

Prepared for:
PERRON DEVELOPMENTS PTY LTD

Lot 5131 Jandakot Road, Treeby

Local Water Management Strategy



NOVEMBER 2021

Report ref. J6704b

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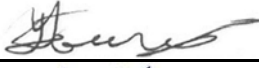
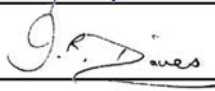
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Document Version No.	Issue Date
J6704a	22 June 2021
J6704b	30 November 2021

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EXECUTIVE SUMMARY

JDA has been appointed by Perron Developments Pty Ltd to prepare a Local Water Management Strategy (LWMS) for Lot 5131 Jandakot Road, Treeby, herein referred to as the Study Area.

This Local Water Management Strategy (LWMS) has been prepared to support the Lot 5131 Jandakot Road, Treeby Local Structure Plan [LSP] (CLE, 2021). The LWMS provides the framework for the application of total water cycle management to the proposed residential structure within the LSP, consistent with the Lot 131 Jandakot Road, Treeby (Banjup) District Water Management Strategy (DWMS) (JDA, 2018), Department of Water and Environmental Regulation's principles of Water Sensitive Urban Design as described in the Stormwater Management Manual (DoW, 2004-2007), and Better Urban Water Management (WAPC, 2008).

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

TABLE 1: SUMMARY OF LWMS DESIGN PRINCIPLES AND OBJECTIVES

Key Guiding Principles		
- Facilitate implementation of sustainable best practice in urban water management - Provide integration with planning processes and clarity for agencies involved with implementation - Minimise public risk, including risk of injury or loss of life - Protection of infrastructure and assets from flooding and inundation - Encourage environmentally responsible development - Facilitate adaptive management responses to the monitored outcomes of development		
Category	DWMS Objectives	LWMS Criteria
Stormwater Management	- Non-structural measures to reduce applied nutrient loads. - At source retention of small storm events (15 mm). - Onsite infiltration of all stormwater runoff up to 1% AEP. - Water quality treatment systems and water sensitive urban design structures designed in accordance with the Stormwater Management Manual for Western Australia (DoW, 2004-2007) Chapter 9 (Structural Controls) and Australian Runoff Quality (Engineers Australia, 1997)	- Runoff from the 'small' event or first 15 mm of rainfall is to be treated and infiltrated at-source where possible. - Runoff for events up to the 1% AEP is to be retained and infiltrated within infiltration areas in POS. - Manage surface water flows from major events to protect infrastructure from flooding and inundation. All lots to be minimum 0.3 m above 1% AEP flood level. - All stormwater management structures located outside of Bush Forever and 50 m Resource Enhancement wetland buffer.
Groundwater Management	- No management of groundwater levels is proposed (subsoil drainage). - Finished levels to provide sufficient separation to groundwater to allow infiltration of stormwater onsite to enhance recharge to the Jandakot Mound. - Limit impacts to Bush Forever and wetland sites. - Limit groundwater abstraction. - Manage fertiliser and pesticide application in streetscapes and POS areas using soil amendments, appropriate plan selection, limiting turf areas and maintenance management plans.	- Manage and minimise changes in groundwater levels and groundwater quality following development, particularly from groundwater level increase from urbanisation within the Study Area and surrounds. - All lots are to have a minimum 1.5m clearance to groundwater levels. - No groundwater management infrastructure in Bush Forever and 50 m wetland buffer.
Water Conservation and Sustainability	- Ensure that 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 to 60 kL/person/year. - Use of waterwise landscaping practices both at development and lot scale.	- Consider alternative fit for purpose water sources where appropriate and cost-effective. - Use of non-potable groundwater for irrigation of POS. - Aim to achieve the State Water Plan target for water use of 100 kL/person/yr. - POS areas to be at least 50% native plants. - Buildings are to comply with water efficiency standards introduced into the building code.
Water Quality	- Adopt nutrient load reduction design objectives for stormwater runoff. - Use of amended soils and ephemeral bioretention systems to treat stormwater.	- Establishment of 'small' event bio-retention zones to treat a minimum of 2% of connected impervious areas from road catchments. - Non-structural controls to reduce applied nutrient loads. - Minimise the average annual pollution load by implementation of a treatment train design for stormwater runoff.
Monitoring	- Continue current monitoring to inform decisions at LWMS stage. - Post-development monitoring program to ensure water quality targets are met.	Groundwater monitoring (levels and quality) to allow quantitative assessment of the hydrological impacts of the proposed development.

1. INTRODUCTION

1.1 Background

This Local Water Management Strategy (LWMS) has been prepared by JDA Consultant Hydrologists on behalf of Perron Developments Pty Ltd in support of the Lot 5131 Jandakot Road, Treeby LSP (see Appendix A) which has an area of 64.36 ha, Figure 1, of which 30.40 ha comprises the LSP area, Figure 2, with the remaining 33.96 ha comprising Bush Forever.

The LWMS provides the framework for the application of total water cycle management to the proposed residential development, consistent with the Lot 131 Jandakot Rd, Treeby (Banjup) District Water Management Strategy (DWMS) (JDA, 2018) and Department of Water and Environmental Regulation (DWER) principles of Water Sensitive Urban Design (WSUD) described in the Stormwater Management Manual (DoW, 2004-2007). This document details stormwater, groundwater and water quality management, at a level of detail suitable for the purpose of the local planning scheme.

1.2 Statutory Framework

1.2.1 Regional Planning

The development area, Figure 2, comprising part of Lot 5131 Jandakot Road, Treeby, was re-zoned from *Rural-Water Protection zone* to *Urban* under the Metropolitan Regional Scheme Amendment 1367/57 (WAPC, 2020; DLP, 2021). The remainder of the Study Area retains the *Rural-Water Protection* zoning and is classified Bush Forever.

1.2.2 District Planning

The Study Area forms part of the larger proposed Treeby urban precinct and is located in the Jandakot Underground Water Pollution Control Area (Jandakot UWPCA). With re-zoning, the development area is also reclassified from a Priority 2 (P2) source protection area to a Priority 3 (P3*) source protection area with urban zoning acceptable as per *Water Quality Protection Note No. 38: Priority 3* (P3*) areas* (DWER, 2018)

A District Water Management Strategy (DWMS) was prepared by JDA in 2018 and provides guidance on water reuse options, stormwater retention basins, monitoring requirements and structural and non-structural controls for stormwater treatment.

1.2.3 Local Structure Plan

This LWMS is presented in support of the Lot 5131 Jandakot Road, Treeby LSP (CLE, 2021), attached as Appendix A, as part of the Better Urban Water Management Framework (WAPC, 2008). This LWMS develops surface water and groundwater management strategies at a local scale.

This LWMS has been prepared in accordance with the requirements of the DWMS (JDA 2020).

1.3 Key Design Principles and Objectives

The LWMS employs the following key documents to define its content, key principles and objectives:

- Stormwater Quantity Management Manual for Western Australia (DoW, 2004-2007);
- Better Urban Water Management (WAPC, 2008);
- Local Governmental Guidelines for Subdivision Development (IPWEA, 2017);
- Decision Process for Stormwater Management in Western Australia (DWER, 2017a);
- Water Quality Protection note 38: Priority 38 (P3*) areas (DWER, 2018) and
- Lot 131 Jandakot Road, Treeby (Banjup) District Water Management Strategy (JDA, 2018).

A summary of the key design principles and objectives from these documents is provided in Table 1 and summarised below.

1.3.1 Stormwater Management Manual for Western Australia (DoW, 2004-2007)

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

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

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

DWER's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW, 2004-2007), which details the management objectives, principles and a stormwater delivery approach for WA. Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles
- To provide a decision framework for planning and design of stormwater management systems and assist in meeting the objectives specified above, DWER released the Decision Process for Stormwater Management in WA, which forms a component of the Stormwater Management Manual for WA (DoW, 2007).

1.3.2 Better Urban Water Management (WAPC, 2008)

The guideline document *Better Urban Water Management* (WAPC, 2008a), focuses on the process of integration between land use and water planning by specifying the level of investigations and documentation required at various decision points in the planning process.

This LWMS complies with the BUWM process.

1.3.3 Lot 131 Jandakot Rd, Treeby (Banjup) DWMS (JDA, 2018)

The DWMS was prepared to support rezoning of Lot 131 (now Lot 5131) Jandakot Road Treeby and demonstrate that the area was capable of supporting the proposed urban rezoning.

The aims of the DWMS are to:

1. Define land area requirements for conveyance of flood flows and protection of future development from peak flood events.

2. Propose a drainage design strategy appropriate for local conditions in the strategy area that incorporates best practice water sensitive urban design measures. The strategy identifies Water Sensitive Urban Design practices to be implemented within both private allotments and the public domain, and the legal mechanisms by which all identified practices will be implemented.
3. Prescribe the design criteria for water quantity and water quality for each catchment.
4. Outline the hydrologic and hydraulic framework parameters and subsequently develop the overall drainage network concept.
5. Define an implementation framework for the drainage design objectives.
6. Recommend monitoring programs for water quantity and quality pre- and post-development as well as for ensuring hydraulic performance over the lifetime of the drainage structure.

2. PROPOSED DEVELOPMENT

The Study Area, 64.36 ha, is located approximately 19 km south of the Perth CBD within the City of Cockburn and comprises a 30.40 ha development area with Bush Forever and classified wetlands comprising the remainder of the lot area. The Study Area is bounded by Calleya Estate to the west, Jandakot Road to the north, 2 ha rural residential lots to the east and Lot 705 Armadale Road to the south. A powerline easement is within the Study Area and runs parallel to the southern Study Area boundary.

The proposed land use is for residential development, consistent with urban zoning and regional planning. The Structure Plan for the Study Area is shown on Figure 2.

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

- Retention and infiltration of frequently occurring rainfall events ('small' event) at-source within residential lots or within planted bio-retention areas in the down-gradient POS (road reserves).
- Retention and infiltration of events up to the major storm event within drainage management areas located at the catchment low-points. Stormwater runoff generated within the upstream catchments areas will be conveyed by pit-and pipe and/or overland flow system (minor and major) and road carriageways (major).
- Integration of POS for flood management of minor and major rainfall events.
- Use of local native species in open spaces and streetscapes to reduce nutrient input and conserve water resources.
- Minimisation of fill consistent with sustainability principles.
- Use of non-potable groundwater for irrigation of POS.

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

TABLE 2: LAND USE BREAKDOWN

Land Use Description	Structure Plan Area (ha)	Study Area (ha)
Residential Lots	15.81	15.81
Road Reserve	9.23	9.23
Public Open Space (POS) / Power Easement (incl. Bush Forever)	5.36	39.32
Total	30.40	64.36

3. PRE-DEVELOPMENT ENVIRONMENT

3.1 Existing Land Use

The Study Area was previously operated as a sand quarry between 1995 and 2006. The Study Area is currently available for infill development as a 'brownfields' site, Figure 3.

3.2 Topography

The existing topography of the Study Area is shown on Figure 4. Substantial amounts of sand have been removed during operation of the site as a sand quarry resulting in a highly modified landscape. In general, the site grades from the north-west corner at approximately 41 m AHD to the south-west corner at 28 m AHD. One ridge along the Bush Forever site parallel to the western boundary grades from 33 m AHD to 30 m AHD towards the north-west.

3.3 Climate

The Treeby area is characterised by a Mediterranean climate with warm dry summers and cool wet winters.

Rainfall data is provided by the nearby Bureau of Meteorology *Jandakot Aero* gauge (Site ID. 009172), 2 km north-west of the Study Area, Figure 5.

The average annual rainfall, 1973 to 2020, for Jandakot Aero was 809 mm, with 30-year and 10-year averages of 765 mm and 760 mm, respectively. This represents a 9% (30-year average) and 10% (10-year average) decrease from the average annual rainfall for Jandakot Aero and is consistent with the decreasing rainfall trend across south-west Western Australia (DoW, 2015). The seasonal rainfall distribution has also altered since 1990, with a reduction of average monthly totals in the winter months, but no reduction or increases in the summer months.

Average annual pan evaporation is estimated at 1,700 mm for the Study Area from gridded BoM (2017) 1975-2005 average pan evaporation data and is similar to 2019/2020 annual evaporation recorded at the Department of Primary Industries and Regional Development (DPIRD) Wattelup weather station of 1,715 mm (2019) and 1,661 mm (2020) and lower than the estimate of 1,900 mm from Luke *et al.* (1987).

3.4 Geology and Soils

Surface geology mapping by Jordan (1986), which predates sand mining, is shown on Figure 6. The Study Area is mapped as "S8" Bassendean Sand with "SP10" Bassendean Sand overlying the Guildford Formation to the east. These sands are fine- to medium-grained, moderately sorted, sub-angular to sub-rounded and of aeolian origin (Jordan, 1986).

3.5 Acid Sulphate Soils

The Study Area is generally classified as Class 2, having moderate to low risk of Acid Sulphate Soils (A.S.S) occurring less than 3 m from surface but high to moderate risk of A.S.S beyond 3 m of natural soil surface, Figure 6 (DWER, 2017b).

Detailed A.S.S. investigations will be undertaken at the time of subdivision. In the event that any A.S.S is encountered an Acid Sulphate Soil Management Plan will be prepared and implemented as part of the subdivision process in accordance with WAPC (2003).

3.6 Surface Water Hydrology

No natural surface water features are present within the Study Area.

3.7 Wetlands and Vegetation

Geomorphic Wetland mapping of the Swan Coastal Plain (DBCA, 2018), Figure 7, show the eastern extent of the Study Area is mapped as Resource Enhance [RE] dampland (UFI 13328). The wetland intersects Bush Forever site 390 which extends beyond the Study Area and across the majority of the western and central extent of the Study Area.

Areas covered by Bush Forever site 390, Figure 7, are generally those outside of the footprint of the former sand quarry and the proposed development area.

3.8 Groundwater Hydrology

3.8.1 Regional Hydrogeology

Superficial Aquifer

The superficial aquifer in the vicinity of the Study Area is referred to as the Jandakot Mound which has an extent of approximately 552 km². The aquifer has a maximum thickness of 40 m and includes three formations which are, in order of increasing depth: Bassendean Sand; Gnangara Sand; and Ascot Formation. Aquifer transmissivities range between 200 to 1,000 m²/day (Davidson & Yu, 2008).

The Bassendean Sand consist of fine- to coarse-grained, moderately-sorted, sub-rounded to rounded quartz sand. The sand is mapped as highly permeable with horizontal hydraulic conductivity ranging between 10 m to 50 m/day. In the Jandakot area where 'coffee rock' is present, limonite cement may reduce the horizontal hydraulic conductivity to less than 10 m/day (Davidson & Yu, 2008).

Gnangara Sand is present beneath the Bassendean Sand and consists of pale-grey, fine- to very coarse-grained, very poorly-sorted, sub-rounded to rounded quartz and feldspar (Davidson & Yu, 2008).

The Ascot Formation is present beneath the Gnangara Sand. The Ascot Formation consists of hard to friable, grey calcarenite with thinly interbedded sand, with shell fragments commonly near the base of the formation. Sands are fine- to coarse-grained and are poorly sorted and angular to rounded in shape (Davidson, 1995).

Ascot Formation overlies the Kardinya Shale (part of the Osborne Formation) and which is a confining bed, consistent of moderately to tightly consolidated, interbedded siltstones and shales (Davidson, 1995).

Vertical fluctuations in the groundwater table may be several metres and occur seasonally, consistent with Perth's winter-dominated Mediterranean rainfall pattern, as can be seen in nearby DWER Bore JM19 (Appendix C). Rainfall recharge to the superficial aquifer is 15 to 25% of total rainfall (Davidson, 1995).

Leederville Aquifer

The Osborne Formation overlies the Leederville Formation from approximately – 15 mAH to -110 mAH and includes the Kardinya Shale (confining bed) and Henley Sandstone formations. The Henley Sandstone formation is included in the Leederville Aquifer (Davidson & Yu, 2008).

The Leederville Aquifer is a major drinking water resource with groundwater salinity beneath the Jandakot Mound typically < 500 mg/L TDS ('fresh').

Yarragadee Aquifer

The South Perth Shale underlies the Leederville Aquifer and acts as the confining bed between the Leederville and Yarragadee aquifers (Davidson & Yu, 2008).

The Yarragadee aquifer is major water resource with groundwater salinities south of Perth typically 1,000 to 2,000 mg/L TDS.

3.8.2 Groundwater Levels

A pre-development groundwater monitoring program was conducted by JDA between September 2018 and October 2020. Six monitoring bores, MW01 to MW06, were installed on 25 September 2018 by Edrill Environmental with supervision by JDA, using hollow stem auger to depth of 5.5 to 7.5 m and screened in the lowest 3 m. Bores were surveyed by Edrill on 04 October 2018. Adjacent DWER Bore JM19 was monitoring quarterly across the same period.

Details of bores are provided in Table 3 with locations shown on Figure 8. The pre-development groundwater monitoring report, including bore lithological logs, is attached as Appendix B.

Groundwater flow direction is from east to west with seasonal water table fluctuation typically 1 to 1.5 m. Since 1975, there has been a general decline in groundwater levels due to declining rainfall with associated reduction in aquifer

recharge and increased groundwater abstraction. Water levels in nearby DWER bore JM19, Appendix C, risen more so than other DWER bores; potentially due to stormwater infiltration from the adjacent Calleya Estate.

TABLE 3: DETAILS OF GROUNDWATER MONITORING BORES

Bore ID	GDA 2020 Coordinates		Natural Surface (mAHD)	Total Depth (mbToC)	Top of Casing (mAHD)	Screened Interval (mbNS)	Installation Date
	Easting	Northing					
MW01	394797	6445662	31.98	8.10	32.58	4.5 to 7.5	25 September 2018
MW02	395112	6445788	29.95	6.60	30.55	3 to 6	25 September 2018
MW03	395039	6445420	29.91	6.60	30.51	3 to 6	25 September 2018
MW04	395024	6445213	28.09	6.10	28.69	3 to 5.5	25 September 2018
MW05	395206	6445462	30.56	6.60	31.16	3 to 6	25 September 2018
MW06	395279	6445651	29.88	6.60	30.48	3 to 6	25 September 2018
JM19	394501	6445394	30.95	18.1	31.62	5.7 to 17.7	06 June 1975

To calculate Average Annual Maximum Groundwater Level (AAMGL) and Maximum Groundwater Level (MGL) for the Study Area, water levels recorded in the JDA bores on 22 July 2020 were correlated to long-term groundwater measurements recorded in DWER monitoring bore JM19, located on the western boundary of the Study Area, Figure 8. Details of JM19 are provided in Table 3.

TABLE 4: DETAILS OF DWER MONITORING BORE

Bore ID	Record Period	Top of Casing (mAHD)	Water Level 22/07/2020 (m AHD)	Calculated Average of Annual Peaks (m AHD)	AAMGL Adjustment (m)	Maximum of Annual Peaks (m AHD)	MGL Adjustment (m)
JM19	1975 – present	31.62	26.59	26.67	+0.08	27.96	+1.37

For DWER bore JM19, the AAMGL and MGL over the period 1975 to *present* are calculated as 26.67 m AHD and 27.96 mAHD respectively (Table 4 and Appendix C). The water level of 26.59 mAHD measured on 22 July 2020 is 0.08 m and 1.37 m, respectively, below the estimated AAMGL and MGL (1975 – present). The AAMGL and MGL (1975 – present) for the Study Area was estimated by applying adjustments of +0.08 m and +1.37 m, respectively, to water levels recorded at MW01 to MW06 on 22 July 2020.

Estimated pre-development AAMGL and MGL contours are shown on Figure 8. In general, groundwater flow across the Study Area is from south-west to north-east with AAMGL ranging from 26.7 mAHD to 25.3 mAHD and MGL from 28.0 mAHD to 26.6 mAHD. Based on topographic contours in Figure 4, groundwater is greater than 3 m below natural surface across the Study Area.

3.8.3 Groundwater Quality

Groundwater quality monitoring was conducted concurrently with groundwater level monitoring between September 2018 and October 2020. Monitoring bores MW01 to MW06 were sampled quarterly with analysis of physio-chemical properties, nutrients, major anions and cations, dissolved metals and total metals (Fe, Hg, Se) undertaken by a NATA-approved laboratory. In-situ analysis of pH and EC was also undertaken by JDA. Where applicable, monitoring results were compared to Australian Drinking Water Guidelines (ADWG) (NHMRC, 2011). The monitoring report is attached as Appendix B with mean results of analysis summarised in Table 5 below.

TABLE 5: PRE-DEVELOPMENT GROUNDWATER QUALITY SUMMARY

Parameter	PQL	Guidance Value	MW01	MW02	MW03	MW04	MW05	MW06
Physico-chemical								
pH <i>in-situ</i>		6.5-8.5 ¹	6.7	6.5	5.9	6.4	6.4	5.2
EC (µS/cm) <i>in-situ</i>		<1000 ¹	458	204	164	345	210	226
TDS (mg/L)		<600 ¹	339	138	121	224	135	131
TDS/EC Ratio	-	-	0.72	0.66	0.75	0.64	0.63	0.60
Nutrients (mg/L)								
NH ₃ _N	0.005	<0.41 ²	0.005	0.0051	0.043	0.097	0.0055	0.0059
NO _x _N	0.005	<11 ²	6.1	1.2	0.16	0.13	0.076	0.74
TKN	0.1	-	1	0.85	0.54	0.44	0.24	0.15
TN	0.01	-	7.1	2	0.7	0.58	0.3	0.9
PO ₄ _P	0.005	-	0.005	<0.005	0.0059	<0.005	<0.005	<0.005
TP	0.01 0.05	-	0.04	0.04	0.04	0.04	0.04	0.04
Dissolved Metals (mg/L)								
Aluminium, Al	0.01	<0.2 ¹	0.075	0.019	0.16	0.076	0.053	0.35
Arsenic, As	0.001	<0.01 ²	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium, Ba	0.001	<2 ²	0.0011	<0.001	0.0013	<0.001	<0.001	0.0045
Boron, B	0.02	<4 ²	0.033	0.02	0.021	0.02	0.023	0.02
Cadmium, Cd	0.0001	<0.002 ²	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00015
Chromium, Cr	0.001	<0.05 ²	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper, Cu	0.001	<1 ¹ <2 ²	0.0016	0.0026	0.0013	0.001	0.0031	0.0065
Lead, Pb	0.001	<0.01 ²	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Manganese, Mn	0.005	<0.01 ¹ <0.05 ²	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum, Mo	0.001	<0.05 ²	0.0029	0.001	<0.001	0.001	0.0023	0.001
Nickel, Ni	0.001	<0.02 ²	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver, Ag	0.001	<0.01 ²	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc, Zn	0.001	<0.02 ¹	0.002	0.0049	0.0036	0.0021	0.006	0.0073
Total Metals (mg/L)								
Iron, Fe	0.01	<0.03 ¹	0.025	0.014	0.11	0.076	0.15	0.063
Mercury, Hg	5E-05	<0.001 ²	<0.00005	<0.00005	0.000054	<0.00005	<0.00005	0.00006
Selenium, Se	0.001	<0.01 ²	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Notes:

PQL = Practical Quantification Limit; defined at the lowest concentration at which an analyte can be detected in a sample with a reasonable degree of accuracy and precision.

- ADWG (2011) *aesthetic* guideline values. Exceedances printed in brown.
- ADWG (2011) *health* guideline values. Exceedances printed in orange.
- Summary values are averages.

A summary of the monitoring results is as follows:

- Groundwater pH are slightly acidic, consistent with natural acidity of superficial aquifer in the area, with higher acidity in MW03 and MW06.
- Groundwater is fresh with Total Dissolved Solids (TDS) of less than 500 mg/L, with Electrical Conductivity (EC; proxy for salinity) less than 500 µS/cm.
- Mean total Nitrogen (TN) concentrations were consistently elevated in MW02, the reason for which is unclear. Nitrogen in MW03 to MW05 was mostly in the form of organic nitrogen. Nitrogen in MW01, MW02 and MW06 was mostly in the form of dissolved inorganic oxides (NO_x_N). These bores are located in old cleared bushland area with the organic content in the soil matrix likely released more than the northern area bores (MW01 to MW03). All nitrogen concentrations were below ADWG.

- Mean dissolved and total metal concentrations were all less than ADWG health and/or aesthetic guideline values except Aluminium at MW06.
- Mean iron concentrations are generally above Drinking Water Guidelines (DWG), potentially reflecting presence of a ferruginous sand layer beneath the Study Area.

3.8.4 Public Drinking Water Source Area

The Study Area is located within the Jandakot Underground Water Pollution Control Area (UWPCA) which occupies a total area of 7,400 ha. The Jandakot UWPCA was proclaimed in 1975 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.

The Study Area is located within a Priority 3* Public Drinking Water Source Area (PDWSA). This P3* zoning is a variation to Priority 3 to address increased risk to water quality from the approved landuse change. Water Quality Protection Note 38 (WQPN) (DWER, 2018) 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 28 includes:

- DWER's 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, policies 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

3.8.5 Groundwater Resources for Irrigation

The Department of Water and Environmental Regulation manages the groundwater of the State under the Rights in Water and Irrigation Act 1914 (RIWI Act). The Study Area is located within the Canning Vale sub-area of the Jandakot Groundwater Management Area.

The superficial aquifer is the most feasible irrigation supply for the Study Area.

The DWER groundwater allocation limit and water allocations from the superficial aquifer are shown in Table 6 and are based on a Resource Allocation Report from DWER as at 22 March 2021. Allocations for the *Perth – Leederville* and *Perth – Yarragadee North* in the Jandakot Groundwater Area are solely held by Water Corporation.

TABLE 6: DWER GROUNDWATER RESOURCE ALLOCATION AND LIMIT, MARCH 2021

GW Sub - Area	Aquifer	Allocation Limit Licencable component, (kL/yr)	Allocated, committed & requested (kL/yr)	% Allocated, & committed	Additionally Requested (kL/yr)
Wright	Superficial Swan	310,000	277,035	76.5	39,975

As at 22 March 2021, the superficial aquifer was 76.5% allocated and committed with an additional 39,975 kL, or 12.9% of the total allocation additionally requested.

This allocation of 39,975 kL/year has since been secured by Perron Developments for the Study Area's irrigation requirements from the superficial aquifer; Licence to Take Water GWL 205947 (Appendix D).

3.9 Contaminated Sites

A search of DWER's publicly available Contaminated Site Database (accessed 18 May 2021) indicated no contaminated sites within or around the Study Area.

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

3.10 Aboriginal Heritage

There are no registered aboriginal sites within the Study Area.

An 'other heritage place' (ID: 3301), 'Banjup: Calsil', is mapped as a 1.4 km diameter area south-east of the Study Area. The Aboriginal Heritage Enquiry System (DPLH, 2021) denotes this area as "*artefacts / scatter, camp*" but with a status denoted the area as stored data and not a site.

4. WATER SUPPLY & CONSERVATION

4.1 Water Supply

Engineering Infrastructure Report (Stantec, 2021) indicates Water Corporation have undertaken conceptual water supply planning, as an extension of the Thomson Lake Gravity Supply Scheme.

An existing DN250 water reticulation pipe located at the intersection of Torwood Avenue and Solitaire Road is proposed to service the development of the Study Area.

4.1.1 Residential Lots

Potable water supply to individual lots would be achieved by the construction of a network of DN100 to DN200 throughout the internal road network (Stantec, 2021).

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

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

4.1.2 Public Open Spaces

A non-potable water supply from groundwater abstraction is proposed for irrigation of POS areas. Perron Developments has a groundwater licence, GWL205947, with allocation of 39,975 kL/year for the irrigation of up to 5.33 ha of POS across the Study Area.

CAW205946, expiry 26 May 2022, provides a licence for the construction of 1 production bore.

Licences to Construct a Well and Take Water are attached as Appendix D.

4.2 Wastewater Management

Engineering Infrastructure Report (Stantec, 2021) indicates the site will have separate Northern and Southern wastewater catchments, in accordance with Water Corporation's wastewater planning. Disposal of wastewater within each respective catchment will be achieved via a network of gravity reticulation sewers.

The northern catchment is provided with an existing gravity wastewater connection at the intersection of Torwood Avenue and Solitaire Road. The southern catchment will be provided with a gravity sewer connection discharging to proposed Jandakot Wastewater Pumping Station B located within Lot 705 Armadale Rd, Treeby.

4.3 Water Efficiency Measures

The State Planning Policy 2.9 regarding water resources (WAPC, 2006) requires new developments to employ a total water cycle approach to the consideration of water resources. 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 scale and lot scale and is identified in the State Water Plan (Government of Western Australia, 2007) as a priority item for potable water. The State Water Plan target for household water use is 100 kL/person/year (potable and non-potable water), with a consumption target for scheme water of 40 to 60 kL/person/year (potable water).

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

- Avoid use of potable water for irrigation in POS areas.
- Reduce household water use to not more 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 to 60 kL/person/year.

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.
- Use of non-potable water supply source (groundwater abstraction bore).
- 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.
- Retain and where appropriate rehabilitate native bush areas.

Lot Scale

Lot scale water conservation measures appropriate for the site include:

- Increased residential density, including smaller lots with reduced ex-house irrigation areas.
- 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 sub-surface irrigation where possible. 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.
- Encourage use of non-potable water supply options for ex-house irrigation uses (i.e. Rainwater tanks, greywater recycling, garden bore etc.)

5. STORMWATER MANAGEMENT

5.1 Stormwater System Design

Local stormwater management is proposed to be consistent with water sensitive design practices and to meet key objectives and criteria as detailed in Table 1. The local stormwater management system will consist of ephemeral water retention areas to capture and infiltrate stormwater runoff from contributing catchments.

Stormwater management has been designed according based on small events, minor drainage and major drainage.

Small event management concentrates on the first 15 mm of rainfall (approximately the 1 EY 1 hour event) and will comprise lot retention and bio-retention areas.

The minor drainage system is defined as a system of drains, pipes, culverts, kerbs, gutters etc. designed to convey runoff generated by low frequency storms, typically less than the 0.2 EY (5 year ARI) for residential areas.

The major drainage system is defined as the arrangement of roads, drainage reserves and attenuation areas planned to provide safe passage of stormwater runoff from extreme rainfall events.

There are no external catchments that contribute into the Study Area.

Stormwater management areas will be located in catchment low points and integrated with public open space areas where possible. A portion of the Western Power easement located across the southern tip of the development area is also proposed for stormwater management. This is consistent with sections of this easement being used for drainage management in other nearby residential developments (Piara Waters), and in particular the adjacent development Calleya 450m to the west.

Based on previous JDA experience, drainage within the Western Power easement is permissible if it includes a 30 m buffer to towers and only contains low level vegetation (no trees). This can be confirmed with Western Power following structure plan adoption with future detailed engineering and landscape design. In the unlikely event stormwater management in the easement is not permissible, there is sufficient public open space in this area external and adjacent to the easement that can be utilised for stormwater management.

5.1.1 Small Event Management

The following strategies are proposed to meet the criteria for small event management:

- All residential lots are to retain and infiltrate the first 15 mm of rainfall from connected impervious areas. This can be achieved by means of systems such as soakwells and/or other underground storage devices.
- Stormwater runoff from roads from the first 15 mm of rainfall will be discharged to bio-retention areas (BRAs) within the downstream Flood Management Areas (FMAs). Flush kerbing around POS, 'leaky' drainage pits/manholes, tree pits adjacent to lots and parklets will provide further at-source treatment within the upstream catchments.
- BRAs will be underlain with amended soils and planted with suitable plant species, consistent with Vegetation Guidelines for Biofilters in South-West Western Australia (Monash University, 2014).

5.1.2 Minor Drainage

To meet the design criteria for the minor drainage system (for events up to the 20% AEP event), the following strategies are proposed:

- Stormwater flow in excess of the small event treatment structures (tree pits and parklets) will be conveyed primarily by the road pipe network sized for 20% AEP event to FMAs in the POS.
- Runoff generated within residential lots in excess of underground storage devices (e.g. soakwells) will flow overland via driveway or front of lot into the road drainage network. Where lot areas are less than 350 m², underground storage devices are to be interconnected within the lot.
- A Ø600 pipe outflow from the c1 FMA distributes flow from stormwater runoff to the southern c3 FMA. The piped outflow is set above the 'small event' water level.

- FMAs are located at the catchment low-point and will retain and infiltrate stormwater runoff. They will have minimum side slope of 1:6 (v:h) with invert minimum 0.5 m above AAMGL.

5.1.3 Major Drainage

The major drainage system is designed to manage rainfall events greater than the 20% AEP (5 year ARI) event up to the 1% AEP (100 year ARI) event. Key points of the major drainage system strategy are as follows:

- Management will include infiltration of stormwater into in-situ sandy soils together with runoff from lots (excess of underground storage systems) and road stormwater runoff.
- Road reserves provide flood storage and conveyance. In major storm events, minor drainage pit and pipe system will be full, excess stormwater will bypass minor drainage structures and flow overland within the road carriageway, with roads graded towards the downstream FMAs; located at the catchment low points.
- All finished lot levels will have minimum 300 mm clearance above estimated 1% AEP flood levels of the FMAs.

5.2 Stormwater Modelling

Stormwater catchments, c1 to c3, are shown on Figure 9. Catchment c1 drains to the central FMA with a piped outflow to the c3 FMA to the south. Runoff from catchment c3 is retained and infiltrated within the c3 FMA.

FMAs for catchments c1 and c2 were sized and modelled in PCSump Version 6.1 (JDA, 2020) for the minor and major rainfall events. For catchment c3, the FMA was sized and modelled using the hydraulic software XP-Storm to incorporate stormwater pipe outflow from catchment c1 for the minor and major rainfall events. The infiltration component of XP-Storm was calibrated to PCSump Version 6.1 results of the c1 FMA.

For the 'small' event, BRAs were modelled in PCSump Version 6.1 for c1 to c3. The c1 FMA pipe outflow is set above the 'small' event top water level.

In PCSump Version 6.1, the Shallow Groundwater Table Model has been used with groundwater levels in the model conservatively set at MGL should groundwater rise from the current AAMGL across the Study Area. Saturated Hydraulic Conductivity has been assumed at 5 m/day.

The design storms modelled were according to the methodology in Australia Rainfall and Runoff (Ball et al., 2019). Rainfall temporal patterns were assumed to be spatially uniform across the catchment with storm durations from 30 minutes to 72 hours.

5.2.1 Catchment Runoff Parameters

A breakdown of the drainage catchment areas and rainfall-runoff loss model parameters for each land use is presented in Table 7 and shown in Figure 9.

Catchment boundaries are based on road earthwork levels. Note that catchment area contributing to the stormwater system is less than the structure plan area (Table 2) due to the following:

- Jandakot Road: Stormwater from a 1.29 ha section of Jandakot Road along the northern boundary (Figure 9) will be managed separately by Main Roads WA, and will not contribute to the Study Area drainage system.
- POS: Areas of Restricted POS along the Bush Forever interface (Figure 9) comprise retained vegetation. Rainfall within these areas will infiltrate onsite and not contribute to the Study Area drainage system.

FMA areas within POS were modelled as 'Drainage' (Table 7).

TABLE 7: CATCHMENT RAINFALL-RUNOFF LOSS MODEL

Land Use	Catchment Area (ha)	Initial Loss (mm)	Continuing Loss (mm/hr)	Proportional Loss (%)
Residential Lots	15.8	15	5	-
Road Reserve	7.94	-	-	10
Public Open Space	1.27	-	-	90
Drainage	1.92	-	-	10

5.2.2 Modelling Results

Stormwater modelling results for the ‘small’ event bio-retention areas (BRAs) including areas, peak water levels and storage volumes are summarised in Table 8. BRA base areas proposed meet minimum 2% of connected impervious area guideline in FAWB (2009).

BRA locations are shown on the stormwater management plan (Figure 10) and ‘small’ event plan (Figure 11).

Stormwater modelling results for the minor (20% AEP) and major (1% AEP) events are summarised in Table 9. Stormwater Event Plans for the ‘small’, minor and major events are shown in Figure 11. Indicative cross-sections of the c1, c2 and c3 FMAs are shown on Figures 12 to 14 with an indicative long-section from the c1 to c3 FMA shown on Figure 15.

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

TABLE 8: SMALL EVENT MANAGEMENT - BIO-RETENTION AREAS (BRAS)

	BRA c1	BRA c2	BRA c3
Catchment Details			
Bio-Retention Road Reserve Area Catchment (ha)	5.64	0.71	1.59
Impervious Catchment Area (ha)	5.08	0.64	1.43
2% of Impervious Catchment Area (m ²)	1,015	128	286
Bio-Retention Base Area Provided (m ²)	1,612	144	322
Storage Details			
BRA Invert (mAHD)	28.84	28.53	28.22
BRA Base Area (m ²)	1,488	28.83	322
Storage Depth (m)	0.20	0.25	0.35
Side Slope (1 in x)	6	6	6
Small Event Management			
Rainfall (mm)	15	15	15
Runoff Volume (m ³)	761	96	215
Water Depth (m)	0.20	0.25	0.35
Top Water Level (mAHD)	29.04	28.78	28.57
Top Water Area (m ²)	1,828	235	562
Stored Volume (m ³)	342	47	153
Stored Volume/Runoff Volume (%)	45	49	71

TABLE 9: STORMWATER MODELLING RESULTS - MINOR AND MAJOR EVENTS

	FMA c1	FMA c2	FMA c3
Catchment Details			
Residential Lots	12.28	1.49	2.03
Road Reserves	5.64	0.71	1.59
POS/Drainage	1.95	0.34	0.90
Small & Minor Event FMA Details			
MGL (mAHD)	27.10	27.0	27.60
Invert Level (mAHD)	28.84	28.53	28.22
Length (m)	62	20.5	46
Width (m)	26	7	7
Base Area (m ²)	1,612	144	322
Slope	6	6	6
Outlet Pipe Diameter to c3 FMA (mm)	Ø600	-	-
Outlet Pipe Invert (mAHD)	29.07	-	-
20% AEP [Minor Event]			
Peak Water Level (mAHD)	29.34	28.98	28.72
Critical Duration (hours)	1	1	6
Maximum Depth (m)	0.50	0.45	0.50
Peak Water Level Area (m ²)	2,170	325	2,20
Peak Water Storage Volume (m ³)	935	105	950
Peak Outflow to FMA c3 (m ³ /s)	0.10	-	-
1% AEP [Major Event]			
Peak Water Level (mAHD)	29.84	29.53	29.22
Critical Duration (hours)	2	6	9
Maximum Depth (m)	1.00	1.00	1.00
Peak Water Level Area (m ²)	9,225	1,305	9,300
Peak Water Storage Volume (m ³)	5,260	700	5,420
Peak Outflow to FMA c3 (m ³ /s)	0.29	-	-

PCSump Version 6.1 modelling results for FMA c1 and c2 (small, minor and major) and FMA c3 (small) are attached as Appendix E.

6. GROUNDWATER MANAGEMENT

6.1 Design Criteria

Groundwater management for the Study Area has been prepared in line with design criteria presented in the DWMS and the Stormwater Management Manual for Western Australia (DoW, 2004-2007):

- Manage groundwater levels to protect infrastructure and assets.
- Maintain groundwater regime for the protection of groundwater-dependent ecosystems.
- Protect the value of groundwater resources.
- Reduce nutrients infiltrating to groundwater.

6.2 Change in Groundwater Levels

A rise in groundwater levels is anticipated due to change in land use from development of the site. This is evident in DWER Ministerial Bore JM19 which shows a marked increase in groundwater levels in recent years (Appendix C). This is likely the aquifer's response to increased recharge resulting from urbanisation of the surrounding land, in particular development of the adjacent Calleya Estate in 2016.

Whilst there is currently no DWER groundwater modelling of possible groundwater changes on the Jandakot Mound in response to urbanisation, water table rise in response to urbanisation will result in increased groundwater gradient and throughflow until a new equilibrium is established. Groundwater rise will not continue year after year following an increase in recharge, but will occur for several years, and be more rapid if the depth to water table is shallow rather than deep.

Water level trend and changes in DWER Bore JM19 should be reviewed prior to detailed design in the UWMP.

6.3 Managing Groundwater Levels

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

For the Study Area, JDA recommends fill is clean sand with minimum hydraulic conductivity of 5 m/day to achieve the required separation to groundwater. If lower hydraulic conductivity fill is used, there is a risk of saturation of soil profile.

Pre-development groundwater contours (AAMGL and MGL) based on local and regional data are shown in Figure 8. Preliminary invert of drainage infrastructure (FMAs) indicate 2 m to 3.1 m clearance from AAMGL, and 0.6 m to 1.7 m from MGL. Lot levels would be approximately 1.5 m higher than the drainage inverts, indicating minimum 3 m clearance to AAMGL and 2.1 m to MGL. Therefore, no groundwater management control system is proposed.

Should future review of DWER Bore JM19 indicate ongoing groundwater rise, subsoil drainage could be used as an option to protect infrastructure. It could be located beneath drainage FMAs and set at or above the pre-development AAMGL. This review of further groundwater monitoring data is to be documented during detail design and presented in the UWMP.

Groundwater mapping presented in Figure 8 should be considered indicative only for assisting in LWMS strategy development purposes and subject to further investigation/refinement during detailed design.

6.4 Groundwater Quality

Being in a P3* area, water quality management measures are required to ensure proposed development does not impact on existing or future water supply. Measures proposed include:

- Use of clean sand fill
- Retention of existing vegetation where possible

- All urban lots connected to reticulated sewer
- Exclusion of high risk land uses (e.g. service stations)
- Use of bioretention areas, tree pits, parklets with amended soil and vegetation to remove nutrients and contaminants from stormwater runoff
- Responsive landscaping with endemic plant species that are water wise with low nutrient requirement
- Post development water quality monitoring program

Further detail on additional water quality management measures are presented in the next section.

7. WATER QUALITY MANAGEMENT

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

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

7.1 Non-Structural Source Controls

Application of non-structural source control strategies can include:

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

7.2 Structural Source Controls

Structural source controls compliment the non-structural source controls and can include:

7.2.1 Flush Kerbing

Flush kerbing bordering road and POS areas allows stormwater runoff from the frequently occurring small rainfall events (15 mm) to flow directly into POS across grassed verge/areas, maximising infiltration at source. It also provides an opportunity to slow water movement through the development and provides a disconnect to the pipe system.



7.2.2 Tree Pits

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



7.2.3 Parklets

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



7.2.4 Bio-Retention Areas (BRAs)

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

Research conducted by the Facility of Advancing Water Bio-filtration (FAWB, 2009) indicates that the desired K_{sat} is in the range of 100 mm to 300 mm/hr (~ 2.5 to 7.5 m/day), to allow infiltration of stormwater while retaining sufficient moisture to support the vegetation. Clogging will occur in the first few years, however once the vegetation is established, the roots and associated biological activity will maintain the hydraulic conductivity of the soil media over time (FAWB, 2009). Minimum specifications for all bio-retention areas are presented in Table 10.

TABLE 10: MINIMUM SPECIFICATIONS FOR BIORETENTION SYSTEMS

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

7.3 Land Use Change Nutrient Impacts

The UNDO (Urban Nutrient Decision Outcomes) decision support tool (DoW, 2016) has been used to help quantify the nutrient inputs for the post-development scenario. The UNDO tool analyses inputs for Total Phosphorus and Total Nitrogen only. Results were calculated for the Study Area (Appendix F). Bush Forever sites were not included in the analysis as these areas will not be altered.

The implementation of the proposed structural and non-structural controls results in a reduction of 21% for Nitrogen and 17% for Phosphorus, compared to urban development without WSUD. These estimates correspond to a reduced Nitrogen input of 2.44 kg/ha/yr (down from 2.70 kg/ha/yr) and a reduced Phosphorus input of 0.05 kg/ha/yr (down from 0.06 kg/ha/yr). The current land use is a combination of bushland and cleared land with low nutrient inputs and the estimated nitrogen and phosphorus inputs following urban development are also relatively low. Due to infiltration of stormwater onsite the estimated nitrogen and phosphorus exports following urban development are low.

7.4 Disease Vector and Nuisance Insect Management

Structural stormwater management systems are designed to minimise the risk of chironomid midge and mosquito breeding. Infiltration, evapotranspiration or drawing down of water via subsoils underlying basins to prevent pooling for longer than four days (96 hours) in late spring to early autumn will prevent completion of the larval stages of the mosquito life cycle (DoW, 2004-2007), as per requirement of the Department of Health.

8. IMPLEMENTATION

8.1 Urban Water Management Plan (Subdivision)

Processes defined in Better Urban Water Management (WAPC, 2008) require an Urban Water Management Plan (UWMP) at subdivision stage. With an approved LWMS, a UWMP is required as a condition of subdivision and prior to any subdivision activities.

Further work that is identified for inclusion in the UWMP:

- Design of treatment structures and flood storages as outlined in the Stormwater Management Manual (DoW, 2004-2007);
- Refine the final configuration (storage side slopes etc) and exact location of the flood detention storage areas, dependent on final earthworks, drainage and road design levels
- Assess whether groundwater management in the form of subsoil drains will be required beneath flood management areas.

8.2 Construction Management

8.2.1 Dewatering

Given the separation to groundwater, dewatering is not expected to be required.

Should dewatering be required, prior to commencement of any dewatering, the construction contractor may need to apply for and obtain from DWER a “Licence to Take Water”. A licence is not required for dewatering if the pump rate does not exceed 10 L/s over a period of less than 30 days and the volume of water taken over the period does not exceed 25,000 kL. If required, dewatering will be carried out in accordance with the licence conditions should a licence to take water be required. Where possible, construction will be timed to minimise impacts on groundwater.

8.2.2 Acid Sulphate Soils

Figure 6 generally shows a moderate to low risk of A.S.S across the Study Area. If An A.S.S is encountered, a Dewatering and Management Plan will be required to demonstrate the measures that will be taken to minimise risk from disturbance of A.S.S. If A.S.S is encountered, it will be investigated and managed in accordance with the applicable DWER Acid Sulphate Guidelines for Identification and Investigation (DER, 2015a) and Treatment and Management (DER, 2015b) of Disturbed Acid Sulphate Soils. Specific methods for treatment and holding times for A.S.S are specified in these guidelines.

8.3 Stormwater System Operation and Management

The stormwater drainage system will require maintenance to ensure correct operation. It is considered the following operating and maintenance practices will be required periodically:

- Inspection and removal of debris, litter and sediments surrounding pipe inlets/outlets.
- Inspection of system for erosion.
- Street sweeping to reduce particular build-up on road surface and gutters.
- Maintenance of planted areas (flood storages and POS) including plant condition and weeds as outlined in the UWMP; and
- Cleaning of sediment build up and litter layer on the bottom of swales as specified in the UWMP.
- Undertake education campaigns regarding source control practise to minimise pollution runoff into the stormwater drainage system.

8.4 Monitoring Program

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development.

The post-development monitoring program is designed to operate over a 3 year period. The program will be periodically reviewed to ensure suitability and practicality. The program may need to be modified as data is collected to increase or decrease the monitoring effect in a particular area or alter the scope of the program itself.

The proposed post-development monitoring is to monitor groundwater levels and quality at 3 pre-development groundwater monitoring sites (MW01, MW04 and MW06, see Figure 8) for comparison to pre-development data (Appendix B).

Post-development water quality trigger values are based on the 80th percentile of pre-development data, commensurate with monitoring and reporting guidelines in ANZECC & ARMCANZ (2000), Table 11.

A summary of the proposed monitoring program and reporting schedule is shown in Table 12 with the frequency of water quality target review and the contingency action plan detailed in Table 13.

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

TABLE 11: GUIDANCE VALUES FOR POST-DEVELOPMENT MONITORING

Parameter	Groundwater Bore		
	MW01	MW04	MW06
pH ¹	6.52 – 6.99	6.20 – 6.33	4.44 – 6.27
EC (µS/cm)	520	370	245
TN (mg/L)	8.1	0.24	1.3
TKN (mg/L)	1.4	0.6	0.2
NOx (mg/L)	7.4	0.24	1.2
NH ₃ -N (mg/L)	<0.005	0.13	0.005
TP (mg/L)	0.005	<0.05	0.05
PO ₄ -P (mg/L)	<0.005	<0.005	<0.005

Note: 1. pH values range from pre-development minimum and maximum

TABLE 12: MONITORING SCHEDULE AND REPORTING

Monitoring Type	Location	Method	Frequency, Timing & Responsibility	Parameter	Reporting
Groundwater Level	Three monitoring sites: MW01 MW04 MW06	Electrical depth probe or logger	Monthly (June to Sept) Quarterly (Dec, Mar) for 3 years by Developer	Water Level (mAHD)	Annual reports to be provided by the developer for a period of 3 years. Reports will be submitted to DWER/CoC within 3 months of completion of the reporting period.
Groundwater Quality		Pumped bore samples	Quarterly for 3 years by Developer (typically Dec, Mar, June, Sept)	In-situ: pH, EC, temp Lab: Nutrients, TDS, Metals*	
			Annually for 3 years by Developer	Lab: anions and cations, organochlorine pesticides, organophosphate pesticides, hydrocarbons	

* Metals: Arsenic, Cadmium, Chromium (III+VI), Copper, Iron, Lead, Mercury, Nickel, Zinc.

TABLE 13: CONTINGENCY PLANNING

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

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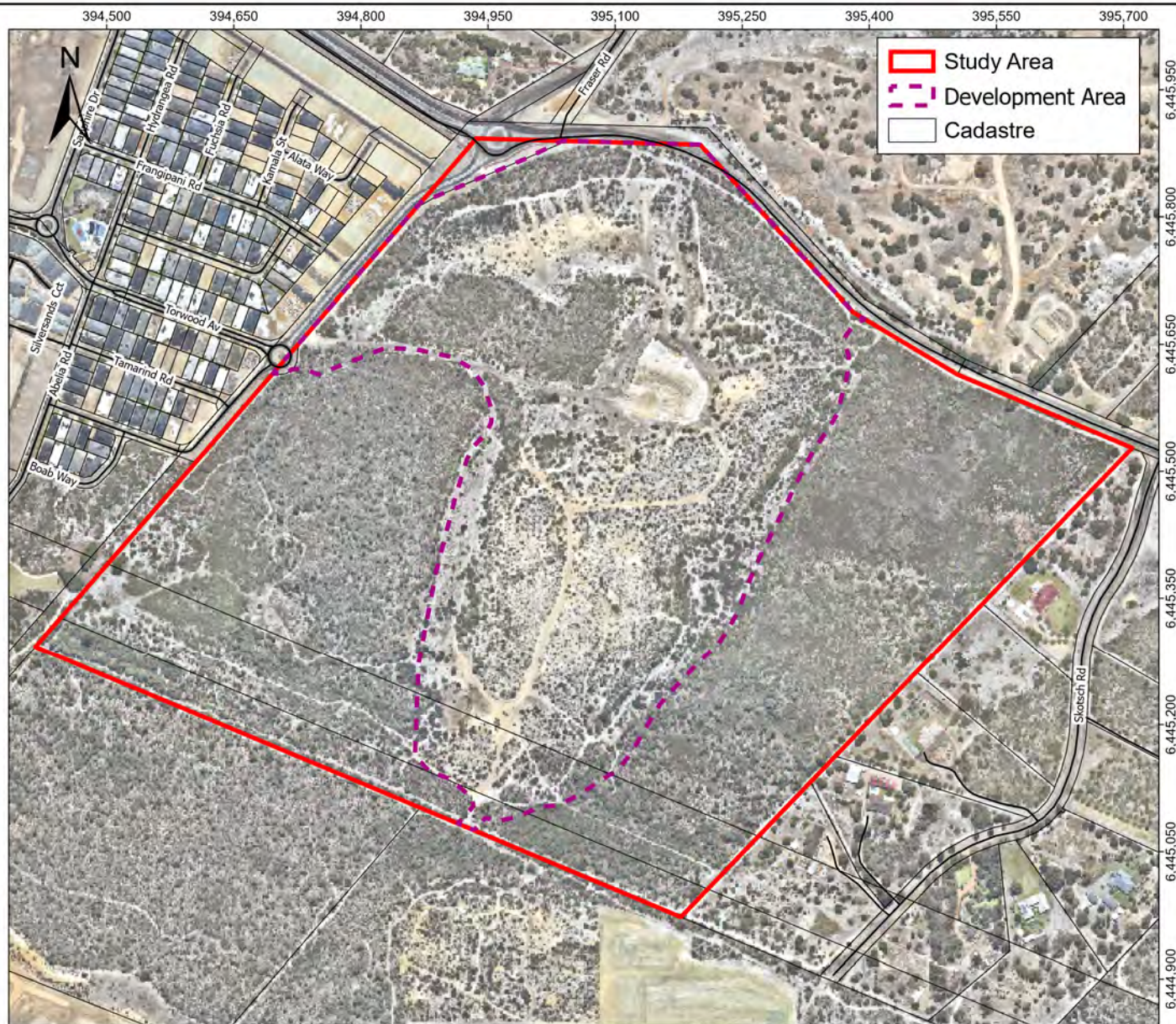
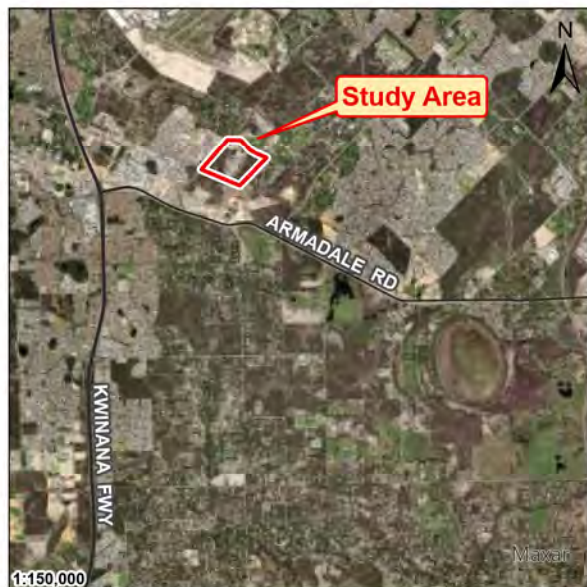
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FIGURES



Data Source: Nearmap (2021) 27 February 2021.

Coordinate System: GDA 2020, Zone 50



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Perron Treeby Pty Ltd
Lot 5131 Jandakot Road, Treeby: Local Water Management Strategy
Figure 1: Location Plan



Data Source: CLE (2021); Nearmap (2021).

Coordinate System: GDA 2020, Zone 50



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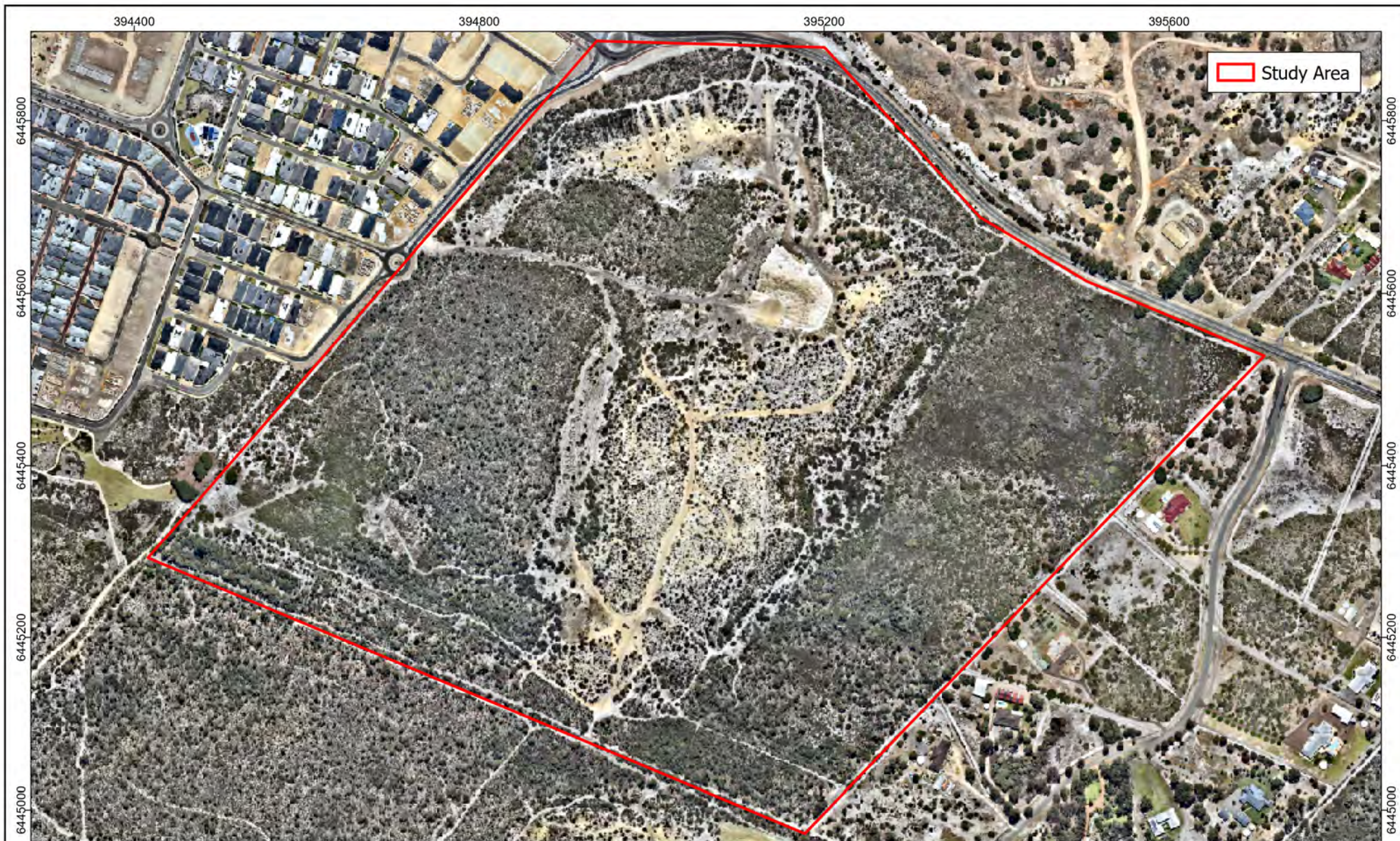
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Figure 2: Proposed Structure Plan



Data Source: Nearmap (2021) 27 February 2021.

Coordinate System: GDA 2020, Zone 50



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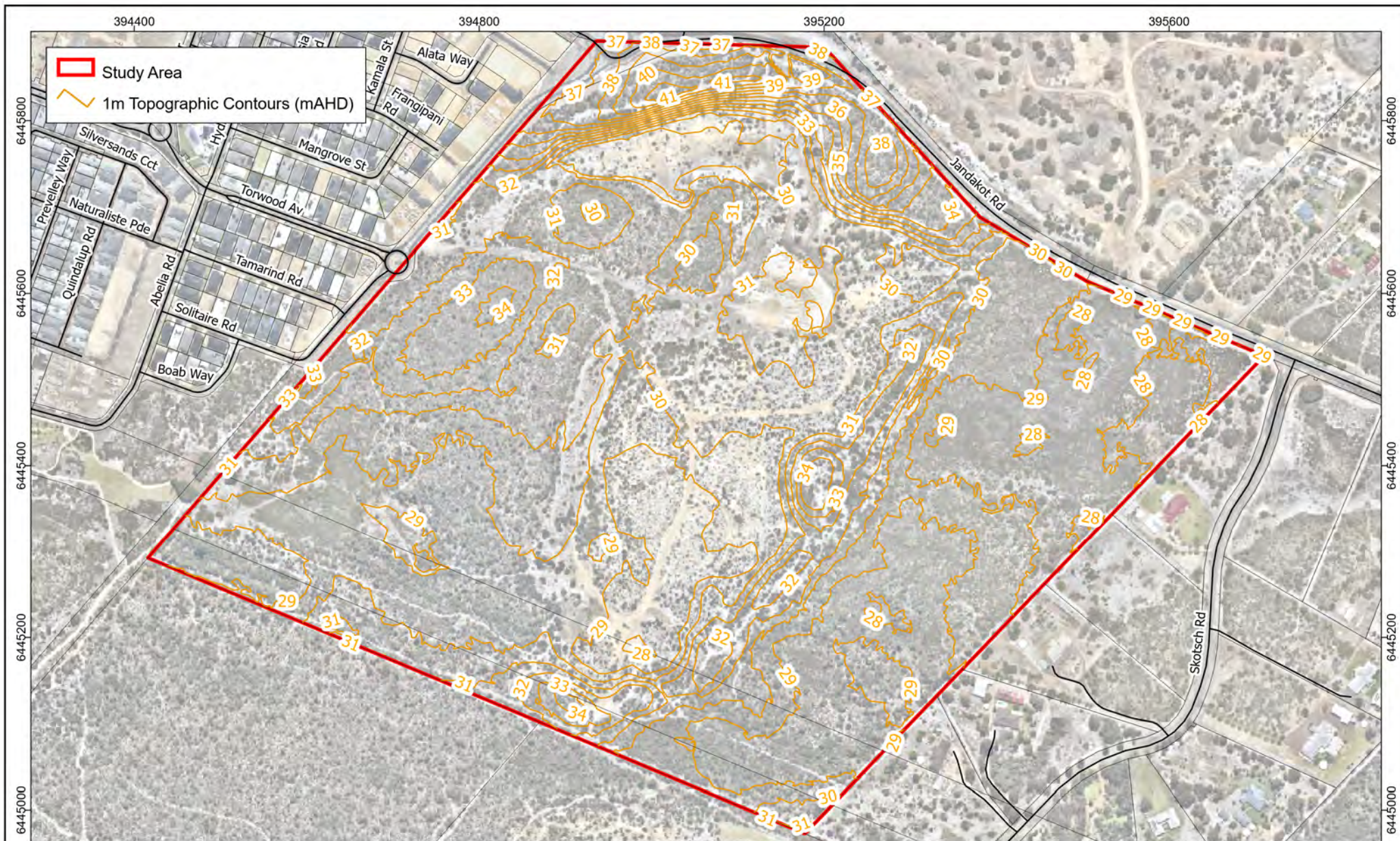
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Figure 3: Aerial Photograph



Data Source: Nearmap (2021); LiDAR (DoW, 2008)

Coordinate System: GDA 2020, Zone 50



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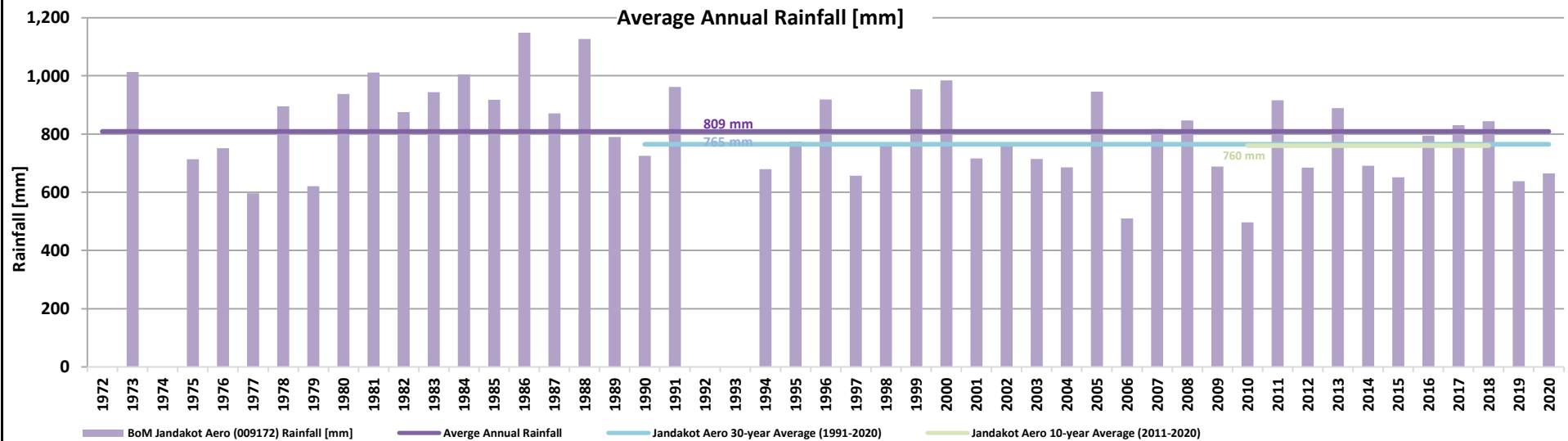
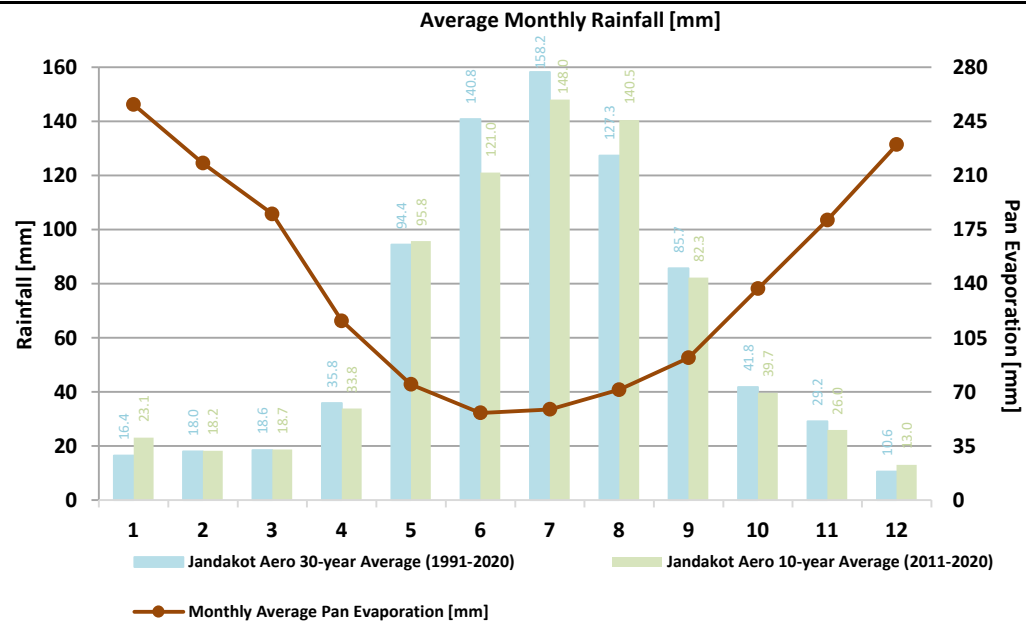
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Figure 4: Topography



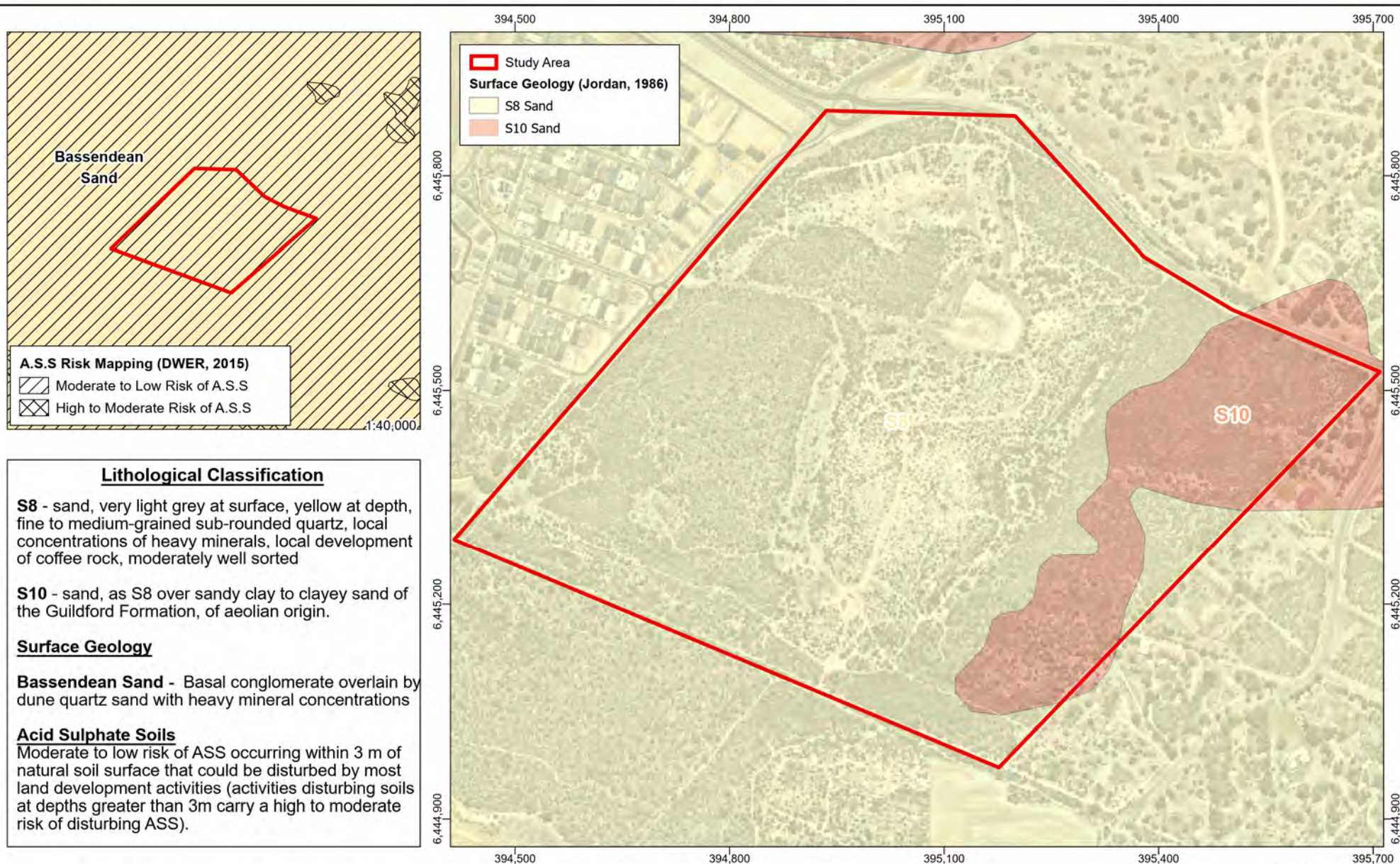
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Figure 5: Rainfall and Evapoation



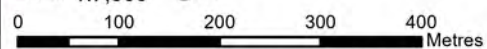
Data Source: Jordan (1986) Environmental Geology Series *Armada*; A.S.S. Risk Mapping (DWER, 2015); Nearmaps (2021).

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Figure 6: Surface Geology and A.S.S. Mapping



Data Source: DBCA (2018) *Geomorphic Wetlands SCP (DBC-019)*.

Coordinate System: GDA 2020, Zone 50



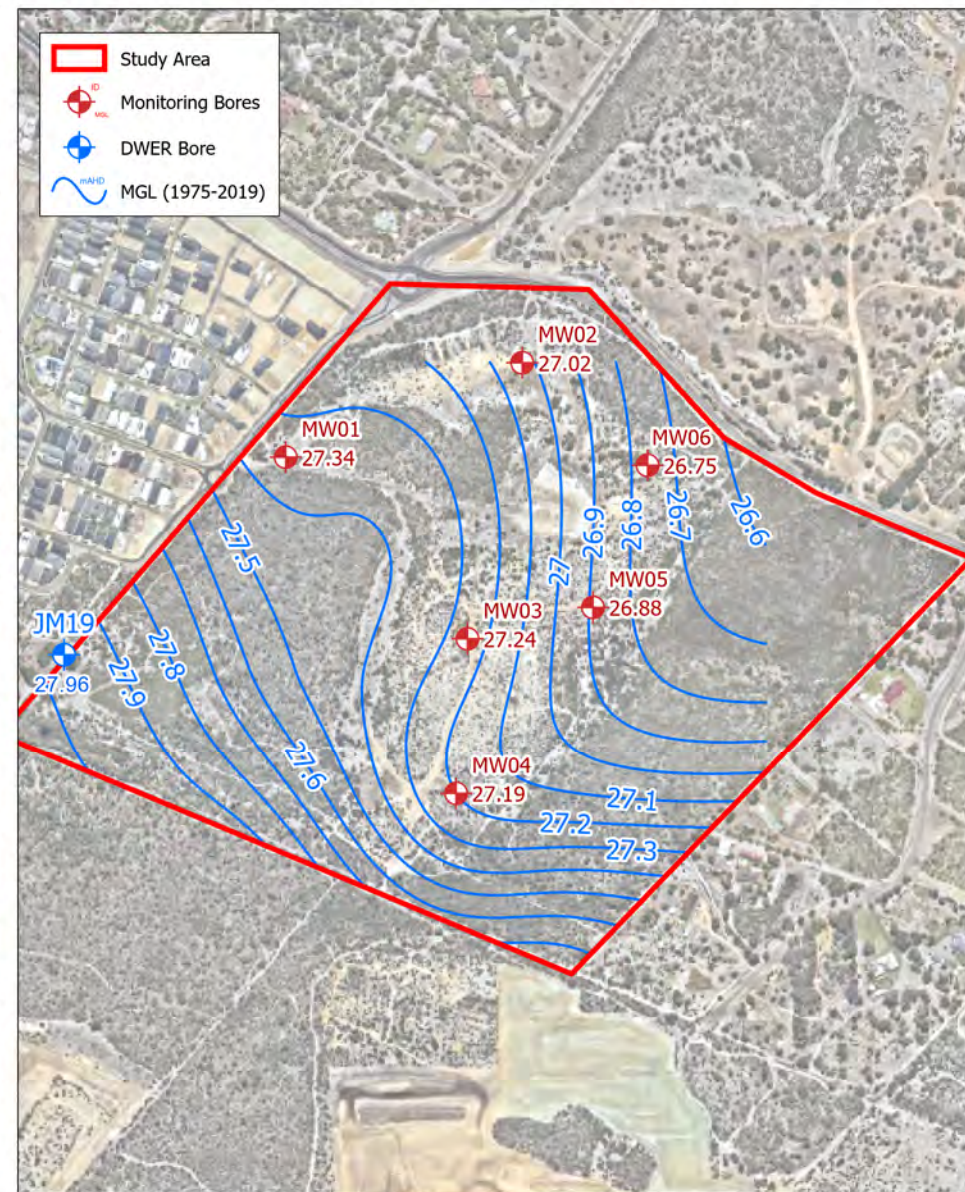
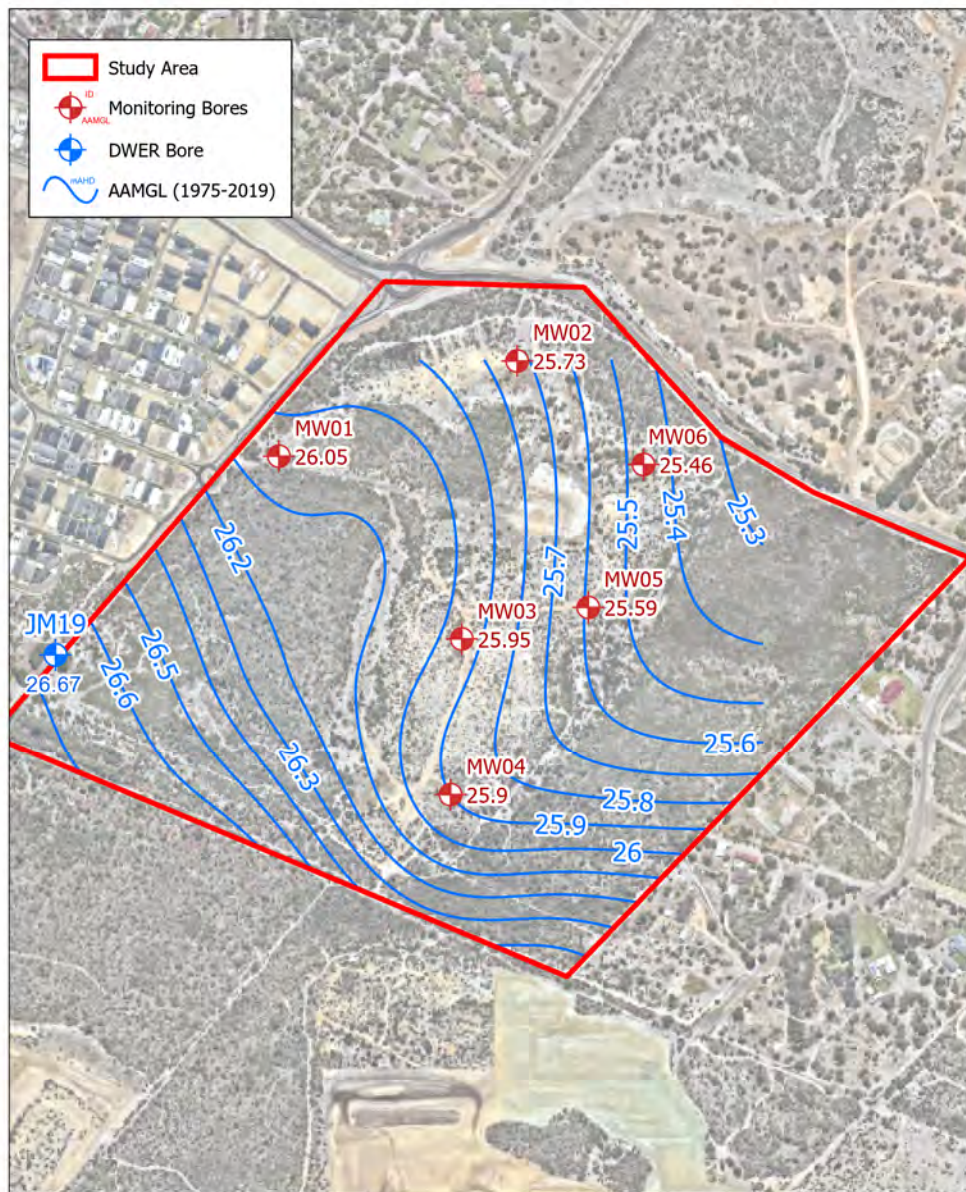
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Figure 7: Wetlands and Vegetation



Data Source: NearMap (2021).

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Meters

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Lot 5131 Jandakot Road, Treeby: Local Water Management Strategy
**Figure 8: Groundwater Monitoring Bore Locations and Estimated
Pre-Development AAMGL and MGL**



Data Source: CLE (2021); Nearmap (2021).

Coordinate System: GDA 2020, Zone 50



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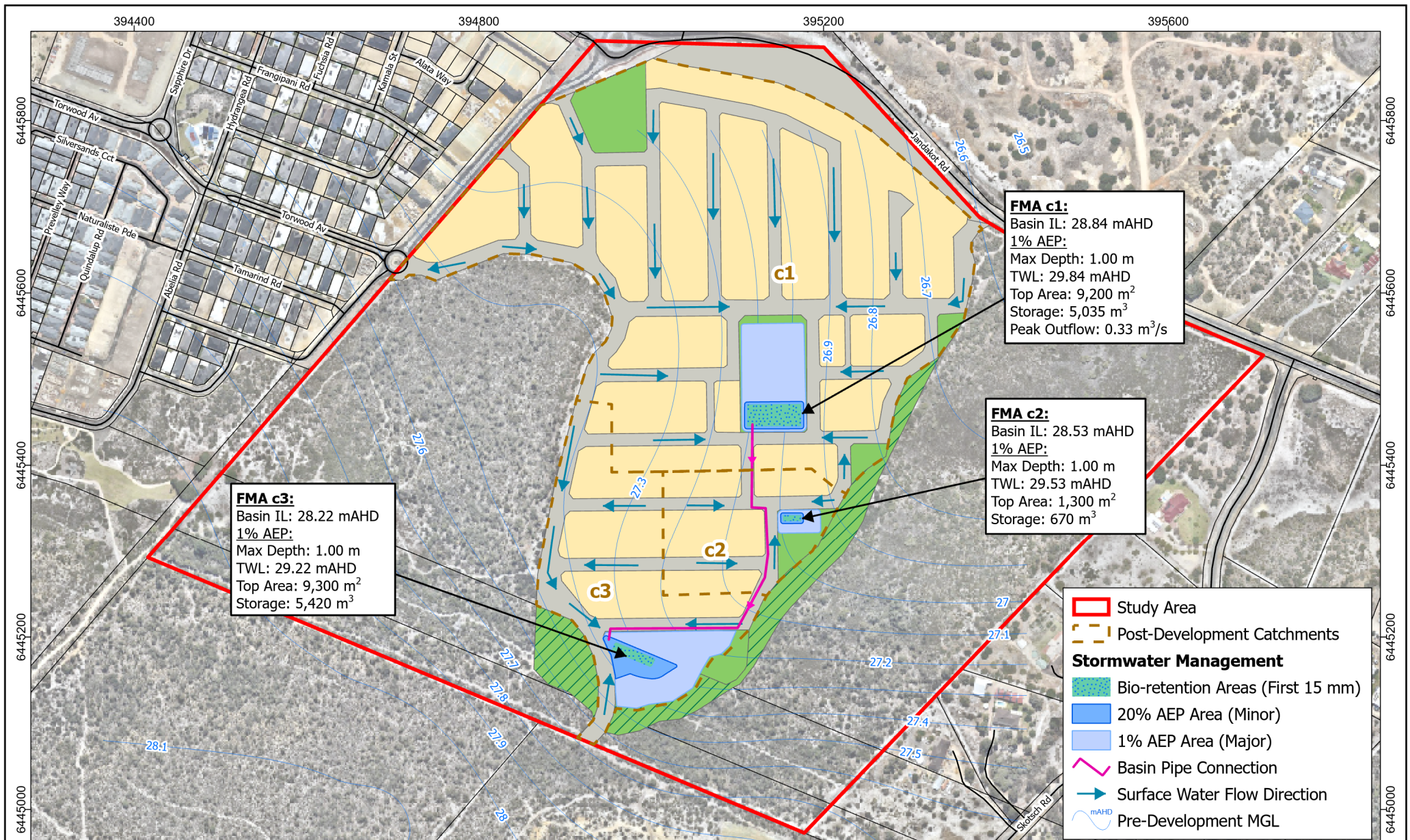
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Figure 9: Post-Development Land Use and Drainage Catchments



Data Source: CLE (2021); Nearmap (2021).

Coordinate System: GDA 2020, Zone 50

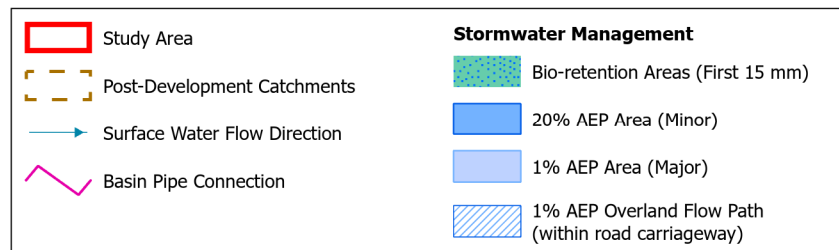
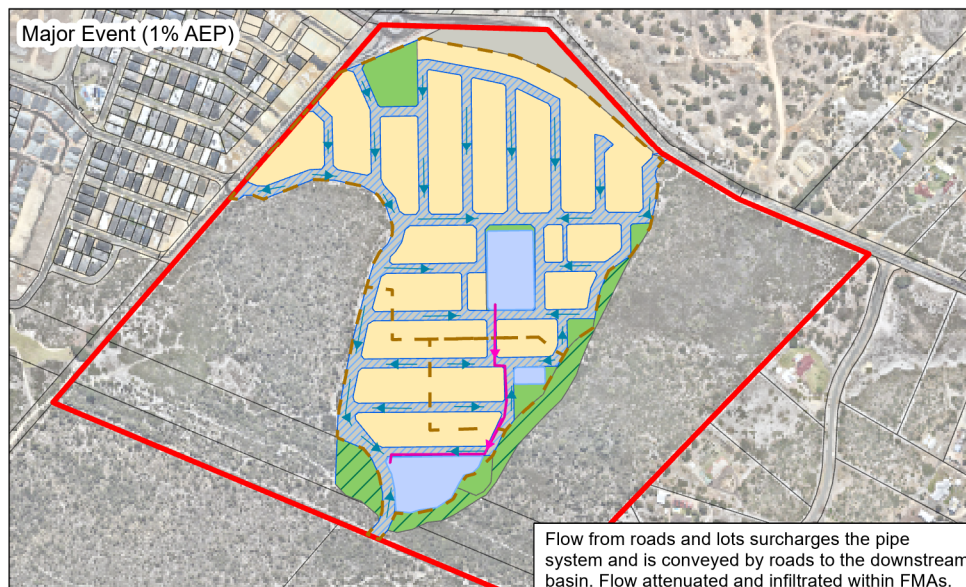
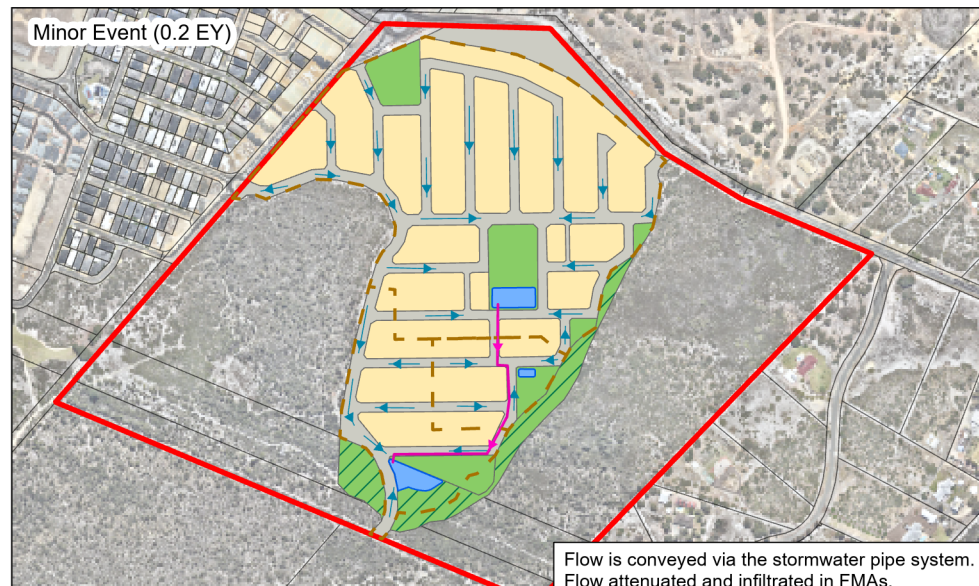


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 Lot 5131 Jandakot Road, Treeby: Local Water Management Strategy
Figure 10: Stormwater Management Plan



	BRA c1	BRA c2	BRA c3
BRA Invert (mAHD)	28.84	28.53	28.22
Side Slope	1 in 6	1 in 6	1 in 6
Water Depth (m)	0.20	0.25	0.35
Top Water Level (mAHD)	29.04	28.78	28.57
Top Water Area (m ²)	1,828	235	562
Stored Volume (m ³)	342	47	153

Data Source: Nearmap (2020), PCSump (2021); XPStorm (2021)

Coordinate System: GDA 2020 MGA Zone 50



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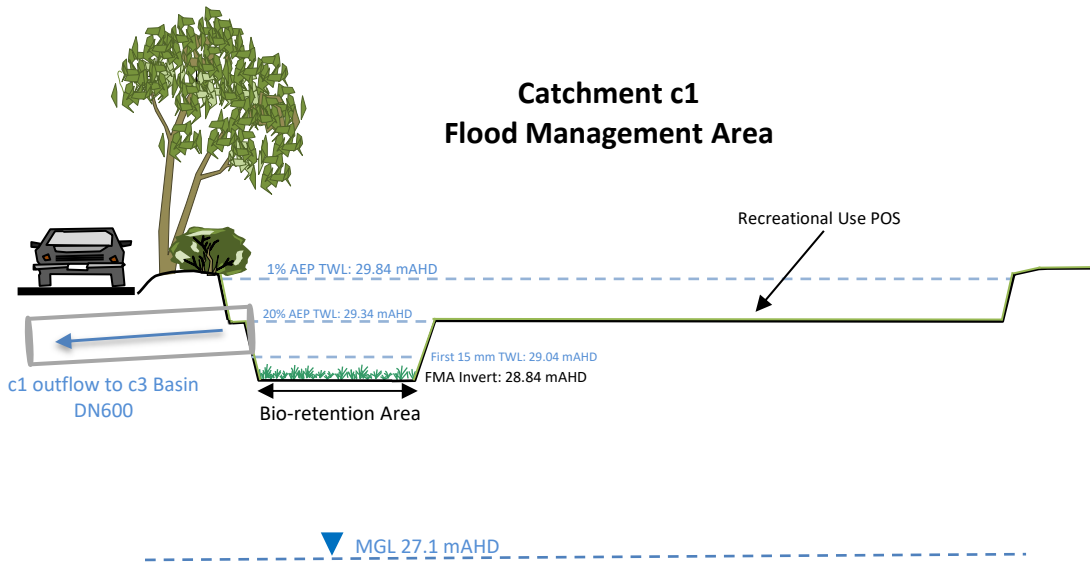


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 Lot 5131 Jandakot Road, Treeby: Local Water Management Strategy
Figure 11: Stormwater Event Plans

Cross-Section

A

A'



Note: Drawing not to scale



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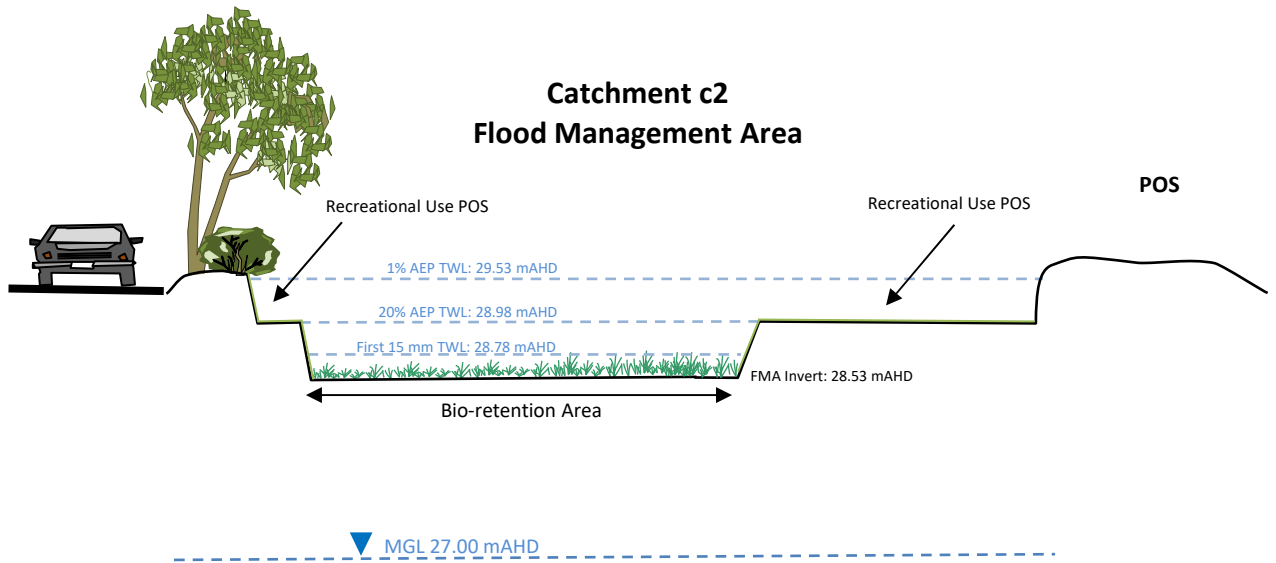
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Figure 12: Flood Management Area c1 Cross-section

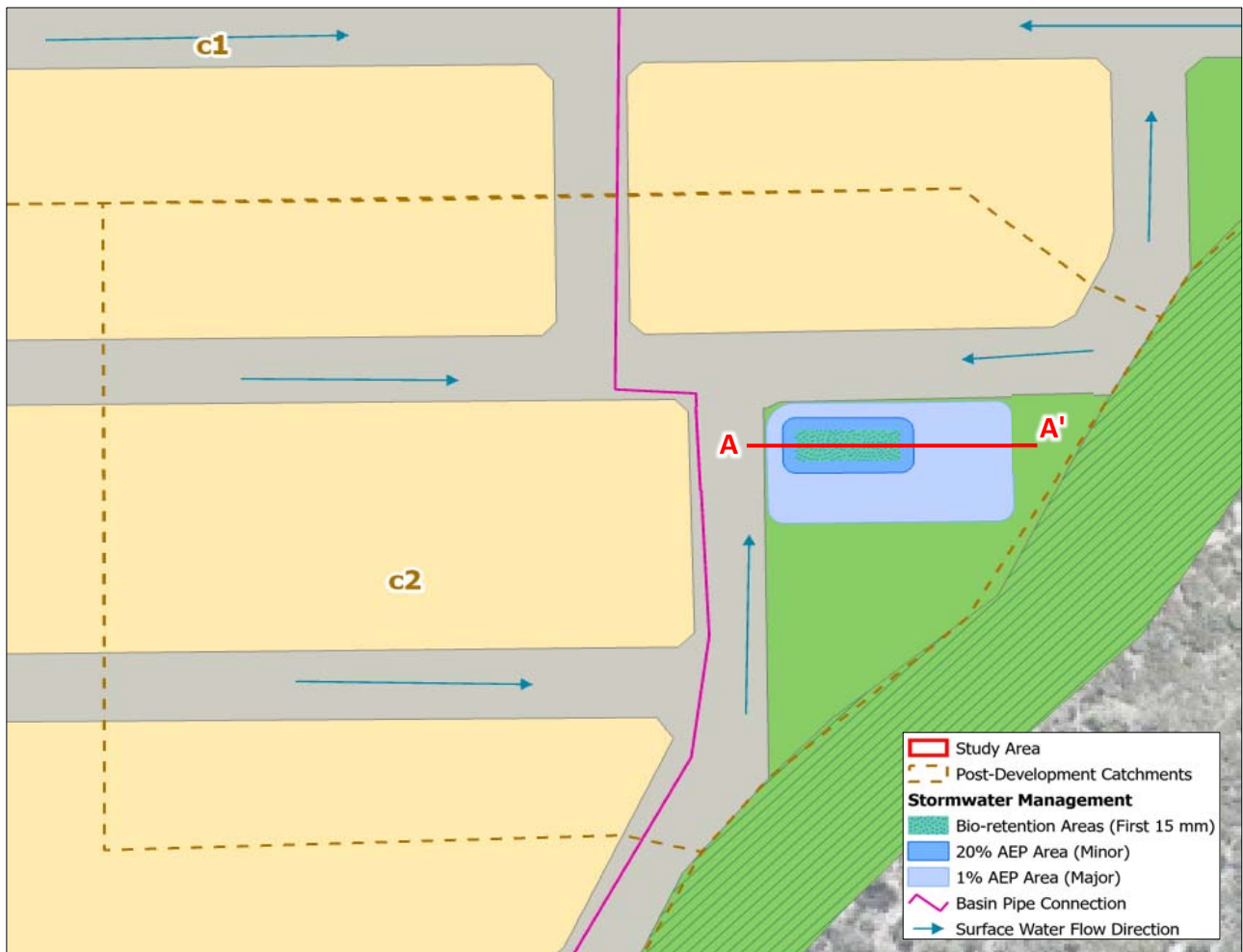
Cross-Section

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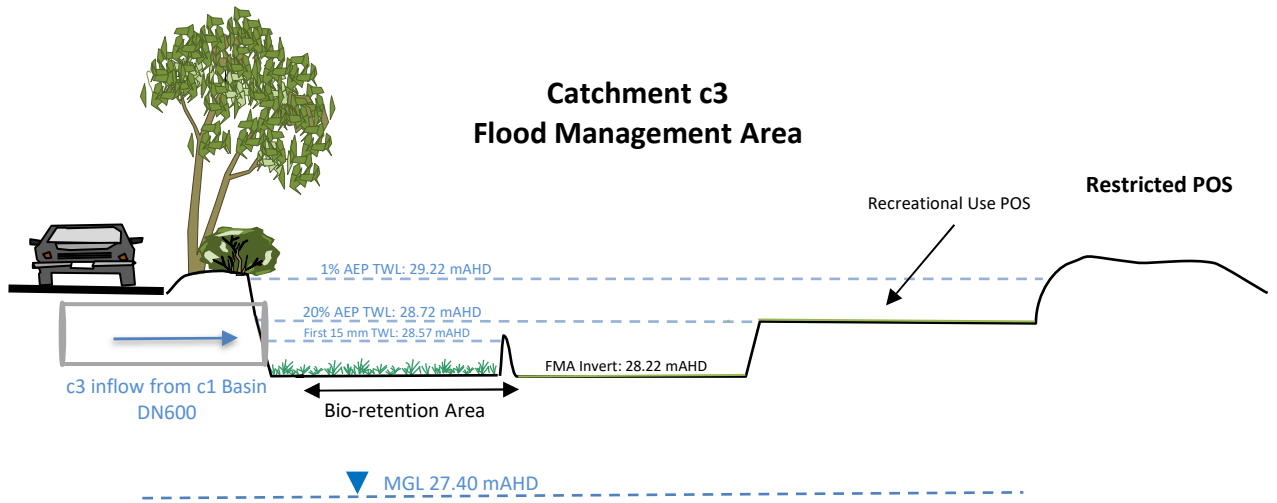
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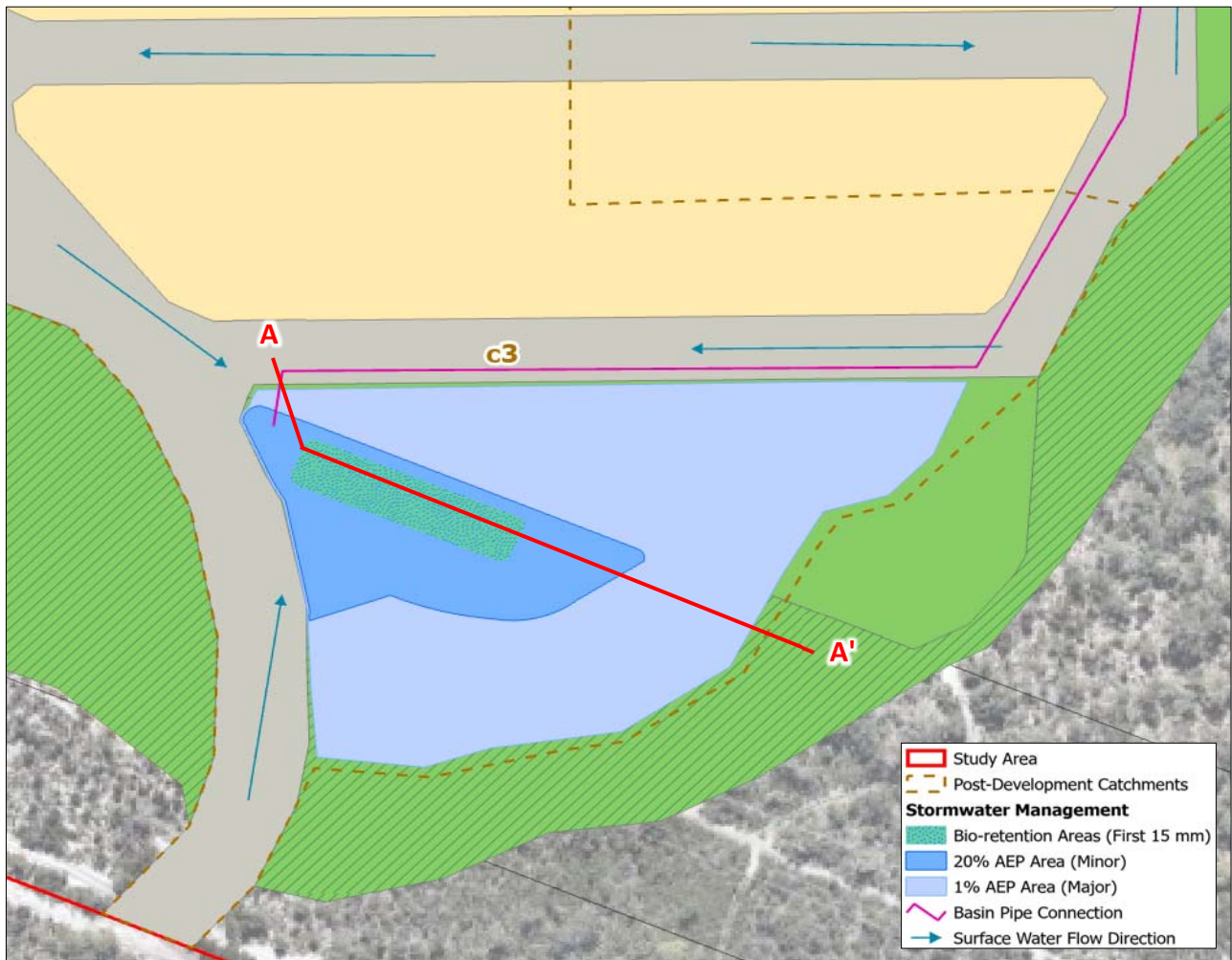
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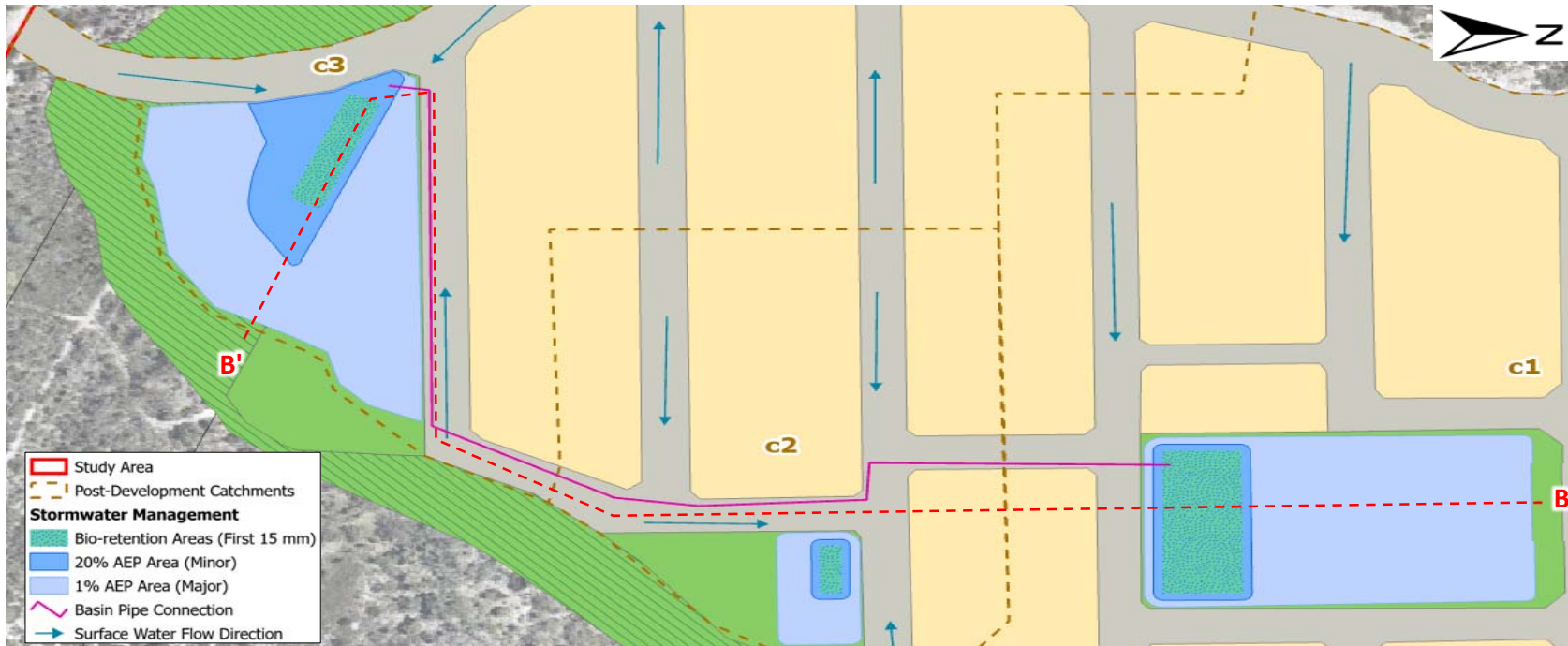
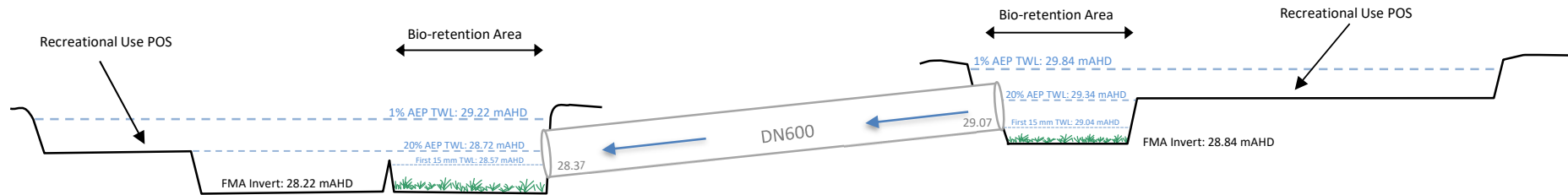


B'

Catchment c3 Flood Management Area

B

Catchment c1 Flood Management Area



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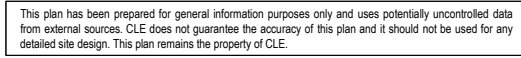
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Lot 5131 Jandakot Road, Treeby: Local Water Management Strategy
Figure 15: Long-Section, Flood Management Area c1 to c3

APPENDICES

APPENDIX A

Local Structure Plan (CLE, 2021)



APPENDIX B

Pre-development Groundwater Level and Quality Monitoring (JDA, 2021)

Perron Developments Pty Ltd

Lot 131 Jandakot Rd, Treeby (Banjup)
Pre-Development Groundwater Monitoring
2018-2020



January 2021

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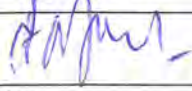
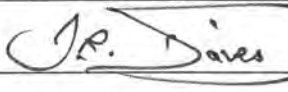
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JDA does not take responsibility for checking any landscape and engineering plans attached to this report for accuracy or consistency with this report.

QUALITY ASSURANCE

The JDA quality control system has been in place since 1997 and meets the requirements of AS/NZS ISO 9001:2008. JDA is committed to maintaining and improving the quality management system.

Document Version No.	Issue Date
J6641a	7 January 2021

	Name	Signature	Date
Author	Sri Adiyanti		7/01/2021
Checked by	Jim Davies		7/01/2021
Approved by	Jim Davies		7/01/2021

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9. Groundwater TP and PO₄-P Concentrations
10. Groundwater Total Iron (Fe), Mercury (Hg) and Selenium (Se) Concentrations
11. Groundwater Dissolved Aluminium (Al), Barium (Ba), Boron (B), and Cadmium (Cd) Concentrations
12. Groundwater Dissolved Copper (Cu), Molybdenum (Mo), and Zinc (Zn) Concentrations

APPENDICES

- A. JDA Lithological Bore Logs
- B. Groundwater Quality Data
- C. Groundwater levels in DWER's bores JM16, JM19, JM26 and JM27

1. INTRODUCTION

Lot 131 Jandakot Rd, Treeby (the Study Area) is located within the City of Cockburn, approximately 19 km south of Perth (Figure 1). It was formerly operated as a sand quarry between 1995 and 2006 and is now available for infill development as a 'brownfields' site.

The Study Area is currently zoned 'Rural – Water Protection' under the Metropolitan Region Scheme (MRS), and classified as Priority 2 (P2) within the Jandakot Mound Underground Water Pollution Control Area (UWPCA), which was proclaimed in 1975 under the Metropolitan Water Supply Sewerage and Drainage Act 1909. Water from the mound is extracted by the Water Corporation as part of the Perth Metropolitan Integrated Water Supply System (IWSS).

Perron Developments Pty Ltd is currently seeking to rezone the land to 'Urban'. A District Water Management Strategy (DWMS) was prepared (JDA, 2018) to support the MRS rezoning application prepared by Perron Developments Pty Ltd. The development of the Study Area will consolidate the Treeby Urban precinct.

1.1 Pre-Development Monitoring Requirement

The Department of Water and Environmental Regulation's (DWER, 2018) *Water Quality Protection Note No. 38 – Priority 3* (P3*) Areas* provides the Department's advice on protecting drinking water quality and public health. When urban development is approved in Public Drinking Water Source Areas (PDWSAs), the risk of water quality contamination increases, as a result of additional sources of contamination.

A pre-development groundwater dataset is required to assess and manage any potential adverse risks to groundwater levels and quality. A two-year pre-development groundwater monitoring was conducted, as described in the DWMS, to inform preparation of a development concept or structure plan and associated LWMS for the Study Area. This report details the pre-development groundwater monitoring results performed by JDA from September 2018 to October 2020.

2. GROUNDWATER MONITORING PROGRAM

2.1 Bore Location

Groundwater levels and quality were monitored in the six JDA monitoring bores MW01-MW06 and the Department of Water and Environmental Regulation (DWER) bore JM19 (only water level), shown in Figure 1 and detailed in Table 2.

Bores MW01-MW06 were installed on 25 September 2018 and surveyed on 4 October 2018 by Edrill Environmental under JDA supervision.

Bore logs of MW01-MW06 are provided in Appendix A.

TABLE 1: GROUNDWATER MONITORING SITE DETAILS

Bore ID	GDA 2020 (MGA 50)		Ground Level (mAHD)	Top of Casing (mAHD)	Total Depth (mbTOC) ¹⁾
	Easting	Northing			
MW01	394797	6445662	31.98	32.58	8.10
MW02	395112	6445788	29.95	30.55	6.60
MW03	395039	6445420	29.91	30.51	6.60
MW04	395024	6445213	28.09	28.69	6.10
MW05	395206	6445462	30.56	31.16	6.60
MW06	395279	6445651	29.88	30.48	6.60
JM19	394501	6445394	30.95	31.62	18.1

¹⁾ mbTOC: metres below top of casing

2.2 Groundwater Levels

Aim: To record pre-development groundwater levels within the Study Area and compare them with the long-term groundwater levels recorded at DWER monitoring bores JM16, JM19, JM26 and JM27 (Figure 1).

Method: Six monitor bores were installed in September 2018 (MW1 to MW6) and equipped with data loggers to record 6-hourly water levels. Manual checks of static groundwater levels were conducted by JDA field staff using an electrical depth probe.

Frequency: Manual checks of static groundwater levels at MW bores were conducted quarterly since September 2018. The last download of loggers' data was on 20 October 2020.

2.3 Groundwater Quality

Aim: To record pre-development groundwater quality within the Study Area. There is not any useful water quality data collected at DWER monitoring bores JM16, JM19, JM26 and JM27.

Method: Samples were collected from the MW bores by JDA field staff, and submitted to a NATA-accredited laboratory for the following parameters analysis:

- Physico-chemical: Electrical Conductivity (EC), pH, and temperature.
- Nutrients: Total Phosphorus (TP), Filterable Reactive Phosphorus (FRP or PO₄-P), Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Nitrogen in nitrogen oxides (NO_x-N) and ammonia (NH₃-N).
- Major Anions: chloride (Cl⁻), sulfate (SO₄²⁻), bicarbonate (HCO₃²⁻).
- Major Cations: calcium (Ca²⁺), potassium (K⁺), magnesium (Mg²⁺), sodium (Na⁺).

- Dissolved Metals: aluminium (Al), arsenic (As), barium (Ba), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), manganese (Mn), molybdenum (Mo), nickel (Ni), silver (Au), and zinc (Zn).
- Total Metals: iron (Fe), mercury (Hg), and selenium (Se).

In addition, EC and pH were also measured on site by JDA staff.

All sampling was conducted in accordance to the guidelines set out by the Australian/New Zealand Standard (AS/NZS) 5667.11: 1998 (R2016) "Water Quality - Sampling Part 11: Guidance on sampling of groundwater". Groundwater samples were field-filtered.

Frequency: 8 groundwater samples were collected from MW bores quarterly October 2018 to July 2020.

All groundwater data collected is stored in JDA ESdat database, with results provided in Appendix B.

Laboratory Results:

Samples were analysed and reported according to the Practical Quantitation Limit (PQL), which was set by the laboratory to ensure confidence and consistency of reporting data.

PQL is defined as the lowest concentration of an analyte that can be determined with acceptable precision (repeatability) and accuracy under the stated conditions of the test. Generally in the laboratory, the PQL is calculated as 5 times the Limit of Detection (LOD), (PQL = 5x LOD).

According to National Environment Protection Measures (NEPMs), the LOD is the concentration of analyte which, when the sample is processed through the complete method, produces a response with a 95% probability that is different from the blank.

3. MONITORING RESULTS AND ANALYSIS

3.1 Rainfall

Treeby has a Mediterranean climate with warm dry summers and cool wet winters.

Figure 2 shows the average monthly and annual rainfall recorded at the Bureau of Meteorology (BoM) Jandakot Aero Station (ID 9172). The long-term (1975 to 2020) average annual rainfall is 804.4 mm. The average has slightly decreased by 8% since 2011 to 761.6 mm, consistent with the general decline in rainfall in southwest Western Australia (DoW, 2015). The short-term (2011 to 2020) average rainfall at Jandakot is 761.6 mm. Relative to this, 2018 was wetter, whereas 2019 and 2020 were drier.

The monthly average pan-evaporation (lower panel of Figure 2) is recorded in the Department of Primary Industry and Regional Development (DPIRD) Medina and Wattelup Evaporation Stations, with annual average of 1771 mm.

3.2 Groundwater Levels

MW bore water levels 2018 to 2020 are plotted in Figures 4 and 5. The comparison between water levels recorded in MW bores and DWER bores (JM16, JM19, JM26 and JM27) for the monitoring period (Table 2) suggests a similarity in the water level variation, except levels recorded in JM19.

The comparison with the long-term (January 1975 to September 2020) recorded groundwater levels in DWER's bores is provided in Appendix C, with significant events identified. In 2016, water levels in JM19 increased significantly more than other DWER bores, possibly due to infiltration of stormwater at nearby Calleya Estate.

Highest recorded groundwater levels of between 27.05 and 26.56 mAHD (with gradient west to east) occurred at bore installation in September 2018, associated with higher 2018 winter rainfall than in 2019 and 2020. These levels are shown in Figure 1 and are generally 1.0 m above the 2004 summer groundwater contours, as expected.

The winter 2018 groundwater levels confirm the design groundwater level of 26.8 mAHD used for preliminary sizing of infiltration basins in the DWMS (JDA, 2018).

TABLE 2: GROUNDWATER LEVELS (mAHD) AT JDA BORES AND DWER BORES

Month	JDA Bores						DWER Bores			
	MW01	MW02	MW03	MW04	MW05	MW06	JM16 ^{*)}	JM19	JM26 ^{*)}	JM27 ^{*)}
Sep-18	27.05	26.62	26.85	26.76	26.63	26.56	25.71	N/M	26.84	25.31
Oct-18	27	26.61	26.81	26.72	26.59	26.56	25.56	27.14	26.72	24.81
Jan-19	26.5	26.07	26.35	26.21	26.06	25.97	24.99	26.55	26.22	24.23
May-19	26.01	25.55	25.87	25.77	25.58	25.48	24.450	26.17	25.65	23.80
Jul-19	26.37	25.89	26.28	26.22	25.98	N/M	25.06	26.7	25.96	24.93
Aug-19	26.49	26	26.33	26.27	26.06	25.94	25.11	26.82	26.34	24.91
Sep-19	26.67	26.19	26.58	26.49	26.28	26.12	25.36	26.99	26.47	25.23
Oct-19	26.65	26.2	26.48	26.39	26.22	26.1	25.28	26.86	26.47	24.81
Nov-19	26.59	26.14	26.42	26.32	26.15	26.05	25.13	N/M	26.31	24.65
Jan-20	26.26	25.72	26.11	25.95	25.77	25.65	24.66	26.44	25.96	23.99
Apr-20	25.91	25.41	25.75	25.65	25.45	25.32	24.28	26.19	25.63	23.59
Jul-20	25.97	25.65	25.87	25.82	25.51	25.38	24.59	26.58	25.69	24.59
Oct-20	26.23	25.72	26.07	25.98	25.78	25.64	24.86	26.53	26.09	24.74
Min	25.91	25.41	25.75	25.65	25.45	25.32	24.28	26.17	25.63	23.59
Max	27.05	26.62	26.85	26.76	26.63	26.56	25.71	27.14	26.84	25.31
Range	1.14	1.21	1.1	1.11	1.18	1.24	1.43	0.97	1.21	1.72

^{*)} Source: DWER Water Information Reporting (2020), values are rounded to the closest cm.

3.3 Groundwater Quality

Detailed dataset and statistics on groundwater quality are provided in Appendix B.

3.3.1 Physico-chemical

The statistical summary of electrical conductivity (EC), pH, temperature, total dissolved solids (TDS) and major ions are provided in Table 3 with the time-series plots provided in Figure 6. The average concentrations of major ions measured (2018-2020) are presented as stiff diagrams in Figure 7.

Applicable Australian Drinking Water Guideline (ADWG) (NHMRC, 2011) values are provided for comparison.

TABLE 3: PHYSICO-CHEMICAL SUMMARY

Parameter	Statistic	MW01	MW02	MW03	MW04	MW05	MW06
Field pH (pH unit) ADWG Aesthetic: 6-5-8.5	N sample	8	8	8	8	8	8
	Min	6.52	6.27	5.62	6.2	6.16	4.44
	Max	6.99	6.62	6.07	6.63	6.7	6.27
	Mean	6.7	6.5	5.9	6.4	6.4	5.2
	Median	6.67	6.51	5.90	6.34	6.39	5.02
Field EC (µS/cm) ADWG Health: Not necessary ADWG Aesthetic: 600 mg/L TDS, equates to 1000 µS/cm	N sample	8	8	8	8	8	8
	Min	335	170	120	305	155	196
	Max	590	220	217	421	253	268
	Mean	458	204	164	345	210	226
	Median	438	210	164	331	219	218
Temperature (°C) ADWG Health: Not necessary ADWG Aesthetic: No value set	N sample	8	8	8	8	8	8
	Min	19.8	19.7	19.5	18.9	18.9	19.6
	Max	23.1	22.8	22.5	23.2	22.5	22.2
	Mean	21.0	21	21	21	21	21
	Median	20.9	20.25	20.65	19.8	20.65	20.5
Lab pH (pH unit) ADWG Aesthetic: 6-5-8.5	N sample	8	8	8	8	8	8
	Min	6.8	6.7	5.7	6.5	6.4	5
	Max	7.1	7	6.3	6.7	6.9	6.3
	Mean	7.0	6.9	6.1	6.6	6.7	5.4
	Median	6.9	6.9	6.1	6.6	6.7	5.2
Lab EC (µS/cm) ADWG Health: Not necessary ADWG Aesthetic: 600 mg/L TDS, equates to 1000 µS/cm	N sample	8	8	8	8	8	8
	Min	380	180	130	310	160	190
	Max	670	230	210	410	250	270
	Mean	471	206	164	350	214	220
	Median	435	210	170	350	230	215
TDS (mg/L) ADWG Health: Not necessary ADWG Aesthetic: 600 mg/L	N sample	8	8	8	8	8	8
	Min	240	100	100	190	110	120
	Max	480	170	150	270	160	150
	Mean	339	138	121	224	135	131
	Median	310	145	115	220	145	130
TDS/EC Ratio	Min	0.60	0.56	0.57	0.59	0.58	0.55
	Max	0.81	0.76	0.88	0.72	0.69	0.65
	Mean	0.72	0.66	0.75	0.64	0.63	0.60
	Median	0.74	0.67	0.77	0.63	0.63	0.60

*) Exceedances are printed in blue

Key interests (Figure 6 and Table 3) include:

- Groundwater is fresh with TDS of less than 500 mg/L, and EC (a surrogate for TDS) of generally less than 850 µS/cm.
- Groundwater pH are generally neutral (6.5 to 7 pH scale), except MW03 and MW06 towards acidic scale and outside the ADWG values (6.5 to 8.5), consistent with the Superficial Aquifer being naturally acidic in this area.

- Temperature recorded at all bores show a seasonal variation; warmer in summer and cooler in winter months.
- Ratio of TDS/EC vary from 0.55 to 0.8 as shown in Table 3.

Stiff diagrams in Figure 7 suggest a variation of major ions between bores:

- In MW01, MW02, and MW04: a strong dominance of cation calcium Ca^{2+} and anion bicarbonate (HCO_3^-).
- In MW05, a strong dominance of cation calcium Ca^{2+} with a relative balance of anions between chloride Cl^- , bicarbonate (HCO_3^-), and sulfate (SO_4^{2-}).
- In MB03 and MW06, cation sodium Na^+ and anion chloride (Cl^-) dominate the ions.

3.3.2 Nutrients

The statistical summary of nutrients (nitrogen and phosphorus) concentrations is provided in Table 4 with the time-series plots provided in Figures 8-9. The NHMRC (2011) ADWG health and aesthetic (taste, odour, staining) trigger values are provided in Tables 4 for comparison.

TABLE 4: NUTRIENTS SUMMARY

Parameter	Statistic	MW01	MW02	MW03	MW04	MW05	MW06
Ammonia as N ($\text{NH}_3\text{-N}$) (mg/L) ADWG Aesthetic: $\text{NH}_3 < 0.5$ mg/L equates to $\text{NH}_3\text{-N} < 0.41$ mg/L	N sample	8	8	8	8	8	8
	Min	<0.005	<0.005	0.034	0.044	<0.005	<0.005
	Max	<0.005	0.006	0.058	0.14	0.009	0.012
	Mean	0.005	0.0051	0.043	0.097	0.0055	0.0059
	Median	0.005	0.005	0.0405	0.0925	0.005	0.005
Oxidised Nitrogen ($\text{NO}_x\text{-N}$) (mg/L) ADWG Health: $\text{NO}_3 < 50$ mg/L equates to $\text{NO}_x\text{-N} < 11$ mg/L	N sample	8	8	8	8	8	8
	Min	4.8	0.78	<0.005	0.023	0.03	0.14
	Max	7.8	1.7	0.44	0.31	0.14	1.5
	Mean	6.1	1.2	0.16	0.13	0.076	0.74
	Median	5.65	1.15	0.077	0.079	0.078	0.705
Total Kjeldahl Nitrogen (TKN) (mg/L) ADWG: -	N sample	8	8	8	8	8	8
	Min	<0.1	0.2	0.3	0.2	0.2	<0.1
	Max	2	4.4	0.7	0.6	0.3	0.3
	Mean	1	0.85	0.54	0.44	0.24	0.15
	Median	1.05	0.35	0.55	0.45	0.2	0.1
Total Nitrogen (TN) (mg/L) ADWG: -	N sample	8	8	8	8	8	8
	Min	5.2	1.1	0.3	0.4	0.2	0.3
	Max	9.2	5.2	1.2	0.8	0.4	1.7
	Mean	7.1	2	0.7	0.58	0.3	0.9
	Median	6.95	1.6	0.65	0.55	0.3	0.85
Phosphate as P ($\text{PO}_4\text{-P}$) (mg/L) ADWG: -	N sample	8	8	8	8	8	8
	Min	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Max	0.005	<0.005	0.01	<0.005	<0.005	<0.005
	Mean	0.005	<0.005	0.0059	<0.005	<0.005	<0.005
	Median	0.005	<0.005	0.005	<0.005	<0.005	<0.005
Total Phosphorus (TP) (mg/L) ADWG: -	N sample	8	8	8	8	8	8
	Min	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Max	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
	Mean	0.04	0.04	0.04	0.04	0.04	0.04
	Median	0.05	0.05	0.05	0.05	0.05	0.05

Total Nitrogen (TN) accounts for organic and inorganic in all forms: dissolved inorganic (nitrogen in nitrogen oxides $\text{NO}_x\text{-N}$, ammonia $\text{NH}_3\text{-N}$), dissolved and particulates organic nitrogen. Total Kjeldahl Nitrogen (TKN) accounts for particulate organic nitrogen and $\text{NH}_3\text{-N}$.

Time-series plots of TN, TKN, NO_x-N, and NH₃-N concentrations (Figure 8) and statistics in Table 4 show:

- Highest TN concentration is consistently recorded in MW01; it is not clear of the cause of this elevated concentration.
- Nitrogen in MW03-MW05 are mostly in the form of organic nitrogen, whilst in MW01, MW02, and MW06 are in the form of dissolved inorganic oxides of nitrogen (NO_x-N). Bores MW03-MW05 are located in newly cleared land with old brick works roads (rubble). Bores MW01, MW02, and MW06 are in old cleared bushed area. Organic-content in the soil matrix are probably released more than northern are bores (MW01, MW02, and WM06).
- No exceedances in any nitrogen concentration, all concentrations are less than the ADWG health and aesthetic trigger guideline value.

Total Phosphorus (TP) accounts for organic phosphorus and inorganic phosphorus/Filterable Reactive Phosphorus (PO₄-P). Time-series plots of TP and PO₄-P (Figure 9) and statistics in Table 4 show that all bores contain TP and PO₄-P concentrations of equal or less than the practical quantitation limit (PQL).

3.3.3 Metals

Tables 5 and 6 summarize the concentrations of total metals (Fe, Hg, Se) and dissolved metals (Al, As, Ba, B, Cd, Cr, Cu, Fe, Pb, Mn, Mo, Ni, Au, and Zn), with time-series plots provided in Figures 10-12.

The NHMRC (2011) ADWG health and aesthetic (taste, odour, staining) trigger values are provided in Tables 5 and 6 for comparison.

Key interests include:

- All metals (except Al, Ba, B, Cd, Cu, Mo, and Zn) concentrations are equal or less than the practical quantitation limit (PQL).
- All concentrations (except Al and Zn) are less than the ADWG health and/or aesthetic trigger guideline values.
- Exceedances of the ADWG aesthetic values are recorded in Al in MW03 and MW06, and Zn in MW06.

TABLE 5: TOTAL METALS SUMMARY

Bore	Statistic	MW01	MW02	MW03	MW04	MW05	MW06
Iron (Fe) (mg/L) ADWG Health: c ADWG Aesthetic: Fe < 0.3 mg/L	N sample	8	8	8	8	8	8
	Min	<0.01	<0.01	0.06	0.04	0.03	<0.01
	Max	0.06	0.02	0.24	0.12	0.76	0.22
	Mean	0.025	0.014	0.11	0.076	0.15	0.063
	Median	0.02	0.01	0.095	0.07	0.065	0.045
Mercury (Hg) (mg/L) ADWG Health: Hg < 0.001 mg/L	N sample	8	8	8	8	8	8
	Min	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
	Max	<0.00005	<0.00005	0.00008	<0.00005	<0.00005	0.00013
	Mean	<0.00005	<0.00005	0.000054	<0.00005	<0.00005	0.00006
	Median	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Selenium (Se) (mg/L) ADWG Health: Se < 0.01 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Max	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Median	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

TABLE 6: DISSOLVED METALS SUMMARY

Bore	Statistic	MW01	MW02	MW03	MW04	MW05	MW06
Aluminium (Al) (mg/L) ADWG Health: c ADWG Aesthetic: Al < 0.2 mg/L	N sample	8	8	8	8	8	8
	Min	0.04	0.01	0.13	0.05	0.02	0.07
	Max	0.13	0.03	0.22	0.11	0.08	0.68
	Mean	0.075	0.019	0.16	0.076	0.053	0.35
	Median	0.07	0.02	0.15	0.075	0.055	0.365
Arsenic (As) (mg/L) ADWG Health: As < 0.01 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Max	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Median	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium (Ba) (mg/L) ADWG Health: Ba < 2 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
	Max	0.002	<0.001	0.003	<0.001	<0.001	0.005
	Mean	0.0011	<0.001	0.0013	<0.001	<0.001	0.0045
	Median	0.001	<0.001	0.001	<0.001	<0.001	0.0045
Boron (B) (mg/L) ADWG Health: B < 4 mg/L	N sample	8	8	8	8	8	8
	Min	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
	Max	0.06	<0.02	0.03	<0.02	0.03	<0.02
	Mean	0.033	0.02	0.021	0.02	0.023	0.02
	Median	0.03	0.02	0.02	0.02	0.02	0.02
Cadmium (Cd)(mg/L) ADWG Health: Cd < 0.002 mg/L	N sample	8	8	8	8	8	8
	Min	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Max	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004
	Mean	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00015
	Median	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
Chromium (III+VI) (Cr ³⁺ ,Cr ⁶⁺) (mg/L) ADWG Health: Cr ⁶⁺ < 0.05 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Max	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Median	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper (Cu) (mg/L) ADWG Health: Cu < 2 mg/L ADWG Aesthetic: Cu < 1 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	0.002	<0.001	<0.001	0.001	0.001
	Max	0.003	0.003	0.002	0.001	0.006	0.01
	Mean	0.0016	0.0026	0.0013	0.001	0.0031	0.0065
	Median	0.0015	0.003	0.001	0.001	0.003	0.007
Lead (Pb) (mg/L) ADWG Health: Pb < 0.01 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Max	<0.001	<0.001	<0.001	<0.001	0.001	0.001
	Mean	<0.001	<0.001	<0.001	<0.001	0.001	0.001
	Median	<0.001	<0.001	<0.001	<0.001	0.001	0.001
Manganese (Mn) (mg/L) ADWG Health: Mn < 0.5 mg/L ADWG Aesthetic: Mn < 0.1 mg/L	N sample	8	8	8	8	8	8
	Min	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Max	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Mean	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
	Median	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Molybdenum (Mo) (mg/L) ADWG Health: Mo < 0.05 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Max	0.005	0.001	<0.001	0.001	0.005	<0.001
	Mean	0.0029	0.001	<0.001	0.001	0.0023	0.001
	Median	0.0025	0.001	<0.001	0.001	0.002	0.001
Nickel (Ni) (mg/L) ADWG Health: Ni < 0.02 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Max	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Median	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver (Ag)(mg/L) ADWG Health: Ag < 0.1 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Max	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Mean	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Median	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc (Zn) (mg/L) ADWG Health: c ADWG Aesthetic: Zn < 0.02 mg/L	N sample	8	8	8	8	8	8
	Min	<0.001	<0.001	<0.001	<0.001	0.001	0.001
	Max	0.004	0.008	0.006	0.004	0.012	0.027
	Mean	0.002	0.0049	0.0036	0.0021	0.006	0.0073
	Median	0.002	0.005	0.0035	0.002	0.0055	0.003

*) Exceedances are printed in blue

c - Insufficient data to set a guideline value based on health considerations (NHMRC, NRMCC, 2011)

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

- Monitoring of groundwater levels and quality has been completed for the 2-year monitoring period from September 2018 to October 2020, consistent with recommendation in the DWMS (JDA, 2018).
- Groundwater levels were highest at bore installation in September 2018, associated with winter 2018 rainfall being higher than in 2019 or 2020.
- The highest groundwater levels in September 2018 provide confirmation of the adopted value of 26.8 mAHD used in preliminary designing of infiltration basins in the DWMS.
- Seasonal variation measured in JDA bores is consistent with the long-term groundwater levels measured in the DWER monitoring bores JM16, JM26 and JM27. JM19 shows somewhat higher levels, probably associated with its location adjacent to an infiltration basin at the adjacent Calleya Estate.
- Groundwater quality generally meets the NHMRC (2011) Australian Drinking Water Guidelines (ADWG) with the exception of aluminium and zinc in bore MW06. The reasons for higher concentrations in this bore are unknown, but occurred on several sampling dates and should be further investigated in future.

4.2 Recommendation

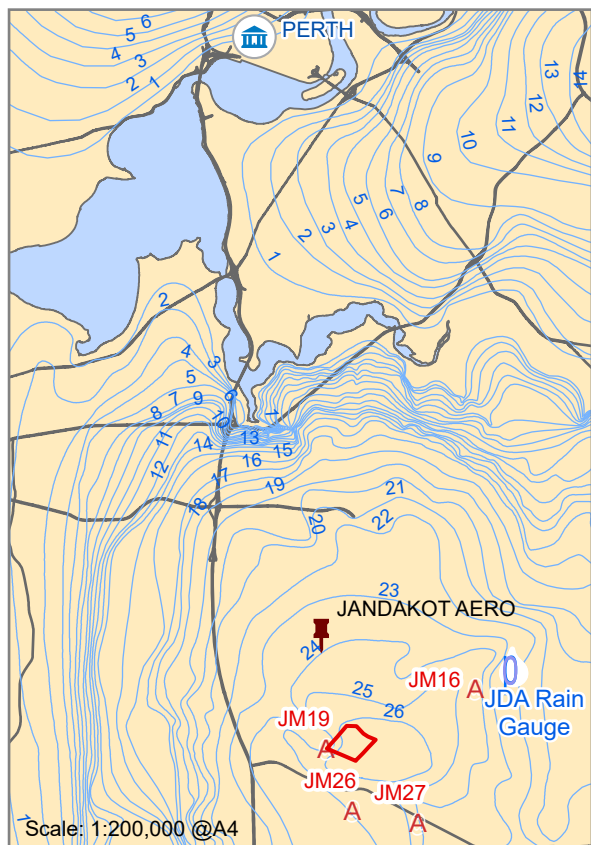
- This monitoring report be incorporated in a future Local Water Management Strategy (LWMS) as pre-development data.

5. REFERENCES

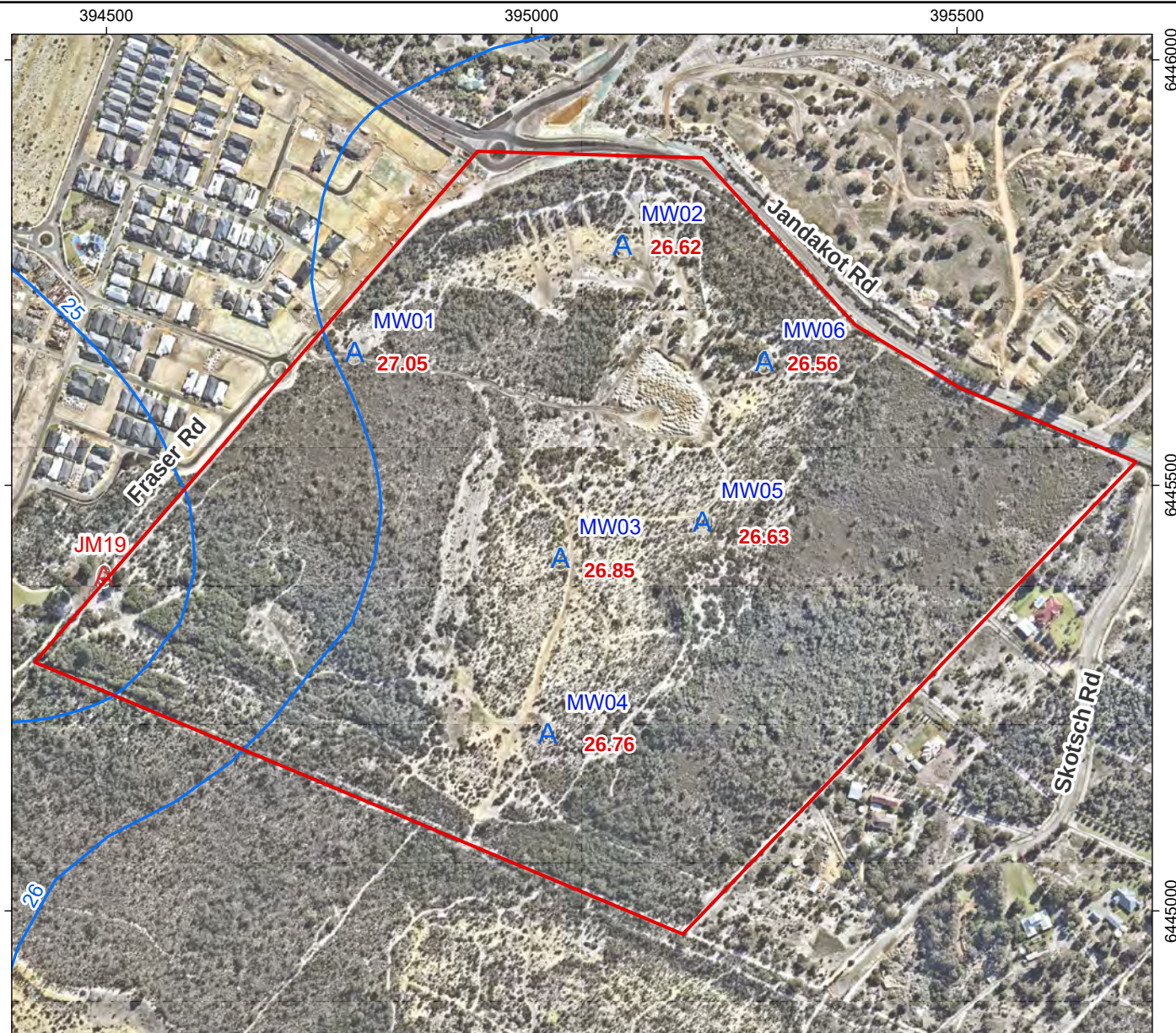
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FIGURES

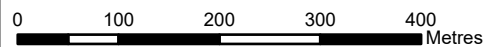
- Study Area
- A JDA Monitoring Bore
- A DWER Monitoring Bore
- p JDA Rain Gauge
- + BOM Rainfall Station
- Groundwater Contour (DoE, 2004)
- 27.05 Water levels (mAHD) 25/9/18 (see Table 2)



Data Source: Nearmap (2020) Aerial Photograph 3 May 2020.



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Scale: 1:7,500 @A4



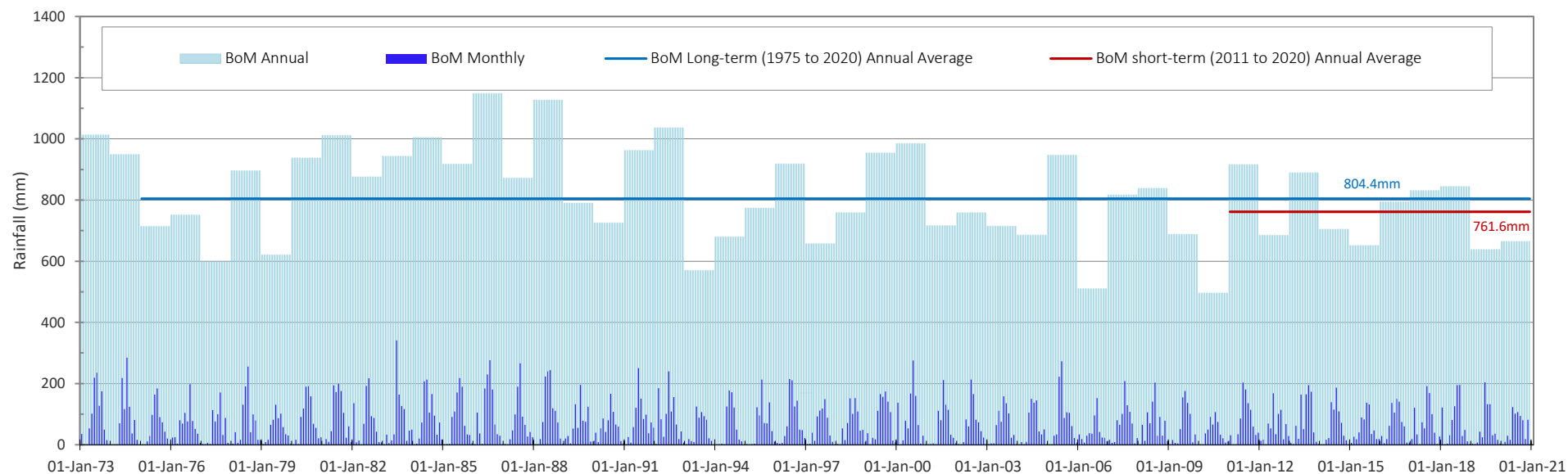
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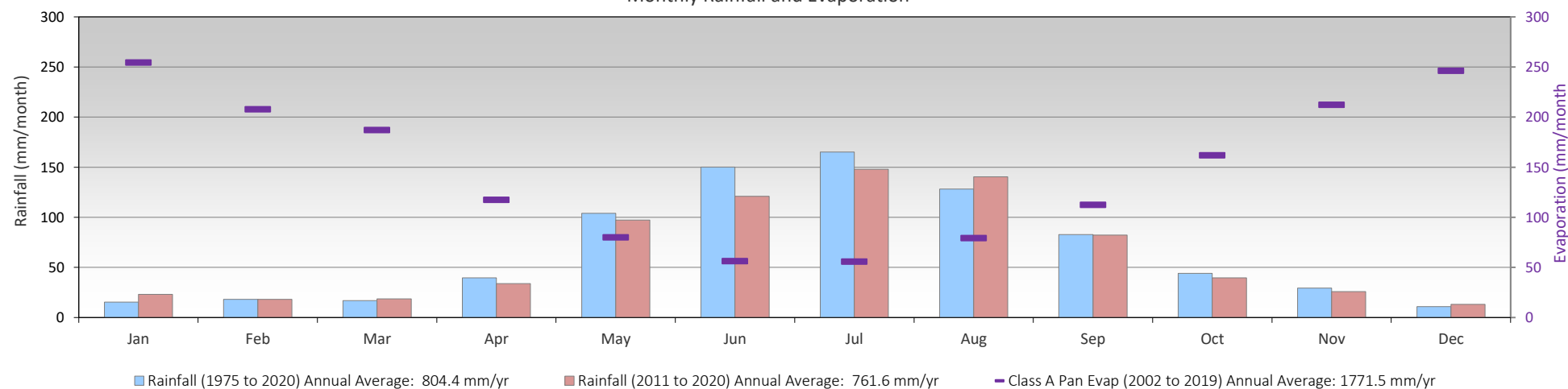
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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 1: Locality and Monitoring Bores Location

Annual and Monthly Rainfall at BoM Jandakot Aero Station (Jan 1973 - Sep 2020) and at JDA Raingauge (Jan 2015 - Sep 2020)



Monthly Rainfall and Evaporation



Data Source: Bureau of Meteorology (BoM, 2020) - Jandakot Aero (ID: 9172), DPIRD Medina & Wattelup Evaporation (2002-2019)

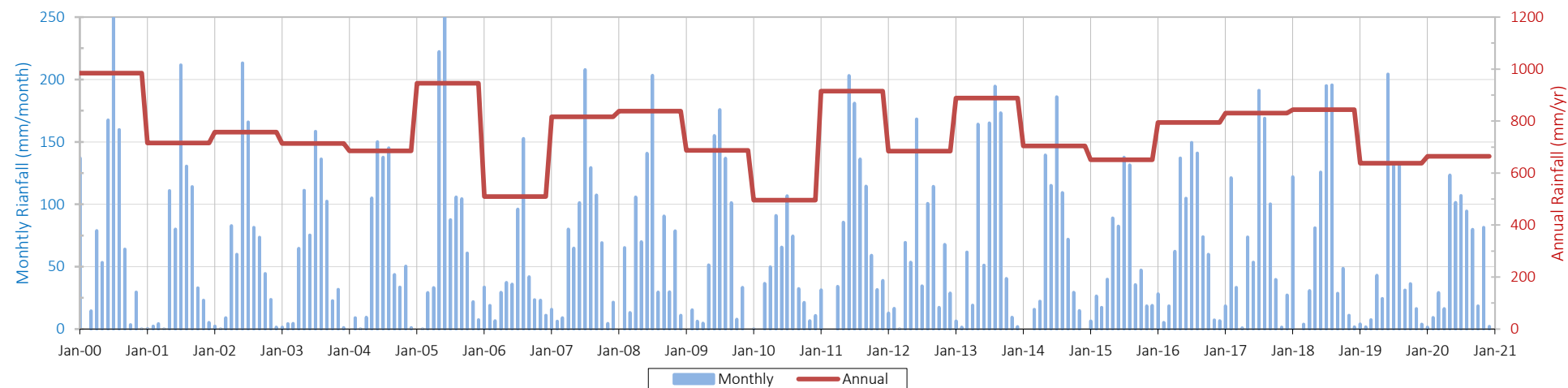
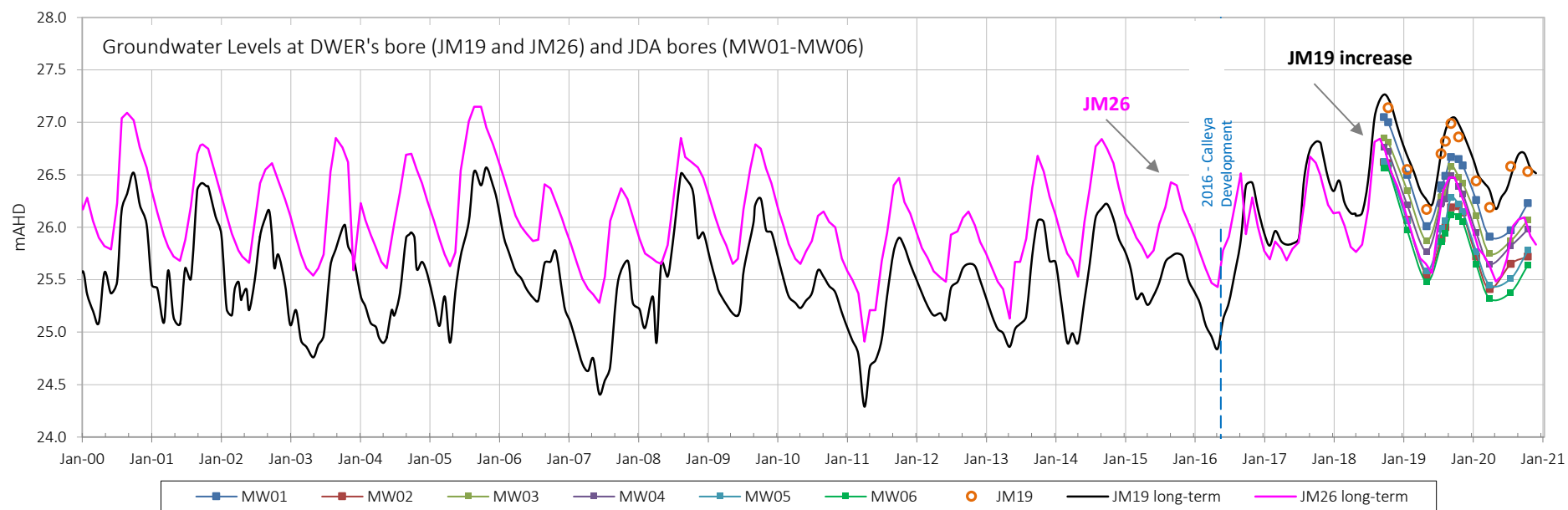


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Figure 2: Jandakot Rainfall (1973 - 2020)



Data Source: Bureau of Meteorology (BoM, 2020) - Jandakot Aero (ID: 9172), Water Information (WIN) database - discrete sample data [13 Oct 2020], DWER Water Information Section, Perth WA



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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 3: Jandakot Rainfall and Groundwater Levels (2000 - 2020)

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HYFLOT V134 Output 07/01/2021

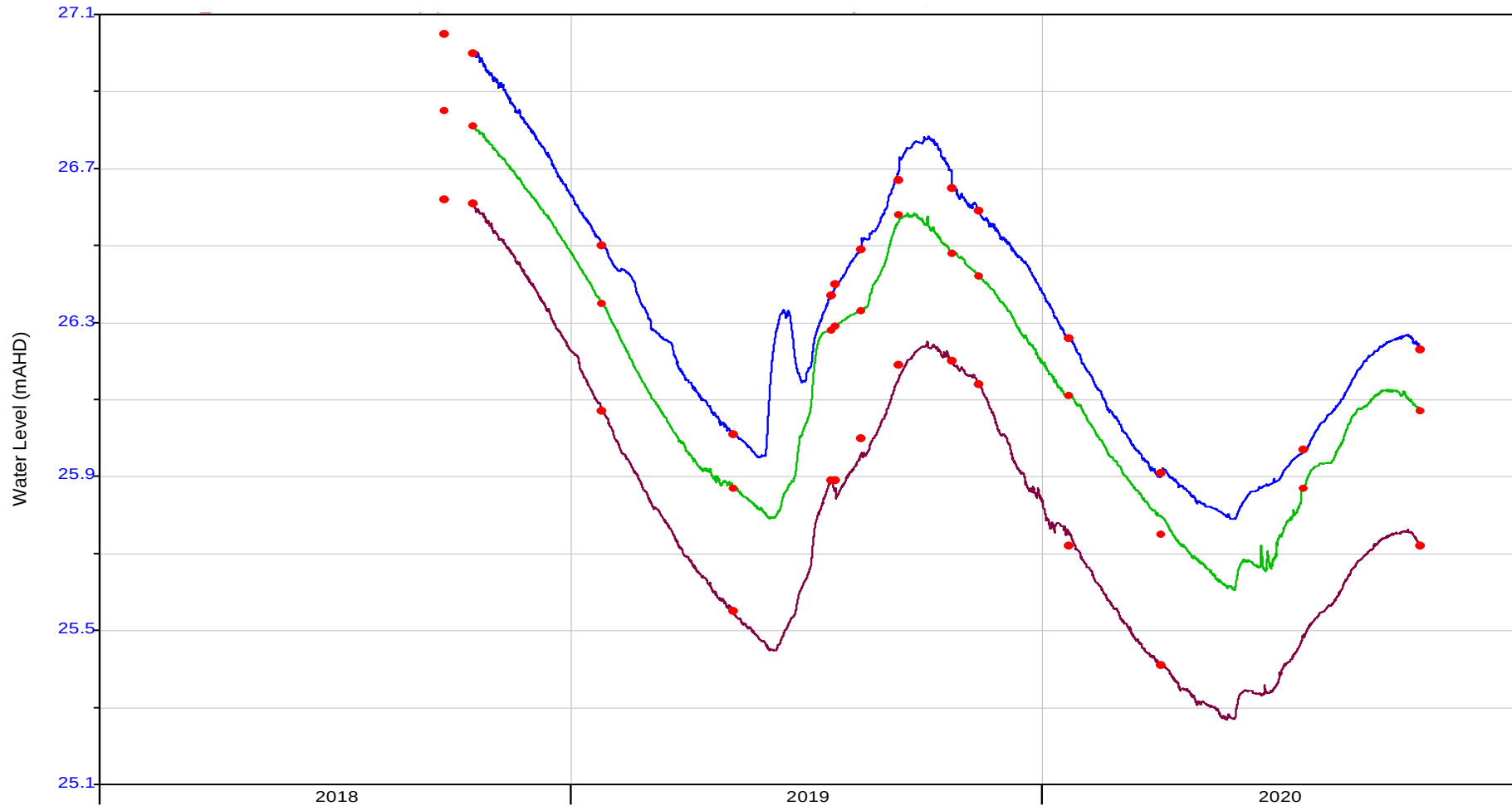
Period 3 Year 01/01/2018 to 01/01/2021

2018-20

— J6641_MW01 Level (m)
— J6641_MW02 Level (m)
— J6641_MW03 Level (m)

Lot 131 Jandakot Rd, Treeby: MW01
Lot 131 Jandakot Rd, Treeby: MW02
Lot 131 Jandakot Rd, Treeby: MW03

● Manual Check



Data Source: JDA Hydstra Database (2020)



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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 4: Groundwater Level at MW01 to MW03

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Period 3 Year 01/01/2018 to 01/01/2021

HYPLOT V134 Output 07/01/2021

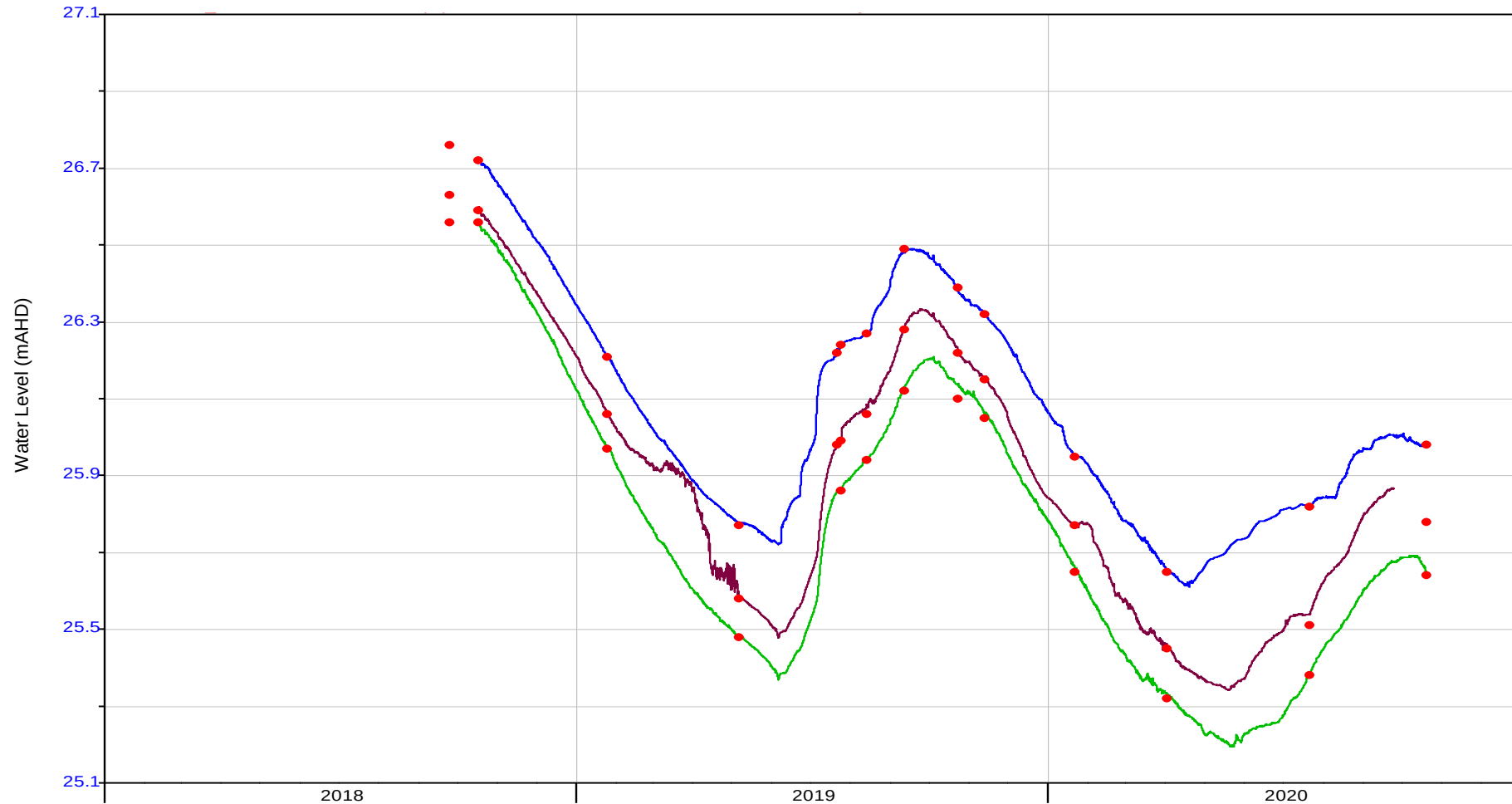
2018-20

— J6641_MW04
— J6641_MW05
— J6641_MW06

Level (m)
Level (m)
Level (m)

Lot 131 Jandakot Rd, Treeby: MW04
Lot 131 Jandakot Rd, Treeby: MW05
Lot 131 Jandakot Rd, Treeby: MW06

● Manual Check



Data Source: JDA Hydstra Database (2020)



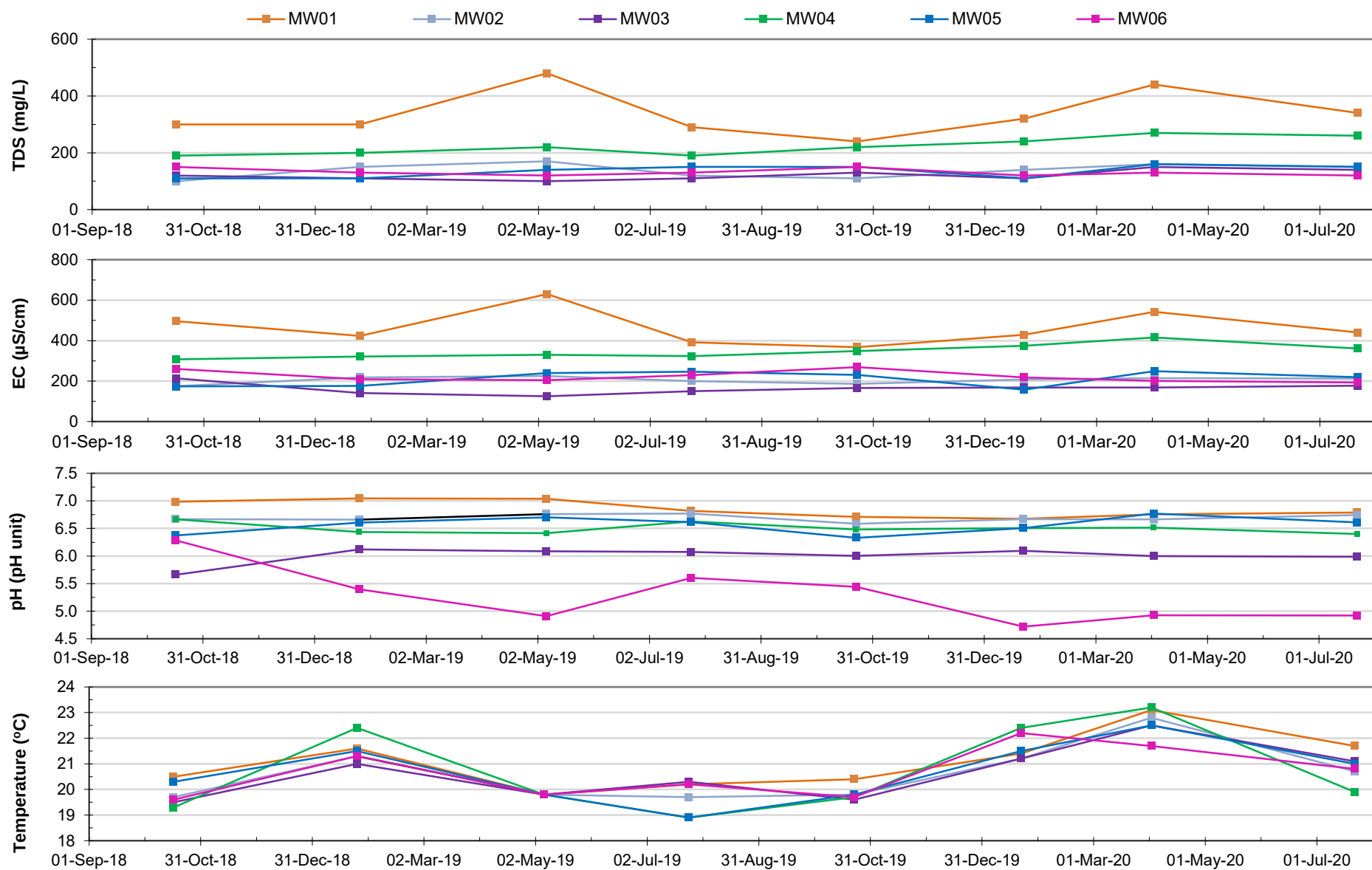
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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 5: Groundwater Level at MW04 to MW06

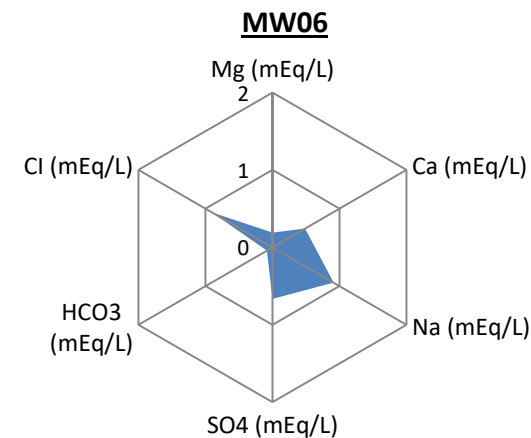
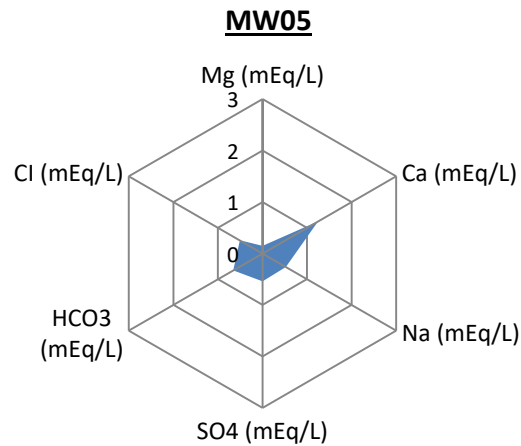
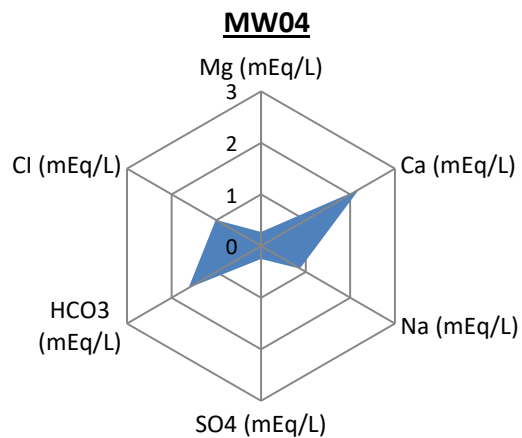
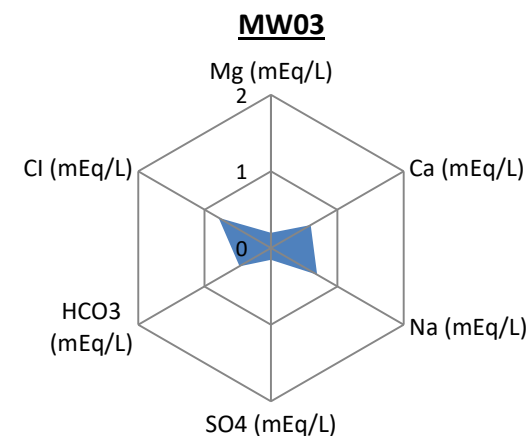
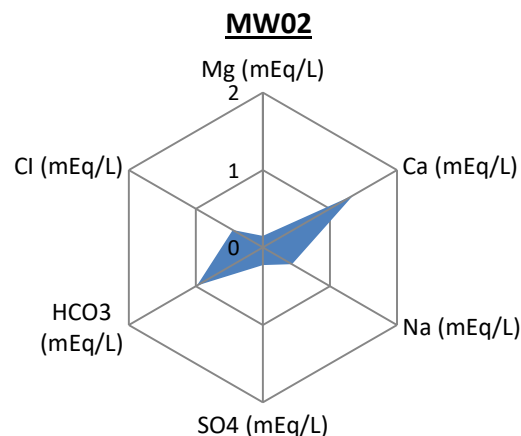
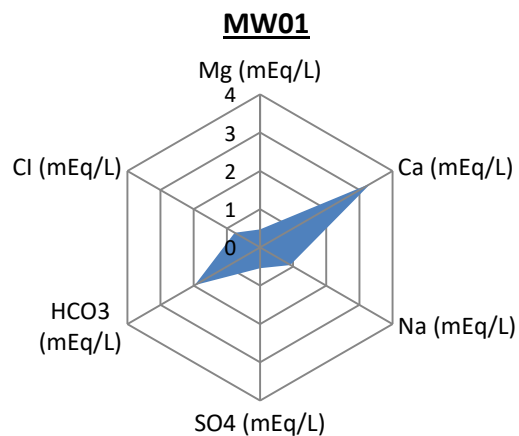


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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 6: Groundwater TDS, EC, pH, Temperature



Note: Stiff plot is based on the 2018-2020 average concentrations of major ions. Units are expressed in miliequivalent per L (mEq/L).

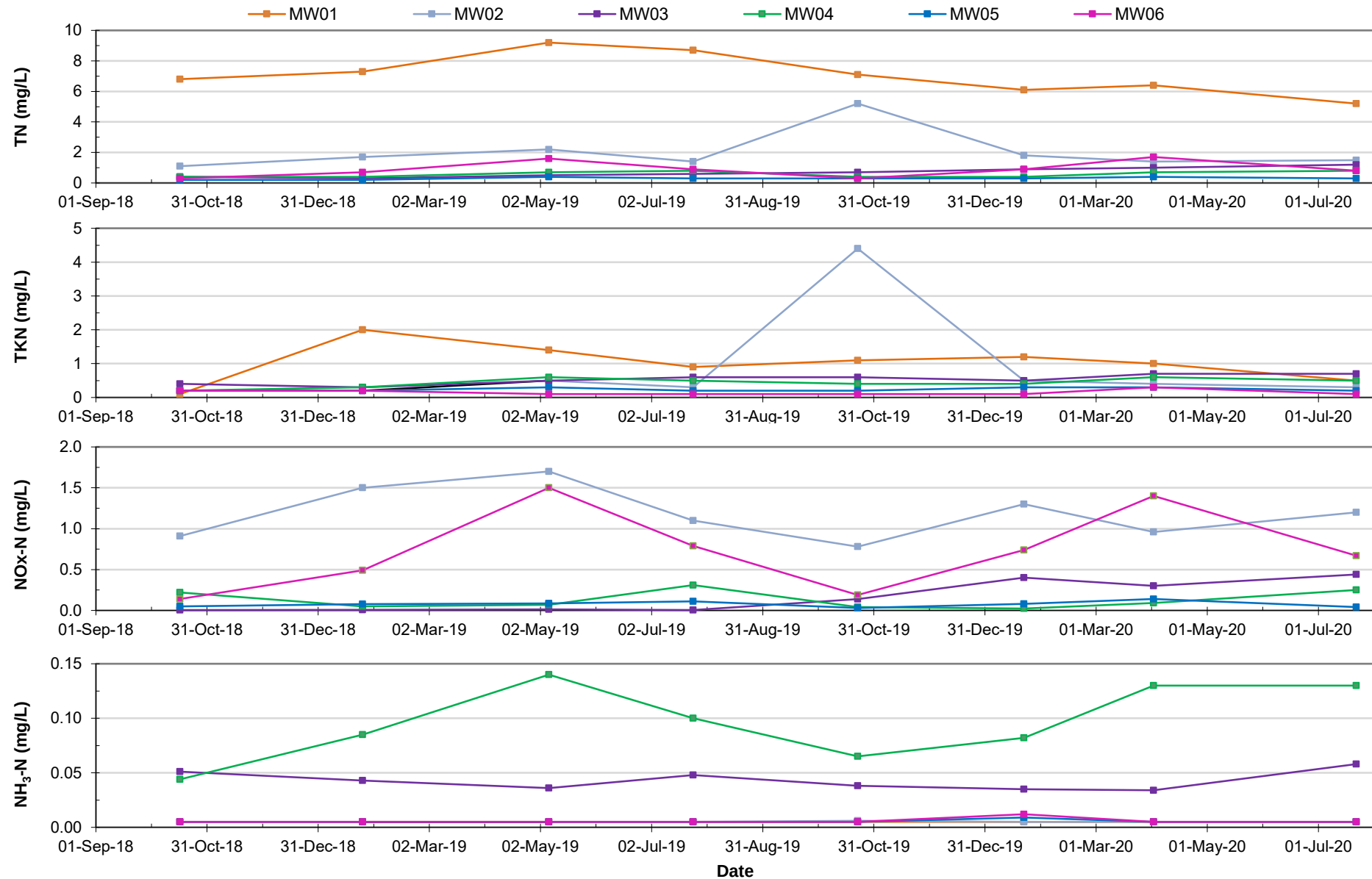


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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 7: Groundwater Major Ions Stiff Plots

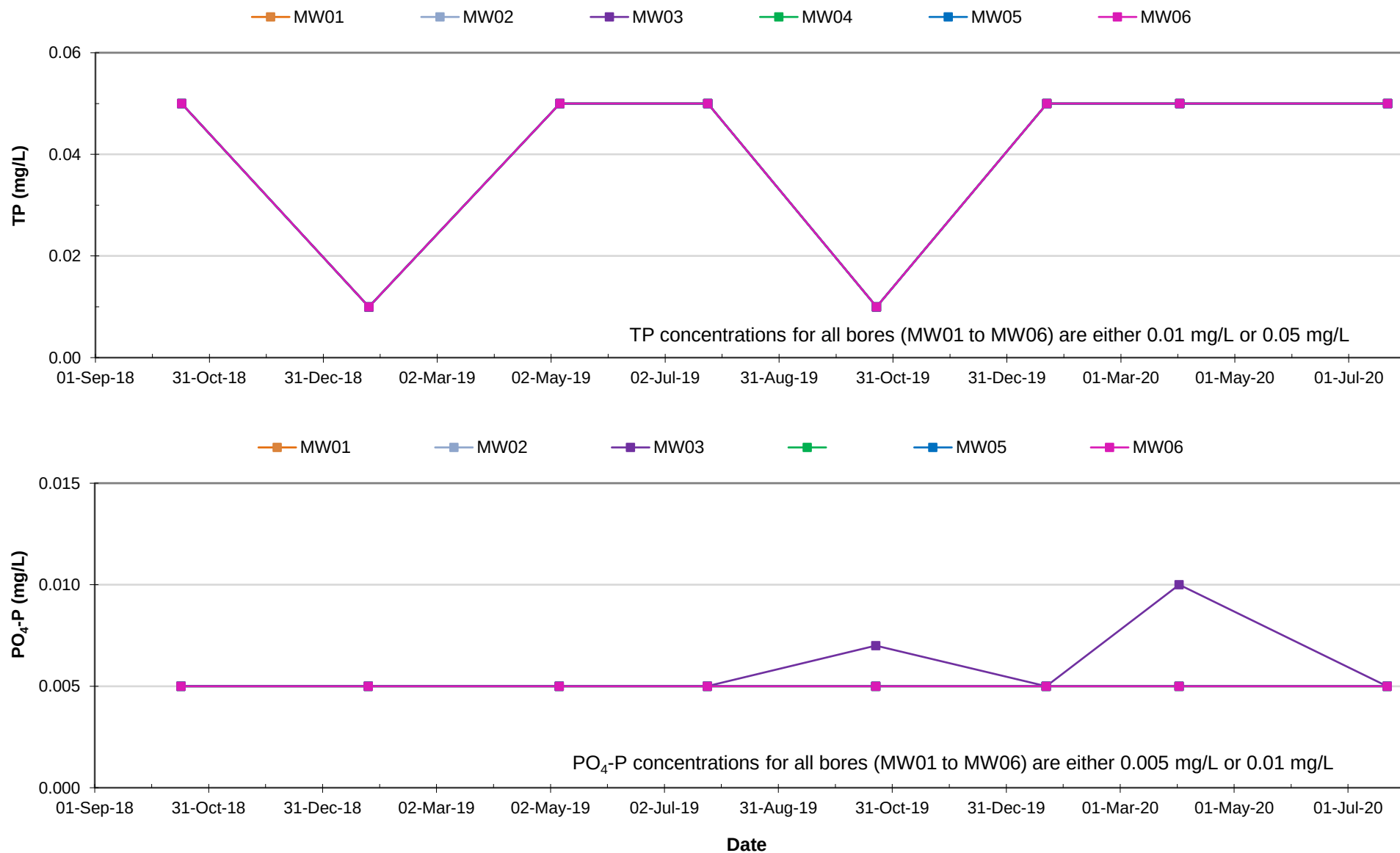


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 Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 8: Groundwater TN, TKN, NO_x-N, and NH₃-N Concentrations



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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

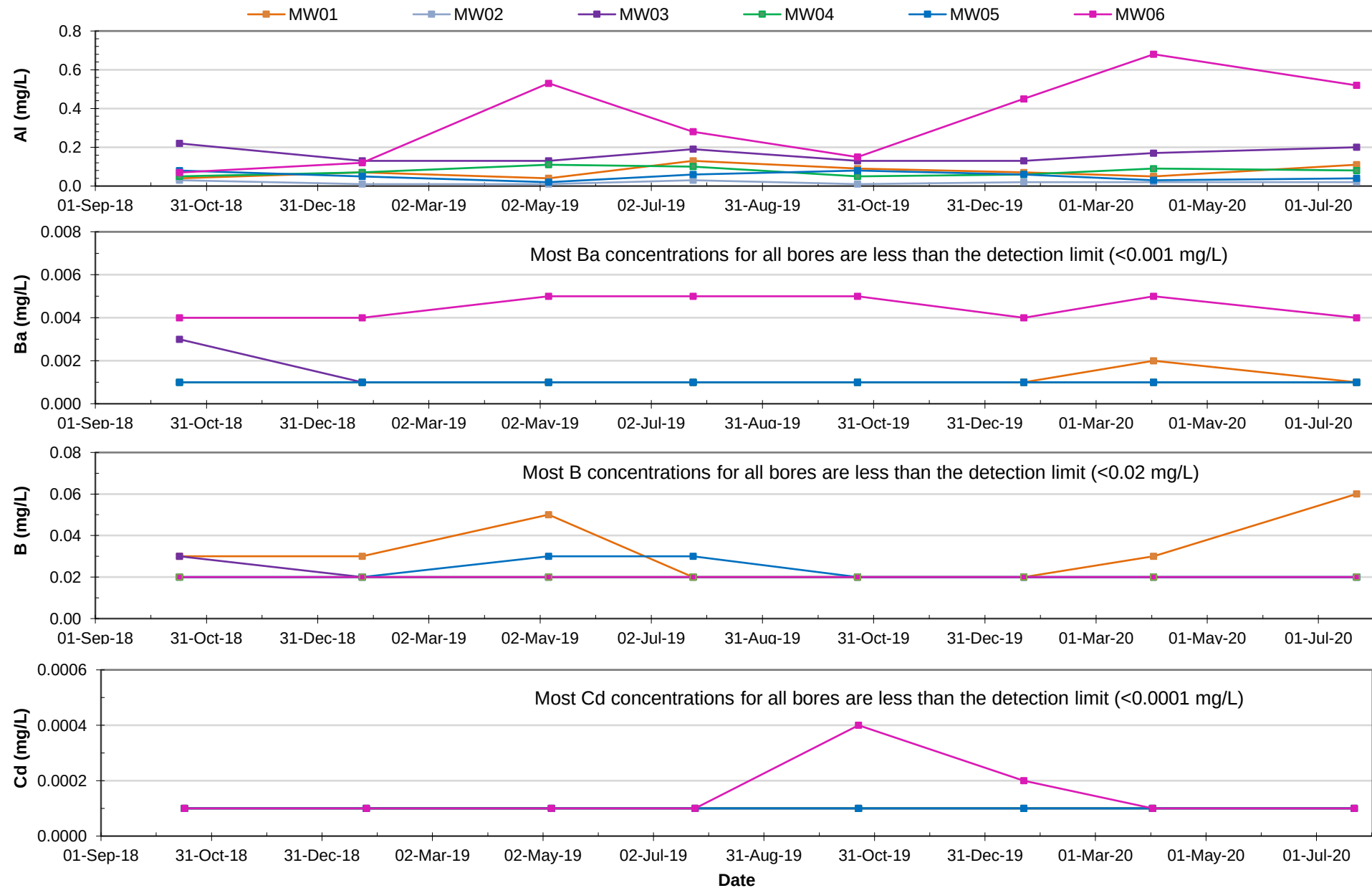
Figure 9: Groundwater TP and PO₄-P Concentrations



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 Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020
Figure 10: Groundwater Total Iron (Fe), Mercury (Hg), and Selenium (Se) Concentrations

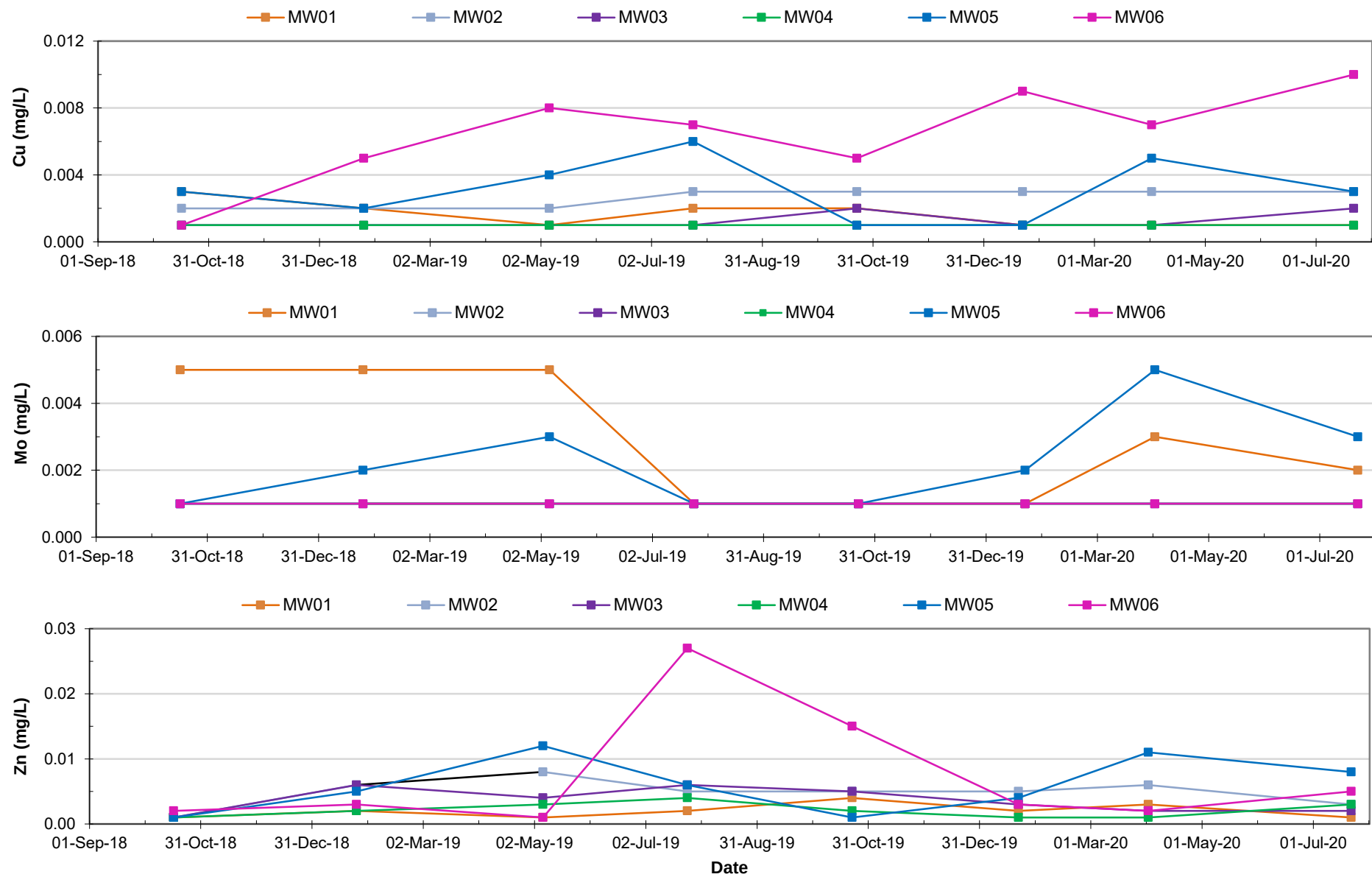


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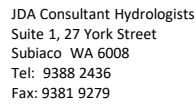
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Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020

Figure 11: Groundwater Dissolved Aluminium (Al), Barium (Ba), Boron (B), and Cadmium (Cd) Concentrations



APPENDIX A

JDA Lithological Bore Logs



LITHOLOGICAL LOG

Client:	Perron Development Pty Ltd.	Job No:	J6641
Project:	Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring	Hole commenced:	25/09/2018
Bore location:	Lot 131 Jandakot Rd, Treeby/Banjup	Hole completed:	25/09/2018
Datum:	GDA '94 MGA Zone 50	E 394796	N 6445661
		Logged by:	SU

Bore Name:	MW01	Total Depth:	7.50 m
Driller and drill type:	Edrill, Hollow Auger	R.L. TOC:	32.58 mAHD
Hole diameter:	150 mm	Casing Diam: 50 mm	Natural Surface: 31.98 mAHD

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG							
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	COMMENTS	
0.5m	EOH		Silty Sand	Black	Fine	Well	Subrounded	Dry		
1.0m										
1.5m										
2.0m										
2.5m										
3.0m										
3.5m										
4.0m										
4.5m										
5.0m										
5.5m										
6.0m										
6.5m										
7.0m										
7.5m										
Gravel Sand Clayey Sand Sandy Clay Clay Coffee Rock Bentonite Grain Size Very Fine Fine Medium Coarse Very coarse Gravel Sorting Poor Moderate Well Very well Grain Shape Angular Subangular Subrounded Rounded Well rounded Moisture Dry Moist Saturated Date 25/09/2018 Stick Up 0.6 m Total Depth 7.5 mBGL Water Level 5.53 mBTC NOTES: 0 - 0.5 mBGL bentonite 3.5 - 7.5 mBGL: gravel 3 m screen: 4.5 - 7.5 mBGL										



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Fax: 9381 9279

LITHOLOGICAL LOG

Client: Perron Development Pty Ltd. Job No: J6641
Project: Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring Hole commenced: 25/09/2018
Bore location: Lot 131 Jandakot Rd, Treeby/Banjup Hole completed: 25/09/2018
Datum: GDA '94 MGA Zone 50 E 395111 N 6445787 Logged by: SU

Bore Name: MW02 Total Depth: 6.00 m
Driller and drill type: Edrill, Hollow Auger R.L. TOC: 30.55 mAHD
Hole diameter: 150 mm Casing Diam: 50 mm Natural Surface: 29.95 mAHD

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	COMMENTS
0.5m			Silty Sand	Grey	Fine - Medium			Dry	
1.0m									
1.5m									
2.0m				Light brown				Moist	
2.5m									
3.0m									
3.5m			Sand	Cream	Medium	Well	Subrounded		
4.0m									
4.5m									
5.0m				White				Saturated	
5.5m									
6.0m	EOH								

- Gravel
- Sand
- Clayey Sand
- Sandy Clay
- Clay
- Coffee Rock
- Bentonite

Grain Size	Sorting	Grain Shape	Moisture
Very Fine	Poor	Angular	Dry
Fine	Moderate	Subangular	Moist
Medium	Well	Subrounded	Saturated
Coarse	Very well	Rounded	
Very coarse		Well rounded	
Gravel			

NOTES:
0.5-1 mBGL bentonite
1-3 mBGL: gravel
3 m screen: 3 - 6 mBGL

Date	25/09/2018
Stick Up	0.6 m
Total Depth	6.0 mBGL
Water Level	3.93 mBTC



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LITHOLOGICAL LOG

Client: Perron Development Pty Ltd. Job No: J6641
Project: Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring Hole commenced: 25/09/2018
Bore location: Lot 131 Jandakot Rd, Treeby/Banjup Hole completed: 25/09/2018
Datum: GDA '94 MGA Zone 50 E 395038 N 6445419 Logged by: SU
Bore Name: MW03 Total Depth: 6.00 m
Driller and drill type: Edrill, Hollow Auger R.L. TOC: 30.51 mAHd
Hole diameter: 150mm Casing Diam: 50mm Natural Surface: 29.91 mAHd

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	COMMENTS
0.5m									
1.0m				Light brown				Moist	
1.5m									
2.0m									
2.5m									
3.0m			Sand		Medium	Well	Subrounded		
3.5m									
4.0m				Cream					Saturated ≥ 3.5 m
4.5m									
5.0m								Saturated	
5.5m									
6.0m	EOH		Coffee Rock	Black brown	Fine-Medium				Coffee rock at 5.7 mBGL

- Gravel
- Sand
- Clayey Sand
- Sandy Clay
- Clay
- Coffee Rock
- Bentonite

Grain Size	Sorting	Grain Shape	Moisture
Very Fine	Poor	Angular	Dry
Fine	Moderate	Subangular	Moist
Medium	Well	Subrounded	Saturated
Coarse	Very well	Rounded	
Very coarse		Well rounded	
Gravel			

NOTES:
3 m screen: 3 - 6 mBGL
Water colour: dark chocolate

Date	25/09/2018
Stick Up	0.6 m
Total Depth	6.0 mBGL
Water Level	3.66 mBTC



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LITHOLOGICAL LOG

Client: Perron Development Pty Ltd. Job No: J6641
Project: Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring Hole commenced: 25/09/2018
Bore location: Lot 131 Jandakot Rd, Treeby/Banjup Hole completed: 25/09/2018
Datum: GDA '94 MGA Zone 50 E 395023 N 6445212 Logged by: SU

Bore Name: MW04 Total Depth: 5.50 m
Driller and drill type: Edrill, Hollow Auger R.L. TOC: 28.69 mAHd
Hole diameter: 150mm Casing Diam: 50mm Natural Surface: 28.09 mAHd

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	COMMENTS
0.5m			Silty Sand	Black/grey	Fine/medium			Dry	
1.0m									
1.5m									
2.0m									
2.5m									
3.0m									
3.5m									
4.0m									
4.5m									
5.0m									
5.5m	EOH								

- Gravel
- Sand
- Clayey Sand
- Sandy Clay
- Clay
- Coffee Rock
- Bentonite

Grain Size	Sorting	Grain Shape	Moisture
Very Fine	Poor	Angular	Dry
Fine	Moderate	Subangular	Moist
Medium	Well	Subrounded	Saturated
Coarse	Very well	Rounded	
Very coarse		Well rounded	
Gravel			

NOTES:
3 m screen: 3 - 6 MBGL

Date	25/09/2018
Stick Up	0.6 m
Total Depth	5.5 MBGL
Water Level	1.93 MBTOC



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LITHOLOGICAL LOG

Client: Perron Development Pty Ltd. Job No: J6641
Project: Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring Hole commenced: 25/09/2018
Bore location: Lot 131 Jandakot Rd, Treeby/Banjup Hole completed: 25/09/2018
Datum: GDA '94 MGA Zone 50 E 395205 N 6445461 Logged by: SU

Bore Name: MW05 Total Depth: 6.00 m
Driller and drill type: Edrill, Hollow Auger R.L. TOC: 31.16 mAHd
Hole diameter: 150mm Casing Diam: 50mm Natural Surface: 30.56 mAHd

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	COMMENTS
0.5m									
1.0m				Light brown	Fine/Medium				
1.5m									
2.0m								Moist	
2.5m									
3.0m			Sand	Darker brown		Well	Subrounded		
3.5m									
4.0m					Medium				Saturated ≥ 4 m
4.5m									
5.0m				Cream				Saturated	
5.5m									
6.0m	EOH								

- Gravel
- Sand
- Clayey Sand
- Sandy Clay
- Clay
- Coffee Rock
- Bentonite

Grain Size	Sorting	Grain Shape	Moisture
Very Fine	Poor	Angular	Dry
Fine	Moderate	Subangular	Moist
Medium	Well	Subrounded	Saturated
Coarse	Very well	Rounded	
Very coarse		Well rounded	
Gravel			

NOTES:
0 - 0.5 mBGL bentonite
3 m screen: 3 - 6 mBGL

Date	25/09/2018
Stick Up	0.6 m
Total Depth	6.0 mBGL
Water Level	4.53 mBTOC



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LITHOLOGICAL LOG

Client: Perron Development Pty Ltd. Job No: J6641
Project: Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring Hole commenced: 25/09/2018
Bore location: Lot 131 Jandakot Rd, Treeby/Banjup Hole completed: 25/09/2018
Datum: GDA '94 MGA Zone 50 E 395278 N 6445650 Logged by: SU

Bore Name: MW06 Total Depth: 6.00 m
Driller and drill type: Edrill, Hollow Auger R.L. TOC: 30.48 mAHd
Hole diameter: 150mm Casing Diam: 50mm Natural Surface: 29.88 mAHd

Depth (m)	BORE CONSTRUCTION	GRAPHICAL LOG	LITHOLOGICAL LOG						
			LITHOLOGY	COLOUR	GRAIN SIZE	SORTING	GRAIN SHAPE	MOISTURE	COMMENTS
0.5m			Silty Sand	Grey	Fine		Subangular	Dry	
1.0m									
1.5m									
2.0m				Light brown				Moist	
2.5m									
3.0m						Well			
3.5m			Sand	Cream	Fine-medium		Subrounded		
4.0m									Saturated ≥ 4 m
4.5m				White					
5.0m								Saturated	
5.5m				Grey/brown					
6.0m	EOH								

- Gravel
- Sand
- Clayey Sand
- Sandy Clay
- Clay
- Coffee Rock
- Bentonite

Grain Size	Sorting	Grain Shape	Moisture
Very Fine	Poor	Angular	Dry
Fine	Moderate	Subangular	Moist
Medium	Well	Subrounded	Saturated
Coarse	Very well	Rounded	
Very coarse		Well rounded	
Gravel			

NOTES:
0.5 - 1.0 mBGL bentonite
1.0 - 3.0 mBGL: gravel
3 m screen: 3 - 6 mBGL

Date	25/09/2018
Stick Up	0.6 m
Total Depth	6.0 mBGL
Water Level	3.92 mBTOC

APPENDIX B

Groundwater Quality Data



		Project ID									Statistical Summary						
		J6641	J6641	J6641	J6641	J6641	J6641	J6641	J6641	J6641							
		Location	MW01	MW01	MW01	MW01	MW01	MW01	MW01	MW01	MW01	Number of Results	Minimum Concentration	Maximum Concentration	Average Concentration	Median Concentration	Standard Deviation
ChemName	Unit	Sampling Date	17/10/2018	25/01/2019	7/05/2019	25/07/2019	23/10/2019	22/01/2020	2/04/2020	22/07/2020							
		PQL															
Field																	
EC (field)	µS/cm		492	436	590	402	335	427	545	440	8	335	590	458	438	81	
Temp (Field)	oC		20.5	21.6	19.8	20.2	20.4	21.4	23.1	21.7	8	19.8	23.1	21	20.95	1.1	
pH (Field)	pH Units		6.87	6.99	6.98	6.74	6.52	6.55	6.61	6.58	8	6.52	6.99	6.7	6.675	0.19	
Major Ions																	
Alkalinity (Bicarbonate as CaCO3)	mg/L	5	-	-	-	-	-	120	-	-	1	120	120		120		
Calcium (Filtered)	mg/L	0.5	77	63	110	49	45	58	81	50	8	45	110	67	60.5	22	
Chloride	mg/L	1	20	18	-	29	22	29	29	40	7	18	40	27	29	7.5	
Hardness	mg/L	3	-	-	-	140	-	170	230	140	4	140	230	170	155	42	
Magnesium (Filtered)	mg/L	0.5	7.2	4.7	9.2	3.4	4.2	6	7.4	3.4	8	3.4	9.2	5.7	5.35	2.1	
Nitrate (as NO3-)	mg/L	0.5	26	26	33	33	26	21	24	18	8	18	33	26	26	5.2	
Nitrite (as NO2-)	mg/L	0.5	<0.5	0.5	0.5	0.7	<0.5	<0.5	0.8	0.6	8	<0.5	0.8	0.58	0.5	0.12	
Potassium (Filtered)	mg/L	0.5	5.6	7.9	11	5	4.2	3.1	5	12	8	3.1	12	6.7	5.3	3.3	
Sodium (Filtered)	mg/L	0.5	15	20	21	24	16	17	21	31	8	15	31	21	20.5	5.2	
Sulphate	mg/L	1	23	19	-	23	18	30	41	26	7	18	41	26	23	7.9	
Miscellaneous Inorganics																	
Electrical Conductivity	µS/cm	1	500	410	670	380	400	430	540	440	8	380	670	471	435	96	
pH (Lab)	pH Units		7.1	7.1	7.1	6.9	6.9	6.8	6.9	7	8	6.8	7.1	7	6.95	0.12	
TDS	mg/L	5	300	300	480	290	240	320	440	340	8	240	480	339	310	81	
Nutrients in Water (Field-filtered)																	
Ammonia as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0	
Kjeldahl Nitrogen Total	mg/L	0.1	<0.1	2	1.4	0.9	1.1	1.2	1	0.5	8	<0.1	2	1	1.05	0.57	
Nitrogen (Total Oxidised)	mg/L	0.005	6.7	5.3	7.8	7.8	6	4.9	5.3	4.8	8	4.8	7.8	6.1	5.65	1.2	
Total Nitrogen	mg/L	0.1	6.8	7.3	9.2	8.7	7.1	6.1	6.4	5.2	8	5.2	9.2	7.1	6.95	1.3	
Phosphate (as P)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	8	<0.005	0.005	0.005	0.005	0	
Phosphorus	mg/L	0.01	<0.05	<0.01	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	8	<0.01	<0.05	0.04	0.05	0.019	
Total Metals in water																	
Iron	mg/L	0.01	0.02	0.02	<0.01	0.06	0.02	<0.01	0.05	0.01	8	<0.01	0.06	0.025	0.02	0.019	
Mercury	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	8	<0.00005	<0.00005	0.00005	0.00005	0	
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0	
Dissolved Metals in Water																	
Aluminium (Filtered)	mg/L	0.01	0.04	0.07	0.04	0.13	0.09	0.07	0.05	0.11	8	0.04	0.13	0.075	0.07	0.033	
Arsenic (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0	
Barium (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	8	<0.001	0.002	0.0011	0.001	0.00035	
Boron (Filtered)	mg/L	0.02	0.03	0.03	0.05	0.02	<0.02	<0.02	0.03	0.06	8	<0.02	0.06	0.033	0.03	0.015	
Cadmium (Filtered)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	8	<0.0001	<0.0001	0.0001	0.0001	0	
Chromium (III+VI) (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0	
Copper (Filtered)	mg/L	0.001	0.003	0.002	<0.001	0.002	0.002	0.001	0.001	0.001	8	<0.001	0.003	0.0016	0.0015	0.00074	
Lead (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0	
Manganese (Filtered)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0	
Molybdenum (Filtered)	mg/L	0.001	0.005	0.005	0.005	<0.001	0.001	0.001	0.003	0.002	8	<0.001	0.005	0.0029	0.0025	0.0019	
Nickel (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0	
Silver (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0	
Uranium (Filtered)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0	
Zinc (Filtered)	mg/L	0.001	<0.001	0.002	0.001	0.002	0.004	0.002	0.003	0.001	8	<0.001	0.004	0.002	0.002	0.0011	



		Project ID	J6641	J6641	J6641	J6641	J6641	J6641	J6641	J6641						
		Location	MW02	MW02	MW02	MW02	MW02	MW02	MW02	MW02						
		Sampling Date	17/10/2018	25/01/2019	7/05/2019	25/07/2019	23/10/2019	22/01/2020	2/04/2020	22/07/2020						
ChemName	Unit	PQL									Number of Results	Minimum Concentration	Maximum Concentration	Average Concentration	Median Concentration	Standard Deviation
Field																
EC (field)	µS/cm		170	217	220	200	182	206	219	215	8	170	220	204	210.5	19
Temp (Field)	oC		19.7	21.3	19.8	19.7	19.8	21.2	22.8	20.7	8	19.7	22.8	21	20.25	1.1
pH (Field)	pH Units		6.54	6.62	6.62	6.54	6.27	6.44	6.43	6.49	8	6.27	6.62	6.5	6.515	0.12
Major Ions																
Alkalinity (Bicarbonate as CaCO3)	mg/L	5	-	-	-	-	-	60	-	-	1	60	60		60	
Calcium (Filtered)	mg/L	0.5	24	29	30	27	26	25	27	29	8	24	30	27	27	2.1
Chloride	mg/L	1	14	17	-	16	13	16	18	18	7	13	18	16	16	1.9
Hardness	mg/L	3	-	-	-	74	-	72	74	79	4	72	79	75	74	3
Magnesium (Filtered)	mg/L	0.5	1.5	1.9	2	1.7	1.7	2	1.8	1.7	8	1.5	2	1.8	1.75	0.17
Nitrate (as NO3-)	mg/L	0.5	3.5	6.1	-	4.1	2.7	-	3.6	4.2	6	2.7	6.1	4	3.85	1.1
Nitrite (as NO2-)	mg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	6	<0.5	<0.5	0.5	0.5	0
Potassium (Filtered)	mg/L	0.5	1.4	1.8	1.3	0.8	1	1.8	1.5	1	8	0.8	1.8	1.3	1.35	0.37
Sodium (Filtered)	mg/L	0.5	8.4	11	10	9.5	9.4	11	12	11	8	8.4	12	10	10.5	1.2
Sulphate	mg/L	1	10	11	-	12	9	12	10	11	7	9	12	11	11	1.1
Miscellaneous Inorganics																
Electrical Conductivity	µS/cm	1	180	220	230	200	190	210	210	210	8	180	230	206	210	16
pH (Lab)	pH Units		6.8	6.7	6.9	7	6.9	6.9	6.9	7	8	6.7	7	6.9	6.9	0.099
TDS	mg/L	5	100	150	170	120	110	140	160	150	8	100	170	138	145	25
Nutrients in Water (Field-filtered)																
Ammonia as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	8	<0.005	0.006	0.0051	0.005	0.00035
Kjeldahl Nitrogen Total	mg/L	0.1	0.2	0.2	0.5	0.3	4.4	0.5	0.4	0.3	8	0.2	4.4	0.85	0.35	1.4
Nitrogen (Total Oxidised)	mg/L	0.005	0.91	1.5	1.7	1.1	0.78	1.3	0.96	1.2	8	0.78	1.7	1.2	1.15	0.31
Total Nitrogen	mg/L	0.1	1.1	1.7	2.2	1.4	5.2	1.8	1.4	1.5	8	1.1	5.2	2	1.6	1.3
Phosphate (as P)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Phosphorus	mg/L	0.01	<0.05	<0.01	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	8	<0.01	<0.05	0.04	0.05	0.019
Total Metals in water																
Iron	mg/L	0.01	0.02	0.02	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	8	<0.01	0.02	0.014	0.01	0.0052
Mercury	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	8	<0.00005	<0.00005	0.00005	0.00005	0
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Dissolved Metals in Water																
Aluminium (Filtered)	mg/L	0.01	0.03	0.01	0.01	0.03	0.01	0.02	0.02	0.02	8	0.01	0.03	0.019	0.02	0.0083
Arsenic (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Barium (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Boron (Filtered)	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	8	<0.02	<0.02	0.02	0.02	0
Cadmium (Filtered)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	8	<0.0001	<0.0001	0.0001	0.0001	0
Chromium (III+VI) (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Copper (Filtered)	mg/L	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	8	0.002	0.003	0.0026	0.003	0.00052
Lead (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Manganese (Filtered)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Molybdenum (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	8	<0.001	0.001	0.001	0.001	0
Nickel (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Silver (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Uranium (Filtered)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Zinc (Filtered)	mg/L	0.001	<0.001	0.006	0.008	0.005	0.005	0.005	0.006	0.003	8	<0.001	0.008	0.0049	0.005	0.0021



		Project ID	J6641	J6641	J6641	J6641	J6641	J6641	J6641	J6641						
		Location	MW03	MW03	MW03	MW03	MW03	MW03	MW03	MW03						
		Sampling Date	17/10/2018	25/01/2019	7/05/2019	25/07/2019	23/10/2019	22/01/2020	2/04/2020	22/07/2020	Statistical Summary					
ChemName	Unit	PQL									Number of Results	Minimum Concentration	Maximum Concentration	Average Concentration	Median Concentration	Standard Deviation
Field																
EC (field)	µS/cm		217	142	120	151	162	167	167	184	8	120	217	164	164.5	29
Temp (Field)	oC		19.5	21	19.8	20.3	19.6	21.2	22.5	21.1	8	19.5	22.5	21	20.65	1
pH (Field)	pH Units		5.62	6.04	6.07	5.95	5.91	5.89	5.9	5.87	8	5.62	6.07	5.9	5.905	0.14
Major Ions																
Alkalinity (Bicarbonate as CaCO3)	mg/L	5	-	-	-	-	-	29	-	-	1	29	29		29	
Calcium (Filtered)	mg/L	0.5	10	12	11	11	12	14	12	13	8	10	14	12	12	1.2
Chloride	mg/L	1	46	21	-	24	27	26	25	28	7	21	46	28	26	8.2
Hardness	mg/L	3				36	-	47	43	46	4	36	47	43	44.5	5
Magnesium (Filtered)	mg/L	0.5	2.3	1.6	1.7	2.1	2.5	2.7	2.8	3.4	8	1.6	3.4	2.4	2.4	0.6
Nitrate (as NO3-)	mg/L	0.5	<0.5	<0.5	<0.5	<0.5	0.7	1.2	1.2	1.5	8	<0.5	1.5	0.83	0.6	0.41
Nitrite (as NO2-)	mg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Potassium (Filtered)	mg/L	0.5	1.3	<0.5	<0.5	0.5	0.9	0.7	<0.5	1	8	<0.5	1.3	0.74	0.6	0.3
Sodium (Filtered)	mg/L	0.5	24	12	11	14	17	14	16	17	8	11	24	16	15	4
Sulphate	mg/L	1	10	5	-	7	7	8	7	7	7	5	10	7.3	7	1.5
Miscellaneous Inorganics																
Electrical Conductivity	µS/cm	1	210	140	130	150	170	170	170	170	8	130	210	164	170	24
pH (Lab)	pH Units		5.7	6.2	6.1	6.2	6.1	6.3	6.1	6.1	8	5.7	6.3	6.1	6.1	0.18
TDS	mg/L	5	120	110	100	110	130	110	150	140	8	100	150	121	115	17
Nutrients in Water (Field-filtered)																
Ammonia as N	mg/L	0.005	0.051	0.043	0.036	0.048	0.038	0.035	0.034	0.058	8	0.034	0.058	0.043	0.0405	0.0087
Kjeldahl Nitrogen Total	mg/L	0.1	0.4	0.3	0.5	0.6	0.6	0.5	0.7	0.7	8	0.3	0.7	0.54	0.55	0.14
Nitrogen (Total Oxidised)	mg/L	0.005	0.006	0.007	0.014	<0.005	0.14	0.4	0.3	0.44	8	<0.005	0.44	0.16	0.077	0.19
Total Nitrogen	mg/L	0.1	0.4	0.3	0.5	0.6	0.7	0.9	1	1.2	8	0.3	1.2	0.7	0.65	0.31
Phosphate (as P)	mg/L	0.005	<0.005	<0.005	0.005	<0.005	0.007	<0.005	0.01	<0.005	8	<0.005	0.01	0.0059	0.005	0.0018
Phosphorus	mg/L	0.01	<0.05	<0.01	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	8	<0.01	<0.05	0.04	0.05	0.019
Total Metals in water																
Iron	mg/L	0.01	0.24	0.11	0.09	0.09	0.1	0.06	0.07	0.1	8	0.06	0.24	0.11	0.095	0.056
Mercury	mg/L	0.00005	0.00008	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	8	<0.00005	0.00008	0.000054	0.00005	0.000011
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Dissolved Metals in Water																
Aluminium (Filtered)	mg/L	0.01	0.22	0.13	0.13	0.19	0.13	0.13	0.17	0.2	8	0.13	0.22	0.16	0.15	0.037
Arsenic (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Barium (Filtered)	mg/L	0.001	0.003	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	0.003	0.0013	0.001	0.00071
Boron (Filtered)	mg/L	0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	8	<0.02	0.03	0.021	0.02	0.0035
Cadmium (Filtered)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	8	<0.0001	<0.0001	0.0001	0.0001	0
Chromium (III+VI) (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Copper (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	0.001	0.002	8	<0.001	0.002	0.0013	0.001	0.00046
Lead (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Manganese (Filtered)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Molybdenum (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Nickel (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Silver (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Uranium (Filtered)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Zinc (Filtered)	mg/L	0.001	<0.001	0.006	0.004	0.006	0.005	0.003	0.002	0.002	8	<0.001	0.006	0.0036	0.0035	0.0019



		Project ID	J6641	J6641	J6641	J6641	J6641	J6641	J6641	J6641						
		Location	MW04	MW04	MW04	MW04	MW04	MW04	MW04	MW04						
		Sampling Date	17/10/2018	25/01/2019	7/05/2019	25/07/2019	23/10/2019	22/01/2020	2/04/2020	22/07/2020						
ChemName	Unit	PQL									Number of Results	Minimum Concentration	Maximum Concentration	Average Concentration	Median Concentration	Standard Deviation
Field																
EC (field)	µS/cm		305	323	320	327	336	370	421	361	8	305	421	345	331.5	37
Temp (Field)	oC		19.3	22.4	19.8	18.9	19.7	22.4	23.2	19.9	8	18.9	23.2	21	19.85	1.7
pH (Field)	pH Units		6.63	6.27	6.33	6.55	6.36	6.41	6.33	6.2	8	6.2	6.63	6.4	6.345	0.14
Ionic Balance																
Alkalinity (Bicarbonate as CaCO3)	mg/L	5	-	-	-	-	-	99	-	-	1	99	99		99	
Calcium (Filtered)	mg/L	0.5	45	40	40	41	45	44	54	46	8	40	54	44	44.5	4.6
Chloride	mg/L	1	21	38	-	33	32	46	45	40	7	21	46	36	38	8.7
Hardness	mg/L	3	-	-	-	120	-	120	150	130	4	120	150	130	125	14
Magnesium (Filtered)	mg/L	0.5	3.4	2.8	2.9	3.2	3.6	3	3.5	4.1	8	2.8	4.1	3.3	3.3	0.43
Nitrate (as NO3-)	mg/L	0.5	0.6	<0.5	<0.5	1	<0.5	<0.5	<0.5	1	8	<0.5	1	0.64	0.5	0.23
Nitrite (as NO2-)	mg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Potassium (Filtered)	mg/L	0.5	1.4	1.4	2.2	1.9	1.4	1.2	1.8	1.9	8	1.2	2.2	1.7	1.6	0.35
Sodium (Filtered)	mg/L	0.5	13	20	21	19	19	23	24	22	8	13	24	20	20.5	3.4
Sulphate	mg/L	1	7	9	-	12	9	12	17	17	7	7	17	12	12	3.9
Miscellaneous Inorganics																
Electrical Conductivity	µS/cm	1	310	320	340	320	360	380	410	360	8	310	410	350	350	34
pH (Lab)	pH Units		6.7	6.6	6.5	6.7	6.6	6.6	6.7	6.6	8	6.5	6.7	6.6	6.6	0.071
TDS	mg/L	5	190	200	220	190	220	240	270	260	8	190	270	224	220	31
Nutrients in Water (Field-filtered)																
Ammonia as N	mg/L	0.005	0.044	0.085	0.14	0.1	0.065	0.082	0.13	0.13	8	0.044	0.14	0.097	0.0925	0.034
Kjeldahl Nitrogen Total	mg/L	0.1	0.2	0.3	0.6	0.5	0.4	0.4	0.6	0.5	8	0.2	0.6	0.44	0.45	0.14
Nitrogen (Total Oxidised)	mg/L	0.005	0.22	0.048	0.068	0.31	0.041	0.023	0.09	0.25	8	0.023	0.31	0.13	0.079	0.11
Total Nitrogen	mg/L	0.1	0.4	0.4	0.7	0.8	0.4	0.4	0.7	0.8	8	0.4	0.8	0.58	0.55	0.19
Phosphate (as P)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Phosphorus	mg/L	0.01	<0.05	<0.01	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	8	<0.01	<0.05	0.04	0.05	0.019
Total Metals in water																
Iron	mg/L	0.01	0.07	0.06	0.04	0.08	0.11	0.07	0.06	0.12	8	0.04	0.12	0.076	0.07	0.027
Mercury	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	8	<0.00005	<0.00005	0.00005	0.00005	0
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Dissolved Metals in Water																
Aluminium (Filtered)	mg/L	0.01	0.05	0.07	0.11	0.1	0.05	0.06	0.09	0.08	8	0.05	0.11	0.076	0.075	0.023
Arsenic (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Barium (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Boron (Filtered)	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	8	<0.02	<0.02	0.02	0.02	0
Cadmium (Filtered)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	8	<0.0001	<0.0001	0.0001	0.0001	0
Chromium (III+VI) (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Copper (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	8	<0.001	0.001	0.001	0.001	0
Lead (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Manganese (Filtered)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Molybdenum (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	8	<0.001	0.001	0.001	0.001	0
Nickel (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Silver (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Uranium (Filtered)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Zinc (Filtered)	mg/L	0.001	<0.001	0.002	0.003	0.004	0.002	<0.001	<0.001	0.003	8	<0.001	0.004	0.0021	0.002	0.0011



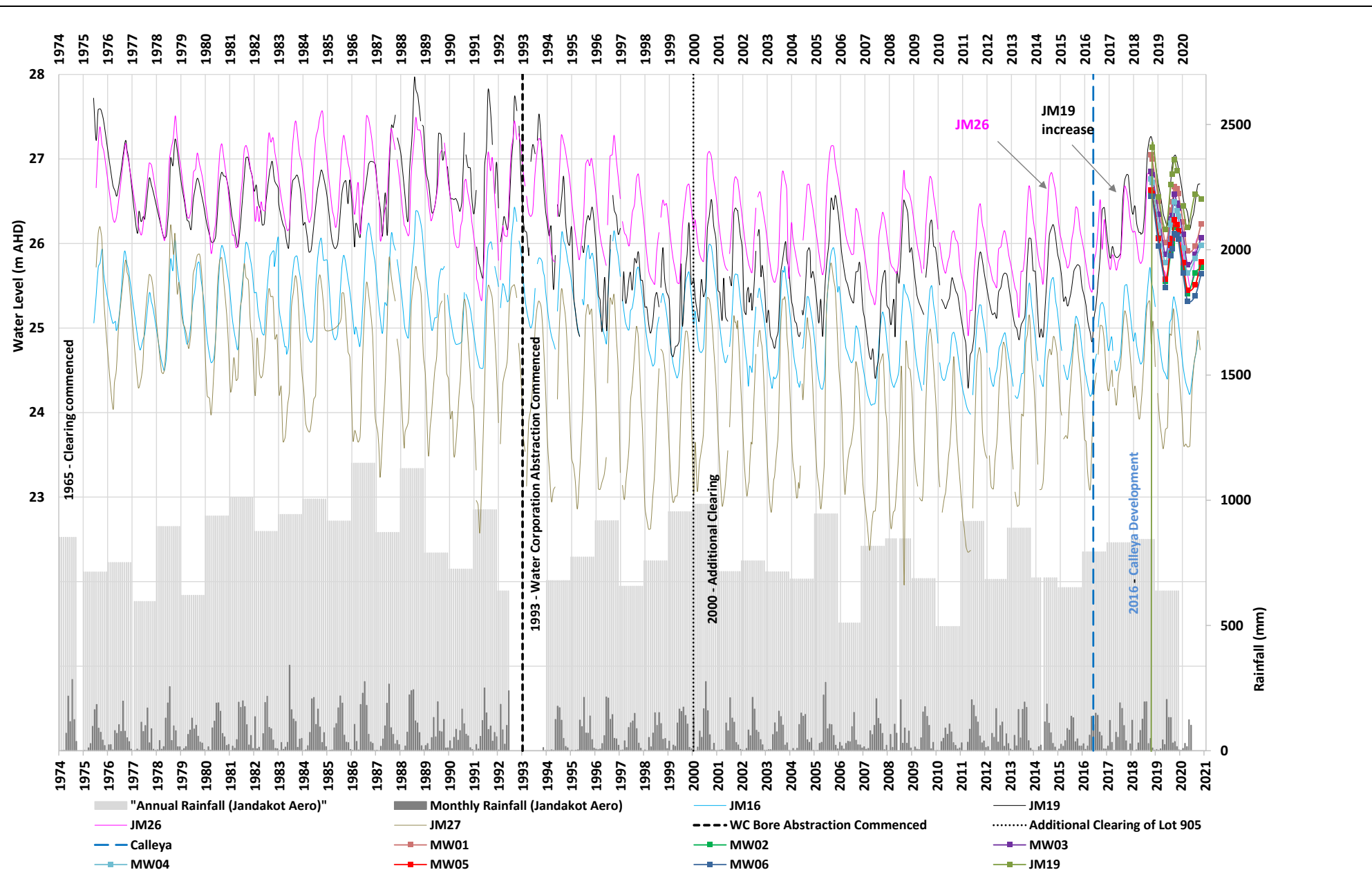
		J6641									Statistical Summary					
		Project ID	J6641	J6641	J6641	J6641	J6641	J6641	J6641	J6641						
		Location	MW05	MW05	MW05	MW05	MW05	MW05	MW05	MW05						
		Sampling Date	17/10/2018	25/01/2019	7/05/2019	25/07/2019	23/10/2019	22/01/2020	2/04/2020	22/07/2020						
ChemName	Unit	PQL									Number of Results	Minimum Concentration	Maximum Concentration	Average Concentration	Median Concentration	Standard Deviation
Field																
EC (field)	µS/cm		168	173	240	253	221	155	248	218	8	155	253	210	219.5	39
Temp (Field)	oC		20.3	21.5	19.8	18.9	19.8	21.5	22.5	21	8	18.9	22.5	21	20.65	1.2
pH (Field)	pH Units		6.35	6.61	6.7	6.43	6.16	6.31	6.64	6.32	8	6.16	6.7	6.4	6.39	0.19
Major Ions																
Alkalinity (Bicarbonate as CaCO3)	mg/L	5	-	-	-	-	-	40	-	-	1	40	40		40	
Calcium (Filtered)	mg/L	0.5	15	19	33	27	26	18	32	30	8	15	33	25	26.5	6.8
Chloride	mg/L	1	24	14	-	16	24	15	19	15	7	14	24	18	16	4.3
Hardness	mg/L	3	-	-	-	73	-	50	87	82	4	50	87	73	77.5	16
Magnesium (Filtered)	mg/L	0.5	1.9	1.6	2.2	1.5	2.1	1.4	1.9	1.9	8	1.4	2.2	1.8	1.9	0.29
Nitrate (as NO3-)	mg/L	0.5	<0.5	0.5	0.5	<0.5	<0.5	0.5	<0.5	<0.5	8	<0.5	0.5	0.5	0.5	0
Nitrite (as NO2-)	mg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Potassium (Filtered)	mg/L	0.5	2	4.1	2.8	8.7	2.4	0.9	2.2	2.2	8	0.9	8.7	3.2	2.3	2.4
Sodium (Filtered)	mg/L	0.5	13	11	11	15	14	9.1	12	12	8	9.1	15	12	12	1.9
Sulphate	mg/L	1	20	15	-	45	32	10	38	23	7	10	45	26	23	13
Miscellaneous Inorganics																
Electrical Conductivity (Non Compensated)	µS/cm	1	180	180	240	240	240	160	250	220	8	160	250	214	230	35
pH (Lab)	pH Units		6.4	6.6	6.7	6.8	6.5	6.7	6.9	6.9	8	6.4	6.9	6.7	6.7	0.18
TDS	mg/L	5	110	110	140	150	150	110	160	150	8	110	160	135	145	21
Nutrients in Water (Field-filtered)																
Ammonia as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	8	<0.005	0.009	0.0055	0.005	0.0014
Kjeldahl Nitrogen Total	mg/L	0.1	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.2	8	0.2	0.3	0.24	0.2	0.052
Nitrogen (Total Oxidised)	mg/L	0.005	0.048	0.077	0.086	0.11	0.03	0.079	0.14	0.041	8	0.03	0.14	0.076	0.078	0.037
Total Nitrogen	mg/L	0.1	0.2	0.2	0.4	0.3	0.3	0.3	0.4	0.3	8	0.2	0.4	0.3	0.3	0.076
Phosphate (as P)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Phosphorus	mg/L	0.01	<0.05	<0.01	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	8	<0.01	<0.05	0.04	0.05	0.019
Total Metals in water																
Iron	mg/L	0.01	0.06	0.07	0.03	0.06	0.76	0.09	0.04	0.1	8	0.03	0.76	0.15	0.065	0.25
Mercury	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	8	<0.00005	<0.00005	0.00005	0.00005	0
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Dissolved Metals in Water																
Aluminium (Filtered)	mg/L	0.01	0.08	0.05	0.02	0.06	0.08	0.06	0.03	0.04	8	0.02	0.08	0.053	0.055	0.022
Arsenic (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Barium (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Boron (Filtered)	mg/L	0.02	<0.02	<0.02	0.03	0.03	0.02	<0.02	0.02	<0.02	8	<0.02	0.03	0.023	0.02	0.0046
Cadmium (Filtered)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	8	<0.0001	<0.0001	0.0001	0.0001	0
Chromium (III+VI) (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Copper (Filtered)	mg/L	0.001	0.003	0.002	0.004	0.006	0.001	0.001	0.005	0.003	8	0.001	0.006	0.0031	0.003	0.0018
Lead (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	8	<0.001	0.001	0.001	0.001	0
Manganese (Filtered)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Molybdenum (Filtered)	mg/L	0.001	<0.001	0.002	0.003	0.001	<0.001	0.002	0.005	0.003	8	<0.001	0.005	0.0023	0.002	0.0014
Nickel (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Silver (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Uranium (Filtered)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Zinc (Filtered)	mg/L	0.001	0.001	0.005	0.012	0.006	0.001	0.004	0.011	0.008	8	0.001	0.012	0.006	0.0055	0.0041



		Project ID	J6641	J6641	J6641	J6641	J6641	J6641	J6641	J6641						
		Location	MW06	MW06	MW06	MW06	MW06	MW06	MW06	MW06						
		Sampling Date	17/10/2018	25/01/2019	7/05/2019	25/07/2019	23/10/2019	22/01/2020	2/04/2020	22/07/2020	Statistical Summary					
ChemName	Unit	PQL									Number of Results	Minimum Concentration	Maximum Concentration	Average Concentration	Median Concentration	Standard Deviation
Field																
EC (field)	µS/cm		261	209	220	239	268	216	202	196	8	196	268	226	218	27
Temp (Field)	oC		19.6	21.3	19.8	20.2	19.7	22.2	21.7	20.8	8	19.6	22.2	21	20.5	0.99
pH (Field)	pH Units		6.27	5.39	4.82	5.51	5.18	4.44	4.85	4.84	8	4.44	6.27	5.2	5.015	0.57
Major Ions																
Alkalinity (Bicarbonate as CaCO3)	mg/L	5	-	-	-	-	-	<5	-	-	1	<5	<5		5	
Calcium (Filtered)	mg/L	0.5	12	9.5	9.7	11	11	7	9.7	8.6	8	7	12	9.8	9.7	1.6
Chloride	mg/L	1	36	29	-	30	45	36	25	25	7	25	45	32	30	7.2
Hardness	mg/L	3	-	-	-	36	-	27	32	30	4	27	36	31	31	3.8
Magnesium (Filtered)	mg/L	0.5	2.9	2.4	1.6	2.4	3	2.2	1.8	2	8	1.6	3	2.3	2.3	0.49
Nitrate (as NO3-)	mg/L	0.5	0.7	2	5	2.6	0.8	2.6	5.1	2.3	8	0.7	5.1	2.6	2.45	1.7
Nitrite (as NO2-)	mg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Potassium (Filtered)	mg/L	0.5	10	8.5	8.1	5.6	7.6	6.4	7.3	5.1	8	5.1	10	7.3	7.45	1.6
Sodium (Filtered)	mg/L	0.5	24	20	19	23	29	22	16	18	8	16	29	21	21	4.1
Sulphate	mg/L	1	29	32	-	40	34	29	30	32	7	29	40	32	32	3.9
Miscellaneous Inorganics																
Electrical Conductivity	µS/cm	1	260	210	190	220	270	220	200	190	8	190	270	220	215	30
pH (Lab)	pH Units		6.3	5.4	5	5.7	5.7	5	5	5	8	5	6.3	5.4	5.2	0.48
TDS	mg/L	5	150	130	120	130	150	120	130	120	8	120	150	131	130	12
Nutrients in Water (Field-filtered)																
Ammonia as N	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	<0.005	<0.005	8	<0.005	0.012	0.0059	0.005	0.0025
Kjeldahl Nitrogen Total	mg/L	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.3	<0.1	8	<0.1	0.3	0.15	0.1	0.076
Nitrogen (Total Oxidised)	mg/L	0.005	0.14	0.49	1.5	0.79	0.19	0.74	1.4	0.67	8	0.14	1.5	0.74	0.705	0.5
Total Nitrogen	mg/L	0.1	0.3	0.7	1.6	0.9	0.3	0.9	1.7	0.8	8	0.3	1.7	0.9	0.85	0.52
Phosphate (as P)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Phosphorus	mg/L	0.01	<0.05	<0.01	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	8	<0.01	<0.05	0.04	0.05	0.019
Total Metals in water																
Iron	mg/L	0.01	0.09	0.22	0.05	0.02	0.06	0.04	0.01	<0.01	8	<0.01	0.22	0.063	0.045	0.069
Mercury	mg/L	0.00005	0.00005	0.00013	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	8	<0.00005	0.00013	0.00006	0.00005	0.000028
Selenium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Dissolved Metals in Water																
Aluminium (Filtered)	mg/L	0.01	0.07	0.12	0.53	0.28	0.15	0.45	0.68	0.52	8	0.07	0.68	0.35	0.365	0.23
Arsenic (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Barium (Filtered)	mg/L	0.001	0.004	0.004	0.005	0.005	0.005	0.004	0.005	0.004	8	0.004	0.005	0.0045	0.0045	0.00053
Boron (Filtered)	mg/L	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	8	<0.02	<0.02	0.02	0.02	0
Cadmium (Filtered)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0004	0.0002	<0.0001	<0.0001	8	<0.0001	0.0004	0.00015	0.0001	0.00011
Chromium (III+VI) (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Copper (Filtered)	mg/L	0.001	0.001	0.005	0.008	0.007	0.005	0.009	0.007	0.01	8	0.001	0.01	0.0065	0.007	0.0028
Lead (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	8	<0.001	0.001	0.001	0.001	0
Manganese (Filtered)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	8	<0.005	<0.005	0.005	0.005	0
Molybdenum (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Nickel (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Silver (Filtered)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	8	<0.001	<0.001	0.001	0.001	0
Uranium (Filtered)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	8	<0.5	<0.5	0.5	0.5	0
Zinc (Filtered)	mg/L	0.001	0.002	0.003	0.001	0.027	0.015	0.003	0.002	0.005	8	0.001	0.027	0.0073	0.003	0.0091

APPENDIX C

DWER Bore Long-Term Water Levels



Data Source: BoM (2020), WIR (2020)

Job No. J6641



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Perron Developments Pty Ltd
 Lot 131 Jandakot Rd, Treeby: Pre-Development Groundwater Monitoring 2018-2020
Appendix C: DWER Bore Long-Term Water Levels

Suite 1, 27 York St, Subiaco WA 6008
PO Box 117, Subiaco WA 6904
Ph: +61 8 9388 2436

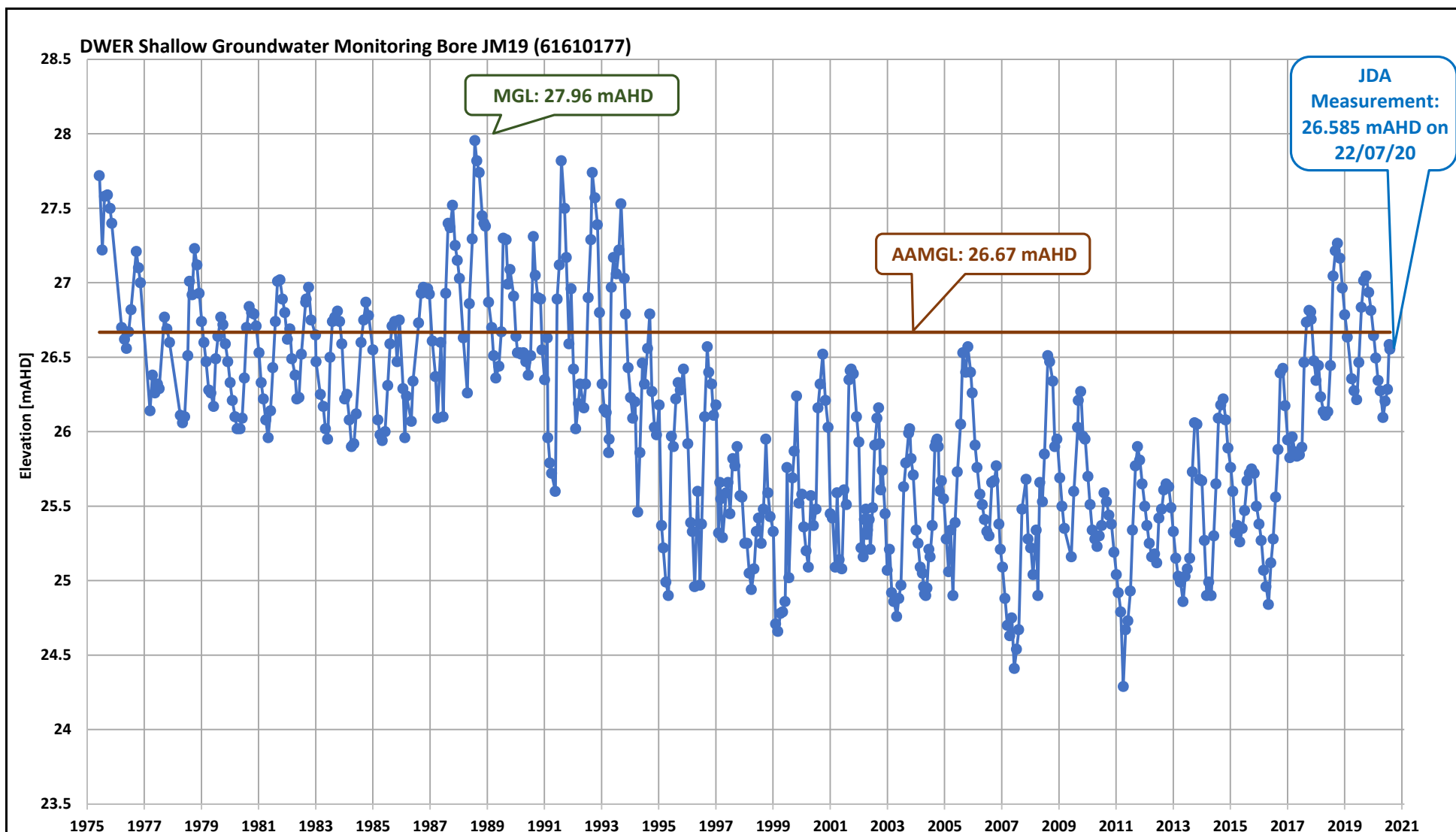
www.jdahydro.com.au

info@jdahydro.com.au



APPENDIX C

DWER Bore JM19 Hydrograph, AAMGL and MGL



Data Source: Department of Water and Environmental Regulation Online Water Information Reporting (WIR) (DWER, 2021).



Job No. J6704

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Perron Treeby Pty Ltd
 Lot 5131 Jandakot Road, Treeby: Local Water Management Strategy
Appendix C: DWER Bore JM19 Groundwater Level Time-Series, AAMGL and MGL

APPENDIX D

Groundwater Licences GWL205947 and
CAW205946



LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Perron Developments Pty Ltd		
Description of Water Resource	Jandakot Perth - Superficial Swan	Annual Water Entitlement	39,975kL
Location of Water Source	Lot 5131 On Plan 416564 Volume/Folio (2972/798)		

Authorised Activities	Taking of water for	Location of Activity
	Irrigation of up to 5.33 ha of public open space	Lot 5131 On Plan 416564 Volume/Folio (2972/798)
Duration of Licence	From 27 May 2021 to 26 May 2031	

This Licence is subject to the following terms, conditions and restrictions:

1. The annual water year for water taken under this licence is defined as 1 June to 31 May.
2. The licensee shall not use water for sprinkler irrigation between 9 am and 6 pm except for the establishment of newly planted areas. For newly planted areas water may be used within these hours for a period of up to 28 consecutive days, commencing from the date of planting.
3. Between 1 June and 31 August in any year, the licence-holder must not water a lawn, garden, or grass-covered area ("turf") by reticulation, provided always that this restriction shall not apply to watering with a hand held hose; or watering, by way of reticulation: newly planted areas for a period of up to 28 days from the date of planting; for renovating turf; or for maintenance of reticulation systems.

End of terms, conditions and restrictions



LICENCE TO CONSTRUCT OR ALTER WELL

Granted by the Minister under section 26D of the Rights in Water and Irrigation Act 1914

Licensee(s)	Perron Developments Pty Ltd	
Description of Water Resource	Jandakot Perth - Superficial Swan	
Location of Well(s)	Lot 5131 On Plan 416564 Volume/Folio (2972/798)	
Authorised Activities	Activity	Location of Activity
	Construct 1 non-artesian well(s).	Lot 5131 On Plan 416564 Volume/Folio (2972/798)
Duration of Licence	From 27 May 2021 to 26 May 2022	

This Licence is subject to the following terms, conditions and restrictions:

1. The well must be constructed by a driller having a current class 1 water well drillers certificate issued by the Western Australian branch of the Australian Drilling Industry Association or equivalent certification recognised nationally by the Australian Drilling Industry Association.
2. The licensee shall construct the well using materials and methods for single aquifers described in 'Minimum construction requirements for water bores in Australia, Fourth Edition, 2020'
3. The depth of the well(s) shall be limited to the superficial aquifer.
4. The licensee shall not construct a bore or excavate a groundwater soak within 200 metres of a groundwater dependant ecosystem or vegetation.

End of terms, conditions and restrictions

APPENDIX E

PCSump Modelling Results



Environmental and Water Resource Software

PCSump Version 6.1



Project Number/Name: J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description: Catchment c1 FMA

1% AEP (Major Event)

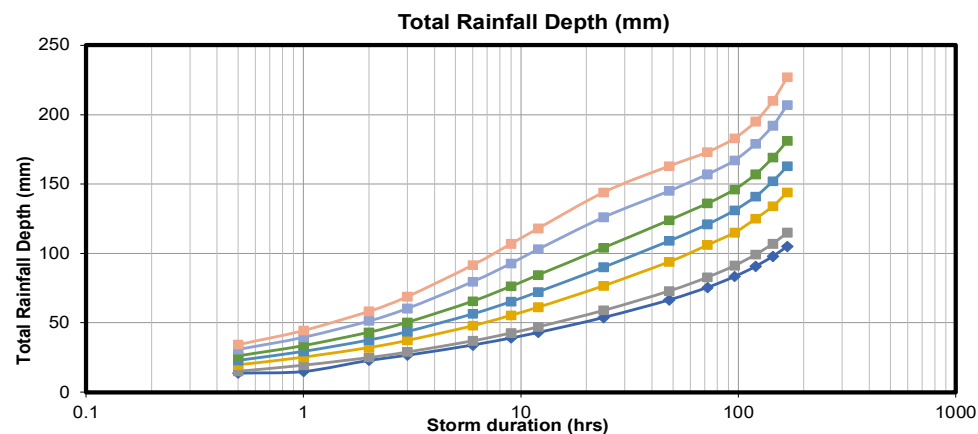
Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1125 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N) N

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.7	15.1	19.6	22.9	26.2	30.7	34.3
1 hour	15	19.5	25.2	29.4	33.6	39.6	44.5
2 hour	23	25.1	32.2	37.6	43.2	51.4	58.3
3 hour	26.6	29	37.3	43.6	50.4	60.3	68.8
6 hour	34	37.1	47.9	56.4	65.6	79.6	91.6
9 hour	39.2	42.7	55.4	65.3	76.3	92.8	107
12 hour	43.1	47.1	61.2	72.3	84.4	103	118
24 hour	53.8	59	76.7	90.1	104	126	144
48 hour	66.5	72.9	93.9	109	124	145	163
72 hour	75.5	82.8	106	121	136	157	173
96 hour	83.3	91.2	115	131	146	167	183
120 hour	90.7	99.2	125	141	157	179	195
144 hour	97.9	107	134	152	169	192	210
168 hour	105	115	144	163	181	207	227

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Lots	12.28	15	5	
Drainage	0.92			10.0%



POS	1.05			90.0%
Road	5.638			10.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-20
Design Groundwater Level (mAHD)	27.1
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	20%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	Y
Base Length (m)	62
Base Width (m)	21.5
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.84
Maximum Allowable TWL (mAHD)	29.84

Pipe Outflow:

Entrance Type	Square edge with headwall
Pipe Diameter (mm)	600
Pipe Length (m)	350
Upstream Invert Level (mAHD)	29.07
Downstream Invert Level (mAHD)	28.37

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

Stage-Area-Volume Relationship:

Stage (mAHD)	Area (m²)	Volume (m³)
28.84	1612	0
29.34	2151	935
29.3401	8087	936
29.84	9230	5264



Environmental and Water Resource Software

Project Number / Name:

J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description:

Catchment c1 FMA

1% AEP (Major Event)

Model Selection:

Shallow Water Table Model

Results:

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m³]	Area [m²]	Temporal Pattern No.
1	30 min	34.3	1%	0.82	29.66	0.18	3,720	8,822	8
2	1 hour	44.5	1%	0.94	29.78	0.06	4,733	9,090	6
3	2 hour	58.3	1%	1	29.84	0.00	5,259	9,229	7
4	3 hour	68.8	1%	0.98	29.82	0.02	5,072	9,179	4
5	6 hour	91.6	1%	0.94	29.78	0.06	4,774	9,101	9
6	9 hour	107.0	1%	0.9	29.74	0.10	4,427	9,009	10
7	12 hour	118.0	1%	0.8	29.64	0.20	3,520	8,769	9
8	24 hour	144.0	1%	0.67	29.51	0.33	2,394	8,472	10
9	48 hour	163.0	1%	0.55	29.39	0.45	1,406	8,211	5
10	72 hour	173.0	1%	0.51	29.35	0.49	1,030	8,112	5
11	96 hour	183.0	1%	0.36	29.20	0.64	678	2,003	10
12	120 hour	195.0	1%	0.35	29.19	0.65	660	1,993	1
13	144 hour	210.0	1%	0.3	29.14	0.70	554	1,931	2
14	168 hour	227.0	1%	0.37	29.21	0.63	693	2,011	1
3	2 hour	58.3	1%	1	29.84	0.00	5,259	9,229	7

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded



Environmental and Water Resource Software

PCSump Version 6.1



Project Number/Name: J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description: Catchment c1 FMA
20% AEP (Minor Event)

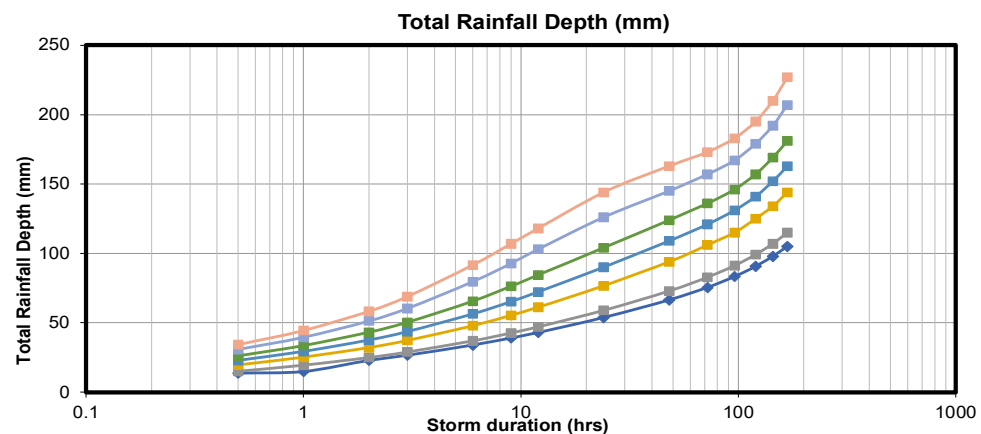
Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1125 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	N
-----------------------	---

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.7	15.1	19.6	22.9	26.2	30.7	34.3
1 hour	15	19.5	25.2	29.4	33.6	39.6	44.5
2 hour	23	25.1	32.2	37.6	43.2	51.4	58.3
3 hour	26.6	29	37.3	43.6	50.4	60.3	68.8
6 hour	34	37.1	47.9	56.4	65.6	79.6	91.6
9 hour	39.2	42.7	55.4	65.3	76.3	92.8	107
12 hour	43.1	47.1	61.2	72.3	84.4	103	118
24 hour	53.8	59	76.7	90.1	104	126	144
48 hour	66.5	72.9	93.9	109	124	145	163
72 hour	75.5	82.8	106	121	136	157	173
96 hour	83.3	91.2	115	131	146	167	183
120 hour	90.7	99.2	125	141	157	179	195
144 hour	97.9	107	134	152	169	192	210
168 hour	105	115	144	163	181	207	227

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Lots		15	5	
Drainage	0.2			10.0%



POS				90.0%
Road	5.638			10.0%

Basin Parameters:

<i>Soil Characteristics:</i>	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-20
Design Groundwater Level (mAHD)	27.1
<i>Initial Conditions:</i>	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	20%
<i>Basin Geometry:</i>	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	62
Base Width (m)	26
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.84
Maximum Allowable TWL (mAHD)	29.34

Pipe Outflow:

Entrance Type	Square edge with headwall
Pipe Diameter (mm)	600
Pipe Length (m)	350
Upstream Invert Level (mAHD)	29.07
Downstream Invert Level (mAHD)	28.37

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

**Project Number / Name:**

J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description:

Catchment c1 FMA

20% AEP (Minor Event)

Model Selection:

Shallow Water Table Model

Results:

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m³]	Area [m²]	Temporal Pattern No.
1	30 min	19.6	20%	0.46	29.30	0.04	850	2,123	8
2	1 hour	25.2	20%	0.5	29.34	0.00	934	2,170	2
3	2 hour	32.2	20%	0.5	29.34	0.00	946	2,177	4
4	3 hour	37.3	20%	0.48	29.32	0.02	909	2,156	5
5	6 hour	47.9	20%	0.45	29.29	0.05	839	2,117	7
6	9 hour	55.4	20%	0.43	29.27	0.07	801	2,096	5
7	12 hour	61.2	20%	0.41	29.25	0.09	750	2,067	10
8	24 hour	76.7	20%	0.37	29.21	0.13	675	2,024	8
9	48 hour	93.9	20%	0.28	29.12	0.22	494	1,918	4
10	72 hour	106.0	20%	0.24	29.08	0.26	427	1,878	10
11	96 hour	115.0	20%	0.15	28.99	0.35	258	1,776	10
12	120 hour	125.0	20%	0.18	29.02	0.32	312	1,809	2
13	144 hour	134.0	20%	0.16	29.00	0.34	271	1,783	3
14	168 hour	144.0	20%	0.14	28.98	0.36	237	1,763	10
2	1 hour	25.2	20%	0.5	29.34	0.00	934	2,170	2

Notes:

Temporal pattern matching closest to mean water level
 If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded



Environmental and Water Resource Software

PCSump Version 6.1



Project Number/Name: J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description: Catchment c1 FMA
First 15 mm

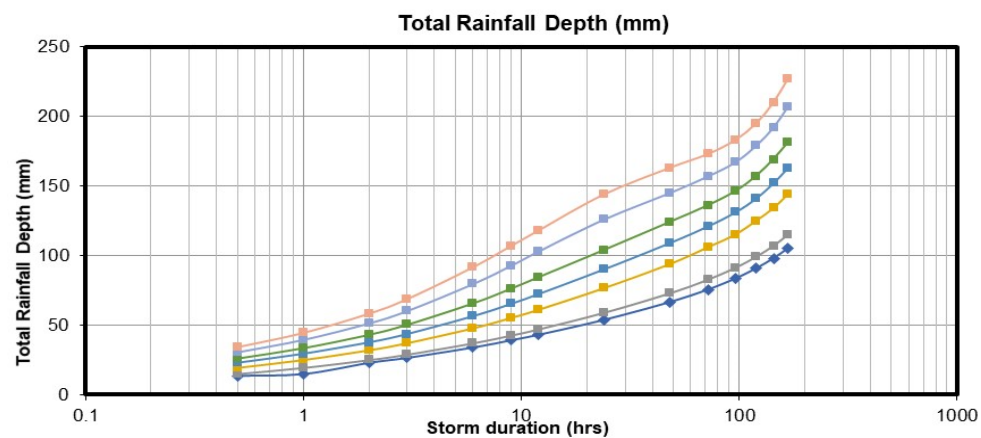
Model Selection:	Deep Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1125 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N) N

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.7	15.1	19.6	22.9	26.2	30.7	34.3
1 hour	15	19.5	25.2	29.4	33.6	39.6	44.5
2 hour	23	25.1	32.2	37.6	43.2	51.4	58.3
3 hour	26.6	29	37.3	43.6	50.4	60.3	68.8
6 hour	34	37.1	47.9	56.4	65.6	79.6	91.6
9 hour	39.2	42.7	55.4	65.3	76.3	92.8	107
12 hour	43.1	47.1	61.2	72.3	84.4	103	118
24 hour	53.8	59	76.7	90.1	104	126	144
48 hour	66.5	72.9	93.9	109	124	145	163
72 hour	75.5	82.8	106	121	136	157	173
96 hour	83.3	91.2	115	131	146	167	183
120 hour	90.7	99.2	125	141	157	179	195
144 hour	97.9	107	134	152	169	192	210
168 hour	105	115	144	163	181	207	227

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Lots		15	5	
Drainage				10.0%



POS				90.0%
Road	5.638			10.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	-5
Porosity	0.2
Aquifer Storage Coefficient	
Base of Aquifer (mAHD)	
Design Groundwater Level (mAHD)	
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	20%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	62
Base Width (m)	26
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.84
Maximum Allowable TWL (mAHD)	29.09

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	



Environmental and Water Resource Software

Project Number / Name:

J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description:

Catchment c1 FMA

First 15 mm

Model Selection:

Deep Water Table Model

Results:

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m ³]	Area [m ²]	Temporal Pattern No.
1	1 hour	15.0	1 EY	0.2	29.04	0.05	342	1,828	2
1	1 hour	15.0	1 EY	0.2	29.04	0.05	342	1,828	2

Critical**Notes:**

Temporal pattern matching closest to mean water level

If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded



Environmental and Water Resource Software

PCSump Version 6.1



Project Number/Name: J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description: Catchment c2 FMA

1% AEP (Major Event)

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1125 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

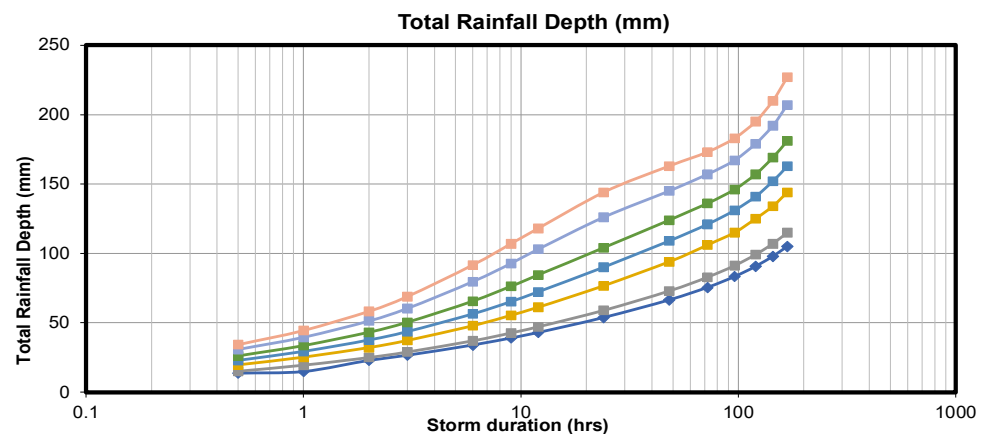
Swale Selection (Y/N)

N

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.7	15.1	19.6	22.9	26.2	30.7	34.3
1 hour	15	19.5	25.2	29.4	33.6	39.6	44.5
2 hour	23	25.1	32.2	37.6	43.2	51.4	58.3
3 hour	26.6	29	37.3	43.6	50.4	60.3	68.8
6 hour	34	37.1	47.9	56.4	65.6	79.6	91.6
9 hour	39.2	42.7	55.4	65.3	76.3	92.8	107
12 hour	43.1	47.1	61.2	72.3	84.4	103	118
24 hour	53.8	59	76.7	90.1	104	126	144
48 hour	66.5	72.9	93.9	109	124	145	163
72 hour	75.5	82.8	106	121	136	157	173
96 hour	83.3	91.2	115	131	146	167	183
120 hour	90.7	99.2	125	141	157	179	195
144 hour	97.9	107	134	152	169	192	210
168 hour	105	115	144	163	181	207	227

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Lots	1.488	15	5	
Drainage	0.1			10.0%



POS	0.24			90.0%
Road	0.711			10.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-20
Design Groundwater Level (mAHD)	27
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	20%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	Y
Base Length (m)	20.5
Base Width (m)	7
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.53
Maximum Allowable TWL (mAHD)	29.53

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

Stage-Area-Volume Relationship:

Stage (mAHD)	Area (m ²)	Volume (m ³)
28.53	144	0
28.98	317	104
28.9801	861	105
29.53	1307	701

**Project Number / Name:**

J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description:

Catchment c2 FMA

1% AEP (Major Event)

Model Selection:

Shallow Water Table Model

Results:

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m³]	Area [m²]	Temporal Pattern No.
1	30 min	34.3	1%	0.75	29.28	0.25	431	1,105	8
2	1 hour	44.5	1%	0.84	29.37	0.16	529	1,178	10
3	2 hour	58.3	1%	0.93	29.46	0.07	629	1,253	2
4	3 hour	68.8	1%	0.96	29.49	0.04	660	1,276	4
5	6 hour	91.6	1%	1	29.53	0.00	698	1,305	9
6	9 hour	107.0	1%	1	29.53	0.00	700	1,306	2
7	12 hour	118.0	1%	0.87	29.40	0.13	562	1,203	9
8	24 hour	144.0	1%	0.69	29.22	0.31	369	1,059	7
9	48 hour	163.0	1%	0.11	28.64	0.89	26	187	2
10	72 hour	173.0	1%	0	28.53	1.00	1	146	2
11	96 hour	183.0	1%	0	28.53	1.00	-	144	10
12	120 hour	195.0	1%	0	28.53	1.00	-	144	1
13	144 hour	210.0	1%	0	28.53	1.00	-	144	10
14	168 hour	227.0	1%	0	28.53	1.00	-	144	9
5	6 hour	91.6	1%	1	29.53	0.00	698	1,305	9

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded



Environmental and Water Resource Software

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Project Number/Name: J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description: Catchment c2 FMA

20% AEP (Minor Event)

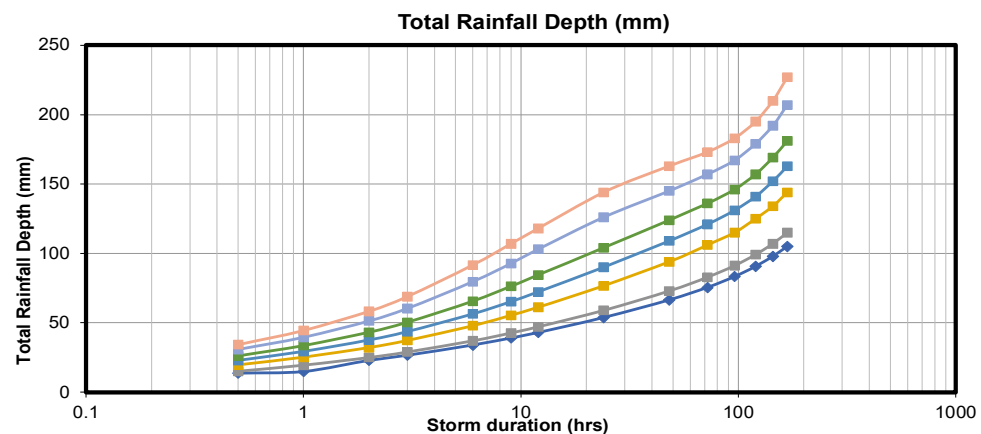
Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	20% AEP (4.48 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1125 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N) N

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.7	15.1	19.6	22.9	26.2	30.7	34.3
1 hour	15	19.5	25.2	29.4	33.6	39.6	44.5
2 hour	23	25.1	32.2	37.6	43.2	51.4	58.3
3 hour	26.6	29	37.3	43.6	50.4	60.3	68.8
6 hour	34	37.1	47.9	56.4	65.6	79.6	91.6
9 hour	39.2	42.7	55.4	65.3	76.3	92.8	107
12 hour	43.1	47.1	61.2	72.3	84.4	103	118
24 hour	53.8	59	76.7	90.1	104	126	144
48 hour	66.5	72.9	93.9	109	124	145	163
72 hour	75.5	82.8	106	121	136	157	173
96 hour	83.3	91.2	115	131	146	167	183
120 hour	90.7	99.2	125	141	157	179	195
144 hour	97.9	107	134	152	169	192	210
168 hour	105	115	144	163	181	207	227

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Lots		15	5	
Drainage	0.1			10.0%



POS				90.0%
Road	0.711			10.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-20
Design Groundwater Level (mAHD)	27
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	20%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	20.5
Base Width (m)	7
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.53
Maximum Allowable TWL (mAHD)	29.03

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

**Project Number / Name:**

J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description:

Catchment c2 FMA

20% AEP (Minor Event)

Model Selection:

Shallow Water Table Model

Results:

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m³]	Area [m²]	Temporal Pattern No.
1	30 min	19.6	20%	0.43	28.96	0.07	95	310	1
2	1 hour	25.2	20%	0.45	28.98	0.05	103	322	10
3	2 hour	32.2	20%	0.45	28.98	0.05	102	321	9
4	3 hour	37.3	20%	0.45	28.98	0.05	102	320	4
5	6 hour	47.9	20%	0.41	28.94	0.09	89	301	10
6	9 hour	55.4	20%	0.37	28.90	0.13	77	284	5
7	12 hour	61.2	20%	0.33	28.86	0.17	66	267	9
8	24 hour	76.7	20%	0.17	28.70	0.33	30	204	5
9	48 hour	93.9	20%	0	28.53	0.50	-	144	10
10	72 hour	106.0	20%	0.06	28.59	0.44	10	165	2
11	96 hour	115.0	20%	0	28.53	0.50	-	144	10
12	120 hour	125.0	20%	0	28.53	0.50	-	144	10
13	144 hour	134.0	20%	0	28.53	0.50	-	144	10
14	168 hour	144.0	20%	0.02	28.55	0.48	2	149	4
2	1 hour	25.2	20%	0.45	28.98	0.05	103	322	10

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded



Environmental and Water Resource Software

PCSump Version 6.1



Project Number/Name: J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description: Catchment c2 FMA

First 15 mm

Model Selection:	Deep Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1125 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

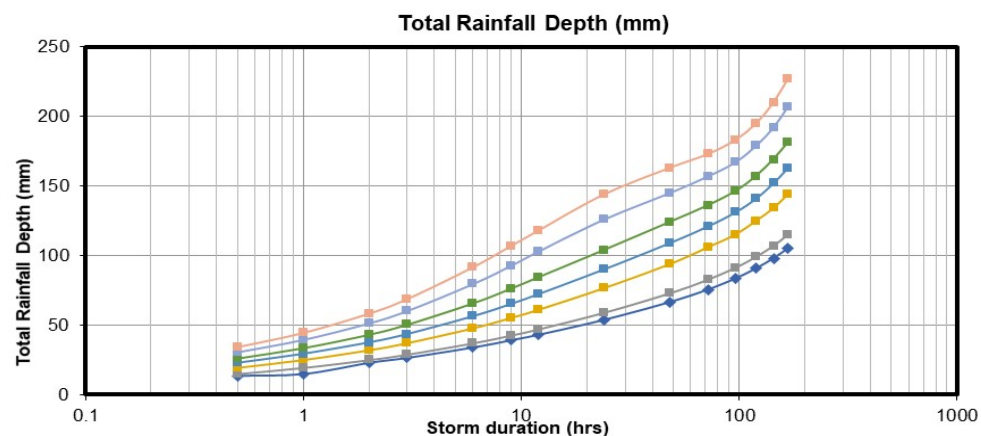
Swale Selection (Y/N)

N

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.7	15.1	19.6	22.9	26.2	30.7	34.3
1 hour	15	19.5	25.2	29.4	33.6	39.6	44.5
2 hour	23	25.1	32.2	37.6	43.2	51.4	58.3
3 hour	26.6	29	37.3	43.6	50.4	60.3	68.8
6 hour	34	37.1	47.9	56.4	65.6	79.6	91.6
9 hour	39.2	42.7	55.4	65.3	76.3	92.8	107
12 hour	43.1	47.1	61.2	72.3	84.4	103	118
24 hour	53.8	59	76.7	90.1	104	126	144
48 hour	66.5	72.9	93.9	109	124	145	163
72 hour	75.5	82.8	106	121	136	157	173
96 hour	83.3	91.2	115	131	146	167	183
120 hour	90.7	99.2	125	141	157	179	195
144 hour	97.9	107	134	152	169	192	210
168 hour	105	115	144	163	181	207	227

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Lots		15	5	
Drainage				10.0%



POS				90.0%
Road	0.711			10.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	-5
Porosity	0.2
Aquifer Storage Coefficient	
Base of Aquifer (mAHD)	
Design Groundwater Level (mAHD)	
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	20%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	20.5
Base Width (m)	7
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.53
Maximum Allowable TWL (mAHD)	28.83

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	



Environmental and Water Resource Software

Project Number / Name:

J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description:

Catchment c2 FMA

First 15 mm

Model Selection:

Deep Water Table Model

Results:

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m ³]	Area [m ²]	Temporal Pattern No.
1	1 hour	15.0	1 EY	0.25	28.78	0.05	47	235	2
1	1 hour	15.0	1 EY	0.25	28.78	0.05	47	235	2

Critical**Notes:**

Temporal pattern matching closest to mean water level

If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded



Environmental and Water Resource Software

PCSump Version 6.1



Project Number/Name: J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description: Catchment c3 FMA

First 15 mm

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1 EY (1 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	CUSTOM
Latitude:	32.1125 (S)
Longitude:	115.8875 (E)
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

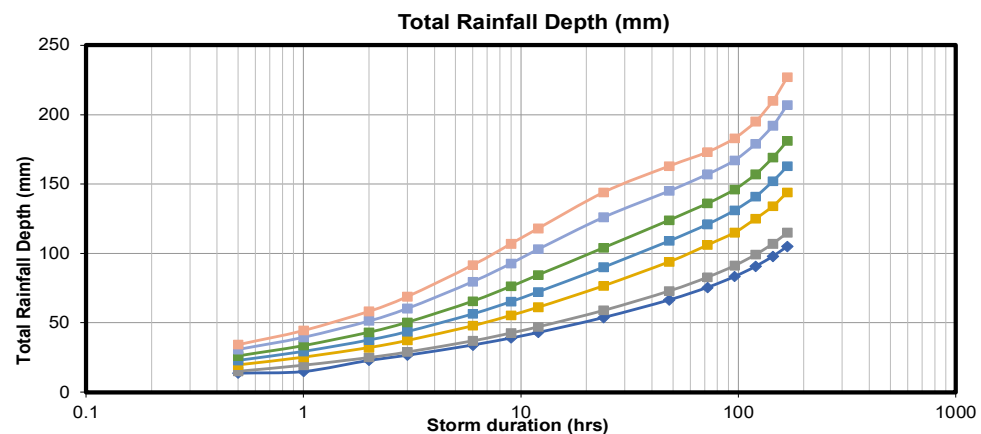
Swale Selection (Y/N)

N

Total Rainfall Depth (mm)							
Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	13.7	15.1	19.6	22.9	26.2	30.7	34.3
1 hour	15	19.5	25.2	29.4	33.6	39.6	44.5
2 hour	23	25.1	32.2	37.6	43.2	51.4	58.3
3 hour	26.6	29	37.3	43.6	50.4	60.3	68.8
6 hour	34	37.1	47.9	56.4	65.6	79.6	91.6
9 hour	39.2	42.7	55.4	65.3	76.3	92.8	107
12 hour	43.1	47.1	61.2	72.3	84.4	103	118
24 hour	53.8	59	76.7	90.1	104	126	144
48 hour	66.5	72.9	93.9	109	124	145	163
72 hour	75.5	82.8	106	121	136	157	173
96 hour	83.3	91.2	115	131	146	167	183
120 hour	90.7	99.2	125	141	157	179	195
144 hour	97.9	107	134	152	169	192	210
168 hour	105	115	144	163	181	207	227

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Lots		15	5	
Drainage				10.0%



POS				90.0%
Road	1.59			10.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-20
Design Groundwater Level (mAHD)	27.6
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	20%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	N
Base Length (m)	46
Base Width (m)	7
Average Slope (1 in X)	6
Basin Base Elevation (mAHD)	28.22
Maximum Allowable TWL (mAHD)	28.57

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	



Environmental and Water Resource Software

Project Number / Name:

J6704: Lot 5131 Jandakot Road, Treeby: LWMS

Project Description:

Catchment c3 FMA

First 15 mm

Model Selection:

Shallow Water Table Model

Results:

Design Storms				Maximum (Mean of Temporal Patterns)					
Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m ³]	Area [m ²]	Temporal Pattern No.
1	1 hour	15.0	1 EY	0.35	28.57	0.00	153	562	10
1	1 hour	15.0	1 EY	0.35	28.57	0.00	153	562	10

Critical**Notes:**

Temporal pattern matching closest to mean water level

If Water Level is coloured **Red**, Maximum Capacity of the Basin has been Exceeded

APPENDIX F

UNDO Modelling Results



Project: J6704: Lot 705 Armadale Road,
Treeby

Date: 14/06/2021

Version: Version 1.2.0.19289

Subregion name: **Residential Lots**

Landuse	Percent (%)	Area (ha)	Input load		Total area (ha)	Total percent (%)
			Nitrogen (kg)	Phosphorus (kg)		
Residential	100	15.81	637.67	171.26	15.81	52
Industrial, commercial & schools	0	0.00	0.00	0.00	Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
Rural living	0	0.00	0.00	0.00		
Public open space	0	0.00	0.00	0.00	45.57	10.98
Road reserve	0	0.00	0.00	0.00	Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
					3.73	0.10

Residential						
Size (m ²)	Percent (%)	Area (ha)	Input load		Total area (ha)	Total percent (%)
			Nitrogen (kg)	Phosphorus (kg)		
<400	60	9.48	222.83	65.28	15.808	100
400-500 m ²	40	6.32	414.84	105.98		
501-600 m ²	0	0.00	0.00	0.00	Nitrogen input (kg)	Phosphorus input (kg)
601-730 m ²	0	0.00	0.00	0.00		
>730 m ²	0	0.00	0.00	0.00	637.67	171.26
Multiple dwellings	0	0.00	0.00	0.00		

Soil and drainage information

Type of drainage	Infiltration	Does it contain imported fill?	No
Soil type	Bassendean	Does subregion contain onsite sewage disposal system?	No
Depth to groundwater (m)	3.5		
Groundwater slope (%)	0.2		
Soil PRI	5.0		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: Road Reserves

Landuse	Percent (%)	Area (ha)	Input load		Total area (ha)	Total percent (%)
			Nitrogen (kg)	Phosphorus (kg)		
Residential	0	0.00	0.00	0.00	9.12	30
Industrial, commercial & schools	0	0.00	0.00	0.00	Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
Rural living	0	0.00	0.00	0.00	5.23	0.15
Public open space	0	0.00	0.00	0.00	Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
Road reserve	100	9.12	0.00	0.00	0.33	0.01

Road reserve

Landuse	Percent (%)	Area (ha)	Total area (ha)	Total percent (%)
Roads	80	7.30	9.12	100
Road reserve - impervious	0	0.00	Nitrogen input (kg)	Phosphorus input (kg)
Road reserve - native garden	0	0.00	0.00	0.00
Road reserve - non-native garden	0	0.00		
Road reserve - turf	0	0.00		
Road reserve - not fertilised	20	1.82		

Soil and drainage information

Type of drainage	Piped drainage	Does it contain imported fill?	No
Soil type	Bassendean	Does subregion contain onsite sewage disposal system?	No
Depth to groundwater (m)	3.5		
Groundwater slope (%)	0.2		
Soil PRI	5.0		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: **Public Open Spaces**

Landuse	Percent (%)	Area (ha)	Input load		Total area (ha)	Total percent (%)
			Nitrogen (kg)	Phosphorus (kg)		
Residential	0	0.00	0.00	0.00	5.47	18
Industrial, commercial & schools	0	0.00	0.00	0.00	Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
Rural living	0	0.00	0.00	0.00		
Public open space	100	5.47	194.26	5.66	40.73	1.19
Road reserve	0	0.00	0.00	0.00	Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
					3.69	0.04

Public Open Space (POS)				
Landuse	Percent (%)	Area (ha)		
Native gardens	15	0.82	Total area (ha)	Total percent (%)
Non-native gardens	0	0.00		
Not fertilised	0	0.00		
Nature	40	2.19	5.47	100
Sport	0	0.00		
Recreation	45	2.46		
Golf course	0	0.00	Nitrogen input (kg)	Phosphorus input (kg)
Bowling green	0	0.00		
Impervious	0	0.00		
Water body	0	0.00	194.26	5.66

Soil and drainage information

Type of drainage	Infiltration	Does it contain imported fill?	No
Soil type	Bassendean	Does subregion contain onsite sewage disposal system?	No
Depth to groundwater (m)	2		
Groundwater slope (%)	0.2		
Soil PRI	5.0		

Note: Please attach the results of soil tests to this report when submitting.

Summary: Nutrient stripping devices

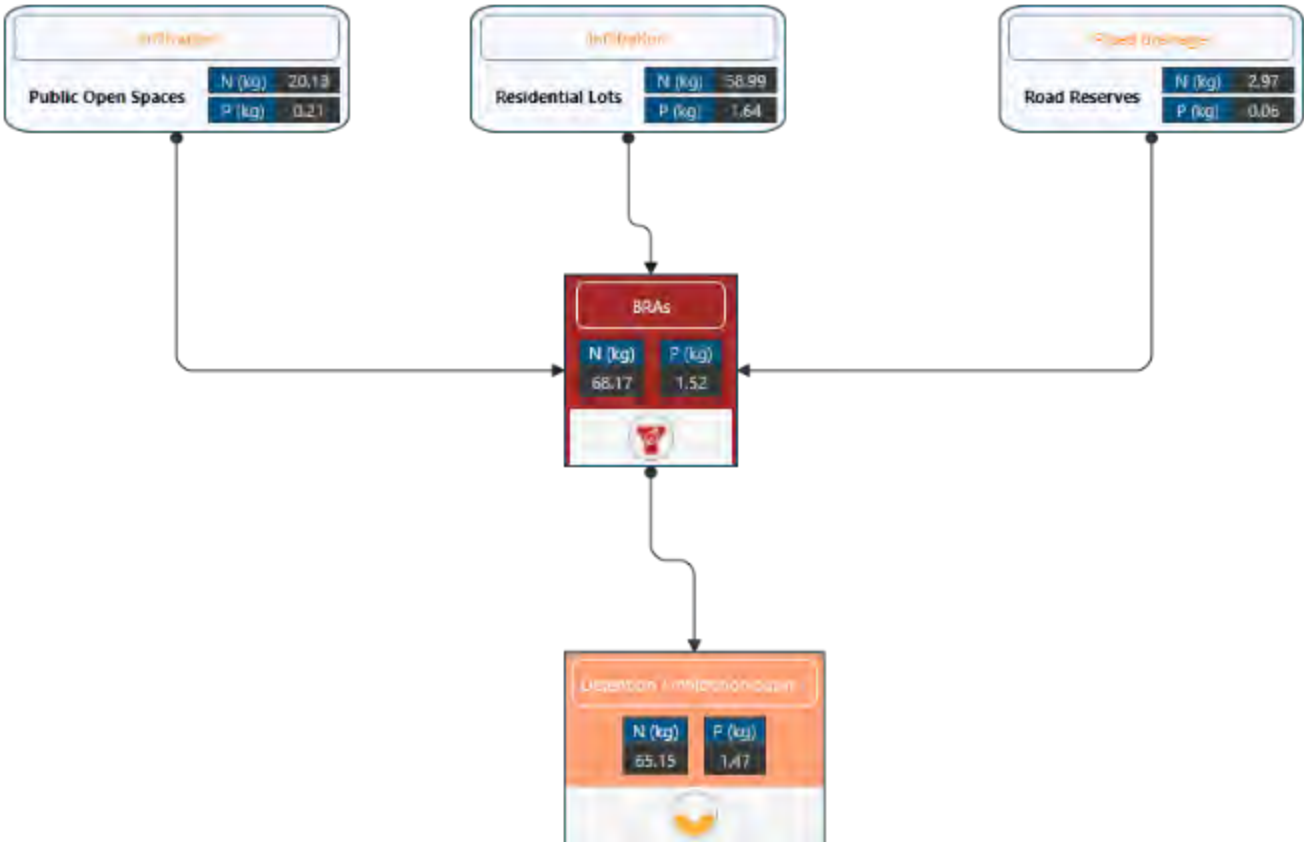
Treatment	Name	Size (m ²)	Treated area (ha)	Treating	N removed (kg/ha/yr)	P removed (kg/ha/yr)
Biofilter	BRAs	1733.00	30.40	Sandy soils – Runoff only (infiltration on lots)	1.32	0.03
Detention / infiltration basin	Detention / infiltration basin 1	19800.00	30.40	Sandy soils – Runoff only (infiltration on lots)	0.28	0.00
Load removed					0.56	0.01
Net export					2.14	0.05

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/ha/yr)	N export (kg/ha/yr)
Residential Lots	15.81	0.10	3.73
Road Reserves	9.12	0.01	0.33
Public Open Spaces	5.47	0.04	3.69

PRE-TREATMENT LOAD (kg/ha/yr)		LOAD REMOVED (kg/ha/yr)		NET LOAD EXPORT (kg/ha/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
2.70	0.06	0.56	0.01	2.14	0.05

Treatment diagram



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