutrient load reduction design objectives for stormwater runoff. • Use of amended soils and ephemeral bioretention systems to treat stormwater.
Monitoring	• Pre- and post-development program to ensure water quality targets are met.

The new edition of Australian Rainfall and Runoff (ARR) Ball et al (2019) adopts different probability terminology from that used in ARR 1987 (Engineers Australia, 1987). In line with ARR 2019, this report adopts new terminology Exceedances Per Year (EY) and Annual Exceedance Probability (AEP) instead of previous terminology, Average Recurrence Interval (ARI) used in ARR 1987, see conversions below.

- 1 EY is equivalent to 1 Year ARI
- 20% AEP equates to 4.48 Year ARI
  (For simplicity, this report adopts 20% AEP as equivalent to 5 Year ARI)
- 10% AEP equates to 9.49 Year ARI
  (For simplicity, this report adopts 10% AEP as equivalent to 10 Year ARI)
- 2% AEP equates to 49.5 Year ARI
  (For simplicity, this report adopts 2% AEP as equivalent to 50 Year ARI)
- 1% AEP is equivalent to 100 Year ARI

2. SITE CHARACTERISTICS

2.1 Existing Land Use & Zoning

The Study Area is approximately 613 ha in size and is bordered by Chitty Road to the North, the Perth – Darwin National Highway (Northlink 3) to the east and bushland to the south and west. Main access routes to the Study Area are via Chitty, Warbrook and Maralla Roads that run east to west (Figure 1).

A number of road reserves exist within the Study Area that whilst gazetted as road reserves or reserves under the MRS, are either currently being constructed or yet to be constructed. The most significant is the Perth-Darwin National Highway reservation which currently terminates to the south of Maralla Road. The Perth-Darwin National Highway has been recently constructed and is located to the west of a Special Use reservation - designated for rapid transit service. It is understood the most likely use of the reservation will be for a light rail transport facility.

The current zoning of properties within the Study Area is defined as ‘General Rural’ as indicated by the City of Swan’s Local Planning Scheme No.17 (District Planning Scheme) and shown in Figure 2. Approximately 45% of the Study Area has been cleared and used for the grazing of stock cattle and sheep, with the remaining 55% covered by native vegetation.

2.2 Rainfall

The Study Area has a Mediterranean climate with warm dry summers and cool wet winters. The Study Area has on average 57 precipitation days per year, which occur predominately between the months of June and September. Annual and monthly rainfall for the Study Area since 1937 is presented in Figure 4. The data is presented from the Bureau of Meteorology (BoM) Pearce RAAF station (No: 009053) which is the nearest station with a long-term dataset, located approximately 7.2 km to the northeast of the Study Area. The long-term average annual rainfall for the period 1937 to 2019 is 665 mm. The short term (2004 to 2019) average annual rainfall is 594 mm, a decrease of approximately 11%, consistent with declining rainfall in South West of WA (DoW, 2015b).

2.3 Topography

Topography of the Study Area has a general gradient from west to the east towards Ellen Brook with elevations ranging from 75 to 40 m AHD respectively (Figure 5).

There are several minor east/west ridges along the southern portion of the site which create localised depressions for minor tributaries.

2.4 Geology & Soils

2.4.1 Regional Mapping

Surface geology mapping by Gozzard (1983) is shown on Figure 5 and indicates the site is generally characterised by a thin veneer of Bassendean Sand overlying clay of the Guilford Formation at depth (S_8, S_{10}), with small areas of peaty clay (Cps) associated with the lower lying wetland areas. Descriptions of the key geological units in the Study Area are:

Sand (S8):	White to pale grey at surface, yellow at depth, fine to medium-grained, moderately well sorted, subangular to subrounded quartz, of eolian origin (Bassendean Sand).
Sand (S10):	As S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin.
Peaty Clay (CPS):	Dark grey and black with variable sand and organic content, of lacustrine origin

Pebbly Silt (Mgs1): Pebbly silt containing fine to occasionally coarse grained laterite quartz, heavily weathered granite pebbles with some fine to medium grained sand

The Bassendean Sand represent highly permeable sandy material with hydraulic conductivity ranging between 10 to 50 m/day. The Guildford Formation contains clayey sediments and has a low hydraulic conductivity of <0.1 m/day (Davidson & Yu, 2008).

2.5 Acid Sulphate Soils

Swan Coastal Plain Acid Sulphate Soils (ASS) risk mapping is shown on Figure 5 (DWER, 2018), indicating that the majority of the Study Area is classified as having moderate to low ASS disturbance risk within less than 3 m from the natural surface. However, there are some high to moderate risk areas associated with the wetland areas.

2.6 Wetlands and Significant Vegetation

Geomorphic Wetlands of the Swan Coastal Plain mapping is shown in Figure 6 (DBCA, 2018). A quarter of the Study Area is classified as a Multiple Use Palusplain wetland (UFI 15732). This reflects the cleared nature of the land and the winter wetness in the soil profile which results from the shallow sloped topography in these areas with underlying clayey soils. It favours the accumulation of shallow soil moisture and perched groundwater during the wet winter months.

A palusplain is defined as an area of flat land that is seasonally waterlogged. Wetlands with a 'Multiple Use' evaluation have few ecological attributes and functions remaining, and are not precluded from development.

There are several Conservation Category Wetlands and Resource Enhancement Wetlands associated with the discharge of groundwater at the junction of the Bassendean Dune System and the Guilford Clay fringes in the western sector of the area. Whilst a 50 m wetland buffer to Conservation Category Wetlands and a 30 m buffer to Resource Enhancement Wetlands is generally adopted to assist in District Structure Planning, a late submission received by the Department of Biodiversity, Conservation and Attractions (DBCA) notes that 50m buffers are to be provided for wetlands that are to be protected. Notwithstanding, in accordance with the DSP, wetland buffers are to be further reviewed at the local structure planning stage, which may include, where appropriate, a wetland reclassification and verification assessment to be undertaken.

Should a wetland reclassification and verification assessment be undertaken, a buffer study in accordance with the *Draft Guideline for the Determination of Wetland Buffer Requirements* may need to be undertaken at subsequent planning phases (i.e. at the local structure planning stage) to accurately determine the buffer required to protect the wetland value or any revised wetland value. The purpose of a site-specific buffer study would be to identify the values, functions and processes of the wetland, the threats posed by the proposed changes, and the appropriate buffer required to mitigate potential threats.

There are two small Bush Forever sites located within the Study Area (Site Numbers 298 and 399), over a total area of 32.5 ha. Further investigation and the development of management plans will be required to assess any protection requirements during and after development.

Details of the wetlands within the Study Area are given in Table 2 and shown in Figure 6.

Table 2: Geomorphic Wetlands

Wetland Category	General Description	UFI Indicator
Conservation	Wetlands which support a high level of attributes and functions	8536, 15045, 15046
Resource Enhancement	Wetlands which may have been partially modified but still support substantial ecological attributed and functions	8538, 15044, 13387
Multiple Use	Wetlands with few remaining important attributes and functions	8519, 8524, 8645, 15732, 15057

2.7 Surface Water Hydrology

2.7.1 Drainage Catchments

The Study Area is located within the Ellen Brook Catchment which is a natural ephemeral waterway. The Ellen Brook Catchment has the largest catchment area of all the sub-catchments on the Swan Coastal Plain (SRT, 2009a) and discharges into the upper reaches of the Swan River. The 1% AEP floodplain mapping of the Ellen Brook indicates it does not encroach into the Study Area (Figure 7).

The Study Area has several relatively flat low lying areas that are representative of the junction between the Bassendean Dunes with the Guildford Clay Formation. In these areas the superficial aquifer discharges at the base of the dunes forming wetlands and providing the source water for a series of seasonal surface drainages which flow to the east and discharge to Ellen Brook. These are represented by numerous small intermittent waterways throughout the Study Area (Figure 7), incised into the local sediments by <1 m. These waterways are shallow flow paths within cleared paddocks, and as such are generally in a degraded condition with only minor pockets of thin strips of riparian vegetation. They mainly assist in relieving prolonged flooding and waterlogging of the paddocks.

For the purposes of guiding the district structure plan, a generic 30 m interim foreshore width has been applied to retained waterways as shown in Figure 3. Whilst the structure plan demonstrates sufficient area has been provided to accommodate the interim foreshore width, the width is likely to be less than 30 m during further foreshore investigation and identification as these minor waterways are small upland tributaries in heavily degraded condition (360 Environmental, 2021). The refinement of applicable foreshore boundaries will be performed as part of the local structure planning process in accordance with *Operational Policy 4.3: Identifying and establishing waterway foreshore areas* (DWER, 2012).

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 catchments within the Study Area are presented in Table 3 and shown on Figure 7. The total catchment area within the Study Area is 765ha.

Table 3: Surface Drainage Catchments (BG&E, 2018)

Catchment[1]	Area (ha)	% in Study Area	Catchment Area in Study Area (ha)	Length (km)	% Cleared
CT1657	177	2	106	2.70	50
CT1724	745	19	176	6.21	25
CT1805	70	100	70	2.00	90
CT1862	126	100	126	2.10	60
CT1923	215	82	180	3.50	15
CT1965	1190	9	107	12.00	60

[1] North to south, see Figure 7

2.7.2 Drainage Infrastructure

Drainage infrastructure within the Study Area includes pipe culverts at road crossings, and the recently constructed section of the Perth-Darwin National Highway along the eastern boundary of the site (North Link Stage 3). BG&E (2018) determined peak flows for sizing of 13 culverts under the Highway, with culverts designed to provide 100 year ARI serviceability without overtopping the Highway. Culvert design details are presented in Table 4 and are shown on Figure 7. These culverts and the Highway form the downstream boundary drainage constraint for the Study Area.

Table 4: Proposed Drainage Infrastructure (BG&E, 2018)

Culvert ID[1]	Width (mm)	Height (mm)	No. of Barrels	Length (m)	US Invert Level (m AHD)	DS Invert Level (m AHD)
CT17.24	1,200	600	2	64.8	39.31	39.11
CT17.34B	1,200	450	1	70.8	39.60	39.31
CT17.45A	900	375	1	15.6	39.92	39.78
CT17.45B	900	375	1	55.2	39.78	39.65
CT17.75	900	375	1	52.8	10.37	40.03
CT17.85A	900	375	1	46.8	40.66	40.32
CT18.05	1,200	375	2	64.8	41.32	40.91
CT18.46	n/a	450	1	48.8	42.35	42.23
CT18.62	1,200	375	4	50.4	42.22	42.10
CT18.78	900	375	1	38.4	43.43	43.20
CT19.23	1,200	375	2	39.6	43.65	43.62
CT19.27	1,200	450	5	40.8	43.45	43.28
CT19.65	2,400	600	4	44.4	43.40	43.30

[1] North to south, see Figure 11

2.7.3 Peak Flow Estimates

BG&E (2018) calculated flow rates for 6 selected cross- drainage culverts as part of the two-dimensional hydrological assessment for the North Link Stage 3 section of the Perth Darwin National Highway for the 1 year, 5 year, 10 year and 100 year ARI storm events. It included calculating design event peak flows by averaging results using the Index Flood and probabilistic Rational Methods for the Wheatbelt region outlined in the 1987 edition of Australia Rainfall & Runoff (ARR 87) based on loamy and lateritic soils. A 30% reduction was then applied to the average flow to obtain design peak flows as approved by Main Roads WA for low gradient areas. XP-RAFTS software was then used to develop design flow hydrographs for drainage catchments which were then applied to TUFLOW modelling. Catchment flow estimates are presented in Table 5.

Table 5: Catchment Flow Estimates from BG&E (2018)

Catchment	Total Area (Ha)	Flow Estimate (m^3/s)			
		1 Year ARI (1 EY)	5 Year ARI (20% AEP)	10 Year ARI (10% AEP)	100 Year ARI (1% AEP)
CT1657	177	0.19	0.64	1.12	5.12
CT1724	745	0.34	1.14	1.97	8.94
CT1805	70	0.16	0.55	0.96	4.47
CT1862	126	0.18	0.59	1.03	4.73
CT1923	215	0.14	0.48	0.84	3.83
CT1965	1190	0.61	2.03	3.51	16.30

BG&E (2018) modelling results for peak flow estimates at selected culverts are presented in Table 6.

Table 6: Culvert Design Flows BG&E (2018)

Catchment	Culvert ID	Flow Estimates (m^3/s)		
		10 Year ARI (10% AEP)	50 Year ARI (2% AEP)	100 Year ARI (1% AEP)
CT1657	CT17.24	1.77	3.1	3.22
	CT17.34B	0.62	1.08	1.1
	CT17.45A	0.3	0.47	0.49
	CT17.45B	0.3	0.48	0.57
	CT17.75	0	0.33	0.48
	CT17.85A	0	0.25	0.37
CT1805	CT18.05	0.28	0.77	1.36
CT1862	CT18.46	0.05	0.13	0.19
	CT18.62	0.34	1.89	2.43
	CT18.78	0	0	0.34
CT1923	CT19.23	0.4	0.86	1.23
	CT19.27	1.03	3.65	4.47
CT1965	CT19.65	2.8	8.69	12.52

Refinement of catchments and detailed modelling will be required in the Local Water Management Strategy (LWMS) for pre- and post-development to determine Study Area outflow with consideration to existing constraints identified in this DWMS.

2.8 Groundwater Hydrology

2.8.1 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 superficial aquifer is unconfined and directly recharged from direct rainfall percolation, and below the Study Area has a saturated thickness of approximately 50 m. The base of the superficial aquifer is estimated to be approximately at -5 m AHD (Department of Environment, 2004).

Davidson (1995) and Water & Rivers Commission (2000b) show that the superficial formations are comprised of Bassendean Sand with fringes of Guilford Clay of the Pinjarra Plain. In addition to these studies the Department of Environment (2004) Groundwater Atlas shows that the typical superficial aquifer groundwater salinity in this area ranges from fresh in the Bassendean Sand to brackish in the Guilford Clay. Salinity can range in the order of 500 - 5000 mg/L.

The superficial formations are underlain by the Mirrabooka, Leederville and Yarragadee formations (Water & Rivers Commission, 2000a). The Mirrabooka Formation comprises of cretaceous mainly sandstone and sand material. The Leederville Formation is made up of the Pinjar and Wanneroo Members. The Yarragadee Formation present beneath the Study Area consists of laterally discontinuous interbedded sandstones, siltstones and shales (Davidson, 1995).

2.8.2 Groundwater Levels

DWER has a widespread even distribution of shallow long term regional groundwater monitoring bores within the Study Area as shown in Figure 8. Preliminary estimates of pre-development Average Annual Maximum Groundwater Level (AAMGL) and Maximum Groundwater Level (MGL) have been calculated by JDA based on data from these bores, with contour mapping of AAMGL and MGL shown in Figure 8. MGL is approximately 0.4 to 0.8 m higher than AAMGL. DWER bore hydrographs are attached in Appendix B.

The estimated pre-development AAMGL contours show groundwater flow direction from west to the east, consistent with regional mapping (DoW, 2004). The AAMGL ranges from approximately 54 m AHD in the west to 40 m AHD in the east. Typical seasonal variation in groundwater levels ranges between 1.0 and 1.5 m across the Study Area.

Depth to pre-development AAMGL, Figure 8 *left*, is less than 1.5 m below the natural surface for approximately one third of the Study Area. This also correlates with the wetland mapping (Figure 6). Depth to MGL mapping, Figure 8 *right*, shows the hydrological connections from east to west across the Study Area, aligning with mapped non-perennial tributaries (Figure 7).

As the soil types in this area comprise either a thin layer of sand over sandy clay and clay, or a clayey sand at the surface underlain by clay, and due to the low lying nature of the land and its flatness, there is seasonal perching of groundwater which in some areas forms surface water that sheet flows into local drainage lines.

2.8.3 Public Drinking Water Source Area

A portion of the site (see Figure 9) is located within the Gnangara Mound Underground Water Pollution Control Area (Gnangara UWPCA) which occupies a total area of nearly 815 km^2. The Gnangara Mound UWPCA was proclaimed in 1990 under the Metropolitan Water Supply Sewage and Drainage Act 1909. Water from the Mound is extracted by the Water Corporation as part of the Perth Metropolitan Integrated Water Supply System.

DWER is the lead agency in protecting catchments for water supply in Western Australia. The Department supports the Australian Drinking Water Quality Guidelines (ADWQG) barrier approach to water quality protection, with catchment management the first barrier of protection. Subsequent barriers are water storage, treatment and disinfection. The catchment management measures are also supported by Wellhead Protection Zones around public water supply wells. There are no production wells located within the Study Area and therefore no wellhead protection zones to consider.

Figure 9 shows the south western fringe of the Study Area is located within a Priority 3 Public Drinking Water Source Area (PDWSA), with a Priority 1 area located immediately outside the Study Area to the west. Water Quality Protection Note 25 (WQPN) (DoW, 2016) sets out the groundwater catchment priority classification system and provides a guide on compatible land uses to protect groundwater from pollution risk.

Priority 1 (P1): – P1 source protection areas are defined to ensure no degradation of the water source. P1 areas are declared over land where the high quality drinking water is the prime beneficial land use protected in accordance with the objective of risk avoidance. Changes to existing land use that introduce additional risks are not recommended.

Priority 2 (P2) – P2 source protection areas are defined to ensure there is no increased risk to the water source. P2 areas are generally declared over land with low intensity development such as pasture which already exists. Public water supply protection is of a high priority relative to other land use values protected in accordance with the objective of risk minimisation. Low levels of development consistent with the rural zoning are considered appropriate (generally with conditions) in P2 areas.

Priority 3 (P3) – P3 source protection areas are defined where it is necessary to manage the risk of pollution to the water source where the land is zoned for urban and commercial or light industrial uses. P3 areas generally have the requirement of using best management practices and connection to deep sewerage. P3 areas are protected in accordance with the objective of risk management.

Any urban development within these priority areas must comply with the compatibility criteria. Other information provided in the WQPN 25 includes:

- DoW's (now DWER) advice on land and water based activities in proclaimed Public Drinking Water Source Areas (PDWSA).
- Best Management Practices (BMPs) guidance used to protect water quality in PDWSAs.
- Overview of legislation, polices and processes used to protect PDWSAs.
- The development of a multi-agency guideline designed to balance views of community, industry and government, in order to maintain a reliable safe public drinking water supply.

2.8.4 Groundwater Availability

The State's groundwater resources are managed by DWER by licensing abstraction in groundwater management areas.

The Study Area is located within the Swan Groundwater Management Area (Figure 9) at the eastern edge of the Gnangara Mound. This management area is divided into two groundwater management subareas; North Swan and Neaves.

A search of DWER's resource allocation licensing database in May 2021 shows that the groundwater resources of the Superficial Aquifer and Leederville Aquifer are fully allocated. There are existing licence holders within the Study Area which have a combined 75,660 kL/yr entitlement from the Superficial Aquifer within the Neaves and North Swan groundwater subareas that can be used for future urban development (Figure 9). Conoble Park Pty Ltd currently has secured a total licence allocation of 89,200 kL/yr (GWL 182065, GWL 184451 and GWL 109820), with another 39,800 kL/yr in the process of acquiring.

2.9 Groundwater & Surface Water Quality

The Ellen Brook Catchment is recognised as being one of the highest contributors of nutrients to the Swan-Canning Estuary with very high levels of phosphorus and moderate levels of nitrogen. The Ellen Brook Catchment Local Water Quality Improvement Plan (LWQIP) (SRT, 2009a) identifies the catchment as being one of eight priority catchments in the Swan Canning Catchment. The nitrogen to phosphorus ratio of approximately 4:1 in the tributary creeks and Ellen Brook identifies these waters as being highly susceptible to the growth of nitrogen fixing blue algae (DoW & GHD 2007).

The principal source of nutrient loading within the Ellen Brook Catchment is associated with agricultural land uses. As the soils within the Study Area have poor phosphorus retention capacity, when high groundwater or perched groundwater and surface water sheet flow are established by winter rainfall, there is a significant loss of phosphorus and nitrogen from both fertiliser and animal manure into the local drainage lines, which then discharge into Ellen Brook and the Swan River.

DoW & GHD (2007) presents monitoring results within the Ellen Brook Catchment carried out by Shams & Smith (2002) which suggests that concentrations of nutrients within surface water discharging into Ellen Brook is greater than that of the superficial groundwater.

Davidson (1995) estimates that the superficial groundwater quality for the Study Area is in the order of:

- Total Dissolved Solids: < 250 mg/L
- Dissolved Iron: 1 mg/L
- Nitrate-Nitrogen Concentration: < 1 mg/L
- Phosphorus Concentration: 0.05 mg/L

The Department of Water obtained groundwater quality samples from monitoring bore GNM14 within the Study Area (Figure 8) between August 2008 and August 2009 with the following results:

- Total Nitrogen range: 1.3 to 2.3 mg/L
- Total Phosphorus range: 0.006 to 0.041 mg/L

DWER has a surface water monitoring site on the Ellen Brook located close to Great Northern Highway, near the Swan River confluence. The range of annual median nitrogen and phosphorus concentrations measured between 1999 and 2015, compared with the short-term and long-term water quality improvement targets are shown in Table 7.

Table 7: Nutrient Concentrations in the Ellen Brook Catchment

Nutrients	Median Concentration (mg/L)			SRT (2009a) Targets (mg/L)	
	Groundwater	Creeks	Ellen Brook[1]	Short Term	Long Term
Total Nitrogen	0.48	2.70	1.3 – 2.5	2.0	1.0
Total Phosphorus	0.14	0.72	0.27 – 0.50	0.2	0.1

[1] Ellen Brook Median Range from Swan Canning Catchment Nutrient Report Update 2015

2.10 Other Considerations

A search of the Department of Water and Environmental Regulation's Contaminated Site Database (accessed 25 February 2020) indicated no contaminated sites in or near the Study Area.

There are two registered Aboriginal Heritage sites (Site 4143 and Site 3525) located within the Study Area as shown on Figure 6, which will be addressed separately to this DWMS.

Further detail on the site environmental characteristics are outlined in the *Environmental Assessment Report* for the site prepared by 360 Environmental (2021).

2.11 Hydrological Opportunities & Constraints

The characteristics described above of the pre-development environment in the Study Area provides a number of key constraints and opportunities for the application of Water Sensitive Urban Design with land use change:

- Sandy soils over part of the site will aid the infiltration of frequently occurring storm events (ie. first 15mm rainfall event) at source where possible via soakwells.

- ASS risk mapping (DWER, 2018) for the Study Area indicates moderate risk of ASS occurring within 3 m of the existing surface for the vast majority of the Study Area, with some areas having a high to moderate risk. An ASS Investigation and Management Plan will be required prior to development.
- Multiple minor tributaries flow through the Study Area to Ellen Brook located to the east of the Study Area. Consideration in regard to the functions of these natural drainage systems and water quality is required. Drainage infrastructure is to be placed within the development's POS.
- Geomorphic Wetland mapping identifies multiple wetlands throughout the Study Area, including Conservation, Resource Enhancement and Multiple Use categories. A detailed assessment of all wetlands will be required at the Local Structure Planning stage to assess the condition, value and any development constraints around each wetland.
- Maximum Groundwater Levels (MGL) and Annual Average Maximum Groundwater Levels (AAMGL) calculated from DWER monitoring bores surrounding the Study Area allows a high level assessment of groundwater levels in relation to the existing natural surface level. Approximately one third of the site has MGL & AAMGL within 1.5 m of the existing natural surface and perched watertables may also develop. Subsoil drainage will be required for management and control of groundwater levels post-development.
- Only a very small portion of the Study Area is located within Priority 3 PDWSA, with urban development a compatible landuse with conditions.
- Several landholders within the Study Area have superficial groundwater licences which can be transferred for urban use.
- Historical rural land use over a large portion of the Study Area has, to varying degrees, affected groundwater quality and there are currently no water quality controls. Change in land use provides an opportunity to improve groundwater quality through application of sustainability principles, water sensitive urban design, and establishment of water quality targets, monitoring and compliance reporting.

These constraints and opportunities are used to assist development of a suitable DWMS for the Study Area.

3. WATER SUPPLY & CONSERVATION STRATEGY

The supply, conservation and sustainable use of water within the proposed development are key components of the water management strategy and are described further below.

3.1 Water Supply

3.1.1 Potable Water

Preliminary advice from Water Corporation indicates whilst there is currently no potable water supply system in place for the proposed Study Area, they will commence planning for this area in 2020. Installation of temporary services to develop the area north of Marshall Road would also be accepted as long as Water Corporation's long-term planning is not compromised (Pritchard Francis, 2018).

3.1.2 Non-Potable Water

Non-potable water supply options that can be investigated further to meet POS irrigation demand and ex-house use are briefly described below.

Water required for irrigation of POS and School areas is generally by groundwater abstraction from the superficial aquifer under licence by DWER. Concept Landscape Plan prepared by EPCAD highlighting possible POS layout is presented in Appendix C. POS area requiring irrigation can be broadly determined by assuming 10% of the Study Area is POS (61.3 ha) and of that 31% will require long term irrigation (19.1 ha). Applying DWER's standard POS irrigation rate of 6,750 kL/ha/yr results in an estimated irrigation requirement of 129,000 kL/yr. In addition, 27,000 kL/yr is estimated for School sites assuming 20% is irrigated (4 ha). This results in total estimated irrigation water demand in the Study Area of 156,000 kL/yr.

Conoble Park Pty Ltd currently has a total licence allocation of 89,200 kL/yr (GWL 182065, GWL 184451 and GWL 109820) with another 39,800 kL/yr in process of acquiring (see Section 2.8.4). Total allocation once acquired will be 129,000 kL/yr, equivalent to estimated POS irrigation requirement. Conoble Park Pty Ltd will continue to seek additional licence allocation through water licence trading where possible. It is noted there are two existing licences totalling ~60,000 kL in two external lots adjacent to the northern boundary, which if acquired would be in excess of the total estimated water requirement. Alternatively, other non-potable water source options could also be investigated in accordance with the *Guidelines for the approval of non-drinking water systems in Western Australia* (DWER, 2013a). Examples of options may include:

Rainwater Tanks

Collection and storage of rainwater runoff from roof and other impervious surfaces have generally been considered of minimal value to supply or supplement irrigation demand in Perth at the development scale. This is due to the vast majority of annual rainfall occurring in the space of a few months when water consumption is at its lowest. It also requires the need for sufficient storage capacity to allow water to be utilised over the course of the year.

Limitations to use of rainwater tanks include reliability of rainfall, infrastructure required to store water either above or below ground, water quality considerations and cost.

Whilst use of rainwater tanks can be beneficial for supplementing non-potable water demand, it is more suitable at the household scale rather than at the development scale for irrigation of POS.

Stormwater Harvesting & Managed Aquifer Recharge

Stormwater runoff generated from the urban development can be collected and conveyed by a stormwater system (network of pipes and swales) to temporary storage areas for treatment/retention/infiltration prior to discharge into a downstream receiving environment.

Collection and reuse (harvesting) of all or part of stormwater can assist in providing an alternative non-potable water source and reduce size of infrastructure required for stormwater flood management.

Harvesting of stormwater to supply POS irrigation demand can be achieved by infiltration into underlying sandy aquifers and reuse via groundwater extraction bores. There may be limited opportunity for infiltration into the shallow superficial aquifer due to the existing shallow depth to water and the underlying clays. However there may be potential to inject deeper into the confined Leederville Aquifer.

Alternatively, above or below ground infrastructure for storage of stormwater for future reuse can also be used. For these storages to be effective, storage needs to be sufficiently large to contain adequate volume for irrigation requirements, with limited use dependent upon rainfall, similar to rainwater tanks. Land take for such storage systems can be generally large and expensive to install and maintain and water quality treatment may also be required.

Impact of harvesting stormwater on downstream ecological water requirements also need to be considered. Whilst stormwater harvesting at the development scale has limitations similar to rainwater tanks, it could also be used to assist in supplementing other POS water source options.

Greywater Recycling

Greywater is water collected from showers, bathrooms and laundry and is potentially available for reuse. Treated greywater is suitable for garden irrigation in accordance with the Code of Practice for the Reuse of Greywater in Western Australia. Where greywater is applied to gardens for irrigation, sandy soils need improved organic matter and soil texture to ensure excessive nutrients do not leach to the watertable.

It is generally considered that greywater can only be stored for up to 24 hours at a time without significant impacts on water quality and subsequent risks to public health. Therefore greywater generated during each day would need to be discharged, either for reuse or for disposal to the sewer network every 24 hours. A water balance would need to be performed to assess volume of water generated against supply required.

Construction of a separate pipe system within the development is required to collect and reuse greywater. A specific area will also be required to be set aside for the greywater treatment system and provision of other supporting infrastructure such as power. Responsibility for ownership and ongoing operation and maintenance of the system also need to be established upfront.

While greywater recycling could be used for development scale water supply for irrigation of POS, it may be cost prohibitive due to additional pipe infrastructure required. It is more suitable at the household scale rather than at the development scale.

Wastewater Recycling

Wastewater is all water generated in a household and includes the combination of greywater (water from showers, bathrooms and laundry) and blackwater (toilet). The collection, treatment and reuse of household wastewater can only be performed at development scale and requires construction of a purpose built on-site wastewater treatment system, commonly referred to as a decentralised wastewater recycling system.

The planning and construction of such a system requires many regulatory clearances, approvals and management plans with various government agencies including but not limited to the City of Swan, Department of Water & Environmental Regulation, Water Corporation, Department of Health and Department of Parks & Wildlife.

Planning also needs to consider location with respect to environmental impacts and required buffers for adjacent land uses. Initial construction costs can be high in comparison to other non-potable water source options. It does not require construction of additional collection pipes as the standard residential sewer network should be sufficient, however responsibility for ownership and ongoing maintenance need to be determined.

A third party licenced Water Service Provider is required to provide this wastewater recycling service. The use of such a system can provide an almost guaranteed water supply with predictable volumes. This is particularly beneficial for irrigation purposes where water demand can be forecast in the POS areas. The wastewater will need to be treated to acceptable levels specified by the relative agencies.

3.2 Wastewater Management

Preliminary advice from Water Corporation indicates there is no wastewater system currently in place for the Study Area, but it is likely that the area will be serviced by one or two wastewater pump stations that will pump wastewater to the Alkimos Treatment Plant. Water Corporation have agreed to start planning to service the area north of Marshall Road in 2020 (Pritchard Francis, 2018).

3.3 Water Conservation Objectives

The objective for water conservation is to minimise use of water and maximise water use efficiency where possible. This objective can be achieved at both the development and household scale and has been identified by the State Government as part of the State Water Plan (Government of Western Australia, 2007) as a priority item for potable water. It has set a target for household water use of 100 kL/person/year, with a consumption target for scheme water of 40-60 kL/person/year.

Consistent with the State Water Plan, the main objectives for the development are:

- Avoid use of potable water for irrigation in POS areas.
- Household water use to be less than 100 kL/person/year.
- Minimise use of potable water where drinking water quality is not essential, particularly ex-house.
- Household consumption targets for in-house potable water use of 40-60 kL/person/yr.

Improvements in water conservation and efficiency to meet these objectives at both the development and lot scale through various mechanisms and measures are described further below.

Development Scale

Development scale water conservation measures appropriate for the site include:

- Strategic planning (orientation, shape, elevation etc.) of irrigation areas such as pocket parks, active and passive public open space areas, and road reserves to minimise long-term irrigation demand.
- Where possible co-locate facilities with significant irrigation demand.
- Within irrigation areas, the use of waterwise landscaping practices including hydrozoning, mulching, soil amendments, water retention products and installation of appropriate water efficient irrigation fixtures.
- POS and turfed areas should be irrigated using groundwater from the existing licensed allocation as discussed in Section 2.8.4. Water conservation could also be achieved by using alternative non-potable water to meet roadside swale and public area irrigation requirements.
- Retain and where appropriate rehabilitate native bush areas.

Lot Scale

Lot scale water conservation measures appropriate for the site include:

- Buildings constructed to current Building Codes of Australia (BCA) water efficiency standards and the State Government 5 Star Plus Scheme. These include using AAA rated appliances such as toilets, washing machines, dishwashers, water saving showerheads, taps and toilets and subsurface irrigation. The Water Corporation's Waterwise Rebate Program will also assist in encouraging the purchase of waterwise AAA rated appliances.
- Initiatives to encourage waterwise landscaping of residential lots including hydrozoning, mulching, soil amendments, water retention products and installation of appropriate irrigation fixtures.
- All buildings should be encouraged and supported to implement these waterwise practices and measures within this development.

3.4 Water Balance

A water balance can be used to enable assessment of the impact of urban development on rainfall recharge across the site. Davidson & Yu (2008) provides regional estimates of rainfall, evaporation, transpiration and recharge for various land uses on Bassendean Sands with deep water table. Whilst this applies to only a portion of the Study Area, the recharge values have still been adopted for the whole site for a simplistic assessment.

The recharge rates as a percentage of rainfall are presented in Table 8, showing pre-development recharge rates for both banksia and pasture are less than those for residential and industrial urban development. This reflects the reduction in evapotranspiration from vegetation, and an increase in rainfall runoff from impervious surfaces in the urban environment. The additional rainfall recharge generated could lead to an increase in post development groundwater levels and provide an opportunity for an additional water source if managed appropriately.

Table 8: Rainfall Recharge of Land Use

Land Use	Recharge Rate of Rainfall
Pre-development	
Banksia (medium density)	18%
Pasture	45%
Post development	
Urban – Residential	50%
Urban – Industrial	63%

To assess the impact of land use change from Rural to Urban on the groundwater and surface water balance for the Study Area, JDA has prepared the report "*North Ellenbrook (West) District Water Management Strategy, 2D Groundwater & Surface Water Modelling*" (JDA, 2021) at the request of DWER.

The report assessed several land use and climate change scenarios and concluded that there was no change in the volume of water stored in the aquifer within the Study Area from land use change from Rural to Urban with future medium climate, compared to the base case scenario of historical climate and land use. This was due to the opposing influences of climate change and land use change on groundwater levels.

4. GROUNDWATER MANAGEMENT

4.1 Key Principles & Objectives

The key objectives for groundwater management for the Study Area as identified in the UWMS (DoW & GHD, 2007) are:

- Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture.
- Protection of groundwater dependent ecosystems from the impacts of urban runoff.
- Managing and minimising changes in groundwater levels and quality following urban development.
- Maintain or improve existing groundwater quality.

4.2 Groundwater Levels

A large proportion of the site has pre-development MGL and AAMGL at or within 1.5 m of the existing natural surface, together with perched watertables. These areas will require some form of groundwater management, such as importation of clean sand fill to ensure adequate separation of building floor level to groundwater and/or the provision of subsoil drainage to control post development groundwater rise.

Management of groundwater levels including subsoil drainage areas, inverts, discharge rates and location are to be established in accordance to *Water Resource Considerations when Controlling Groundwater Levels in Urban Development* (DWER, 2013b) and are to further consider:

- Refinement of pre-development maximum groundwater level (MGL) and annual average maximum groundwater level (AAMGL) presented in this report based on more site specific monitoring data and correlation to long term monitoring data.
- Subsoil drainage to manage post development rise in groundwater levels, particularly in low lying areas and to protect wetlands. Subsoil drainage should be installed at or above the pre-development AAMGL and have free-draining outlets.
- Subsoil drainage may be used to provide a controlled groundwater level (CGL). If invert levels are below pre-development AAMGL, further groundwater and environmental assessment must be performed to demonstrate negligible impact on groundwater levels for groundwater dependent ecosystems, such as wetlands, waterways (creeks and Sawpit Gully) and retained bushland.
- Appropriate analysis should be performed to assess influence of subsoil drainage on groundwater levels, including extent of groundwater drawdown and mounding between subsoil lines.
- Drainage inverts are to be set at or above the pre-development AAMGL, however drainage lines with existing inverts below pre-development AAMGL may remain.

4.3 Groundwater Quality

Key factors to maintain or improving existing groundwater quality are:

- Drainage inverts set at or above pre-development AAMGL to minimise nutrient export.
- Groundwater discharge from existing drainage lines with invert below pre-development AAMGL should be conveyed into a water quality treatment area where sufficient hydraulic grade permits.
- Subsoil drainage used to control groundwater level is to discharge into a water quality treatment system.
- Stormwater runoff from frequently occurring rainfall events (15 mm) to be treated via bio-retention areas prior to infiltration or discharge from site.

- Use of a combination of soil amendments and landscape design (native vegetation, minimising turf areas etc) to limit fertiliser and pesticide application in public open space areas.

Specific details on the local scale of application, and responsibilities for individual best management practices will be appropriately addressed during later planning stages in accordance with Better Urban Water Management (WAPC, 2008) requirements.

5. STORMWATER MANAGEMENT

5.1 Key Design Criteria

The key objectives for surface water management for the Study Area as identified in the UWMS (DoW & GHD, 2007) and the *Decision Process for Stormwater Management in Western Australia* (DWER, 2017) are for the implementation of water sensitive urban design to:

- Protect public health and safety.
- Protect public and private infrastructure and buildings from flooding.
- Protect and enhance sensitive receiving environments by managing the water cycle, water quality, habitat diversity and biodiversity.
- Enable economically sustainable construction, maintenance and renewal/replacement costs.
- Achieve good urban amenity.

These objectives can be achieved using best practice stormwater management strategies as presented in the Stormwater Management Manual for Western Australia (DoW, 2007) which include:

- Retain, restore and/or replicate the functions of the natural drainage system including waterways, wetland and groundwater features and regimes, and integrate these elements into the urban landscape.
- Design of stormwater management system to maintain pre-development hydrological regime as close as possible in wetlands, waterways and discharge from the Study Area.
- Use of vegetation and amended soils within infiltration swales and bioretention areas to treat stormwater runoff and improve the quality of stormwater infiltrating to the groundwater.
- Use of a strategic drainage network comprised of swales, pipe drainage and the arrangement of road and grading to convey major storm events away from houses and other key infrastructure to designated flood management areas.
- Management of rainfall events up to the 1% AEP on site by integrating flood management areas into Public Open Spaces.

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

5.2 Catchments

Preliminary earthwork design indicates the Study Area can be divided into 21 surface drainage catchments as shown in Figure 10. Drainage from all catchments discharge to a low point into a nearby waterway that discharges under the Perth-Darwin National Highway. Catchments 11 to 13 drain north into a waterway that discharges outside of the Study Area prior to passing under the Highway. Catchment land use breakdown is presented in Table 9.

Table 9: Catchment Land Use Breakdown

Catchment	Land Use Breakdown Area (ha)						Total Area (ha)
	Residential Lots	Road Reserve	School	POS	Commercial Use	Centre	
1	16.7	7.8					24.5
2	18.7	8.5					27.2
3A	13.2	7.4	0.2	0.4	3.0	1.4	25.6
3B	14.9	6.9	3.8				25.5
4		0.7	12.2	8.5			21.4
5	5.8	2.5		0.0			8.3
6	7.1	2.9		0.7			10.7
7	20.2	10.9		0.3			31.4
8	2.5	1.5					3.9
9	8.8	7.9				7.1	23.8
10	12.6	5.9	3.9	0.7			23.2
11	2.0	1.7					3.8
12	34.9	14.7		1.3		0.3	51.3
13		6.1			9.8		15.9
14A		3.0		0.1	13.6		16.7
14b		6.3			16.7		23.0
15	21.0	10.1		1.0	0.0		32.2
16A		2.6			15.5		18.2
16B		3.9			14.6		18.6
17		3.8			14.4		18.1
18	2.5	2.6		0.7			5.8
Total	180.8	117.8	20.0	13.8	87.7	8.8	428.9

Note: Creek/Waterway reserve areas not included in catchments; All values are in 1 decimal place.

5.3 Stormwater Quantity

Stormwater system design should adopt the following design criteria:

- Pre-development flows entering and leaving the Study Area to be maintained. Stormwater management system designed for the safe conveyance of runoff of peak flows for the Small (15 mm), Minor (20% AEP) and Major (1% AEP) rainfall events, consistent with flow rates in Tables 5 and 6.
- Small event runoff managed by a combination of infiltration structures (swales, underground cells, tree pits, permeable pavers etc) on the majority of roads in the upper catchment prior to reaching bio-retention area at downstream discharge location.
- Utilise overland (pipeless) system where possible including roadside or median swales in neighbourhood connector roads.
- Minor and Major event runoff managed by detention of storm events high in the catchment using roadside or median swales, POS, tree pits, flush kerbing adjacent to POS or underground storage to minimise stormwater retention area/detention areas in POS.
- Detention areas integrated into existing waterways outside of wetland buffers using road and pedestrian crossing as stormwater attenuation points to create living streams. Additional stormwater management areas can be located throughout the upper catchment as required. These are to either infiltrate or discharge into the living streams as offline systems.

- Post-development flows attenuated to pre-development flow rates (see Table 6) by detention of runoff in stormwater management areas. These can be located in landscaped POS, linear multiple use corridors or drainage reserve areas. A typical living stream cross section in shown in Appendix C.
- A stormwater management area must be located at each catchment outlet to ensure post development flow is attenuated prior to leaving the site.
- Finished floor levels to have a clearance from the 1% AEP water level in adjacent watercourses of 0.5 m and should be at least 0.3 m above the 1% AEP overland flow flood level.

Water storage volume and area required for each drainage catchment has been estimated as follows:

- Runoff coefficient of 50% for residential lots and school site, 80% for road reserve, 10% for POS, and 100% for commercial use lots and centre.
- Bio-retention area provides storage for road runoff only for the small event (15 mm rainfall).
- Storage area for bio-retention area calculated on an assumed water depth of 0.5 m.
- Minor Events (20% AEP), storage volume based on 1 m^3 for 40 m^2 of contributing impervious area.
- Major Events (1% AEP), storage volume based on 1 m^3 for 20 m^2 of contributing impervious area.
- Storage area for detention basin is calculated assumed water depth of 1.0 m.

Estimated water storage volumes and areas based on assumptions above are in Table 10.

Table 10: Catchment Water Storage Volumes and Areas

Catchment	Equivalent Impervious Area (ha)	Storage Volume (m^3)			Storage Area (m^2)		
		Small Event	Minor Event	Major Event	Small Event	Minor Event	Major Event
1	14.6	930	3,600	7,300	1,900	3,600	7,300
2	16.1	1,000	4,000	8,100	2,000	4,000	8,100
3A	17.1	890	4,300	8,500	1,800	4,300	8,500
3B	14.8	820	3,700	7,400	1,600	3,700	7,400
4	7.5	90	1,900	3,800	180	1,900	3,800
5	4.9	290	1,200	2,400	590	1,200	2,400
6	6.0	350	1,500	3,000	700	1,500	3,000
7	18.9	1,300	4,700	9,400	2,600	4,700	9,400
8	2.4	180	600	1,200	350	600	1,200
9	17.8	950	4,400	8,900	1,900	4,400	8,900
10	13.1	710	3,300	6,500	1,400	3,300	6,500
11	2.4	210	600	1,200	420	600	1,200
12	29.7	1,800	7,400	15,000	3,500	7,400	15,000
13	14.7	730	3,700	7,300	1,500	3,700	7,300
14A	16.0	360	4,000	8,000	710	4,000	8,000
14b	21.7	760	5,400	11,000	1,500	5,400	11,000
15	18.7	1,200	4,700	9,000	2,400	4,700	9,000
16A	17.6	320	4,400	8,800	630	4,400	8,800
16B	17.8	470	4,400	8,900	950	4,400	8,900
17	17.4	450	4,300	8,700	900	4,300	8,700
18	3.4	320	850	1,700	630	850	1,700
Total (21)	292.5	14,130	72,950	146,100	28,160	72,950	146,100

Note: Major event area and volume includes Minor event; EIA values are in 1 decimal place; Storage Volume and Area are in 2 significant figures.

Area occupied by bio-retention areas and detention storages for each catchment are shown in Figure 10, to demonstrate these drainage areas can be accommodated within the structure plan. Note that drainage shapes and locations shown are indicative only.

The stormwater management plan is shown in Figure 11.

Further details on the adopted measures including sizing and location of drainage infrastructure is to be detailed in the LWMS to assist the local structure planning process.

5.4 Stormwater Quality

Stormwater quality is to be managed through implementation of best management practices in a treatment train approach to achieve water sensitive urban design. These include structural and non-structural measures to assist in reducing applied nutrient loads such as:

- Use of soakwells and rainwater tanks on Lots to retain the small event (15 mm) at source, where groundwater separation and geotechnical conditions permit.
- Industrial and commercial lots to include oil & grease separators to treat stormwater runoff prior to discharge into local stormwater drainage system.
- Gross pollutant trap (GPT) to be installed on catchment stormwater system pipe outlets to remove pollutants including sediment and hydrocarbons prior to discharge.
- Road catchment stormwater runoff from the small rainfall event (15 mm) to be treated by Bio-retention areas / amended soils / rain gardens / tree pits / permeable pavers / median or roadside swales / flush kerbing adjacent to POS in the catchment, prior to infiltration or discharge to downstream environment.
- Overland (pipeless) conveyance systems including living streams, roadside and median swales planted with vegetation to increase roughness and reduce peak stormwater flows to remove sediment and increase nutrient uptake. These are to be incorporated into the neighbourhood connector roads.

Implementation and appropriate design suitability of these measures will be further investigated in the LWMS.

6. WATER QUALITY MANAGEMENT

Nutrient input will change with change in land use from existing native vegetation and rural grazing areas, to urban development (residential and industrial). Preliminary assessment of the impact of this change based on the indicative district structure plan is presented below.

6.1 Post Development Nutrient Inputs

NiDSS is a tool developed by JDA Consultant Hydrologists to assist in landuse management planning, and allow quantitative estimation of nutrient input rates and the potential reduction in nutrient input (including costings) for various combinations of water sensitive urban design (WSUD) water quality management measures. NiDSS focuses on the adoption of an integrated catchment approach to water quality management, including measures to minimise nutrient inputs at source, and provides a logical framework for the evaluation of the effectiveness of various best management practices for nutrient input management.

It calculates the total expected nutrient input for a particular development proposal based on aggregating individual nutrient inputs from different land uses (lots, POS, road reserves, conservation areas) prior to implementation of stormwater management measures. The impact of individual source and in-transit controls on nutrient input can then be determined by either turning on/off individual controls or varying the effectiveness of these measures. The results present information on:

- Estimates of Total Phosphorus (TP) and Total Nitrogen (TN) application to an area.
- Estimates of reductions due to source control measures (education, street sweeping).
- Estimates of reductions due to in-transit controls (Gross Pollutant Traps).
- Estimates of the cost of removal (in PV terms) for a selected WSUD program.

NiDSS was applied to the Study Area to model existing land use and the proposed Structure Plan land use. Nutrient application rates were adopted from the Southern River Urban Water Management Strategy (JDA, 2002), which based application rates on a nutrient input survey conducted by JDA of medium density residential areas, and on previous work of Gerritse et al (1991,1992) on rural residential lots.

Pre-development and post-development estimates of nutrient input rates from NiDSS are shown in Table 11 and detailed in Appendix D.

In summary, proposed land use change results in a significant increase in total nitrogen and total phosphorus input without implementation of any water sensitive urban design (WSUD) measures. These inputs can be reduced to pre-development levels by encouraging community education on 1 in 3 lot owners on landscape design on the lot (ie. replacing exotic gardens and lawn areas) and fertiliser application consistent with manufacturers frequency and rate (see Appendix D).

Table 11: Pre and Post Development Nutrient Input Analysis Using NIDSS Model

Nutrient	Pre-development Input		Post-development Input			
			Without WSUD		With WSUD	
	t/yr	kg/ha/yr	t/yr	kg/ha/yr	t/yr	kg/ha/yr
Total Nitrogen	24.43	27.00	94.00	104.07	23.19	25.60
Total Phosphorus	8.14	9.0	22.85	25.25	4.17	4.61

6.2 Non-Structural Controls

Non-structural source controls to reduce nutrient export from the site focus on reducing the need for nutrient inputs into the landscape. At the lot scale, this includes an emphasis on community education to ensure appropriate landscape design (ie. replacing exotic gardens and lawn areas with native vegetation) and fertiliser application.

Similarly, use of native vegetation in public open space and streetscape areas, with nutrient application based on actual plant requirement from appropriate soil and leaf tissue testing should be adopted.

The impact of non-structural controls on nutrient input reduction is demonstrated in the NiDSS assessment presented in Section 6.1 and in Appendix D.

6.3 Structural Controls

Structural source controls are proposed to complement the non-structural source controls and provide a complete treatment train for stormwater.

The Stormwater Management Manual for Western Australia (DoW, 2007) outlines expected pollutant removal efficiencies for structural controls vegetated swales and detention/retention systems that can be incorporated into the stormwater management strategy.

While DoW (2007) does not provide expected pollutant removal efficiencies for all BMP's, application of a treatment train approach by using a combination of non-structural and structural measures will assist in achieving design objectives for water quality. Note that use of bioretention areas instead of vegetated swales provide increased nutrient reduction performance.

Table 12 presents the expected nutrient output reduction for these structural controls which are proposed to be incorporated in this stormwater management strategy.

Table 12: BMP Water Quality Performance in Relation to Design Criteria

Parameter	Structural Controls Nutrient Output Reduction [1]	
	Vegetated Swales	Detention/ Retention Measures
Total Suspended Solids	60-80%	65-99%
Total Phosphorus	30-50%	40-80%
Total Nitrogen	25-40%	50-70%
Gross Pollutants	-	>90%

1. Typical Performance Efficiencies via DoW (2007)

Other structural water quality control measures such as use of swales, constructed wetlands, living streams, floating wetlands, rain gardens, tree pits, permeable pavers, bioretention areas etc. should also be included in the concept design phase. Impact of these measures on nutrient load can be further assessed with DWER's "Urban Nutrient Decision Outcomes" (UNDO) decision support tool at the LWMS stage.

6.4 Water Quality Targets

Water quality management for the Study Area is to determine existing water quality by monitoring, establishing targets, implementing water quality measures to achieve targets, and monitoring post development to assess performance.

Pre-development groundwater and surface water monitoring is required to be conducted (inclusive of 2 years winter periods) to establish baseline target nutrient concentrations (see Section 7.2).

Notwithstanding, surface water quality monitoring should aim to meet the short- and long-term targets established for the Ellen Brook from SRT (2009a) as follows:

Table 13: UWMS Water Quality Targets

Guideline for Ellen Brook	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Short-term	2	0.2
Long-term	1	0.1

7. IMPLEMENTATION FRAMEWORK

7.1 Local Structure Planning

The water management planning requirements for the various stages of land use planning are set out in Better Urban Water Management (WAPC, 2008) and include a Local Water Management Strategy (LWMS) in support of the Local Structure Plan and an Urban Water Management Plan (UWMP) as a condition of subdivision approval. The design objectives outlined in this DWMS form the basis for design criteria to be developed and reported in the LWMS. The design criteria of the LWMS are implemented through the final design concept presented in the UWMP.

Specific issues raised in the DWMS that need to be further investigated as part of the LWMS include:

- Hydrological management of the wetlands and protection of environmental assets.
- Define wetland buffers to the satisfaction of DBCA.
- Survey of waterways and retention of existing flow paths and natural drainage systems located throughout the Study Area.
- An ASS Investigation and Management Plan will be undertaken at the appropriate development phase to identify the exact extent and depth and whether it will impact future proposed development.
- Irrigation supply and water efficiency measures for irrigation of POS.
- Detailed site geotechnical investigation and earthwork and fill strategy.
- Refine drainage catchment areas, location of drainage infrastructure, flood storage volumes, levels and areas and discharge rates to maintain pre-development flows entering and leaving the site. Assess opportunities to implement further water sensitive urban design.
- Refine living stream concept with cross section on levels and areas with online flood management.
- Refine groundwater levels, MGL and AAMGL contours and provide further detail on groundwater management strategy including subsoil drainage design.
- Continuation of groundwater & surface water monitoring to inform LWMS and refine post development Monitoring Program.

7.2 Monitoring Requirements

A detailed groundwater and surface water monitoring program has not been undertaken specifically for the Study Area. Pre-development monitoring of groundwater and surface water quality is recommended to be undertaken at the local Study Area scale to establish baseline water quality to assess the hydrological impacts of (proposed) development, support the planning and engineering design, and assist in establishing targets and a contingency action plan with associated trigger values for specified parameters.

The nature of post development monitoring, including the scope and extent of monitoring, will be determined based on the type, form, and staging of development ultimately proposed in the Local Structure Plan. Monitoring will be undertaken in accordance with DWER requirements. Specific details of proposed post-development monitoring program are to be included in the LWMS. All water quality testing must be conducted by a National Association of Testing Authorities (NATA) accredited laboratory.

7.2.1 Pre-Development Monitoring

Pre-development monitoring is required for at least 2 years prior to development as outlined in WAPC (2008) Better Urban Water Management. Monitoring sites, parameters and frequency are summarised in Table 14. At the end of the 2 year program results to be submitted to the DWER and the City of Swan and will assist in preparation of the LWMS.

Table 14: Pre-Development Monitoring Requirements

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 (m AHD)
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

7.2.2 Post Development Monitoring

Post-development monitoring is required for 2 years after the completion of each stage of development. The monitoring program will be designed to allow a quantitative assessment of the hydrological impacts of the proposed development within the Study Area. Table 15 summarises the proposed post-development monitoring programme. Samples will be collected quarterly for 12 months with ongoing sampling to be reviewed and presented in the annual report. The post-development monitoring program should be further refined at the LWMS stage. Pre-development monitoring bores should be retained if possible for post-development monitoring.

Table 15: Post-Development Monitoring Requirements

Monitoring Type	Number of Sites	Frequency & Timing	Parameter	Reporting
Groundwater Levels	Sufficient coverage to spatially represent the stage of development	Water level data loggers for 2 years then review	Continuous Water Level (m AHD)	Annual Summary Report
Groundwater Quality	Sufficient coverage to spatially represent the stage of development	Quarterly for 2 years then review	In-situ: pH, EC, TDS, temp Lab: nutrients, selected metals and cations & anions	
Surface Water Quality	Outlets of all proposed detention basins	Quarterly for 2 years then review	In-situ: pH, EC, TSS, temp Lab: nutrients, selected metals and cations & anions	
Surface Water Outflow	Selected water courses downstream boundary of Study Area	Water level data loggers and rating curves based on discharge measurements using Velocity Area Method for 2 years then review	Continuous Flow rate	

7.3 Ongoing Responsibilities

Table 16 provides a summary of key implementation actions and responsibilities in accordance with the WAPC's requirements (2008).

Further specific detail of responsibilities will be appropriately defined and refined at LWMS stage.

Table 16: Implementation and Responsibilities

IMPLEMENTATION	RESPONSIBILITY		
Action	**Developer**	**DWER**	**City of Swan**
Preparation of an Local Water Management Strategy to support local structure planning	✓		
Review and Approval of LWMS		✓	✓
Preparation of an Urban Water Management Plan for individual development stages	✓		
Review and Approval of UWMP		✓	✓
Construction of stormwater system and maintenance post construction until council handover	✓		
Long term stormwater system operation and maintenance			✓
Conduct Post Development Monitoring program and Annual Reporting	✓		
Review of Monitoring Data and Annual Reports		✓	✓

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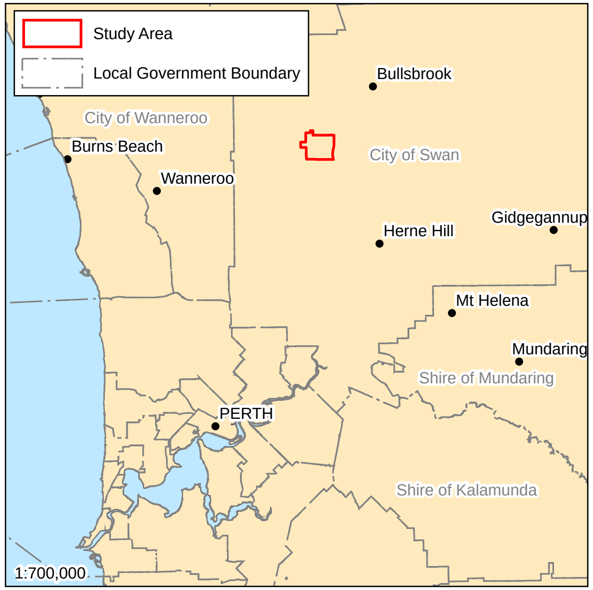
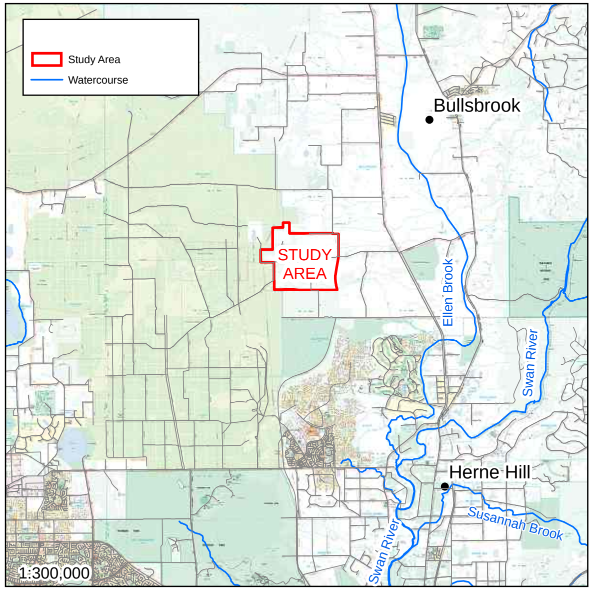
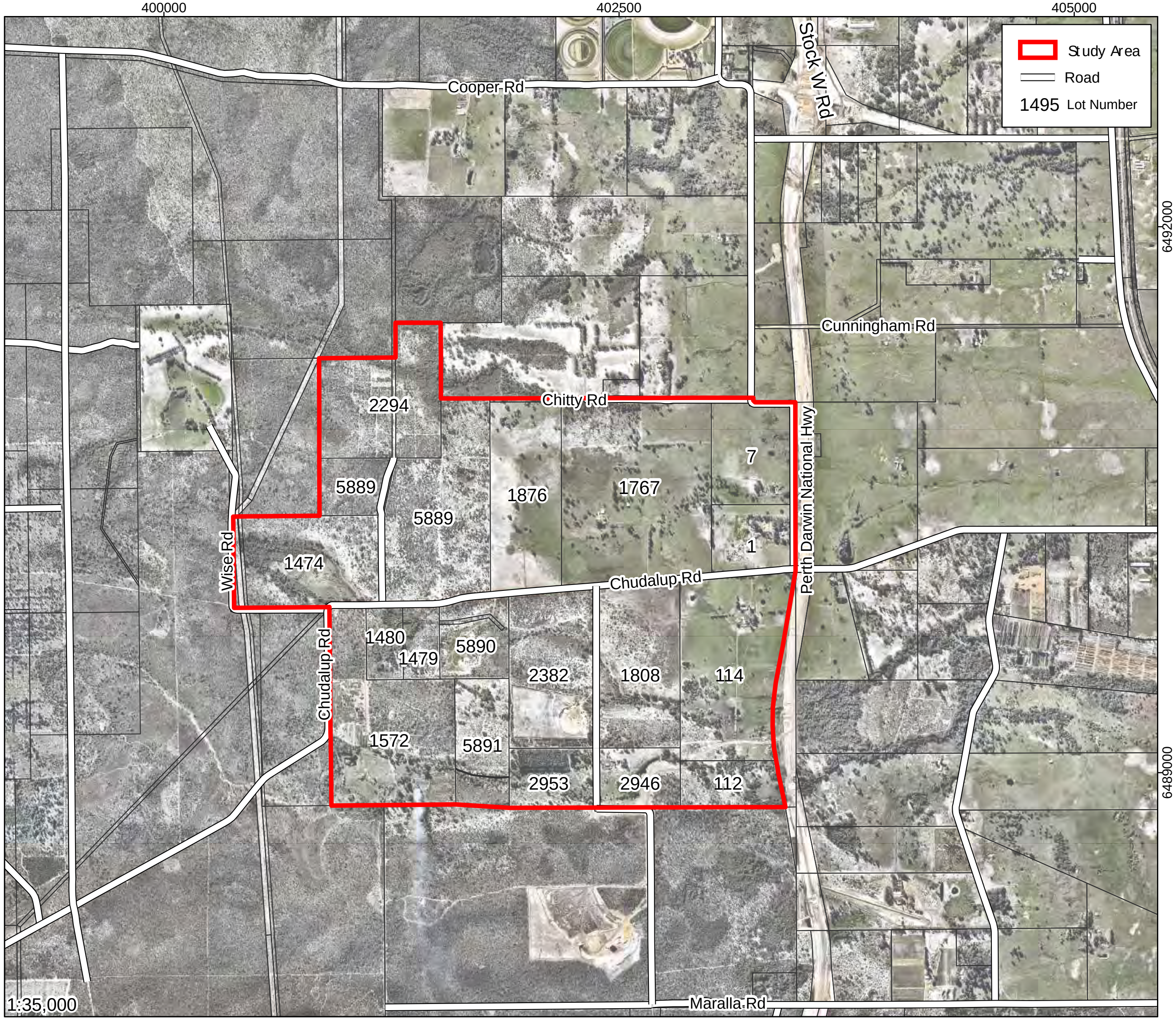
FIGURES







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North Ellenbrook (West) - District Water Management Strategy

Figure 1: Location Plan

Study Area

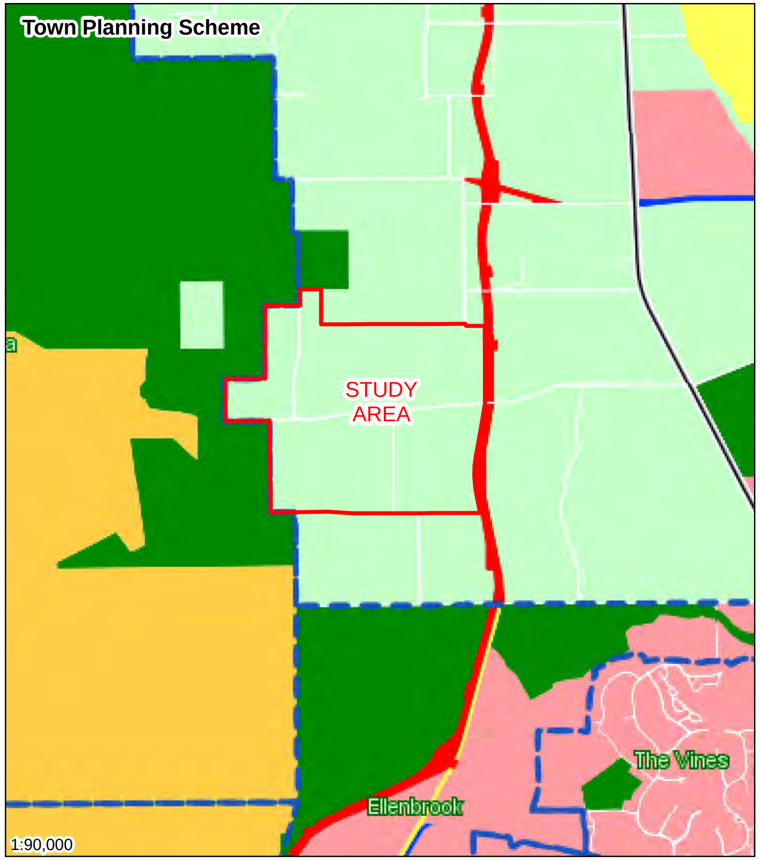
Local Town Planning Scheme Zoning

- General Rural
- Local Reserve - Local Road
- Regional Reserve - Other Regional Road
- Regional Reserve - Parks & Recreation
- Regional Reserve - Primary Regional Road
- Regional Reserve - State Forests
- Special Use

LEGEND

- DISTRICT STRUCTURE PLAN BOUNDARY
- LOCAL STRUCTURE PLAN BOUNDARY
- CADASTRAL BOUNDARIES
- RESIDENTIAL
- LIGHT INDUSTRIAL / SERVICE COMMERCIAL
- DISTRICT CENTRE
- NEIGHBOURHOOD CENTRE
- PS PUBLIC PURPOSE - PRIMARY SCHOOL
- HS/PS PUBLIC PURPOSE - HIGH SCHOOL / PRIMARY SCHOOL COMBINED
- OPEN SPACE
- FUTURE MRS PARKS AND RECREATION RESERVE
- PRIMARY DISTRIBUTOR ROAD
- INTEGRATOR ARTERIAL ROAD
- NEIGHBOURHOOD CONNECTOR ROAD

Town Planning Scheme



District Concept Plan

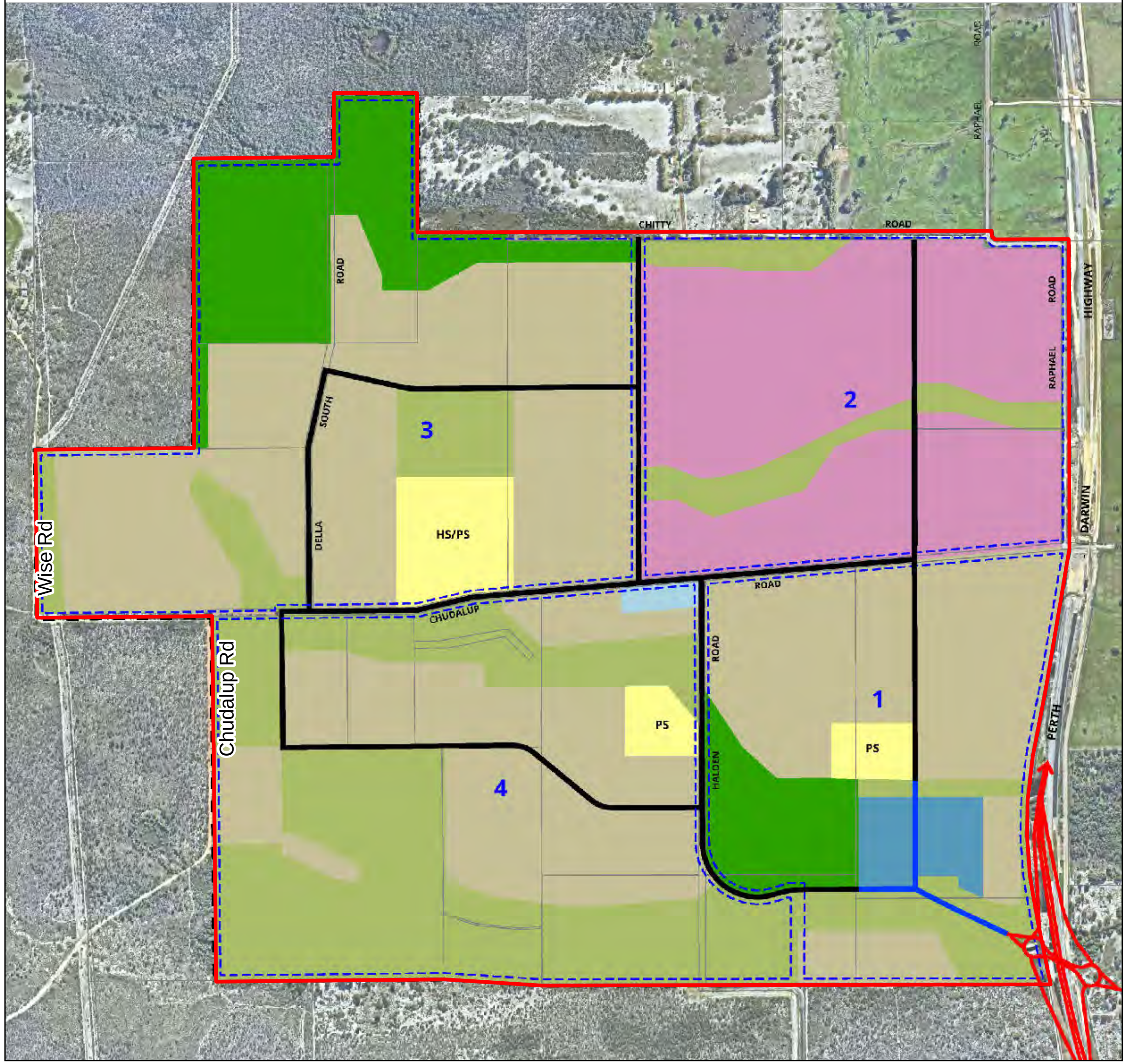


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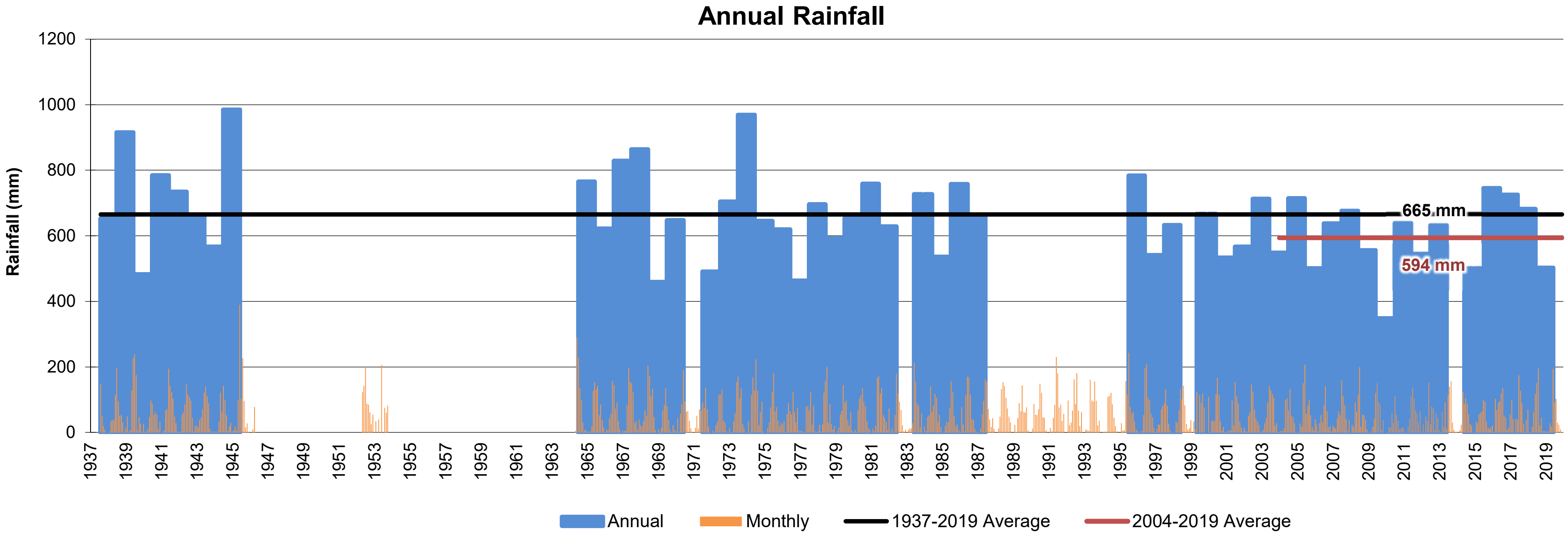
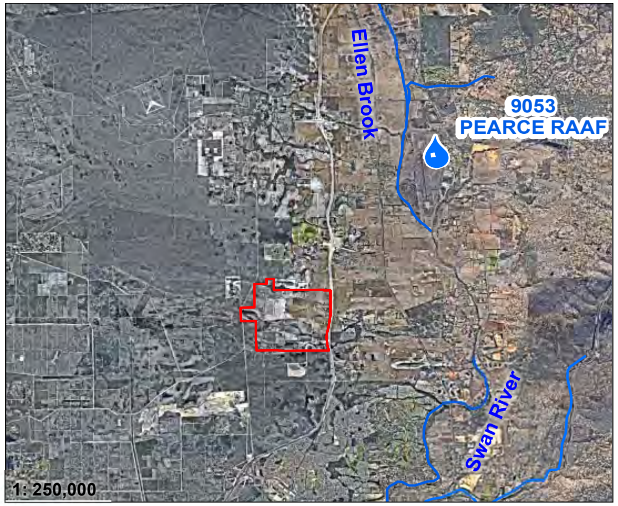
Figure 2: District Structure Plan





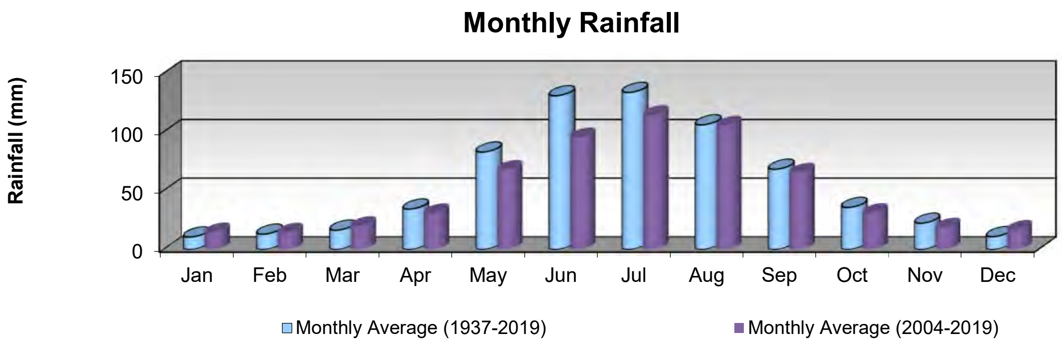


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Figure 4: Annual and Average Monthly Rainfall

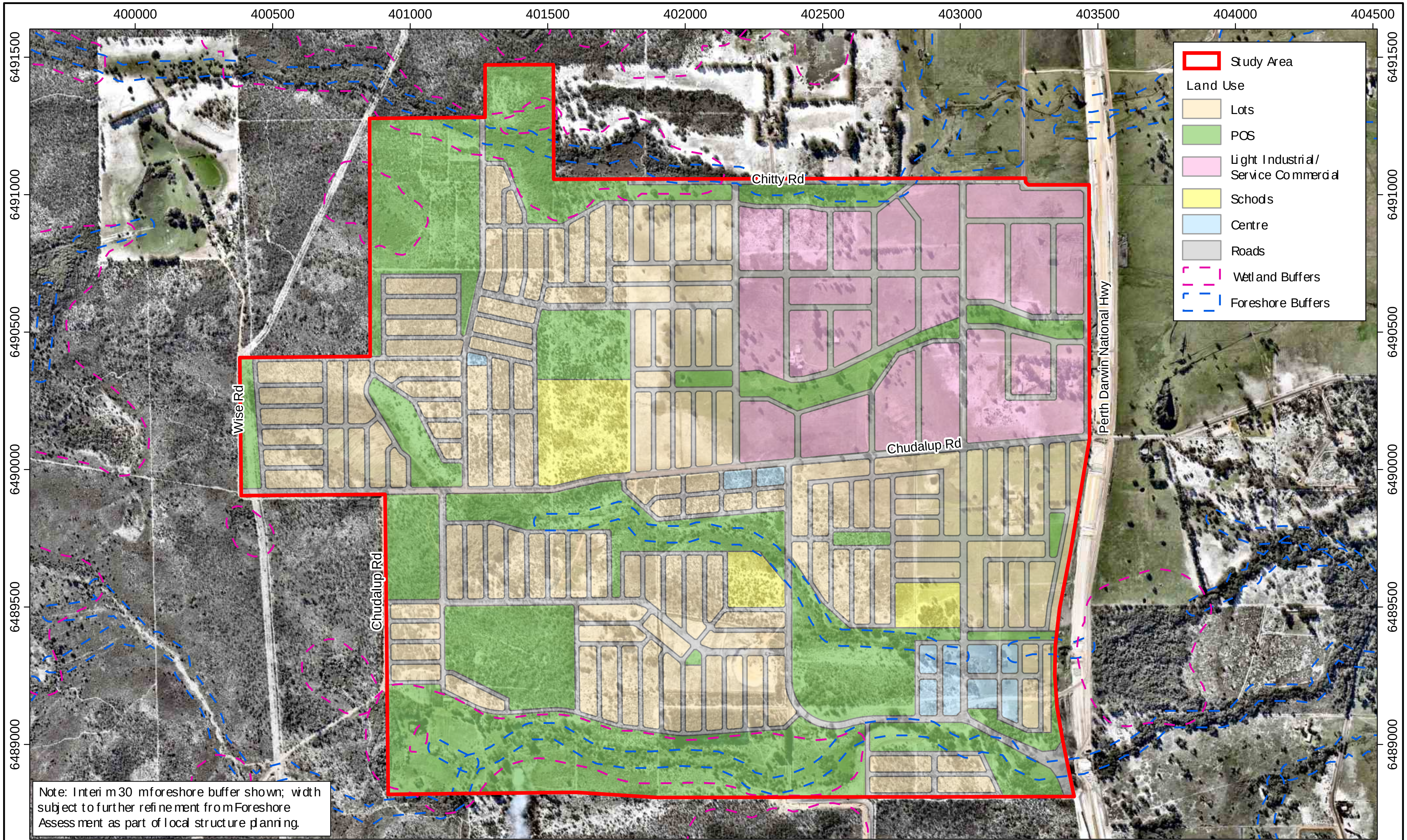

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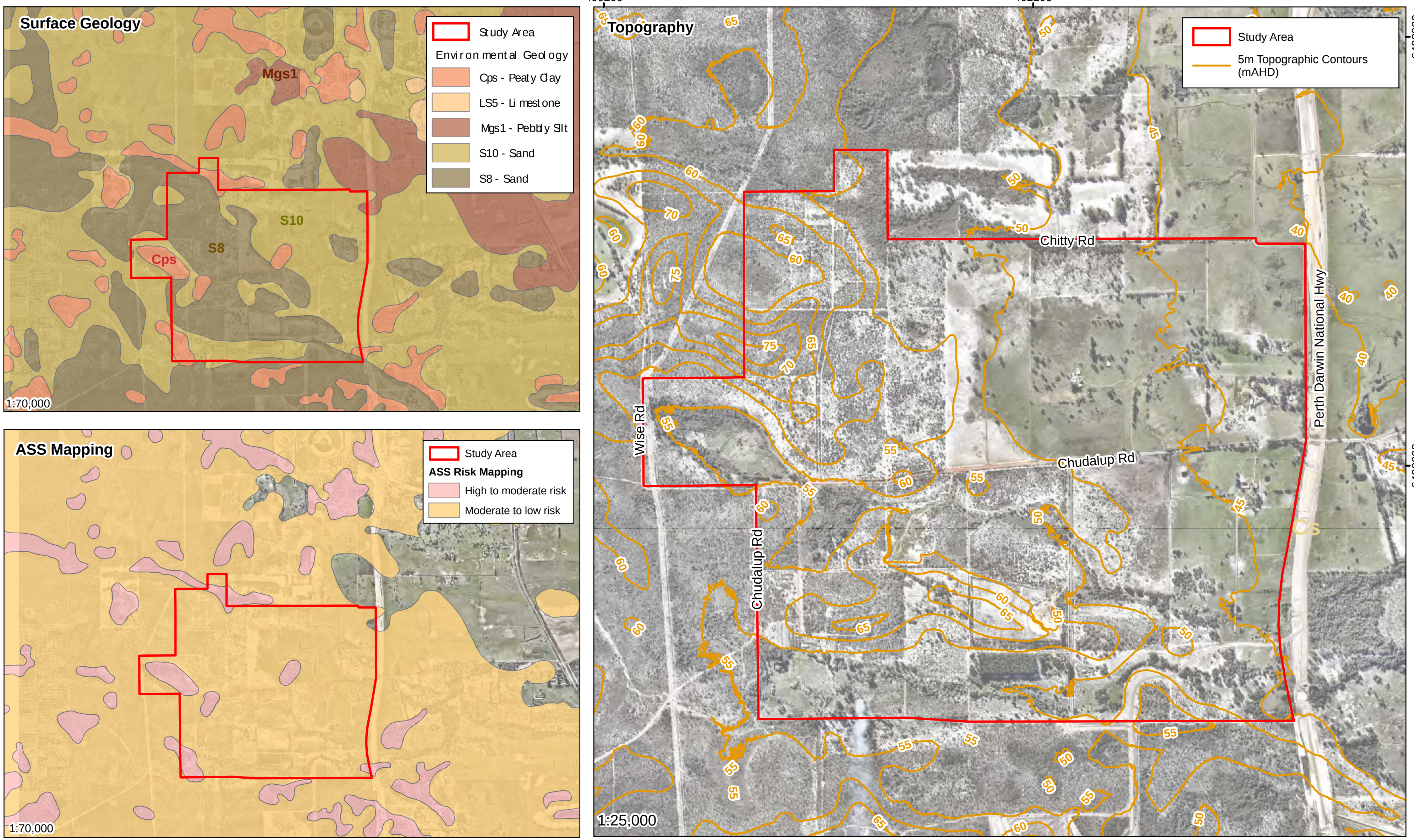
Figure 3: District Structure Plan Concept



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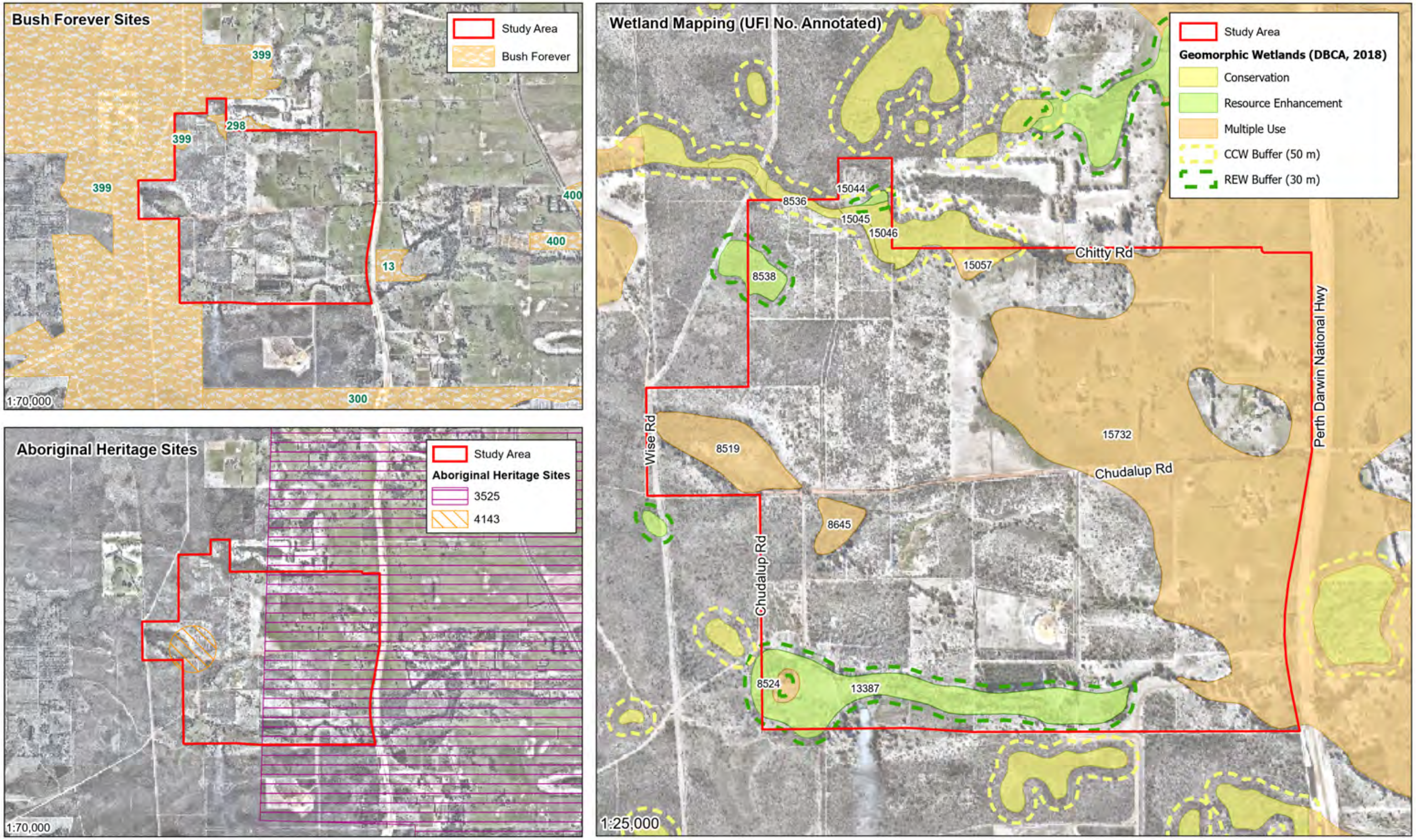
North Ellenbrook (West) - District Water Management Strategy

Figure 5: Topography and Surface Geology



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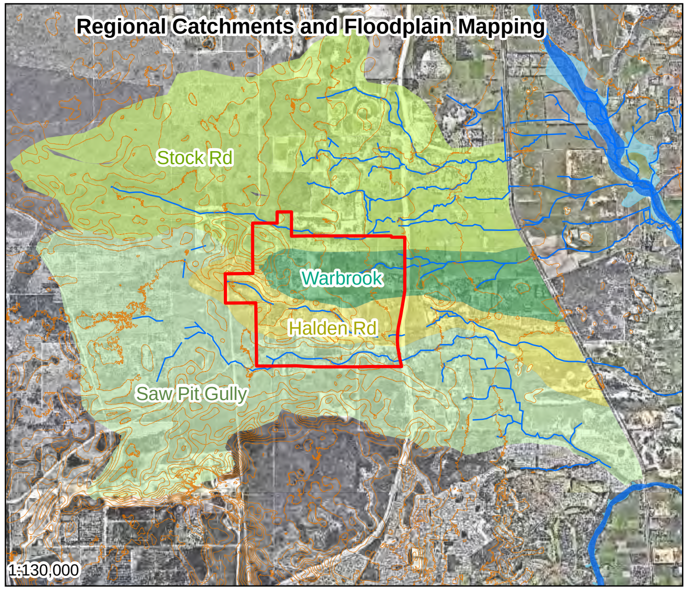
North Ellenbrook (West) - District Water Management Strategy

Figure 6: Environmental Factors

Study Area
5m Topographic Contours (mAHD)
Regional Catchments
Stock Catchment
Warbrook Catchment
Halden Catchment
Sawpit Gully Catchment

Ellen Brook Flood Mapping
Flood fringe
Floodway
Proposed Culverts (BG&E, 2018)
Drainage Catchments (BG&E, 2018)
Minor River Non Perennial

Catchment	Total Area (Ha)	Flow Estimate (m^3/s)			
		1 Yr ARI (1 EY)	5 Yr ARI (20% AEP)	10 Yr ARI (10% AEP)	100 Yr ARI (1% AEP)
CT1657	177	0.19	0.64	1.12	5.12
CT1724	745	0.34	1.14	1.97	8.94
CT1805	70	0.16	0.55	0.96	4.47
CT1862	126	0.18	0.59	1.03	4.73
CT1923	215	0.14	0.48	0.84	3.83
CT1965	1190	0.61	2.03	3.51	16.3



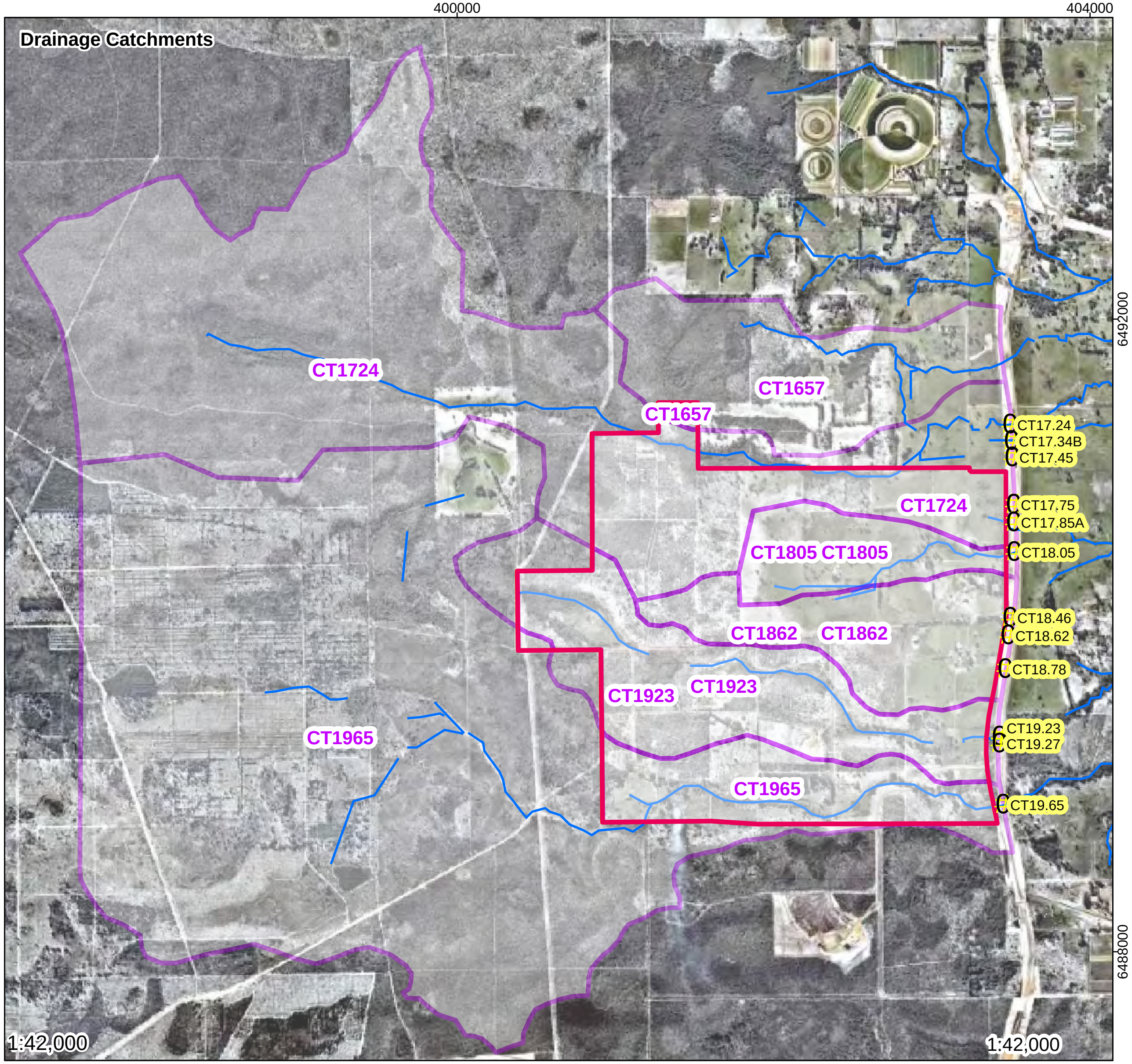


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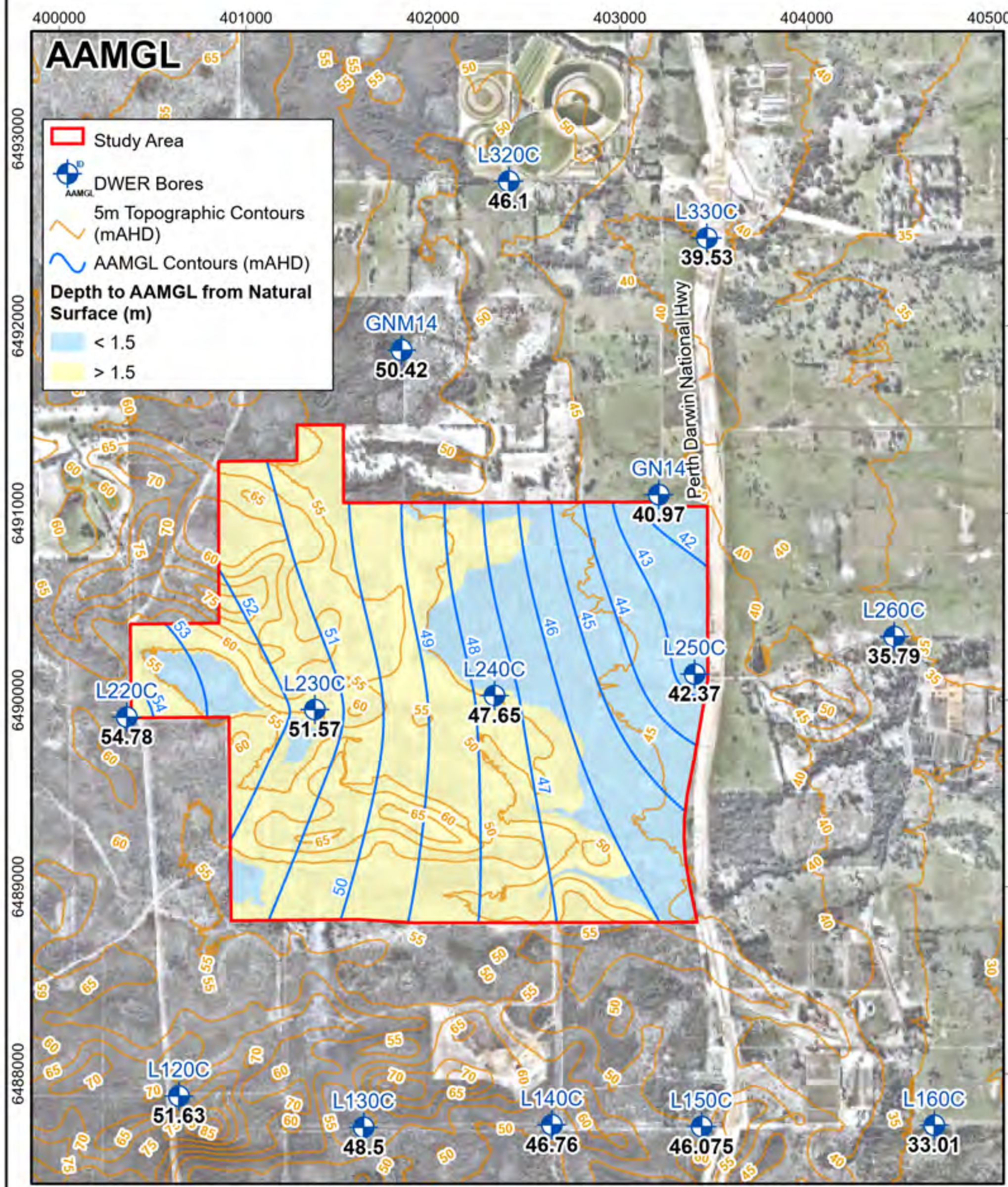
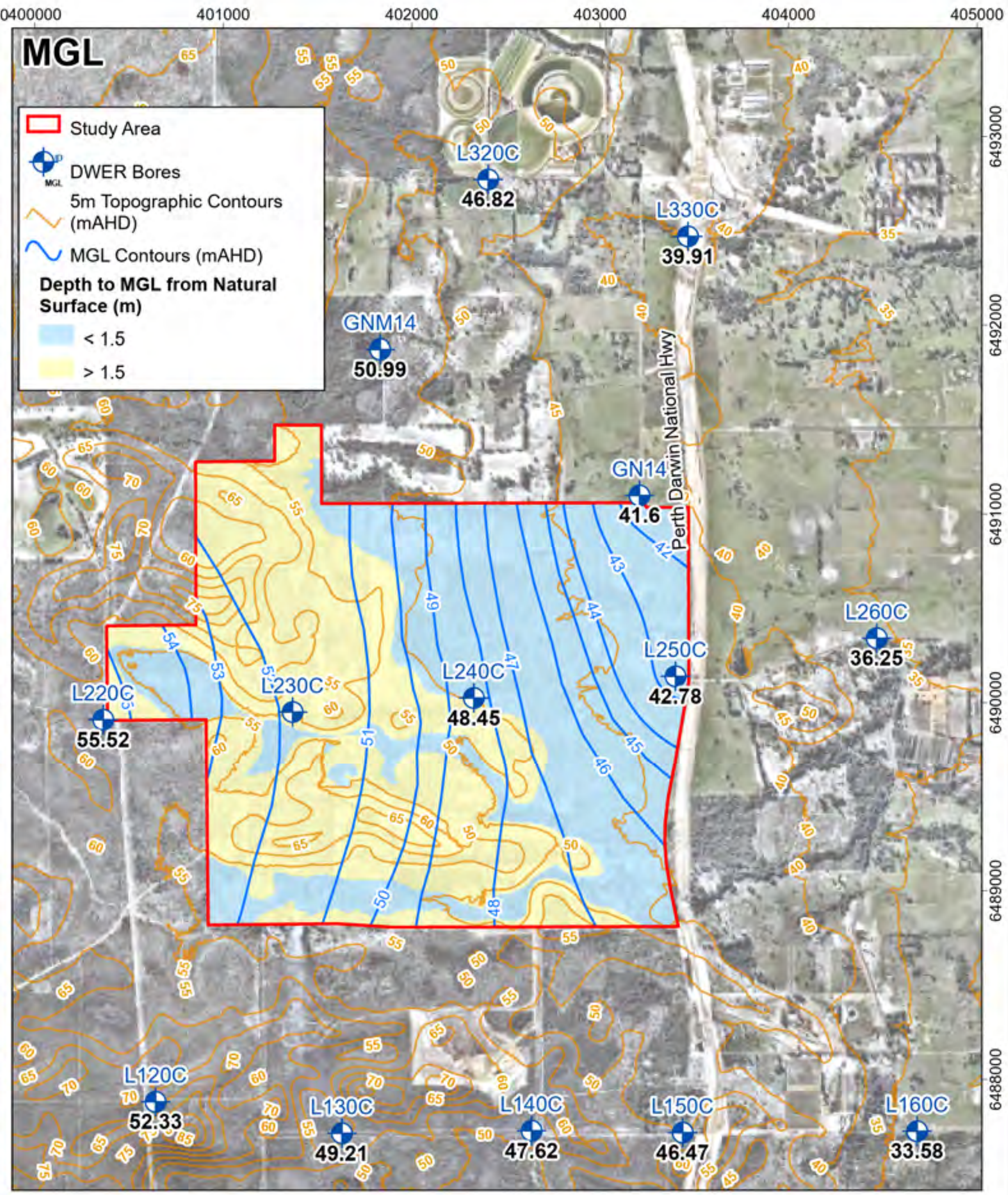
Figure 7: Surface Water Catchments and Pre-Development Flows





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North Ellenbrook (West) - District Water Management Strategy

Figure 8: Groundwater Contours (AAMGL and MGL)

Study Area

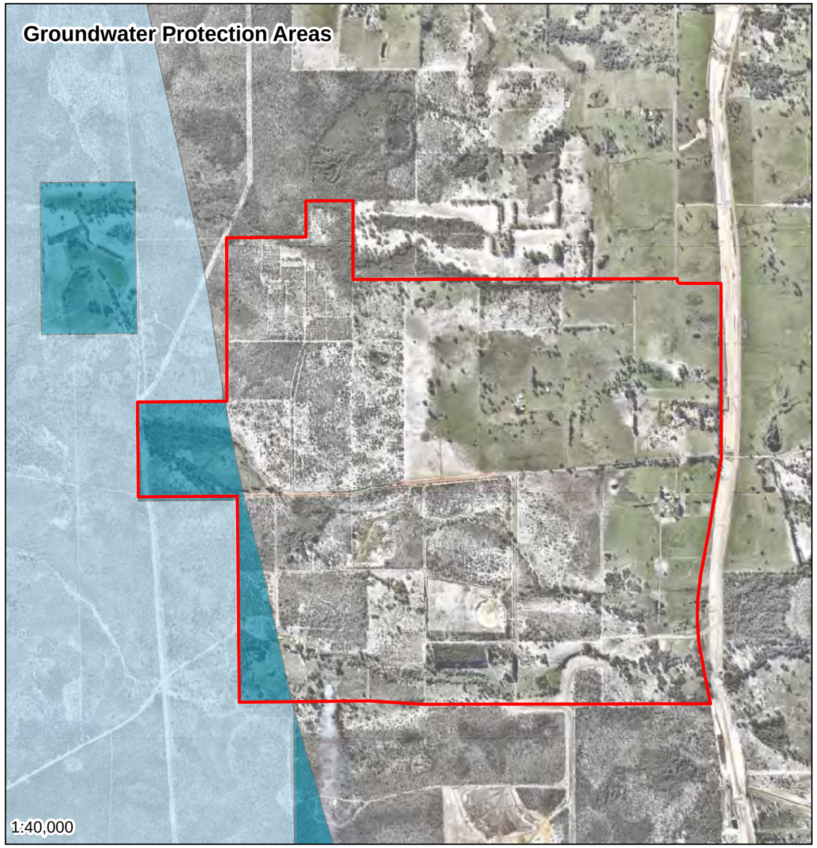
Underground Water Pollution Control Areas

- Priority 1
- Priority 2
- Priority 3
- Current Groundwater Licences

16,670 kL Licence Allocation (kL/yr)

Groundwater Management Subareas

- Neaves
- North Swan
- Gnangara Confined
- Radar



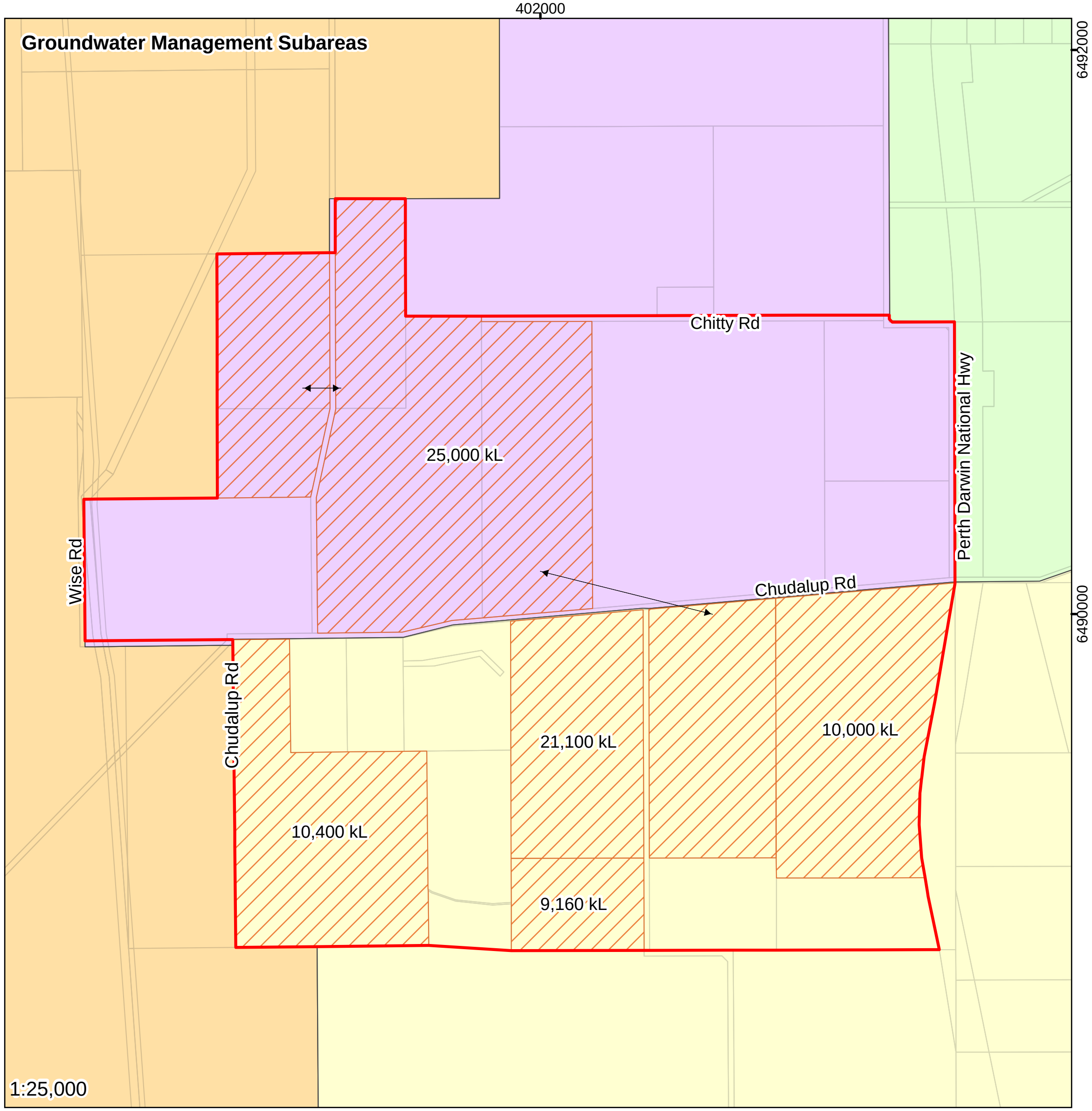


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Figure 9: Groundwater Protection and Management Areas

Study Area

Storage Area

Small Events: First 15 mm Rainfall

Minor Events: 20 % AEP Storm Event

Major Events: 1 % AEP Storm Event

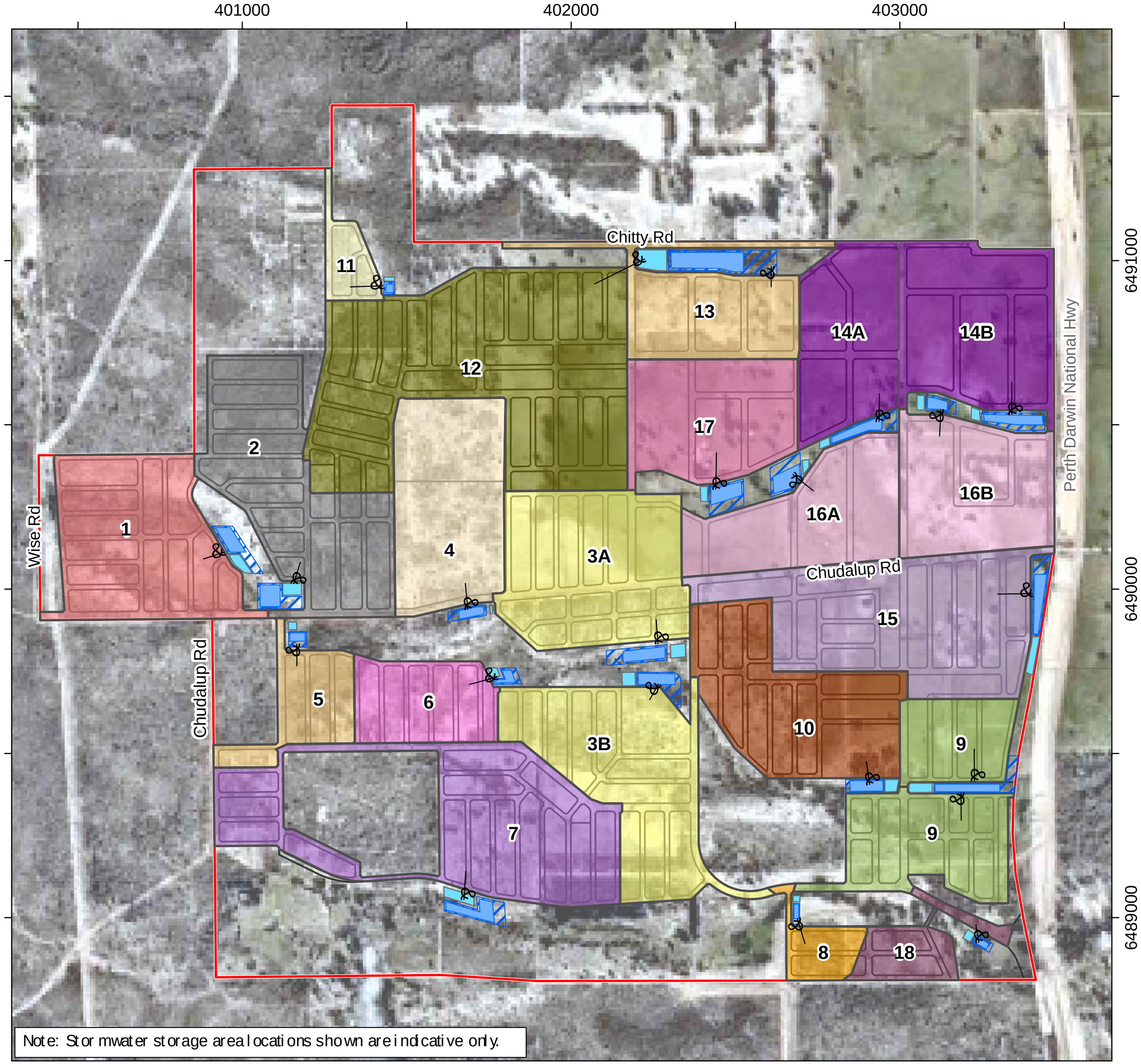
Storage Volume:

Small Event: First 15 mm rainfall to be stored for road impervious area.
Minor Event: Assuming 1 m³ to be stored for per 40 m² impervious area.
Major Event: Assuming 1 m³ to be stored for per 20 m² impervious area.

Storage Area:

Small Event: Bioretention Storage Area calculated assuming 0.5 m average water depth.
Minor and Major Event: Detention Storage Area calculated assuming 1.0 m average water depth.

Catchment	Required Water Storage Volume (m^3)			Storage Area (m^2)		
	Small Event	Minor Event	Major Event	Small Event	Minor Event	Major Event
1	930	3,600	7,300	1,900	3,600	7,300
2	1,000	4,000	8,100	2,000	4,000	8,100
3A	890	4,300	8,500	1,800	4,300	8,500
3B	820	3,700	7,400	1,600	3,700	7,400
4	90	1,900	3,800	180	1,900	3,800
5	290	1,200	2,400	590	1,200	2,400
6	350	1,500	3,000	700	1,500	3,000
7	1,300	4,700	9,400	2,600	4,700	9,400
8	180	600	1,200	350	600	1,200
9	950	4,400	8,900	1,900	4,400	8,900
10	710	3,300	6,500	1,400	3,300	6,500
11	210	600	1,200	420	600	1,200
12	1,800	7,400	15,000	3,500	7,400	15,000
13	730	3,700	7,300	1,500	3,700	7,300
14A	360	4,000	8,000	710	4,000	8,000
14b	760	5,400	11,000	1,500	5,400	11,000
15	1,200	4,700	9,000	2,400	4,700	9,000
16A	320	4,400	8,800	630	4,400	8,800
16B	470	4,400	8,900	950	4,400	8,900
17	450	4,300	8,700	900	4,300	8,700
18	320	850	1,700	630	850	1,700
Total (21)	14,130	72,950	146,100	28,160	72,950	146,100



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Scale: 1:20,000 @A4

0 200 400 600 800 Metres

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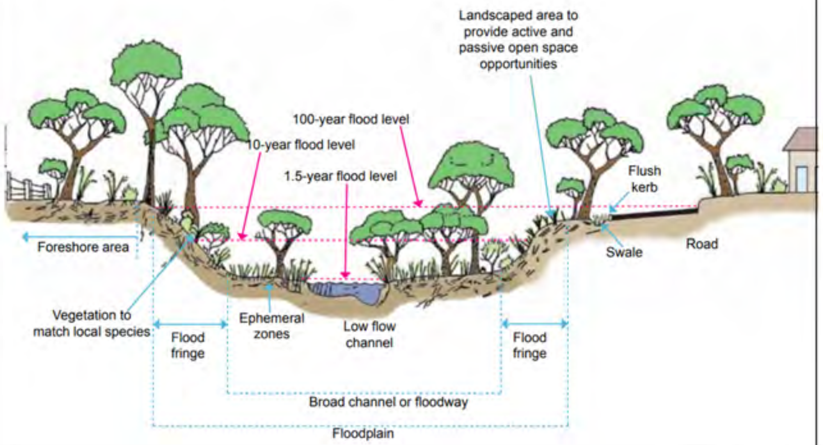
Conoble Park Pty Ltd

North Ellenbrook (West) - District Water Management Strategy

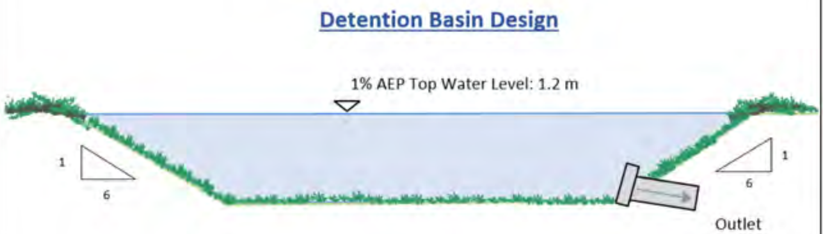
Figure 10: Post Development Catchment Plan

Typical Living Stream Cross Section



Source: DoW (2011)

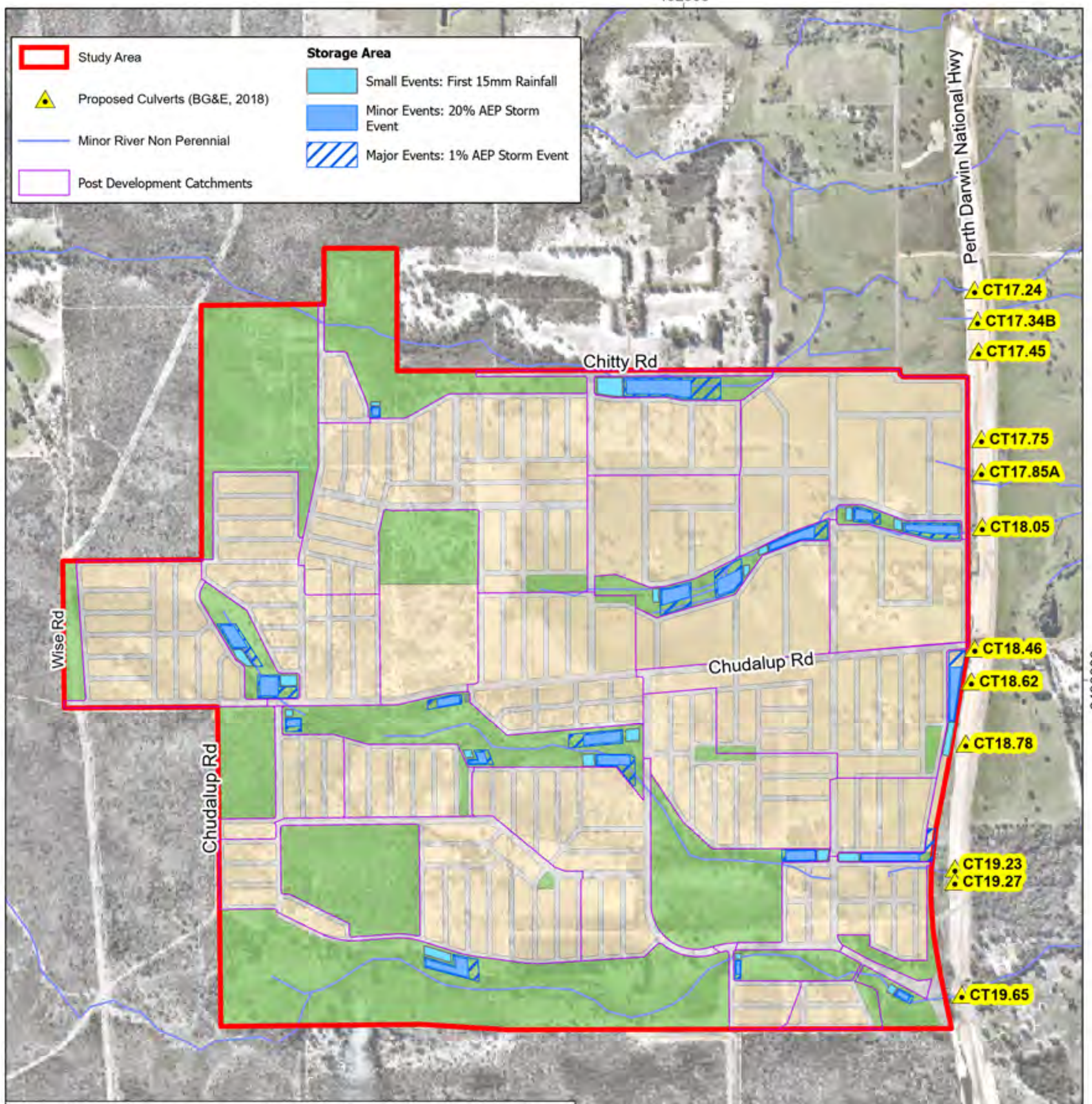
Detention Basin Design Criteria



Design Criteria:

- Side slopes below Top Water Level (TWL) no steeper than 1:6
- Maximum depth of 1.2m for events between 0.2 EY and 1% AEP
- Maximum time of water after rainfall event not exceeding 96hrs
- Minimum 300mm freeboard between TWL of 1% AEP rainfall event and nearest building habitable floor level

Source: IPWEA (2017)



Note: Stormwater storage area locations shown are indicative only.

Data Source: Nearmap (2018), DoW (2011), IPWEA (2017)

Coordinate System: GDA 94, Zone 50

JDA

Job No. J6636

1:25,000

0 250 500 1,000 1,500 Metres

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North Ellenbrook (West) - District Water Management Strategy

Figure 11: Stormwater Management

APPENDIX A

DWMS Checklist

Appendices

Appendix 1 – District water management strategy guide

Use the guide below to assist with the completion of the DWMS. Tick the box where items have been met. If the item is not applicable to the DWMS, include N/A with explanation in the notes column. Provide any other relevant comments briefly in the notes column.

District water management strategy item	☑	Notes
Executive summary		
Describe proposed water management objectives and how the objectives will be met.	☒	Chapter 1 and Table 1
Planning background and previous studies		
Map the location of the site.	☒	Location or site context plan Figure 1
State which planning document the strategy is supporting.	☒	District structure plan if available Chapters 1.1&1.2, and Figures 2&3
Provide references to the key state and/or local policies, guidelines, strategies and their relevance.	☒	Chapters 1.1, 1.2 & 1.4
Design criteria		
Recognise water management principles, objectives and design criteria.	☒	Chapter 1.4
Design objectives from previous water strategies and/or plans.	☒	Chapter 1.4
Pre-development environment (identification of assets, risks and constraints)		
Describe site characteristics: provide preliminary desktop assessments and/or field investigations (if required)	☒	Include existing data Chapter 2.1
Describe climate.	☒	Description Chapter 2.2 and Figure 4
Describe and map topography, landform and geotechnical conditions.	☒	Aerial photo Geotechnical plan Acid sulfate soil risk mapping Chapters 2.3, 2.4 & 2.5 and Figure 5

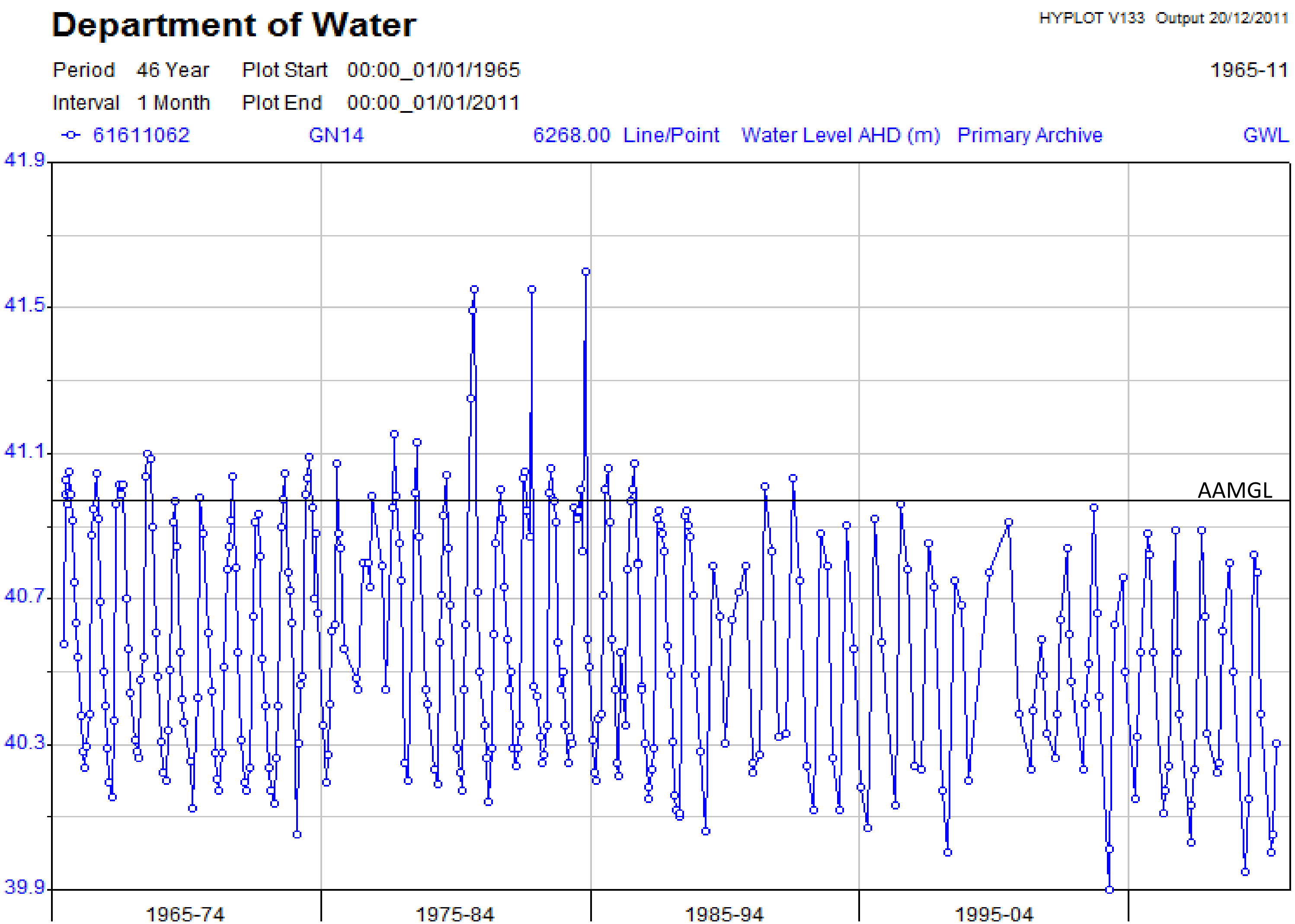
District water management strategy item	☑	**Notes**
Describe the existing land use.	☒	Description Chapter 2.1
Identify environmental assets and their significance.	☒	Environmental plan plus supporting data where available Chapter 2.6 and Figure 6
Detail the social, cultural and heritage considerations.	☒	Chapter 2.10 and Figure 6
Describe the hydrology and hydrogeology of the area: • surface water • groundwater • water-dependent ecosystems • water resource issues.	☒	Surface water hydrology plan Chapters 2.7 & 2.11 and Figure 7 Groundwater and topographic contours plan (or depth to groundwater) Chapters 2.8 & 2.11 and Figure 8 Waterways and wetlands plan Chapters 2.9 & 2.11 and Figure 9 Indicative water balance (pre- and post-development water balances can be presented together – see below) Chapter 3.4
Describe existing drainage infrastructure and other infrastructure likely to affect management of water resources.	☒	Arterial drainage plan (if available) including local drainage Chapter 2.7.2 and Figure 7
Post-development water management		
Identify the proposed broad scale management strategies that will address water resource issues and meet the objectives and design criteria.	☒	Chapters 4.1, 5.1 & 6.4
Calculate an indicative water balance.		Indicative water balance. May be presented as a diagram including pre- and post-development volumes with explanatory notes Chapter 3.4
Describe the impacts to water resources and/or impacts to proposed change in land use from water issues.		Chapters 3, 4 ,5 & 6
Surface water – Estimate land requirements for water management. – Identify water quality issues and scope for improvement. – Describe proposed strategy for management of small, minor and major surface flows.	☒	Include any existing data Chapters 5 & 6, and Figures 10 & 11
Describe groundwater levels, use, management and maintenance.	☒	Include data if available Chapter 4

District water management strategy item	☑	**Notes**
Identify water-dependent ecosystems	☒	Chapters 5.2 & 5.3, and Figures 10 & 11
Identify contamination issues – high risk acid sulfate soils, contaminated sites or areas with historical high nutrient and/or non-nutrient contaminants.	☒	Include data or plans if available Chapter 5.4
Water services and efficiency initiatives		
Describe potable water supply – options including details of technical, environmental and regulatory feasibility – regulatory approvals, technical investigations and any obtained written approvals – recommendations for water efficiency and conservation	☒	Written evidence if obtained Chapters 3.1.1 and 3.3
Identify wastewater servicing – options including preferred option, location, treatment process, level of treatment, disposal, buffers and infrastructure – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	☒	Written evidence if obtained Chapter 3.2
Identify non-potable (fit-for-purpose) water supply – non-potable water source options. Highlight preferred option with consideration of pre and post development water balance – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	☒	Written evidence if obtained Chapters 3.1.2 and 3.3

District water management strategy item	☑	**Notes**
Implementation framework		
Describe commitments and obligations for the next stage of the planning process (e.g. LWMS). Identify issues that need specialised investigation and management for the subsequent LWMS. Make recommendations for implementing the DWMS.	☒	Commitments and obligations may be displayed in table format Chapter 7

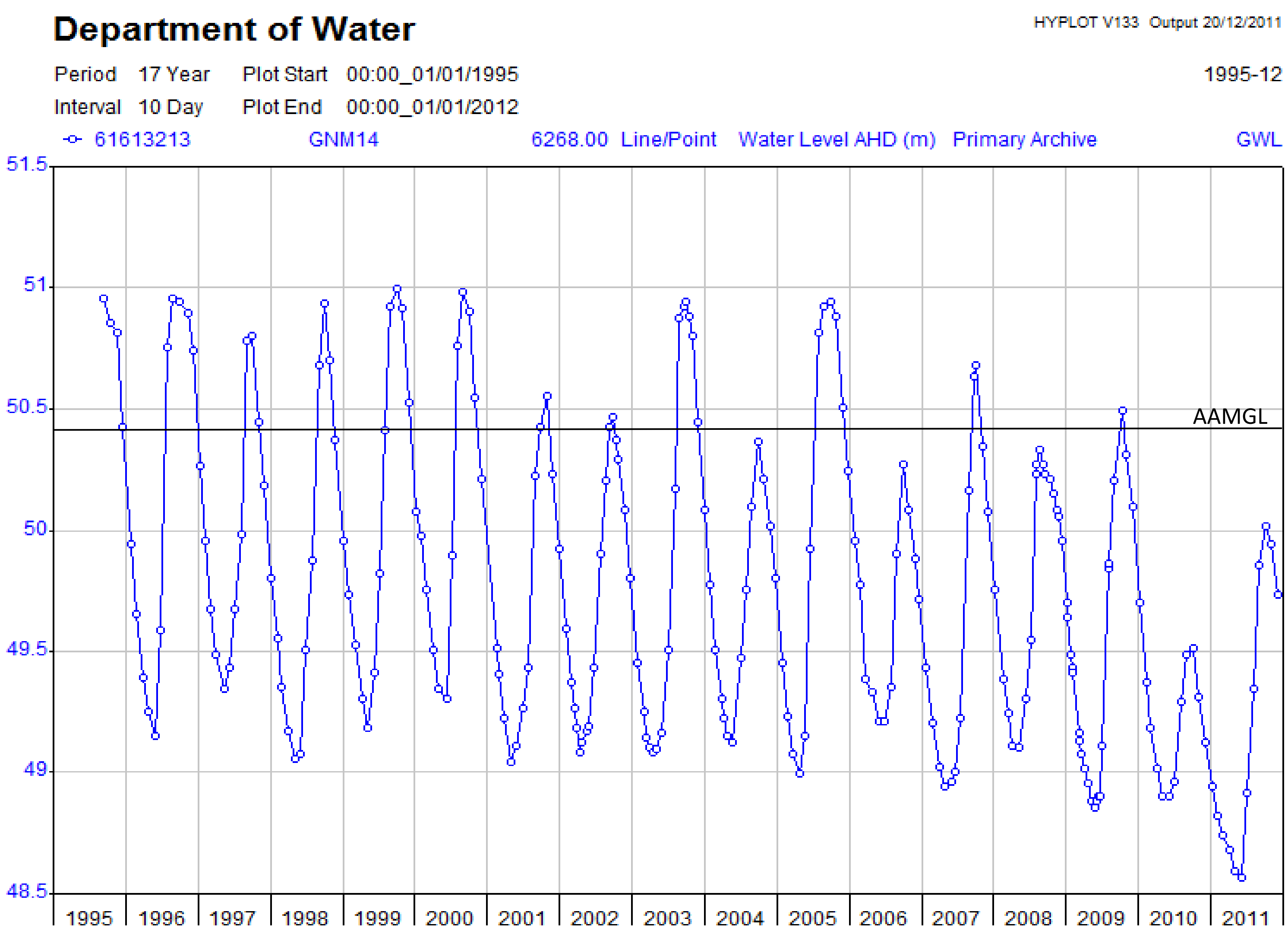
APPENDIX B

DWER Bore Hydrographs



Data Source: Water Information Reporting (2021).

JDA	Job No. J6636 © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2021	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B1: DWER Bore GN14 (61611062) and AAMGL**



Data Source: Water Information Reporting (2021).

Job No. J6636	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B2: DWER Bore GNM14 (61613213) and AAMGL**

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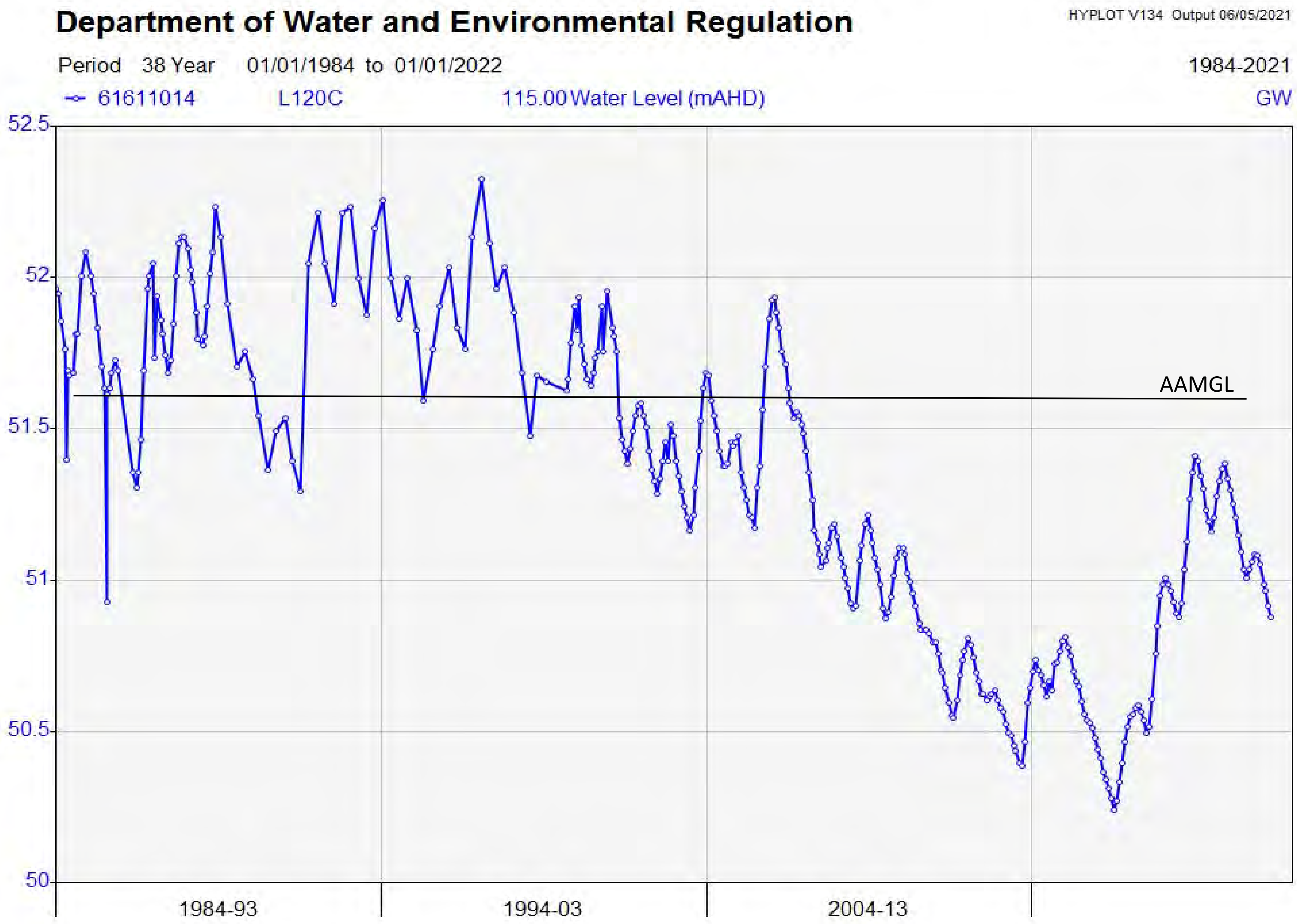

Data Source: Water Information Reporting (2021).

Job No. J6636

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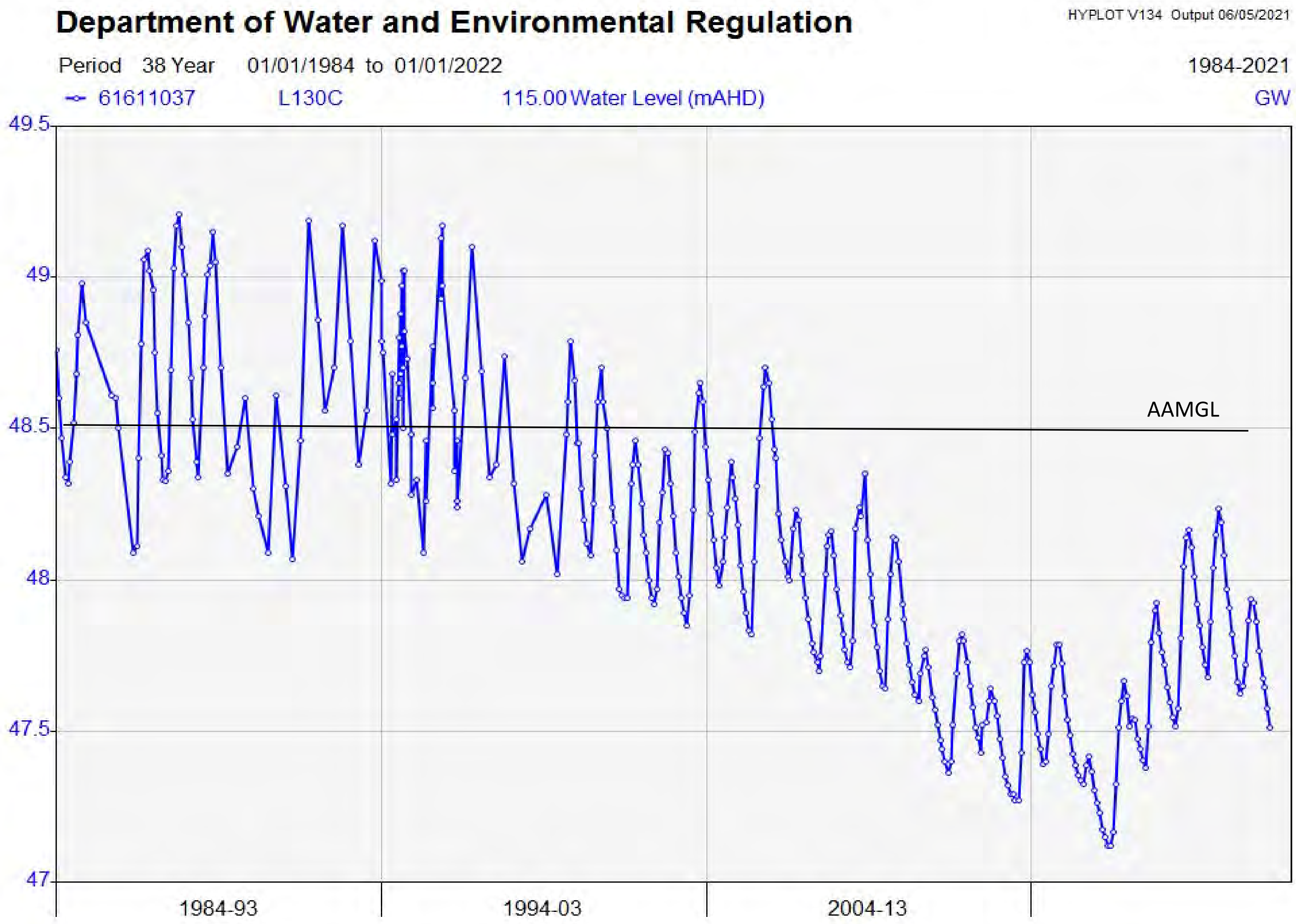
North Ellenbrook (West) – District Water Management Strategy

Appendix B3: DWER Bore L120C (61611014) and AAMGL



Data Source: Water Information Reporting (2021).

JDA Consultant Hydrologists	Job No. J6636	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B4: DWER Bore L130C (61611037) and AAMGL**

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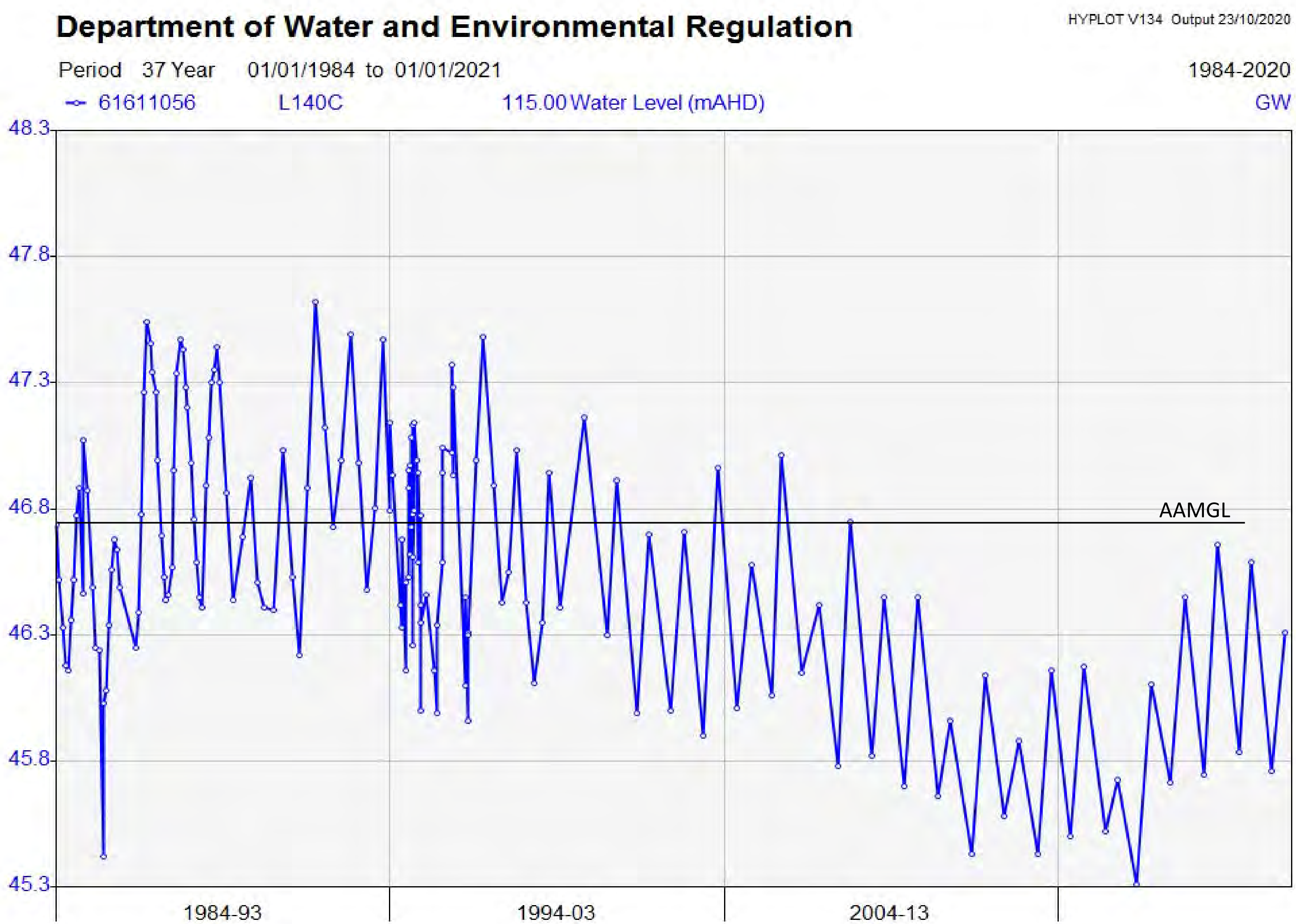

Data Source: Water Information Reporting (2021).

JDA Consultant Hydrologists	Job No. J6636	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B5: DWER Bore L140C (61611056) and AAMGL**

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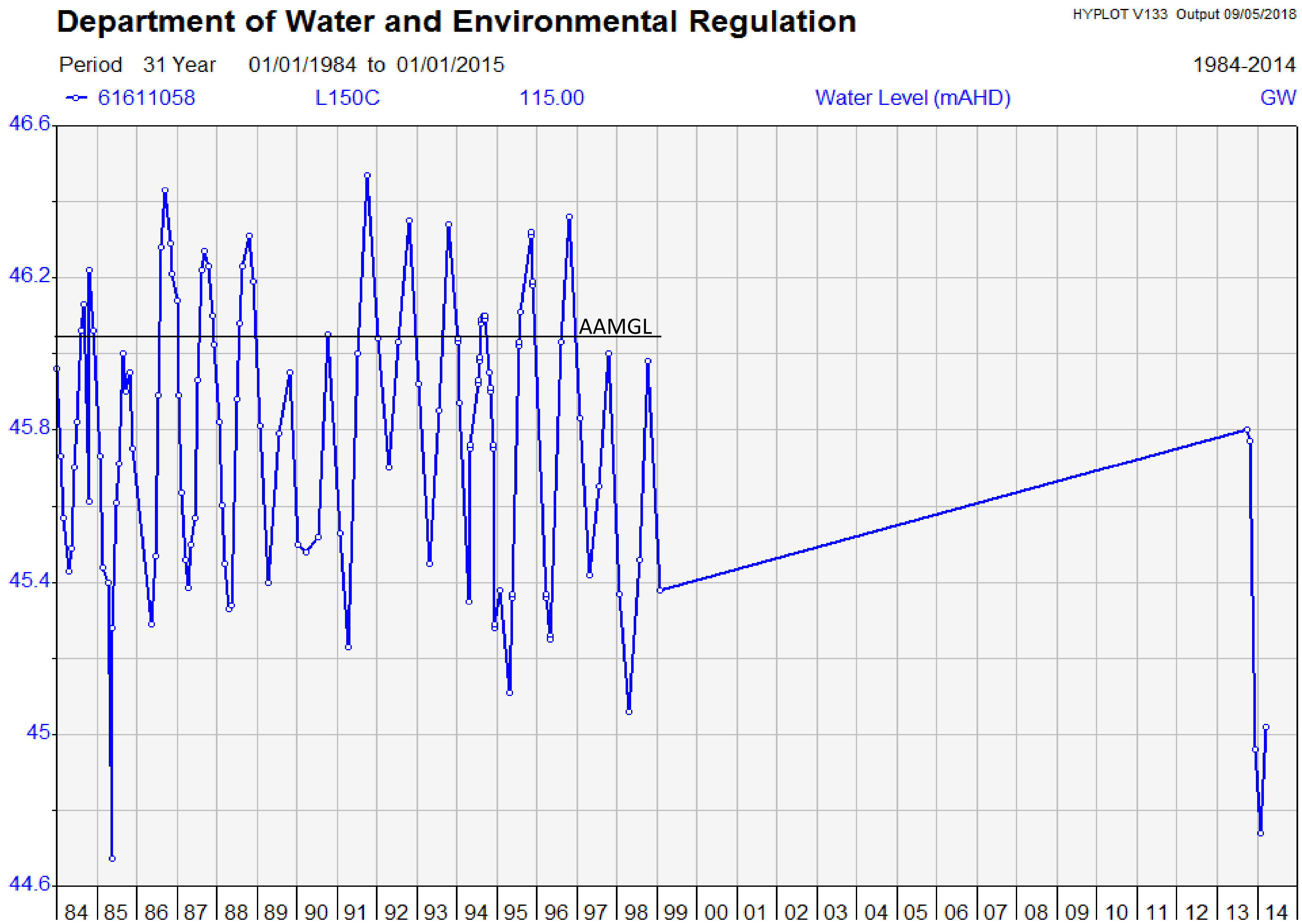

Data Source: Water Information Reporting (2021).

Job No. J6636

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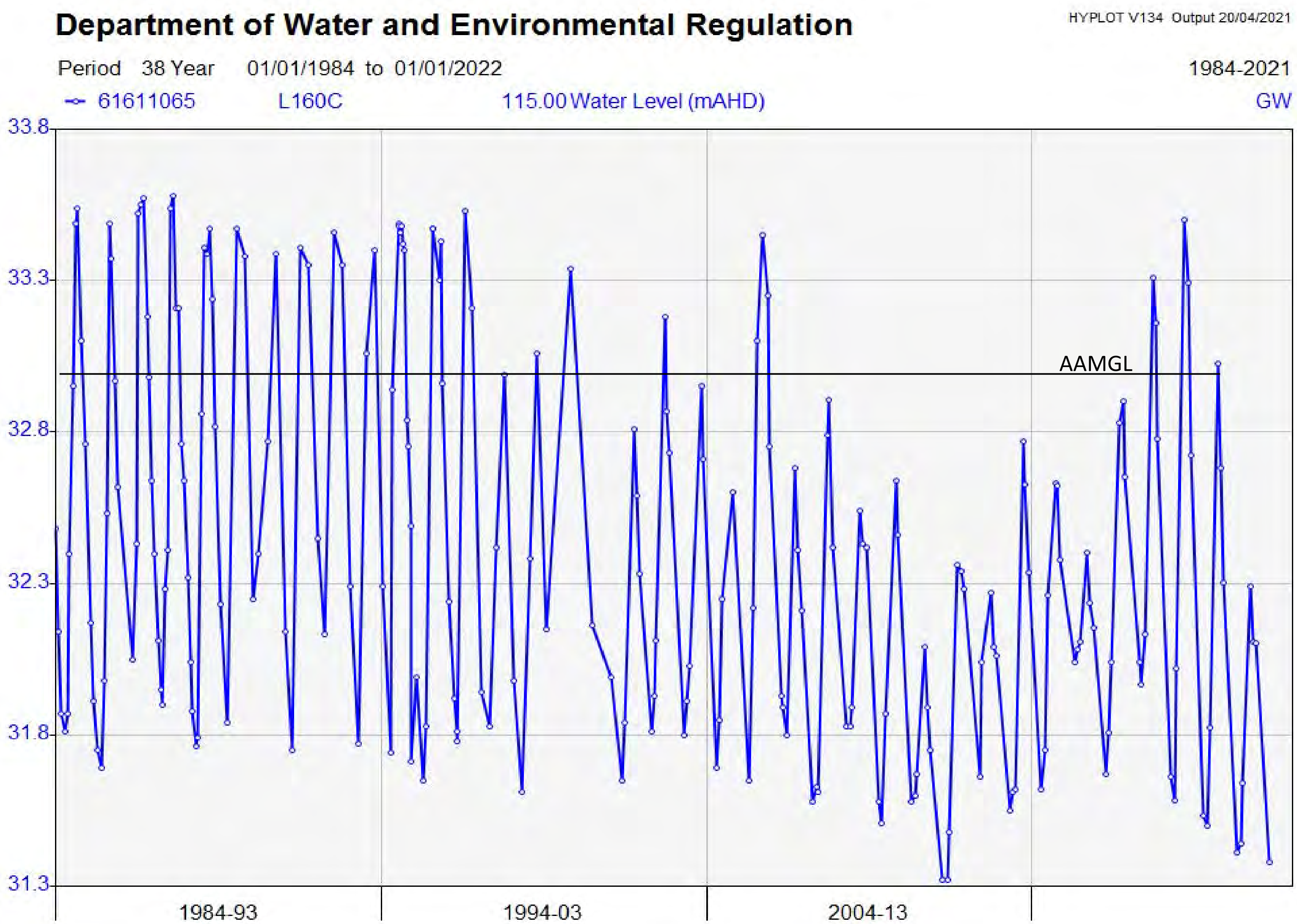
North Ellenbrook (West) – District Water Management Strategy

Appendix B6: DWER Bore L150C (61611058) and AAMGL



Data Source: Water Information Reporting (2021).

Job No. J6636

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North Ellenbrook (West) – District Water Management Strategy

Appendix B7: DWER Bore L160C (61611065) and AAMGL

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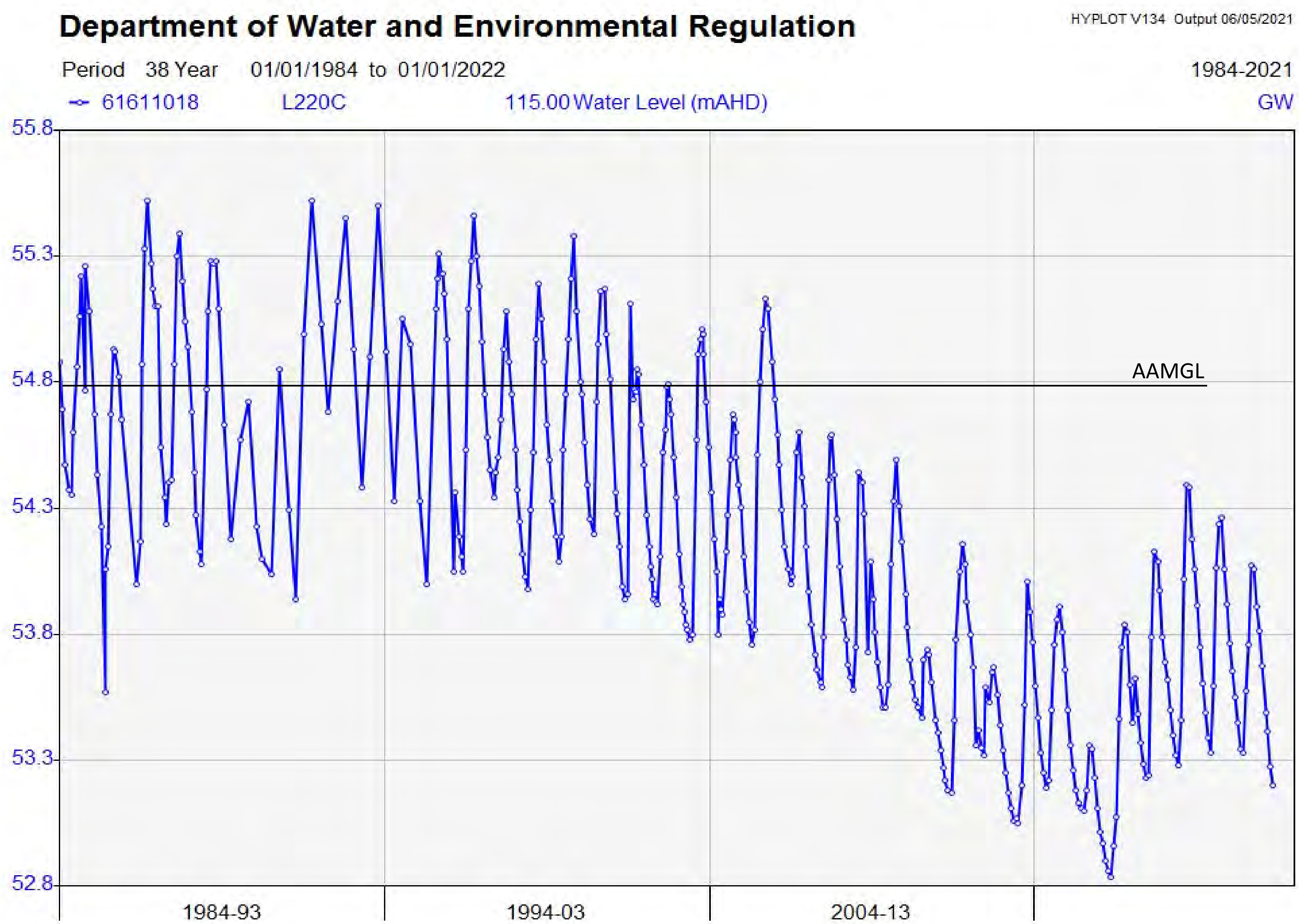

Data Source: Water Information Reporting (2021).

JDA Consultant Hydrologists	Job No. J6636	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B8: DWER Bore L220C (61611018) and AAMGL**

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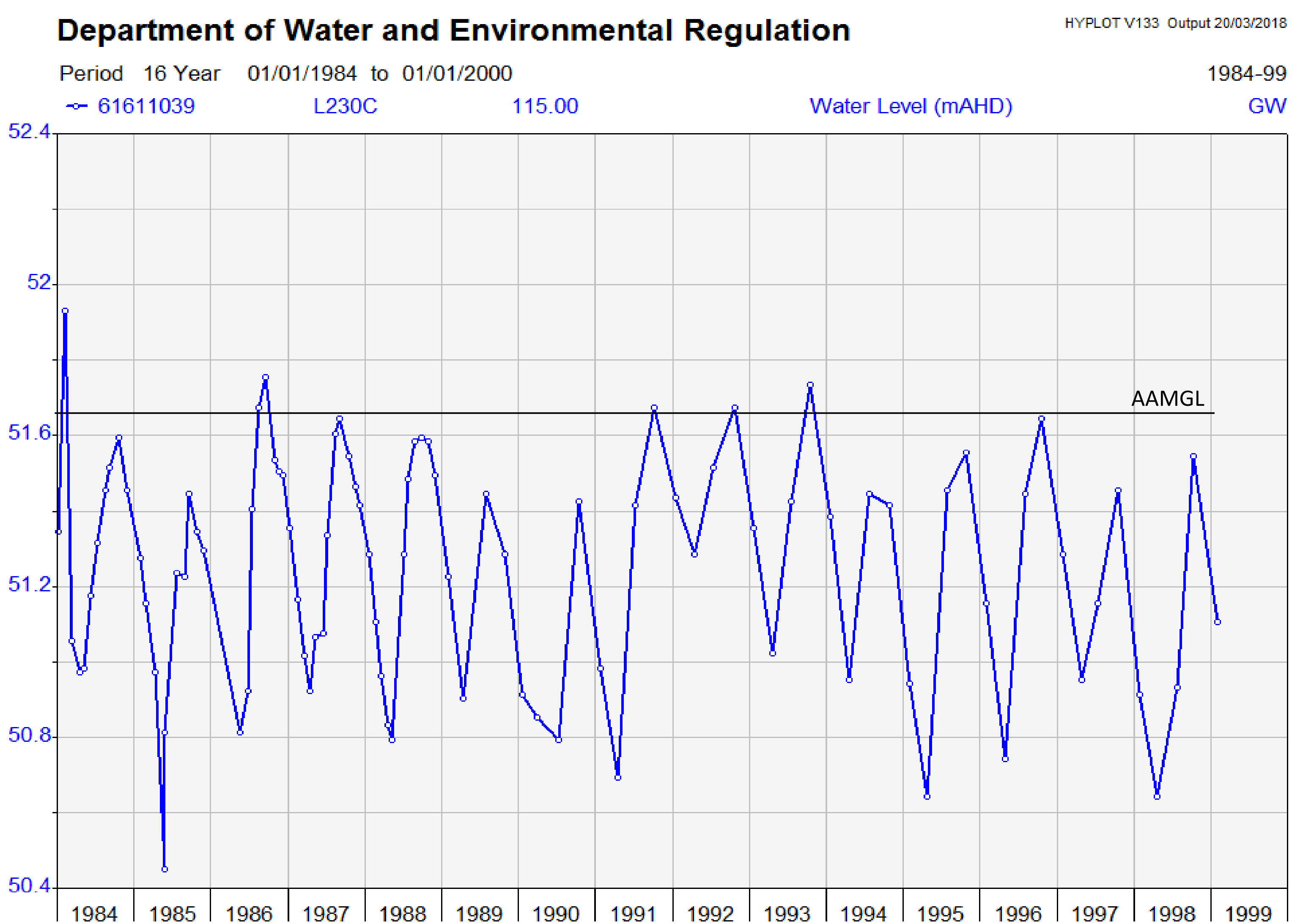
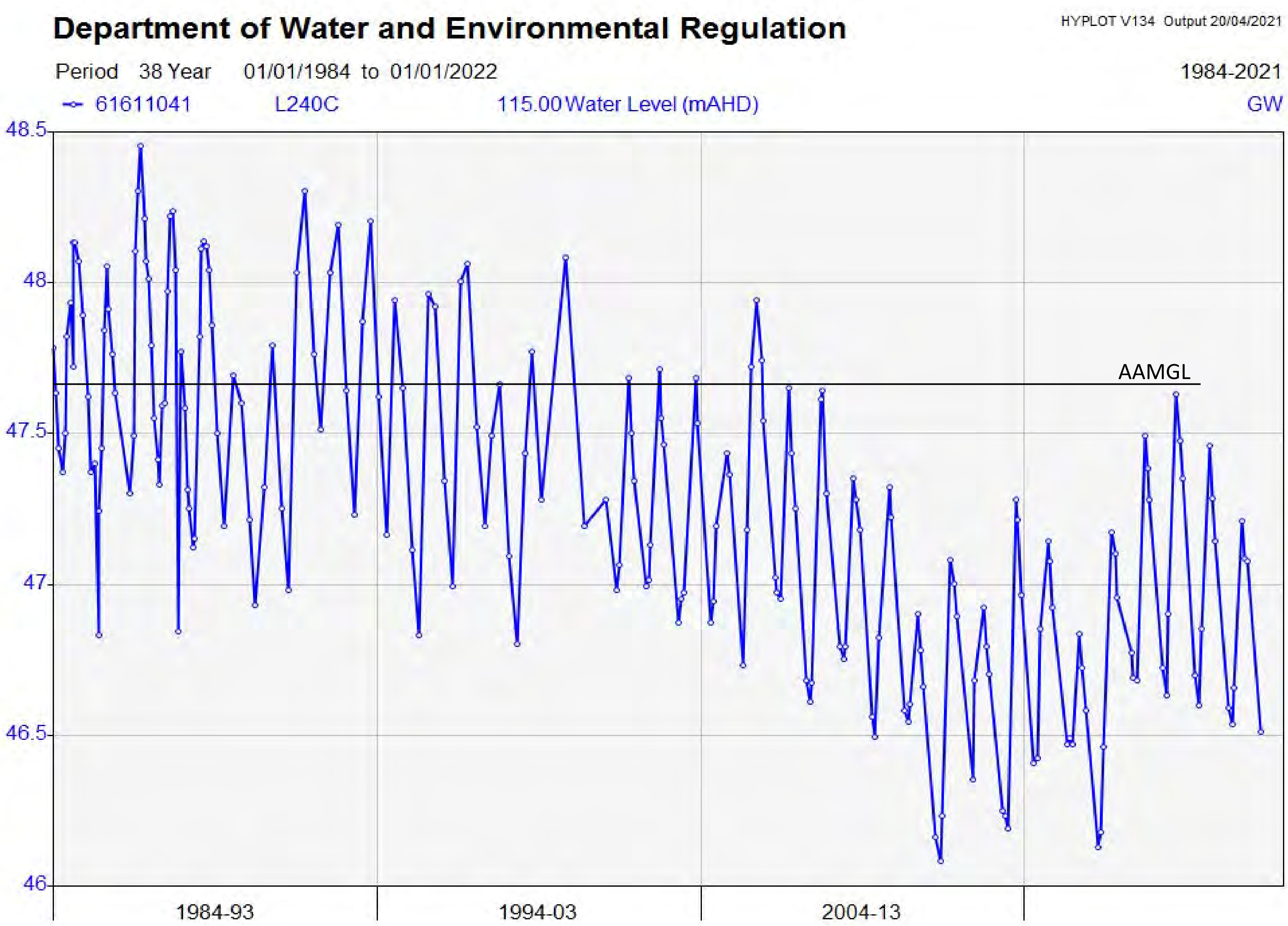


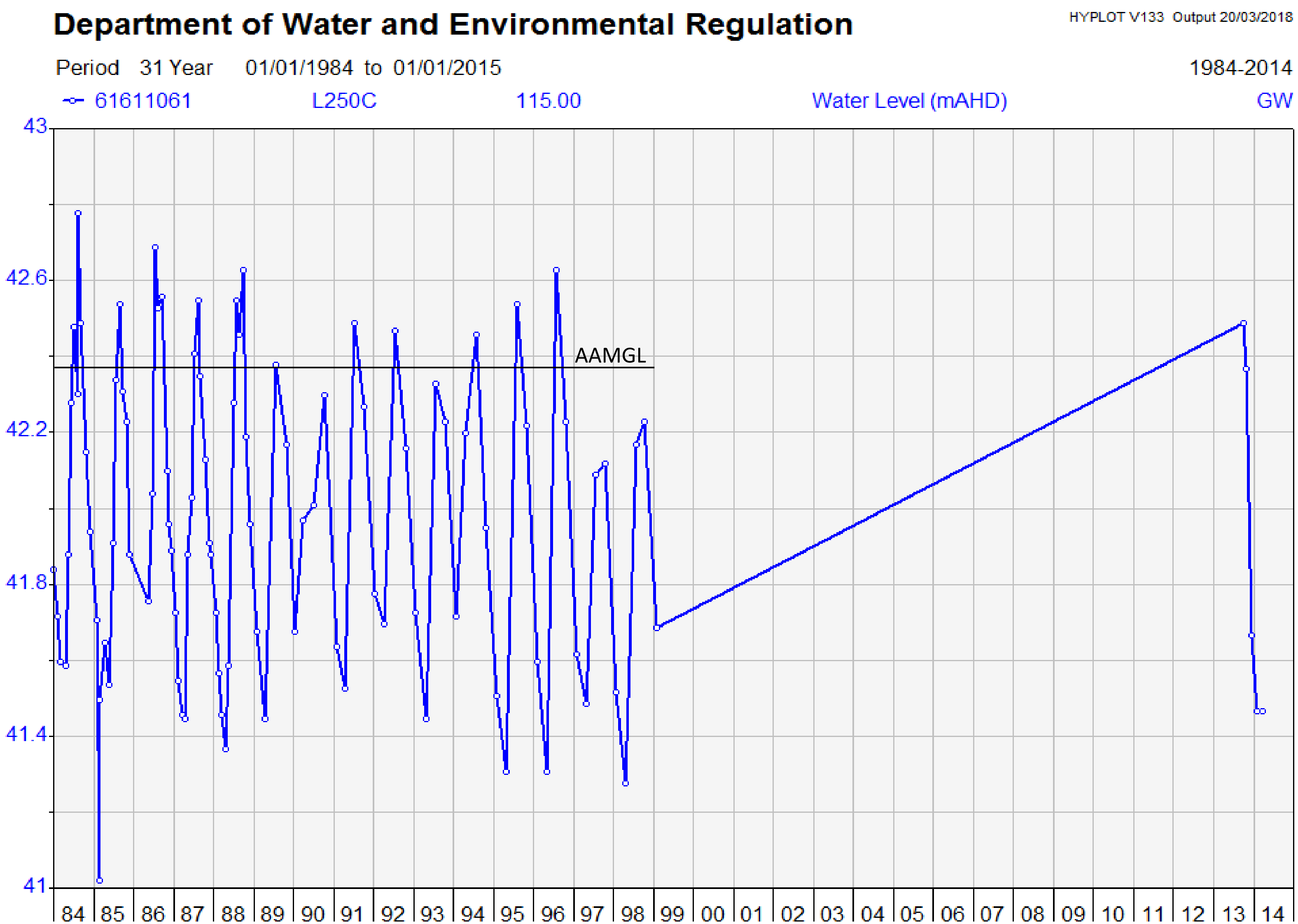
Data Source: Water Information Reporting (2021).

JDA	Job No. J6636 © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2021	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B9: DWER Bore L230C (61611039) and AAMGL**



Data Source: Water Information Reporting (2021).

JDA Consultant Hydrologists	Job No. J6636 © COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2021	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B10: DWER Bore L240C (61611041) and AAMGL**



Data Source: Water Information Reporting (2021).

JDA	Job No. J6636	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B11: DWER Bore L250C (61611061) and AAMGL**

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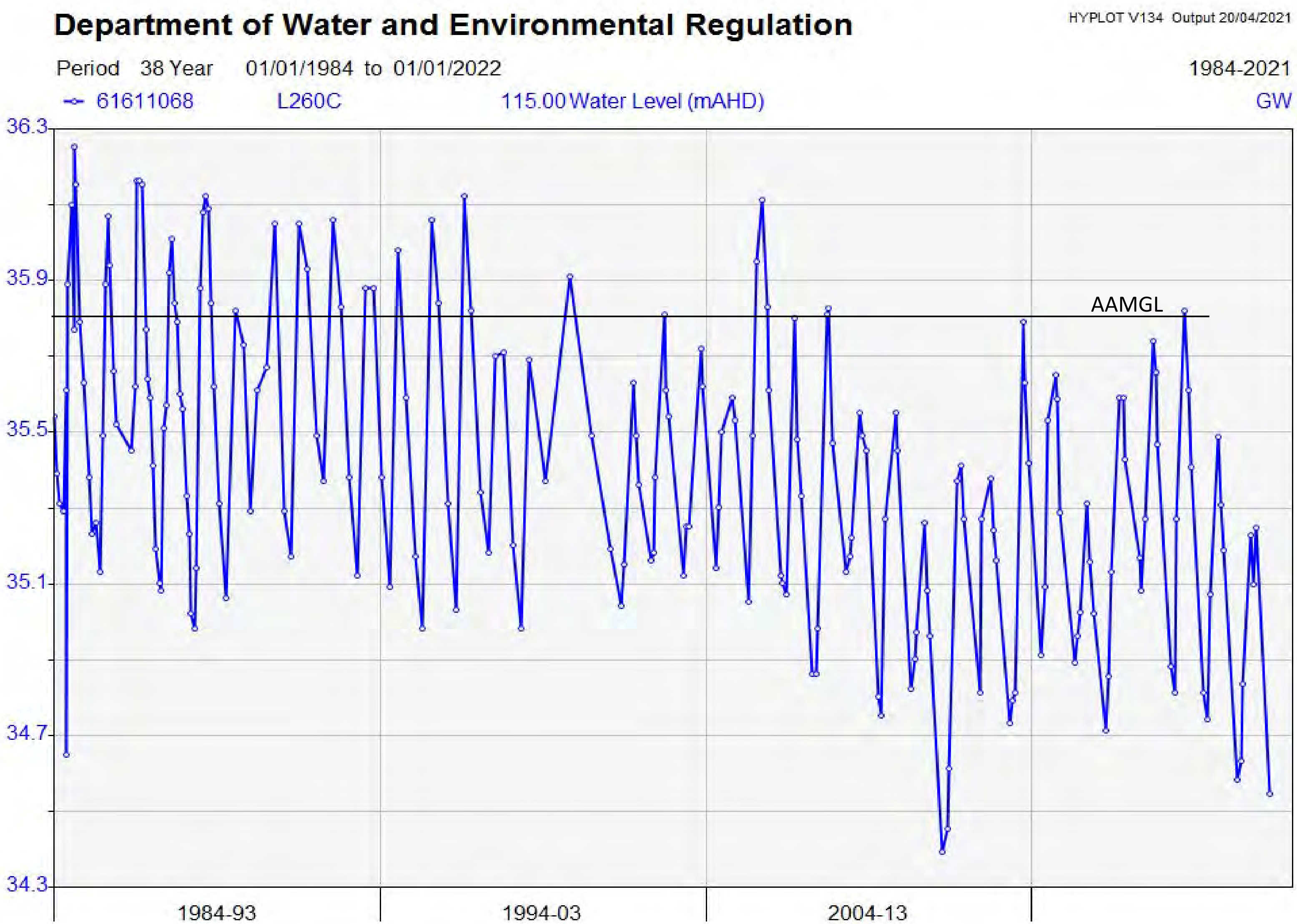

Data Source: Water Information Reporting (2021).

JDA Consultant Hydrologists	Job No. J6636	Conoble Park Pty Ltd North Ellenbrook (West) – District Water Management Strategy **Appendix B12: DWER Bore L260C (61611068) and AAMGL**

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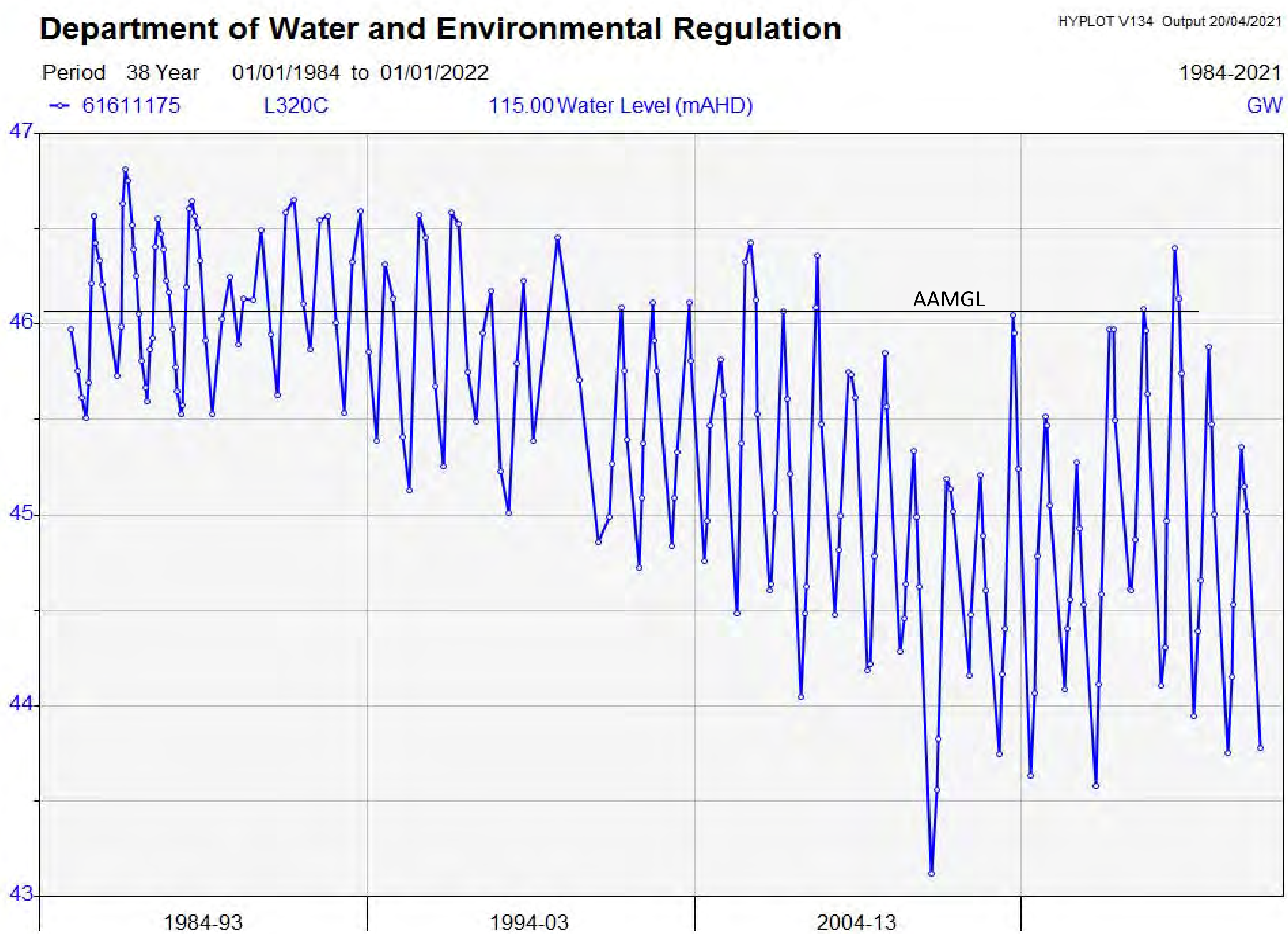

Data Source: Water Information Reporting (2021).

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North Ellenbrook (West) – District Water Management Strategy

Appendix B13: DWER Bore L320C (61611175) and AAMGL

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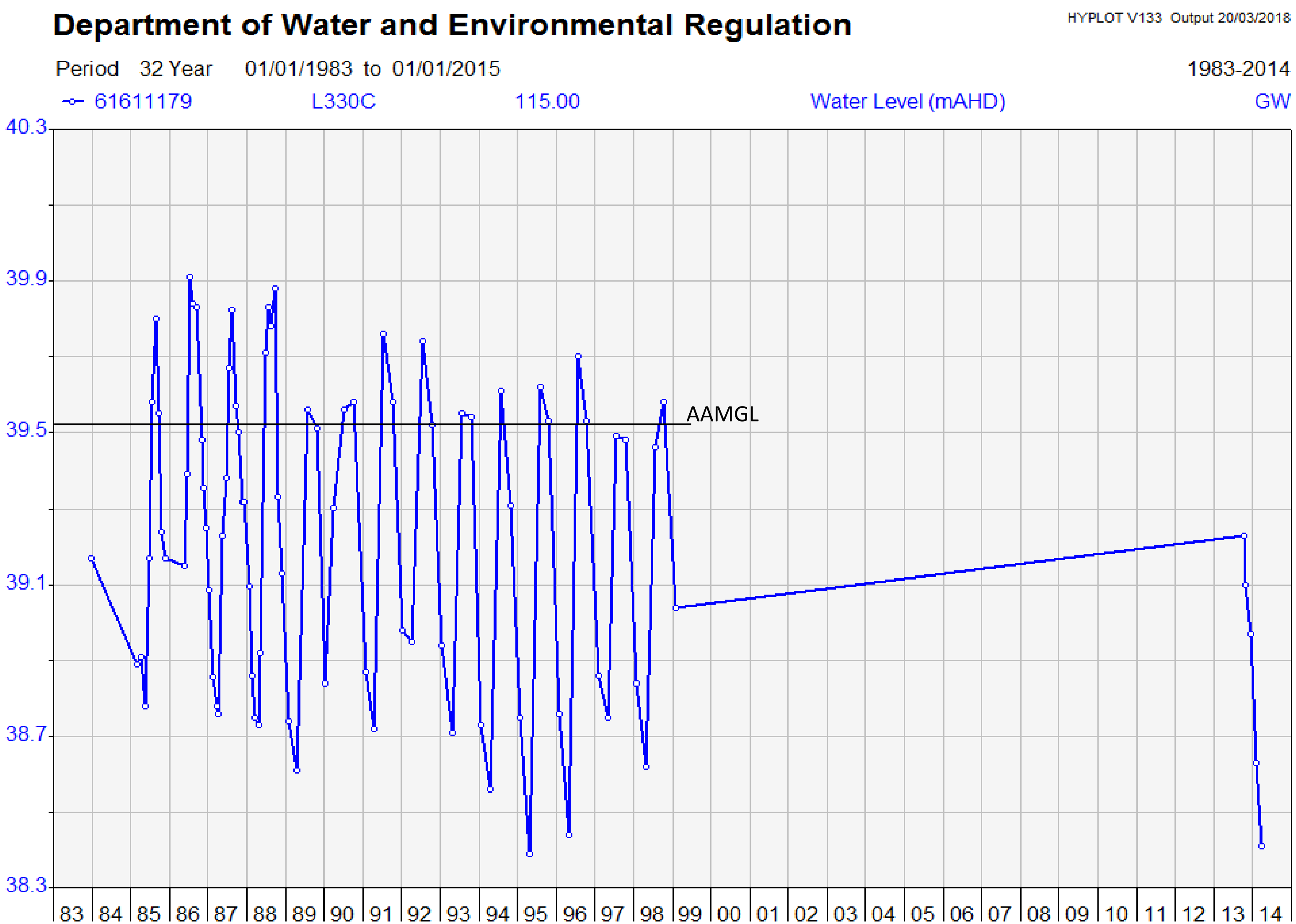

Data Source: Water Information Reporting (2021).

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North Ellenbrook (West) – District Water Management Strategy

Appendix B14: DWER Bore L330C (61611179) and AAMGL

APPENDIX C

Concept Landscape Plan (EPCAD, 2021)

Legend

Active Amenity POS

POS 1 2 9

These active parks contain larger turf areas for kickabout, play, fitness equipment, shade, family picnic area. They will contain an entry statement and more formal landscaping which appropriately introduces and welcomes visitors to the estate.

POS 6

This District Open Space will contain large open turf areas for active amenity and a football oval which can be used by the nearby schools. It will also contain play, fitness equipment, fitness circuit and family picnic areas.

POS 3 4 5 7

These medium to small POS with active amenity, contain smaller turf kickabout areas, play, shade and family picnic areas.

Passive Amenity & Rehabilitation POS

POS 10 11

These linear POS predominantly function as drainage swales with some passive amenity and opportunities for interpretation and elevated decks overlooking the POS.

POS 14 16

These large POS will primarily contain retained vegetation and topography with some smaller areas of active amenity space positioned towards the fringes of the POS. Degraded areas will be rehabilitated through revegetation and access control by fencing. Footpaths provide gentle, meandering walks with shaded rest points and seating. These will follow the existing watercourse in places and contain boardwalks, bridges, view decks, interpretive/wayfinding signage and opportunities for integrated public art/sculpture trails. The existing creeks and watercourses will be used to accomodate stormwater drainage. Road and pedestrian crossing points will form attenuation points to create required storage behind them. Where abutting a school site the POS will provide educational opportunities such as the creation of outdoor classrooms.

POS 15

This POS will primarily contain retained vegetation and topography with some smaller areas of active amenity space positioned towards the fringes of the POS. Rehabilitation through revegetation of degraded areas. Informal footpaths provide gentle, meandering walks up to lookouts placed at strategic viewpoints which take advantage of existing elevated topography. Shaded rest points with seating, wayfinding signage and opportunities for integrated public art.

POS 17

This POS will primarily contain retained vegetation and topography. Rehabilitation through revegetation of degraded areas. Informal footpaths provide gentle, meandering walks and cycle routes. Shaded rest points with seating, wayfinding signage and integrated public art.

POS 18

This POS will contain retained vegetation and drainage areas integrated with the exisitng watercourse. Degraded areas will be rehabilitated through revegetation and access control by fencing. Footpaths provide gentle, meandering walks with shaded rest points and seating. These will follow the existing watercourse in places and contain boardwalks, bridges, view decks, interpretive/wayfinding signage and opportunities for integrated public art/sculpture trails. Pedestrian crossing points will form attenuation points to create required storage behind them.

Passive Amenity, Rehabilitation & Aboriginal Heritage Zone - (POS contains or is likely to contain registered aboriginal cultural heritage places and landforms)

POS 20 21

Largley passive amenity spaces these POS will contain retained vegetation, topography with some intermittent areas of active amenity space. Footpaths provide gentle, meandering walks with shaded rest points and seating. Where abutting a school site the POS will provide educational opportunities such as the creation of outdoor classrooms. Any proposed landscaping treatment would be subject to significant consultation with local aboriginal people.

POS 19 22 23

Passive amenity spaces which contain retained vegetation and topography. Footpaths provide gentle, meandering walks with shaded rest points and seating. Any proposed landscaping treatment would be subject to significant consultation with local aboriginal people.

Conservation POS

POS 12 24 25 26

Areas to be rehabilitated in accordance with native vegetation clearing permit condition requirements.

General

All the active and passive parts of the parks are commonly surrounded by a multi-tiered structure of tree and shrub planting. Parks are designed using sound water sensitive design practice and all planting is native or native derivative shrub species with a combination of native trees and feature ornamental trees that are recognised as 'one drop' or 'two drop' species in the Water Corporation 'Waterwise Guide to Gardening'. Wherever possible, hard surfaces or low water alternatives are used instead of turf, with grass being limited to' run around' based activity within the parks. Water harvesting is also exploited wherever possible using swales, weirs, channels and ground amendment to reduce the need for overall water consumption. Banksia Woodland within POS will be retained insitu where possible and viable.

North Ellenbrook (West) Landscape Masterplan - Rev C

0 100 150 200 300m

SCALE nts

N

scale : nts @ A1

date : 24 May 2021

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EPCAD

APPENDIX D

Nutrient Input Analysis using NiDSS Model

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005 - OTH 1.01

JDA Consultant Hydrologists

Report Date : 14-Sep-18

Ellenbrook North Landowners	
Total Nutrient Input - No WSUD (kg/yr)	**8,145**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

◉ Total Phosphorus
○ Total Nitrogen

Catchment Name	Ellenbrook North Landowners	
Option Description	Pre-development scenario	
Catchment Area	905	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	0.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	55.0%	native vegetation
Rural : Pasture	45.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	**0.0%**
Total Area	**100.0%**

Nutrient Input Without WSUD

Residential	Garden	29.70	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	14.00		0.00		0		0.0%
	Pet Waste	3.96		0.00		0		0.0%
	Car Wash	0.13		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	20.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	20.00	kg/ha Rural/yr	9.00	kg/gross ha/yr	8,145	kg/yr	100.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			9.00		8,145		100.0%
			Total	**9.00**	kg/gross ha/yr	**8,145**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	20%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	20%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	50%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%			
Nutrient Input : Rural Area	9.00	8,145	100.0%			
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**9.00**	**8,145**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005 - OTH 1.01
JDA Consultant Hydrologists
Report Date : 14-Sep-18

Ellenbrook North Landowners	
Total Nutrient Input - No WSUD (kg/yr)	**24,435**
Reduction due to WSUD (kg/yr)	**0**
Percentage Overall Reduction	**0.0%**
Pecentage Development Reduction	**0.0%**
Cost of Selected Program ($/kg/yr)	**$0**

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name	Ellenbrook North Landowners	
Option Description	Pre-development scenario	
Catchment Area	905	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	0.0%	maintainance of verge by landowners		
Road Reserves : Major	0.0%	maintainance of verge by local authority		
POS : Active	0.0%	grassed areas		
POS : Passive / Basins	55.0%	native vegetation		
Rural : Pasture	45.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**0.0%**
Rural : Poultry	0.0%	specific high nutrient input land use	Total Area	**100.0%**
Commercial/Industrial	0.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	64.90	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	92.40		0.00		0		0.0%
	Pet Waste	15.72		0.00		0		0.0%
	Car Wash	0.04		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Minor Roads	132.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Rural	Pasture	60.00	kg/ha Rural/yr	27.00	kg/gross ha/yr	24,435	kg/yr	100.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			27.00		24,435		100.0%
			Total	**27.00**	kg/gross ha/yr	**24,435**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 20%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	20%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	20%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	100%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	50%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	0.00	0	0.0%
Nutrient Input : Rural Area	27.00	24,435	100.0%

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**27.00**	**24,435**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005 - OTH 1.01

JDA Consultant Hydrologists

Report Date : 14-Sep-18

Ellenbrook North Landowners	
Total Nutrient Input - No WSUD (kg/yr)	**22,847**
Reduction due to WSUD (kg/yr)	**18,679**
Percentage Overall Reduction	**81.8%**
Pecentage Development Reduction	**81.8%**
Cost of Selected Program ($/kg/yr)	**$1**

(●) Total Phosphorus
( ) Total Nitrogen

Catchment Name	Ellenbrook North Landowners	
Option Description	Post-development scenario	
Catchment Area	905	ha

Land Use Breakdown

Residential : ~R15	30.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	10.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	15.0%	maintainance of verge by landowners		
Road Reserves : Major	5.0%	maintainance of verge by local authority		
POS : Active	3.0%	grassed areas		
POS : Passive / Basins	7.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**40.0%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	30.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	31.73	kg/net ha/yr	12.69	kg/gross ha/yr	11,484	kg/yr	50.3%
	Lawn	14.88		5.95		5,385		23.6%
	Pet Waste	6.81		2.72		2,464		10.8%
	Car Wash	0.13		0.05		47		0.2%
	Sub Total			21.42		19,381		84.8%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.08	kg/gross ha/yr	71	kg/yr	0.3%
	Pet Waste	23.34		0.70		634		2.8%
	Sub Total			0.78		704		3.1%
Road Reserve	Major Roads	1.04	kg/ha RR/yr	0.05	kg/gross ha/yr	47	kg/yr	0.2%
	Minor Roads	20.00		3.00		2,715		11.9%
	Sub Total			3.05		2,762		12.1%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**25.25**	kg/gross ha/yr	**22,847**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

- [x] Native Gardens (Lots - Garden)
- [x] Native Gardens (Lots - Lawn)
- [x] Native Gardens (POS)
- [ ] Street Sweeping
- [x] Community Education : Fertiliser
- [x] Community Education : Pet Waste
- [ ] Community Education : Car Wash

Education Effectiveness: 33%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	100%	12.69	11,484	50.3%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	100%	5.95	5,385	23.6%	$0	$0	$0.0
Native Gardens (POS)	100%	0.08	71	0.3%	$0	$0	$0.0
Community Education : Fertiliser	100%	0.79	717	3.1%	$0	$4,299	$6.0
Community Education : Pet Waste	100%	1.13	1,022	4.5%	$0	$8,003	$7.8
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**20.64**	**18,679**	**81.8%**	**$0**	**$12,302**	**$0.7**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

- [ ] Gross Pollutant Trap
- [ ] Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	50%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	25.25	22,847	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	20.64	18,679	81.8%	$0	$12,302	$0.7
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	20.64	18,679	81.8%	$0	$12,302	$0.7
Net Nutrient Input	**4.61**	**4,168**	**18.2%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005 - OTH 1.01

JDA Consultant Hydrologists

Report Date : 14-Sep-18

Ellenbrook North Landowners	
Total Nutrient Input - No WSUD (kg/yr)	**94,181**
Reduction due to WSUD (kg/yr)	**70,985**
Percentage Overall Reduction	**75.4%**
Pecentage Development Reduction	**75.4%**
Cost of Selected Program ($/kg/yr)	**$0**

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name Ellenbrook North Landowners
Option Description Post-development scenario
Catchment Area 905 ha

Land Use Breakdown

Residential : ~R15	30.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	10.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	15.0%	maintainance of verge by landowners
Road Reserves : Major	5.0%	maintainance of verge by local authority
POS : Active	3.0%	grassed areas
POS : Passive / Basins	7.0%	native vegetation
Rural : Pasture	0.0%	general pasture
Rural : Residential ~R2.5/R5	0.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	30.0%	town centre etc

Total Residential **40.0%**
Total Area **100.0%**

Nutrient Input Without WSUD

Residential	Garden	69.33	kg/net ha/yr	27.73	kg/gross ha/yr	25,096	kg/yr	26.6%
	Lawn	98.18		39.27		35,539		37.7%
	Pet Waste	27.01		10.80		9,778		10.4%
	Car Wash	0.04		0.01		13		0.0%
	Sub Total			77.82		70,426		74.8%
POS	Garden/Lawn	73.40	kg/ha POS/yr	2.20	kg/gross ha/yr	1,993	kg/yr	2.1%
	Pet Waste	92.61		2.78		2,514		2.7%
	Sub Total			4.98		4,507		4.8%
Road Reserve	Major Roads	29.36	kg/ha RR/yr	1.47	kg/gross ha/yr	1,329	kg/yr	1.4%
	Minor Roads	132.00		19.80		17,919		19.0%
	Sub Total			21.27		19,248		20.4%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
			Total	**104.07**	kg/gross ha/yr	**94,181**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☑ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☐ Street Sweeping
☑ Community Education : Fertiliser ☑ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 33%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	100%	27.73	25,096	26.6%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	100%	39.27	35,539	37.7%	$0	$0	$0.0
Native Gardens (POS)	100%	2.20	1,993	2.1%	$0	$0	$0.0
Community Education : Fertiliser	100%	4.75	4,301	4.6%	$0	$4,299	$1.0
Community Education : Pet Waste	100%	4.48	4,057	4.3%	$0	$8,003	$2.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**78.44**	**70,985**	**75.4%**	**$0**	**$12,302**	**$0.2**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	100%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	50%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	104.07	94,181	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	78.44	70,985	75.4%	$0	$12,302	$0.2
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	78.44	70,985	75.4%	$0	$12,302	$0.2
Net Nutrient Input	**25.63**	**23,196**	**24.6%**			

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